Canada 2022

Energy Policy Review

International Energy Agency

INTERNATIONAL ENERGY AGENCY

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Foreword

The International Energy Agency (IEA) has conducted in-depth peer reviews of its member countries' energy policies since 1976. This process supports energy policy development and encourages the exchange of and learning from international best practices. By seeing what has worked – or not – in the "real world", these reviews help to identify policies that deliver concrete results.

Since the last IEA in-depth review in 2015, Canada has made a series of international and domestic commitments, putting the country on a path towards an ambitious transformation of its energy system, while remaining a stable and reliable supplier of energy to the world. Most recently, Canada set a target to cut greenhouse gas emissions by 40-45% from 2005 levels by 2030 and legislated a commitment to reach net zero emissions by 2050.

I am especially grateful to Canada's Minister of Natural Resources, Jonathan Wilkinson, for his leadership on energy and climate issues and his support for key IEA initiatives, including in his previous role as Minister of Environment and Climate Change. In particular, I was impressed by the leadership shown by Canada at COP26. This came through in its more ambitious targets for cutting carbon emissions and its participation in the Global Methane Pledge, which was underlined by Canada's commendable commitment to reduce methane emissions from oil and gas operations by 75% by 2030, as recommended in recent IEA analysis. Notably, Canada has promoted a people-centred approach to its clean energy transition, including initiatives to promote gender equity in clean energy sectors; programmes to increase access to clean energy in northern, remote and Indigenous communities; and actions to enable just transitions for fossil fuel workers.

Achieving Canada's enhanced targets presents both challenges and opportunities given the country's profile as a major producer, consumer and exporter of energy. Moreover, its highly decentralised system of government means coordination among federal, provincial and territorial governments is essential for a successful energy transition. Canada has a number of policy measures in place to support its energy and climate targets, including an ambitious carbon-pricing scheme, clean fuel regulations, a commitment to phase out unabated coal use by 2030, nuclear plant extensions, upstream methane regulations, energy efficiency programmes and measures to decarbonise the transport sector.

Canada's electricity supply is among the cleanest in the world, thanks in large part to the dominance of hydro power and the important role of nuclear. Greater interconnections among provinces and territories can ensure balanced progress towards national goals for decarbonising the power sector. Steeper emissions reductions are still needed in other sectors, notably oil and gas production, transport and industry. To this end, Canada has focused its efforts on a number of technologies, including carbon capture, utilisation and storage; hydrogen; and small modular nuclear reactors, with a view to serving as a supplier of energy and climate solutions to the world.

I sincerely hope that the recommendations proposed in this report will help Canada navigate its energy system transformation and pathway to net zero by 2050.

Dr. Fatih Birol

Executive Director

International Energy Agency

Foreword

The twin crises of climate change and biodiversity loss pose enormous threats to long-term global security and economic well-being around the world. Canada, alongside others in the international community, must rapidly reduce carbon emissions to fight climate change and seize the significant economic opportunities presented for businesses, communities and workers.

As Canada's Minister of Natural Resources, I am very pleased to welcome the International Energy Agency's (IEA) review of Canada's approach to building a clean energy future. This report acknowledges our ambitious efforts and historic investments to develop pathways to achieve net-zero emissions by 2050 and ensure a transition that aligns with our objective of limiting global warming to 1.5 degrees Celsius. These pathways will drive inclusive economic prosperity for our workers while yielding technology, products and know-how that can be exported and applied around the world.

Canada is blessed with an abundance of natural resources that position us to be a global leader in clean energy. We also have a skilled workforce and innovative organizations at the helm of the transition, with 12 Canadian companies featured in the 2020 Global Cleantech 100 and Indigenous leaders across the country building and operating renewable energy projects for their communities.

The key to Canada's clean energy future will be empowering our workers to harness Canada's vast resources in ways that make sense environmentally and economically for their region — and that's exactly what our government is doing.

We have committed more than $100 billion toward climate action and clean growth since 2015, including major investments in clean power, energy efficiency, industrial decarbonization, clean technology and transportation. We also have a world-leading price on pollution and action plans for promising technologies like hydrogen and small modular reactors.

All of this is intended to ensure that emissions go down at a pace and on a scale aligned with our 1.5 degree Celsius targets — but more must be done.

That's why our government recently committed to new measures to accelerate the clean energy transition, including:

- requiring the oil and gas sector to be net-zero by 2050 and setting interim five-year targets;
- requiring oil and gas companies to reduce methane emissions by at least 75 percent below 2012 levels by 2030;
- creating a 100-percent net-zero electricity system by 2035; and
- providing support for domestic procurement of Canadian clean technology.

As this report recognizes, Canada's energy policies, programs and investments align with our ambitious climate goals. We believe that we can achieve our targets while creating good jobs, a stronger economy and a more inclusive future for all regions of the country.

Of course, for any nation to succeed in the fight against climate change, we must all succeed. Canada is working with our partners to support a truly global transition and build on the momentum from COP26.

I am proud of the progress that Canada has made in the last six years, and I believe the future is bright. I thank the IEA for the work it does to help governments build a clean energy future and, specifically, for this report.

The Honourable Jonathan Wilkinson

Canada's Minister of Natural Resources

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1. Executive summary

Overview

Since the International Energy Agency's (IEA) last in-depth review in 2015, Canada has made a series of international and domestic commitments, putting it on a path toward achieving an ambitious energy system transformation and climate transition. Most recently, Canada announced a target to cut greenhouse gas (GHG) emissions by 40-45% from 2005 levels by 2030 and legislated a commitment to reaching net zero emissions by 2050.

Canada's current energy and economic profile presents both challenges and opportunities in achieving these targets given its profile as a major producer, consumer and exporter of energy, and its northern climate. Energy is critical to Canada's economy; it makes up 10% of the nation's gross domestic product and is a major source of capital investments, and trade flows, and a key generator of middle-class jobs, including for Indigenous peoples.

Energy production and use in Canada accounts for over 80% of the country's GHG emissions, with fuel combustion in energy industries (including oil and gas extraction, electricity and heat generation, and refining) representing 26%, transportation 26%, buildings 13%, manufacturing industries 9%, and fugitive emissions 7% of overall emissions. Canada's electricity system is 83% non-emitting and among the cleanest in the world, with heavy dominance of hydropower as well as an important role for nuclear. Considerable variation in electricity generation profiles across jurisdictions means that increased interconnectivity across regions will be crucial to ensuring balanced progress across provinces and territories to meet national targets.

Improving the rate of energy technology innovation will be critical to enable the deep decarbonisation across sectors required to achieve net zero emissions by 2050. To this end, Canada is actively advancing a number of technologies, most recently announcing additional support for carbon capture, utilisation and storage (CCUS); hydrogen; and nuclear small modular reactors (SMRs), with a view to serving as a supplier of energy and climate solutions to the world.

Canada has a number of policy measures in place to support its national and international targets. To start, Canada introduced an ambitious carbon pricing scheme in 2019, which will notably provide appropriate price signals to shift consumption to cleaner fuels. To complement the carbon price, Canada's policies include: the 2016 Pan-Canadian Framework on Clean Growth and Climate Change (PCF) and 2020 Strengthened Climate Plan, the Greenhouse Gas Pollution Pricing Act, the Clean Fuel Regulations, a commitment to phase out unabated coal use by 2030, nuclear plant extensions, upstream methane regulations, stringent vehicle emissions standards and energy efficiency measures.

As one of the few energy exporting country members of the IEA, the security considerations prompted by the clean energy transition are different for Canada than for those of energy importers, particularly regarding its ability to diversify its economy to remain an energy security partner to its global allies. As such, Canada needs clear policy signals to help attract energy sector investments that align supply capacity with demand trends. Policies must also take into account Canada's plans to become a major producer of clean electricity and clean fuels to support global energy security during the transition. Central to this will be maintaining energy investments at sufficient levels to ensure that physical infrastructure continues to function properly and supply is adequate to avoid disruptions or price spikes that could adversely affect consumers. This includes energy production facilities, transmission and distribution systems, and export infrastructure.

And as the clean energy transition brings new vulnerabilities from an energy security perspective, Canada has developed plans to increase its production and supply chains of critical minerals for both domestic consumption and export.

Canada also remains committed to ensure a people-centred approach to its clean energy transition, and has put forth initiatives to promote diversity and inclusion of marginalised groups in clean energy sectors, measures that empower the participation of Indigenous peoples, and actions to enable a just transition for coal power workers.

With a highly decentralised system of government, Canada's provinces and territories hold considerable jurisdiction over energy policy and regulation, making co-ordination across provinces and with the federal government an essential element to successful energy transition outcomes.

Importantly, Canada has attempted to align post Covid-19 recovery efforts with its climate ambitions by developing green stimulus measures, targeting areas such as upstream emissions, clean energy infrastructure, buildings efficiency and zero-emission vehicles. Canada's Strengthened Climate Plan, aimed at meeting and exceeding Canada's Paris Agreement targets and achieving net zero by 2050, will also be central to the government's goal of creating 1 million jobs, restoring employment to pre-pandemic levels – of which climate action and clean growth is a cornerstone.

Climate change plans and targets

Over the past several years, the government of Canada has made near and long-term emissions-reduction pledges and released plans and legislation to reach them. Under the Paris Agreement, in 2015, Canada pledged to meet or exceed a GHG emissions-reduction target of 30% below 2005 levels by 2030.

To achieve its climate agenda, elected leaders of all provinces and territories and the federal government endorsed the PCF in December 2016. The PCF is built on four pillars: 1) pricing carbon pollution; 2) complementary actions to reduce emissions; 3) adaptation and climate resilience; and 4) clean technology, innovation and jobs. The PCF includes over 50 concrete actions that cover all sectors of the economy.

In December 2019, the federal government committed to strengthening existing and introducing new GHG reduction measures to exceed Canada's 2030 emissions-reduction goal, and to set Canada on a path to achieve net zero emissions by 2050. In November 2020, the government introduced in parliament the Net-Zero Emissions Accountability Act as part of its commitment to develop a plan to achieve net zero emissions by 2050.

In December 2020, the federal government proposed Canada's Strengthened Climate Plan, *A Healthy Environment and a Healthy Economy*. Building on the PCF, the plan includes 64 new measures and CAD 15 billion in investments.

At the April 2021 Leaders Summit on Climate hosted by the United States, Canada's prime minister pledged to update the country's nationally determined contribution under the Paris Agreement to 40-45% below 2005 levels by 2030.

Carbon pricing

The Pan-Canadian Approach to Pricing Carbon Pollution, released in October 2016, set a "federal benchmark" requiring all provinces and territories to implement carbon pricing systems with a certain level of stringency, while also ensuring the provinces and territories have the flexibility to design their own policies and programmes. A "federal backstop" carbon pollution pricing system applies in any jurisdiction that requested it or that did not implement its own system that meets the federal benchmark's stringency requirements. The backstop has two components: a fuel charge and an Output-Based Pricing System for large industrial emitters, which is a regulated emissions trading programme. Canada's 2021 carbon price is CAD 40 per tonne of carbon dioxide equivalent (t CO_2-eq) and will rise to CAD 50/t CO_2-eq in 2022.

More recently, the government has confirmed an escalation of the carbon price by CAD 15/t CO_2-eq annually to reach CAD 170/t CO_2-eq in 2030.

Electricity transition

Canada already has one of the cleanest electricity systems in the world (led by hydropower), with over 83% of production from non-emitting sources, and aims to increase that to 90% by 2030. Early actions, like the federal commitment to phase out traditional coal power across the country by 2030 and new hydro projects, will help to meet this goal.

The dominant role that hydroelectricity plays in several Canadian provinces, along with the fact that many hydro projects in Canada are large and have sizeable reservoirs, will also significantly assist with the integration of variable generation, as wind and solar generation are poised for growth.

Canada also identifies a significant opportunity to leverage regional advantages to increase the penetration of both hydro and variable renewables through the buildout of interprovincial interconnections. Strengthening interprovincial connectivity offers considerable upside to allow fossil fuel-dependent provinces to decarbonise and electrify their economies.

The role of nuclear energy is recognised as fundamental to achieving and sustaining Canada's climate change goals and the technology is seen as a long-term source of baseload electricity supply. In particular, SMRs are considered a key priority.

Decarbonising upstream oil and gas production

Canada's oil and gas sector is a major contributor to GHG emissions, accounting for an estimated 25% of all emissions in Canada, and will need to be addressed as part of its overall emissions reduction policies. The industry, in part bolstered by government

policies, has made inroads in reducing emissions intensity of operations, which have fallen by 32% in the oil sands since 1990. An additional 17-27% reduction in emissions intensity is expected from operations over the period 2018-30. Still, more work is needed to meet 2030 and 2050 goals, in part because the reductions in intensity are partially offset by increased oil and gas production.

Canada announced in October 2021 its commitment to join the Global Methane Pledge, which aims to reduce global methane emissions by 30% below 2020 levels by 2030. Methane accounts for 13% of Canada's reported GHG emissions. The majority of these emissions come from three sectors – oil and gas (37%), landfills (27%) and agriculture livestock (24%). Meeting the objectives of the pledge will require significant reductions across all three sectors, but a focus in the near term on methane emissions from oil and gas is essential to achieving rapid, large-scale reductions.

In April 2018, Environment and Climate Change Canada published the final federal regulations for methane emissions from the oil and gas sector, which were developed in consultation with the provinces. The regulations, which took effect in January 2020, call for methane reductions from upstream oil and gas facilities of 40-45% below 2012 levels by 2025, including by requiring industry to regularly inspect and repair equipment to reduce emissions. As of October 2021, the government of Canada commited to strengthen its oil and gas methane emissions reduction target to at least a 75% reduction below 2012 levels by 2030. In fall 2020, the government of Canada launched the CAD 750 million Emissions Reduction Fund (ERF), to support oil and gas workers weather the double shocks of Covid-19 and global oil markets, by supporting investments to reduce methane emissions.

Canada is also leveraging its abundant natural gas supply to position itself as a global liquefied natural gas (LNG) supplier, with a focus on reducing emissions from LNG facilities to well below the global average.

Energy efficiency

Canada sees significant potential for energy efficiency to contribute to its 2030 emissions goals and 2050 net zero targets. Energy efficiency in Canada is a shared responsibility between the federal and provincial/territorial governments.

The federal government has built partnerships and invested heavily in energy efficiency improvements since committing to the PCF, including energy efficiency investments through the CAD 2 billion federal Low Carbon Economy Fund in buildings, industry and transport, as well as CAD 950 million to support municipal efficiency intiatives. More recently in 2020, it committed to invest over CAD 6 billion through various initaitives to incentivise energy-efficient retrofits in homes and public and commercial buildings.

In August 2017, Natural Resources Canada (NRCan) released Build Smart: Canada's Buildings Strategy in collaboration with provinces and territories. Build Smart, which falls under the PCF, outlines Canada's plan to transform its buildings sector, articulating federal, provincial and territorial commitments in moving toward a clean energy future by making homes and buildings more energy efficient. This has been underpinned by sizeable budgetary outlays to improve energy efficiency through homes and building design, retrofits and new builds, as well as updated building codes for new and existing homes that are currently underway.

NRCan's industrial energy efficiency programme helps industry improve energy efficiency through the implementation of energy management systems such as ISO 50001 and Superior Energy Performance, as well as other energy management activities and benchmarking tools such as the ENERGY STAR Certification and Challenge.

In transport, the government applies emissions standards to light- and heavy-duty vehicles; green levies on fuel-inefficient vehicles, develops consumer information tools and materials to nudge consumers towards more efficient options as well as curriculum for fuel efficient driver training for the light-duty and freight sector; enables freight and logistics companies to benchmark their energy use; and supports the assessment and retrofit or fuel switching in freight fleets.

Clean fuels

Clean fuels represent an opportunity for Canada to transition its existing energy sector to a low-carbon future. Clean fuels include hydrogen, advanced biofuels, renewable natural gas, sustainable aviation fuel and synthetic fuels. Today, these fuels make up less than 6% of Canada's total energy supply, but between 10% and 51% of Canada's national energy demand is expected to be met with clean fuels in 2050 to reach its net zero goal.

To achieve such an ambitious target, the government of Canada has introduced a number of measures that support the production of clean fuels industries:

- the Hydrogen Strategy for Canada, which outlines opportunities for the domestic production and use of clean hydrogen, as well as export potential for clean hydrogen and technologies
- the Clean Fuel Regulations, which aim to reduce emissions, accelerate the use of clean technologies and fuels, and create jobs in a diversified economy
- the Clean Fuels Fund, which will support the buildout of new clean fuels production capacity, establish biomass supply chains, and develop enabling codes and standards; and
- the Emissions Reduction Fund, which is a targeted Covid-19 relief measure to help oil and gas companies invest in green solutions to reduce methane and other GHG emissions.

Technology and innovation

Canada sees technology and innovation as an integral component of its pathway toward net zero emissions. Through Budget 2017, Canada committed CAD 2.3 billion toward a clean growth policy agenda, as outlined in the PCF under the clean technology, innovation and jobs pillar. This investment resulted in the creation of new research, development and demonstration (RD&D) programmes that incorporated novel approaches to design and implementation, including cohort-based capacity building, milestone-based prize challenges, and partnerships with the private sector and foreign governments.

Notably, Canada has introduced the Strategic Innovation Fund, which has been supporting the creation and growth of innovative businesses across several sectors. Subsequent measures were announced under Budget 2021, including a Net Zero Accelerator, which will invest a total of CAD 8 billion to support faster decarbonisation from large emitters, scale up clean technology and accelerate industrial transformation.

Canada's SMR Roadmap, released in 2018, identified significant potential for these innovative reactors to address a range of energy needs, along with opportunities for the Canadian nuclear industry to meet international demand. Canada then released its SMR Action Plan in December 2020, and a number of reactor designs are in the pre-licensing review process with a view to deployment in the late 2020s and early 2030s.

In addition to Canada's strong leadership to advance SMRs, Canada is a global leader in CCUS technologies, with 4 of the world's 26 commercial projects in operation. The country also hosts extensive expertise in CCUS research and development, and the Strengthened Climate Plan proposes the development of a national CCUS strategy.

Canada sees a sizeable role and competitive advantage in the production and eventual export of hydrogen, given its abundance of feedstocks, skilled workforce and existing position as a leader in intellectual property and exporting hydrogen technologies. In December 2020, the government published the Hydrogen Strategy for Canada, which is designed to spur investment in hydrogen production and create partnerships that establish Canada as a global supplier of hydrogen.

People-centred energy transitions

The Canadian government is making progress to ensure that the transition to a low-carbon economy remains people-focused through several initiatives on gender equality, indigenous inclusion, and ensuring a just transition for coal workers and all affected communities.

To ensure that the low-carbon transition is equitable and inclusive, the government of Canada co-leads the Clean Energy Education and Empowerment (C3E) International Initiative, a joint effort between the Clean Energy Ministerial and the International Energy Agency (IEA), which works to advance gender equality in the energy sector globally. Canada also leads the Equal by 30 Campaign, under C3E International, which encourages voluntary commitments by both public and private sector organisations to work toward equal pay, equal leadership and equal opportunities for women in the energy sector by 2030.

Domestically, Canada has stepped up its own data collection efforts. Developed by Statistics Canada, and funded by NRCan, the Human Resource Module of the broader Natural Resources Satellite Account provides detailed and reliable statistics on the demographics of natural resources production in Canada.

Canada is ensuring that Gender-Based Analysis Plus (GBA+) is applied comprehensively to all aspects of policy development and decision making, and is committed to strengthening the quality of GBA+ with better data and the full consideration of impacts. Canada's Strengthened Climate Plan initiatives are also applying GBA+ analysis to programme design.

Canada has also recommitted its focus on empowering Indigenous peoples as part of its clean energy transition. Over 200 northern and remote communities in Canada, the majority of which are Indigenous, are reliant on diesel for heat and power generation.The government of Canada is committed to increase the opportunity of Indigenous, remote and rural communities to be powered by clean, reliable energy by 2030 through programmes such as the Clean Energy for Rural and Remote Communities Program, the Indigenous

Off-Diesel Initiative, the Northern Responsible Energy Approach for Community Heat and Electricity Program, and the Arctic Energy Fund.

Lastly, to address the implications of the accelerated phase-out of coal power on workers and communities, in 2018, the government established the Task Force on Just Transition for Canadian Coal Power Workers and Communities to engage coal-affected communities in Alberta, Saskatchewan, Nova Scotia and New Brunswick, and recommend a path forward. The task force released its final report in March 2019, which included a series of recommendations for the government's consideration. In response, the government has committed funds toward skills development and infrastructure to support economic diversification.

In July 2021, the government of Canada announced its intention to develop just transition legislation that would include just transition principles that put people at the centre of the government's climate action, as well as establish an external Just Transition Advisory Body to provide advice on regional and sectoral just transition strategies that support workers and communities.

In June 2021, Canada, along with the United States and the European Commission, launched the "Empowering People Initiative" under the Clean Energy Ministerial. This initiative will focus on workers and communities in the clean energy transition across the range of energy technology initiatives.

Key recommendations

The government of Canada should:

- Model pathways to net zero by 2050 for Canada's energy system, and develop national emissions reduction strategies in consultation with provinces, territories and other stakeholders for key sectors such as oil and gas, transport, buildings, and industry.
- Explore ways to enhance the federal government's role in strengthening inter-provincial connectivity, expanding the use of interconnectors, and accelerating key projects of grid modernisation and electrification.
- Develop a comprehensive energy efficiency strategy in consultation with provinces and territories that sets clear targets for energy efficiency in each sector (buildings, industry and transport).
- Increase federal funding in support of accelerating R&D and innovation of clean energy technologies to achieve 2050 targets, with an eye to also advancing future export opportunities.

2. General energy policy

Key data (2020 provisional)

Total energy supply (TES): 287.6 Mtoe (natural gas 39.1%, oil 32.7%, hydro 11.5%, coal 3.7%, bioenergy and waste 4.6%, wind 1.1%, solar 0.1%), +10.3% since 2010

TES per capita: 7.5 toe/cap (IEA average:* 3.8 toe/cap), -1.3% since 2010

TES per unit of GDP: 175 toe/USD million (IEA average:* 91 toe/USD million) -3.8% since 2010

Energy production: 515.1 Mtoe (oil 50.5%, natural gas 30.1%, hydro 6.4%, coal 4.8%, nuclear 5.0%, bioenergy and waste 2.6%), +29.3% since 2010

Total final consumption (TFC) (2019): 205.5 Mtoe (oil 45.3%, natural gas 25.6%, electricity 22.2%, bioenergy and waste 5.3%, coal 1.2%), +11.9% since 2009

* Weighted average among the 30 IEA member countries.

Note: GDP is expressed in 2015 prices and purchasing power parity (PPP) unless otherwise noted.

Country overview

Canada is the world's second-largest country by surface, with an area of 9.98 million square kilometres (3.85 million square miles) (Figure 2.1). Canada is bordered by the Atlantic Ocean to the east, the Pacific Ocean to the west, the Arctic Ocean to the north, and neighbours the United States to the south and north-west (Alaska). Most of Canada has a continental climate, with cold winters and warm summers, although average temperatures across Canada vary according to the location. Winters can be severe in many regions of the country, particularly in the central and northern parts.

Canada is divided into ten provinces (Alberta, British Columbia, Manitoba, New Brunswick, Newfoundland and Labrador, Nova Scotia, Ontario, Prince Edward Island, Quebec, and Saskatchewan) and three territories (Northwest Territories, Nunavut and the Yukon). The capital city is Ottawa, in the province of Ontario. The three largest metropolitan areas are Toronto (Ontario), Montreal (Quebec) and Vancouver (British Columbia). Canada's official languages are English and French.

Canada is home to more than 1.4 million Indigenous peoples, consisting of 3 distinct groups – First Nations, Inuit and Métis – each with their own unique history, geography, traditions, culture and languages. Indigenous communities are dispersed throughout Canada, with many located in rural and remote areas, coastal regions, and in Canada's northern regions of Inuit Nunangat. Historical and modern treaties have been forged between indigenous nations and the Crown or the government of Canada. Often, these treaties and agreements set out the continuing treaty rights and benefits of each group,

including rights to land and resources, among other things. These treaties span across Canada's various regions and the process of treaty-making in Canada is ongoing and continues to evolve.

Globally, Canada is a major energy producer. It is a top ten producer of oil, natural gas, hydropower, uranium, nuclear power, biofuels and wind, as well as a leading producer of over 60 minerals and metals, including a wide range of critical minerals. Canada's population has grown steadily in recent years, with a population of approximately 38 million in 2020 and a growth rate of 1.1% since 2019. More than half of Canadians reside in 2 provinces: over 14 million in Ontario and over 8.4 million in Quebec. Canada's population density is one of the lowest within the Organisation for Economic Co-operation and Development (OECD), at four people per square kilometre, most of which live near the US border. Over 1.6 million people in Canada identified as indigenous in 2016, making up 4.9% of Canada's population.

The Canadian Constitution outlines the powers of the ten provinces, while the three territories hold powers that are similar to those of the provinces but outlined in federal legislation. Under the Constitution, natural resources are a shared responsibility between the federal government and the provinces and territories. Federal responsibility exists for interprovincial and international trade, resource-based science and technology, and federal control of natural resources on federal lands. For example, resource projects that cross provincial or international boundaries – such as pipelines and transmission lines – fall under federal jurisdiction, as do exports. On the other hand, the Constitution explicitly recognises the provinces' and territories' rights to explore, develop, conserve and manage their own non-renewable natural resources, as well as forestry resources and electrical energy. This also includes the power to levy mining taxes and royalties. The shared responsibility between the federal and provincial/territorial governments includes working together to address energy efficiency, environmental protection and conservation, and economic development.

Through treaties, land claims, self-government agreements and devolution to territorial governments, Indigenous peoples and northerners are assuming increasing responsibility and control over lands, resources and the environment. The government of Canada also has statutory, contractual and common law obligations to consult with Indigenous peoples, and where appropriate, accommodate, when the government contemplates conduct that might adversely impact potential or established aboriginal or treaty rights. As such, it is important for governments and industry to engage with Indigenous peoples early and often when contemplating any type of resource development.

Figure 2.1 Map of Canada

Politics

Canada is a federal parliamentary democracy within a framework of a constitutional monarchy, where the Queen is the head of state and the prime minister is the head of government. Canada's governor-general is appointed by the Crown on the advice of the prime minister.

The parliament consists of three parts: the Monarch (represented by the governor-general), the Senate (105 members) and the House of Commons (338 members). Historically, Canada has been governed by two main political parties: the Liberal Party of Canada and the Conservative Party of Canada. Other parties with parliamentary representation include: the New Democratic Party, the Bloc Québécois and the Green Party of Canada.

Canada was one of the founding members of the United Nations in 1945, of the OECD in 1961 and of the International Energy Agency (IEA) in 1974. Canada is also a member of both the G7 and G20.

Economy

Canada is the tenth-largest economy in the world by nominal gross domestic product (GDP). In 2019, Canada's GDP was USD 1.7 trillion, and its GDP per capita USD 46 194 (World Bank, 2021a). Since 2017, the GDP growth rate has slowed down, to reach 1.6% in 2019. The Covid-19 pandemic is expected to affect real GDP growth, decreasing by 5.4% in 2020 and rebounding by 4-6% in 2021 (OECD, 2021; Government of Canada, 2021a). Although Canada has a broad range of free trade agreements with about two-thirds of the global economy, demand for exports has been mostly supported by a robust US economy. The termination of the North American Free Trade Agreement (NAFTA) was expected to have a small but material effect of around -0.5% on GDP. However, the Canada-United States-Mexico Agreement (CUSMA) replaced NAFTA on 1 July 2020, reducing uncertainty on total exports, with a significant benefit to Canadian industries (Global Affairs Canada, 2020a).

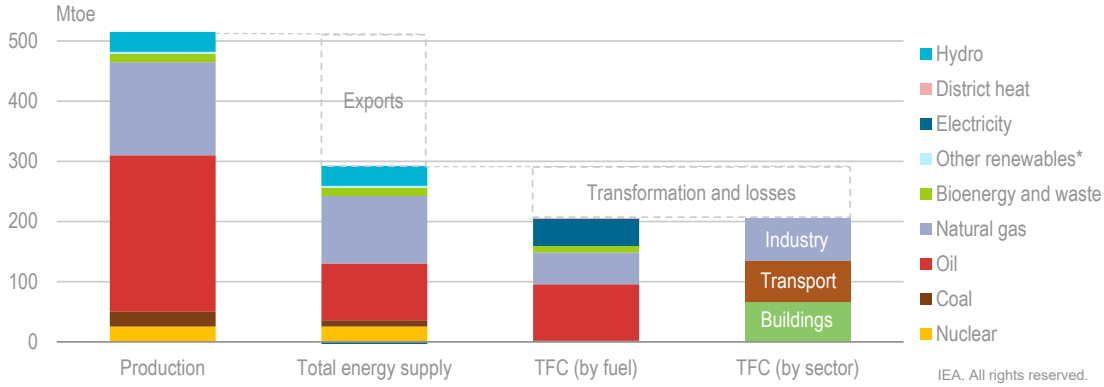
The Canadian economy is highly dependent on the services sectors, accounting for more than half of Canada's economy (World Bank, 2021b). Industry, including manufacturing, construction, utilities, mining, and oil and gas extraction is the second-largest economic sector, with a 27% share of GDP in 2019 (Global Affairs Canada, 2020b). The main industries in Canada are primary sectors, such as extraction of raw materials, mining, energy and agriculture. Canada is the fourth-largest crude oil and fifth-largest natural gas producer in the world. It holds the third-largest oil reserves in the world, most of which are located in producing areas in Western Provinces. Canada also has vast reserves of natural gas, particularly in British Columbia and Alberta (CAPP, 2021). Moreover, Canada produced the third-largest amount of hydroelectricity, behind the People's Republic of China (hereafter "China") and Brazil, and ranked seventh as a coal exporter (95% of which is coking coal) in 2018 (Government of Canada, 2021b). Canada's mineral sector plays an important role in its economic performance; in 2018, total Canadian mineral production reached a value of USD 47 billion (Government of Canada, 2019). Canada is the second-largest producer and fourth-largest exporter of uranium, and is a leading global supplier of minerals to produce batteries and steel. The agricultural sector represents 1.7% of total GDP, and Canada is one of the largest exporters of agricultural products in the world.

Energy supply and demand

Thanks to its reserves and production capacity of oil and natural gas, Canada produces more energy than its own needs, and in 2020 exported 44% of domestic energy production (Figure 2.2). In 2020, fossil fuels accounted for 76.5% of total energy supply (TES). Natural gas was the largest energy source in 2020 (39% of TES), followed by oil (33%). Canada's energy supply also consists of significant shares of hydro (12%), nuclear (8.9%) and coal (3.7%).

Almost half of total final consumption (TFC) in 2019 was covered by oil (45%), followed by natural gas (26%), electricity (22%), and bioenergy and waste (5.3%). Industry, transport and buildings account for one-third of TFC each.

Figure 2.2 Overview of Canada's energy production, supply and demand, 2020



Canada exports 44% of its total domestic energy production. Energy supply and demand is dominated by fossil fuels, mainly oil and gas.

* *Other renewables* includes wind and solar.

** Data are from 2019.

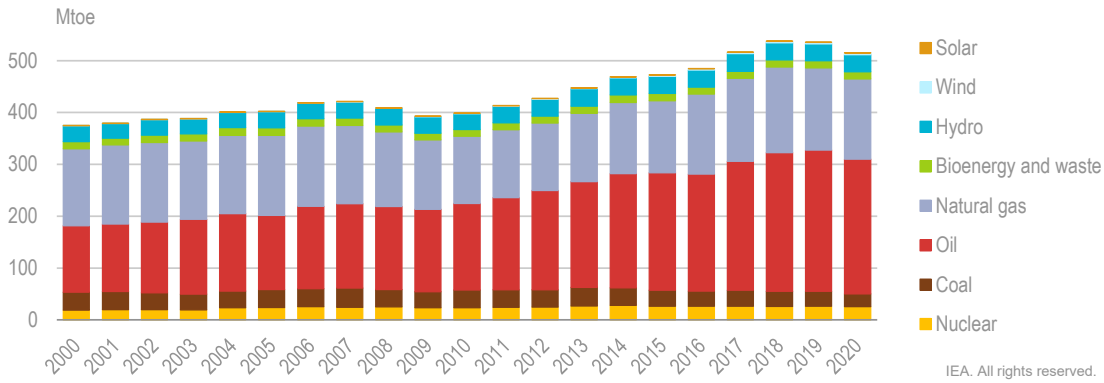
Notes: Mtoe = million tonnes of oil equivalent. TFC = total final consumption. 2020 data are provisional.

Source: IEA (2021), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Domestic production and energy surplus

Domestic energy production in Canada is dominated by the extraction of oil and natural gas, and amounted to 515 million tonnes of oil equivalent (Mtoe) in 2020, representing a growth rate of 29% since 2010 (Figure 2.3). Most of the increase in domestic production came from oil, which increased by 55%, from 167 Mtoe in 2010 to 260 Mtoe in 2020, when oil accounted for more than half (51%) of total energy production. The second source of energy production was natural gas, accounting for 30% of total production in 2020, followed by hydro (6.4%), coal (4.8%), nuclear (5.0%), and biofuels and waste (2.6%).

Figure 2.3 Canada's energy production by source, 2000-20



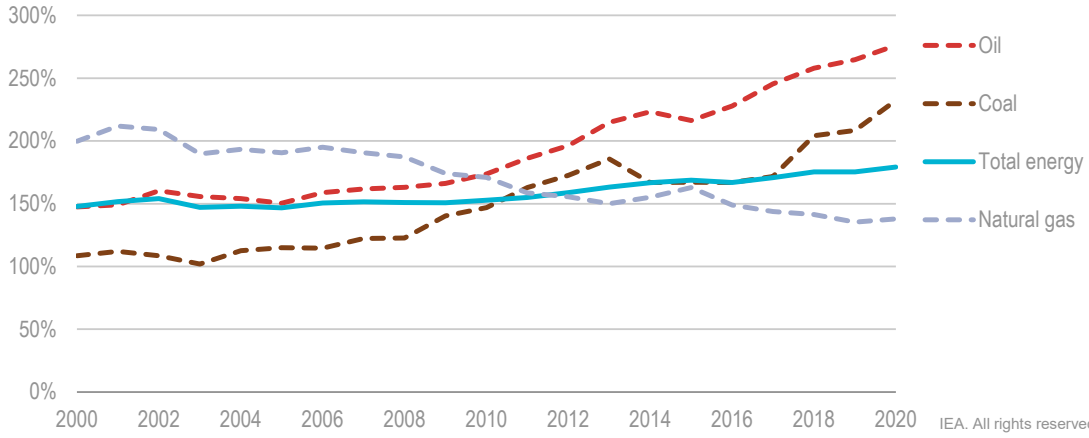
Increasing oil extraction drove growth in total domestic energy production between 2009 and 2019. The Covid-19 pandemic caused a 4% drop in energy production in 2020.

Notes: Mtoe = million tonnes of oil equivalent. 2020 data are provisional.

Source: IEA (2021), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

The energy surplus in Canada has increased in recent years, as domestic production reached 179% of total energy supply needed to cover domestic demand in 2020 (Figure 2.4), while domestic production of oil, coal and natural gas accounted for 276%, 232% and 138% of domestic energy needs, respectively. This allows Canada to be a large net exporter of fossil fuels, mainly to the neighbouring United States, but also to a variety of other countries around the world (see the sections on oil, natural gas and coal below).

Figure 2.4 Canada's energy import self-sufficiency, 2000-20



Domestic production of fossil fuels allows Canada to produce 179% of its domestic needs.

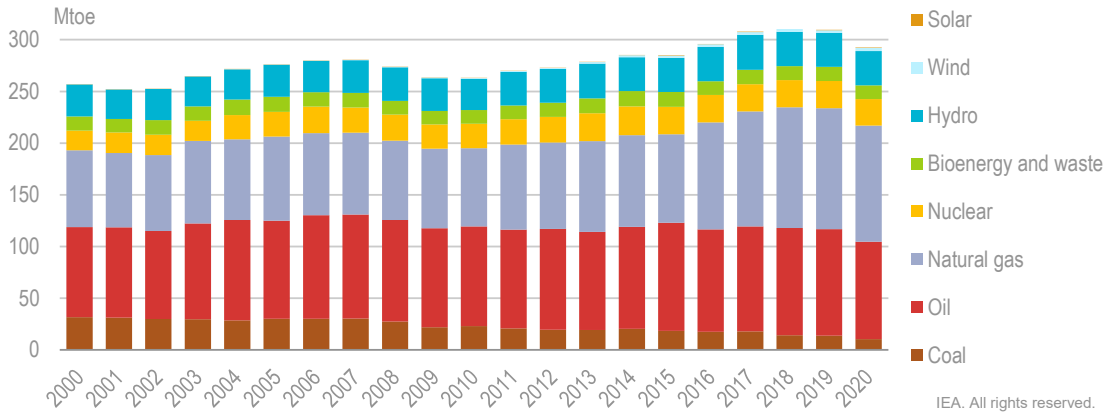
Note: 2020 data are provisional.

Source: IEA (2021), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Total energy supply

TES increased by 17% between 2009 and 2019, as a result of the expanding economy and increasing energy demand, to reach 306 Mtoe in 2019 (Figure 2.5). Most of the growth was covered by increased supply of natural gas, which increased by 41% in the 2009-19 decade. In 2020, the Covid-19 pandemic caused a 6% drop in TES with respect to the previous year, to reach 288 Mtoe. The 2020 drop in energy supply was notable for coal (-24%) and oil (-9%), while wind and solar increased by 11% and 4%, respectively. The largest energy source in Canada was gas in 2020, covering 39% of TES. Oil immediately followed at 33%, before hydro (12%), nuclear (8.9%) and coal (3.7%). Bioenergy and waste is the second-largest renewable energy source in the country's TES after hydro, at 4.6% in 2020, while other renewables, mainly wind and solar, are growing fast but still together only accounted for 1.2% of TES in 2019.

Figure 2.5 Total energy supply by source in Canada, 2000-20



The 16% increase of total energy supply between 2009 and 2019 was driven by a 41% increase in natural gas supply. In 2020, TES dropped by 6% as coal and oil supply fell.

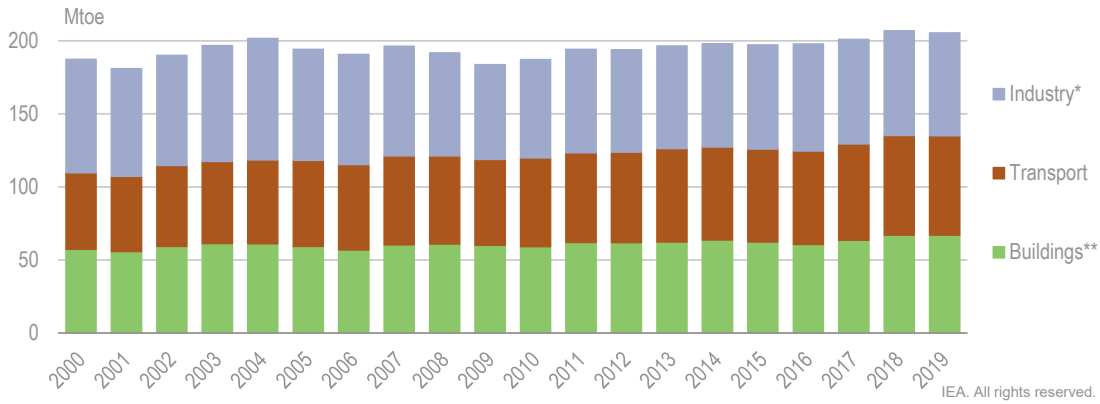
Notes: Mtoe = million tonnes of oil equivalent. 2020 data are provisional.

Source: IEA (2021), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Energy demand

TFC increased by 12% between 2009 and 2019, when it was 206 Mtoe (Figure 2.6). The industry sector accounts for the highest share (34%) of energy demand, accounting for 71 Mtoe in 2019. The transport sector grew by 16% between 2009 and 2019, reaching 68 Mtoe, or 33% of TFC. Energy demand from buildings increased by 11% between 2009 and 2019, driven by increasing energy demand in the services sector.

Figure 2.6 Total final consumption by sector in Canada, 2000-19



Industry, transport and buildings accounted for one-third each of total final consumption in 2019.

* *Industry* also includes non-energy use (16.5 Mtoe in 2019) and agriculture (7.0 Mtoe in 2019).

** *Buildings* consist of residential and commercial and public services sectors.

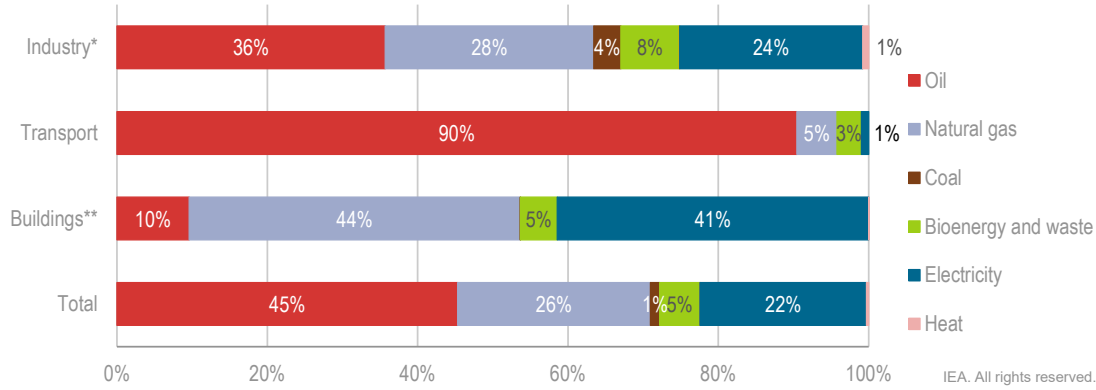
Note: Mtoe = million tonnes of oil equivalent.

Source: IEA (2021), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Energy efficiency improved by 12% between 2000 and 2018. During this time, GDP increased by 42% while actual consumption only rose by 8%. Without energy efficiency savings, energy use would have grown by 2%. This improvement reduced energy use by approximately 22.6 Mtoe and, according to the government of Canada's estimates, avoided 54.7 million tonnes (Mt) of greenhouse gas (GHG) emissions in 2018. Canada's energy intensity per GDP (TFC/GDP) also improved, by 24%, between 2000 and 2019.

Oil covered almost half (45%) of TFC in 2019, followed by natural gas (26%), electricity (22%), bioenergy (5%) and the direct use of coal (1%) (Figure 2.7). Oil is the main energy source in the transport sector, where it covers 90% of total demand, and in industry, where it covers 36% of demand due to the presence of a large chemical and petrochemical sector. Natural gas is the main fuel used in the buildings sector (44%). Electricity also plays a major role in buildings, accounting for 41% of total energy demand in the sector. Bioenergy is mostly used in buildings and industry, but biofuels also cover around 3% of transport consumption.

Figure 2.7 Canada's total final consumption by sector and per fuel, 2019



Oil and gas together accounted for 61% of total final consumption in Canada. They contribute to at least half of the demand in all sectors.

* *Industry* also includes non-energy use and agriculture.

** *Buildings* consist of residential and commercial and public services sectors.

Source: IEA (2021), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Energy projections

The Covid-19 pandemic has significantly impacted the Canadian energy system with a 6% reduction in energy demand in 2020, according to energy projections recently released in the Canada Energy Regulator's (CER) *Canada's Energy Future 2020* report. It is expected that following a recovery in 2021 and 2022 to pre-pandemic levels, energy use across all sectors will decline slowly through 2050 to a level 18% lower than in 2019.

In its "Evolving Scenario" (which assumes a continuation of the trajectory of climate policy stringency), the CER projects that Canada's energy mix will continue to change. Energy demand from renewables and nuclear will grow by 32% from 2019 to 2050 and become a larger share of the energy mix. Oil and gas, however, will still each represent approximately a third of Canada's total end-use demand.

Technologies enabling Canada's transition to a low-carbon economy will continue to make inroads across the energy system, particularly in electricity generation. According to the CER model, electricity's share of end-use demand will increase from approximately 16% currently to around 27% in 2050, when half of all passenger vehicles sales are expected to be electric vehicles.

Renewable sources will also account for a larger share of electricity generation. By 2050, over 90% of electricity generation is targeted to come from renewables and nuclear generation (compared to 81% today). Canada's share of renewables-based electricity generation (hydro, wind, solar, biofuels) is projected to grow from 69% in 2020 to 80% by 2050.

Canada will continue to be a supplier of oil and gas to the world, with crude oil production projected to increase steadily until peaking in 2039 at 5.8 million barrels per day (mb/d) and natural gas, driven by growing exports of liquefied natural gas (LNG), peaking at 18.4 billion cubic feet per day (bcf/d) (190 billion cubic metres per year [bcm/year]) by 2040.

While the Evolving Scenario does not reflect Canada's current ambitions of achieving net zero emissions by 2050, the CER is undertaking new analysis in its upcoming 2021 Canada's Energy Future Report, with scenarios exploring what Canada's electricity system might look like in a net zero world.

Other modelling, such as for Canada's Hydrogen Strategy (see below), shows that in a net zero future, up to 60% of Canada's energy mix could come from clean fuels by 2050, of which 30% would be hydrogen. Moreover, the recently created Net Zero Advisory Body (see below) has been given a mandate to identify net zero emissions pathways to 2050, which will provide stronger guidance on actions and technologies required to achieve long-term targets.

According to modelling conducted by Environment and Climate Change Canada (ECCC) for the Strengthened Climate Plan (see below), the updated plan would result in reductions of 227 Mt CO_2 equivalent in 2030 compared to 2005, with declines seen across all sectors. In the Reference Scenario (based on policies in place as of September 2020), total GHG emissions would fall by 73 Mt over the same period, led by the electricity sector.

Institutional overview

At the federal level, various government departments have an impact on policies related to energy supply and demand, including the departments of Transport Canada and Innovation, Science and Economic Development Canada. Natural Resources Canada (NRCan) supports the sustainable and inclusive development of Canada's natural resources and the integrated management thereof, including energy, forests, minerals and metals. It collaborates with other federal departments; provincial, territorial and local governments; Indigenous peoples; academic institutions; and industry to conduct science and research, which helps inform regulatory functions; promote innovation and pre-commercial technology advancements; and develop standards, codes and guidance to support industry practices, as well as provide expert advice and guidance to decision makers. NRCan manages a broad range of energy-related funding programmes to promote renewables, clean fuels, energy efficiency and zero-emission vehicles (ZEVs)

under Canada's Strengthened Climate Plan, the Pan-Canadian Framework on Clean Growth and Climate Change (PCF) and other federal initiatives.

The Major Projects Management Office (MPMO) was established in 2007. It links natural resource regulatory, engagement and policy processes to increase the certainty of resource development in Canada. The MPMO supports all players in navigating the natural resource development process, while considering the United Nations Declaration on the Rights of Indigenous Peoples.

NRCan also manages a portfolio of federal funding programmes related to energy technology innovation within its Energy Technology Sector, and houses the national CanmetENERGY and CanmetMATERIALS laboratories, which conduct research and development on energy-related technologies from four locations across the country. CanmetMINING, another principal R&D arm of NRCan, plays an important role in the decarbonisation of the energy sector as well as technology innovation to improve health, safety and environmental issues at mine sites.

The ECCC is the lead federal department for strategic action on a wide range of environmental matters, including clean growth and climate change, preventing and managing pollution, conserving nature, and predicting weather and environmental conditions. The ECCC is responsible for the direct regulation of GHG and air pollutant emissions (e.g. from industrial and transportation sources). Its mandate also includes the preservation and enhancement of the quality of the natural environment; conservation of Canada's renewable resources; conservation and protection of Canada's water resources; forecasting weather and environmental change; enforcement of rules relating to boundary waters; and co-ordinating environmental policies and programmes for the federal government.

Statistics Canada (StatCan) collects, compiles and analyses information about industries and individuals in Canada, and has the legislative authority, under the Statistics Act, to acquire administrative data from any level of government, corporation or organisation across the country. A lot of StatCan's energy data are collected and disseminated by the department's energy statistics programme, whose focus is on the production, transformation, distribution and consumption of energy. Other areas of StatCan collect information pertaining to the energy sector, such as labour force statistics and information on energy science and technology.

Crown-Indigenous Relations and Northern Affairs Canada works to renew the nation-to-nation, Inuit-Crown and government-to-government relationship between Canada and First Nations, Inuit and Métis. In this capacity, the department supports the efforts of indigenous and northern communities to pursue their own vision of self-determination, which can include economic development, sustainable resource and land management, and addressing and adapting to climate change.

Indigenous Services Canada works collaboratively with partners to improve access to high-quality services for First Nations, Inuit and Métis. It also has an important role in developing natural resources and protecting the environment in most First Nations communities and the territories, and works to transfer responsibility and control over lands, resources and the environment to Indigenous peoples and northerners.

Atomic Energy of Canada Limited (AECL) is a nuclear science and technology organisation. As a federal Crown corporation, its mandate is to enable nuclear science and

technology and to protect the environment by fulfilling the government of Canada's radioactive waste and decommissioning responsibilities. The AECL receives federal funding to deliver on its mandate and reports to parliament through the Minister of Natural Resources. It also leverages the unique capabilities at its sites to support industry and other third parties on commercial terms. The AECL delivers its mandate through a long-term contract with Canadian Nuclear Laboratories for the management and operation of its sites.

The Canadian Nuclear Safety Commission is Canada's independent nuclear regulator. It regulates the use of nuclear energy and materials to protect health, safety, security and the environment; implements Canada's international commitments on the peaceful use of nuclear energy; and disseminates objective scientific, technical and regulatory information to the public.

The Canadian Centre for Energy Information, a new one-stop shop for energy data and analysis, was launched in 2020. It will further bolster fact-based policy and decision making.

The federal government also jointly manages offshore energy development with provincial/territorial governments. The Canada-Nova Scotia Offshore Petroleum Board is the independent joint agency of the governments of Canada and Nova Scotia responsible for the regulation of petroleum activities in the Nova Scotia Offshore Area. The Canada-Newfoundland and Labrador Offshore Petroleum Board facilitates the exploration and development of hydrocarbon resources in the Newfoundland and Labrador Offshore Area.

The Northern Pipeline Agency has been the federal regulator of the Alaska Highway Gas Pipeline in Canada since the Northern Pipeline Act was passed in 1978. It serves as a single window for the federal regulation of the project.

Regulatory reform

Canada has modernised its environmental and regulatory systems to support transparency and instil greater public confidence in their effectiveness. This is part of Canada's efforts to improve rules for the review of major energy projects.

In June 2019, parliament passed Bill C-69, which replaced the National Energy Board Act with the Canadian Energy Regulator Act.

The newly established CER oversees how energy moves in Canada. It is charged with making transparent decisions, orders and recommendations with respect to pipelines, power lines, offshore renewable energy projects and abandoned pipelines. The CER also: reviews applications for new projects and upgrades to current ones; provides oversight of oil and gas exploration and activities on frontier lands and offshore not otherwise regulated under territorial law or joint federal/provincial accord; decides what can be transported in pipelines and how much companies are allowed to charge for their services; approves the export and import of natural gas and the export of oil; and provides the public with reliable energy statistics, analysis and information.

The passage of Bill C-69 also helped to update and streamline Canada's environmental and regulatory system by modernising the Canadian Environmental Assessment Agency through the creation of the Impact Assessment Agency of Canada, which reports to the

Minister of Environment and Climate Change. The Impact Assessment Agency of Canada is charged with undertaking high-quality impact assessments that contribute to informed decision making on major projects in support of sustainable development.

Bill C-69 also set out responsibilities for both the CER and the Impact Assessment Agency to consult, and accommodate when required, with Indigenous peoples during project reviews and throughout the life cycle of a project. As such, the approval process for large-scale resource projects requires early, meaningful and inclusive engagements and consultations with Indigenous peoples. The process now includes indigenous knowledge in decision making and the implementation of indigenous advisory boards to provide decision makers with expert advice.

With over 440 major resource projects – worth over CAD 540 billion in investments – planned or under construction across Canada over the next ten years, the new rules are designed to boost investor clarity and ensure that viable projects can move forward in a timely way. To this end, the new impact assessment system includes a more inclusive participation process, provides clear expectations and shorter legislated timelines, and aims to avoid duplication with other jurisdictions wherever possible with a "one project, one review" approach. The new process reflects substantive input from Indigenous peoples, provinces and territories, companies, environmental groups, and the public over the course of three years of engagement.

Provincial and territorial energy responsibilities

Energy administration takes place both federally and provincially in Canada. The Canadian Constitution provides that legislative authority, which has an influence on energy use, be divided between provincial and federal levels of government, both geographically and functionally. In reality, many energy issues are a shared responsibility, and the federal government works closely with the provinces and territories to ensure co-ordinated action.

Table 2.1 Canada's provincial and federal resources administration

Federal responsibility	Shared responsibility	Provincial responsibility
International and interprovincial energy trade	Environmental regulation of energy projects	Jurisdiction and management of energy resources
International and interprovincial energy infrastructure	Scientific research and development	Royalty design and collection
Regulation of nuclear energy and uranium	Management of offshore under accords	Electricity production, distribution and regulation
Energy resources on federal Crown land, offshore and north of 60º latitude		Land-use planning and allocation

Federal responsibility	Shared responsibility	Provincial responsibility
Research and funding for building energy codes for homes and buildings	Regulation of energy-using products (federal regulation of cross-border trade, provincial regulations cover products manufactured and sold in a province) Development of house and building energy codes	Laws and regulations on exploration, development, conservation and energy use Adoption and enforcement of house and building energy codes

Source: Canadian response to IEA questionnaire for this review.

Several driving forces shape energy policy at the provincial and territorial levels. Notably, provinces and territories have significantly different primary resource endowments. Provinces are the owners of their ground resources (apart from resources located in indigenous reserve lands and some small pockets of federal land) and have primary responsibilities for shaping policies implemented in their jurisdictions as it relates to these resources.

Energy plays an important role in the creation of wealth for some provinces and territories (e.g. Alberta, Quebec, Saskatchewan, Nova Scotia, and Newfoundland and Labrador). For many provinces, the share of external energy trade with bordering US states is often larger than with Canadian neighbouring provinces and territories. Electricity is almost exclusively regulated by provincial and territorial governments, except international electricity lines that transport power between Canada and the United States, certain designated interprovincial power lines, and nuclear generation (see Chapter 7).

Energy and climate policy overview

Since the IEA's last in-depth review in 2015, the government of Canada has made a series of international and domestic commitments that strive toward a balanced approach between promoting economic growth and strengthening environmental performance. As part of this commitment, under the Paris Agreement, Canada pledged to reduce carbon dioxide (CO_2) emissions by 30% by 2030 compared to 205 levels, with deeper reductions planned beyond that. More recently, Canada updated its nationally determined contribution (NDC) to 40-45% below 2005 levels by 2030.

To achieve its climate agenda, elected leaders of all provinces and territories[1] and the federal government endorsed the PCF on 9 December 2016. The PCF is built on four pillars: 1) pricing carbon pollution; 2) complementary actions to reduce emissions; 3) adaptation and climate resilience; and 4) clean technology, innovation and jobs. The PCF includes over 50 concrete actions that cover all sectors of the economy.

In December 2019, the federal government committed to the continued implementation of the PCF, while strengthening existing and introducing new GHG reduction measures to

[1] With the exception of Saskatchewan and Manitoba; Manitoba has since joined. Saskatchewan still tracks progress towards the 2030 NDC.

exceed Canada's 2030 emissions reduction goal and set Canada on a path to achieve a net zero emissions future by 2050. In November 2020, the government introduced in parliament the Net-Zero Emissions Accountability Act as part of its commitment to develop a plan to achieve net zero emissions by 2050. In February 2021, the Net-Zero Advisory Body was established to conduct research, advise the federal government and consult Canadians about Canada's path for net zero emissions by 2050 (see Chapter 3).

In December 2020, the federal government proposed Canada's Strengthened Climate Plan, *A Healthy Environment and a Healthy Economy*. It includes 64 new measures and CAD 15 billion in investments to further reduce emissions by 32-40% below 2005 levels by 2030.

Since the announcement, Canada's updated NDC has been supported by CAD 17.6 billion (as part of Budget 2021) in additional climate spending beyond what was announced in the Strengthened Climate Plan.

A central policy tool for achieving emissions targets is carbon pricing. The Pan-Canadian Approach to Pricing Carbon Pollution, released in October 2016, set a "federal benchmark" requiring all provinces and territories to implement carbon pricing systems with a certain level of stringency while also ensuring the provinces and territories have the flexibility to design their own policies and programmes. A "federal backstop" carbon pollution pricing system applies (in part or in full) in any jurisdiction that requested it or that did not implement its own system that meets the federal benchmark's stringency requirements (see Chapter 3). The backstop has two components: a fuel charge and an Output-Based Pricing System for large industrial emitters, which is a regulated emissions trading programme. Canada's 2021 carbon price is CAD 40 per tonne of carbon dioxide equivalent (t CO_2-eq) and will rise to CAD 50/t CO_2-eq in 2022. The Strengthened Climate Plan proposed an increase of the carbon price trajectory by CAD 15/t CO_2-eq annually to CAD 170/t CO_2-eq in 2030, which the government has confirmed will be enacted.

Generation Energy

The Canadian Energy Strategy, endorsed by premiers in July 2015, set the stage for a co-operative approach among provinces and territories toward sustainable energy development. Although the strategy was developed without federal participation, it served as an important foundation for the Generation Energy dialogue.

In April 2017, the government of Canada launched Generation Energy, a signature initiative meant to engage Canadians from all backgrounds, to listen to what they had to say about the best ways for meeting Canada's climate change and economic goals. Following a 6-month engagement with over 380 000 Canadians, the 14-member Generation Energy Council (representing perspectives from academia, industry, Indigenous peoples and leading energy non-governmental organisations) presented its report in 2018. The report identified four pathways to achieve a clean, affordable and reliable future energy system: 1) clean power; 2) energy efficiency; 3) cleaner oil and gas; and 4) renewable fuels. The council also identified an additional cross-cutting pathway to address the unique leadership responsibilities and opportunities that Indigenous peoples and their governments have in Canada's energy future.

Canada's energy policy is now guided by these four pathways, each with their own national goals. These targets include:

- by 2035, produce nearly 100% of electricity from non-emitting sources
- by 2030, to increase the opportunity for Indigenous, remote and rural communities to be powered by clean, reliable energy
- by 2035, 100% of light-duty vehicles sales must be ZEVs
- improve the annual rate of energy efficiency from 1% to 3% by 2030 (non-binding)
- increase cleaner fuel use
- by 2040, establish a leading hydrogen and fuel cell technology cluster
- promote innovation to achieve a net zero petroleum sector
- diversify the oil and gas sector to support low-carbon solutions.

Clean power

Canada already has one of the cleanest electricity systems in the world (led by hydropower), with over 81% of production from non-emitting sources, and aims to increase that share to 90% by 2030. Early actions, like the federal commitment to phase out traditional coal power across the country by 2030 and new hydro projects, will help toward this end (see Chapter 7).

The dominant role that hydroelectricity plays in several Canadian provinces, along with the fact that many hydro projects in Canada are large and have sizeable reservoirs, will also significantly assist with the integration of variable generation as wind and solar generation are poised for growth. Canada also identifies a significant opportunity to leverage regional advantages to increase the penetration of both hydro and variable renewables through the buildout of interprovincial interconnections.

To further support the growth of renewables in electricity, the Smart Renewables and Electrification Pathways Program was announced in June 2021, providing up to CAD 964 million over four years for smart renewable energy and electrical grid modernisation projects.

The role of nuclear energy is recognised as fundamental to achieving and sustaining Canada's climate change goals and the technology is seen as a long-term source of baseload electricity supply. In particular, small modular reactors (SMRs) were identified in the Generation Energy report as key to the sustainable development of Canada's energy and natural resources. To this end, in 2018, NRCan convened the SMR Roadmap project with interested provinces and territories, industry, indigenous communities, and civil society to chart a path forward for this technology in Canada. The SMR Roadmap was released in November 2018, followed by the release of Canada's SMR Action Plan in December 2020 (see Chapter 8).

Energy efficiency

Improvements in energy efficiency have allowed Canada to make progress in decoupling economic growth and energy consumption. Looking ahead, Canada sees significant potential from energy efficiency to contribute to its 2030 emissions goals and 2050 net zero targets. Over one-third of planned emissions reductions under the PCF will come from energy efficiency measures, making it a key pillar to reach Canada's emissions commitment under the Paris Agreement. The IEA estimates an additional 30% in energy savings from 2018 levels could be achieved by 2030 (IEA, 2018), and has programmes underway across sectors, including buildings, industry and transport (see Chapter 4).

At the federal level, energy efficiency work is guided by the Energy Efficiency Act, whose modernisation is a key priority to support current and future Canadian priorities of enhancing competitiveness and promoting innovation, while continuing to improve energy efficiency.

Energy efficiency in Canada is a shared responsibility between the federal and provincial/territorial governments. The federal government works with stakeholders to develop model building codes, which can then be adopted and enforced by provinces. The federal Energy Efficiency Regulations set appliance standards for products that cross internal and international borders – representing the vast majority of appliance and equipment used in Canada. Provinces and territories develop energy use policies, regulate energy utilities and energy codes, as well as standards for building designs, building components and equipment within their borders. The federal government has engaged in extensive dialogues with provinces to advance energy efficiency, including through aligned building codes and equipment regulation. Canada also recognises that different provinces have different needs based on the structure of their economies, geographies and energy options. Many provinces have run their own energy efficiency programmes for some time, in some cases supported by federal funding. Financial incentives for energy efficiency targeting individuals and businesses vary by jurisdiction, with a range of provincial, territorial and municipal measures available.

In transport, the government applies emissions standards to light- and heavy-duty vehicles, green levies on fuel-inefficient vehicles, consumer information campaigns, and federal funding programmes to support the production, demand and infrastructure for electric vehicles. In June 2021, the government announced the intention to regulate a target of 100% ZEV sales by 2035.

Decarbonising oil and gas

Canada is the fourth-largest producer of oil and natural gas and home to the world's third-largest oil reserves. This creates employment for Canadians and secure and reliable oil and gas for both domestic and global markets. But simply having those resources will not be enough to compete in rapidly transforming global energy markets. Canada's oil and gas production must become both cost- and carbon-competitive in domestic and international markets, as many countries are implementing net zero targets and will seek the most affordable and least polluting supplies in a carbon constrained economy.

Canada's oil and gas sector is a major contributor to GHG emissions. Upstream oil and gas activities represented nearly 22% of Canada's total GHG emissions in 2019 (UNFCCC, 2021), a large share of which are methane emissions, which will need to be addressed as part of Canada's overall emissions reduction policies. The industry, in part bolstered by government policies, has made inroads in reducing the emissions intensity of operations, which have fallen by 32% in the oil sands since 1990. The government of Canada continues to work with oil and gas companies to enhance performance and reduce environmental impacts, recognising that global markets will progressively demand cleaner fuels and will discriminate in favour of more carbon-competitive products. Notably, Canada has committed to reducing methane emissions from the oil and gas sector by 40-45% below 2012 levels by 2025. The government has a number of programmes and funding in place that will help the industry meet or exceed these targets, including a CAD 750 million Emissions Reduction Fund (see Chapters 3 and 11). As of October 2021, this target was increased to at least a 75% reduction below 2012 levels by 2030.

Canada is also home to a nascent LNG sector. Several LNG export facilities are proposed and are at different stages of project development. Currently, LNG Canada (Phase 1) is under construction, with an export capacity of 14 million tonnes of LNG per year, with the potential to double capacity in a future second phase. The use of hydro electricity to power their operations affords Canada the potential to be one of the cleanest LNG producers in the world (see Chapter 10).

Clean fuels

Clean fuels represent an opportunity for Canada to transition its existing energy sector to a future low-carbon economy, thereby supporting innovation, competitiveness and energy security while providing a new revenue stream from forest and agriculture waste, as well as municipal solid waste. They include hydrogen, advanced biofuels, renewable natural gas, sustainable aviation fuel and synthetic fuels (see Chapters 3 and 5).

Today, these fuels make up less than 6% of Canada's total energy supply, but in 2050, between 10% and 51% (or up to 60% according to some projections) of Canada's national energy demand is expected to be met with clean fuelsto reach its net zero goal. In particular, clean fuels can be an effective way to decarbonise hard-to-abate industries such as cement, steel, heavy-duty transport, and oil and gas, which represent nearly two-thirds of Canada's emissions.

Notably, Canada has an abundant and diverse range of sustainable feedstocks that can be used to produce a variety of biofuels and bio-products, as well as hydrogen, helping to grow its circular economy and provide for export potential. Toward this end, in June 2021, Canada launched the Clean Fuels Fund, a CAD 1.5 billion programme over five years to support the buildout of new clean fuel production capacity, establish biomass supply chains, and develop enabling codes and standards (see Chapter 5).

The Clean Fuel Regulations will require suppliers of liquid fossil fuels (gasoline, diesel) to reduce the carbon intensity of the fuels they produce and import for use in Canada over time. The regulations target the carbon intensity of liquid fuels used in Canada to be around 13% below 2016 levels by 2030. They will reduce the annual GHG emissions in 2030 by at least 20 Mt and further drive the adoption of clean fuels (also see Chapter 5). The final regulation is targeted for late 2021 and will come into effect in December 2022.

Canada also sees a sizeable role and competitive advantage in the production and eventual export of clean fuels (including hydrogen, advanced biofuels, renewable natural gas, sustainable aviation fuel and synthetic fuels, among others), given its abundance of renewable fuel feedstocks, skilled workforce, and existing position as a leader in intellectual property and exporting technologies.

In December 2020, Canada published the Hydrogen Strategy for Canada, which is designed to spur investment in hydrogen production, distribution and use, as well as create partnerships that establish Canada as a global supplier of hydrogen (see Chapter 3). It shows that by 2050, hydrogen could contribute up to 30% of Canada's energy mix, supporting sizeable CO_2 reductions. In addition, Canada's CAD 50 million/year Energy Innovation Program recently allocated an additional CAD 25 million over five years to develop codes and standards to support the Hydrogen Strategy for Canada.

Technology and innovation

Canada sees technology and innovation as an integral component in its pathway toward net zero emissions. Through Budget 2017, Canada committed CAD 2.3 billion toward a clean growth policy agenda, as outlined in the PCF, with one of the pillars being clean technology, innovation and jobs. It also introduced the Strategic Innovation Fund (SIF), which has been supporting the creation and growth of innovative businesses across the economy, including in the automotive, aerospace and mining sectors. In 2020, the SIF Net Zero Accelerator was announced. It is a CAD 8 billion programme that supports projects that will help decarbonise heavy industry, support clean technologies and help accelerate domestic GHG emissions reductions by 2030.

More recently, Budget 2021 announced various tax incentives, such as a 50% reduction in the general corporate and small business income tax rates for businesses that manufacture zero-emission technologies, and a tax credit for capital invested in carbon capture, utilisation and storage (CCUS) projects (effective in 2022).

The federal government plays an important role in energy research, development and demonstration (RD&D), which complements efforts of provincial and territorial governments, the private sector, and academia. Further, the federal government helps tie these efforts together in support of national goals and outcomes. The federal government also performs energy-related RD&D at federally operated laboratories (see Chapter 6).

To reinforce these efforts, Canada participates in key international RD&D fora, such as Mission Innovation, a global initiative to catalyse action and investment in RD&D to make clean energy affordable, attractive and accessible. In addition to Canada's strong leadership to advance SMRs (see Chapter 8) and hydrogen (see Chapter 3), Canada is a global leader in CCUS technologies, with 4 of the world's 26 commercial CCUS projects in operation. The country also hosts extensive expertise in CCUS research and development.

Industry, particularly the energy-intensive trade-exposed sectors including iron and steel, cement, chemicals, pulp and paper, and mining, will need to continue to research, develop and demonstrate new technologies and processes to reach net zero. Many of the technology pathways remain in the early stages of development and require additional RD&D to become commercialised.

People-centred energy transitions

Canada acknowledges that changes in the energy sector will affect not only the energy security of the system itself, but also the consumers and workers who depend on it for energy services and employment. Therefore, considerations such as affordability for energy consumers and employment in the energy sector are at the forefront of Canada's policies and programmes related to clean energy and climate change.

The Canadian government is making progress to ensure that the transition to a low-carbon economy remains people-focused and is committed to supporting the livelihoods and well-being of workers and their communities, including through several initiatives on gender equality and diversity, indigenous inclusion, and ensuring a just transition for coal workers.

Gender equality

Gender equality is one of the key priorities for Canada, which is being advanced through the implementation of policies that empower women to become equal participants in all aspects of society. The government has launched a number of initiatives to close the pay gap between men and women, ensure that women play an equal role in policy decisions, improve gender-based data collection, and increase job opportunities for women.

The government of Canada recognises that successfully transitioning to a low-carbon future will depend on the country's ability to harness diverse talents and perspectives. Moreover, Canada understands that gender, equity and diversity must be central to the global energy sector's recovery efforts, recognising the disproportionate impact that the pandemic has on women, particularly in the workforce.

To ensure that the low-carbon transition is equitable and inclusive, the government of Canada co-leads the Clean Energy Education and Empowerment (C3E) International Initiative, a joint effort between the Clean Energy Ministerial and the IEA, which works to advance gender equality in the energy sector globally.

Canada leads the Equal by 30 Campaign, under C3E International, which encourages voluntary commitments by both public and private sector organisations to work towards equal pay, equal leadership and equal opportunities for women in the energy sector by 2030. Since the launch of the campaign in 2018, over 170 organisations and governments from around the world have signed on.

Canada also leads the Awards & Recognition programme under C3E International, which recognises outstanding individuals and organisations contributing to a clean energy future while advancing the empowerment of women, in an effort to promote career advancement and inspire women of all ages to contribute to the clean energy field and help close the gender gap.

Given a persistent lack of sustained gender-disaggregated data collection in the energy sector, which makes inclusive policy development and decision making more difficult, the government of Canada recently developed a reporting framework under Equal by 30 to help organisations and governments measure their progress on gender equality commitments, track progress, and create a much-needed baseline of gender-disaggregated data for the energy sector.

Results of the reporting framework were released in March 2021 and found that the energy industry remains one of the most gender imbalanced sectors, with women making up just 32% of the global energy workforce, and only 26% of executive and C-Suite positions.

Canada is also ensuring that Gender-Based Analysis Plus (GBA+), an analytical process for assessing diversity and inequality, is applied comprehensively to all aspects of policy development and decision making, and is committed to strengthening the quality of GBA+ with better data and the full consideration of impacts.

Canada's Strengthened Climate Plan's initiatives apply a GBA+ lens to programme design, for example through training and recruitment strategies that will target underrepresented groups and require programme applicants to provide GBA+ related data so the government can more accurately assess the socio-economic impacts of all programmes.

The government is addressing diversity and inclusion in the clean fuels sector by asking organisations to take on the 50-30 Challenge, supported by a funding envelope of CAD 33 million over three years, starting in 2021-22. The 50-30 Challenge asks participating organisations to make two commitments and report regularly on progress towards gender parity (50%) and significant representation of diverse populations (30%) on boards and senior management, including racialised Canadians, Indigenous peoples, people with disabilities and members of LGBTQ2 (lesbian, gay, bisexual, transgender, queer and two-spirited) communities.

Domestically, Canada has stepped up its own data collection efforts. Developed by Statistics Canada, and funded by NRCan, the Human Resource Module of the broader Natural Resources Satellite Account provides detailed and reliable statistics on the demographics of natural resources production in Canada. The module provides annual estimates of employment and wage statistics (number of jobs, hours worked, wages and salaries, average annual hours worked, average annual wages and salaries, and average hourly wage) with a high level of detail in diversity characteristics, including gender and intersections with age, immigration status, indigenous self-identification, and educational attainment. These statistics are available for the energy sector, energy subsectors and by occupation type.

According to the latest data available, women represent 26% of the Canadian energy sector workforce. On average, women in the energy sector earn 70% of the average earnings of their male counterparts and 81% of the hourly wages earned by men (or CAD 10.54 less per hour). On average, women work 15%, or 6 hours per week, less than men, and represent 23% of hours worked in the energy sector. Women are overrepresented in administrative, support, human resources, auditing, accounting and law occupations, and underrepresented in engineering, trade and operations occupations.

Indigenous inclusion

The government of Canada recognises the vital role Indigenous peoples play in the transition to a low-carbon economy, given their strong relationship to the land and unique role in the stewardship of natural resources. Empowered Indigenous-led clean energy solutions can accelerate the transition, while advancing community resilience, autonomy, self-determination and reconciliation.

The energy sector is an important source of jobs and skills development for Indigenous peoples and is a significant supporter of Indigenous-owned businesses. Indigenous people made up 4.9% of the energy sector workforce in 2019 (compared to 3.3% of the workforce in all sectors). Canada's energy sector employed 14 031 Indigenous people in 2019, representing 2.4% of Indigenous employment across the country. The oil and gas sector employed around 10 414 indigenous workers in 2019. The electricity and renewables sector employed 3 309 indigenous workers in 2019.

In general, the pandemic has exacerbated socio-economic gaps and deepened inequities of vulnerable groups, including those faced by Indigenous peoples. To be successful, the clean energy transition, aligned with long term recovery, would see Indigenous peoples and communities at the heart of these efforts. Integrating Indigenous knowledge, skills and capacity will help increase participation in the clean energy sector workforce as the transition progresses.

Given the dispersed geographic location of indigenous communities across Canada, major resource projects, such as energy operations and mines, are often near indigenous

communities and overlap with their traditional territories. In many of these communities, natural resources provide unique economic opportunities and become the main driver of growth and employment. This also places an expectation on project proponents and industry to establish and maintain relationships with communities before, during and after the life cycle of a proposed project in order to form meaningful partnerships, share economic benefits and seek ways to mitigate potential impacts earlier on.

As Canada transitions to a low-carbon economy, it is crucial that indigenous communities are not left behind and have pathways to transition in ways that align with their priorities and energy needs. There are many examples of partnerships and collaboration between indigenous communities, governments and industry to build upon, including for Indigenous peoples to be leaders in the energy transition. By taking learnt best practices in the energy sector and applying them to new opportunities, Canada can ensure a more people-centred energy transition.

In Canada, there are over 200 northern and remote communities, the majority of which are Indigenous and reliant on imported diesel for heat and power generation. This dependency can lead to high operating costs, poor air quality, and other negative environmental and health impacts. The government of Canada is committed to increase the opportunity of Indigenous, remote and rural communities to be powered by clean, reliable energy by 2030.

As a cornerstone of its Strengthened Climate Plan, Canada has committed to empowering Indigenous clean energy leadership. Along with diesel displacement, several other measures are being developed to create opportunities for capacity building and employment for Indigenous workers; to harness the knowledge and innovation potential of Indigenous businesses; and to strengthen community resilience, autonomy and self-determination in support of reconciliation.

Canada is also committed to reconciliation and working collaboratively with Indigenous peoples through the implementation of the United Nations Declaration on the Rights of Indigenous Peoples Act, which came into force June 2021. The act requires the government to work in partnership with Indigenous peoples to take measures necessary to ensure federal laws are consistent with the declaration, and to develop an action plan to achieve its objectives.

Through meaningful dialogue, the implementation of the declaration can help develop stronger economic and social outcomes as well as a more sustainable and predictable path for Indigenous peoples, the government of Canada and industry. Article 23 of the declaration states that Indigenous peoples have the right to determine and develop priorities and strategies for exercising their right to development. Ensuring that Indigenous peoples have the ability to lead their participation in the transition will contribute to a more inclusive economy, as well as support Indigenous peoples' inherent right to self-determination.

Supporting workers and communities in the low carbon transition

To address the implications of the accelerated phase-out of coal power on workers and communities supported by this industry, in 2018, the government established the Task Force on Just Transition for Canadian Coal Power Workers and Communities to engage coal-affected communities in Alberta, Saskatchewan, Nova Scotia and New Brunswick

and recommend a path forward. The task force was made up of experts in sustainability, workforce development and the electricity sector, including representatives from labour associations, unions and municipalities.

The task force released its final report in March 2019, which included a series of recommendations for the government's consideration. In response, the government has committed CAD 185 million, including CAD 35 million over five years (funded through Budget 2018) for the Canada Coal Transition Initiative, to support skills development and economic diversification, and CAD 150 million for a dedicated infrastructure fund beginning in 2020/21 to support economic diversification (see Chapter 9).

NRCan is also working with the Atlantic provinces, Alberta and Saskatchewan, to identify key projects that can support the transition away from coal in these regions. In March 2019, the Atlantic provinces and the federal government agreed to develop a Clean Power Roadmap for Atlantic Canada. The road map outlines a collective vision for how jurisdictions may collaborate over the coming decades to build a clean power superhighway across the region.

In July 2021, NRCan launched public consultations to gather diverse views on proposed just transition legislation that could include:

- people-centred just transition principles that put workers and communities at the centre of the government's policy and decision-making processes on climate change action
- a Just Transition Advisory Body to provide the government with advice on regional and sectoral just transition strategies that support workers and communities, and increase diversity and inclusion.

Just transition legislation will build on existing efforts to support the future and livelihood of Canadian workers and their communities as the world moves toward a low-carbon future. NRCan is working with other government departments, workers, communities, provinces and territories, Indigenous peoples, businesses and stakeholders to establish principles and an ongoing consultantion process to ensure that Canadian workers, businesses and communities have the skills, resources and support to be leaders in the global clean economy.

Energy security in clean energy transitions

As the evolving energy system decreases its reliance on traditional hydrocarbons and increases its reliance on clean fuels and technologies, Canada sees the notion of energy security evolving from security of fossil commodity supply to a broader sustainability model that stresses the efficiency of energy use, production of cleaner energy, greater reliance on clean power, using technology to harness renewable resources and a cleaner fuel mix.

As the clean energy transition unfolds, accessing secure supplies of critical minerals and key components necessary for the manufacture of clean energy technologies that are not available domestically will be an increasing focus of energy security for Canada. Canada is uniquely positioned as one of the few countries in the western hemisphere with all the minerals and metals needed for the production of advanced batteries, and has the fourth-largest reserves of rare earth elements, which are essential components in the permanent magnets used in electric vehicle (EV) motors and wind turbines.

Clean fuels provide not only environmental and economic benefits, but energy security as well, both for Canada and beyond, when exported. Increasing domestic clean fuel

production capacity allows Canada to meet demand driven by the Clean Fuel Regulations and protect against the risk of global supply disruptions, providing flexibility and energy security.

In parallel with growing electrification, the automation, digitalisation and deployment of smart devices in power systems will increase the vulnerability of the energy system to cybersecurity risks if appropriate countermeasures are not taken. Canada is aware of the significant consequences for national security, public safety and economic security that a potential disruption could cause and is actively involved in improving cybersecurity and defences (see Chapter 7). Canada has already seen increased cyber activity, leading to stepped up efforts to protect energy infrastructure, including by strengthening regional network collaboration, notably with the United States.

Likewise, the threat to energy system reliability posed by the increasing frequency and severity of extreme weather events and long-term climatic shifts exacerbated by climate change remain a concern. Canada is working with the energy sector and across multiple levels of government to improve the reliability and resilience of its energy system (see Chapter 3).

Critical minerals in clean energy transitions

Canada's minerals and metals sector is a major contributor to the Canadian economy. In 2019, it generated 719 000 direct and indirect jobs across the country and contributed CAD 70.9 billion to GDP (3.3% of total). Canada is already producing over 60 minerals and metals, and is capable of producing many more.

To fully unlock Canada's minerals and metals potential, the government is taking a "mines to manufacturing" approach, leveraging Canada's resource wealth and mining expertise to build the battery and critical mineral supply chains needed to supply the global electric vehicle market and support the wider clean energy transition. The overall approach is grounded in the Canadian Minerals and Metals Plan, a policy framework co-developed with provincial and territorial governments, industry, and indigenous groups.

As a first step, Canada released its Critical Minerals List in March 2021.The list of 31 minerals provides greater certainty and predictability to industry, investors, provinces and territories and Canada's international partners on Canada's minerals priorities. It also enables targeted policy actions to address pressure points in critical minerals supply chains and secure growth opportunities.

The Canadian government is currently undertaking work across a number of policy areas to support this goal. This includes:

- Research and analysis to identify where Canada's competitive advantage lies in various critical mineral value chains.
- Exploring ways to reduce risk and environmental liability, as well as create economic opportunities through mining value from waste.
- Engaging provinces and territories through the newly created Federal-Provincial-Territorial Task Team on Critical Minerals, which will support efforts to develop a list of critical minerals that can be produced in Canada, leverage programmes and policies to support the critical minerals industry, and support co-ordinated international engagement.
- Collaborating with allies such as Australia, the European Union, Japan, the United Kingdom and the United States to promote greater policy alignment, and identify how to best leverage resources to strengthen global supply chains.

Both federal and provincial governments are also making strategic investments in projects that will help advance domestic critical mineral supply chains. Some examples include:

- In Budget 2021, the government of Canada announced an investment of CAD 9.6 million over three years to create a Critical Minerals Centre of Excellence at NRCan and CAD 36.8 million over three years for federal R&D to advance critical battery mineral processing and refining expertise.
- In December 2020, the federal government and the government of Ontario announced investments of CAD 5 million each in the First Cobalt Corporation to accelerate domestic production of battery-grade cobalt sulphate, a required element needed to produce long-range EVs.
- In October 2020, the Canadian government announced a joint investment of CAD 590 million with the government of Ontario to support Ford Motor Company of Canada in the retooling of its Oakville Assembly Complex to produce battery electric vehicles.
- In August 2020, the government of Saskatchewan announced CAD 31 million in funding for a Rare Earth Separation and Processing Facility in Saskatchewan, the first of its kind in Canada.
- In April 2020, the government of Quebec invested around CAD 5 million to support Nouveau Monde Graphite's efforts to produce purified graphite (a project also supported by the federal government), and more recently partnered with investors to acquire a provincial lithium project.

Canada believes that resource development must be undertaken while applying the best possible environmental, social and governance (ESG) practices, which are needed to develop critical mineral value chains in a responsible and sustainable manner. As a global mining leader, Canada is recognised for its strong ESG credentials and clean mining practices.

Canada is a major supporter of the Intergovernmental Forum on Mining, Minerals, Metals and Sustainable Development, which supports more than 75 countries committed to leveraging mining for sustainable development to ensure negative impacts are limited and financial benefits are shared. It is also a leading contributor to the Energy Resource Governance Initiative, which promotes sound mining sector governance, and secure and resilient supply chains for critical energy minerals in resource-rich countries.

Finally, Canada is home to world-leading research and innovation, with expertise to turn minerals into advanced materials and to extract minerals from waste streams and unconventional sources. For example, Canada's minerals and metals sector is already incorporating artificial intelligence and machine learning into mineral exploration and production to reduce risks, costs and environmental impacts.

International co-operation

Canada is committed to working with its counterparts domestically, in North America and beyond to advance shared objectives with respect to the responsible and reliable development of natural resources as well as the transparent, predictable and sustainable trade of energy.

Canada works within the International Energy Agency; the Clean Energy Ministerial (CEM); Mission Innovation, the International Energy Efficiency Hub, IRENA, the World Circular Economy Forum, and the International Partnership for Hydrogen and Fuel Cells

in the Economy; the G7 and G20; and regional fora (e.g. the Asia-Pacific Economic Cooperation) to promote and protect Canadian interests, reinforce alliances with like-minded partners, and enhance global energy security through dialogue and co-operation with emerging economies. Canada also encourages countries to adopt climate-friendly energy security policies and works with developing countries to boost co-operation and investment in clean technology innovation while meeting its international obligations with respect to climate-friendly official development assistance.

Canada has established itself as a key leader within the CEM, hosting the 10th annual ministerial meeting in May 2019 in Vancouver. For the first time ever, Canada featured a Youth Leaders' Forum that ran parallel to the ministerial meetings, increasing the diversity of perspectives around the table.

Canada co-leads 9 of the 22 CEM work streams across a wide range of topics that are of strategic importance to the clean energy transition. This includes work to advance nuclear innovation, women's education and empowerment, the deployment of EVs, increasing energy efficiency in buildings and industry, and the deployment of hydrogen fuel cell technology. Canada also participates in areas of work targeting CCUS, power system flexibility, smart grids, clean energy solutions, and super-efficient equipment and appliances.

Canada is also an active leader within the governance and initiatives of Mission Innovation (MI), and was instrumental in shaping the second phase of MI. The next phase focuses on ambitious, outcomes-oriented, public-private missions, as well as an Innovation Platform to advance collaboration and accelerate pathways to net zero emissions.

Canada actively participates in all governance structures of the IEA, including the Committee on Energy Research and Technology (CERT), which co-ordinates and promotes the development, demonstration and deployment of technologies to meet challenges in the energy sector. Canada participates in 22 IEA Technology Collaboration Programmes, international partnerships that enable governments, businesses, industries, international organisations and non-governmental organisations to share research on breakthrough technologies, to fill existing research gaps, build pilot plants, and carry out deployment or demonstration programmes (see Chapter 6).

Canada is also playing an international leadership role in the drive to phase out the use of unabated coal-fired electricity generation, committed to achieving this phase-out in a sustainable and economically inclusive way, including appropriate support for workers and communities. To this end, the Canadian and the UK governments launched the Powering Past Coal Alliance at COP23 in Bonn, Germany in November 2017.

Canada is expanding energy trade and relations with key markets in China, the European Union, Germany, India, Japan and the United Arab Emirates. These efforts include a Ministerial Dialogue on Clean Energy with China, the 2019 NRCan-METI Memorandum of Cooperation in the Field of Energy with Japan and the Canada-EU High Level Energy Dialogue.

In the North American context, Canada has taken a number of actions with Mexico and the United States in recent years to foster collaboration, including:

- Canada worked with its North American counterparts to renegotiate NAFTA, securing a bilateral energy side-letter with the United States that will facilitate energy development

through greater co-operation and enhanced regulatory and transparency measures, and provide unfettered access to energy infrastructure.

- Canada maintained engagement with Mexico and the United States to advance North American energy collaboration and energy market integration, with an agreement to advance a new framework for collaboration.
- Canada signed the Canada-US Implementing Arrangement for Nuclear Science and Technology Collaboration in 2015.
- Canada signed the North American Memorandum of Understanding on Energy Information in 2014.
- In 2017, Canada, Mexico and the United States launched the North American Cooperation on Energy Information website to create a framework for consultation and for sharing publicly available materials to improve energy information and energy outlooks for North America.
- In January 2020, Canada and the United States announced they had finalised the Canada-US Joint Action Plan on Critical Minerals Collaboration, advancing mutual interest in securing supply chains for the critical minerals needed for the energy transition.
- Canada and the United States are working together to foster efficiencies in siting and permitting of cross-border electric transmission projects by expanding the US Department of Energy's Regulatory and Permitting Information Desktop (RAPID) Toolkit.
- Canada and the United States co-ordinated in the development of fuel efficiency standards for light- and heavy-duty vehicles.
- NRCan is working with the US Department of Energy on the development of binational codes and standards for alternative fuelled vehicles and infrastructure as part of its ongoing collaboration under the Regulatory Cooperation Council.
- NRCan collaborates with the US Department of Energy on energy efficiency standard alignment and with the Environmental Protection Agency on implementing ENERGY STAR certifications and related tools and programming for buildings and industry.

Covid-19 response

The Covid-19 pandemic significantly impacted the Canadian energy system, with a 6% reduction in energy demand in 2020 according to CER estimates. On average, oil and gas firms reduced their 2020 capital spending by 30% compared to 2019, according to the Bank of Canada. As a result, the energy sector labour force fell by 12% in May 2020 compared to 2019, with much higher job losses in support activities for oil and gas extraction. Employment in natural resources overall was down 5.2% on a year-over-year basis. Jobs in natural gas distribution and electric power generation, transmission and distribution remained relatively resilient, while the impacts on operational renewables projects, particularly renewable electricity generation, were low.

Despite the significant impacts of the Covid-19 pandemic on Canada's economy and energy sector, Canada's electricity sector was able to deliver services without incident throughout this period.

In response to the pandemic, firms across Canada's energy sector have received general-purpose federal support – in the form of wage subsidies, loans and loan guarantees – through the Canada Emergency Wage Subsidy, Business Credit Availability Program and Large Employer Emergency Financing Facility.

In the spring of 2020, the government of Canada introduced targeted Covid-19 relief measures to help oil and gas companies invest in green solutions to reduce methane and other GHG emissions. The measures include CAD 1.72 billion to clean up orphan and inactive oil and gas wells; a CAD 750 million Emissions Reduction Fund, with a focus on methane; and CAD 320 million for Newfoundland and Labrador's offshore energy sector to fund safety improvements, maintenance and upgrades for existing facilities, as well as R&D.

The government of Canada's Fall Economic Statement 2020: Supporting Canadians and Fighting Covid-19, published in November 2020, placed climate action at the centre of Canada's economic recovery plans. The *Fall Economic Statement* announced funding for energy-efficient home retrofits, ZEV infrastructure, planting 2 billion trees, public transit and other climate-related measures.

Statistics

Canada has a decentralised energy information system. At the federal level, energy data are managed and/or disseminated by StatCan, NRCan, the CER and the ECCC. There are also numerous providers of energy information at the provincial and territorial levels. Each federal, provincial, territorial, academic and research organisation produces information in support of their own mandates, based on their own assumptions, and delivered to their distinct service and privacy standards. For this reason, energy information can be inconsistent, incomplete, untimely and inaccessible, compromising the quality of policy analysis and transparency of decision making.

As a result, provinces and territories, as stated at the 2019 Energy and Mines Ministers' Conference, agreed on a need to standardise energy information and improve access to it, committing to increased collaboration to improve the system. This includes building on existing data-sharing agreements among federal, provincial and territorial governments.

Also in 2019, the federal budget provided CAD 15.2 million over five years (plus CAD 3.4 million per year in ongoing support) to establish a virtual Canadian Centre for Energy Information. The centre is mandated to work with a wide range of stakeholders to improve the accessibility and overall quality of Canada's energy data. In October 2020, it launched an initial website that brought together in one place over 500 energy information products from more than 50 different data providers across federal, provincial and territorial governments; industry associations; utilities; academic institutions; think tanks; non-governmental organisations; and international organisations. In addition to expanding content on its one-stop website, the Canadian Centre for Energy Information will also work with stakeholders to reconcile and integrate existing energy data, identify and fill key gaps in energy data, and improve data quality across each province's and territory's energy system.

Assessment

Canada benefits from diverse and significant energy resources. It exports 44% of its domestic energy production and the sector is an important contributor to the economy, representing in 2020 8% of GDP, CAD 95 billion in exports and about 845 500 jobs. Importantly, it is also a key contributor to stable global energy supply.

Since the IEA's last in-depth review in 2015, Canada has made a series of international and domestic commitments, putting it on a path toward achieving an ambitious energy system transformation and climate transition by 2050. These include: the PCF of December 2016 (backed by sizeable financial outlays to support emissions reductions); the Net-Zero Emissions Accountability Act of June 2021 to facilitate achieving net zero emissions by 2050 with 5-year targets beginning in 2030; and Canada's Strengthened Climate Plan, with 64 new measures and CAD 15 billion in investments to further reduce emissions by 32-40% below 2005 levels by 2030. More recently, Canada updated its NDC target to cut emissions by 40-45% from 2005 levels by 2030.

Canada's current energy and economic profile presents both challenges and opportunities in achieving these targets. In 2020, fossil fuels accounted for 77% of Canada's total energy supply. TFC by source is dominated by oil (45%), followed by natural gas (26%), electricity (22%), bioenergy (5%) and coal (1%). By sector, industry, transport and residential account for about one-third of TFC each. Oil is the main energy source in the transport sector (90%) and in industry (36%), while natural gas is the main fuel used in the buildings sector (44%), followed by electricity (41%).

The production and use of energy accounts for over 80% of Canada's GHG emissions. While upstream production of oil and natural gas and its transformation into end-use products accounts for approximately 25% of these emissions, the lion's share is attributed to end-use energy consumption, most of which comes from fossil fuels and which must decline significantly to achieve "net zero by 2050".

Improving the rate of energy technology innovation will be critical to enable the deep decarbonisation required to achieve net zero emissions by 2050. Key opportunities include leveraging Canada's robust clean power resources to drive electrification across the economy, which will simultaneously improve energy efficiency. This will require significant investments in end-use technologies, as well as in smart grids. Canada is well-positioned, as it is home to some of the world's leading technology companies, including in energy.

Canada is also a global leader in CCUS technologies, with 4 of the world's 26 commercial projects in operation, along with extensive expertise in CCUS research and development. CCUS and other technologies play an important role in reducing Canada's GHG intensity for upstream crude oil production, which is currently the third-highest globally. Additional R&D in new energy technologies and innovation, where significant investments are being made, will be critical to reducing these impacts and further driving emissions reductions. The government acknowledges that many of the other clean energy technologies needed to achieve net zero are not yet commercially ready, which makes the case for innovation even stronger. Though Canada's funding and programmes to support innovation are significant, support should be revisited and updated regularly based on the rate of technological progress to ensure progress toward net zero.

Despite an overall strong role for fossil fuels in Canada's energy mix, its electricity system is one of the cleanest in the world, with heavy dominance of hydropower as well as an important role for nuclear (with considerable variation across jurisdictions). Canada also set a target of further decarbonising its electricity system from its current level of 81% of production from non-emitting sources to 90% by 2030. Notably, Ontario and New Brunswick plan to preserve the role of nuclear in their generation mixes.

Moreover, Canada has developed a road map for the initial deployment of several SMRs by the late 2020s which may contribute to emissions reductions via on-grid power,

including the replacement of coal power plants in several provinces, on- and off-grid co-generation[2] for heavy industry, and power for remote off-grid communities. In December 2020, Canada launched the SMR Action Plan, which continues to build on the work of the road map to advance SMRs. Additional funding has also been provided to advance progress on SMRs.

Clean fuels also represent an opportunity for Canada to transition its energy sector to the low-carbon economy of the future, with over 50% of Canada's national energy demand expected to be met with clean fuels in 2050 to reach its net zero goal, supporting innovation, competitiveness and energy security.

Other measures to help Canada meet its climate goals include: 2018 federal regulations to phase out all conventional coal-fired power plants by 2030, 2018 regulations to reduce methane emissions from the oil and gas sector (which will be revisited to support Canada's recently increased target to at least a 75% reduction by 2030 from 2012 levels), the CAD 750 million Emissions Reduction Fund focused on methane in the oil and gas sector, Clean Fuel Regulations expected to come into effect in 2022, a Hydrogen Strategy for Canada published in December 2020, a CAD 8 billion Net-Zero Accelerator Fund to support decarbonisation of large emitters and scale up clean technologies, and a CAD 1.5 billion Clean Fuels Fund.

Canada also introduced a Pan-Canadian Approach to Pricing Carbon Pollution, which became effective in 2019, setting a federal benchmark requiring all provinces and territories to implement a carbon pricing system while giving them the flexibility to design their own policies and programmes or to apply a "federal backstop" pricing system. Canada's Strengthened Climate Plan proposed that the federal carbon price continue to rise annually through 2030, and the government has approved the increase. The proposed carbon pricing trajectory is undoubtedly one of the most ambitious in the world, with a target to reach CAD 170/t CO_2 by 2030 (from CAD 30/t CO_2 in 2020). However, the depth of decarbonisation required by Canada's net zero pledge still warrants additional, complementary policies and regulations to drive desired outcomes.

Canada has taken steps to update and streamline its environmental and regulatory systems, including the enactment of Bill C-69 to modernise the National Energy Board and the Canadian Environmental Assessment Agency through the creation of the Canada Energy Regulator and the Impact Assessment Agency of Canada. A new impact assessment system, with input from Indigenous peoples, provinces and territories, and other stakeholders, is intended to clarify procedure expectations, provide more certainty in the regulatory decision-making process on proposed projects and avoid duplication with other jurisdictions.

The IEA commends Canada on ensuring a people-centred approach to its clean energy transition, including focusing its policy-making process on identifying ways to improve inclusivity (e.g. GBA+). The IEA welcomes Canada's active participation in the recently launched IEA Global Commission on People-Centred Clean Energy Transitions. Canada's efforts include, among others, C3E International and the Equal by 30 Campaign to promote greater gender equality in clean energy sectors; programmes to increase access to clean

[2] Co-generation refers to the combined production of heat and power.

energy in northern, remote and indigenous communities; as well as actions to ensure a just transition for coal workers based on recommendations from a multi-stakeholder task force.

North American energy integration remains a priority for Canada, with a Canada-US energy trading relationship valued at more than USD 100 billion per year, an extensive network of electricity and pipeline connections, and collaboration in many other areas. The Canada-United States-Mexico Agreement of November 2018, which includes a Canada-United States side letter on energy, presents additional opportunities for co-operation. Canada is also expanding energy relations with key markets in China, the European Union, India, Japan and the United Arab Emirates, and engages in multilateral fora such as the G7, the G20, the IEA, the Clean Energy Ministerial and Mission Innovation to shape global energy policy.

Covid-19 related economic impacts significantly affected the Canadian energy sector in 2020, including a 6% decline in energy demand, a 30% fall in capital expenditures and a 12% decline in jobs, particularly in oil and gas extraction. In the spring of 2020, the government introduced targeted Covid-19 relief measures that support oil and gas companies while incentivising them to reduce emissions. The government of Canada's Fall Economic Statement 2020: Supporting Canadians and Fighting Covid-19, published in November, announced funding for energy-efficient home retrofits, additional support for ZEV infrastructure deployment and other climate-related measures.

Several factors play a unique role in influencing Canada's energy policy decision making. These include its status as one of the few major global fossil fuel producers committed to achieving net zero by 2050. In fact, in May 2021, Canada, Norway, Qatar, Saudi Arabia and the United States announced that they will form the Net-Zero Producers' Forum to develop long-term strategies to reach global net zero emissions. The five countries collectively represent 40% of global oil and gas production.

Regional energy differences also matter, with some provinces being major oil producers, others having significant hydro and clean tech, while remote communities remain heavily dependent on diesel for electricity generation. Canada's shared jurisdictional model for energy sector governance also represents a well understood structural challenge, which will require that the federal government co-ordinate closely with provincial and territorial authorities on aligning key energy and climate goals, regulations, and standards critical for achieving 2030 and 2050 GHG reduction goals.

As the second most energy-intensive OECD country after Luxembourg in terms of TFC per capita, Canada views energy efficiency as key to achieving its 2030 emissions reduction goal and net zero by 2050, and it identified the potential to reduce energy demand by more than 30% by 2030 compared to 2000. Canada is already making progress, achieving 12.3% in energy efficiency improvements between 2000 and 2018. In addition to planning significant investments to support energy efficiency improvements in buildings, including CAD 2.6 billion over seven years to retrofit homes, Canada has identified industry (which in 2019 accounted for 38% of CO_2 emissions, including agriculture and forestry) and transport (34% of CO_2 emissions) as the areas where energy efficiency gains can be significant, and sees considerable opportunity for energy efficiency related jobs growth. In its efforts to decarbonise the transport sector, the government has announced the intention to regulate 100% ZEV sales by 2035. The government is also reviewing the modernisation of the 1992 Energy Efficiency Act to ensure it can enhance

competitiveness and promote innovation while continuing to improve energy efficiency. It also recognises the importance of aligning regulatory policies with provinces and territories, which share authority in this area. Setting more specific sectoral indicators and targets and monitoring progress will also help accelerate improvements and enhance Canada's ability to achieve 2030 and 2050 net zero goals.

Looking ahead, the CER's *Canada's Energy Future 2020* "Evolving Scenario" projects that by 2050, 90% of electricity generation will come from renewables and nuclear energy, and electricity's share of end-use energy demand will increase to over 27%, as the share of electric vehicles and other electricity demand grows. However, in a net zero scenario, electricity demand is expected to double, and non-emitting electricity generation will need to grow by two to three times today's level. This requires paying close attention to the challenges facing the transformation of the electricity sector to ensure it will be able to meet growing needs for transmission capacity, generation adequacy and system integration. The development of a comprehensive national electrification strategy that provides guidance to provinces and territories, given their own jurisdiction over electricity markets, and which reinforces the importance of strengthening interprovincial connectivity and system resilience, should be considered. Clean fuels are expected to play an essential role in reaching the net zero goal in areas where electrification will be more challenging.

Canada also aims to remain a major global oil and gas supplier beyond 2050. *Canada's Energy Future 2020* "Evolving Scenario" foresees peak crude oil production in 2039, peak natural gas production in 2040 and an increase in LNG exports until 2040. However, given that GHG emissions from oil and gas production are a significant contributor to Canada's overall emissions, addressing the sector's role in a net zero future will be necessary.

Though notable gains have been made in improving efficiency and lowering emissions from upstream production to date, sizeable additional gains will be needed in a net zero future. Canada's plans for hydrogen production from natural gas, coupled with CCUS technology, could help reduce the carbon footprint of this and other sectors. Biofuels can also play an important role. Moreover, Canada should pay close attention to shifting demand for oil and gas globally, as countries around the world undertake their own energy transitions and put in place net zero targets. Canada must focus on significantly decarbonising its oil and gas sectors while at the same time ensuring competitiveness in increasingly well-supplied world markets. While Canada scores well on overall ESG indicators relative to many other oil and gas producers, the environmental profile of oil sands production, in particular, will become a greater focus for importing countries and warrants action. In addition, Canada is leveraging its strong ESG performance to position itself to become a global leader in the production and export of clean LNG to help countries transition away from higher emitting fuels, such as coal.

Overall, Canada's ambitious energy transformation agenda is moving forward, on the basis of extensive consultations, with support from many stakeholders across industry, the provinces and territories. At the same time, successfully maintaining the necessary societal and political consensus in support of this challenging and multifaceted agenda while simultaneously ensuring the oil and gas sector remains a major driver of the Canadian economy beyond 2050, presents significant policy, resource, regulatory, shared governance and innovation challenges that will require close collaboration and sustained commitment and direction in the years and decades to come.

Recommendations

The government of Canada should:

- Develop national emissions reduction strategies in consultation with the provinces, territories and other stakeholders for key sectors such as transport, buildings and industry to meet the strengthened 2030 nationally determined contribution target and net zero by 2050 goal.
- Based on technological progress, regularly update support for RD&D and innovation of clean energy technologies to achieve 2050 targets, with an eye to also advancing future export opportunities for clean fuels and other clean technologies.
- Ensure the timely development and deployment of technologies that can decarbonise fossil fuel production to help achieve climate targets and safeguard hydrocarbon production and export goals to 2050 and beyond.
- Given significant anticipated growth in the electrification of key sectors and a doubling in electricity demand by 2050 to meet net zero goals, develop a comprehensive strategy to substantially increase zero-emissions generation and interconnection capacity to provide guidance to provinces and territories for their planning.

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3. Energy and climate change

Key data (2019)

GHG without LULUCF:* 730.2 Mt CO_2-eq, -1.4% since 2005, +35% since 1990

GHG with LULUCF:* 740.1 Mt CO_2-eq, -1.3% since 2005, +21% since 1990

Energy-related CO_2 emissions:

CO_2 emissions from fuel combustion (2020 provisional): 523.2 Mt CO_2, +11.4% between 2009 and 2019, -8% between 2019 and 2020

CO_2 emissions by fuel: oil 49.2%, natural gas 41.2%, coal 9.4%, waste 0.2%

CO_2 emissions by sector: industry 37.8%, transport 33.5%, electricity and heat generation 14.8%, buildings 13.9%

CO_2 intensity per GDP:** 0.332 kg CO_2/USD (IEA weighted average 0.197 kg CO_2/USD)

* Land use, land-use change and forestry (Source: UNFCCC).

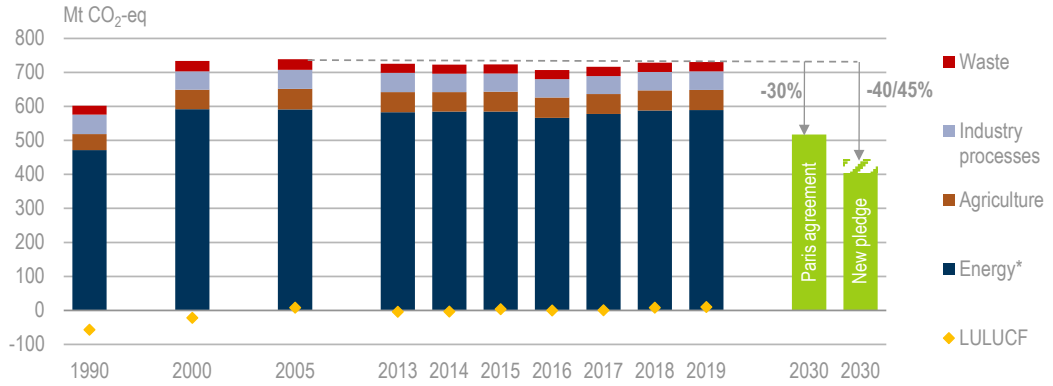
** Gross domestic product in 2015 prices and purchasing power parity (PPP).

Overview

In July 2021, Canada submitted its updated nationally determined contribution (NDC) under the Paris Agreement under which it pledged to reduce total greenhouse gas (GHG) emissions by 40-45% from 2005 levels by 2030 (Figure 3.1). In 2019, Canada's total GHG emissions were 730 million tonnes of CO_2 equivalent (Mt CO_2-eq) excluding land use, land-use change and forestry (LULUCF). This is approximately the same amount as in 2005, but 35% more than in 1990. In 2019, the LULUCF sector contributed as a net source of emissions, releasing 9.9 Mt CO_2-eq. Canada's emissions in 2018 made up 1.5% of total GHG emissions globally.

The production and use of energy in Canada – including emissions from power and heat generation, transport, industry, buildings, and the services sector – is the largest contributor to total GHG emissions, accounting for over 80% in 2019. While upstream production of oil and natural gas and its transformation into end-use products accounts for approximately 26% of these emissions, the lion's share is attributed to end-use energy consumption, most of which comes from fossil fuels and which must decline significantly to achieve net zero by 2050. Emissions from agriculture represented 8% of total GHG emissions, while emissions from industrial processes and product use represented 7% of total GHG emissions. The waste sector represented 4%.

Figure 3.1 Canada's greenhouse gas emissions by sector, from 1990 to 2030 outlooks



The level of GHG emissions in Canada did not change significantly between 2005 and 2018. The country has recently increased its pledge for cutting emissions by 2030.

* Energy-related emissions from combustion processes in power and heat generation, transport, industry, buildings, and other sectors.

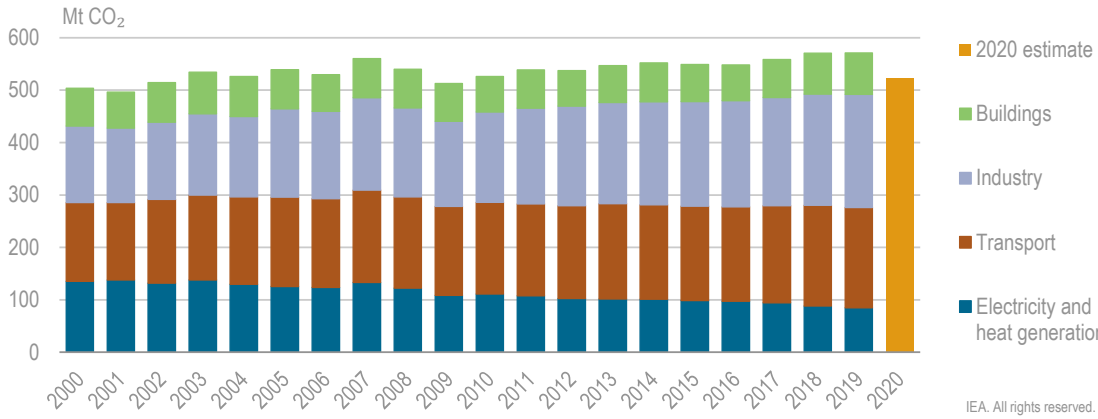
Note: Mt CO_2-eq = million tonnes of carbon dioxide equivalent. LULUCF = land use, land-use change and forestry.

Source: UNFCCC (2020), *Greenhouse Gas Inventory Data*, https://di.unfccc.int/detailed_data_by_party.

Energy-related CO_2 emissions

Energy-related CO_2 emissions in Canada were 571 Mt CO_2 in 2019, a 13% increase compared to 2000 (Figure 3.2). Emissions noticeably declined by 8.5% between 2007 and 2009 due to the economic recession, but rose again by 11% between 2009 and 2019. The Covid-19 pandemic caused CO_2 emissions to decline by 8% between 2019 and 2020, dropping to 523 Mt CO_2.

Figure 3.2 Canada's energy-related CO_2 emissions per sector, 2000-20



After a drop between 2007 and 2009, CO_2 emissions have steadily increased in Canada, driven by increasing activity in the industry sector (including oil and gas production) and in transport.

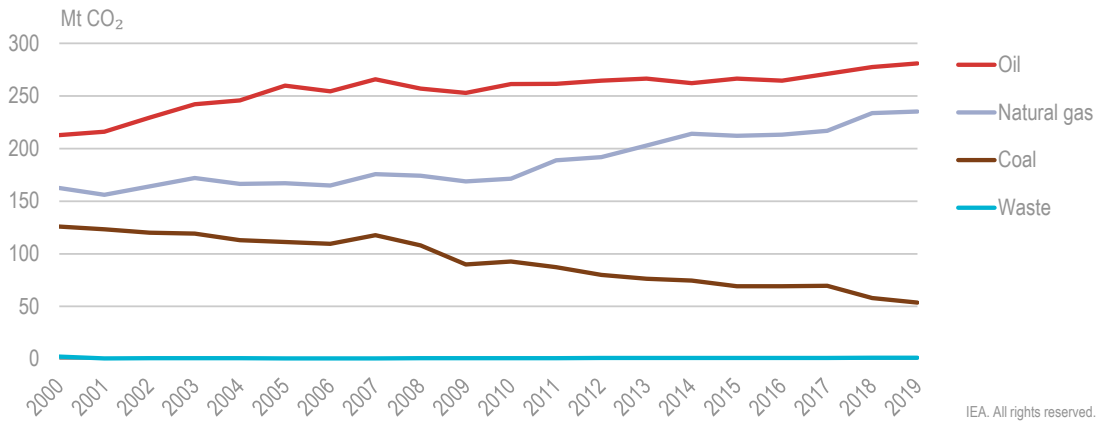
Note: Mt CO_2-eq = million tonnes of carbon dioxide equivalent.

Source: IEA (2021a), *CO_2 Emissions from Fuel Combustion* (database), www.iea.org/statistics.

In the past decade, most sectors have experienced stable growth in emissions. However, emissions from the electricity and heat generation sector dropped by 22% from 2009 to 2019, thanks to an increase in renewable energy resources and the retirement of many conventional coal plants. In 2019, industry (including oil and gas production and refining) was the sector with the largest energy-related CO_2 emissions in Canada, with a share of 38%. Transport accounted for 34%, followed by electricity and heat generation at 15%, and buildings at 14%.

The largest source of energy-related CO_2 emissions in Canada is oil, accounting for almost half of the total (49%) in 2019, followed by natural gas at 41% and coal at 9% (Figure 3.3). Oil emissions have consistently increased (+11% since 2009), in line with a growing share of emissions from the transport sector and refining industries. Emissions from natural gas have increased by 39% since 2009, reflecting increased gas consumption in coke ovens, oil and gas extraction, and oil refineries. Emissions from coal have dropped by 40%.

Figure 3.3 Canada's energy-related CO_2 emissions by energy source, 2000-19



Emissions from gas and oil increased as their consumption increased in industrial sectors, while coal emissions decreased in line with declining coal-fired electricity generation.

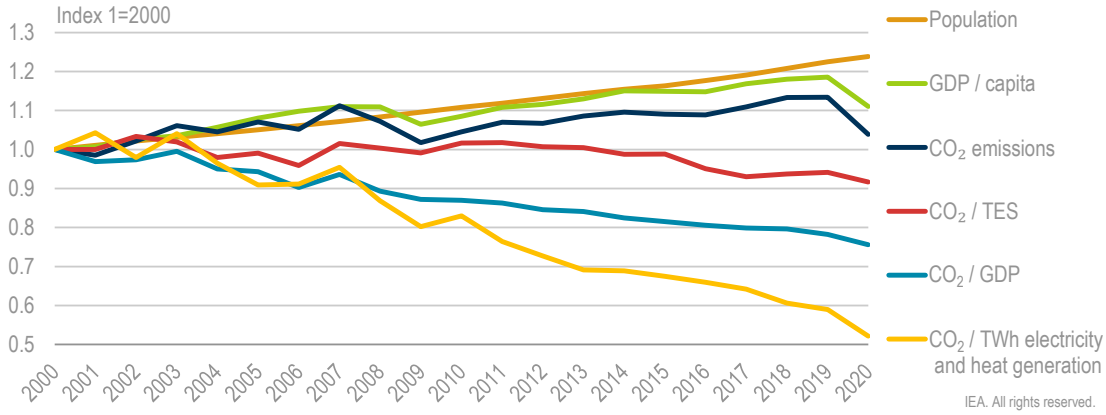
Note: Mt CO_2-eq = million tonnes of carbon dioxide equivalent.

Source: IEA 2021a), *CO_2 Emissions from Fuel Combustion* (database), www.iea.org/statistics.

CO_2 emissions drivers and carbon intensity

From 2009 to 2019, total energy-related CO_2 emissions in Canada steadily increased by 11%, in line with 12% growth in population and 24% growth in GDP per capita (Figure 3.4). In 2020, the Covid-19 pandemic caused a 6% decline in GDP per capita and an 8% reduction in CO_2 emissions. The carbon intensity of energy supply (CO_2/TES) (carbon dioxide/total energy supply) decreased by 10% in the decade from 2010 to 2020. In the same decade, the carbon intensity of the economy (CO_2/GDP) decreased by 13% and the carbon intensity of electricity and heat generation (CO_2/terawatt hour) decreased by 37%, as coal power generation began to be phased out.

Figure 3.4 Canada's energy-related CO_2 emissions and key drivers, 2000-20



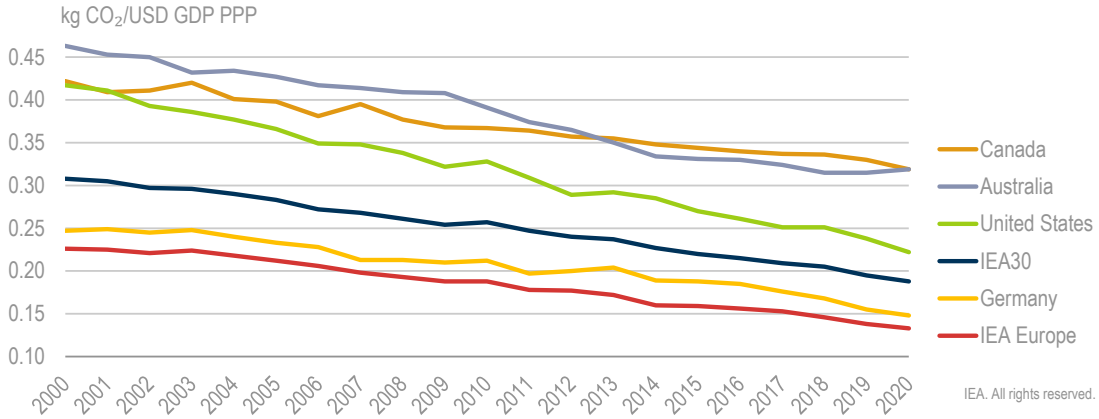
Energy-related CO_2 emissions increased in line with population and GDP until 2019, while the carbon intensity of total energy supply did not fall enough to counter the increase in population and GDP.

* Real GDP in USD 2015 prices and purchasing power parity (PPP).

Notes: GDP = gross domestic product. TES = total energy supply. TWh = terawatt hour. 2020 data are provisional.

Source: IEA 2021a), *CO_2 Emissions from Fuel Combustion* (database), www.iea.org/statistics.

Figure 3.5 CO_2 intensity per GDP in selected countries, 2000-20



The energy intensity of the economy decreased at a lower rate in Canada than in other IEA countries.

Note: Real gross domestic product in USD 2015 prices and purchasing power parity.

Source: IEA (2021a), *CO_2 Emissions from Fuel Combustion* (database), www.iea.org/statistics.

In 2020, CO_2 emissions per unit of GDP in Canada were 0.32 kilogrammes of carbon dioxide (kg CO_2) per United States dollar (USD), which is 70% above the IEA weighted average (0.19 kg CO_2 per GDP) (Figure 3.5). Despite the decrease in CO_2 intensity per GDP by 13% since 2010, Canada had the second-highest carbon intensity of the economy among IEA member countries in 2020 after Australia. However, emissions intensity in the electricity and heat generation sector in Canada (115 g CO_2/kWh) is more than two times lower that the IEA weighted average (281 g CO_2/kWh), thanks to the high share of hydropower in electricity generation (60% in 2020) as well as nuclear (15%). Emissions

from electricity and heat generation in 2020 were down 48% since 2000, due to less coal-fired generation and the growth in renewable energy sources and natural gas.

Emissions targets and policy

Under the 2009 Copenhagen Accord, Canada committed to reduce its emissions by 17% below 2005 levels by 2020, but fell short of this target. In 2015, Canada committed to reduce GHG emissions by 30% below 2005 levels by 2030, a target that it confirmed later that year under the Paris Agreement. Canada has more recently strengthened its pledges, including a floor of 36% below 2005 levels in its Budget 2021 and a target of 40-45% below 2005 levels at the April 2021 Leaders' Summit on Climate hosted by the United States. Canada submitted its updated NDC under the Paris Agreement in July 2021, with a target of 40-45% below 2005 levels by 2030. Canada is also committed to moving to net zero emissions by 2050.

While Canada overall faces a sizeable task in cutting emissions, considerable variations exist across industries, with the electricity sector already significantly decarbonised in many parts of the country due to high shares of hydro and nuclear power. While challenges remain to decarbonise the electricity sector, significant emissions reductions are needed in other sectors, especially in buildings, transport, and upstream oil and gas production.

Pan-Canadian Framework on Clean Growth and Climate Change

Introduced in 2016, the Pan-Canadian Framework (PCF) on Clean Growth and Climate Change is Canada's plan – developed with the provinces and territories and in consultation with Indigenous peoples – to meet its emissions reduction targets, develop the economy and build resilience to a changing climate. The framework outlines how Canada will meet its GHG targets by 2030. A cornerstone of the PCF is a carbon pricing regime (see below). The PCF is intended to serve as a flexible system that allows each jurisdiction to design its own emissions reduction policies and programmes with the support of federal investments. The PCF was projected to lower GHG emissions by 227 million tonnes (Mt) by 2030, or 19% below 2005 levels.

Strengthened Climate Plan

A Healthy Environment and a Healthy Economy ("the Strengthened Climate Plan"), released in December 2020, provides Canada's most recent GHG emissions projections, and further strengthened its climate measures. The plan states that Canada could further reduce emissions by at least 85 Mt beyond the reductions that will be driven by the PCF, putting Canada on track to reduce emissions by 31% from 2005 levels. In conjunction with supplemental measures from provinces and territories, the plan projects that additional reductions in the range of 32-40% below 2005 levels by 2030 could be achievable.

The Strengthened Climate Plan proposes an increasing carbon price trajectory to 2030 (see below) and investments in renewable electricity, zero-emission vehicles, home retrofits, public transit, industrial decarbonisation, agriculture, reducing emissions from waste and nature-based solutions, as well as an indication that new regulations and initiatives – including a carbon capture, utilisation and storage (CCUS) strategy for Canada – will be developed and introduced. The plan includes CAD 15 billion for 64 strengthened and new measures.

The plan centres on five pillars:

1. "Making the places Canadians live and gather more affordable by cutting energy waste". Measures will focus on home and building retrofits.

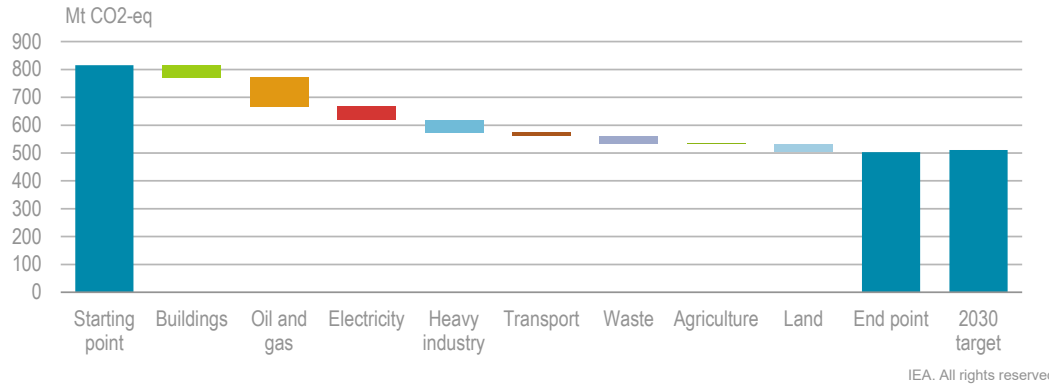
2. "Making clean, affordable transportation and power available in every community". Measures will focus on expanding the supply of clean electricity, especially renewables and next-generation technologies, advancing grid modernisation projects, as well as encouraging clean modes of transportation, such as zero-emission vehicles.

3. "Continuing to ensure pollution isn't free and households get more money back". Focused on advancing the carbon pricing mechanism and ensuring that most households receive more money back than they pay.

4. "Building Canada's clean industrial advantage". Measures assist Canadian companies to transition their own facilities to lower emissions as well as to undertake new investments to meet demand for low-carbon goods and services.

5. "Embracing the power of nature to support healthier families and more resilient communities". Measures include planting 2 billion trees and investments in lands that increase carbon sequestration.

Figure 3.6 Emissions reductions under Canada's Strengthened Climate Plan, December 2020



Note: Mt CO2-eq = million tonnes of carbon dioxide equivalent.
Source: Government of Canada (2020a), A Healthy Environment and a Healthy Economy, https://www.canada.ca/en/services/environment/weather/climatechange/climate-plan/climate-plan-overview/healthy-environment-healthy-economy.html.

Additional investments and commitments to climate ambition

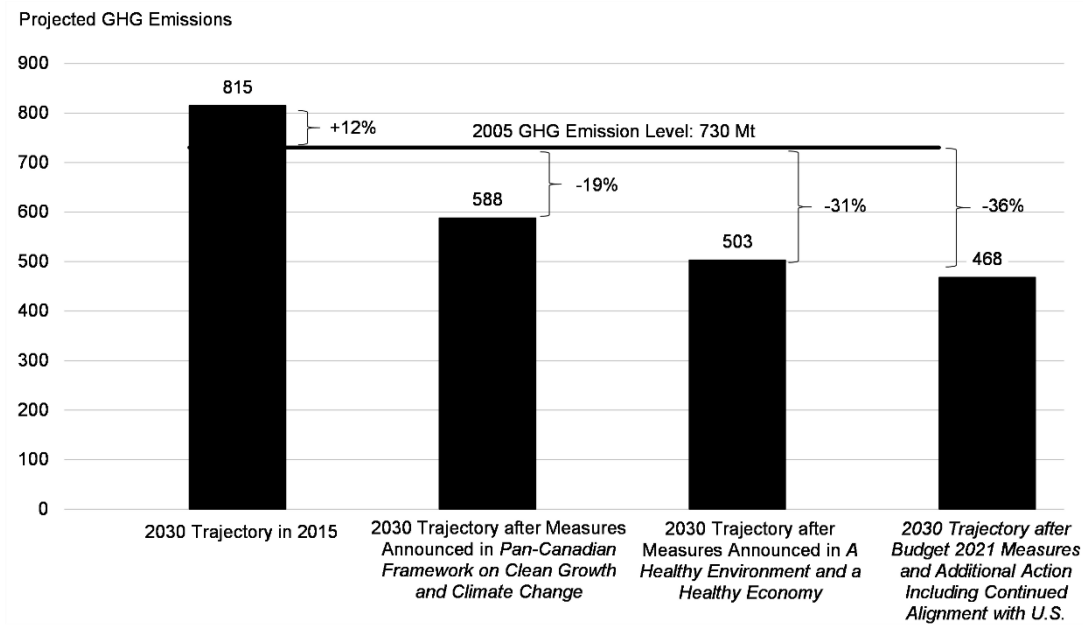
Given the importance of cross-border co-ordination on key sources of emissions, in early 2021, Canada and the United States forged a renewed bilateral relationship through the release the *Roadmap for a Renewed US-Canada Partnership*, and the launch of the US-Canada High Level Ministerial Dialogue on Climate Ambition. This will allow enhanced co-operation on key sources of emissions like methane from oil and gas activities, and transportation.

The government of Canada invested approximately CAD 60 billion in climate mitigation and adaptation action between 2015 and 2019. Since then, an additional CAD 15 billion in climate change investments were made through the 2020 Fall Economic Statement and

CAD 17.6 billion in Budget 2021. These investments support, among other low-carbon solutions, renewables and next-generation clean energy, retrofitting homes and buildings, zero-emission vehicles, and nature-based solutions.

In addition, Canada has also strengthened its climate ambition ahead of 2030. In recognition of the need for even further reductions, Canada's Prime Minister announced at the April 2021 Leaders Summit on Climate hosted by the United States that Canada would update its NDC under the Paris Agreement to 40-45% below 2005 levels by 2030. This NDC has since been formally updated and submitted to the United Nations Framework Convention on Climate Change.

Figure 3.7 Projected Canadian greenhouse gas emissions in 2030 (April 2020)



Note: GHG = greenhouse gas. Mt = million tonne. US = United States.

Source: Government of Canada (2021a), Budget 2021: A Recovery Plan for Jobs, Growth and Resilience, https://www.budget.gc.ca/2021/home-accueil-en.html.

Net zero by 2050

Building on the success of the PCF, in November 2020, the government of Canada tabled Bill C-12, the Canadian Net-Zero Emissions Accountability Act. Bill C-12 received Royal Assent in June 2021. It enshrines the goal of achieving net zero emissions by 2050 and establishes a legally binding process for the federal government to set emissions reduction targets at five-year intervals for the years 2030, 2035, 2040 and 2045. These targets must be supported by national emissions reduction plans that reflect Canada's unique circumstances and will help achieve a clean energy transition while maintaining economic competitiveness.

As such, the act will require the government to report to parliament with plans to reach the targets, interim progress reports on implementation and effectiveness, as well as final assessment reports on each target. The five-year plans are meant to allow for correcting

course toward the 2050 target. The act will also create requirements to support transparency and accountability in the development and assessment of climate plans and implementation of climate measures.

The act establishes that Canada's 2030 target will be the one set out in Canada's NDC under the Paris Agreement (now 40-45% below 2005 levels). The act requires that Canada's emissions reduction plan for 2030 include an interim objective for 2026 to be established within six months of the act coming into force. A ninety day extension may be granted if there is a legitimate reason the government needs more time. Due to the 2021 federal election, the government is expected to seek an extension.

The act also establishes an independent advisory body mandated to provide the Minister of Environment and Climate Change with advice on achieving net zero emissions by 2050. The Net-Zero Advisory Body was launched in February 2021 and published its first publication, entitled "Net-zero pathways: Initial observations", in July. In the months ahead, the Net-Zero Advisory Body will launch a transparent and inclusive engagement process to hear from Canadians, and continue to undertake expert analysis structured around four key lines of inquiry: buildings, transportation, oil and gas, and governance. The advisory body plans to publish its first annual report in early 2022.

In April 2021, Canada announced that it will join the United States in establishing a new Net-Zero Producers Forum, a platform for oil- and gas-producing countries to discuss how the sector can support the implementation of the Paris Agreement on climate change and the goal of achieving net zero emissions by 2050.

Additionally, given that co-managing financial climate risks will be key to meeting 2050 climate targets, the act will require the Minister of Finance, in co-operation with the Minister of Environment and Climate Change, to publish an annual report outlining key measures that federal departments and Crown corporations have taken to manage the financial risks and opportunities related to climate change. This means that every department and all federal Crown corporations will include climate risks and opportunities in their planning.

Carbon pricing

The Pan-Canadian Approach to Pricing Carbon Pollution, released in October 2016, gives provinces and territories the flexibility to implement their own carbon pricing systems aligned with minimum national stringency standards (the "federal benchmark"). A "federal backstop" carbon pollution pricing system applies (in part or in full) in any jurisdiction that requests it or that does not implement its own system that meets the federal benchmark.

Under the federal benchmark, jurisdictions can implement: an explicit price-based system (a carbon tax like British Columbia's or a "hybrid" carbon levy and performance-based emissions system like the federal backstop system) or a cap-and-trade system, such as those in place in Quebec and Nova Scotia.

Provinces and territories were required to present plans for a carbon pollution pricing instrument by September 2018. At that time, systems were already in place in the Canadian provinces of Alberta (hybrid system), British Columbia (carbon tax) and Quebec (operating a cap-and-trade system linked with California). Additional provincial and territorial systems were launched in 2019, including: Nova Scotia's cap-and-trade programme, Newfoundland and Labrador's carbon tax and output-based pricing system for industrial emitters, Prince Edward Island's carbon levy, the Northwest Territories'

carbon tax, and Saskatchewan's output-based pricing system for some industrial sectors. All these provincial systems were found to fully meet the federal benchmark criteria for the sources they cover.

In provinces and territories that did not have a carbon pollution pricing system that met the federal benchmark stringency requirements, or in cases where they requested the federal system, the federal backstop measures applied, in part or in full. The federal backstop currently applies in full in Yukon, Nunavut, Manitoba and Ontario, and partially in Saskatchewan, Alberta[1] and Prince Edward Island.[2]

The federal backstop has two components: 1) a fuel charge on fossil fuels like gasoline and natural gas; and 2) an Output-Based Pricing System (OBPS) for large industrial emitters. The fuel charge applies in Ontario, Manitoba, Yukon, Alberta, Saskatchewan and Nunavut. The OBPS currently applies in Ontario, Manitoba, Prince Edward Island, Yukon, Nunavut, and partially in Saskatchewan.

The OBPS puts a price on carbon pollution for industrial facilities that emit 50 000 tonnes of CO_2 equivalent (t CO_2-eq) or more per year. Those that emit 10 000 tonnes or more and that are assessed to be at significant risk of carbon leakage due to carbon pricing can voluntarily participate. Facilities subject to the OBPS will generally not pay the carbon pollution price on fuel they purchase for use at their covered facility. Instead, under the OBPS, participants are required to compensate for GHG emissions that exceed an annual facility emissions limit. The Minister of the Environment issues surplus credits to facilities that emit less than their limit. These surplus credits can be sold to facilities that need credits for compliance or banked for future use. Facilities can also use offset credits to compensate for emissions that exceed their limit. This includes either provincial offset credits that have been recognised for use or credits from the federal GHG offset system currently under development. An annual tightening rate for emissions limits will be considered as part of a review of the federal OBPS launched in early 2021.

Meanwhile, the fuel charge on 21 fossil fuels is generally paid to the federal government by fuel producers and distributors in jurisdictions where it applies.

The Canadian government does not keep any of the direct proceeds from carbon pollution pricing; they are returned to the province or territory of origin. Provincial and territorial governments that have voluntarily adopted the federal system receive these proceeds directly from the federal government and have the flexibility to decide on how to use them. For the other provinces where the federal fuel charge applies, the federal government returns the bulk of direct proceeds (approximately 90%) directly to individuals and families in these jurisdictions in the form of non-taxable Climate Action Incentive payments when they file personal income taxes. For the 2020 tax year, a family of four will receive CAD 600

[1] In Alberta, home to Canada's oil sands production, the Technology Innovation and Emissions Reduction Regulation establishes an output-based carbon pricing system for larger industrial facilities and sets GHG emissions intensity benchmarks by facility or by sector. The carbon price is aligned with the federal carbon price schedule charged on emissions above the benchmark (e.g. CAD 30 per tonne in 2020 and CAD 40 in 2021). Facility-level benchmarks were set at 90% of 2013-15 emissions intensity for 2020 and decrease by 1% per year (see Chapter 11).

[2] On 1 September 2021, the Order Amending Part 2 of Schedule 1 to the Greenhouse Gas Pollution Pricing Act (the Order) was published in the Canada Gazette, Part II. This Order removes New Brunswick from Part 2 of Schedule 1 to the Greenhouse Gas Pollution Pricing Act retroactively to 1 January 2021 and Ontario as of 1 January 2022.

in Ontario, CAD 720 in Manitoba, CAD 1 000 in Saskatchewan and CAD 981 in Alberta, while families in rural and small communities receive 10% in addition to these amounts (Government of Canada, 2020b).

Canada's Strengthened Climate Plan announced that the government will continue to put a price on carbon, with the price rising every year until 2030, and will continue to return proceeds back to households, ensuring that the majority receive more payments than they face in costs. As part of this next phase of carbon pricing, the federal government has updated the benchmark it uses to assess provincial systems, in order to maintain effective price signals to reduce emissions while still allowing provinces and territories the flexibility to choose the pricing system that works best for them. The federal government will also shift household Climate Action Incentive payments from annual to quarterly instalments starting in 2022.

Canada's carbon price started at CAD 20/t CO_2-eq in 2019, with a trajectory to rise by CAD 10 annually to CAD 50 in 2022. Under the Strengthened Climate Plan, the carbon price would rise by CAD 15 per tonne annually to CAD 170 per tonne in 2030. In March 2021, Canada's Supreme Court upheld the legality of the federal carbon price based on legal challenges from three provinces (Alberta, Saskatchewan and Ontario) (Supreme Court of Canada, 2021).

As Canada's carbon price continues to escalate, concerns over carbon leakage and loss of competitiveness are also growing. While the OBPS was designed to mitigate the cost impacts on industry, the government is also exploring the potential for border carbon adjustments, including in discussions with like-minded international partners, to consider how border carbon adjustments could fit into a broader strategy to meet climate targets while ensuring a fair environment for businesses.

Coal phase-out

Other measures will also help Canada meet its climate goals, notably a plan to phase out all unabated coal-fired generation by 2030 (see Chapters 7 and 9). In 2012, Canada became the first country to introduce federal GHG regulations for coal-fired electricity, requiring units to meet a stringent performance standard of 420 tonnes of carbon dioxide emissions per gigawatt hour (t CO_2/GWh).[3] The regulations applied to new units built after 1 July 2015, and to existing units that have reached the end of their useful life (defined as 45-50 years after their commissioning date).

In December 2018, under the PCF commitments, Canada published amendments to the 2012 regulations in order to accelerate the phase-out of conventional coal-fired electricity across Canada to 2030. The amendments requires all units to meet the performance standard of 420 t CO_2/GWh at the end of their useful life or by 31 December 2029, whichever comes first.

Concurrently, in 2018, the government also enacted regulations on natural gas-fired generators that require new natural gas-fired electricity generation to meet emissions limits (420 t CO_2/GWh or 550 t CO_2/GWh, depending on the size of the unit)[4], ensuring that natural gas units replacing coal units are better performing. Recent coal closures have

[3] An average ultra-supercritical coal plant emits approximately 800 t/GWh.
[4] Top-performing natural gas units can achieve 370 t/GWh.

largely been replaced by natural gas units, which remain the most economical option in coal-reliant regions of Canada, such as Alberta and Saskatchewan. As a result, gas is projected to contribute to 18% of electricity supply in 2040, up from 10% in 2019 under the Canada Energy Regulator's (CER's), *Canada's Energy Future 2020* "Evolving Scenario".

Inefficient Fossil Fuel Subsidies

Under commitments made at the 2016 North American Leaders' Summit and more recently at the G7, Canada has committed to phase out or rationalise inefficient fossil fuel subsidies by 2025. The country has already taken significant actions to phase out or rationalise tax measures that provide preferential tax treatment to the fossil fuel sector. In particular, eight tax measures have been or are being phased out or rationalised. Actions were taken gradually to enable industry to adapt.

The flow-through share regime is the only remaining tax expenditure that provides a preference to, among others, the fossil fuel sector. Flow-through shares allow companies to renounce or "flow-through" tax expenses associated with certain exploration and development expenses to investors, who can deduct the expenses in calculating their own taxable income. The tax expenditure associated with flow-through shares for oil and gas and coal mining is forecasted to be approximately CAD 8 million per year for 2020 and 2021, though the bulk comes from oil and gas.

Canada committed to undergo a peer review of inefficient fossil fuel subsidies under the G20 process. Peer reviews of inefficient fossil fuel subsidies can increase transparency, encourage international dialogue and help develop best practices while moving toward a low-carbon economy. This voluntary process will improve knowledge and push forward the global momentum to identify and reduce inefficient fossil fuel subsidies.

In June 2019, Environment and Climate Change Canada, which is leading the review of non-tax measures, concluded public and targeted consultations on the draft assessment framework used to evaluate potential inefficient fossil fuel subsidies. The results of the public and targeted consultations will inform Canada's peer review self-report.

Clean electricity

In conjunction with the coal phase-out, Canada plans to further decarbonise its electricity sector through increased transmissions, hydro and other renewables as well as continued use of nuclear. The government estimates that a doubling or tripling of the supply of clean power is required to meet the 2050 net zero goal.

While variable renewables (i.e. wind and solar) account for a relatively small share of total electricity generation in Canada (6% in 2019), they are the fastest growing sources of electricity generation in the country (see Chapter 7). Variable renewable energy capacity is expected to keep growing in the future, as a number of projects will be commissioned in the coming years and as provinces and territories invest to decarbonise their electricity systems and electrify their economies.

Historical support programmes have included the ecoENERGY for Renewable Power (ecoERP) and the ecoENERGY for Renewable Heat (ecoERH), which provide production incentives for electricity generated from eligible renewable energy projects. More recent support programmes include the Emerging Renewable Power Program, which provides funding to expand the portfolio of commercially viable renewable sources available to

provinces and territories. Canada also provides two tax incentives to promote business investment in clean energy generation equipment, which were expanded as part of the federal government's Budget 2021 announcements (see Chapter 5).

In recent years, Canada has also taken concrete actions to develop its offshore renewable energy potential, reduce the reliance of northern and remote communities on diesel fuel by supporting clean, renewable energy infrastructure while also focusing on grid modernisation efforts, including CAD 100 million for smart grid deployment and demonstration.

Canadian provinces have also put in place competitive procurement requests for proposals, standard offer contracts, feed-in tariffs, renewable portfolio standards, small equipment rebates and tax credits to support growth in renewables. Moreover, provincial policies such as British Columbia's clean electricity standard and Ontario's coal phase-out have been major drivers of overall emissions reductions from the electricity sector.

Canada's sizeable hydro generation capacity will also play an important role in a future low-carbon electricity system, including to assist with the integration of variable generation.

Given the varied energy profiles and endowments of Canada's jurisdictions, the government has identified regional integration as a key strategy of the clean energy transition, in particular to avoid regions with heavy coal usage rushing to (unabated) gas generation. Canada identifies a significant opportunity to leverage regional advantages to increase the penetration of both hydro and variable renewables through the buildout of interprovincial interconnections. Currently, interprovincial interconnectivity is relatively limited, in part due to the varied market and regulatory structures across jurisdictions (see Chapter 7).

Under the Roadmap for a Renewed US-Canada Partnership (February 2021), Canada and the United States agreed to enhance co-operation on sustainable and equitable energy transitions, clean energy innovation, connectivity, and low-carbon transportation. The two countries will also be taking a co-ordinated approach to accelerate progress towards sustainable, resilient and clean energy infrastructure, including encouraging the development of cross-border clean electricity transmission. The United States affirmed the goal to achieve a net zero carbon pollution-free power sector by 2035 and Canada reaffirmed its goal to achieve 90% non-emitting electricity by 2030.

The Canadian government acknowledges that the current regulations on phasing out coal and coal-to-gas conversions, combined with the proposed increase in ambition on the carbon price outlined in the Strengthened Climate Plan, may be insufficient to achieve the required massive expansion in clean energy generation. It therefore announced in the Strengthened Climate Plan that it will work with provinces, territories, utilities, industry and interested Canadians to ensure that Canada's electricity generation achieves net zero emissions before 2050. The government of Canada will explore the role of a clean electricity performance standard in the context of the full set of measures in place and proposed by this plan.

Decarbonising road transport

Policies to reduce emissions from road transport include: emissions performance standards (requiring a 5% annual improvement for passenger cars between 2017 and 2025, and 3.5% for light trucks between 2017 and 2021 and 5% over 2022-25);

purchase incentives for zero-emission vehicles (ZEVs); investment in electric vehicle charging and alternative fuelling infrastructure (i.e. research, development, demonstration and deployment; codes and standards); investments in low- and zero-emission vehicle production; energy efficiency in freight; investments in zero-emission buses, associated infrastructure and other public transit; supporting the use of cleaner fuels through the proposed Clean Fuel Regulations and Clean Fuels Fund; awareness and education measures; public procurement commitments; and carbon pricing (see Chapters 4 and 5).

The government announced in June 2021 that it intends to set a mandatory target for all new light-duty cars and passenger truck sales to be ZEVs by 2035, which is an acceleration of its previous goal for 100% to be ZEVs by 2040. It will work with partners to develop interim 2025 and 2030 targets, along with additional measures that may be needed to support these targets.

The ZEV share of light-duty vehicle sales has doubled three times in the last five years and reached a 3.5% market share across Canada in 2020 (Statistics Canada, 2021). The potential for faster growth is illustrated by the differences between provinces. ZEV registrations in British Columbia (8.4%) and Quebec (6.5%) are up to two to three times higher than the national average as a result of a combination of higher consumer purchase incentives (federal and provincial) and provincial level regulations. Polling suggests that nearly two-thirds of Canadians are inclined to buy an electric vehicle (EV) as their next vehicle (Clean Energy Canada, 2020); however, price, charging infrastructure availability, consumer education, model diversity and long waiting times are reported to be significant barriers. The availability of EVs in British Columbia and Quebec, which both have ZEV mandates (along with federal and provincial purchase incentives), is around three to ten times higher than in other provinces.

The government is also committed to conducting stakeholder consultations on measures to increase the supply of, and demand for, medium- and heavy-duty ZEVs in Canada. In 2020, several Canadian automakers with operations in Canada made a number of significant electrification announcements in both the light-duty and commercial vehicles market segments, which included federal and provincial investments.

The government has committed to work with partners in 2021-22 on policy options, including regulations and investments to accelerate and expand the production and consumer availability of ZEVs in Canada as demand grows. The government has also committed to aligning Canada's light- and heavy-duty vehicle regulations with the most stringent GHG emissions performance standards in North America post-2025, whether at the US federal or state level.

Through the Greening Government Strategy, the government is also taking steps to reduce emissions in its own operations, including a goal for at least 80% of the government's fleet to be ZEVs by 2030 (Government of Canada, 2021b). As part of the strategy, the government also commits to buying low-carbon fuels for use in the federal domestic air and marine fleets.

Buildings emissions

An estimated 75% of Canada's building stock that will exist in 2030 has already been built, increasing the importance of making existing homes more energy efficient. Actions to decarbonise homes and buildings focus on promoting deep energy-efficient retrofits, highly efficient equipment and energy management.

In 2017, the government launched Build Smart: Canada's Building's Strategy, in collaboration with provinces and territories, to increase energy efficiency and reduce CO_2 emissions from buildings (see Chapter 4 for more details). This strategy supports actions under the PCF, and includes a plan for increasingly stringent national model energy codes for new and existing buildings, specifically requiring all new buildings to be "net zero energy ready" by 2030. It includes significant investments in research, development and demonstration (RD&D) projects to build confidence in high-performing buildings. Build Smart also includes a number of programmes to support homeowners, builders and manufacturers to become "net zero energy ready" (see Chapter 4). Model building codes for net zero energy ready new buildings are expected to be published in late 2021 and efforts to ensure rapid adoption by provinces and territories are underway. In addition, development of the first model energy code for alterations to existing buildings is underway.

In 2019, the federal government invested CAD 950 million for municipalities to drive action in energy efficiency in buildings and homes, support provinces and territories in the implementation of this plan, promoting efficiency improvements through building design, renovation, construction and operation.

Under the December 2020 Strengthened Climate Plan, the government committed CAD 2.6 billion over seven years to provide grants of up to CAD 5 000 to help homeowners make energy-efficient improvements to their homes. This has now been formalised by the government with the announcement of the Canada Greener Homes Grant in May 2021. Moreover, Budget 2021 includes a new interest-free loan programme to complement the grant program and support deeper home energy retrofits. The Strengthened Climate Plan will also invest CAD 1.5 billion for green and inclusive community buildings, with at least 10% of this funding to be allocated to projects serving First Nations, Inuit and Métis communities.

The federal government is also investing CAD 2 billion to finance retrofits in larger public and commercial buildings, as part of the Public Building Retrofit Program. Similarly, a number of innovative retrofit financing organisations are emerging in Canada, such as SOFIAC in Quebec, and are seeking to leverage limited public capital to mobilise private investment in retrofits.

The Greening Government Strategy also calls for all new federal buildings (including build-to-lease and public-private partnerships) to be net zero carbon, unless a life cycle cost-benefit analysis recommends net zero carbon ready construction, and for government buildings to use 100% clean electricity by 2022, where available, and by 2025, at the latest, by producing or purchasing renewable electricity (Government of Canada, 2021b).

Upstream oil and gas sector emissions

Canada's sizeable oil and gas industry is a major contributor to emissions. The industry's upstream operations, which include oil and gas exploration, production, and processing, account for 22% of total GHG emissions (UNFCCC, 2021). The industry, in part bolstered by government policies, has made inroads in reducing the emissions intensity of its operations. According to Canadian estimates, the emissions intensity of oil sands has fallen by 32% since 1990 and that of upstream natural gas by 13% since 2010. Moreover, industry forecasts a 17-27% reduction in emissions intensity from oil sands operations (that use enhanced modified steam and gas push and steam-assisted gravity drainage) over the period 2018-30. Future growth in Canada's oil production is expected to be driven

by oil sands output, making emissions reductions from the sector critical to overall climate goals. To this end, in June 2021, the main Canadian oil sands companies announced the Oil Sands Pathways to Net Zero initiative, with a goal to work collectively with the federal and Alberta governments to achieve net zero emissions from oil sands operations by 2050.

The oil and gas sector's strong track record of improving its emissions intensity is, in part, credited to its large investments in clean technology and environmental protection. The sector is a leading investor in clean technology and innovation, fuelling over 64% of all energy R&D investments in Canada (averaging CAD 1 billion annually over the decade to 2017). Additionally, in 2018, the oil and gas extraction industry spent CAD 3.6 billion on environmental protection expenditures. This represents, by far, the largest environmental protection expenditure of any sector, representing 37% of total environmental protection expenditures made by businesses in Canada. Canadian oil and natural gas producers are leveraging their improving environmental, social and governance performance and Canada's stringent environmental regulations to build a global competitive advantage as countries' interests in cleaner fuels and investors' interests in the environmental sustainability of their investments grow.

Canada plans to leverage methane emissions regulations, investments in renewable energy infrastructure and CCUS technology to drive down emissions throughout the value chain and to align with the country's net zero by 2050 objective.

The emissions intensity of global crude oils span a wide range, with light crude typically on the lower end of the spectrum and heavier crude on the higher end since they require more resources and energy to extract and process. Oil sands mining operations that use an extraction technology called Paraffinic Froth Treatment produce a product that is approaching the global carbon intensity average of all crudes. *In situ* operations that use steam-assisted gravity drainage or cyclic steam stimulation require additional upgrading before being shipped via pipeline and as a result are on the higher end of the carbon intensity spectrum. The government of Canada and industry stakeholders are pursuing research that focuses on solvent extraction, electrification, energy efficiency and CCUS to continuously improve and lower the emissions intensity of all crude oils, with a particular focus on the oil sands. Also, proposed liquefied natural gas facilities along the coast of British Columbia, once completed, are projected to have the lowest emissions intensity in the world due to process electrification that uses clean energy.

Federal investments and programming to enhance sustainability include the Clean Growth Program, which aims to advance emerging clean technologies toward commercial readiness so that natural resource operations including upstream oil and gas can better reduce their environmental impacts on air, land and water. The programme is supporting industry-led oil and gas RD&D projects to reduce GHG emissions from energy production and use. Federal labs are also working on key areas of clean tech research, including CCUS, air emissions, energy efficiency, fuel switching, process energy intensity improvements, decreasing GHG and water use in tight oil and gas reservoirs, and pipeline materials, among others.

The government projects that without Canada's climate plan, emissions from the oil and gas sector would reach 213 Mt by 2030. However, with existing policies in place (as of December 2020) and regulations, they are expected to remain at current levels of 194 Mt in 2030 (see Chapter 11). However, additional reductions of 56 Mt/year by 2030 are required across the economy to exceed Canada's previous target of reducing emissions

by 30% from 2005 levels by 2030, and still greater reductions are needed to meet Canada's new target of achieving a 40-45% reduction. R&D in new technologies, such as solvent injection and improved energy efficiencies, have the potential to reduce emissions intensities even further.

Clean fuels offer a crucial low-carbon pathway for Canada's conventional energy sector. For example, Canada's vast natural gas and petroleum reserves combined with carbon abatement can be leveraged to produce low-carbon hydrogen, which can in turn be used as feedstock in oil and gas production processes, further reducing emissions in this sector. Moreover, the production of low-carbon fuels, including hydrogen, is an important diversification pathway for the oil and gas sector.

Methane regulations and reductions

In April 2018, Environment and Climate Change Canada published the final federal regulations for methane emissions from the oil and gas sector, which were developed in consultation with provinces. Canadian methane regulations will help reduce emissions from unintentional fugitive equipment leaks and intentional venting and flaring from the oil and gas sector.

The regulations will provide a meaningful contribution toward Canada's 2030 climate targets as well as reduce harmful air pollution. The current regulations call for methane reductions from the upstream oil and gas sector by 40-45% below 2012 levels by 2025, including by requiring industry to regularly inspect and repair equipment to reduce emissions. Implementation of these requirements began in January 2020, with full implementation beginning in 2023. Alberta, British Columbia, and Saskatchewan all expressed interest in wanting their own jurisdiction over regulations and in 2020, the federal government issued orders to withdraw the federal methane regulations in those provinces after they provided emissions reduction plans equivalent to the federal measures.

In October 2021, the government of Canada committed to an increased oil and gas methane emissions reduction target of at least 75% below 2012 levels by 2030. Current methane regulations will be revisited to support this increased target. Methane emissions in the oil sands mainly occur from the mine face and tailings ponds, with smaller amounts from leaks and venting; therefore, methane regulations have a lesser impact on oil sands compared to conventional oil and natural gas operations.

Canada's Strengthened Climate Plan includes the CAD 750 million Emissions Reduction Fund. The fund was launched in fall 2020 to support capital investments and research to reduce GHG emissions. It focuses on methane from onshore and offshore oil and gas. Of the CAD 750 million, up to CAD 675 million is available to onshore upstream/midstream conventional oil and gas companies to reduce or eliminate the routine intentional flaring or venting of methane-rich natural gas. The remaining CAD 75 million is for the deployment of emissions-reducing technologies and related RD&D in the offshore sector. The programme is moving forward projects with very low costs per tonne, many of which will reduce emissions incremental to what will be achieved through methane regulations for those sources.

The Canadian Emissions Reduction Innovation Network Program is another federal investment in energy RD&D, supporting methane and other GHG emissions reductions. Natural Resources Canada (NRCan), with the province of Alberta, is investing

CAD 15.15 million to accelerate the development, validation and deployment of technologies to reduce methane and other emissions in the oil and gas sector. By creating a world-class emissions management network and technology testing facilities, the programme expects to position Canada as a leader in achieving cost-effective emissions reductions and allow industry to meet or exceed methane regulations.

In the Roadmap for a Renewed US-Canada Partnership (February 2021), Canada and the United States reaffirmed their shared commitment to reduce methane emissions from oil and gas to protect public health and the environment by the best science.

Carbon capture, utilisation and storage

Canada's Mid-Century Long-Term Low-Greenhouse Gas Development Strategy (2016) notes the potential of CCUS in the electricity sector, as well as in the oil and gas, iron and steel, pulp and paper, chemical, and cement sectors. In addition, the Deep Decarbonisation Pathways Project – conducted in 2015 for 16 of the world's largest GHG emitting countries by leading research institutions – found that CCUS is one of the critical transformative technologies for enabling deep reductions across a range of sectors in Canada to 2050.

More recently, the Canadian Institute for Climate Choice's report, "Canada's net zero future" (CICC, 2021), reached a similar conclusion, with mature CCUS technologies needed in all scenarios to meet Canada's 2030 and 2050 (net zero) emissions targets. Further, CICC's modelling finds that advanced "next-generation" forms of CCUS and engineered negative emissions solutions (e.g., direct air capture, bioenergy with carbon capture and sequestration) – which are currently at the development and demonstration stage – may play a significant role on the path to net zero by 2050, if proven cost-effective and scalable. These findings emphasise the key role of CCUS innovation.

The CER's Evolving Scenario sees a gradual increase in CCUS uptake in Canada, which assumes an additional 15 Mt and 30 Mt sequestered per year by 2040 and 2050, respectively, beyond existing projects. The publication also highlights that Canada's goal of achieving net zero emissions by 2050 will require an accelerated rate of energy transition, including through greater deployment of low-carbon technologies such as CCUS.

The federal government's Strengthened Climate Plan proposes the development of a comprehensive CCUS strategy for Canada that reflects the opportunities CCUS offers across regions and sectors. This strategy will establish a vision and a set of recommended federal actions to accelerate the CCUS industry in Canada and realise its GHG reduction and commercial potential. It will consider technology RD&D efforts needed along with other enabling measures for the wider deployment of CCUS, to support Canada's 2030 and 2050 energy and climate goals. NRCan has been gathering insights and perspectives from key partners and stakeholders (e.g. technology developers, industry adopters, academia, the finance community, environmental non-governmental organisations, and provincial and territorial governments) to help shape the CCUS strategy.

Budget 2021 developments will inform the federal CCUS strategy. Notably, Budget 2021 included a proposal for an investment tax credit (ITC) for capital invested in CCUS projects with the goal of reducing emissions by at least 15 Mt CO_2 annually. The government intends for the new ITC to take effect in 2022 and be available for a broad range of CCUS applications across different industrial subsectors (e.g. concrete, plastics, fuels), including

low-carbon hydrogen projects and direct air capture projects, but not for enhanced oil recovery projects. In June 2021, the government initiated a 90-day public consultation with stakeholders on the design of the ITC, which closed on 7 September. Budget 2021 also proposed CAD 319 million over seven years for RD&D to improve the commercial viability of CCUS technologies. NRCan is advancing the implementation of this funding, with an early priority for these funds to support the development of front-end engineering and design studies for CCUS projects across Canada.

Additional policies or programmes that can help support CCUS development in Canada include: carbon price systems (federal or provincial equivalents); the Clean Fuel Regulations (see below); the coal-fired electricity regulation; the government of Canada's CAD 8 billion Strategic Investment Fund – Net Zero Accelerator, which will expedite decarbonisation of heavy industry; NRCan's CAD 1.5 billion Clean Fuels Fund; and other federal and provincial funding programmes. A recent example at the provincial level is the government of Alberta's CAD 80 million Industrial Energy Efficiency and Carbon Capture, Utilization and Storage (IEE CCUS) Grant Program, as well as Alberta's 2021 Budget, which earmarked CAD 227 million from the Technology Innovation and Emissions Reduction Fund over three years (2021-24) for future CCUS. Given their jurisdiction over sub-soil natural resources, provinces also bear much of the responsibility for legal and regulatory frameworks for CCUS.

Canada has abundant geological CO_2 storage capacity of over 130 billion tonnes, notably in Western Canada, according to the North American Carbon Storage Atlas (Government of Canada, 2012). Canada has four large-scale CCUS projects in operation:

1. Weyburn and Midale CO_2-EOR operations, which have stored over 40 Mt CO_2.

2. Boundary Dam coal-fired power plant in Saskatchewan, which has captured over 4 Mt CO_2, with most of it used in EOR and stored, and a smaller portion injected and stored in Aquistore, a deep geological CO_2 storage research site.

3. Quest, which has so far captured and stored over 6 Mt CO_2 from a bitumen upgrader in Alberta.

4. Alberta Carbon Trunk Line Project, which collects approximately 1.6 Mt CO_2 per year from the North West Redwater Sturgeon Refinery and Nutrien's fertiliser facility for transport to CO_2-EOR sites (around 90% of the line remains unused, suggesting sizeable additional capacity for more capture projects). The project has stored over 1.5 Mt CO_2 since June 2020.

In addition to large-scale CCUS projects, the federal government, in collaboration with provincial governments, the private sector and academia, is funding a variety of pilot- and test-scale projects to advance CCUS innovation, including in the area of new carbon capture and conversion processes (see Chapter 6). For example, NRCan recently launched its first call for expressions of interest, open until 22 September 2021, which is the first in a series of calls for support for CCUS via the CAD 319 million seven-year envelope that was announced in Budget 2021. This call is aimed to support "front-end engineering design" studies for a breadth of novel CCUS applications that have the potential to significantly mitigate emissions.

Clean fuels

Clean fuels represent an opportunity for Canada to transition its existing energy sector to a future low-carbon economy, in particular to decarbonise hard-to-abate sectors such as cement, steel, heavy-duty transport, and oil and gas. They include hydrogen, advanced biofuels, renewable natural gas, sustainable aviation fuel and synthetic fuels (see Chapter 5).

Toward this end, in June 2021 Canada launched the Clean Fuels Fund, an investment of CAD 1.5 billion over five years to derisk the capital investment required to build new or expand existing clean fuel production facilities (including facility conversions). The Clean Fuels Fund is designed to support the proposed Clean Fuel Regulations (CFR) and the Hydrogen Strategy for Canada.

The CFR will require liquid fossil fuel (gasoline and diesel) suppliers to gradually reduce the carbon intensity of the fuels they produce and import for use in Canada over time. The regulations will lead to a decrease of approximately 13% (below 2016 levels) in the carbon intensity of liquid fossil fuels used in Canada by 2030 (also see Chapter 5). The final regulations are due to be published in the fall of 2021 and to take effect in December 2022. The government estimates that the regulations will reduce GHG emissions by more than 20 Mt in 2030.

Bioenergy will play a key role in the low-carbon energy transition. In part due to investments from federal and provincial governments, the Canadian biofuels industry's production capacity grew from just over 200 million litres of ethanol and no commercial biodiesel plants in 2005, to approximately 2 billion litres of ethanol and 650 million litres of biodiesel in 2020, placing Canada eighth in the world for overall biofuels production capacity. The government estimates that by 2030, total demand for low-carbon liquid fuels (i.e. ethanol, biodiesel, renewable diesel) in the transportation sector will be 2.5 times greater than 2020 levels, largely driven by climate change policies. Currently, around 80% of feedstock for ethanol comes from corn, while half of biodiesel feedstock comes from canola oil (see Chapter 11 for more information on the biofuel blending policies).

Hydrogen

Canada sees a sizeable role and competitive advantage in the production, distribution, end-use and eventual export of hydrogen and related technologies, given its abundance of feedstocks, skilled workforce and existing position as a leader in intellectual property and export of hydrogen technologies. Hydrogen is expected to play a key role in Canada's pathway to meeting its net zero goals.

Already, an estimated 3 Mt of conventional hydrogen is produced annually for industrial use, making Canada one of the top 10 global hydrogen producers. This includes about 0.3 Mt of electrolytic hydrogen and hydrogen produced from natural gas with carbon abatement, making Canada one of the top producers of clean hydrogen in the world. Canada also has world-renowned hydrogen and fuel cell companies, which currently employ 2 200 workers and generate over CAD 200 million in revenues, predominantly from export.

In December 2020, Canada published the Hydrogen Strategy for Canada (NRCan, 2020). The strategy is designed to spur investments in hydrogen production and use across the economy, and create partnerships that establish Canada as a global supplier of hydrogen.

Hydrogen technology can help decarbonise hard-to-abate sectors, including upstream and downstream oil and gas activities, industrial processes, mass transit long-range transport, marine and aviation. Canada's abundant natural gas can also be used to produce clean hydrogen when coupled with CCUS. Such hydrogen production presents a new market opportunity for these resources and provides an important decarbonisation pathway for the Canadian oil and gas. Hydrogen is therefore an area of close alignment between the federal government and Canada's primary gas-producing provinces (Alberta, British Columbia and Saskatchewan). Alberta also identified a key role for hydrogen in its energy future as part of its broader natural gas strategy (Alberta Government, 2020). In fact, all provinces and territories see both economic and environmental opportunities for hydrogen in the short, medium and long term.

The Hydrogen Strategy suggests that hydrogen can account for 6% of energy end-use by 2030, with clean or low-carbon hydrogen meeting up to 30% of Canada's energy demand by 2050, cutting up to 190 Mt CO_2-eq of GHG emissions. The government is considering all pathways (electrolysis, fossil fuels with CCUS, methane pyrolysis, biomass and industrial by-products) that will account for reducing carbon intensity rather than specific production modes, with a trajectory toward zero emissions, on a life cycle basis. The Hydrogen Strategy estimates that the total domestic revenue from hydrogen could reach CAD 50 billion by 2050, with an additional CAD 50 billion or more coming from export, which offers Canada an important opportunity to retain its role as a major global supplier of energy.

Specifically, the Hydrogen Strategy includes 32 recommendations in 3 phases (Norton Rose Fulbright, 2021). In the near term (2020-25), actions focus on laying a foundation for a future hydrogen industry that will drive demand, including developing new infrastructure and supporting early deployment and demonstration as well as the early establishment of hubs, which bring together interested parties from across the value chain to ensure supply and demand grow at the same pace. In the medium term (2025-30) actions focus on expanding the sector toward applications such as long-range transport, blending with natural gas and projects to support hydrogen as a utility-scale storage solution. The longer term (2030-50) would focus on the more comprehensive buildout of hydrogen supply and demand infrastructures, including possible dedicated hydrogen pipelines.

Covid-19 recovery

Canada has attempted to align post Covid-19 recovery efforts with its climate ambitions by developing green stimulus measures. In the spring of 2020, the federal government introduced targeted Covid-19 relief measures that support oil and gas companies to reduce their emissions. The measures include CAD 1.72 billion to clean up orphan and inactive oil and gas wells; the CAD 750 million Emissions Reduction Fund, with a focus on methane; and CAD 320 million for Newfoundland and Labrador's offshore energy sector to fund safety improvements, maintenance and upgrades for existing facilities, as well as R&D.

The government's Fall Economic Statement 2020: Supporting Canadians and Fighting Covid-19, published on 30 November 2020, placed climate action at the centre of Canada's economic recovery plans. The Fall Economic Statement announced funding for energy-efficient home retrofits, ZEV infrastructure, planting 2 billion trees, public transit and other climate-related measures.

In its Budget 2021, the government of Canada announced plans to issue CAD 5 billion in green bonds in 2021-22 to finance clean energy infrastructure development, the first of such federal bonds issued in the country (Government of Canada, 2021c).

Climate adaptation

The *Canada's Changing Climate Report* notes that the country has experienced increased average temperatures and precipitation in recent decades, with significant geographic and temporal disparities. Notably, it highlights the increased risk of water supply shortages in the summer, which are likely to reduce the local capacity of Canada's hydropower assets (NRCan, 2019).

Climate change will also impact energy demand patterns. Warmer average temperatures will lead to a reduction in heating degree days, which is likely to lower energy use for heating. Higher temperatures are also linked to an increase in cooling degree days, which is likely to increase demand for cooling and could potentially impact local peak electricity demand. On balance, energy consumption is expected to fall, as reduced demand for heat will far outweigh higher demand for cooling (albeit with varying energy sources for heating relative to cooling) (IEA, 2021b).

Electricity security will also be impacted; storms have the potential to disrupt the electricity supply of large areas, directly taking down power lines and poles, or indirectly uprooting trees and dropping branches on the lines.

Canada's Climate Change Adaptation Platform, established in 2012, is a national forum that brings together key groups in Canada to collaborate on climate change adaptation priorities. Members include representatives from federal, provincial and territorial governments; industry; communities; academics; and indigenous, professional and not-for-profit organisations.

The platform has various working groups, including an Energy Working Group, which facilitates exchanges between policy makers, experts and industry sectors to create strategies to develop and disseminate products to advance useful decision making on climate change adaptation in the energy sector.

In 2017, the Energy Working Group completed its *State of Play* report, which provided a snapshot of the state of adaptation in the energy sector, assessing leadership, forecasting risks and opportunities, response, prioritisation, lessons learnt, and gaps and key priorities for adaptation in the energy sector.

In support of the Energy Working Group's programme of work, NRCan funds a range of energy adaptation projects, including to evaluate the impacts of climate change on hydro assets as well as to help utilities and municipalities improve community resilience and develop low-carbon local solutions. For example, NRCan supports a project led by the Canadian Electricity Association, Resilience Building and Outreach in the Canadian Electricity Sector, to develop targeted climate adaptation guidance for each electricity subsector, including training and help enacting the guidance.

The government has taken important steps to support science-based action on adaptation, including the release of the *Canada's Changing Climate Report*, and the *National Issues Report* under the National Climate Change Impacts and Adaptation Knowledge Assessment process "Canada in a Changing Climate: Advancing Our Knowledge for

Action". The *National Issues Report* found that climate change impacts every stage of the energy value chain, from exploration, production and supply chains through transmission and distribution. These reports complement research by external organisations, including the Council of Canadian Academies' *Canada's Top Climate Change Risks* report and the Canadian Institute for Climate Choices *Tip of the Iceberg: Navigating the Known and Unknown Costs of Climate Change for Canada*. Adaptation actions have also been supported by the launch of a new climate data portal (www.climatedata.ca) by the Canadian Centre for Climate Services.

As part of Canada's Strengthened Climate Plan, the government committed to work with provincial, territorial and municipal governments; Indigenous peoples; and other key partners to develop Canada's first-ever National Adaptation Strategy. The strategy, due to be completed at the end of 2022, will establish a shared vision for climate resilience in Canada, identify key priorities for increased collaboration and establish a framework for measuring progress at the national level. This work will help inform where the government should best target its policies, programmes and investments.

Climate financing

In 2015, in support of the Paris Agreement, Canada pledged CAD 2.65 billion over five years (2015-20) in climate finance to pursue ambitious action on climate change in developing countries. Canada delivered on its commitment by implementing concrete initiatives through various multilateral and bilateral partners. Through its climate finance, Canada has also helped to empower women and girls through climate action and has mobilised private sector capital to address climate change.

Over 2017 and 2018, Canada provided approximately CAD 1.5 billion to developing countries for climate action. This support included: CAD 704 million as part of Canada's CAD 2.65 billion climate finance commitment; CAD 246 million as part of its regular international assistance projects with a climate change component; CAD 17 million from Canadian provincial and municipal support; CAD 509 million from Export Development Canada, its export credit agency, to mobilise private finance; and USD 30 million by the newly established development finance institution, FinDev Canada, for climate-related investments.

Canada supports a wide range of initiatives in key sectors, such as clean and renewable energy, greener agriculture, and disaster prevention and preparedness. Of Canada's climate finance provided over 2017 and 2018, CAD 192 million targeted climate change adaptation, delivering on Canada's commitment of increasing adaptation support. CAD 315 million was provided for mitigation initiatives and CAD 498 million for cross-cutting initiatives (both adaptation and mitigation efforts). In addition, support provided over 2017 and 2018 covered a wide geographical area, with 54 countries directly benefiting from Canada's climate finance and various other countries benefiting from Canada's support through multilateral funds.

Canada's climate finance supports the institutions and financial mechanisms of the United Nations Framework Convention on Climate Change, recognising the fundamental role that they play in global action on climate change, in support of the Paris Agreement. Canada continues to support the Green Climate Fund, the world's largest dedicated climate change fund, with its initial CAD 300 million contribution announced in 2014 and an additional CAD 300 million contribution to the first replenishment of the Green Climate Fund announced

in 2019. Canada also continues to be a strong supporter of the Global Environment Facility through regular contributions, which allow developing countries to pursue activities to address climate change. In addition, Canada supports the Least Developed Countries Fund through its CAD 37.5 million contribution to address the urgent adaptation needs of the poorest and most vulnerable countries. Canada's core contributions to multilateral development banks also help support climate action in developing countries.

Canada's climate finance also helps to empower women and girls through climate action, working with the private sector and non-traditional donors to multiply climate investments, and continuing to take action on the cross-cutting implications of climate change as regards development. Women and girls continue to be disproportionately impacted by the adverse effects of climate change due to a range of economic and social factors. At the same time, they still do not fully take part in deciding climate action, despite their crucial role in leading the fight against climate change in their communities. Canada's climate finance has a strong focus on the empowerment of women and girls and gender equality, in line with Canada's Feminist International Assistance Policy. Canada works with a wide range of partners, including international organisations, government institutions, businesses and civil society, to advance gender mainstreaming and ensure that women and girls play a leadership role in designing, developing and implementing climate change adaptation and mitigation strategies.

The impacts of climate change also have undeniable repercussions on people's lives and livelihoods in all other areas of development such as food security, health and safety, security, and economic growth. In order to accelerate progress by taking into account the evident interlinkages between climate and development, Canada continues to integrate climate considerations into its development funding. Canada's climate finance further contributes to the United Nations' Sustainable Development Goals, including Goal 13 – Climate Action.

In June 2021, Canada announced that it will commit CAD 5.3 billion for its next round of climate finance (2021-26), which will include an increased proportion of grant funding (from 30% to 40% of the total envelope) and increased support for adaptation as well as nature and nature-based solutions. The funding will help developing countries build domestic capacity to take climate action, build resiliency and reduce pollution, including by finding nature-based solutions to climate change like protecting biodiversity and planting trees, and supporting the transition to clean energy and the phasing out of coal.

Assessment

Since the IEA's last in-depth review, Canada has committed to a target of net zero emissions by 2050. The IEA welcomes this commitment, which is consistent with the Paris Agreement goals. In December 2020, the government announced a new Strengthened Climate Plan, *A Healthy Environment and a Healthy Economy*, building on the foundations of the Pan-Canadian Framework on Clean Growth and Climate Change, released in 2016. The Strengthened Climate Plan includes 64 strengthened and new measures overall, and has been supported by over CAD 32 billion in investments to date. The latest GHG projections indicate that Canada is on track to reduce emissions by 36% below 2005 levels by 2030; Canada's new nationally determined contribution commits to a 40-45% reduction below 2005 levels by 2030.

Since Canada's emissions in 2019 were roughly the same as in 2005, Canada has considerable work ahead to meet its target. Achieving it in a cost-effective way will require strong policies in all emitting sectors of the economy.

The government passed the Canadian Net-Zero Emissions Accountability Act in June 2021, enshrining the goal of achieving net zero emissions by 2050 and establishing a legally binding requirement for the federal government to set emissions reduction targets at five-year intervals for the years 2030, 2035, 2040 and 2045. The targets must be supported by Emission Reduction Plans describing how the government will meet each target. The act also established the Net-Zero Advisory Body with a mandate to provide the Minister of Environment and Climate Change with independent advice with respect to achieving net zero emissions by 2050. The IEA commends these moves as an important strengthening of transparency and accountability around targets and progress in reducing emissions. Some limitations are unavoidable: future governments cannot be prevented from repealing the act, and some important policy-making power relevant to reducing emissions lies constitutionally with Canada's provinces and territories. Ensuring that the Net-Zero Advisory Body has an authoritative and independent membership, its own technical staff, a mandate to review progress as well as advise on policy, and the capability to undertake its own detailed analysis, could all help to create a more robust and stable institutional environment. Establishing concrete emissions budgets have also proven successful in other countries and could be considered in Canada.

Though Canada's GHG emissions are at largely the same level as in 2005, this overall stability masks differences across sectors. Emissions from the oil and gas and transport sectors increased between 2005 and 2019, while this increase was offset by reductions in emissions from electricity and heavy industry sectors. Although the CO_2 intensity of economic output fell by 20% between 2005 and 2020, Canada had the second-highest carbon intensity of the economy and emissions per capita among IEA member countries in 2020. The main sources of Canada's emissions are industry (including oil and gas production and refining) at 38% and transport at 34%, followed by electricity and heat generation at 15%, and buildings at 14%.

Canada already generates more than 80% of its electricity from zero emissions sources, making its electricity system one of the cleanest in the world. A transition away from coal power has reduced emissions in recent years, and in 2018 the government announced regulations to phase out unabated coal power by 2030. The growth of variable renewable generation is also contributing to emissions reductions, driven by a federal production incentive and provincial programmes and policies, including feed-in tariffs and renewable portfolio standards (though many of these have since been discontinued).

The challenge ahead is to eliminate the remaining emissions while increasing capacity to support electrification of end-uses: a doubling or tripling of the supply of clean power is estimated to be required to meet the 2050 net zero goal. The government's investments of CAD 964 million to advance smart renewable energy, grid modernisation projects and energy storage, including CAD 200 million in less established renewable technologies such as tidal and geothermal energy, will help expand the range of decarbonisation options available in the medium term. In the medium term, investments in unabated new gas plants present a risk to cost-effective decarbonisation. Gas is projected to contribute 18% of electricity supply in 2040 (under the "Evolving Scenario" compiled by the Canada Energy Regulator), up from 10% in 2019. Unless equipped with CCUS, or fuelled with low-carbon gases like biomethane or hydrogen/ammonia, new gas plants will slow the rate of

decarbonisation, and may need to be retired before the end of their lifetimes (which can be ~40 years). The government is working with provinces, territories, utilities, industry and other stakeholders to consider options, including exploring the role of a clean electricity performance standard in the context of the full set of measures in place and proposed by the Strengthened Climate Plan.

Canada's extensive hydropower resources, with their capability to provide inter-seasonal and even inter-annual energy storage, have great potential to support a fully decarbonised electricity system for all of Canada, if hydro-rich provinces were better linked with provinces that lack hydropower. More progress in the government's efforts to improve regional integration and transmission links between provinces and territories will need to be made for this potential to be fully realised.

A number of policies are in place to reduce emissions from road transport, including emissions performance standards for vehicles, purchase incentives for ZEVs and other measures supporting the ZEV transition, including support for charging infrastructure and carbon pricing.

Canada has an important opportunity to use its clean electricity to decarbonise transport through increased electrification. The government is placing more emphasis on promoting ZEVs by its intention to accelerate Canada's previous goal of 100% sales by 2040 to a mandatory target for all new light-duty cars and passenger trucks sales to be zero-emission by 2035. Evidence from provinces suggests that ZEV mandates can help increase the supply of ZEVs, thereby leading to increased consumer uptake.

Including heavy-duty vehicles within the scope of any tightened regulations will be important, since emissions from heavy-duty vehicles have increased by 36% since 2005 and are expected to overtake those from light-duty vehicles by around 2040 under existing policies and programmes. The government will need to ensure that faster transitions to ZEVs in both light and heavy road transport are supported by a congruent buildout of electric vehicle charging (and hydrogen refuelling) infrastructure.

Actions to decarbonise homes and buildings include promoting deep energy-efficient retrofits, highly efficient equipment and energy management. In 2017, the government launched Build Smart: Canada's Buildings Strategy, a joint strategy with provinces and territories to increase energy efficiency and reduce emissions in buildings. This includes a plan for increasingly stringent national model codes for new buildings, requiring new buildings to be "net zero energy ready" by 2030. The design of these codes, and of the measures to ensure compliance, will be a strong determinant of emissions.

Buildings, including homes, account for 12% of Canada's GHG emissions. An estimated 75% of Canada's building stock that will exist in 2030 has already been built. Making existing homes and buidlings more energy efficient will need to be a key part of Canada's objectives for improving efficiency and reducing emissions. Under the Strengthened Climate Plan released in December 2020, the government committed CAD 2.6 billion over seven years to provide grants of up to CAD 5 000 to help homeowners make energy-efficient improvements to their homes. The government is currently developing the first model energy codes for alterations to existing buildings, as well as a new interest-free loan programme to support deeper home energy retrofits. The strength and effectiveness of these policies under development could have a critical impact on the future emissions

of this sector. Further regulatory measures and incentives may be needed to lift the rate of retrofitting from its current level of <1% per year to a level consistent with a net zero trajectory.

The government has committed to reduce methane emissions from the oil and gas sector by 40-45% below 2012 levels by 2025. In October 2021, that commitment was increased to at least a 75% reduction below 2012 levels by 2030. As part of Canada's Strengthened Climate Plan, the government also committed to review and publicly report on the efficacy of the suite of federal actions to achieve its methane targets.

Emissions reductions will be achieved through a combination of strengthened policies and programming, including through the implementation of targeted emissions reduction programmes such as the Emissions Reduction Fund. This fund is achieving emissions reductions beyond what is currently prescribed under Canada's methane regulations for those sources, while enhancing oil and gas competitiveness resulting from hydrocarbon recovery/gas conservation.

In the longer term and to achieve greater GHG emissions reductions, CCUS or further electrification is likely to be essential to reducing the sector's emissions. Canada has four commercial CCUS projects in operation in power, oil and gas, and fertiliser applications, and extensive expertise in CCUS R&D. The government's 2020 climate plan proposes the development of a comprehensive CCUS strategy that reflects the opportunities CCUS offers across regions and sectors, which will further support Canada's 2030 and 2050 energy and climate goals. In addition to reducing their own emissions from operations, a focus on CCUS could provide Canadian oil and gas companies with a competitive advantage in the CCUS industry even outside the sector given the country's subsurface expertise, large project management experience, capital availability and scalability potential. Work has already begun on the development of a CCUS strategy based on internal analysis and stakeholder input to support Canada's 2030 and net zero targets.

The government expects that clean fuels could could generate 10%-51% of Canada's national energy supply by 2050 and will drive Canada's transition to a low-carbon economy. The Hydrogen Strategy outlines opportunities to grow the export market potential and global leadership for clean hydrogen production and technologies. The Clean Fuels Fund will support the buildout of new clean fuels production capacity, establish biomass supply chains, and develop enabling codes and standards. The proposed Clean Fuel Regulations aim to decarbonise fuel supply by requiring producers and importers to reduce the carbon intensity of their fuels over time.

Since the IEA's last in-depth review, Canada has continued to develop new cross-sectoral policies to promote decarbonisation across the economy. The proposed Clean Fuel Regulations aim to decarbonise fuel supply by requiring producers and importers to reduce the carbon intensity of their fuels over time. The government's 2020 climate plan proposes increasing the carbon price by CAD 15 per tonne each year beyond 2022, until reaching CAD 170 per tonne in 2030.

These are ambitious policies, and the intended carbon price for 2030 is high by international standards and could be a meaningful driver toward deeper decarbonisation. The government's efforts to mitigate its impact on consumers and businesses by maintaining revenue neutrality are equally notable. In combination with other policies, the carbon price could accelerate transitions to clean technologies in sectors where they are already close to cost competitiveness. The proposed Clean Fuel Regulations and the

Pan-Canadian Approach to Pricing Carbon Pollution are both designed to increase the effective cost of CO_2-equivalent emissions incrementally over time. In the near term, this is likely to incentivise incremental change, such as increases in efficiency. Decarbonisation of these sectors will ultimately require large investments in new capital stock. The larger incentives to enable this are planned to come later, but many of these investments have long lead times. This creates a risk: businesses will only invest on the basis of higher future incentives if they are confident that no future government will change the policy. This risk could be mitigated by complementary policies to support early deployment of zero-emission fuels and technologies in these sectors, such as targeted investments, public procurement or regulatory mandates.

In each of the emitting sectors, and in carbon pricing, significant policy-making power lies with the provinces and territories. This can present a challenge to integrated strategies for national decarbonisation. However, the diversity of policy approaches to decarbonisation also presents an opportunity. If the effectiveness of policies in each sector is systematically monitored and compared, it may be possible to replicate those that are the most successful, increase future alignment across jurisdictions and support faster progress at the national level.

Canada has a number of climate resilience policies and tools at its disposal; a number of factors, however, have slowed the pace of adaptation implementation at the national scale, and this is a challenge the National Adaptation Strategy will need to address. Placing energy at the centre of future risk evaluation and adaptation plans, developing actions plans specifically aimed at the energy sector, and considering both electricity demand and supply in future policies could enhance the country's policy readiness to climate change.

While Canada is committed to phase out or rationalise inefficient fossil fuel subsidies by 2025 and has reduced tax support for oil/gas exploration and coal mining in the past years, it provides support through the flow-through share regime. The government may want to reform the federal tax incentives to support the development of technology and innovation, and new export industries in Canada's coal regions. Also, the government should conclude the peer review of inefficient fossil fuel subsidies it committed to undertake under the G20 process to provide transparency to markets and stakeholders, and a basis for further reduction of such subsidies.

Recommendations

The government of Canada should:

- Give the new Net Zero Advisory Body the mandate and capability to review progress nationally, and to systematically monitor and compare the effectiveness of policies across provinces and territories in each sector, so that the most successful policies can be identified and replicated.
- Discourage investments in new, long-lifetime greenhouse gas-emitting power plants where economically feasbile, for example by implementing a clean electricity performance standard and increasing interconnections between regions.
- Develop additional policies to meet Canada's target of zero-emission vehicles comprising 100% of new car and light-truck sales by 2035.
- Building on initiatives such as the Clean Fuels Fund and the Strategic Innovation Fund, develop policies to directly support the first deployment of zero emissions fuels and technologies in energy-intensive industries, shipping and aviation.
- Finalise Canada's peer review of inefficient fossil fuel subsidies as a first step to reduce and eventually end fossil fuel subsidies.

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4. Energy efficiency

Key data (2019)

Total final consumption (TFC): 205.5 Mtoe (oil 45.3%, natural gas 25.6%, electricity 22.2%, bioenergy and waste 5.3%, coal 1.2%, heat 0.3%,) +11.9% since 2009

TFC by sector: industry 34.3%, transport 33.1%, buildings 32.6%

TFC per capita: 5.47 toe/capita (IEA average* 2.9 toe/capita), +0.05% since 2009

TFC per GDP:** 119 toe/USD million (IEA average*: 65 toe/USD million), -9.8% since 2009

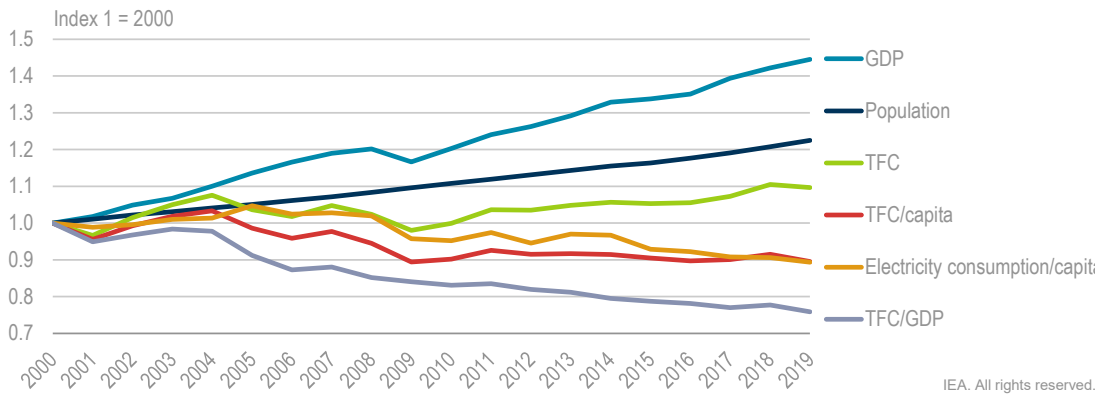
* Weighted average among the 30 IEA member countries.

** GDP in USD 2015 prices and PPPs (purchasing power parities).

Overview

Canadian gross domestic product (GDP) grew by around 24% between 2009 and 2019, as the population increased by 12% (Figure 4.1). However, total final consumption (TFC) increased by only 12% over the same period, thanks to improvements in energy efficiency, which allowed some decoupling of the country's economy and its energy consumption. The decoupling is also evident in the reduction of energy intensity, in terms of TFC/GDP (-10%). TFC per capita in 2019 was at a level similar to that in 2009.

Figure 4.1 Canada's energy demand (total final consumption) and drivers, 2000-19

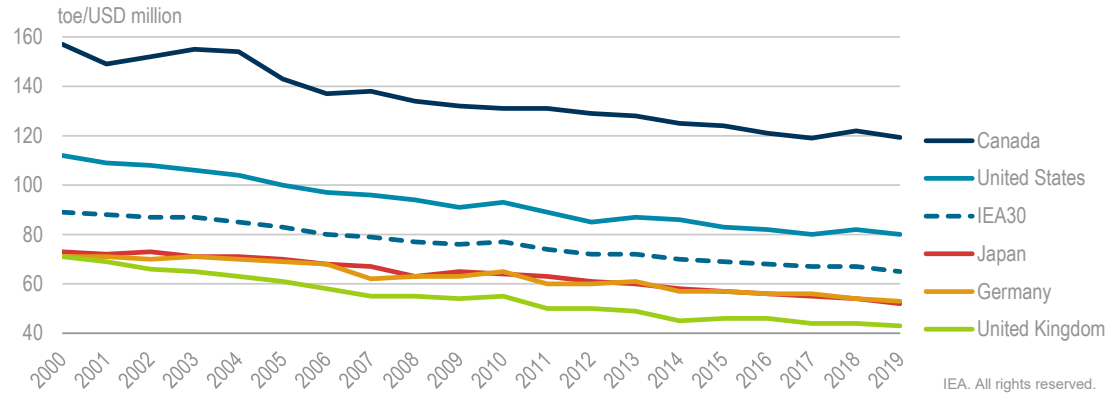


While Canadian GDP increased by 24% between 2009 and 2019, total final consumption increased by 12%, showing some decoupling between economic growth and energy demand.

Notes: GDP = gross domestic product. TFC = total final consumption. GDP data are in billion USD 2015 prices and PPPs (purchasing power parities).

Source: IEA (2021a), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Figure 4.2 Energy intensity in selected IEA countries, 2000-19



Canada has the highest energy intensity of the economy (TFC/GDP) among IEA member countries, despite a steady decline.

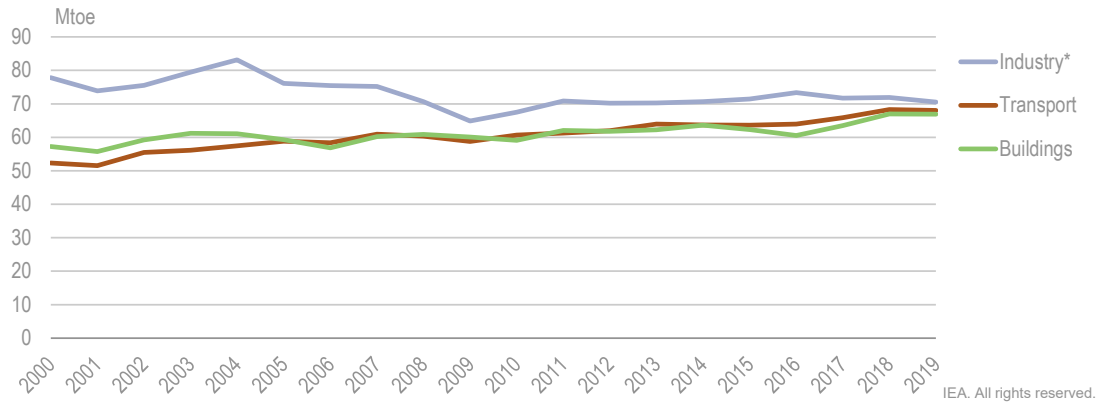
Notes: toe = tonne of oil equivalent. GDP data are in billion USD 2015 prices and PPPs (purchasing power parities).
Source: IEA (2021a), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

However, in 2019, Canada still had the highest energy intensity in terms of TFC/GDP among IEA member countries (119 tonnes of oil equivalent [toe]/USD million), and the second-highest in terms of TFC/capita (5.47 toe/capita) after Luxembourg. TFC/GDP since 2000 has fallen at a rate similar to other IEA countries, but further effort is needed to achieve Canada's climate targets (Figure 4.2).

Energy demand by sector

Energy consumption in industry has decreased, after peaking in 2004, to reach 71 million tonnes of oil equivalent (Mtoe) in 2019. Meanwhile, the expansion of the Canadian economy drove a steady increase in energy consumption in the transport sector, reaching 68 Mtoe in 2019, and in buildings at 67 Mtoe in 2019 (Figure 4.3). The three sectors accounted for about one-third of TFC each in 2019.

Figure 4.3 Total final consumption in Canada by sector, 2000-19



Energy consumption in industry decreased after peaking in 2004 and has been stable in recent years, while energy demand in transport and buildings has continued to increase.

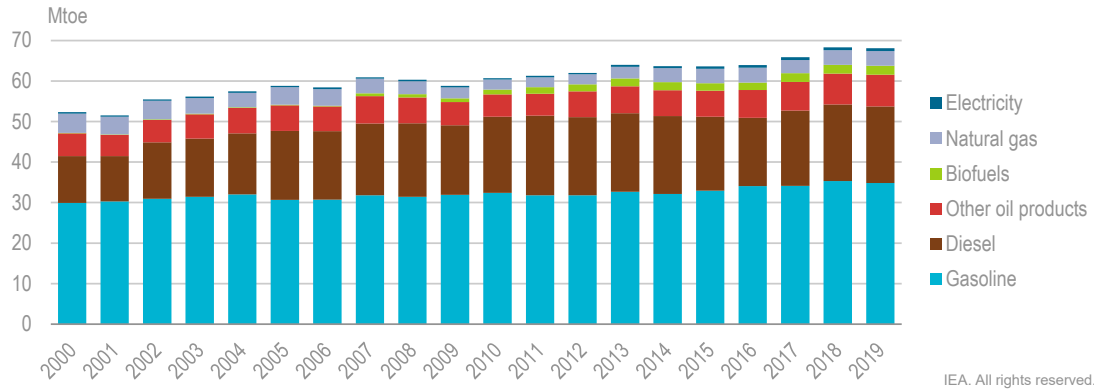
* *Industry* includes non-energy use in the chemical and petrochemical sector.

Note: Mtoe = million tonnes of oil equivalent.
Source: IEA (2021a), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Transport

After a minor drop following the 2008 financial crisis, energy demand in the transport sector increased by 16% between 2009 and 2018, then slightly decreased (-0.3%) in 2019 (Figure 4.4). Most energy demand in the transport sector is fuelled by oil products. Of these, gasoline is the most used fuel, accounting for more than half (51%) of TFC in the transport sector in 2019, followed by diesel (28%) and kerosene (10%). Natural gas covered 5% of consumption in transport; only 1% was provided by electricity. The use of biofuels has increased significantly in recent years, with a 150% growth between 2009 and 2019, to reach 3% of TFC in transport in 2019, or 2.2 Mtoe. Biofuels in Canada consist mainly of bioethanol (72%) and biodiesel (28%).

Figure 4.4 Total final consumption in Canada in transport by fuel, 2000-19



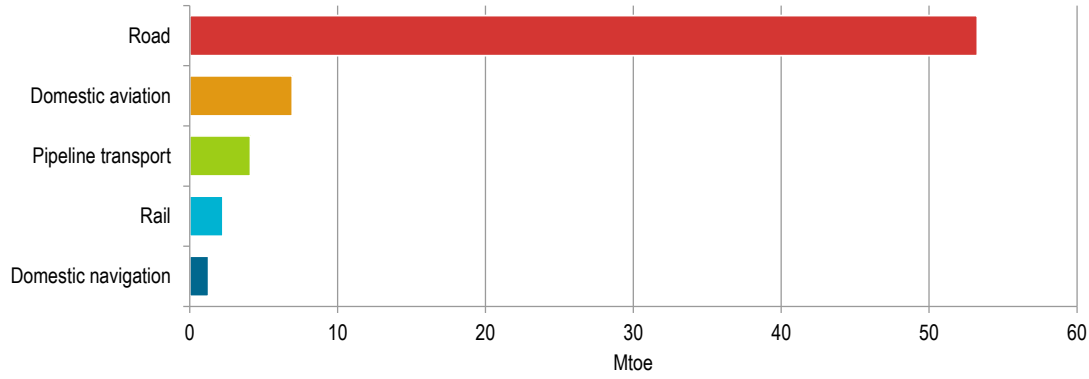
Energy demand in transport has been increasing in recent decades, but was slightly lower in 2019 than in the previous year. Gasoline covers half of TFC in transport.

Notes: Mtoe = million tonnes of oil equivalent. Transport sector demand excludes international aviation and navigation.

Source: IEA (2021a), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Road transport accounted for 79% (53 Mtoe) of energy demand in the transport sector in 2019, followed by domestic aviation (10%) and pipeline transport (6%) (Figure 4.5). Cars and light trucks accounted for half of road transport (51%) in 2018, followed by freight trucks (47%) and buses (2%). Almost all energy used by cars and light trucks (98%) comes from motor gasoline, while diesel covers 62% of the energy demand of freight trucks. The market share of electric vehicles (EVs) has been increasing in recent years, and reached 4.2% of new passenger light-duty vehicle (hereafter “car”) sales in 2020, including both battery only and plug-in hybrid cars (Figure 4.6). More than 50 000 new EVs were registered each year in both 2019 and 2020.

Figure 4.5 Canada's total final consumption in transport by mode, 2019

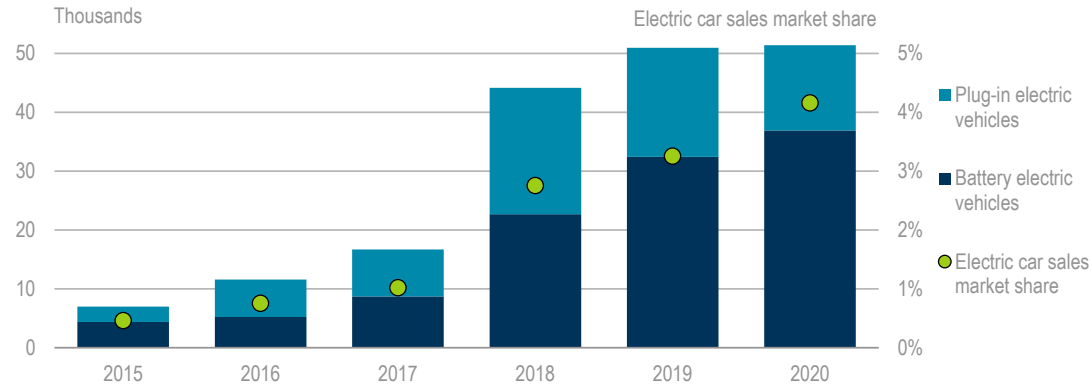


Road transport accounted for 79% of energy demand in the transport sector in 2019.

Notes: Mtoe = million tonnes of oil equivalent. Transport sector demand excludes international aviation and navigation.

Source: IEA (2021a), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Figure 4.6 Electric car registrations and market share in Canada, 2015-20



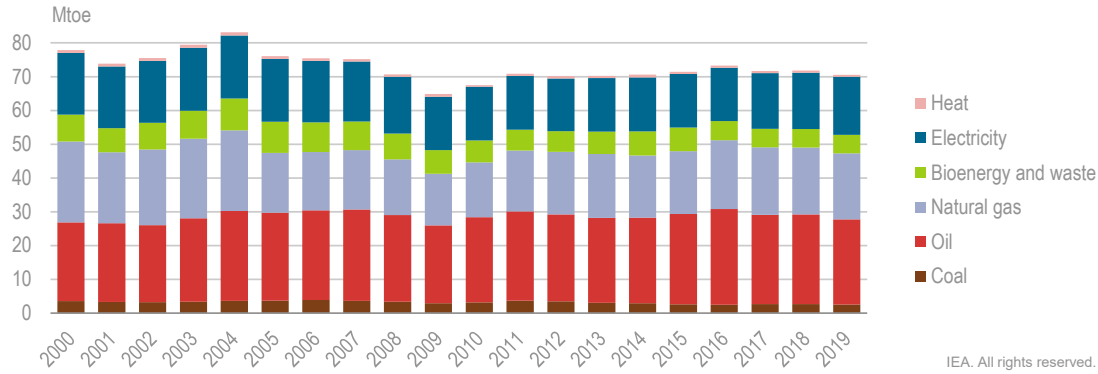
The market share of electric cars has increased in recent years, to reach 4.2% in 2020.

Source: IEA (2021b), *Global EV Outlook 2021*, https://www.iea.org/reports/global-ev-outlook-2021.

Industry

Contrary to the trend in other sectors, energy demand in industry has decreased since 2000, with a stronger decline between 2004 and 2009, stabilising around 71 Mtoe between 2011 and 2019 (Figure 4.7). Due to the presence of a large chemical and petrochemical sector, oil covers the largest share of TFC in industry, at 36% in 2019, with notable contributions from natural gas (28%) and electricity (24%). Bioenergy covered 8% of industrial demand in 2019, consisting mainly of solid biomass (96%), with some contributions from industrial waste (3%) and biogases (1%).

Figure 4.7 Total final consumption in industry in Canada by source, 2000-18



After a marked drop between 2004 and 2009, energy demand in industry has stabilised at around 71 Mtoe. Oil and gas account for nearly two-thirds of energy consumption in industry.

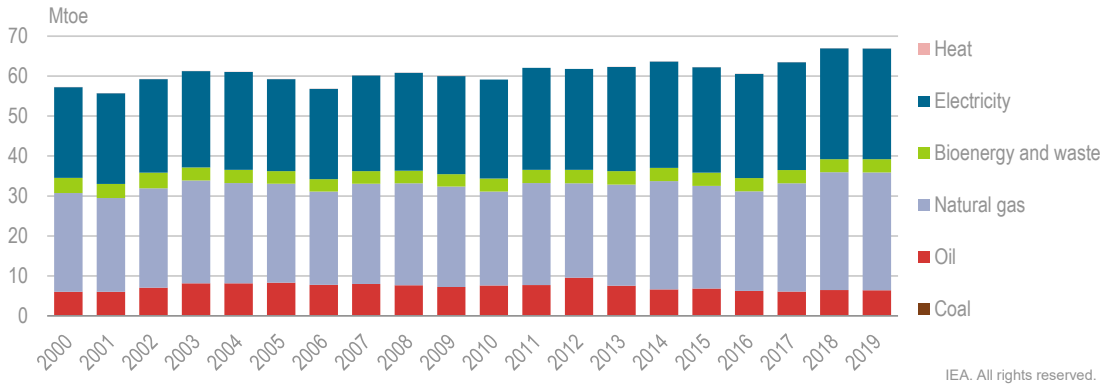
Notes: Mtoe = million tonnes of oil equivalent. Includes non-energy use in the chemical and petrochemical sector.
Source: IEA (2021a), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

After the chemical and petrochemical sector, which is responsible for 44% of TFC in industry (including fuels that are used as raw materials, and are not consumed as a fuel or transformed into another fuel), paper, pulp and print cover one-quarter of industrial consumption, followed by non-ferrous metals (13%), iron and steel (10%), and mining and quarrying (8%).

Buildings

The buildings sector's energy demand includes residential (53% in 2019) and commercial and public services (47%). Energy consumption in buildings increased by 11% between 2009 and 2019, mainly driven by a 23% increase of demand by service sector buildings. Energy demand from residential buildings was more constant (4% increase in the same decade). Most of this energy is provided by natural gas (44%) and electricity (41%), followed by oil (10%) (Figure 4.8). Bioenergy, mainly solid biomass, is primarily used in the residential sector, and accounted for 5% of total buildings sector consumption in 2019.

Figure 4.8 Total final consumption in buildings in Canada by source, 2000-19

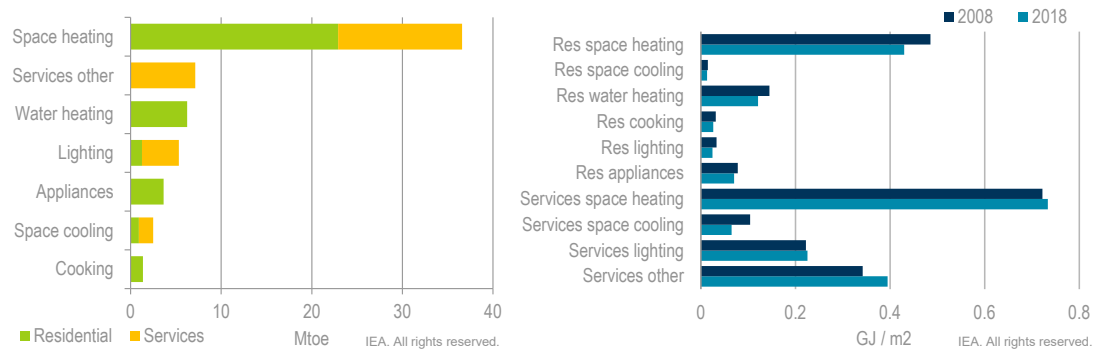


Energy demand in buildings increased by 10% between 2016 and 2019. Natural gas and electricity cover most of energy consumption in the sector.

Note: Mtoe = million tonnes of oil equivalent.
Source: IEA (2021a), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Most energy demand in buildings comes from space heating, which accounted for 58% of energy demand in the buildings sector in 2018, followed by other energy use in the service sector (11%) and water heating in residential buildings (10%) (Figure 4.8). Energy consumption per square metre decreased by 16% between 2008 and 2018 in the residential sector, driven by energy efficiency improvements in space and water heating. On the other hand, there were fewer energy efficiency improvements in the services sector, as the energy consumption per square metre in this sector increased by 2% between 2008 and 2018, driven by increased energy consumption per square metre for space heating in service sector buildings.

Figure 4.9 Canada's total final consumption in buildings by end-use, 2018, and energy consumption per square metre, 2008-18



Space heating dominates buildings energy demand in both residential and service sector buildings.

* *Services other* includes energy used by service sector buildings for end-uses other than space heating, space cooling and lighting.
Note: Mtoe = million tonnes of oil equivalent. GJ/m² = gigajoule per square metre. Res = residential.
Source: IEA (2020), *Energy Efficiency Indicators: Overview*, https://www.iea.org/reports/energy-efficiency-indicators.

Energy efficiency targets and policies

Energy efficiency in Canada is a shared responsibility between the federal and provincial/territorial governments. The federal government works with stakeholders to develop model building codes, which can then be adopted and enforced by provinces. The federal Energy Efficiency Regulations set appliance standards for products that cross internal and international borders – which represents the vast majority of appliance and equipment used in Canada. Municipalities and utilities play an important role in managing energy use and promoting energy efficiency with local policies and programmes.

At the federal level, Natural Resources Canada (NRCan) is the main organisation responsible for energy efficiency policy and programmes and works closely with other federal departments to advance energy efficiency.

The federal government has engaged in extensive dialogues with provinces to advance energy efficiency, including through aligned building codes and equipment regulation. NRCan co-chairs the Steering Committee on Energy Efficiency with provinces and territories. The steering committee is a platform to facilitate the discussion aimed at a long-term, co-ordinated approach to accelerating both energy efficiency and demand-side management in Canada. The Steering Committee on Energy Efficiency is also the co-ordinating body for delivering annual energy efficiency reports to the Energy and Mines

Ministers' Conference, the annual gathering of federal, provincial and territorial ministers responsible for energy and mining portfolios.

Provinces and territories develop energy use policies and regulate energy utilities; co-develop and adopt energy codes and standards for buildings and components; and regulate equipment within their borders. A sizeable share of the provincial and territorial work in energy efficiency takes place through energy utilities, which can offer direct programming to consumers.

Canada also recognises that different provinces have different needs based on the structure of their economies, geographies and energy options. Many provinces have run their own energy efficiency programmes for some time, in some cases supported by federal funding. Financial incentives for energy efficiency targeting individuals and businesses vary by jurisdiction, with a range of provincial, territorial and municipal measures available. Measures include home renovation rebates, demand-side management incentives, and financial support for high-efficiency heating systems and appliances (Government of Canada, 2019).

On 17 November 2020, Efficiency Canada (a national advocacy organisation) released Canada's second Provincial Energy Efficiency Policy Scorecard. The scorecard highlights energy efficiency programmes and policies across Canada that are delivered directly by provinces and territories, or through utilities and municipalities. The report finds that all jurisdictions offer some energy efficiency programming, though the investment and focus vary. Research from the report shows that spending on energy efficiency programmes in Canada increased by 29% between 2016 and 2018, reaching CAD 1.22 billion. Net incremental savings reached 26.1 petajoules (PJ) in 2017, but dropped to 23.9 PJ in 2018 (Efficiency Canada, 2020).

Energy Efficiency Act

The Energy Efficiency Act allows authorities to regulate energy-using products that cross borders, promote the efficient use of energy and alternative fuels, deliver programmes for energy savings and reducing emissions, and collect data on energy use. Introduced in 1992, the scope of the act is limited in its ability to address current challenges related to changes in technology, public policy and the business environment, rapidly increasing demand for energy across the economy. Review of the Energy Efficiency Act, with an eye to modernisation, is a key priority as Canada looks to expand its authorities to support current and future Canadian priorities of enhancing competitiveness and promoting innovation while continuing to improve energy efficiency. Notably, given that energy efficiency is an area of shared jurisdiction, the federal government will need to continue to co-ordinate strategies and data-sharing closely with provinces and territories to align regulatory policies.

NRCan also has a mandate under the Energy Efficiency Act to "provide energy use data to Canadians and to report to Parliament." The Minister of Natural Resources is also granted authority to collect statistics and information from energy companies through the Energy Monitoring Act and the Energy Supplies Emergency Act.

Climate plans

Canada's plan to reach and exceed its emissions reduction targets and climate commitments under the Paris Agreement is a key driver of its energy efficiency progress.

It is a key pillar of the Pan-Canadian Framework on Clean Growth and Climate Change (PCF), with energy efficiency measures accounting for over one-third of planned emissions reductions. Energy efficiency also plays an important role under Canada's Strengthen Climate Plan. Under the new plan, Canada has already invested CAD 2.6 billion to retrofit up to 700 000 homes. Other efficiency measures are in the works (see Chapter 3).

Low Carbon Economy Fund

The federal government has built partnerships and invested heavily in energy efficiency improvements since committing to the PCF in 2016, including energy efficiency investments in buildings, industry and transport. The CAD 2 billion federal Low Carbon Economy Fund, launched in 2017, supports the PCF by investing in projects that generate clean growth and reduce GHG emissions. Examples of programmes and projects supported by the fund include:

- Expansion of British Columbia's EfficiencyBC programme, which offers financial incentives, information and support to help households switch to high-efficiency heating equipment and upgrade building envelopes.
- Incentives for Manitoba's trucking industry to adopt fuel-saving solutions.
- Ontario's Energy Savings Rebate Program, which provided funding to 169 eligible retailers to support point-of-sale rebates for selected energy-efficient products.
- Expansion of Efficiency Nova Scotia's Home Energy Assessment and Green Heat programme, which offers free energy-efficient product installations to homeowners and renters.
- Improved energy efficiency in provincial public buildings in Newfoundland and Labrador, including 35 buildings approved for retrofits in 2019.
- Northwest Territories' government GHG Grant Program, supporting energy efficiency retrofits and GHG emissions reduction projects and initiatives of local governments, municipalities and indigenous governments.
- Support for the South Baffin Energy Management Project to improve energy efficiency and introduce renewable energy in 45 buildings owned by the government of Nunavut.

Climate Action Incentive Fund

Announced in May 2019, the Climate Action Incentive Fund allocated up to CAD 218 million in Saskatchewan, Manitoba, Ontario and New Brunswick (provinces that had not committed to their own carbon pollution pricing systems) for projects that reduce energy use and/or GHG emissions. This included the Municipalities, Universities, Schools and Hospitals Retrofit stream announced in June 2019, with schools identified as the priority for 2019-20. In addition, the Small and Medium-sized Enterprises Project stream opened in July 2019, funding up to 25% of the costs for energy-efficient retrofits and other projects to reduce energy use and save money.

Energy efficiency measures targeting indigenous, northern and remote communities

Approximately 200 communities across Canada rely completely on diesel for heat and power, the majority of which are in remote areas and are Indigenous. As such, the federal government committed to support Indigenous communities as they transition from diesel to clean, renewable and reliable energy by 2030. Launched in 2018, NRCan leads two

programmes to reduce diesel consumption: the Clean Energy for Rural and Remote Communities (CERRC) programme and the Impact Canada Indigenous Off-Diesel Initiative.

Innovative demonstrations to reduce diesel use in the CERRC programme can include the validation of energy efficiency technologies and applications. In both the CERRC programme and the Impact Canada Indigenous Off-Diesel Initiative, energy efficiency is a consideration in many supported capacity building initiatives, such as the development of community clean energy plans and training initiatives. NRCan has worked to ensure that the CERRC programme is accessible by continuously adjusting its design and parameters to enhance indigenous participation: over 90% of projects are in, or for, Indigenous communities.

In addition, Crown-Indigenous Relations and Northern Affairs Canada administers the Northern Responsible Energy Approach for Community Heat and Electricity (Northern REACHE) initiative. Launched in 2017, this programme implements energy projects in remote Indigenous and northern communities across Canada's three territories. Some supported projects include energy efficiency and capacity building measures (such as retrofitting lighting in municipal buildings, retrofits of community housing, and the development of community energy plans).

Energy efficiency programmes in northern communities are further supported through the Low Carbon Economy Fund funding, such as for Arctic Energy Alliance programmes and services to create new energy efficiency programmes for commercial and residential buildings, energy rebates and incentives, winterisation upgrades for low-income owner-occupied homes, and new electric heat incentives for commercial buildings in the Northwest Territories.

Skills training and workforce development

In 2018, around 436 000 Canadians worked in jobs related to the energy efficiency sector – more than in the oil and gas sector, and growing at a faster pace than the overall economy. As part of the government's commitment to restoring economy-wide employment to pre-pandemic levels, it plans to support direct investments in the social sector and infrastructure, immediate training to quickly upskill workers, and incentives for employers to hire and retain workers.

NRCan is working with partner organisations on opportunities for targeted investments in training and upskilling/retooling to build a skilled workforce to support current and anticipated energy efficiency sector growth. This work focuses on building a workforce with skills and knowledge related to energy management and energy performance across the building life cycle and in the adoption of building codes and national energy codes to ensure that workers have the skills needed to lead Canada's clean energy future. Some current projects are helping to provide virtual training to Canadians at discounted rates during the Covid-19 pandemic to help ensure there are enough qualified workers to support energy audits, retrofits and net zero home construction.

Energy service companies

Energy service companies (ESCOs) operating in Canada represent only a very small portion of the global market. An IEA analysis showed ESCO revenues in Canada were valued at USD 360 million (from a growing global market of USD 28 billion) (IEA, 2018).

Barriers to ESCO growth in Canada include cheaper access to electricity than in many other countries and a lack of awareness of the sector as a whole.

At the federal level, NRCan's Greening Government Services administers the Federal Buildings Initiative, a programme designed to facilitate energy efficiency retrofits in government buildings with ESCOs. With technical support from NRCan and the Canadian Infrastructure Bank, federal departments and agencies can enter into contracts using a list of ten pre-qualified companies.

Transport

Various federal funding programmes and investments support efficient transportation, including cleaner technologies such as full hybrids, plug-in hybrids, full battery electric, fuel cell electric, as well as electrification infrastructure such as public chargers, EV fleets and public transit. Funding sources include the Green Infrastructure Bank, the Low Carbon Economy Fund, the Green Municipal Fund, the Green Freight Assessment Program, the EV and Alternative Fuel Infrastructure Deployment Initiative, and the Zero Emission Vehicle Infrastructure Program.

Vehicle standards

Canada set GHG emissions standards for light-duty vehicles that came into force in 2011. The regulations were amended in 2014 to establish GHG emissions standards for the 2017-25 model years that incorporate the United States' Environmental Protection Agency (US EPA) standards by reference. The regulations establish GHG emissions performance standards for new light-duty on-road vehicles for sale in Canada. The standards are specific to each automobile manufacturer or importer based on its sales-weighted fleet average emissions performance for a given model year, expressed in grammes per mile of CO_2 equivalent, based on standardised emissions tests. The GHG emissions standards were set to progressively increase in stringency at about 5% per year for passenger cars over 2017-25, and for light trucks at about 3.5% per year over 2017-21 and 5% annually over 2022-25.

However, in April 2020, the United States reduced stringency improvements to 1.5% per year beginning with model year 2021. Because of the incorporation by reference of the US standards in Canadian regulations, this rollback automatically applied in Canada. In February 2021, Environment and Climate Change Canada completed a mid-term evaluation of the regulations and determined that the 1.5% annual stringency increase of the standards is not sufficient to reach Canada's emissions reduction goal. Furthermore, in August 2021, the US EPA proposed new standards to increase stringency at about 10% for model year 2023 and 5% from model years 2024-26. Canada's standards will automatically become more stringent and aligned with the US standards for model years 2023-26 once they are finalised (expected in late 2021).

Canada's Strengthened Climate Plan commits Canada to working to develop and align vehicle emissions standards with the most stringent levels in the United States, be they at the federal or state level.

The latest Heavy-duty Vehicle and Engines Greenhouse Gas Emission Regulations were published in May 2018 and apply increasingly stringent GHG emissions standards to new on-road heavy-duty vehicles and engines imported or manufactured in Canada starting with model year 2021, gradually tightening up to model year 2027. The government

expects that some vehicle types will see GHG emissions reductions of up to 25% from 2027 (Government of Canada, 2018).

Carbon pricing and Clean Fuel Regulations

The Pan-Canadian Approach to Pricing Carbon Pollution set a "federal benchmark" requiring all provinces and territories to implement carbon pricing systems with a certain level of stringency, while also ensuring the provinces and territories have the flexibility to design their own policies (see Chapter 3). A "federal backstop" carbon pollution pricing system applies (in part or in full) in any jurisdiction that requested it or that did not implement its own system that meets the federal benchmark's stringency requirements. The benchmark carbon price is legislated to grow from CAD 20/ t CO_2-eq in 2019 to CAD 50/t CO_2-eq by 2022, and will grow to CAD 170/ t CO_2-eq by 2030. Part of the federal backstop is a carbon price on fuels, which should motivate lower consumption in the transport sector.

Canada also put forward Clean Fuel Regulations. They will provide economic opportunities for producing and using clean fuels through the generation of credits. While the regulation requires the reduction in carbon intensity of liquid fossil fuels, the Clean Fuel Regulations will create incentives for clean gaseous fuels including biogas, renewable natural gas and hydrogen. There are various ways credits can be generated from clean gaseous fuels, including through the use of low-carbon intensity hydrogen as a feedstock in the production of fossil fuels or low-carbon intensity fuels and through the supply of renewable natural gas and hydrogen to the transportation sector (via fuel cell vehicles and natural gas vehicles). The final regulations are expected to be published in late 2021 and come into effect in December 2022 (see Chapters 3 and 5).

Additional measures to promote fuel efficiency

The Canada Revenue Agency imposes an excise tax (green levy) on fuel-inefficient automobiles (including station wagons, vans and sport utility vehicles) designed as passenger vehicles. Pickup trucks, vans with ten or more seats, ambulances and hearses are not subject to the green levy. The excise tax rate is calculated based on weighted fuel consumption, as determined by the vehicle's fuel efficiency ratings published by NRCan. Automobiles with a weighted average fuel consumption rating of 13 or more litres per 100 kilometres are subject to a one-time excise tax of between CAD 1 000 and CAD 4 000.

The government also offers informational services to encourage and enable consumers and businesses to consider the purchase of more efficient, lower emitting vehicles. Some examples include:

- the EnerGuide label, which provides consumers with information on fuel consumption, emissions and possible fuel costs
- a Fuel Consumption Guide on NRCan's website that compares fuel consumption for new and used cars
- an EV and Alternative Fuel Refuelling Map, which provides an online interactive map of clean fuel options
- the Smart Driver training curriculum, which helps new drivers learn how to drive more efficiently
- the Zero-Emissions Vehicle Awareness Initiative, which uses a variety of tools to outline the benefits and considerations of owning a zero-emission vehicle (ZEV)

- Auto$mart, which targets Canadian motorists with information and tools to help them purchase, drive and maintain their vehicles with energy efficiency in mind (updated in 2020 to include an expanded section on hybrids and ZEVs).

Zero-emission vehicles

In June 2021, the federal government announced an intention to set mandatory sales targets of 100% ZEVs by 2035. This would accelerate earlier commitments made in 2019, when the federal government set (non-binding) targets for ZEVs to account for 10% of new annual light-duty vehicle sales by 2025, 30% by 2030 and 100% by 2040.

To support the original target, the government has invested more than CAD 1 billion to support ZEV purchase incentives, EV and alternative fuel infrastructure demonstration and deployment; introduced a 100% first-year tax write-off for company investments in ZEVs to support business adoption; and supported initiatives designed to increase awareness and public confidence in ZEVs.

More specifically, the government has allocated CAD 587 million towards the Incentives for Zero-Emission Vehicles Program, which provides a point-of-sale rebate of up to CAD 5 000 on eligible ZEVs. Since its inception on 1 May 2019, over 100 000 Canadians and Canadian businesses have benefited from the programme.

The EV and Alternative Fuels Infrastructure Deployment Initiative, launched in 2016 with CAD 96.4 million in funding, supports the establishment of a coast-to-coast network of EV fast-chargers, natural gas refuelling stations along key freight corridors and hydrogen stations in metropolitan centres. The programme, which runs through March 2022, is on track to meet or exceed its targets of 1 000 EV fast-chargers, 15 hydrogen stations and 21 natural gas stations open to the public (Government of Canada, 2021a).

Building off the EV and Alternative Fuels Infrastructure Deployment Initiative, under NRCan's Zero-Emission Vehicle Infrastructure Program, in 2019 the federal government allocated CAD 130 million over five years to support the deployment of infrastructure in public places, on the streets, in multi-unit residential buildings, workplaces, as well as strategic infrastructure projects for urban delivery, and fleet applications (Government of Canada, 2021b). Canada's 2020 Fall Economic Statement included an additional CAD 150 million over three years for the programme, with overall programme targets of 33 500 new chargers and 10 new hydrogen fuelling stations.

NRCan has also been working for more than a decade with the US Department of Energy to develop, revise and align codes and standards for electric and alternative fuelled vehicles and refuelling infrastructure, through the Regulatory Cooperation Council.

Addressing gaps and misalignments in relevant technical and safety codes and standards enables common testing and verification of new technologies, and facilitates their safe and efficient use.

In addition, NRCan supports various transportation-related research, development and demonstration (RD&D) projects, including:

- The Electric Vehicle Infrastructure Demonstration Program (CAD 76 million over six years starting in 2016-17) supports the demonstration of next-generation and innovative EV charging infrastructure to address technical and non-technical barriers to the installation, operation and management of EV charging technologies.

- The Energy Innovation Program supports private sector projects to advance a wide range of clean energy technologies to reduce emissions, including in the transportation sector, with the aim of meeting 2050 clean growth targets.
- The Program of Energy Research and Development supports R&D activities led by federal labs to advance clean energy technologies, including those for transportation.

Provinces and territories offer additional programming and incentives to promote energy efficiency and ZEVs in transport. For example, British Columbia and Quebec currently offer financial rebates to consumers who purchase or lease electric, plug-in hybrid or hydrogen fuel cell vehicles. Both provinces also have ZEV mandates in place, applied to automobiles sold in the province, to encourage greater supply in the market. Congruently, they are also the markets that have seen the greatest penetration of EVs (Clean Energy Canada, 2020). Other provinces and territories also offer ZEV incentives, including Yukon, Northwest Territories, Nova Scotia, Prince Edward Island, and Newfoundland and Labrador.

Battery innovation

The Canadian government recognises the competitive advantage its mining industry can have in developing battery supply chains. To this end, in 2019 it launched stakeholder consultations to assess opportunities in the global battery value chain. Canada has all the mineral and metal resources required to produce advanced batteries (lithium, nickel, copper, graphite and cobalt). It also boasts a strong research and development ecosystem; many start-ups in niche markets, including recycling; and a sizeable automotive industry.

Canada aims to leverage its mineral and metal resources to attract leading battery manufacturers to establish homegrown stationary energy storage, as well as battery technologies of the future, including related to end-of-life recycling.

NRCan is now actively supporting battery initiatives across Canada to enhance market growth toward the transition to a low-carbon economy. This includes funding initiatives such as the Charging the Future Challenge, launched in 2019, which aims to accelerate the most promising made-in-Canada innovations of battery technology. The governments of Canada and Quebec also announced investments of CAD 100 million into Lion Electric for the construction of a battery-pack assembly plant (Prime Minster of Canada, 2021). Canada's Strengthened Climate Plan includes commitments to position Canada as a global leader in the production of batteries and other clean technologies.

Public transport

Under the 2016 Investing in Canada Plan, the federal government committed more than CAD 180 billion over 12 years toward infrastructure upgrades and expansions, including public transit. Under the plan, investments of over CAD 13 billion have been made in more than 1 300 public transit projects across Canada, including to build new urban transit networks and service extensions. These investments have helped build more than 240 kilometres of new public transit subway and light rail lines; purchase over 300 zero-emission buses; and create almost 500 kilometres of active transportation trails, bike and pedestrian lanes, and recreational paths (Government of Canada, 2020).

In August 2021, the government announced the launch of a CAD 2.75 billion Zero Emission Transit Fund (over five years) to enhance public transit systems and switch them to cleaner electrical power, including supporting the purchase of zero-emission public transit and school buses. The funding is part of an eight-year, CAD 14.9 billion public

transit investment, which will also support municipalities, transit authorities and school boards with transition planning; increase electrification of transit systems; and help purchase 5 000 zero-emission buses over the next five years (Government of Canada, 2021c).

Federal fleet

The government of Canada's Greening Government Strategy commits federal organisations to achieving net zero emissions by 2050. To reach this goal, the government will reduce emissions by 40% from 2005 levels by 2025 and by at least 90% by 2050.

Under this strategy, starting in fiscal year 2019, 75% of new light-duty unmodified fleet vehicle purchases must be ZEVs or hybrids, with the objective that at least 80% of the government's light-duty fleet be composed of ZEVs by 2030.

NRCan's Greening Government Operations programme supports these commitments by collaborating with interested agencies and departments to identify opportunities to green their fleets. Through the deployment of on-board telematics, the programme collects real-time utilisation data (e.g. fuel consumption, distance travelled, dwell times, etc.) to identify opportunities for right-sizing, assess fleet vehicles for ZEV and hybrid suitability, and make recommendations for the planning of charging infrastructure.

Twelve of the government's 15 largest fleet-owning departments have participated in the programme, with more than 2 700 vehicles assessed to date.

In May 2018, the *Greening Government Fleets Best Practice Guide* was developed and shared with governments at the provincial, territorial and municipal levels, as well as internationally to help government fleets at all levels adopt lower emitting options in their operations.

Freight and fleets

NRCan has been supporting the freight industry to reduce fuel consumption and save on fuel costs for over a decade.

The Smartway Transport Partnership is a government-industry collaboration to reduce emissions from the freight industry through capacity building and information sharing. It is a free and voluntary international programme that enables shippers and carriers to benchmark their fuel usage against their competitors and identify areas for continuous improvement. Over 3 600 North American companies have signed on to the partnership, which was launched by the US EPA. SmartWay has been run in Canada by NRCan since 2012.

The SmartDriver Training programme is a free, practical training led by NRCan to help Canada's commercial and institutional fleets lower their fuel consumption, operating costs and harmful vehicle emissions. The fleet energy management training is designed to help truckers, transit operators, school bus and other professional drivers improve fuel efficiency by up to 35%.

Lastly, the Green Freight Assessment Program (CAD 3.4 million over four years) helps companies take data-driven investment decisions to reduce their emissions and save on fuel costs. Initial investments help companies undertake energy assessments of their medium/heavy-duty fleet and identify areas to improve energy efficiency and fuel

consumption. Once assessments are completed, additional resources can be provided to implement recommendations, including fuel efficient retrofits or lower carbon vehicle purchases.

Industry

NRCan's industrial energy efficiency programme helps industry improve energy efficiency through the implementation of energy management systems such as ISO 50001 and Superior Energy Performance, as well as other energy management activities, including benchmarking tools such as the ENERGY STAR for industry, process integration studies and computational fluid dynamic studies.

Process integration studies identify potential heating and cooling efficiencies in complex industrial processes; results can be applied to maximise heat recovery between processes. Computational fluid dynamic studies identify ways to improve combustion performance in large furnaces and boilers; results can increase equipment life and productivity and lower fuel consumption.

NRCan collaborates with the US EPA on the ENERGY STAR for industry programme. ENERGY STAR for industry is a certification programme that helps companies reduce energy consumption by standardising energy efficiency measurements and improvements. The programme consists of two parts:

- ENERGY STAR Certification uses sector-specific benchmarking models that allow companies to compare their energy data with those of their competitors, and identify potential cost savings through greater energy efficiency. Top performers can become ENERGY STAR certified and gain recognition as best-in-class performers.
- ENERGY STAR Challenge is a call-to-action to reduce a facility's energy intensity by 10% in five years. Energy savings can be realised through low-cost actions such as turning off lights and equipment when not in use, and fixing leaks in compressed air systems. Facilities that achieve the 10% target gain recognition as an ENERGY STAR achiever, which lets customers know they are doing business with a company that is serious about the environment and corporate sustainability.

As of 2020, Canada had over 160 ISO 50001 certified buildings and facilities, including commercial and institutional buildings as well as industrial facilities. NRCan is also working with the US EPA to bring the 50001 Ready Navigator programme and Superior Energy Performance to Canada.

- 50001 Ready Navigator is an online tool that provides a step-by-step guide to implement and maintain an energy management system in conformance with the ISO 50001 Standard.
- Superior Energy Performance is a certification programme based on ISO 50001 with verified energy performance improvements over time. Industrial facilities can take advantage of tools, resources and protocols to set energy performance targets, after which they can achieve and measure sustained savings to earn silver, gold or platinum level certifications.

In addition, NRCan brings the industrial sector together through the Canadian Industry Partnership for Energy Conservation to find energy efficiency solutions. This industry-government partnership network focuses on reducing energy costs, improving economic performance and meeting climate change objectives. Through the partnership, industry

and government collect energy data, share information, facilitate mentoring on energy and related matters, and communicate success. NRCan publishes and disseminates guides to help industry improve its energy performance. Guides include the national energy use database; energy use calculators; energy management guidelines; employee guidebooks; and awareness resources on topics like energy management systems, energy management and information systems, and energy use factsheets.

The Canadian government does not require industrial operators to conduct energy audits. NRCan provides advice and expertise to industrial operators regarding the process and benefits of conducting an audit, as well as funding programmes and tools to support the implementation of energy management systems as noted above. Programmes and available resources are accessible on the NRCan website, including an energy audit manual and excel spreadsheets for estimating or measuring changes in energy consumption.

The government also promotes training and education to expand the role and strengthen the capacities of energy service companies.

Canada's large industrial emitters are also subject to the Output-Based Pricing System (OBPS) that is part of the federal government's carbon pricing regulation. The OBPS puts a price on carbon pollution for industrial facilities that emit 50 000 tonnes or more per year. Facilities subject to the OBPS will generally not pay the carbon pollution price on fuel they purchase for use at their covered facility. Instead, under the OBPS, participants are required to pay for GHG emissions that exceed an annual facility emissions limit.

The industry sector faces a number of barriers to adopting and implementing energy efficiency measures in Canada, including access to timely and granular data on energy consumption; fragmentation of standards and regulations across the country; and access to financing.

Buildings

In August 2017, NRCan released Build Smart: Canada's Buildings Strategy, developed in collaboration with the provinces and territories, to increase energy efficiency and reduce CO_2 emissions in buildings. Build Smart, which supports actions under the PCF, outlines Canada's plan to transform its built environment by making homes and buildings more energy efficient. This strategy includes a plan for increasingly stringent national model energy codes for new buildings, specifically requiring new buildings to be "net zero energy ready" by 2030. Build Smart also includes a number of programmes to support homeowners, builders and manufacturers to become "net zero ready", including ENERGY STAR for New Homes, R-2000 certification and Local Energy Efficiency Partnerships. In support of this strategy, the government is engaging with stakeholders to address barriers to greater market uptake of high-performance space and water heating equipment and next-generation windows through the Market Transformation Roadmap. Build Smart also contains measures to benchmark, label and share building energy use, and programme supports to accelerate the adoption of energy management best practices. Significant investments have also been made in RD&D projects to build confidence in high-performing buildings.

Over recent years, the government of Canada has facilitated improvements in energy efficiency in buildings through financial support. Budget 2016 included CAD 120 billion in long-term infrastructure investment, increasing to over CAD 180 billion over 12 years in

Budget 2017 under the Investing in Canada Plan. This included CAD 2 billion for the Low Carbon Economy Fund and CAD 181.8 million for the Green Infrastructure Fund to help provinces and territories increase energy efficiency and address climate change through homes and building design, renovation, and construction.

In 2019, the federal government announced a CAD 1.01 billion investment to increase energy efficiency in residential, commercial and multi-unit buildings. This includes the CAD 950 million allocation to the Federation of Canadian Municipalities' Green Municipal Fund. Over 2 000 municipalities at the national level will see loans, grants, capital investments and local climate hubs delivered through this fund.

Energy and building codes

The National Energy Code of Canada for Buildings (NECB) and Section 9.36 of the National Building Code of Canada for low-rise housing and small buildings set technical provisions to address energy efficiency in the design and construction of new homes and buildings and additions to existing homes and buildings. These model codes become regulation once adopted and/or adapted by a province or territory.

The most recent energy codes available for adoption by subnational jurisdictions are the NECB 2017 and the National Building Code of Canada 2015. The NECB 2017 (or equivalent or higher) has been adopted in Alberta, Saskatchewan, Ontario, Nova Scotia and Prince Edward Island, and covers approximately 56% of new floor space being built in Canada. The 2015 model housing code (or equivalent or higher) has been adopted in all jurisdictions (Newfoundland's adoption is from its municipalities rather than as a province).

The PCF and Build Smart lay out a strategy for federal-provincial-territorial partners and stakeholders to develop increasingly stringent model energy codes for new homes and buildings leading to "net zero energy ready" code adoption, as well as codes to drive energy-efficient alterations to existing buildings. Work has progressed on both of these fronts. The 2020 model national codes for new buildings are in the final stage of development and scheduled for publication in 2021. The new codes for adoption by provinces and territories include tiered energy performance targets, with the highest tiers representing net zero energy read levels of construction. The new codes are expected to be 10-15% more efficient than previous codes on average and 60-70% more efficient at the highest tiers. Under Build Smart, provinces and territories have committed to adopting the net zero ready level by 2030. Work is also underway to broaden the application of the 2025 cycle of model national energy codes to include existing buildings and homes. Technical research and study are underway to inform the new requirements.

The government is currently developing the first model energy code that will trigger improved energy efficiency alterations to existing buildings (to be announced in 2023 and published in 2025). This code will help guide energy efficiency improvements for existing home renovations. A guidance document has been drafted, outlining the policy and technical considerations related to the alterations of existing homes. The developed policy framework includes guiding principles and code triggers, while significant technical research is underway to inform the code committees on these new requirements.

To drive timely code adoption, provinces and territories are working to harmonise code adoption as part of the Regulatory Reconciliation and Cooperation Table under the Canada Free Trade Agreement. This agreement aims to eliminate the current patchwork

of building code requirements across Canada through a voluntary commitment by signatory provinces and territories to adopt the 2020 model national codes within 24 months of their publication and to adopt all future updates of the model national codes within 18 months of publication. For example, new model code requirements for alterations to existing buildings will be developed and incorporated into existing codes for the 2025 code cycle, making their adoption part of the automatic process established under the harmonisation agreement. Although voluntary, it represents an important step forward, as the economic benefit from energy savings to Canada from harmonisation and timely adoption of construction codes is estimated to be between CAD 750 million and CAD 1 billion by 2028.

NRCan is investing in code training and compliance tools for designers, builders and building inspectors to ensure the market is ready to build to current and new codes, as well as in projects that research, develop, validate and demonstrate emerging technologies and construction practices. This will encourage the uptake of new codes while lowering the costs to build or renovate at higher energy efficiency standards.

The government of Canada is also investing CAD 48.4 million in RD&D to accelerate the development and adoption of net zero energy ready codes for new buildings, as well as the first codes for alterations to existing buildings. Since 2018, 12 projects have been selected for funding, covering all Canadian climate zones. The selected projects include the construction of 16 new buildings, which will provide business cases for net zero energy ready construction, as well as four deep energy retrofits. Other projects will develop three nationally applicable software tools to optimise energy-efficient building design and operation and explore the cost-effectiveness of modular and prefabrication construction practices. A third call for project proposals is currently underway.

Federal buildings

The Greening Government Strategy sets aggressive commitments for the government of Canada to guide the transition to low-carbon, climate-resilient and green operations, including to achieve net zero carbon buildings by 2050. Through the Greening Government Strategy, federal organisations also commit to use 100% clean electricity by 2025 at the latest, and to reduce embodied carbon in structural building material by 30% starting in 2025. To meet these commitments, federal organisations pursue opportunities to maximise energy efficiency, rationalise portfolios and switch to lower carbon fuels in their buildings.

NRCan's Greening Government Services programme supports these commitments by working collaboratively with other federal organisations to improve GHG and energy performance within their buildings. Support services are offered for a wide variety of building projects addressing topics such as energy audits, modelling simulations, benchmarking, recommissioning, deep retrofits and energy performance contracts. Strategic guidance is offered to support net zero portfolio plans, energy management plans, project planning and implementation. A variety of in-depth technical training sessions and certifications are delivered through accredited practitioners, and a community of practice is facilitated to bring awareness to inspiring building projects.

Between the 2005 baseline and the 2019-20 fiscal year, GHG emissions fell by 35%, and energy has been reduced by 10% across the federal buildings portfolio.

Benchmarking, labelling and disclosure

Under the PCF and Build Smart, the federal government committed to working together with the provinces and territories with the aim of requiring labelling of building energy use, to provide consumers and businesses with transparent information on energy performance across the country.

Federal and provincial/territorial and municipal partners and stakeholders collaborate through the Labelling and Disclosure Working Group to develop a harmonised approach to building, labelling and disclosure in Canada through shared capacity building, resources and tools. To date, the group has carried out workshops and learning tours with European partners, as well as a needs assessment for a national framework. A comprehensive Model National Framework guideline for building, labelling and disclosure best practices for buildings was subsequently developed in collaboration with working group members and in consultation with North American experts and stakeholders.

NRCan continues to adapt and expand Canadian content in the ENERGY STAR Portfolio Manager benchmarking tool so that it is relevant for Canadian users. Portfolio Manager is a free online tool developed by the US EPA to support wide-scale efficiency upgrades and improved building performance. The tool enables building owners, operators and others to track energy use, GHG emissions, and water and waste consumption, and to compare energy performance against national medians or an ENERGY STAR score. In collaboration with the US EPA and using data from NRCan's energy use surveys, the availability of ENERGY STAR scores has increased to ten building types. Work continues to increase the availability of scores to 21 building types by 2025-26, to cover the most common types of buildings in Canada.

NRCan launched a three-year programme starting in 2018-19 to cost-share projects with provinces, territories, municipalities and other stakeholders in support of mandatory energy labelling and disclosure. To date, 13 initiatives are in progress or have been completed across Canada. This includes funding to develop the GRID online platform to support programme management and public disclosure of energy performance. Several jurisdictions are piloting this online platform, which works in conjunction with the ENERGY STAR Portfolio Manager benchmarking tool. Ontario adopted labelling and disclosure requirements for commercial and institutional buildings in 2018, while Quebec and British Columbia intend to adopt various labelling and disclosure requirements. Voluntary energy benchmarking and reporting programmes are in place in greater Vancouver, Richmond, Edmonton, Calgary and Toronto.

Conducted every five years, the national Survey of Commercial and Institutional Energy Use provides the public with national estimates on the energy profiles and building characteristics of commercial and institutional buildings in Canada, as well as foundational data to update and expand Canadian content in the ENERGY STAR Portfolio Manager benchmarking tool.

In March 2018, Canada launched the ENERGY STAR certification programme for commercial and institutional buildings, covering ten building types by 2019-20. This programme recognises buildings with an ENERGY STAR score greater than 75 (top 25th percentile), and that meet other programme requirements. By March 2020, 187 unique buildings had been certified and an additional 90 buildings were recertified.

The federal-provincial-territorial Labelling and Disclosure Working Group was established in April 2017 to develop a harmonised approach and tools for jurisdictions to adopt labelling and disclosure, one of the PCF's priorities.

One of the activities to support labelling of building energy use is to provide open access to home energy use data in support of efforts by stakeholders and partners such as provinces, territories, municipalities and other organisations. In 2019, NRCan created an EnerGuide Home Labelling Portal to help homeowners access their EnerGuide rating on line, including energy efficiency, energy consumption, estimated carbon output and recommended upgrades. Homeowners can now share energy use data with others, including potential homebuyers.

Support for retrofits

The government of Canada has in recent years increased support for building retrofits as a critical component of its energy and climate agenda. The country's yearly retrofit rate is currently less than 1%. Canada supports retrofits in the buildings sector through expanded financial incentives; increased consumer awareness and tools, such as ENERGY STAR Portfolio Manager; and the development of new model energy codes for alterations to existing buildings, which it also sees as an opportunity to create jobs. Importantly, energy efficiency retrofits were explicitly mentioned as part of Canada's strategy of "building back better" from the economic crisis brought on by the Covid-19 pandemic, particularly for indigenous and northern communities.

In December 2019, the Prime Minister of Canada requested that the Minister of Natural Resources work with the Canadian Mortgage and Housing Corporation to move forward with new financial incentives. These include up to CAD 40 000 in interest-free loans for retrofits to encourage homeowners and landlords to advance home energy efficiency as well as launching a national competition to create four long-term funds to help attract private capital that can be used for deep retrofits of large buildings such as office towers.

Canada's Greener Home Grant programme was launched in May 2021 and proposes CAD 2.6 billion over seven years (starting in 2020-21) to help homeowners make energy-efficient improvements to their homes by providing up to 700 000 grants of a maximum of CAD 5 000, up to 1 million free EnerGuide energy assessments, and support to recruit and train EnerGuide energy advisers to meet increased demand.

Moreover, the Canada Infrastructure Bank officially announced in October 2020 the creation of a CAD 10 billion infrastructure plan to "Grow the Economy and Create Jobs", which includes CAD 2 billion for energy-efficient buildings retrofits.

To address energy poverty, in November 2017, the federal government announced Canada's first-ever National Housing Strategy, a ten-year plan to help reduce homelessness and improve the affordability, availability and quality of housing for Canadians in need. Delivered by the Canadian Mortgage and Housing Corporation, the National Housing Strategy includes initiatives like the CAD 13.2 billion National Housing Co-Investment Fund, which sets ambitious minimum energy efficiency and emissions reduction requirements for construction and renovations of accessible and socially inclusive housing. For example, retrofit projects must demonstrate that they will achieve a minimum 25% reduction in energy use and GHG emissions, compared to the existing code.

The Federation of Canadian Municipalities' Green Municipal Fund received a CAD 950 million endowment from the government of Canada through Budget 2019 for energy-efficient homes and buildings. New funding streams supported through this investment include: Community Efficiency Financing (CAD 300 million), launched in March 2020, which supports municipalities in offering innovative financing programmes for homeowners; Sustainable Affordable Housing (CAD 300 million), launched in May 2020, which enables affordable housing developments targeting both retrofits and net zero energy ready new builds; and Collaboration on Community Climate Action (CAD 350 million), which supports seven cities across Canada to create climate hubs and helps jurisdictions undertake deep retrofits of community buildings (expected spring 2021).

In addition, there are commercially available financing instruments for energy efficiency in Canada, though specifically targeted products are limited.

Appliances, equipment, lighting

Canada has two key policy instruments to advance the energy efficiency of products:

1. Energy Efficiency Regulations
2. the ENERGY STAR programme.

Administered under the Energy Efficiency Act, Canada's Energy Efficiency Regulations establish minimum energy performance standards, product labelling and data collection requirements for 65 energy-using product categories used in the residential, commercial and industrial sectors in Canada. Products include household appliances, water and space heating, air conditioning equipment, electronic products, lighting products, and other commercial and industrial products.

Regular amendments ensure alignment with technological change and maximising savings. Amendments create or update minimum energy performance standards for products in the residential, commercial and industrial sectors, and update testing methodologies or labelling requirements. Amendments have been made in recent years to better align minimum energy performance standards with the goals of the PCF.

The ENERGY STAR programme identifies high-efficiency models for consumers and encourages energy-efficient choices. An ENERGY STAR certification indicates that a product is in the top 15-30% of its class for energy performance. Products with the symbol have been tested according to prescribed procedures and meet or exceed higher energy efficiency levels without compromising performance. More than 1 000 major manufacturers and retailers of energy-efficient products, utilities and energy retailers promote the label on almost 80 types of products.

The EnerGuide label compares the energy performance of a product to others in its class. By law, the label must be visibly affixed on major home appliances and room air conditioners prior to sale. NRCan works with manufacturer associations to administer the EnerGuide label on a voluntary basis for eight types of home heating and cooling products.

Through continued funding in and beyond Budget 2016, NRCan continues to increase the energy efficiency of consumer and commercial products. Funding supported the alignment of federally regulated standards and ENERGY STAR voluntary certifications with the United States, as well as collaboration with provinces, territories and North American partners to prepare for regulation of products with high energy savings potential.

In August 2016, Canada's energy ministers established a framework for co-operation on energy efficiency standards. Under this framework, federal, provincial and territorial action plans are published annually and include detailed collaboration plans; shared priorities for new and updated standards; and areas to improve regulatory development, implementation and transparency. The most recent action plan was published for 2018-19 and included goals for residential water heaters and commercial gas furnaces, among many other products (NRCan, 2018).

In August 2018, federal, provincial and territorial energy ministers endorsed Paving the Road to 2030 and Beyond: Market Transformation Road Map for Energy-Efficient Equipment in the Building Sector. Through the road map, Canadian energy ministers endorsed long-term aspirational goals for high-efficiency heating technologies in Canada, including that all space and water heating technologies sold in Canada meet an energy performance of more than 100% by 2035 and a complementary goal to see today's highest efficiency residential windows become the standard option for sale by 2030.

NRCan and the US Department of Energy engaged through the Regulatory Cooperation Council on energy efficiency standards in 2014. There were significant regulatory differences, with less than 50% of products aligned. A joint work plan resolving the majority of differences was successfully implemented under the Regulatory Cooperation Council, which informed the development of four regulatory amendment packages that NRCan published between 2016 and June 2019. In fall 2019, NRCan and the US Department of Energy agreed to a new joint work plan under the Regulatory Cooperation Council evaluating whether alignment and/or consolidation of information collection is viable.

District heating and cooling

Interest in and the development of district energy has grown significantly in Canada over the past 20 years. At least 28 new systems have been commissioned since 2009, 5 of which have been commissioned since the IEA's last in-depth review.

District energy system ownership in Canada is divided between the institutional, government and private sectors. District energy is predominantly district heating using steam or water as a heat transfer medium. While district cooling does exist in city centres (e.g. Enwave's Deep Lake-Water Cooling in Toronto) and many educational campus settings, it is difficult to justify it over in-house chillers. Co-generation,[1] allowing the system to provide electricity to the grid, is not common in Canada due to the limitations of its electrical grids.

The technologies in Canada vary, depending on the location (local fuel sources) or the size of the system. A combination of fuels is often used to optimise the economic operation of the system. From the most recent inventory survey, over 80% of systems use at least one fossil fuel (natural gas or oil) for providing thermal energy. However, 34% of reporting systems indicated using at least one renewable fuel (biofuel [includes biomass, biodiesel, and biogas], geo-exchange or solar thermal). Comprehensive data on detailed fuel consumption of district systems are limited.

[1] Co-generation refers to the combined production of heat and power.

International collaboration

Canada has been an active leader and participant in international collaboration efforts on energy efficiency. The government sees collaboration as an important element to staying up-to-date on emerging trends and best practices, sharing Canada's experience with partners around the world, and incorporating insights into domestic policy making and strategies.

Canada's participation includes serving as the chair of the IEA's 4E Technology Collaboration Programme (2020-22), a steering committee member of the United Nations' Global Alliance for Buildings and Constructions, a leading role in the Clean Energy Ministerial's Energy Management Working Group, vice-chair of the Energy Efficiency Hub as well as a member of the Three Percent Club.

Canada also co-leads several initiatives under the Clean Energy Ministerial, which contribute to efficiency, electrification and fuel switching across the economy. Specifically, Canada co-chairs the Electric Vehicle Initiative, which fosters greater electrification of transport; the Biofutures Initiative, which encourages greater production and use of clean fuels across the economy; and the Hydrogen Initiative, which is the cornerstone of global collaboration on growing a hydrogen economy.

Assessment

Canada has made progress in decoupling economic growth and energy consumption. Its gross domestic product grew by 24% between 2009 and 2019 and its population increased by 12%, while total final consumption increased by only 12% over the same time frame, thanks to improvements in energy efficiency.

This is also shown in the reduction of energy intensity. Electricity consumption per capita fell by 7% between 2009 and 2019, and total energy consumption per GDP decreased by 10% over the same period. However, Canada's energy intensity is still one of the highest in the IEA and energy demand is still growing, suggesting that significantly more progress can be made.

Notably, energy efficiency can play an important role in reaching Canada's net zero emissions target, as well as the GHG emissions target for 2030 by applying the "energy efficiency first" principle. Under the Pan-Canadian Framework, energy efficiency measures will account for one-third of the planned emissions reductions to 2030, estimated at 28.3 Mt, including 11.2 Mt for buildings, 10.4 Mt for equipment and 6.7 Mt for industry. However, the path toward this outcome should be elaborated for greater clarity, especially on sectoral contributions. In particular, energy use trends in each sector should be further analysed to identify least-cost solutions for energy efficiency and decarbonisation.

Moreover, there could be more data analysis to follow up on the impacts of energy efficiency measures. New targets will be developed under the new Strengthened Climate Plan.

Energy efficiency is a policy area where the federal and provincial governments share responsibility. The federal government works with stakeholders to develop model building codes, which can then be adopted and enforced by provinces. Provinces can opt to set their own standards, adopt federal regulations and standards, or a combination of the two.

The federal Energy Efficiency Regulations set appliance standards for products that cross internal and international borders – which represents the vast majority of appliances and equipment used in Canada. The federal government has engaged in extensive dialogues with provinces to advance energy efficiency, including through aligned building codes and equipment regulation. NRCan co-chairs the Steering Committee on Energy Efficiency with the provinces and territories, which serves as a platform to facilitate discussion toward a long-term, co-ordinated approach to accelerating both energy efficiency and demand-side management in Canada.

Canada also recognises that different provinces have different needs based on the structure of their economies, geographies and energy options. Therefore, energy efficiency policies and programmes can differ between provinces. Many provinces have run their own energy efficiency programmes for some time, in some cases supported by federal funding. Furthermore, the question of energy costs and addressing energy poverty will remain of paramount importance in the context of energy efficiency policies throughout Canada.

Buildings

The buildings sector includes residential buildings (53% in 2019) and service sector buildings (47%). Energy consumption in this sector increased by 11% between 2009 and 2019, driven by increased floor area; energy efficiency gains were achieved in terms of energy consumption per floor area, which decreased by 16% between 2008 and 2018 in the residential sector. Most of the energy used in the buildings sector is provided by natural gas (44%) and electricity (41%), followed by oil (10%). Bioenergy, mainly solid biomass, is primarily used in the industrial sector and accounted for 5% of total buildings sector consumption in 2019.

In August 2017, NRCan released Build Smart: Canada's Buildings Strategy, in collaboration with provinces and territories. Build Smart, which falls under the PCF, outlines Canada's plan to transform its buildings sector, articulating federal, provincial and territorial commitments in moving toward a clean energy future by making homes and buildings more energy efficient.

Moreover, Canada has expanded its toolbox of policies to achieve energy efficiency outcomes in buildings, including updated codes and standards; information and capacity building initiatives; financing and incentives; and technology and innovation options.

In particular, strong building codes can yield significant results in reducing energy consumption from buildings. The government plans to publish more stringent model energy codes for new homes and buildings in late 2021. The new codes for adoption by the provinces and territories include tiered energy performance targets, with the highest tiers representing net zero energy ready levels of construction. Under Build Smart, provinces and territories have committed to adopting the net zero energy ready level by 2030 for all new homes and buildings. Work is also underway to broaden the application of the 2025 cycle of model national energy codes to include existing buildings and homes. Technical research and study are underway to inform these new requirements. Given a relatively low retrofit rate of less than 1% per year currently, and the fact that around 75% of homes and buildings that exist today will still be in use 30 years from now, the upside potential from retrofits is enormous. Canada continues to support retrofits in the buildings sector through expanded financial incentives, increased consumer awareness and tools (such as ENERGY STAR Portfolio Manager), and the development of new model energy

codes for alterations to existing buildings, which it also sees as an opportunity to create jobs. However, lack of a clear definition of "net zero energy ready" can hinder investments in new technologies before the updated codes and standards are implemented by 2030.

The IEA recommends bringing the timelines for the new codes forward. In many IEA countries, net zero codes are already the norm for new buildings. In the Canadian context, the time frames associated with finalising and implementing new building codes can be lengthy, as provinces need to undergo a process of adoption and implementation that can take years. Opportunities to fast-track the process of finalising codes and helping provinces adopt and implement them, including through capacity building and skills training, should be investigated.

The federal government promotes energy efficiency in existing and new buildings through several programmes. For example, the CAD 2 billion Low Carbon Economy Fund, the CAD 950 million top-up to the Federation of Canadian Municipalities' Green Municipal Fund, and the CAD 2 billion through the Canada Infrastructure Bank for large building retrofits all represent considerable financial support to the sector. However, it is important to set targets for each financial programme in order to clearly identify desired outcomes and measure progress and success. Building codes for existing buildings can be a way of determining what types of measures these programmes should achieve.

Canada should also keep in mind the issue of energy poverty while addressing energy efficiency. Around 8% of the population suffers from energy poverty in Canada (CER, 2017), and both federal and provincial/territorial governments have policies to address it. The government should identify ways to align energy efficiency outcomes with measures to combat energy poverty. Notably, support for retrofits and promotion of better insulation, as well as support for heat pumps in space and water heating can be important for decreasing energy poverty. Currently, a low-income specific energy efficiency programme is lacking.

Transport

After a minor drop following the 2008 financial crisis, energy demand in the transport sector increased by 16% between 2009 and 2018, to slightly decrease (-0.3%) in 2019. As such, there is a particular need to lower energy demand in the sector to meet Canada's decarbonisation targets.

Canada is a large country with long distances to travel, which partly explains its high energy demand from transport. However, it is also an urbanised country where large parts of the population are concentrated in cities and urban areas. This provides an opportunity to promote public transport and modal shifts for achieving efficiency in mobility, notably by supporting the buildout of relevant infrastructure and employing appropriate price signals to shift consumer behaviour.

Vehicle standards are another part of the solution. Emissions standards for vehicle model years 2017-25 require CO_2-equivalent emissions performance improvement of passenger cars by approximately 5% per year, and emissions performance improvement of light trucks by approximately 3.5% per year over 2017-21 and 5% per year over 2022-25. The latest Heavy-duty Vehicle and Engines Greenhouse Gas Emission Regulations were published in May 2018, and apply increasingly stringent GHG emissions standards to new on-road heavy-duty vehicles and engines imported or manufactured in Canada starting with model year 2021. Furthermore, Canada's Strengthened Climate Plan committed

Canada to working to develop and align vehicle emissions standards with the most stringent levels in the United States, be they at the federal or state level.

The government also imposes an excise tax (green levy) on fuel-inefficient automobiles (including station wagons, vans and sport utility vehicles) designed as passenger vehicles and offers consumer information campaigns to motivate changes in vehicle purchases toward cleaner models.

Most energy demand in the transport sector is fuelled by oil products. Gasoline is the most used fuel, accounting for more than half (51%) of energy consumption in 2019, followed by diesel (28%). Natural gas covered 5% of consumption in transport. The use of biofuels has significantly increased in recent years, by 150% between 2009 and 2019, to reach 3% of energy consumption in transport in 2019. Within biofuels, bioethanol (72%) and biodiesel (28%) are the most common.

The federal carbon pricing system, in which the benchmark price will grow to CAD 50 by 2022, and subsequently to CAD 170 by 2030, will drive price differentials in fuels to favour cleaner options. Canada has also published Clean Fuel Regulations that will take effect in December 2022 which will support less carbon-intensive production of transport fuels, increased blending of biofuels into transport fuels and end-use fuel switching in transportation.

Only 1% of energy consumption in transport was provided by electricity, though the government envisions electric vehicles playing a much more significant role toward net zero goals. Various federal funding programmes and investments support efficient transportation, including cleaner technologies such as plug-in hybrids, full battery electric and fuel cell electric, as well as electrification infrastructure such as public chargers, EV fleets and public transit. Funding sources include the Green Infrastructure Bank, Green Infrastructure – Investing in Canada funding, the Low Carbon Economy Fund, and the Green Municipal Fund. Budget 2017 approved CAD 21.9 billion in green infrastructure over the subsequent ten years, and the Canada Infrastructure Bank allocated an additional CAD 5 billion for transport in 2019. This includes more than CAD 300 million worth of investments in EV and alternative fuel infrastructure, and CAD 150 million in zero-emission vehicles purchase incentives.

In 2019, the federal government set non-binding targets for ZEVs reaching 10% of new light-duty vehicle sales per year by 2025, 30% by 2030 and 100% by 2040. Since then, the federal government has announced the intention that by 2035, all new light-duty vehicle sales will need to be ZEVs. Budget 2019 provided CAD 300 million for a new federal purchase incentive programme to encourage Canadians to buy or lease eligible ZEVs (CAD 2 500-5 000 per car). An additional CAD 287 million was allocated to the federal incentive programme in fall 2020. The federal government also announced in Budget 2019 a 100% first-year tax write-off for company investments in ZEVs to support business adoption.

However, given the rate of penetration of EVs required to meet longer term emissions targets, the government should consider a ZEV mandate, which would drive increased supply of EVs. Such a policy has already increased the availability of EVs in the provinces of Quebec and British Columbia compared with the rest of the country. Notably, Canada is in a rather unique position, having the option to develop a complete value chain of battery production domestically, given its advanced technologies; world-class research; advanced

manufacturing talent; and its abundance of critical minerals such as lithium, nickel, copper, graphite and cobalt.

Canada also supports its sizeable freight industry to reduce fuel consumption and save on fuel costs, including through the Smartway partnerships, fuel efficient driving curriculum and green freight programming.

More broadly, Canada would benefit from a national strategy on decarbonisation of the transport sector that could serve as a guiding tool for enabling regulations, financial incentives and technological solutions. Currently, the policies with respect to transport have been developed in separate stages rather than taking a more holistic approach to the sector.

Industry

The industrial sector in Canada accounted for one-third of TFC in 2019. Energy demand peaked in 2004 and then fell, but has plateaued since 2010. In industry, the largest share of energy consumption consists of oil, at 36% in 2019, natural gas (28%) and electricity (24%). Bioenergy covered 8% of industrial demand in 2019, consisting mainly of solid biomass (96%), with some contributions from industrial waste (3%) and biogases (1%).

Reductions in industrial energy consumption and emissions will also form an important component for Canada to meet its 2030 targets as well as its net zero goals by 2050. Emissions in energy-intensive industrial sectors are primarily covered by various federal and provincial systems that are designed to price emissions while minimising competitiveness risks. While these policy measures will be an important driver for energy efficiency improvements in industry, more targeted policies are needed to complement these efforts, especially to drive deeper reductions in energy consumption needed to meet net zero targets.

The industry sector faces a number of barriers to adopting and implementing energy efficiency measures in Canada, including access to timely and granular data on energy consumption; fragmentation of standards and regulations across the country; and access to financing.

Currently, NRCan's industrial energy efficiency programme helps industry improve energy efficiency through the implementation of energy management systems standards such as ISO 50001. NRCan also collaborates with the US Environmental Protection Agency on the ENERGY STAR for industry programme. Canada can build upon the ISO 50001 certification process to combine it with more incentives or regulations. Specific support should target small and medium-sized enterprises that do not have the resources or competencies to undertake reviews of energy management systems on their own.

Moreover, implementation of energy management systems and energy audits often requires the use of external competencies. The government should expand the promotion of training and education in order to increase the role and strengthen the capacities of energy service companies.

Notwithstanding limitations due to the disparate regulatory models across jurisdictions, Canada should also step-up work with provinces and territories to improve the availability of energy consumption data. Without adequate data on energy consumption, it is difficult to follow up on energy savings or results from energy efficiency measures. It could also

make it more difficult to carry out an energy audit if data are not available or difficult to access. Improved data collection could also underpin benchmarking efforts that can drive better outcomes.

Recommendations

The government of Canada should:

- Develop a comprehensive energy efficiency strategy in consultation with provinces and territories that analyses and identifies the potential for energy efficiency in each region and sector (buildings, industry and transport), and sets clear targets for energy efficiency for each sector.
- Expedite the development and implementation of retrofit and net zero energy ready building codes to well before 2025 and 2030, respectively.
- Set outcome-based targets for each financial programme targeting energy efficiency in buildings; ensure that these programmes also address energy poverty.
- Strengthen policies to drive energy efficiency in the transport sector, including through the establishment of a zero-emission vehicle mandate and more targeted policies to promote a modal shift in transport (including increased use of public transport, cycling and walking in urban centres) through price signals and integrated city planning.
- Promote energy management systems, including the implementation of results from energy audits, in industry more actively, either through incentives or regulations, especially to support the uptake among small and medium-sized enterprises.

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5. Renewable energy

Key data (2019)

Renewables in total final energy consumption (TFEC): 40.9 Mtoe (hydro 26.8 Mtoe, bioenergy 11.5 Mtoe, wind 2.3 Mtoe, solar 0.3 Mtoe). 22% of TFEC (IEA average:* 13%)

Renewables in electricity generation (2020): 435.1 TWh (hydro 384.6 TWh, wind 36.1 TWh, bioenergy 10.1 TWh, solar 4.3 TWh). 68% of electricity generation (IEA average:* 27%)

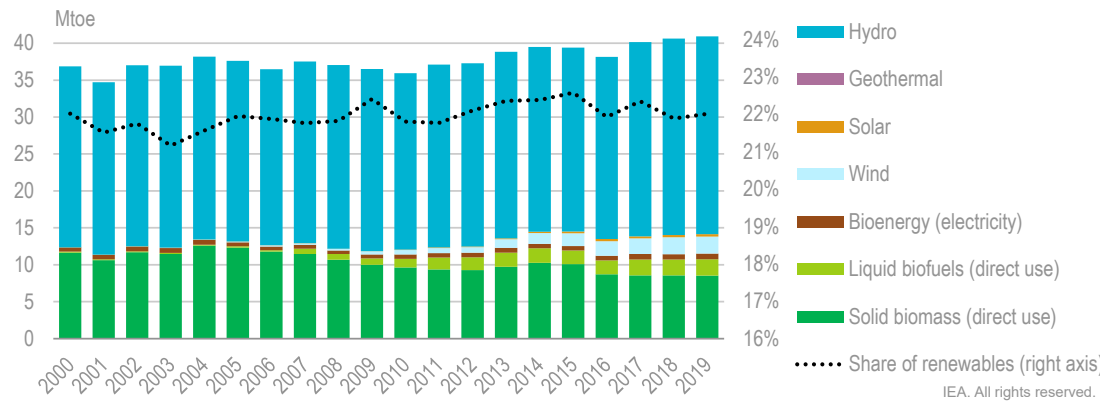
Renewables by sector: industry 34%, buildings 31%, transport 4%

* Weighted average of IEA member countries.

Overview

In Canada, the share of renewables in total final energy consumption (TFEC) has fluctuated at around 22% since 2009, as the increase in renewable energy (17% between 2009 and 2019) corresponded to an increase in TFEC (14% between 2009 and 2019) (Figure 5.1). Renewable energy in Canada is dominated by hydropower, which is the main source for electricity generation and accounted for 14% of TFEC in 2019. Bioenergy (6% of TFEC in 2018) mainly consists of solid biomass used in industry and in the residential sector, with some contributions by biofuels in transport and small shares of biogas injected in the grid. Wind and solar have experienced rapid growth in the past decade, but still accounted for only 1.2% and 0.2% of TFEC, respectively, in 2019.

Figure 5.1 Renewable energy in total final energy consumption in Canada, 2000-19



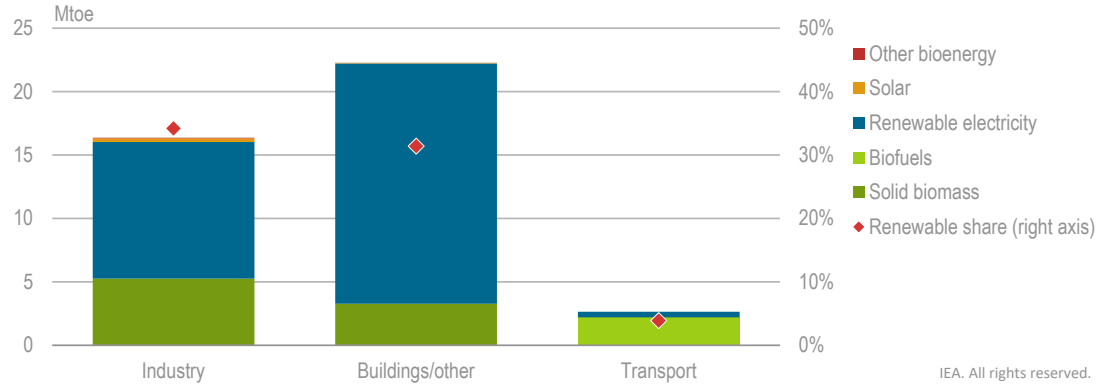
Renewable energy supply in Canada is dominated by hydro electricity generation, but wind and liquid biofuels increased between 2009 and 2019.

Note: Mtoe = million tonnes of oil equivalent.
Sources: IEA (2021), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

In 2019, renewables covered 34% of energy demand in industry, 31% in buildings/other and 4% in transport (Figure 5.2). Most renewable energy consists of renewable electricity used in the buildings/other sector, where it covered 27% of the sector's consumption, and 23% in industry, but the direct use of solid biomass also had significant shares in these two sectors. In transport, biofuels accounted for 3% of total consumption and electricity for 1%.

In a comparison among IEA member countries, Canada ranked tenth for the share of renewables in TFEC (Figure 5.3) in 2019. While Canada ranked sixth for the share of renewables in electricity generation, the penetration of renewables in heat generation is much lower.

Figure 5.2 Renewable energy in Canada in each sector, 2019

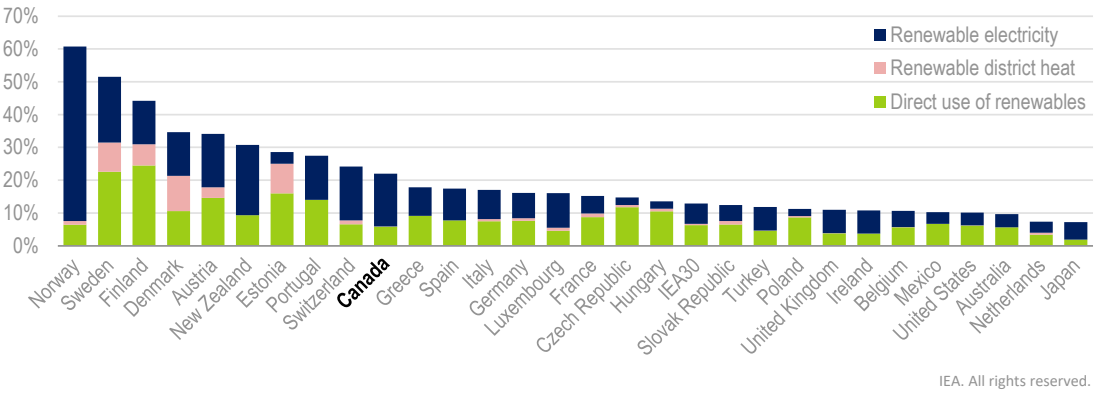


Renewables covered 34% of energy consumption in industry and 31% in buildings, but only 4% in transport.

Note: Mtoe = million tonnes of oil equivalent.
Source: IEA (2021), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Given Canada's biomass advantage, there is also significant opportunity for a range of biomass feedstocks to be used for producing and exporting clean fuels and clean energy.

Figure 5.3 Renewable energy in total final energy consumption in IEA countries, 2019



Canada ranked tenth among IEA countries for renewable penetration in total final energy consumption in 2019.

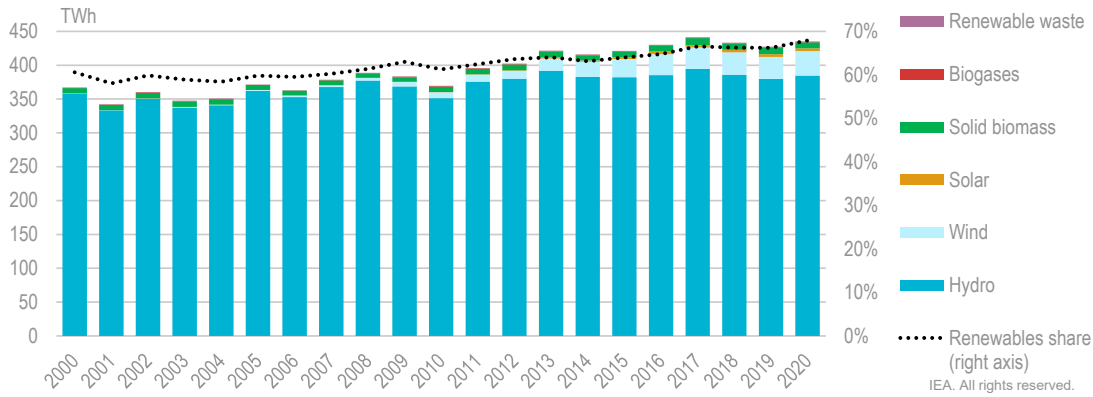
Source: IEA (2021), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Renewable energy supply

Renewable electricity

Renewable electricity generation was 435 terawatt hours (TWh) in 2020 and accounted for 68% of total electricity generation. Hydro is the main source of electricity in Canada, accounting for 60% of total electricity generation in 2020. The past decade has been characterised by rapid growth of electricity generation from wind and solar (though growth has slowed in more recent years). Electricity generation from wind increased fourfold between 2010 and 2020, when it reached 36 TWh, or 5.6% of total electricity generation, while generation from solar photovoltaic (PV) increased from 0.3 TWh to 4.3 TWh in the same time frame, to reach 0.7% of total generation. Electricity from bioenergy (mainly solid biomass) increased by 11% in the decade from 2010 to 2020, and accounted for 1.6% of the total in 2020.

Figure 5.4 Renewable energy in electricity generation in Canada, 2000-20



Hydro accounts for most renewable electricity, but generation from solar and wind increased notably between 2010 and 2015, while the growth rate has slowed down in more recent years.

Note: TWh = terawatt hour.
Sources: IEA (2021), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Canada is well-endowed with a natural resource advantage in hydro, making it the fourth-largest hydropower producer in the world by capacity (IHA, 2021). Notably, Canada's hydropower potential is more than double its current capacity, spread across all regions (Canadian Hydropower Association, 2020).

Several new large-scale hydro projects have been commissioned in recent years that are expected to be in service by 2024: the Site C project in British Columbia (1 100 megawatts [MW]); the Muskrat Falls project in Labrador (824 MW); the Keeyask project in Manitoba (695 MW); and the La Romaine 4 project in Quebec (245 MW) (IHA, 2021). In addition, several small hydro projects are also progressing. Though there are a number of additional promising sites for new hydro projects from a technical perspective, it remains an open question whether these would be developed given the high costs associated with recent projects. Instead, more recent investments have been moving toward variable renewables and storage.

Building on strong recent growth, variable renewable energy capacity is expected to keep growing in the future, as a number of projects will be commissioned in the coming years

and as provinces and territories invest to decarbonise their electricity systems and electrify their economies. The Canada Energy Regulator forecasts that wind capacity will triple over the next 20 years, driven by favourable market conditions and an abundant, high-quality wind resource. Solar PV is currently mostly located in Ontario, but British Columbia, Saskatchewan and Alberta are also seeing strong growth. In contrast, rooftop solar has not seen much uptake in Canada compared to other countries, given existing access to affordable electricity for ratepayers.

Notably, based on the levelised cost of electricity, wind and solar have proven to be competitive with other sources of generation in recent years. However, some impediments that have slowed progress to date include: weak load growth and electricity surpluses in large markets such as Ontario, British Columbia and Quebec; market structure barriers to corporate power purchase agreements (PPAs), impediments to distributed generation and energy storage in vertically integrated, regulated electricity markets; and shifting policy frameworks (such as to carbon pricing, tariff structures and net metering rules) in provinces such as Ontario and Alberta (see Chapter 7).

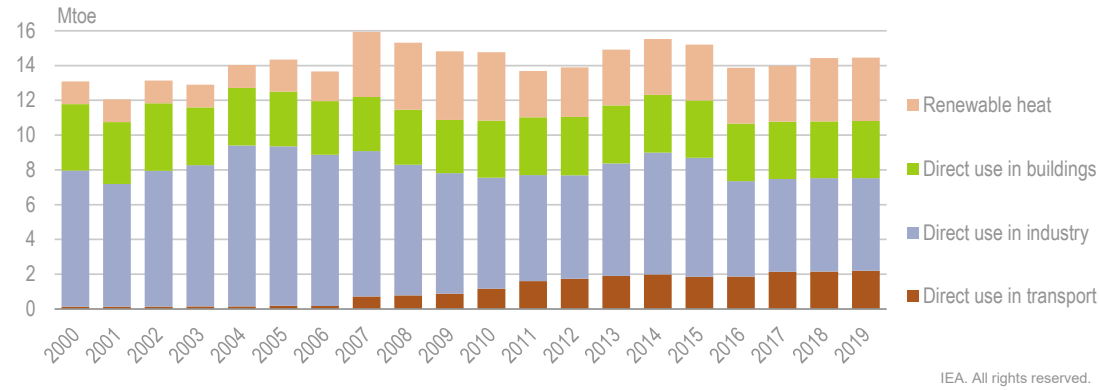
Canada's penetration of variable renewables is around 6%, which is manageable for existing provincial grids, though expected future growth in wind and solar will increase the importance of variable renewable integration. Canada plans to promote a reliable and flexible grid by bolstering regional interconnections, increasing the flexibility of existing power plants and deploying more flexible non-emitting technologies, moving toward a distributed model through the deployment of smart grid technologies and fostering regulatory innovations, and by deploying storage technologies and developing local supply chains. Notably, the dominant role that hydroelectricity plays in several Canadian provinces, along with the fact that many hydro projects in Canada are large and have sizeable reservoirs, will significantly assist with the integration of variable generation (see Chapter 7).

Direct use of renewables and renewable heat

Renewables are also used as a direct source of energy and to produce heat (Figure 5.5). In 2019, 5.3 million tonnes of oil equivalent (Mtoe) of renewable energy was directly used in the industry sector. These consist mainly of solid biofuels, with a small share of biogas. Direct use of renewables in industry decreased by 23% between 2009 and 2019. In the buildings sector, 99% of the 3.3 Mtoe of renewable energy used in 2019 was solid biomass in the residential sector. While renewables in buildings have fluctuated and overall increased by 7% between 2009 and 2019, the transport sector experienced by far the largest increase in the decade, more than doubling the direct use of renewables from 0.9 Mtoe in 2009 to 2.2 Mtoe in 2019 (see next section and Figure 5.6 for more details). In 2019, 3.7 Mtoe of renewable municipal waste was used to produce heat in heating or co-generation[1] plants.

[1] Co-generation refers to the combined production of heat and power.

Figure 5.5 Direct use of renewables and renewable heat in Canada, 2000-19



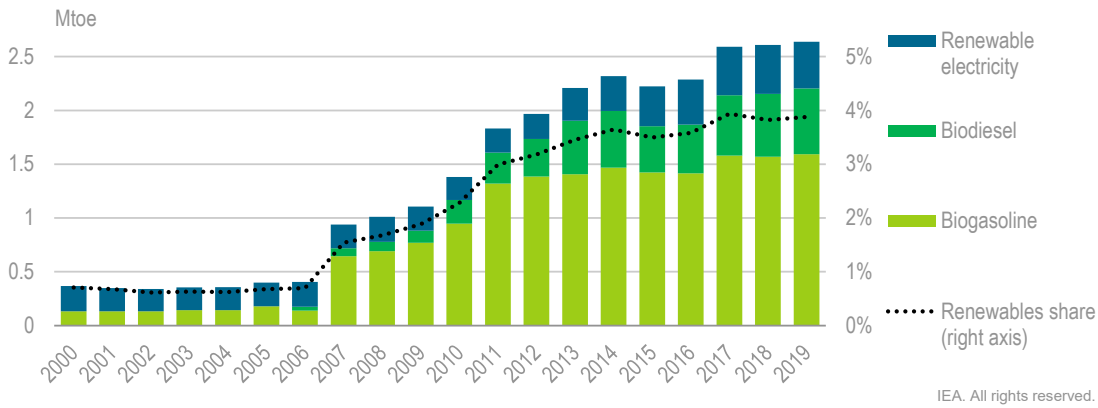
While direct use of renewables either decreased or was stable in industry, buildings and heat, renewables in transport increased by 150% between 2009 and 2019.

Note: Mtoe = million tonnes of oil equivalent.
Sources: IEA (2021), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Renewables in transport

Renewables in transport consist mainly of biofuels (Figure 5.6). In 2019, ethanol provided 1.6 Mtoe, biodiesel 0.6 Mtoe and renewable electricity 0.4 Mtoe, for a total of 2.6 Mtoe of renewable energy used in transport. This corresponds to 3.9% of total energy used in the sector, which has more than doubled since 2009, when renewables in transport amounted to 1.1 Mtoe or 1.9% of the energy demand in transport. This evolution is thanks to the Renewable Fuel Regulation.

Figure 5.6 Renewable energy in transport in Canada, 2000-19



Renewables in transport consist mainly of biogasoline and biodiesel.

Note: Mtoe = million tonnes of oil equivalent.
Sources: IEA (2021), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Renewable energy policies

Through a number of programmes and initiatives, the government of Canada is demonstrating its long-term commitment to reducing greenhouse gas (GHG) emissions

and supporting provinces and territories as they transition to energy systems in which renewable energy covers an increasing share of energy use.

Federal fiscal measures

As part of the Strengthened Climate Plan announced in December 2020 (see Chapter 3) and Budget 2021, the government of Canada also outlined a number of investments, which may directly or indirectly support renewable energy and electrification, inculding:

- CAD 964 million to advance smart renewable energy and grid modernisation projects.
- CAD 300 million in rural, remote and indigenous communities.
- CAD 8 billion over seven years to expedite decarbonisation projects, support industrial transformation and develop clean technologies.
- CAD 1 billion over five years to leverage private investments toward large transformative clean technology projects. This initiative will eliminate risk from decarbonisation projects for traditional lenders, bringing down the cost of capital, and making many of these large-scale projects more economically feasible.
- CAD 1.5 billion in a Clean Fuels Fund to support the buildout of new clean fuel production capacity, the establishment of sustainable biomass supply chains, and the development of critical codes and standards.
- CAD 227.9 million over eight years to implement a Low-Carbon Fuel Procurement Program within the Greening Government Fund.
- Up to CAD 35 million to help establish British Columbia's Centre for Innovation and Clean Energy, with a focus on clean fuels and carbon capture, utiisation and storage.
- CAD 287 million to further support the existing Incentives for the Zero-Emission Vehicles Program (initially launched with CAD 300 million of funding) for both personal and commercial vehicles as well as an additional CAD 150 million over three years to the existing Zero Emission Vehicle Infrastructure Program (initially funded with CAD 130 million through Budget 2019) to support the deployment of charging and refuelling stations across Canada.
- CAD 5 billion in public transit, with CAD 1.5 billion to expand and accelerate the adoption of zero-emission buses and to procure 5 000 zero-emission public transit buses and school buses by 2025.
- A number of investments to support energy efficiency measures in buildings, which may include renewable energy investments on site: CAD 2.6 billion over seven years, starting in 2020-21 to help homeowners improve their home energy efficiency, and CAD 1.5 billion over three years for green and inclusive community buildings retrofits.
- CAD 166 million over seven years to support the agricultural industry in developing transformative clean technologies and help farmers adopt commercially available clean technologies.

Moreover, as part of its recovery plan from the Covid-19 pandemic, the Canada Infrastructure Bank plans to invest CAD 10 billion in major infrastructure projects across the country, of which CAD 2.5 billion would be devoted to clean power generation, transmission and storage over three years. This is part of a broader goal for the Canada Infrastructure Bank to invest CAD 5 billion in clean power initiatives in the medium term (CIB, 2020).

Canada also provides two tax incentives to promote business investment in clean energy generation equipment that uses renewable energy (e.g. wind, solar, geothermal) or energy

from waste (e.g. landfill gas, wood waste), or conserves energy (including in the use of fossil fuels). Since the IEA's last in-depth review, the scope of these provisions has been expanded to cover electric vehicle charging equipment, electrical energy storage equipment, and a broader range of geothermal energy projects and expenses. The two incentives are:

1. Capital Cost Allowance (CCA) Classes 43.1 and 43.2: provide capital cost allowance rates of 30% and 50%, respectively, for qualifying investments. Such investments currently benefit from an enhanced first-year allowance of 100%, subject to a phase-out commencing in 2024.

2. Canadian Renewable and Conservation Expense: allows certain intangible start-up expenses associated with projects eligible for the above-noted CCA Classes 43.1 and 43.2 to be deducted in full in the year incurred, carried forward indefinitely for use in future years or transferred to investors using flow-through shares.

As part of its Budget 2021 announcements, Canada proposed the following tax incentives that will have an impact on the renewables sector:

- A 50% reduction in the general corporate and small business income tax rates for businesses that manufacture zero-emission technologies, including wind turbines, solar panels, equipment used in hydroelectric facilities, geothermal energy systems, electric vehicles, batteries and fuel cells for vehicles, electric vehicle charging and hydrogen refuelling systems, and certain energy storage equipment. It also includes the production of biofuels from waste materials and hydrogen by electrolysis of water. The reductions would take effect on 1 January 2022 and be gradually phased out starting 1 January 2029 until they are eliminated by 1 January 2032. It is estimated that this measure will reduce federal revenues by CAD 45 million over five years, starting in 2021-22.
- An expansion of the eligible equipment in CCA Classes 43.1 and 43.2 and Canadian Renewable and Conservation Expense measures to include equipment used in pumped hydroelectric energy storage, renewable fuel production, hydrogen production by electrolysis of water and hydrogen refuelling, while also removing certain restrictions on water-current, wave and tidal energy; active solar heating; and geothermal energy technologies. It was also proposed to update eligibility criteria so that certain fossil-fuelled and low efficiency waste-fuelled electrical generation equipment will no longer be eligible after 2024. It is estimated that these measures will reduce federal revenues by CAD 142 million over five years starting in 2021-22.

Prior to the more recent suite of measures, fiscal support programmes to support renewables in power and heat have centred on the ecoENERGY for Renewable Power (ecoERP) and the ecoENERGY for Renewable Heat (ecoERH) programmes, which ended their authority to enter into new contribution agreements on 31 March 2011 (although payments for existing agreements will continue until March 2021). EcoERP, a 14-year long programme, supports 4 458 MW of renewable energy capacity, including hydro, wind, solar PV and biomass, by providing a production incentive of 1 cent per kilowatt hour for up to ten years for electricity generated from eligible renewable energy projects.

The federal government is also investing CAD 200 million in the Emerging Renewable Power Program, which supports the deployment of renewable energy technologies that are commercially available but have yet to be deployed in Canada, like geothermal and tidal. Federal investment is helping derisk upfront capital investments in emerging renewable power projects to expand the portfolio of commercially viable, investment-

ready, renewable energy technologies and support the development of new supply chains. The programme's funding has been fully allocated, but payments will continue until April 2023. Eligible technologies include: offshore wind, geothermal (both hot fractured rock and sedimentary rock resources), tidal and advanced photovoltaic. Investments have included tidal projects in Nova Scotia and a geothermal project in Alberta (Government of Canada, 2021a).

Moreover, the Smart Grid Program is investing CAD 100 million to support the deployment and demonstration of smart grid integrated systems on the existing electricity grid. The programme supports projects from utilities, electrical system operators, and transmission owners and operators. Funding has been fully allocated, but payments will be disbursed until 2023. One of the stated objectives of the programme is to increase renewable energy integration within Canada's electricity grids. Given the focus on grid modernisation, much of the renewable energy investment within supported projects is distributed and small scale.

Emissions regulations

In 2021, Canada strengthened its GHG reduction pledges, including a floor of 36% below 2005 levels in its Budget 2021 and a target of 40-45% below 2005 levels at the April 2021 Leaders Summit on Climate hosted by the United States. Canada announced that the target of 40-45% below 2005 levels by 2030 would be included in its updated nationally determined contribution under the Paris Agreement.

This added more ambition to its 2016 national climate plan, the Pan-Canadian Framework on Clean Growth and Climate Change (PCF). In December 2018, Canada published amendments to regulations to accelerate the phase-out of conventional coal-fired electricity generation (see Chapter 7). Coal-fired units are now required to meet a 420 tonnes of carbon dioxide per gigawatt hour (t CO_2/GWh) performance standard either at their "end-of-life" or by 31 December 2029, whichever comes first. The emissions standard for large gas power plants is the same, (and is higher for small gas power). These regulations have the effect of supporting early conversion of coal-fired units to natural gas more than investments in renewable energies.

In order to prevent coal plant closures from leading to a "dash for gas", the government announced that it is exploring the need for a clean electricity performance standard, which would aim to reduce the CO_2-equivalent emissions intensity of electricity production and help support increased investment in cleaner sources of electricity generation.

Canada's carbon price, applied to fossil fuels and large industrial facilities (see Chapter 3), can also help increase the role of renewables in the energy system. The federal carbon price started at CAD 20 per tonne of CO_2-equivalent (t CO_2-eq) in 2019, with a trajectory to rise by CAD 10 annually to CAD 50 t CO_2-eq in 2022. More recently, in 2021, the government committed to increase the carbon price by CAD 15 per tonne annually to CAD 170/t CO_2-eq in 2030.

The Strengthened Climate Plan also includes a national emissions reduction target of 30% below 2020 levels by 2030 for the fertiliser sector. The government estimates that since 2005, direct emissions from nitrogen fertiliser production have increased by around 60%. As such, the government plans to work with fertiliser manufacturers, farmers, provinces and territories to develop an approach to cut emissions, which could help drive increased production and use of renewables.

However, the Strengthened Climate Plan does not include indicative targets specifically for renewable energy deployment in any sector.

Through the Greening Government Strategy, the federal government is also taking steps to reduce emissions and increase the role of renewables in its own operations, including a goal for the government's fleet of light-duty vehicles to be comprised of at least 80% zero-emission vehicles by 2030; requiring all new federal buildings (including build-to-lease and public-private partnerships) to be net zero carbon unless a life cycle cost-benefit analysis indicates net zero carbon ready construction; and targeting that government buildings use 100% clean electricity by 2022, where available, and by 2025, at the latest, by producing or purchasing renewable electricity; and investing in the procurement of clean fuels for use in government aviation and marine operations (Government of Canada, 2021b).

Offshore renewables

In recent years, Canada has taken concrete actions to develop its offshore renewable energy potential, and improve market and regulatory certainty for industry, investors and stakeholders. For instance, the Canadian Energy Regulator Act (which replaced the National Energy Board Act) came into force in 2019 and establishes a legislative framework for the construction and operation of offshore renewable projects and their associated power lines in federal offshore areas. Moving forward, Natural Resources Canada (NRCan) will work to develop safety and environmental protection regulations under the Canadian Energy Regulator Act for offshore renewable energy, while at the same time pursuing discussions with interested coastal provinces for the joint management of offshore renewable energy.

Through the Emerging Renewables Power Program, the federal government is also supporting the emergence of a marine renewable energy industry in Nova Scotia by funding two in-stream tidal projects, each with an installed capacity of 9 MW. A third tidal energy demonstration project in Nova Scotia is being funded by the Energy Innovation Program (Government of Canada, 2021c). The programme is also supporting marine renewable energy standards development (Government of Canada, 2021d). These projects are located at FORCE, Canada's lead research facility for tidal stream technology.

Geothermal

While geothermal energy has been used for residential heating for decades in Canada, geothermal power production is a nascent industry in the country. Through the Emerging Renewables Power Program, the government of Canada is supporting the emergence of this source of generation by supporting the deployment of the country's first four geothermal projects across Western Provinces.

Biomass

As a heavily forested country, accounting for 9% of the world's forests and 9% of the world's forest product trade, Canada also has strong potential for forest biomass. Approximately three-quarters of the country's managed forests are certified as sustainably managed. Though around 85% of Canada's bioenergy comes from forest biomass, biomass as a whole accounts for only around 4% of total energy supply. Canada is undertaking a number of research projects to support the increased use of forest biomass

in the bioeconomy, including a project support the technological development of sustainable biorefineries.

Given Canada's biomass advantage, there is significant opportunity for a range of biomass feedstocks to be used for producing clean fuels and clean energy. Furthermore, because Canada's forest and agricultural feedstocks are recognised as highly sustainable, Canadian clean fuels can be attractive to other foreign markets like the European Union, which has imposed strict sustainability requirements on clean liquid fuels and solid biofuels.

Challenges do exist. As feedstocks can account for up to 70-90% of production costs, clean fuel producers need a reliable and timely supply of raw materials or feedstock in close proximity to production facilities. Increasing domestic clean fuel production cannot happen without robust domestic supply of biomass feedstock.

Existing agriculture and forest product supply chains are mostly developed to meet traditional markets for biomass (e.g. lumber, pulp and paper, food and feed). Existing and emerging biofuel production technologies have different feedstock affordability, quality specifications and economies of scale than those of traditional forest and agricultural products. Delivery of a secure supply of feedstock, at the required specifications (e.g. quantity and quality) is critical for biofuel production facilities to meet their yield, production and financial goals. Biomass supply chain hubs can act as central locations to gather and pre-process feedstock from diverse sources and locations, and ensure that clean fuel producers receive a sufficient quantity of high-quality feedstocks.

The Clean Fuels Fund (see below) includes a biomass supply chain component, which will ensure a steady and usable supply of sustainable feedstock is available to clean fuel production facilities across the country. It will, for example, support the establishment of regional hubs to gather feedstock from diverse sources and locations. Establishing sustainable supply chains will benefit farmers, grain handlers, forest harvest operators, sawmills and municipal waste services by opening up new opportunities for both traditional feedstocks, like canola and wood processing residues, as well as new markets for waste streams for producing advanced clean fuels.

Provincial policies

Provincial governments have exclusive jurisdiction over the development and management of energy resources in their respective provinces, including decisions related to electricity market design. As such, they lead in developing policies and programmes to support the growth of renewable energy within their borders.

To this end, Canadian provinces have put in place competitive procurement requests for proposals, standard offer contracts, feed-in tariffs, renewable portfolio standards, small equipment rebates, tax credits, etc. The drivers behind the growth of renewables vary, depending on the province's situation and objectives for GHG emissions reductions, local economic development and energy diversification. As such, Canada has not only a vast renewable resource potential, but also a rich experience of deploying renewable energies in different electricity systems, energy markets and under different forms of support schemes and grid operation (see Chapter 7).

There are quantity-based or price-based power procurement methods. The first mechanism sets a minimum quantity of energy or capacity from renewable power within a

certain time frame, through requests for proposals/tenders or renewable portfolio standards, and the market establishes the price. The standards are adopted by the Atlantic provinces of Nova Scotia and New Brunswick. In the price-based method, long-term contracts are set by technology at a pre-arranged price, through feed-in tariffs or standard offer contracts, and the market subsequently determines the capacity or energy. In addition to tenders, carbon pricing mechanisms also support the development of renewable energy, as they encourage the use of clean fuels.

Provincial renewable energy targets include: 93% renewable or clean electricity in British Columbia (already exceeded); 30% renewable electricity in Alberta by 2030 (with interim targets); 50% renewable electricity in Saskatchewan by 2030; and a 25% increase in renewable energy production by 2030 from 2013 levels in Quebec (already 99% in electricity).

Corporate power purchase agreements

In many countries, direct corporate procurement of renewable energy in the form of PPAs has proven to be an effective mechanism to promote the expansion of renewables in the electricity sector. Nonetheless, Canada has lagged behind a number of markets such as the United States and Europe in this regard. One of the main impediments to the growth of corporate PPAs in Canada is the vertically integrated, regulated utility model that is prevalent in most Canadian jurisdictions.

However, the corporate PPA sector has been experiencing recent growth in Alberta, which has a fully deregulated electricity market along with strong wind and solar resource potential (Becker, 2019). For example, Royal Bank of Canada, which has a goal to source all of its electricity from clean sources by 2025, recently signed a PPA with two Alberta-based solar developers, resulting in 80 000 MWh of renewable electricity connected to the grid annually starting in 2021 (Graney, 2021). The province's emissions regulations for large industrial consumers could also increase demand for renewables procurement as a compliance strategy (Wilson, 2020). Nova Scotia has plans to enable corporate procurement of renewables as well.

Expanding access to renewable energy

Given that over 200 northern, remote and Indigenous communities in Canada are reliant on diesel for heat and power generation, which has negative economic and environmental implications, the government of Canada has committed to support Indigenous, remote and rural communities to be powered by clean, reliable energy by 2030. The Clean Energy for Rural and Remote Communities (CERRC) Program is investing CAD 220 million to support the deployment and demonstration of renewables solutions and strengthen local capacity to reduce diesel reliance in rural, remote and northern communities and off-grid industrial sites. The programme is technology neutral and targets commercially available, medium to large (250 kilowatts [kW] to >1 MW) renewable energy solutions. Funding has been fully allocated, but payments will be disbursed until 2026.

Complementing the CERRC Program, the Northern Responsible Energy Approach for Community Heat and Electricity (Northern REACHE) Program (under implementation) targets the deployment of commercially available small to medium renewable energy systems (up to 249 kW), co-generation, heat pumps, energy efficiency measures, technology demonstrations and capacity building for indigenous and northern

communities. This includes all communities north of the 60th parallel, Nunavik and Nunatsiavut. Since 2018-19, Indigenous and Northern Affairs Canada has been investing CAD 53.5 million over ten years and CAD 5.4 million in ongoing funding for the Northern REACHE Program.

Last, the Arctic Energy Fund invests CAD 400 million to support energy security, reliability and efficiency in fossil fuel-dependent communities in the territories, including indigenous communities. The Arctic Energy Fund provides funding for communities to upgrade existing fossil fuel-based energy systems or to supplement or replace these systems with renewable energy options, which contributes to improved reliability, efficiency and pollution reduction.

Buildings

In the buildings sector, in 2017, the government launched Build Smart: Canada's Building's Strategy, in collaboration with provinces and territories, to increase energy efficiency and reduce CO_2 emissions from buildings. This strategy supports actions under the PCF, and includes a plan for increasingly stringent national model energy codes for new buildings, calling for new buildings to be net zero energy ready by 2030. The government is also currently developing the first model energy codes that will trigger improved energy efficiency for alterations to existing buildings (to be announced in 2022 and to take effect by 2025), as well as a new fiscal support programmes to support deeper home energy retrofits (see Chapter 4). These measures could help increase the role of renewables in the buildings sector.

Clean fuels policies

Canada already has a high share of renewables in electricity, led by hydropower, and is dedicating policy efforts to expanding the role of renewables in other sectors, especially in transport. To this end, in addition to clean power, Canada sees strong potential for clean fuels to play a significant role in its net zero future.

Clean fuels represent an opportunity for Canada to transition its existing energy sector to a future low-carbon economy, thereby supporting innovation, competitiveness, and energy security while providing a new revenue stream from forest and agriculture residues, as well as municipal solid waste. They include hydrogen, advanced biofuels, renewable natural gas, sustainable aviation fuel and synthetic fuels.

Today, these fuels make up less than 6% of Canada's total energy supply, but between 10%-51% (or up to 60% according to some projections) of Canada's national energy demand is expected to be met with clean fuels in 2050 to reach its net zero goal. The rapid deployment of clean fuels will be necessary for Canada to meet its GHG mitigation targets in 2030 and 2050.

Canada also sees a competitive advantage to leverage its existing expertise, abundant and diverse range of sustainable feedstocks and infrastructure that can be used to produce a variety of biofuels and bio-products, helping to grow its circular economy and become a global leader in the clean fuels space. Clean fuels can also help decarbonise Canada's conventional energy sector and reduce reliance on fossil fuels by the country's industrial sector.

In December 2020, Canada published the Hydrogen Strategy for Canada, which is designed to spur investment in hydrogen production and create partnerships that establish Canada as a global supplier of hydrogen. It shows that by 2050, hydrogen could contribute up to 30% of Canada's energy mix, supporting sizeable CO_2 reductions. In addition, Canada's CAD 82.5 million/year Energy Innovation Program recently allocated an additional CAD 25 million over five years to develop codes and standards to support the Hydrogen Strategy for Canada.

First announced in the Strengthened Climate Plan and reaffirmed in Budget 2021, on 21 June 2021, Canada launched the Clean Fuels Fund, a CAD 1.5 billion programme over five years to support the buildout of new clean fuel production capacity, establish biomass supply chains, and develop enabling codes and standards. The fund will derisk the capital investment required to build or expand clean fuels production facilities and support a broad suite of clean fuels, including hydrogen, renewable diesel, renewable natural gas and co-processed biocrude in existing refineries. The Clean Fuels Fund will support the implementation of the Clean Fuel Regulations and the Hydrogen Strategy for Canada.

Bioenergy will be a key part of the transformation that Canada is undergoing. Announced in 2006, the Renewable Fuels Regulation (RFR) requires an average of 5% renewable fuel content in gasoline (since 2010) and 2% renewable fuel content in diesel fuel and heating distillate oil (since 2011), for each compliance period. The regulations came into force in August 2010. As a result of amendments in 2013, heating distillate oil volumes for space heating purposes were exempted from the requirements. The regulations include provisions that govern a trading system of compliance units. Refiners are already overcomplying with the regulations on ethanol, blending on average 7% of ethanol into gasoline and are meeting the 2% blended requirement of biodiesel into diesel. With the development of the new Clean Fuel Regulations (CFR) from 2022 (see below), the RFR will be repealed in 2024 with the last compliance period in 2022.

Provinces also have blending mandates and other regulations to support biofuels. Five provinces (Alberta, British Columbia, Manitoba, Ontario and Saskatchewan) have mandates equivalent to or stronger than the federal RFR, while Quebec has draft regulations underway. Alberta and Ontario also have carbon intensity requirements for renewable fuels while British Columbia already has a low-carbon fuel standard in place.

Canada has also historically offered fiscal support to grow the production of biofuels and support the development of next-generation biofuels, including: the CAD 500 million NextGen Biofuels Fund to support the production of next-generation biofuels; the CAD 200 million ecoAgriculture Biofuels Capital Initiative to support farmers and feedstocks (ended in 2012); and NRCan's CAD 1.5 billion ecoENERGY for Biofuels (ecoEBF) programme that provided production incentives to stimulate domestic biofuels production (ended in 2017). Canada's Budget 2021 also announced tax measures to support clean technologies, including in the clean fuels space, through an expansion of CCA Classes 43.1 and 43.2 to include additional clean energy technologies and a 50% reduction in the general corporate and small business income tax rates for businesses that manufacture zero-emission technologies.

In part due to investments from federal and provincial governments, and the RFR, the Canadian biofuels industry grew from a production capacity of just over 200 million litres of ethanol and no commercial biodiesel plants in 2005 to approximately 2 billion litres of ethanol and 650 million litres of biodiesel in 2020, placing Canada eighth in the world for

overall biofuels production capacity. The government estimates that by 2030, total demand for low-carbon liquid fuels (i.e. ethanol, biodiesel, renewable diesel) will be 2.5 times greater than 2020 levels in the transportation sector, largely driven by climate change policies. Currently, around 80% of feedstock for ethanol comes from corn, while half of biodiesel feedstock comes from canola oil.

Nonetheless, at present, Canada is a net importer of biofuels. In 2019, Canada imported roughly 45% of its annual ethanol consumption and close to 100% of biodiesel and renewable diesel consumption. Canada exports most of its biodiesel, with 84% of its annual domestic production exported to the United States due to favourable policy incentives.

Still, Canada expects that its sizeable biomass resources could position it to serve international markets, especially as jurisdictions look for sustainable feedstock options. Canada foresees that it can make use of its abundant sustainable feedstocks, along with its innovation in fuels and technology and its existing petroleum refining infrastructure that can be repurposed to co-process biogenic material, to produce a variety of low-carbon fuels, including ethanol, renewable diesel, sustainable aviation fuel and renewable natural gas. It is also exploring using municipal waste as a feedstock for clean fuels, with benefits for the circular economy. Advanced Biofuels Canada estimated that capital investments of CAD 6 billion by 2030 would result in 12-20 new or expanded biofuels facilities, increasing production by 5.5 billion litres and creating 40 000 jobs and contributing CAD 15 billion per year in economic output (Advanced Biofuels Canada, 2019).

Canada sees particular global opportunities in the renewable diesel space given its low life cycle GHG emission profile and drop in fuel properties. Building off its expertise, the government also expects that in the longer term, Canada can become a leader in the export of clean hydrogen. An estimated 3 million tonnes (Mt) of conventional hydrogen is already produced annually for industrial use, making Canada one of the top 10 global hydrogen producers. This includes about 0.3 Mt of electrolytic hydrogen, making Canada the top producer in the world. Canada also has world-renowned hydrogen and fuel cell companies, which currently employ 2 200 workers and generate over CAD 200 million in revenues, predominantly from export. The recently released Hydrogen Strategy for Canada estimates that the combined global and domestic market represents at least a CAD 50 billion opportunity by 2050, similar in scale to the oil sands today. The strategy is designed to spur investment in hydrogen production and create partnerships that establish Canada as a global supplier of hydrogen. It shows that by 2050, hydrogen could contribute up to 30% of Canada's energy mix, which could lead to a reduction of up to 190 Mt CO_2 (see Chapter 3).

Clean Fuel Regulations

The CFR were first announced as part of the PCF in 2016 and form an integral part of Canada's Strengthened Climate Plan from December 2020. The regulation, which will come into effect in 2022, will require liquid fossil fuel (e.g. gasoline, diesel) suppliers to steadily reduce the carbon intensity of the fuels they produce and import for use in Canada, leading to a decrease of approximately 13% (below 2016 levels) in the carbon intensity of liquid fuels used in Canada by 2030. The government estimates that the CFR will reduce GHG emissions by more than 20 Mt in 2030, along with providing an incentive to switch to low-carbon fuels and technologies through a market-based approach. They are designed to complement carbon pricing, through a more targeted approach for transformation of fuel production to support longer term decarbonisation.

The CFR require improvements in the life cycle carbon intensity of liquid fossil fuels over time that will support the development and deployment of lower carbon biofuels and alternative technologies such as hydrogen and electric vehicles.

The CFR replaces the federal RFR blending requirement with a carbon intensity approach, but maintains blending requirements. Obligated parties (producers and importers of liquid fossil fuel used in Canada) can generate credits to meet the requirements of the regulation using three options:

1. reducing the life cycle carbon intensity of fossil fuels (such as through carbon capture and storage, on-site renewable electricity generation, or co-processing)
2. supplying low-carbon fuels (such as ethanol and biodiesel)
3. investing in advanced vehicle technologies (such as electric or hydrogen fuel cell vehicles).

In 2022, obligated parties would need to reduce the carbon intensity of their fuels by 2.4 g CO_2-eq/megajoule (MJ), rising to 12 g CO_2-eq/MJ in 2030 (Government of Canada, 2021e). The requirements only apply to liquid fossil fuels used domestically, not to exports.

The regulation also includes several compliance flexibilities to help mitigate compliance costs and ensure robust supply of credits, including:

- A credit clearance mechanism, which regulated parties with credit shortfalls may use to buy voluntarily pledged credits at a government-imposed price, with a maximum of CAD 300 per credit in 2022, indexed to inflation.
- A Compliance Fund mechanism where regulated parties can contribute up to 10% of their annual obligation at a price set by the government, proposed at CAD 350 in 2022, indexed to inflation.
- A carry-forward option in which regulated parties can carry forward up to 10% of their annual obligation for up to two years with 20% interest.
- Cross “fuel class” credits, under which regulated parties can use credits from actions to reduce the life cycle carbon intensity of gaseous fuels (e.g. natural gas) and solid fuel (e.g. petroleum coke) for up to 10% of their annual obligation.

The regulation completed its last comment period in March 2021, with final regulations due to be published in late 2021. The reduction requirements will take effect in December 2022.

Assessment

Canada is rich in renewable energy resources, in particular hydro and wind, which has allowed it to achieve a considerable penetration of renewables in its electricity sector. As a result, Canada already has among the cleanest electricity generation profiles among IEA countries, ranking sixth in terms of the share of electricity generation from renewables in 2020. Canada’s future challenges are to build on this success to significantly expand the role of renewables, not just in electricity in provinces and territories where fossil generation is still substantial, but also in the heating and transport sectors, as it strives toward deeper emissions reductions and net zero emissions by 2050.

While hydropower dominates the Canadian electricity mix, variable renewable sources such as wind and solar account for a relatively small share of total electricity generation (6.3% in 2020).

Initially, largely due to provincial and federal support, wind and solar installations grew rapidly. Wind energy capacity grew from 3 282 MW in 2009 to 13 413 MW by the end of December 2019. Similarly, solar PV capacity grew from just 107 MW in 2009 to 3 327 MW by the end of 2019. However, between 2016 and 2019, wind and solar energy saw only moderate growth: around 480 MW of new wind installations and 221 MW of solar per year.

Canada also possesses significant biomass potential. However, biomass energy, which could generate power on demand and be used for baseload generation, currently produces less than 2% of Canada's electricity generation.

Canada's biomass potential from its forestry and agricultural feedstocks could be turned into sustainable clean fuels that can be attractive to foreign markets such as the European Union, which have strict sustainability requirements on clean liquid fuels. The government of Canada is helping to address some challenges associated with creating a robust domestic feedstock supply chain, including through the Clean Fuels Fund.

Provinces and territories have jurisdiction over their natural resources and decide the pace and extent of resource development, including electricity generation, transmission and distribution, as well as the development and deployment of renewable energy. Notably, recent tenders in provinces such as Alberta and Quebec have shown positive results. The government of Canada has introduced complementary measures to support the deployment of renewable energy technologies.

However, recent growth of renewable energy sources has been limited by a number of factors, including: weak load growth and electricity surpluses in major markets like Ontario, Quebec and British Columbia; barriers to corporate procurement of renewable energy resulting from vertically integrated regulated utility structures in most of Canada's electricity markets; shifting policy frameworks in key markets like Ontario and Alberta; and market and regulatory frameworks that create barriers to the deployment of distributed generation and energy storage.

Canada identifies deeper regional grid integration and electricity trade across Canadian jurisdictions and the North American continental grid through strengthened interconnections as a key driver for further deployment of renewable energy generation capacity in areas of Canada with significant renewable energy potential. Spurred by grid decarbonisation efforts and electrification, this improved grid connectivity will provide opportunities to more fully harness renewable energy resources in Canadian jurisdictions where internal electricity demand is not sufficient (see Chapter 7).

A few federal programmes that used to support energy production from renewable energy sources have either ended or have already allocated all their funding, which means they are not available to new investors. Among such programmes are the Wind Power Production Incentive Program, the ecoENERGY for Renewable Power and ecoENERGY for Renewable Heat Programs, and the CERRC Program for medium to large renewable energy solutions. The Emerging Renewable Power Program, supporting the deployment of renewable energy technologies like geothermal, tidal energy, offshore wind and advanced solar energy, has also fully allocated its funding, which will be paid by April 2023.

Several support programmes aim to reduce diesel reliance in rural, remote and northern communities, including indigenous communities, and off-grid industrial sites.

Complementing the CERRC Program, whose funding has already all been allocated, the Northern REACHE Program targets the deployment of commercially available small to medium renewable energy systems (up to 249 kW). The Arctic Energy Fund provides funding for communities to upgrade existing fossil fuel-based energy systems or to supplement or replace these systems with renewable energy options.

Besides that, the government of Canada is working on improving regulatory conditions for offshore wind. As part of the Canadian Energy Regulator Act, a new legislative framework for the construction and operation of offshore renewable projects and their associated power lines in federal offshore areas was introduced in 2019. NRCan is planning to develop safety and environmental protection regulations under the Canadian Energy Regulator Act for offshore renewable energy, while at the same time pursuing discussions with interested coastal provinces for the joint management of offshore renewable energy.

The Smart Grid Program supports projects from utilities, electricity system operators, and transmission owners and operators focusing on the deployment and demonstration of smart grid integrated systems on the existing electricity grid, which will support increased renewable energy integration in Canada's electricity grids.

The government of Canada provides two tax incentives – CCA Classes 43.1 and 43.2, and the Canadian Renewable and Conservation Expense – to promote business investment in clean energy generation equipment that use renewable energy, energy from waste or conserve energy (including in the use of fossil fuels). Since the IEA's last in-depth review in 2015, the scope of these tax incentives has been expanded, including most recently in the government's Budget 2021. The government's most recent budget also proposed a 50% reduction in the general corporate and small business income tax rates for businesses that manufacture zero-emission technologies.

Renewable energy sources in the electricity sector face a number of market access challenges. Vertically integrated utilities in the regulated electricity markets of Canada do not guarantee grid access for renewable energy generators and, if/when they do, they do not always allow electricity sales through PPAs. The federal government can help inform provincial and territorial regulatory reforms that create a more enabling environment for renewables in a context of rapid changes in the electricity space.

Moreover, Canada's regulations to phase out conventional coal-fired electricity generation by 2030 have the effect of supporting early conversion of coal-fired units to natural gas more than investments in renewable energies.

Currently Canada does not have a certificate trading system for renewable electricity similar to the one in Europe. A green certificate is an official record proving that a specified amount of green electricity has been generated, which represents the emissions reduction value of renewable energy production. The certificates can be traded separately from the energy produced. Green certificates could facilitate investments across different provinces, since investors, including regulated utilities, would not be bound to their home provinces when taking investment decisions. Using certificates, a utility could offer its consumers a choice of the power sources they would like to consume and create an opportunity for the utility to green its production mix independently from its home location. However, such programmes should be carefully structured to avoid granting windfalls to power suppliers without additional renewable capacity produced.

As part of the Strengthened Climate Plan from 2020, the Canadian government is also considering the need for and timing of a clean electricity performance standard to ensure that all investments in electricity generation are consistent with the goal of net zero emissions by 2050.

Furthermore, the Strengthened Climate Plan envisions a number of investments, which may directly or indirectly support renewable energy and electrification, including grid modernisation projects, funds to increase production and scaling up of clean technologies, support for zero-emission vehicles and infrastructure, and investments in upgrading energy efficiency in buildings. The impact of these investments on the expansion of renewable energies will largely depend on the design of respective support programmes.

In the buildings sector, the government of Canada is intending to develop a new retrofit code for existing buildings by 2025 and for new buildings by 2030. Renewable energy minimum standards for retrofitting houses are currently not considered, but could provide additional impetus for increasing the role of zero-emision fuels in home heating/cooling.

In addition to clean power, Canada sees strong potential for clean fuels to play a significant role in meeting its 2050 net zero target. Canada considers that clean fuels represent the most effective way for hard-to-abate industries such as cement, steel, heavy-duty transport, and oil and gas to lower their emissions. Its recently launched CAD 1.5 billion Clean Fuels Fund is expected to support these ambitions, as are the Clean Fuel Regulations and the Hydrogen Strategy for Canada.

Canada introduced draft CFR in December 2020, designed to complement carbon pricing. Regulated parties must reduce the carbon intensity of liquid fossil fuels by 2.4 g CO_2-eq per megajoule in 2022, increasing to 12 g CO_2-eq/MJ in 2030. Liquid fossil fuels include gasoline and diesel, which are mainly used in transportation, and to a lesser extent for machinery in industry. Once the regulation takes effect, scheduled for December 2022, the policy will likely drive increased penetration of renewable fuels in Canada's energy mix.

The main regulatory measure suggested in the Strengthened Climate Plan is a more ambitious federal benchmark for carbon pricing, starting at CAD 50 in 2022 and increasing by CAD 15 per year to CAD 170 in 2030. Over time, such levels of carbon pricing should also provide additional economic incentives to switch from fossil fuels to renewable fuels across sectors, especially considering the low local prices for oil and natural gas in Canada.

However, the Strengthened Climate Plan does not include targets for renewable energy deployment in any sector. The lack of such targets might negatively affect investment decision making due to related insecurity over demand for renewable sources. Concrete targets can help clarify the planned energy mix pathway and guide private sector investment decisions better.

Moreover, while there are plans to introduce polices to reduce GHG emissions in transport and industry, which may indirectly lead to the electrification of these sectors, there is no clear electrification strategy for these sectors. Such a strategy would help clarify expected load growth and the role that renewables can play in the longer term energy mix.

Recommendations

The government of Canada should:

- Encourage provinces and territories to clarify the process of grid access and remuneration for renewable electricity to facilitate investments and stimulate corporate power purchase agreements.
- Consider introducing an interprovincial green certificates trading system to empower consumer choice and support renewables generation investments.
- Consider minimum renewable standards for upcoming regulations in the buildings sector to guide investments in renewable energy.
- To encourage investments in renewable energy, introduce indicative economy-wide and sectoral renewable energy targets, complemented by incentives, especially for heating and industry.

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6. Energy research, development and innovation

Key data (2020* estimated)

Government energy RD&D budget: CAD 1 371 million (USD 1 022 million)**

Energy R&D of GDP: 0.62 per 1 000 GDP units (IEA median:** 0.34)

* RD&D budget data in this chapter refer to the fiscal year; for example, 2020 refers to 1 April 2020 to 31 March 2021. All data are in 2020 prices.

** Conversion based on 2020 prices and exchange rates.

*** Median of 27 IEA member countries for which 2019 data are available.

Overview

Energy innovation is expected to play a key role in Canada's energy future. In fact, the 2016 Pan-Canadian Framework on Clean Growth and Climate Change (PCF) includes clean technology and innovation as one of four key pillars. While existing technologies have significant near-term emissions reductions potential, it is expected that Canada will need to rely on emerging technologies to achieve net zero emissions by 2050.

In 2020, Canada's public budget for energy-related research, development and demonstration (RD&D) was CAD 1 371 million. In real terms, this is a return to the level of the 2013 peak, following a sharp decline to CAD 707 million in 2016 (based on 2020 prices). While the 2013 peak and subsequent dip were linked to provincial and territorial spending on the execution of several large carbon capture, utilisation and storage (CCUS) projects, the last five years' growth has been spread across more projects and technology areas. In particular, government energy RD&D spending on energy efficiency almost tripled between 2010 and 2020. On the other hand, spending on nuclear energy decreased by 61% over the same decade. Canada met its Mission Innovation pledge to double federal spending on clean energy R&D by 2020, with actual spending of CAD 786.8 million in 2019-20, exceeding its target of CAD 775 million.

Canada ensures strong linkages between its federal R&D programmes and other aspects of energy and climate policy, in large part because of their co-location within Natural Resources Canada (NRCan). For example, federal laboratories and other NRCan technology experts are closely involved in policy discussions, and provide scientific and technical support to other government departments working on clean energy innovation programming (e.g. Innovation, Science and Economic Development Canada). These efforts are also aligned with the climate policy agenda of Environment and Climate Change Canada.

Several initiatives related to energy technology innovation have been launched or announced since 2020 as part of Canada's Strengthened Climate Plan, *A Healthy Environment and a Healthy Economy,* and Budget 2021. These include:

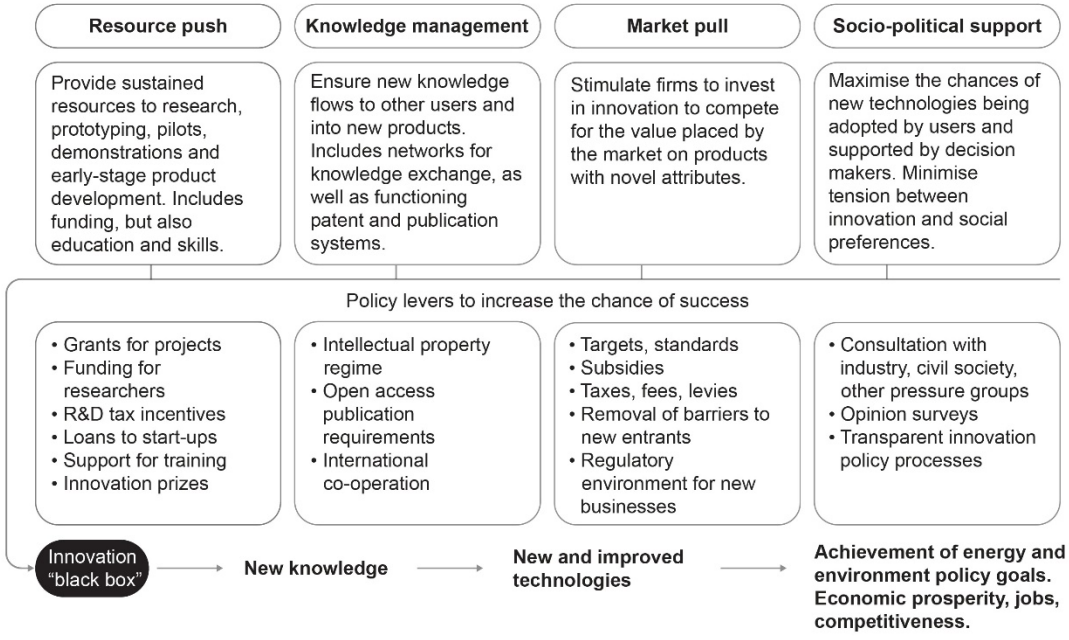
- CAD 8 billion over seven years for a Strategic Innovation Fund – Net Zero Accelerator. Through the Net Zero Accelerator, Canada will scale up its support for projects that will help decarbonise heavy industry, commercialise clean technologies and help meaningfully accelerate domestic greenhouse gas emissions reductions (GHG) by 2030. While this fund is of general application, it is anticipated that it will include investments in emerging energy technologies (CAD 3 billion in the Strengthened Climate Plan, with an additional CAD 5 billion announced in Budget 2021).
- Up to CAD 1 billion over five years, on a cash basis, to help draw in private sector investment for transformative, large-scale clean technology projects which require investment at a scale and time horizon outside of the scope of traditional project financing as part of the "Propelling Clean Tech Projects" initiative (Budget 2021).
- CAD 75 million for the deployment of emissions-reducing technologies and related RD&D in the offshore sector through the Emissions Reduction Fund (announced in April 2020).
- CAD 750 million over five years to Sustainable Development Technology Canada to support start-ups and to scale up companies to enable pre-commercial clean technologies to successfully demonstrate feasibility as well as to support early commercialisation efforts (Strengthened Climate Plan).
- CAD 319 million over seven years to support RD&D that would improve the commercial viability of CCUS technologies. In addition, the government committed in its Strengthened Climate Plan to develop a comprehensive CCUS strategy for Canada (Budget 2021, Strengthened Climate Plan).
- CAD 36.8 million over three years for federal R&D to advance critical battery mineral processing and refining expertise; and a further CAD 9.6 million over three years to create a Critical Battery Minerals Centre of Excellence to co-ordinate federal policy and programmes; work with provincial, territorial and other partners; and help implement the Canada-US Joint Action Plan (Budget 2021).
- CAD 35 million in partnership with the government of British Columbia to help establish the Centre for Innovation and Clean Energy to advance the scale-up and commercialisation of clean technologies in the province and across Canada (Budget 2021).
- Commitments to use public procurement to support emerging clean technologies across Canada's economic sectors, such as technologies to reduce emissions in federal buildings and to reduce embodied carbon in construction materials as part of an updated Greening Government Strategy (Strengthened Climate Plan).

This chapter introduces the primary priority-setting documents, followed by the main actors in Canada's energy innovation ecosystem. It then describes the implementing actions and funding, organised by the pillars of the IEA framework for assessing energy innovation policies (Box 6.1). The chapter closes with a review of Canada's approach to monitoring and evaluation of innovation performance and an overall assessment, followed by recommendations.

Box 6.1 IEA framework for energy innovation policies

Technology innovation processes are complex and decision makers must pay attention to a variety of elements that characterise successful energy innovation systems (IEA, 2020a). The IEA groups these elements into four core functions: A) resource push; B) knowledge management; C) market pull; and D) socio-political support (Figure 6.1).

Figure 6.1 The IEA's four functions of a successful innovation ecosystem for energy



Source: IEA (2020b), *Tracking Clean Energy Innovation: A Framework for Using Indicators to Inform Policy*, https://www.iea.org/reports/tracking-clean-energy-innovation.

While the appropriate policy measures to address each function can vary widely with the size of a country's economy, the technologies it prioritises and the strength of its existing research and development (R&D) base, successful energy innovation ecosystems have effective policies in each of the four areas. In some cases, the policies might operate at different levels, such as local, national or municipal.

- **Resource push:** A sustained flow of R&D funding, a skilled workforce (e.g. researchers and engineers) and research infrastructure (laboratories, research institutes and universities) is required. These resources can come from private, public or even charitable sources, and can be directed to specific problems or basic research.
- **Knowledge management:** Knowledge should flow smoothly between researchers, academia, companies, policy makers and international partners, among others.
- **Market pull:** The expected market value of new products or services must be high enough to make the R&D risks worthwhile, and this is often a function of market rules and incentives established by legislation. If the market incentives are high, then much of the risk of developing a new idea can be borne by the private sector.
- **Socio-political support:** There needs to be broad socio-political support for new products or services, despite potential opposition from those whose interests might be threatened.

Energy innovation priorities and guiding documents

Through Budget 2017, the government of Canada committed CAD 2.3 billion to clean technology innovation in support of a clean growth policy agenda, as outlined in the main overarching frameworks, including the PCF, which states clean technology, innovation and jobs as a core pillar. In 2017, the government also launched Generation Energy – a national dialogue on energy transformation – through which innovation has been identified as a fundamental component to the energy transition, including for: switching to clean power by powering the economy with clean electricity; wasting less energy by increasing energy efficiency; growing the use of low-carbon fuels; and producing cleaner oil and gas.

The PCF provides the overarching guidance for energy innovation policy in Canada. This strategic document stresses the need to focus innovation on clean energy technologies. While it does not mention specific technology prioritisation, it instructs the Canadian government to undertake actions to address weaknesses in four areas:

- Building early-stage innovation: new approaches to R&D, including innovative partnerships with the private sector; and mission-oriented approaches to R&D.
- Accelerating commercialisation and growth: co-ordination of support to clean technology businesses among federal, provincial and territorial governments; increased funding for these businesses to bring products to market; strengthening of support for skills development; expediting immigration of relevant skilled personnel; promoting exports; and shaping international standards.
- Fostering adoption: public sector adoption of clean technologies; supporting Indigenous peoples and northern and remote communities to adopt clean technologies; improving the relationships between regulators and industry; and creating markets for clean technology products, including through certification.
- Strengthening collaboration and metrics for success: co-ordinate policies and programmes and share data and best practices between governments; and regularly collect and publish comprehensive data on clean technology in Canada to inform decision making and innovation.

Since the IEA's 2015 review of Canada's energy policies, Canada has experimented with new innovation policy tools with the aim of implementing the PCF and improving the match between innovators' needs and public support offerings. For example, the Clean Growth Hub was created as a whole-of-government focal point to support clean technology stakeholders in accessing federal supports (such as funding, regulatory advice or procurement opportunities) to advance their clean tech initiatives.

There have also been concerted efforts to match innovation programmes with broader energy policy objectives and improve monitoring and evaluation. Canada has been proactive in adopting best practices from other governments where appropriate. Among the most notable developments in the last five years are systematised partnerships with provinces, territories and the private sector; for example, by recognising and sharing evaluations of proposals, new means of supporting start-ups, and small and medium-sized enterprises, and new programme models (e.g. the Impact Canada Initiative's Clean Technology Stream).

To boost innovation and growth in priority areas, as part of the Innovation and Skills Plan, Budget 2017 launched the Innovation Superclusters Initiative, bringing together companies, researchers and academics, not-for-profit organisations, and accelerators and incubators.

Since the IEA's last review in 2015, NRCan has evolved its approach to one that identifies the problems to be solved to advance the transformation of the energy system, while also examining priority areas for Canadian technology development. Priorities and innovation policy tools follow budget cycles, however, and several programmes are ending soon; there is currently little visibility on future technology priorities for R&D.

Key actors in Canada's energy innovation ecosystem

The federal government plays an important role in energy R&D in Canada, and complements efforts of provincial and territorial governments. For example, data indicate that federal energy RD&D spending in Canadian fiscal year 2018-19 was CAD 678 million, just over 40% higher than provincial and territorial spending combined. The federal government seeks to tie these efforts together in support of national goals and outcomes, and guide the efforts of the private sector and academia. At the federal level, these activities, and most of the funding, are led by NRCan. Further, NRCan co-ordinates between federal organisations that also perform energy R&D, such as the National Research Council, Environment and Climate Change Canada, and Agriculture and Agri-Food Canada, among others.

Canada's federal government supports external research through various tools. These include funding externally led projects; convening stakeholders (e.g. innovators, adopters, investors, business incubators and accelerators, and indigenous communities); and facilitating R&D collaboration across Canada's energy innovation ecosystem. Overall, the federal government helps address market failures (e.g. spillovers) and reduce the risks and costs of energy technology development and commercialisation.

The private sector in Canada also constitutes a fundamental part of the energy innovation ecosystem. One such example is Canada's Oil Sands Innovation Alliance. This industry-led alliance of oil sands producers is focused on accelerating the pace of improvements to environmental performance in Canada's oil sands through collaborative action and innovation.

Over the decade to 2019, petroleum sector R&D investments (including CCUS) averaged close to CAD 1 billion per year, representing 61% of all energy R&D investments (source: Statistics Canada). Energy-related R&D expenditures by area of technology, average of 2007-19).

In recent years, governments have been exploring new models of partnerships with the private sector to amplify the impact of investments and greatly enhance the pace and scale of clean energy adoption. For example, NRCan has partnered with the Bill Gates-led Breakthrough Energy and the Business Development Bank of Canada to deliver a first-of-kind public-private initiative called Breakthrough Energy Solutions Canada.

Business incubators and accelerators such as MaRS Discovery District and Écotech Québec, just to name a few, are playing an increasing role, supporting the private sector and working with Canadian governments to mobilise all segments of energy innovation ecosystems and drive impact.

Through research activities, Canadian universities play a critical role in linking Canada to the global pool of knowledge, technology and talent; developing young talent; and developing and advancing knowledge and its applications. The Natural Science and Engineering Research Council of Canada is the primary funding body for basic research in Canadian universities.

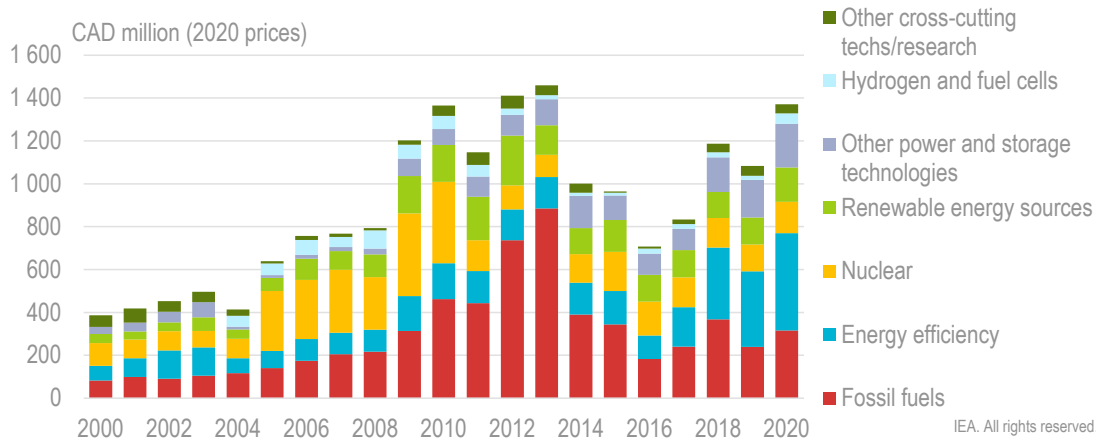
Finally, vertically-integrated, provincially regulated utilities are important actors in Canada's energy and electricity systems that typically have low regulatory incentives to innovate. While exceptions to regulatory lowest-cost provisions can be granted by provinces, and indeed unlocked well over CAD 1 billion of rate-payer funding for the Boundary Dam CCUS demonstration in Saskatchewan, discussions are at an early stage on performance-based regulation that could systematise incentives. For instance, in Ontario, facilitating innovation in the electricity sector is now a guiding objective of the province's independent regulator, the Ontario Energy Board. In British Columbia, a gas utility has been granted a CAD 25 million ratepayer-funded innovation fund. These considerations are likely to become more important given the scale of the net zero challenge. Decisions on the future of gas grids in a net zero scenario are critical near-term concerns, even if the net zero target remains three decades away.

Resource push

Public spending on energy RD&D

In 2020, Canada's public spending on energy RD&D reached its highest level since 2016 in absolute terms – at CAD 1 371 million – and as a share of GDP. It remains, however, far from the level of 0.1% of GDP in the 1980s when nuclear R&D dominated the budget.

Figure 6.2 Energy-related public RD&D spending by sector in Canada, 2000-20



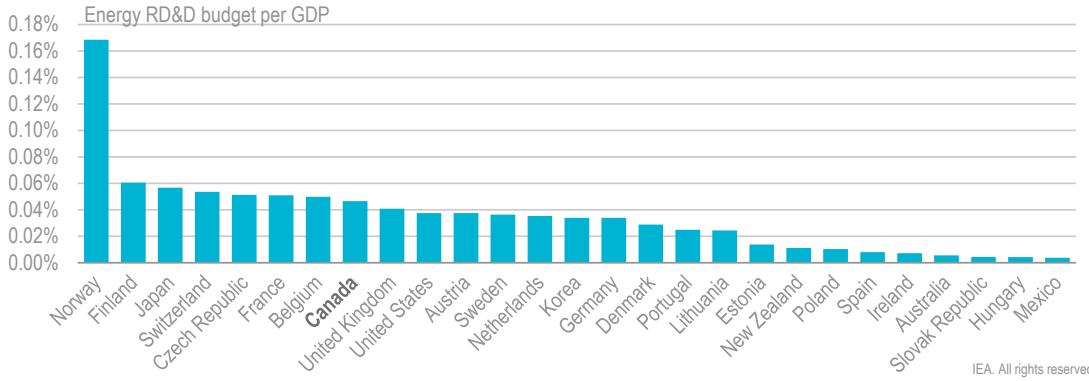
After decreasing between 2013 and 2016, public funding in RD&D has increased again in recent years, especially the share of funding for energy efficiency.

Source: IEA (2021), *Energy Technology R&D Budgets 2020*, www.iea.org/statistics.

Canada spent 0.062% of its GDP on energy-related R&D in 2020, and 0.047% in 2019 (Figure 6.3). In an IEA comparison, Canada had the eighth-highest energy-related RD&D spending per unit of GDP in 2019, above the median value of 0.034% (Figure 6.3). In 2020,

among the 17 countries for which data are available, Canada ranks third after Norway and Belgium (but data for several countries, including Finland and France, are not available for 2020 at the time of publication).

Figure 6.3 Energy-related public RD&D spending per GDP in IEA countries, 2019



Canada had the eighth-highest energy-related R&D budget in 2019 among IEA countries.

Note: RD&D = research, development and demonstration. GDP = gross domestic product.
Source: IEA (2021), *Energy Technology R&D Budgets 2020*, www.iea.org/statistics.

In 2020, energy efficiency had the largest share of combined federal and provincial public energy-related RD&D spending, at 33% of total budget, used mainly for improving efficiency in the industry and transport sectors. 12% of the RD&D budget was directed at CO_2 capture, usage and storage, and 10% at oil and gas, principally to reduce the environmental impacts of the sector.

Also in 2020, other power and storage technologies received 15% of the total budget, used mainly for RD&D in energy storage (46%) and electricity transmission and distribution (43%). Renewables received 12% of the total energy-related public budget, 49% of which was allocated to biofuels, 19% to solar, 5% to geothermal and 5% to wind energy. The funds for nuclear accounted for 11% of the total budget, 28% of which were invested in plant safety and integrity. The rest were small shares for hydrogen and fuel cells at 3%, and other cross-cutting technologies and research at 3%.

Canada joined Mission Innovation in 2015 at a time when its energy R&D funding had begun to decline from a peak that followed the financial crisis stimulus funding packages launched in 2009. As part of its Mission Innovation membership, Canada made a pledge to double its federal investments in clean energy R&D over five years, from CAD 387 million in 2014-15 to CAD 775 million in 2019-20.[1] In 2021, Canada announced that it had met and exceeded its pledge, by spending CAD 786.8 million in clean energy R&D in 2019-20. Recent commitments by the government through the Strengthened Climate Plan and Budget 2021 continue to build momentum and support for clean energy technology advancement and deployment.

[1] All federal spending reported in the IEA Survey of Energy R&D Expenditures is included in Canada's Mission Innovation reporting, with the exception of two nuclear line items: "other nuclear supporting technologies" and "unallocated nuclear fission and fusion".

Canada's energy innovation system retains a central role for the national laboratories at NRCan and the National Research Council. R&D performed at the Canmet (NRCan) facilities fulfils a critical function in advancing basic and applied R&D that is often not addressed by the private sector. Focus on these activities has been critical to advance early-stage technologies to the point where they may be advanced by the private sector. For example, Canmet leadership on CCUS in the early 1990s galvanised early data generation, scientific publications and technology demonstrations that proved the technology's viability and supported its inclusion in emissions reduction strategies. Energy RD&D in the federal laboratories supports technologies that require a boost in innovation and de-risking to ensure they are market ready – a key component to reaching net zero.

Energy RD&D at federal laboratories is funded in part through the Program of Energy Research and Development (PERD) and the Energy Innovation Program (EIP). The current budget of PERD is CAD 32 million per year and that of the EIP CAD 50 million per year. In 2021, the EIP received several limited term top-ups for specific technology issues, including CCUS (CAD 319 million over seven years) and hydrogen codes and standards (CAD 25 million over five years). PERD is limited to funding public sector researchers, while the EIP funds both internal and external proponents.

The EIP is the primary funding programme for pilot and demonstration projects of pre-commercial technologies by Canadian companies and researchers. Projects, which can range in size up to CAD 50 million, are funded in response to calls for proposals and through Trusted Partnership arrangements with provincial and territorial energy funding organisations. Project reviews are conducted by federal scientists, engineers and technical experts to ensure that high-potential projects are selected. Projects generally require co-funding at various levels with higher co-funding expected for demonstrations compared to R&D projects.

In 2018, to implement the Pan-Canadian Framework on Clean Growth and Climate Change (PCF), NRCan aimed for a more "mission-oriented" approach to the EIP. This builds on the success of the R-2000 programme in buildings efficiency (which can be traced back to the 1960s). There are currently 21 such missions in 5 groupings. The intention is to address specific technology gaps and assign measurable public-interest objectives to each mission. NRCan will make the first evaluations of the impact of this approach, and how well it links with commercialisation policies, in the coming years.

In 2017, R&D to address the environmental impact of Canada's extractive industries was separately supported through a dedicated programme that includes fossil fuels, mining and forestry. The Clean Growth Program invested CAD 155 million over five years (extended from four due to Covid). Like the EIP, it supports projects from prototype to large-scale demonstration, and can fund front-end engineering and design studies. Projects can receive from CAD 300 000 to CAD 10 million in public funds, and are also eligible to access the substantial and unique science and technology resources that exist at federal research centres under the Science and Technology Acceleration for Cleantech (STAC) model, which was developed to ensure better alignment between external funding and the R&D performed at the Canmet facilities.

The STAC model is directed towards small and medium-sized enterprises, academia, and non-profit organisations, which typically face capacity gaps impeding their ability to bring their technologies and services to markets, such as a lack of technical expertise, research infrastructure and cash flow. STAC helps to address these gaps by allowing recipients to

access the substantial and unique science and technology resources that exist at federal research centres. In addition, the STAC model allows leading experts in the federal government and in the industry to collaborate to advance clean tech solutions. Further efforts have been made to establish an institutional framework for more co-ordination between federal and provincial public laboratories.

Since 2017, under the PCF, a new programme has supported investments in green infrastructure demonstrations that can test standards, generate experience and overcome barriers to the deployment of clean energy technologies in the areas of buildings, power grids, electric vehicle infrastructure and remote communities. Only demonstration projects and front-end engineering and design studies are eligible. The total budget envelope is CAD 182 million over eight years. The green infrastructure demonstration component has a complementary deployment programme component led by other sectors in NRCan.

Impact Canada Initiative's Clean Tech Stream is an innovative funding approach launched in 2018 with a budget of CAD 75 million over four years to accelerate the pace of technology innovation and capacity building needed to address several key barriers to a cleaner future. The programme adopted diverse models, including cohort-based capacity building programmes, milestone-based prize challenges, and partnerships with the private sector and foreign governments for greatest impact. The six challenges focus on female-led innovation; sustainable aviation fuel; grid flexibility and integration; rock-crushing efficiency; supporting indigenous communities to develop and implement plans to reduce use of diesel; and revolutionising battery design in Canada. The programme has highlighted the importance of capacity building, co-creation and collaboration, and network and partnership development.

The statistics on public energy RD&D funding collected by NRCan come from approximately 30 federal departments, agencies and organisations, including NRCan, and all provincial and territorial governments. Some important energy innovation programmes and policies are outside the direct responsibility of NRCan. Among the initiatives of other departments and agencies is the Strategic Innovation Fund (SIF), operated by Innovation, Science and Economic Development Canada for projects needing over CAD 10 million. Federal funding for SMRs has largely come through Innovation, Science and Economic Development Canada's SIF. In 2020-21, SIF announced CAD 20 million to advance the Ontario-based Terrestrial Energy molten salt reactor and CAD 47.5 million to develop the New Brunswick-based Moltex Energy reactor and technology to recycle radioactive spent fuel waste into new fuel.

The SIF Net Zero Accelerator is a CAD 8 billion programme that supports projects that will help decarbonise heavy industry, support clean technologies and help meaningfully accelerate domestic GHG emissions reductions by 2030.

The Jobs and Growth Fund is a CAD 700 million programme over three years delivered by the regional development agencies to support job creation and position local economies for long term growth, which includes supporting their transition to a green economy.

Sustainable Development Technology Canada is an independent, federal foundation established to fund the development and demonstration of new sustainable development technologies related to climate change, clean air, clean water and clean soil. Since its inception in 2001, Sustainable Development Technology Canada has invested over CAD 1.28 billion of federal funds in almost 450 projects (as of March 2020).

In 2020, Canada renewed its support for Sustainable Development Technology Canada through the Strengthened Climate Plan by announcing investment of an additional CAD 750 million over five years. Innovation, Science and Economic Development Canada also operates Innovative Solutions Canada, which funds R&D and prototype testing. The National Research Council of Canada Industrial Research Assistance Program also provides advice, connections and funding to help Canadian small and medium-sized businesses increase their innovation capacity and take ideas to market. Specifically, Budget 2018 directed CAD 150 million over five years with CAD 30 million per year ongoing to the National Research Council in support of multi-party R&D programmes, with most of the funding being used to provide grants and contributions to universities and industry. The Business Development Bank of Canada and Export Development Canada are also involved in funding energy technology development.

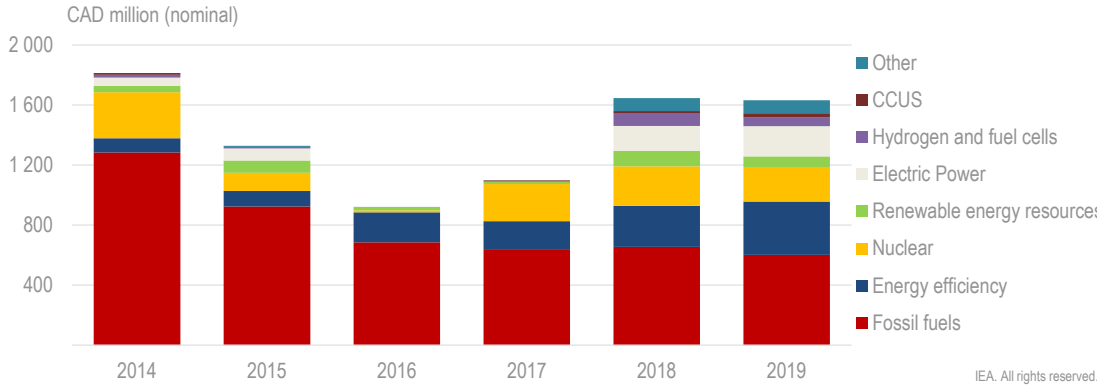
The Natural Sciences and Engineering Research Council is the main funder of basic energy research, placing the earliest stages of R&D and the development of skills and training outside the co-ordination of NRCan. Nonetheless, enhanced co-operation is advisable to ensure continuity of funding and flexibility of researchers to be able to respond to the latest needs of policy.

Private spending on energy R&D

At CAD 1 6 billion, self-reported private sector spending on energy R&D in 2019 – the latest year for which data are available – was 50% higher than that of the public sector (Statistics Canada, 2021). These data are from Canada's annual Energy Research and Development Expenditures by Area of Technology Survey, which asks companies across all sectors to report on their R&D spending in accordance with energy technology categories that are similar to the IEA technology categories. While the total reported value is not dissimilar to the value in 2014, the fossil fuel share has been in decline since dropping by one quarter in the wake of the plunge in oil prices in 2014 (Figure 6.4). It has, however, remained the area with the largest investment in energy technology in Canada. In 2018 and 2019, the total reported spending by the private sector rose, driven by increases in spending on electric power, energy efficiency and hydrogen-related technologies.[2]

[2] This analysis is based on publicly available data from Statistics Canada. However, because Statistics Canada has a responsibility to ensure that corporate confidentiality is maintained in the aggregate figures published, the publicly available dataset may not be representative of the full spending reported by all companies. Separate analysis by NRCan has identified higher spending in 2015-2017 that indicates a shallower slump of spending in those years (NRCan, 2020). In addition, unlike IEA public energy R&D spending data, the private sector survey data does not include spending on demonstration projects.

Figure 6.4 Private spending on energy R&D in Canada, 2014-19



Note: CCUS = carbon capture, utilisation and storage.
Source: Statistics Canada (2018), Research and development on energy efficiency technologies more than doubled in 2018, https://www150.statcan.gc.ca/n1/en/daily-quotidien/200925/dq200925a-eng.pdf?st=YtS7O-Jr.

Canada's federal government offers a volume-based tax credit for private R&D that provides a general 15% non-refundable tax credit (that can be carried over to future years for up to 20 years or carried back up to 3 years) on all eligible scientific research and experimental development expenditures. An enhanced refundable tax credit is available at a rate of 35% is available for eligible small and medium-sized eligible Canadian-controlled private corporations on up to CAD 3 million in eligible expenditures per year per claimant, and is fully refundable. The cost of these federal tax credits across the economy was CAD 2.6 billion in 2019 (similar tax credits are available at the subnational level). The share of tax credits, including subnational tax credits, in total public R&D support has remained relatively stable in recent years (it was about 76% in 2018), and remains above the OECD average (OECD, 2021).

Education and skills

Canada ranks fifth in the OECD for expenditure on higher education per student, 50% higher than the OECD average, and third for expenditure on higher education as a share of GDP (OECD, 2019; 2020). Roughly half of this expenditure comes from government sources. Canada ranks fourth in the OECD for the percentage of the population with a higher education degree. Of particular relevance to energy innovation, 13% of higher education graduates in Canada are in engineering, manufacturing and construction, just below the OECD average of 14%.

Knowledge management

International co-operation

Canada's approach to energy innovation is anchored in strong international collaboration. Canada is an active leader within the governance and initiatives of Mission Innovation (MI), was instrumental in shaping the second phase of MI, and takes on a vice-chair role within the MI Steering Committee. The next phase of MI focuses on ambitious, outcomes-oriented, public-private missions, as well as an Innovation Platform to advance collaboration and accelerate pathways to net zero emissions. During this phase, Canada has committed to participating in missions on green power and clean hydrogen, sharing

policy and programme experiences, co-leading the Materials for Energy initiative, and participating in the Innovation Community on Affordable Heating and Cooling.

Canada also chairs the IEA Committee on Energy Research and Technology and officially participates in 22 of the IEA's technology collaboration programmes. In addition to multilateral engagement, Canada has established bilateral initiatives in energy science, technology, and innovation (STI) with key partners such as the People's Republic of China, Germany, Japan, Korea, the United Kingdom and the United States, including joint innovation initiatives (e.g. Canada-UK Power Forward Challenge), memoranda of understanding (e.g. Canada-US on energy co-operation, Canada-Korea on Cooperation in Innovation and Energy Technologies) and joint committees (e.g. Canada-China STI Committee).

Support to start-ups and small and medium-sized enterprises working on clean energy technologies has substantially increased, as identified in the PCF. As well as more involvement of the national laboratories, one notable initiative is Breakthrough Energy Solutions Canada, with a budget up to CAD 40 million under the EIP. Built upon connections established through MI, the initiative is a partnership between NRCan and one for-profit venture capital fund, Breakthrough Energy Ventures (BEV), to identify clean energy technologies. The initiative also attracted the Business Development Bank of Canada, which brought co-financing. In the first round, NRCan and BEV chose ten companies to receive grant funding for further development of technologies, giving BEV the option of screening the companies further and taking an equity stake. The success of this policy experiment, which has parallels with elements of the ARPA-E programme in the United States but with more involvement of a private investor, and its potential for scale-up, could provide valuable insights for policy makers around the world.

Canada also co-operates on international patent families (IPFs), registering eight times among the five biggest bilateral parings for the top 10 clean energy technologies, in all instances partnered with the United States. Over 2005-19, co-IPFs related to low-carbon energy in Canada represented 29% of the total international patent families, up from 20% in 2000 (EPO and IEA, 2021).

Market pull

As described elsewhere in this report, Canada has a variety of mechanisms that create early markets for low-carbon energy products and services. These include a carbon price, a coal phase-out, nuclear plant extensions, Clean Fuel Regulations, upstream methane regulations, energy efficiency measures and vehicle emissions standards.

Such market support is often essential for channelling private investments to technologies before they are able to command a competitive advantage over alternatives that are less well-aligned with a net zero emissions future. From the perspective of innovation, these investments support cost reductions through economies of scale and learning-by-doing, as well as performance improvements that come with experience in manufacturing and use. In addition, market support policies provide a strong signal to innovators that profitable markets for clean energy technologies await, thereby stimulating research and unlocking risk capital.

The announced increase in Canada's carbon price serves this market pull function across multiple energy applications nationwide. The certainty that it will rise from CAD 50 per

tonne of CO_2 (t CO_2) in 2022 by CAD 15 annually until it reaches CAD 170 t CO_2 in 2030 is a firm signal to companies and researchers. For technologies related to liquid fuels production – like those for advanced biofuels, CCUS, hydrogen and electric mobility – the Clean Fuel Regulations will offer flexibility for regulated parties to cover up to 10% of their annual reduction requirement through the Compliance Fund mechanism, which is proposed at CAD 350 in 2022. While both systems will raise the overall costs of fossil fuel supply, they will substantially narrow the gap between the costs of using fossil fuels and low-carbon fuels. Furthermore, the economy-wide nature of the carbon price will incentivise energy efficiency innovation in order to lessen the impacts on energy bills for companies and other consumers.

Socio-political support

Canada is a leader internationally in terms of its emphasis on equity outcomes related to energy technology innovation. One objective of this approach is to create broad support across society for innovation and technological change, as well as engage a wider variety of talent in the process. The Impact Canada Initiative has prioritised funding for technologies to support clean energy in indigenous communities and tackle gender inequality in energy entrepreneurship. For gender equality, the Women in Cleantech Challenge was launched in 2018 to highlight and support female innovators to develop businesses around high potential impact technologies. The programme selected six finalists to undergo a three-year programme of incubation support and exposure to potential investors, run by a private incubator. NRCan funded the incubator to operate the programme and funded national labs to provide technical services, in addition to providing a CAD 0.25 million stipend to each finalist and CAD 1 million to the winner. The initiative has been commended for drawing attention to female energy innovators and creating a supportive environment for their development. While it will not be repeated by NRCan, the government has played a role in seeding the idea, which will be adopted by the incubator with private sector support and continued access to federal labs.

Importantly, technology innovation enjoys broad political support in Canada, with spending for fossil fuel-related research in particular surviving most political changes at the federal and provincial levels. Strong support steam from the economic benefits of investments in innovation that programmes have fostered, including as they relate to the creation of quality jobs, global market opportunities and domestic supply chains.

In recent years, hydrogen energy has emerged as a topic that crosses industrial and political divides. A policy statement entitled “A Hydrogen Strategy for Canada” was published in December 2020 following consultations with over 1 500 stakeholders from across the value chain (Government of Canada, 2021). Among the objectives of the strategy are positioning Canada to become a world-leading supplier of hydrogen technologies and contributing to economic recovery from the Covid-19 pandemic. To achieve its targets, the strategy envisages support to different hydrogen production pathways that could include roles for companies from across the energy spectrum. Like CCUS, hydrogen fits the skills and interests of Canada’s oil and gas sector incumbents, as well as renewable energy proponents.

Moreover, Canada has developed a road map for the initial deployment of several SMRs by the late 2020s which may contribute to emissions reductions via on-grid power, including the replacement of coal power plants in several provinces, on- and off-grid

co-generation[3] for heavy industry, and power for remote off-grid northern and maritime communities. In December 2020, Canada launched the SMR Action Plan, which continues to build on the work of the road map to advance SMRs.

Monitoring, evaluation and tracking of results

Canada has made extensive efforts in the challenging area of metrics and evaluation for public energy R&D and innovation policies since 2015. NRCan's publication of a five-year audit and evaluation plan is part of a commitment to greater transparency (NRCan, 2021). The Energy Innovation Program, for example, is due to be evaluated in 2022-23. Energy Innovation R&D programmes monitor progress at multiple levels, including individual projects, individual technologies, technology areas and by specific programmes. They are audited by the internal Audit and Evaluation Branch of NRCan and the implementation of its recommendations is tracked by senior managers.

Recent initiatives include in-depth technology outcome reports of recent buildings ("R-2000") and CCUS R&D funding. These assessments found that beyond funding for RD&D, federal support plays a critical role in convening the necessary expertise required to address non-technical barriers to technology advancement. A variety of quantitative metrics have been developed to assess immediate, intermediate and ultimate outcomes. These evaluations revealed differences in the nature of the valuable impacts of these programmes.

NRCan has recently integrated more mission-oriented and outcomes-based approaches that allow for more precise tracking of specific advances towards addressing concrete challenges or specific gaps in clean energy innovation technologies. Programmes such as the Impact Canada Cleantech Challenges have been assigned *ex ante* policy objectives to enable future evaluation. However, it is too early to assess the effectiveness of the metrics and framework.

Assessment

Canada will depend on emerging technologies to achieve net zero emissions. The diversification of federal research programmes in the past five years, coupled with a greater emphasis on evaluation of performance, provides a strong foundation for meeting this challenge. The Impact Canada Initiative is a good example of creative policy making and represents international good practice in supporting female energy innovators. As a by-product, the challenges within this initiative have helped the government to better understand the landscape of existing expertise in Canada and be receptive to adapting future programmes accordingly.

There is clear recognition in the government of Canada that the 2050 net zero emissions target changes the outlook and needs for technology development and RD&D. For example, reduced emphasis on projects that focus exclusively on internal combustion engines has been announced, accompanied by a shift in focus to zero tailpipe emission vehicle solutions. As the target was only announced recently, it has not yet translated into new R&D or technology priorities.

[3] Co-generation refers to the combined production of heat and power.

NRCan's co-ordination and funding of energy-related RD&D by other departments is impressive, such as in the areas of biorefineries and renewable resource data. However, despite strong linkages between energy innovation policy and other elements of energy policy, for some technologies – including CCUS, industrial emissions reduction technologies and long-distance transport – key federal enabling policies such as carbon pricing and regulations are critical to ensure there is a sustainable and dependable market to attract private innovation capital.

The 2020 Hydrogen Strategy finds that the lack of sustained investment in innovation is preventing Canada from achieving its goals for hydrogen, including being a world-leading supplier of hydrogen technologies. However, Canada has a firm foundation to build on, with many decades of leadership in fuel cells and industrial use of hydrogen, which could move to low-carbon hydrogen sources in the coming years. It is also home to the world's largest operating hydrogen plant with CO_2 capture and dedicated geological CO_2 storage. The Hydrogen Strategy is ambitious: it will require co-ordination of increased R&D funding and deployment policies across multiple sectors and regions, embedding hydrogen as a top priority in NRCan's energy innovation programmes.

To assist decision making, it would be valuable to rapidly clarify to several outstanding uncertainties, including the role of hydrogen, the sectoral contribution of CCUS, the future of natural gas infrastructure and the pace at which CO_2 storage potential can be brought online in different regions. Technologies related to fossil fuel extraction and use, including internal combustion engines for on- and off-road transportation, may be less compatible with the target, especially if they have long lead times.

In 2009-10, stimulus funding from provincial and federal governments co-funded three major CCUS projects with industry. Since then, no new federal programmes have allocated public funding in excess of CAD 100 million to large-scale demonstration projects. While the Strategic Innovation Fund could potentially play this role, there may be a need for additional funding instruments for large-scale technologies such as CCUS. Less funding per project may be needed than in the previous decade, given the higher stage of maturity, the types of projects that still require demonstration and the changing policy environment. For example, Budget 2021 announced an investment tax credit for capital invested in CCUS projects, which would take effect in 2022, with the goal of reducing emissions by at least 15 Mt CO_2 annually.

While the federal government has the capacity to co-ordinate much of the national energy RD&D agenda, shared jurisdiction with provinces and territories for the overall energy system can present some challenges to the development of co-ordinated, market-based technology support, which is intended to increase the size and pace of expansion of markets for new clean energy technologies. For some clean energy technologies for which manufacturing scale-up is expected to play a key role in reducing costs, market fragmentation can hinder innovation.

Canada's collection of public and private RD&D spending data, as well as its commitment to international co-operation on energy innovation, continue to be examples of international good practice from which other countries could learn. Following recent efforts, this is now also true for Canada's commitment to policy evaluation and learning from experience.

Recommendations

The government of Canada should:

- Ensure alignment of energy and industrial technology priorities with the 2050 net zero target, including focusing fossil fuel R&D on technologies that are compatible with deep decarbonisation (e.g. hydrogen; carbon capture, utilisation and storage; small modular reactors).
- Maintain the commitment to increase clean energy innovation funding after having doubled its federal spending on clean energy R&D in the first phase of Mission Innovation, while continuing ongoing work to match funding tools with the needs of innovators, maximising private sector investments and integrating lessons learnt from policy experiments.
- Regularly update the capabilities of the national laboratories to conduct early-stage R&D adapted to new market conditions and technologies, and to assist the government in the development of regulatory frameworks, codes and standards for clean energy technologies.
- Work with provincial governments and regulators to enable regulated utilities with opportunities for experimentation within regulatory frameworks in order to accelerate the adoption of innovative clean energy technologies and facilitate knowledge-sharing across utilities, regulators, policy makers and other electricity stakeholders.
- Clarify the policies to create markets for sustained private investments in technologies, such as carbon capture, utilisation and storage; clean fuels; and low-carbon steelmaking and low-carbon cement, especially to help optimise innovation programmes and minimise stranded demonstration investments.
- Institutionalise best practices that Natural Resources Canada is developing in programme and portfolio innovation metrics and evaluation, and ensure that the resources are available to continually improve capacities and share experiences internationally.

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7. Electricity

Key data (2020 provisional)

Electricity generation: 640.8 TWh (hydro 60.0%, nuclear 15.3%, natural gas 11.1%, coal 4.9%, wind 5.6%, bioenergy 1.6%, oil 0.8%, solar 0.7%), +6% since 2010

Electricity trade: 57.4 TWh net exports (9.8 TWh imports, 67.2 TWh exports), +126% since 2010

Electricity consumption (2019): 567 TWh (industry 33%, residential 30%, services 28%, energy sector 6%, transport 1%), 12% increase since 2009

Overview

Canada has one of the cleanest electricity systems in the world, with almost 83% of its electricity generation from non-emitting sources in 2020 (including hydro, nuclear and non-hydro renewables). Canada is striving to source 90% of its electricity from non-emitting sources by 2030. Canada's electricity sector accounts for only around 10% of the country's total greenhouse gas (GHG) emissions, well below the average of advanced economies at 26%. Compared with other countries that are more reliant on fossil fuels for electricity generation, Canada's mostly decarbonised electricity system represents an early advantage for greater electrification of other fossil fuel-dominated sectors, such as transportation, buildings, industry, and oil and gas production (where technically and economically feasible), contributing toward its net zero emissions goal by 2050.[1]

Jurisdiction over electricity is mostly held by the provinces and territories. The federal government's role in electricity is limited to federal lands, international transmission lines and, to a certain extent, interprovincial electricity trade. The federal government exerts significant influence, however, in the area of environmental performance, with tools such as taxation, emissions performance standards and carbon pricing. Moreover, it engages intensively with jurisdictions and stakeholders through various forms of co-operation and dialogue.

Potential drivers of future regulatory reform will be innovative technologies and a new electricity sector paradigm, with a greater role for distributed supply, demand response, storage and smart grid operations. Strengthening interprovincial connectivity offers a considerable upside to allow fossil fuel-dependent provinces to decarbonise and electrify

[1] Clean fuels are expected to play an essential role in reaching the net zero goal in areas where electrification will be more challenging.

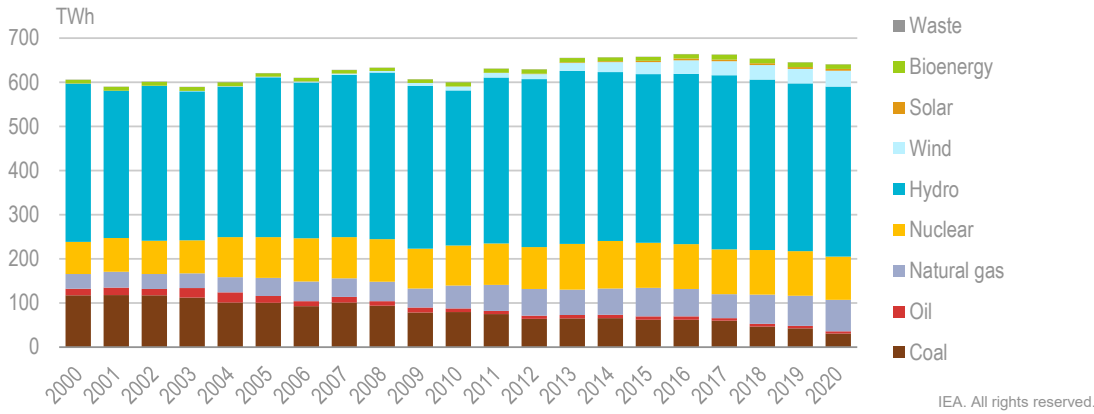
their economies. Electricity trade is still dominated by exports to the United States, which represent 10% of the country's generation, with a significantly higher trade amount compared to domestic interprovincial trade.

Electricity supply and demand

Electricity generation

Hydro was the main electricity generation source in Canada, at 385 terawatt hours (TWh) in 2019 (60% of total generation), followed by nuclear at 98 TWh (15%) and natural gas at 71 TWh (11%). Wind power has increased steadily, from 0.3 TWh (0.04%) in 2000 to 8.7 TWh (1.4%) in 2010 and 36.1 TWh (5.6%) in 2020. Electricity from solar has increased quickly since 2010, but still accounted for only 0.7% of total generation in 2020, or 4.3 TWh. Some 5.1 TWh (0.8%) of electricity was still produced using oil products in 2020, especially in remote communities. Renewables accounted for 68% of overall electricity generation in 2020, or 435 TWh (Figure 7.1).

Figure 7.1 Canada's electricity generation by soure, 2000-20



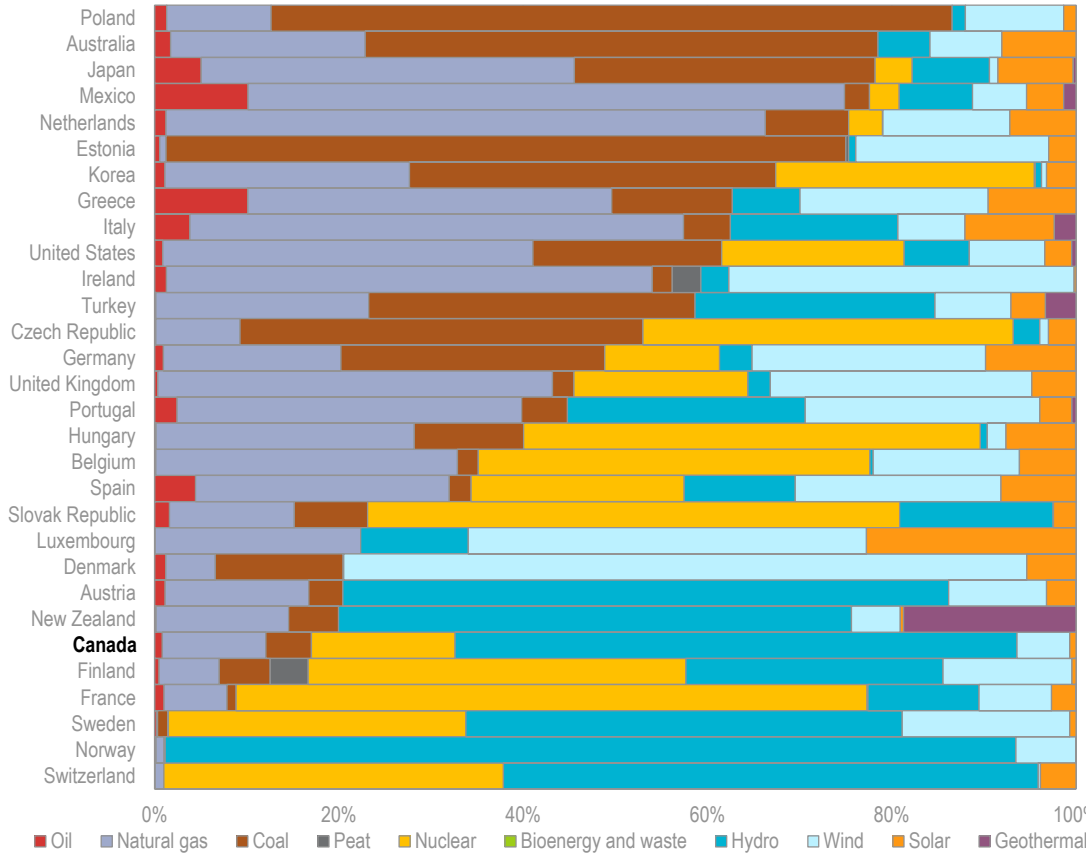
Canada's electricity supply comes mainly from hydro and nuclear.

* *Solar* generation is hard to distinguish at this scale, given its limited overall generation (0.7%, 4.4 TWh in 2019).
Note: TWh = terawatt hour.
Source: IEA (2021a), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Different jurisdictions use different sources for power generation. British Columbia, Manitoba, Quebec, and Newfoundland and Labrador each generate over 96% of their electricity from hydro. Yukon generates close to 88% from renewable energy sources. Ontario, New Brunswick and the Northwest Territories rely on various combinations of nuclear, hydro, wind, biomass, coal, natural gas and petroleum – although not all provinces use all of these sources. Alberta, Saskatchewan, Nova Scotia and Nunavut generate the majority of their electricity from fossil fuels such as coal, natural gas or petroleum.

Canada's share of fossil fuels is the ninth-lowest in an IEA comparison, at 19% overall of its total electricity generation mix (Figure 7.2).

Figure 7.2 Canada's electricity generation by source, 2020



Canada's share of fossil fuels in electricity generation ranked ninth-lowest in an IEA comparison.

Note: countries are ranked by decreasing share of fossil fuels in the electricity generation mix.
Source: IEA (2021a), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Electricity generation capacity

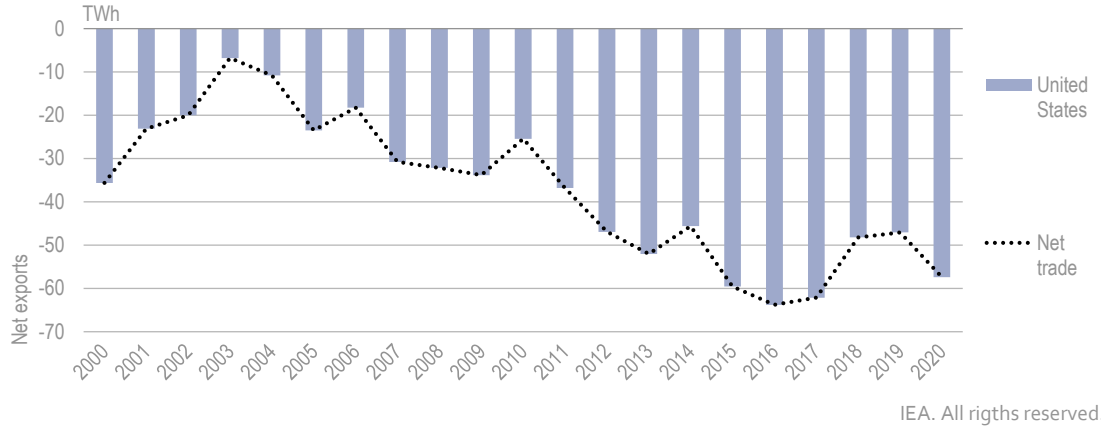
Total installed electricity generation capacity was 150 gigawatts (GW) in 2019. Hydro power plants accounted for a total capacity of 81 GW, while Canada also relies on 17 GW from gas-fired plants, 14 GW from nuclear, 13 GW from wind, 9.7 GW from coal-fired plants, 6.0 GW from liquid fuels and refinery gas power plants, and 3.3 GW from installed photovoltaic solar panels. The recent decade was characterised by a rapid increase of solar (from 33 megawatts [MW] in 2009 to 3 327 MW in 2019) and wind (from 3.3 GW in 2009 to 13.4 GW in 2019) capacity. At the same time, a number of coal power plants shut down, reducing installed capacity from 16 GW to 9.7 GW.

Electricity trade

The Canada-United States electricity grid is deeply integrated, with major transmission lines connecting the majority of Canadian provinces with neighbouring US states. This integration facilitates substantial trade in electricity between the two countries. To that end, electricity trade most frequently occurs in a north-south direction, between Canadian provinces and US states, rather than in an east-west direction between Canadian provinces.

Canada only trades electricity with the United States. In 2020, Canada exported 60 TWh to the United States and imported 13 TWh, for net exports of 57 TWh. This represents a reduction from 2016, when net exports reached a maximum of 64 TWh (Figure 7.3). Net exports of electricity were previously lower, at 25 TWh in 2010.

Figure 7.3 Canada's electricity imports and exports with the United States, 2000-20



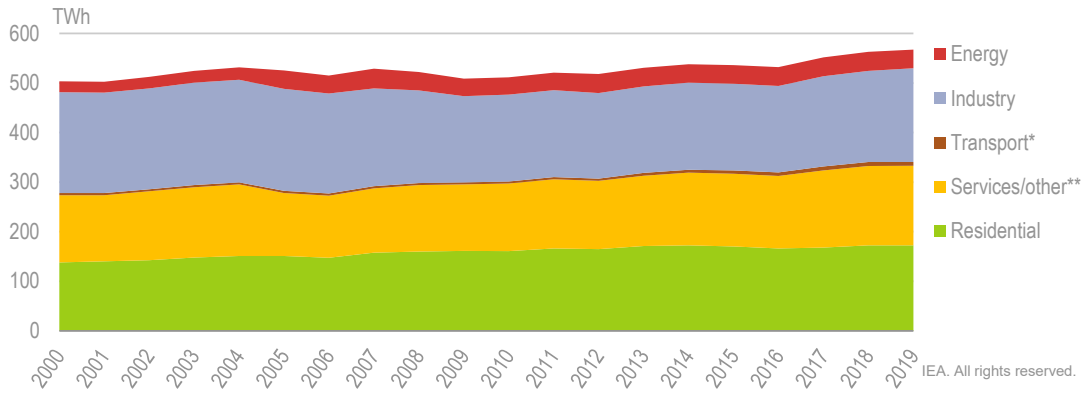
The United States is Canada's only electricity trading partner, with Canada serving as a net exporter.

Note: TWh = terawatt hour.
Source: IEA (2021a), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Electricity demand

Electricity demand in Canada was 567 TWh in 2019 (Figure 7.4). The industry sector accounted for the largest share, at 33% (189 TWh) in 2019, followed by the residential sector at 30% (172 TWh) and the commercial sector at 28% (161 TWh). The energy and transport sectors represented relatively low demand, consuming 37.7 TWh (6%) and 7.7 TWh (1.4%) in 2019, respectively. Overall electricity demand has grown by 12% over the past decade, with the most noticeable increase in the transport sector (with an 85% increase from 2009 to 2019), followed by services (+20%) and industry (+9%).

Figure 7.4 Canada's electricity demand by sector, 2000-19



The industry sector accounts for the largest share of electricity demand in Canada, followed by the residential sector.

* *Transport* demand for electricity (mostly from rail) varied between 4.0 TWh and 8.0 TWh from 2000 to 2019.

** *Services/other* includes commercial and public services, agriculture, forestry, and fishing.

Note: TWh = terawatt hour.

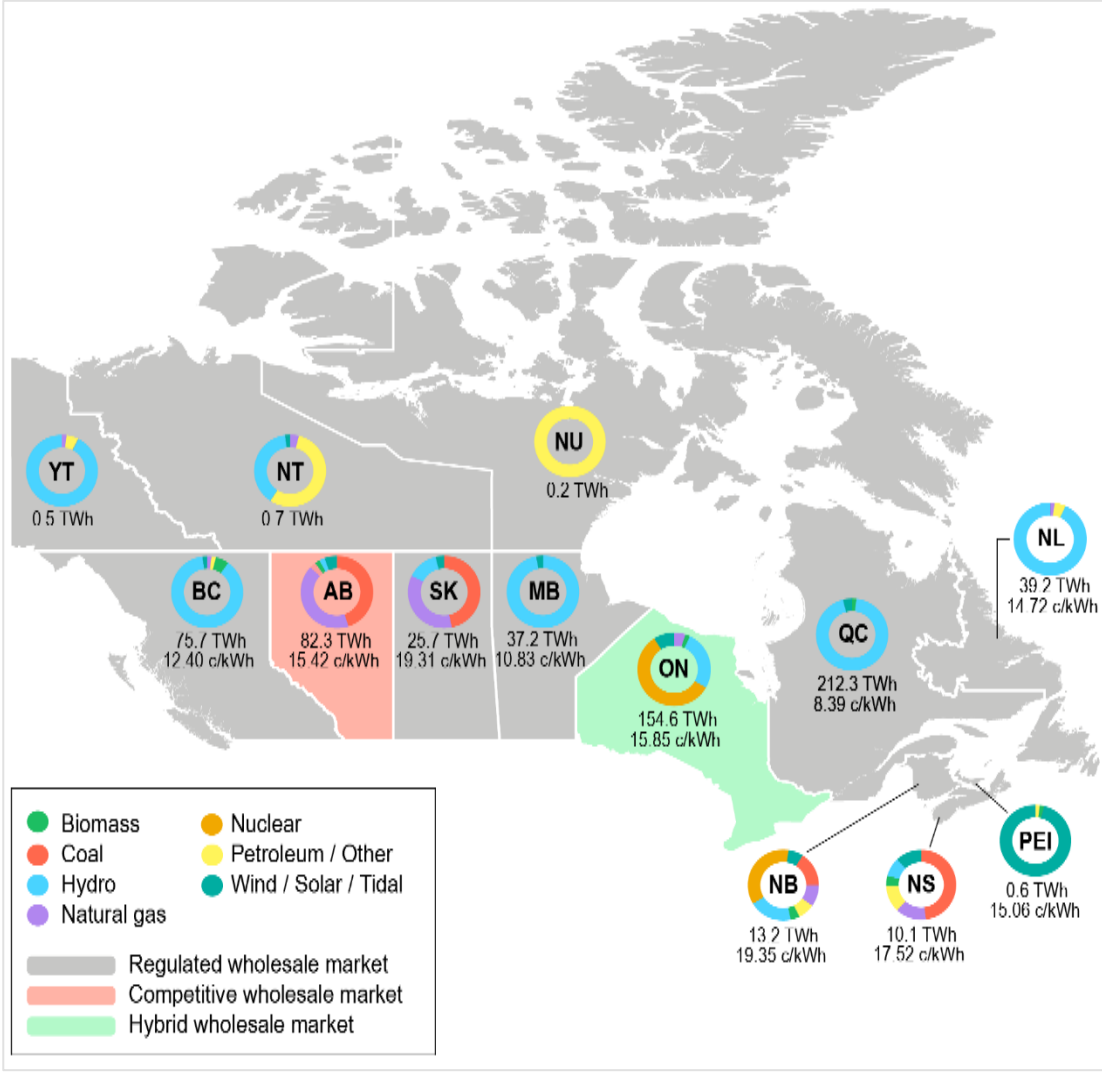
Source: IEA (2021a), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Market structure

Under Canada's Constitution, each province controls the electricity generation, intra-provincial electricity transmission, electricity distribution and market structure within its borders. However, the federal government has authority to regulate certain toxic substances (including GHGs), and authority over certain aspects of the nuclear generation sector, electricity exports, and interprovincial and international transmission.

The electricity industry is highly integrated in most provinces, with the bulk of generation, transmission and distribution services provided by a few dominant utilities. Although some of these are privately owned, most are Crown corporations owned by the provincial governments. In some cases, relatively small generators also exist, but rarely in direct competition with a Crown corporation. Deregulated wholesale electricity markets only exist in Alberta and Ontario.

Figure 7.5 Diverse market structures in Canadian provinces and territories



Industry structure varies from province to province. In many cases, the previously integrated utilities are increasingly becoming functionally unbundled to accommodate the introduction of wholesale competition. In several provinces, however, the various components are structurally distinct.

Ontario and Alberta together account for around one-third of Canadian power consumption and enjoy wholesale and retail competition. Notably, in these markets, there is a great diversity of structural models with functions for the most part unbundled. Most other provinces have moved, or are moving, to some form of wholesale competition.

In other provinces, parts of the industry are privately owned, but provincial Crown corporations remain dominant in the generation and transmission sectors of the industry. Municipal ownership is prominent in several places; for example, in Ontario, where utilities such as Toronto Hydro and Hydro Ottawa are municipally owned. EPCOR in Alberta is owned by the City of Edmonton.

Generally, the main utility in the province is responsible for managing supply and demand and maintaining reliability. Exceptions are in Alberta and Ontario, which have established independent system operators to manage the market and the grid, and Manitoba, which co-operates with the Midwest Independent System Operator in the United States.

Although Canada's electricity system is highly integrated with its neighbour to the south, it does not share any retail electricity markets with the United States.

See Annex 7A.1 for provincial electricity market structures.

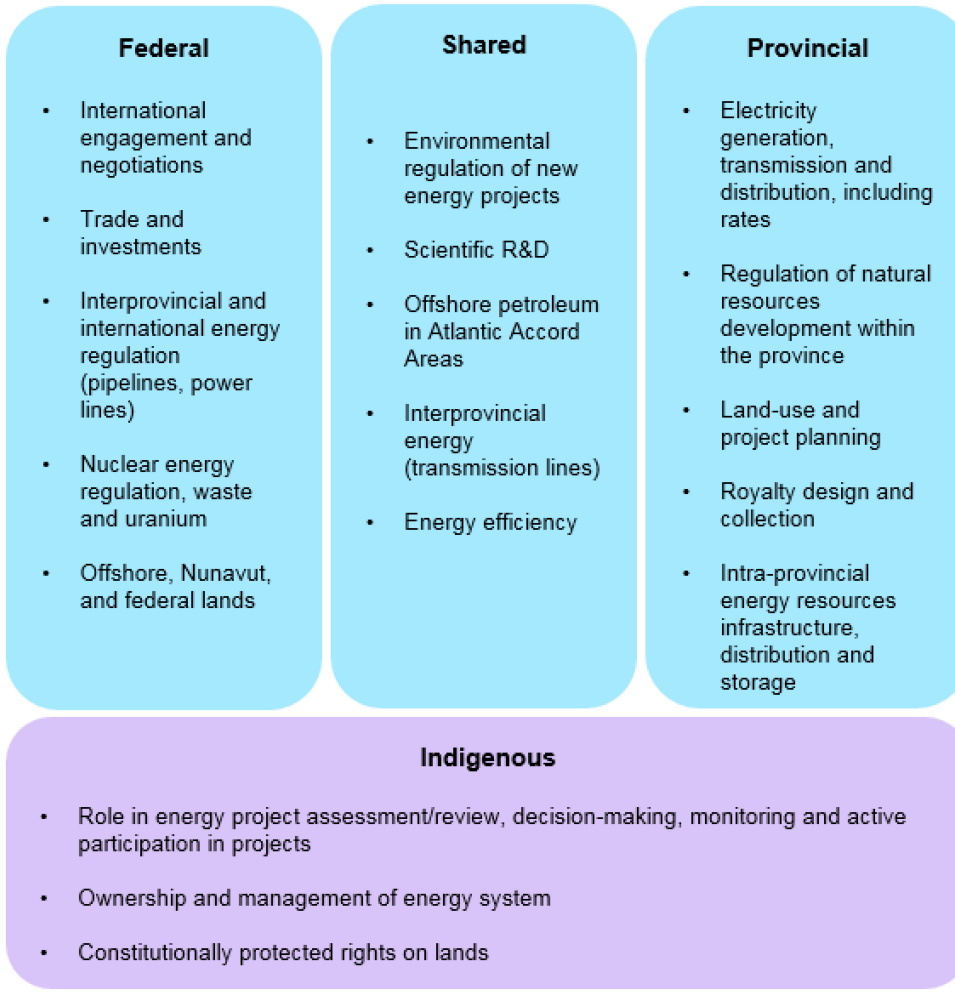
Electricity market regulation

The Canadian electricity system is part of an integrated North American electricity grid, but Canada's electricity industry is organised along provincial lines. As such, regulatory oversight rests primarily within the jurisdiction of the provinces. International electricity trade and designated interprovincial lines fall under federal jurisdiction.

The Canada Energy Regulator is responsible for regulating the international electricity lines that transport power from Canada to the United States and has latent powers to designate interprovincial power lines as subject to its regulations. Its responsibilities include the export of electricity and the construction and operation of international and designated interprovincial power lines. Meanwhile, regulation of the nuclear power sector falls under the jurisdiction of the Canadian Nuclear Safety Commission.

However, the vast majority of generation, transmission and distribution services in Canada is overseen by provincial regulatory agencies, which have a number of features in common. These boards and commissions are generally independent, quasi-judicial adjudicative tribunals that take decisions independent of government direction in accordance with enabling legislation, regulation and stated public policy. The regulators report to provincial legislative assemblies through their responsible minister (see Annex 7A.1 for regulatory models in each province and territory).

Figure 7.6 Shared jurisdiction of electricity in Canada



Source: Canadian government.

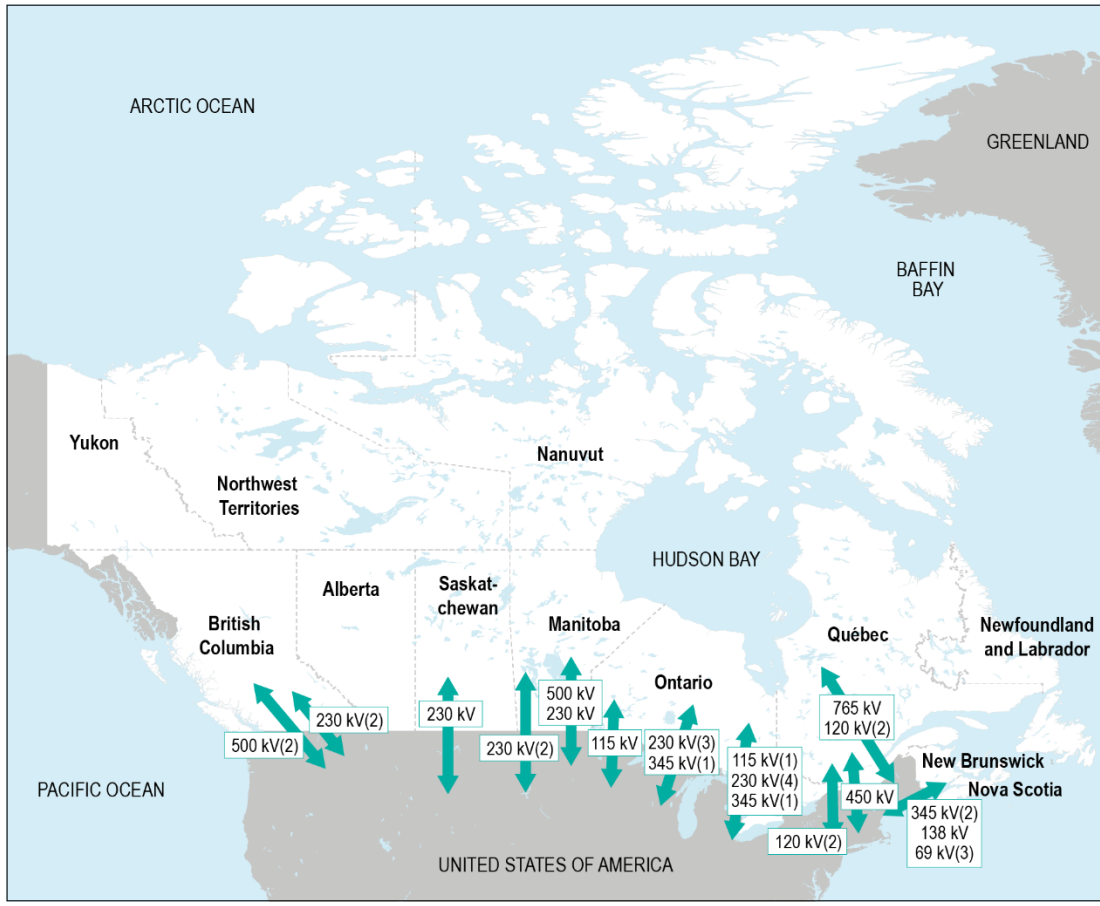
The two provinces with wholesale electricity markets have institutions to police market behaviour. Ontario has the Market Surveillance Panel, part of the Ontario Energy Board, to monitor, investigate and report on activities and behaviour in the province's electricity markets. Similarly, Alberta has the Market Surveillance Administrator, an independent statutory agency appointed by the Minister of Energy, to ensure competitive electricity markets. The Competition Bureau, an independent Canadian law enforcement agency, also plays a role in governing business conduct and preventing anti-competitive practices in competitive electricity markets. The Commissioner of Competition is appointed by the government and reports to parliament through the Minister of Industry.

Interconnections

The Canadian transmission network extends over 160 000 kilometres. It is characterised by north-south backbones, in part due to the location of most major load centres near the Canadian-US border and major hydro projects in the northern regions of British Colombia, Manitoba, Ontario and Quebec. In all regions of the country, transmission upgrades are required to accommodate greater loads, more generation points, enhanced interprovincial and international trade, and reliability. Transmission planning is a provincial responsibility.

There are currently 37 interconnection points between Canada and the United States, with several additional lines currently under construction or proposed. This allows Canada to export around 10% of its electricity generation and for the United States to cover about 2% of its demand with Canadian imports.

Figure 7.7 Canada's cross-border transmission lines



Note: kV = kilovolt.

Source: Canadian government.

In Canada, one transmission provider dominates each province, so transmission tariff pancaking (the accumulation of transport charges as power moves across different systems) can only occur for transactions crossing multiple provincial borders. Given the large geographical area of most provinces, cross-jurisdictional transfers of electricity are not as common.

A strategy adopted in the United States to eliminate transmission tariff pancaking is to put all the transmission providers under the control of a single system operator in the form of a regional transmission operator (RTO) or independent system operator (ISO). Market participants within an RTO/ISO region pay only a single transmission tariff, whether they are moving power within a single utility or across several utilities in that region. For trade purposes, Manitoba Hydro participates in the Midwest Independent System Operator.

The United States has required any Canadian utility wishing to sell electricity directly to customers in the United States at market-based prices to provide reciprocal open transmission access for US companies to Canadian electricity customers. As such, many

Canadian transmission providers have filed an open access transmission tariff with the US regulator, the United States Federal Energy Regulatory Commission.

Similarly, the procedure for connecting new capacity to the grid varies from province to province. Although independent power generators have access to the wholesale markets in Quebec, Manitoba, Saskatchewan and Nova Scotia, administration of connections to provincial grids and open access transmission tariffs have been left to the provinces' incumbent utility.

Canada's Atlantic regions have made important strides to enhance the transmission and use of clean power across the region. The completion of the Muskrat Falls hydroelectric station in Labrador, the Labrador-Island Link, and the Maritime Link between Nova Scotia and the island of Newfoundland, will reduce Labrador's own emissions and begin supplying clean electricity to its neighbours and beyond (see below).

In Manitoba, a new 230 kilovolt (kV) transmission line now nearing completion will increase the ability of Saskatchewan and Manitoba to exchange electricity. Construction of the Birtle-Tantallon Transmission Project began in summer 2020 and was completed in spring 2021.

Alberta's interconnection with British Columbia is not currently operating at, or near, its original planned capacity. To restore the interconnector, the Alberta Electric System Operator has determined that additional equipment and upgrade work is needed, which remains in the planning stage.

New Brunswick Power and Hydro-Québec have signed three deals that will see Quebec sell more electricity to New Brunswick and help with the refurbishment of the Mactaquac hydroelectric generating station. Under the first agreement, Hydro-Québec will export 47 TWh of electricity to New Brunswick between now and 2040 over existing power lines – expanding on an agreement in place since 2012. The second deal will see Hydro-Québec share expertise for part of the refurbishment of the Mactaquac dam to extend the useful life of the generating station until at least 2068. The third agreement calls for talks to begin for the construction of additional power connections between Quebec and New Brunswick to increase the amount of electricity that can be transmitted for exports to Atlantic Canada and the United States.

Major transmission and infrastructure upgrades are planned across Canada, including major lines in British Columbia, Alberta, Saskatchewan, Manitoba and Quebec (Table 7.1).

Table 7.1 Major expected transmission upgrades in Canada

Project	Province	kV	Status
La Romaine Havre	Quebec	315	Construction
Manitoba-Minnesota	Manitoba	500	Completed
Birtle-Tantallon	Manitoba	230	Completed
Transmission line 1201L	British Columbia	500	Planned

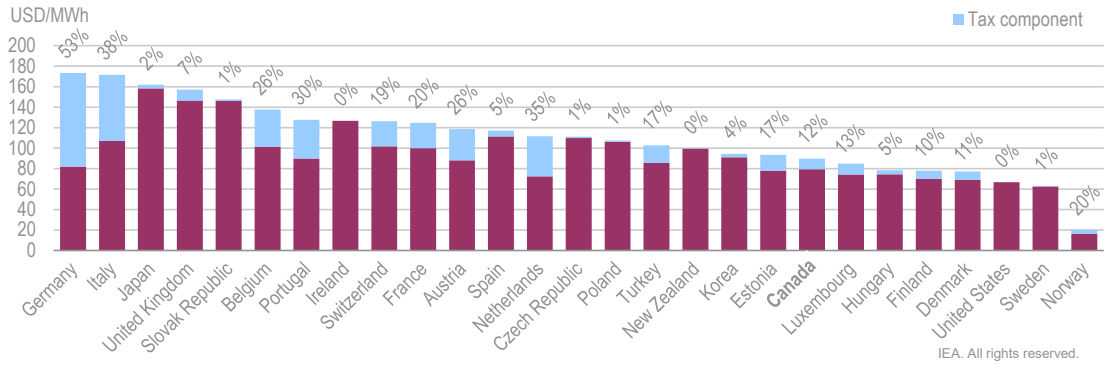
Note: kV = kilovolt.
Source: Canadian government.

Retail prices and taxes

Canada's electricity prices are low compared to most IEA member countries (Figure 7.8). For industry prices, Canada's prices were the eighth-lowest, at 89.7 USD/MWh, with a 12% tax rate, while its household electricity prices were fourth-lowest compared to IEA countries at 109 USD/MWh, with an 11% tax rate. Canada's industry and household electricity prices have increased over time, and displayed differing trends from the Mexico and the United States (Figure 7.9).

Figure 7.8 Electricity prices for industry and households in IEA countries, 2020

Industry



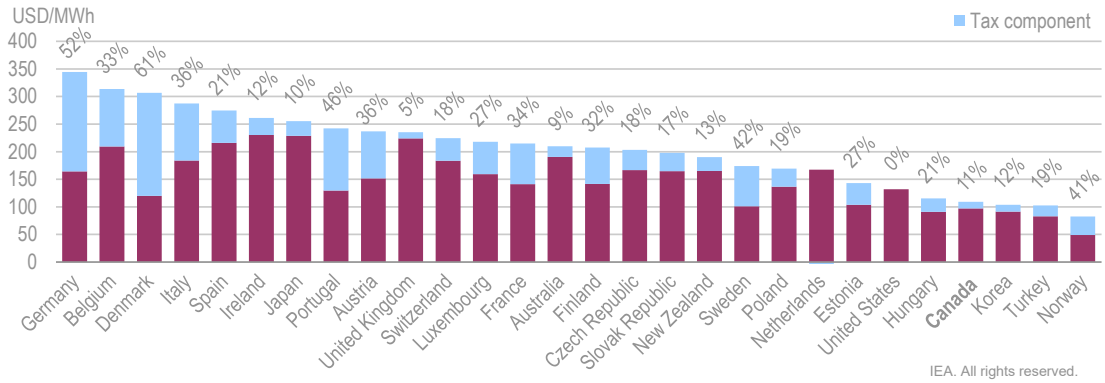
Canada's industry electricity prices are the eighth-lowest among IEA countries.

* Tax information is not available for Ireland or the United States.

Notes: MWh = megawatt hour. Industry price data are not available for Australia, Greece or Mexico.

Source: IEA (2021b), *Energy Prices and Taxes 2020* (database), www.iea.org/statistics.

Households



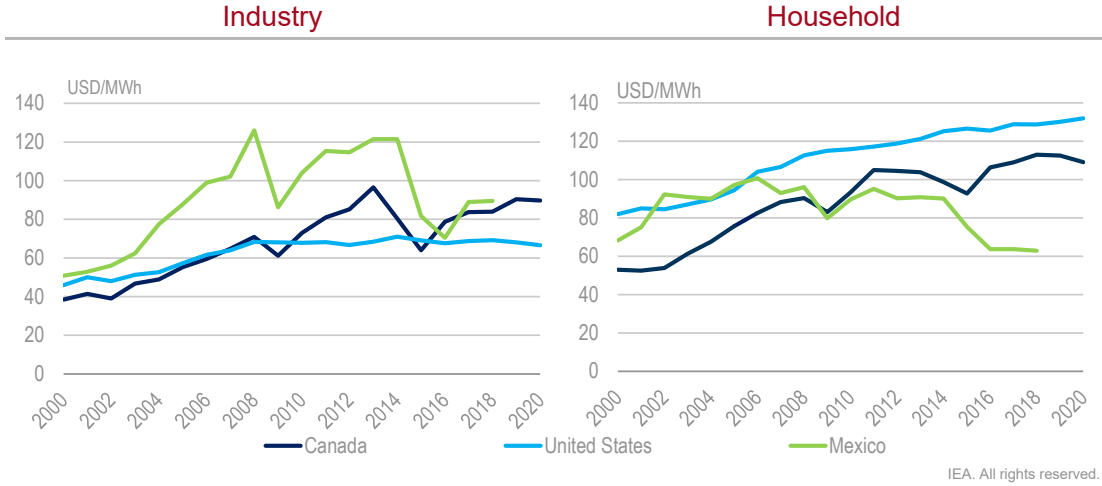
Canada's household electricity prices are the fourth-lowest among IEA countries.

* Tax information is not available for the United States.

Note: Household price data are not available for Greece or Mexico.

Source: IEA (2021b), *Energy Prices and Taxes 2020* (database), www.iea.org/statistics.

Figure 7.9 Electricity prices in Canada and neighbouring IEA countries, 2000-20



Canada's electricity prices have fluctuated more compared to the United States and follow different trends than Mexico.

* Data are not available for Mexico for 2019 and 2020.

Note: MWh = megawatt hour.

Source: IEA (2021b), *Energy Prices and Taxes 2020* (database), www.iea.org/statistics.

Electricity pricing in Canada varies by province or territory according to the volume and type of available generation and whether prices are market-based or regulated. With the exception of Alberta and Ontario, prices are regulated by a quasi-judicial board or commission. At the retail level, the price of electricity is not only affected by the cost of production, but also by the cost of transmission and local distribution, which may vary depending on factors such as geography and population density. In Quebec, Nova Scotia, Prince Edward Island, and Newfoundland and Labrador, electricity rates are regulated on a cost-of-service basis. In Alberta and Ontario, they are set through the market, although households and smaller commercial consumers have the option of subscribing to a regulated rate, which is frequently applied (in Ontario, the regulated rate is the default option with over 90% uptake).

Electricity policy

Emissions reduction measures

Canada has one of the cleanest electricity systems in the world. In 2020, 83% of its electricity generation came from non-emitting sources, including hydro (60%); nuclear (15%); and non-hydro renewables such as wind, solar and bioenergy (8%). Coal-fired electricity generation has been on a steady decline since 2010, contributing 6.2% to overall generation in 2020, while natural gas, oil and other fossil fuel sources were responsible for 12%. Canada is striving to have 90% of its electricity from non-emitting sources by 2030.

In terms of emissions reductions, the electricity sector has outpaced all other major industries in Canada, with emissions from electricity generation falling by almost 47% between 2000 and 2019, largely owing to the reduced use of coal.

To help manage overall electricity demand, governments and utilities across Canada offer financial incentives for energy efficiency. Although they vary by jurisdiction, a range of provincial, territorial and municipal measures are available that target individuals, businesses and industry (see Chapter 4).

Canada plans to phase out unabated coal-fired electricity by 2030. In 2012, it became the first country to introduce federal coal-fired electricity GHG regulations (Reduction of Carbon Dioxide Emissions from Coal-Fired Generation of Electricity Regulations), requiring coal-fired electricity units to meet a "clean-as gas" performance standard of 420 tonnes of carbon dioxide emissions per gigawatt hour (t CO_2/GWh). The regulations developed under the Canadian Environmental Protection Act, 1999 applied to new units built after 1 July 2015, and to existing units that have reached the end of their useful life (defined as 45-50 years after their commissioning date).

In December 2018, under the Pan-Canadian Framework on Clean Growth and Climate Change commitments, Canada published amendments to the 2012 regulations in order to accelerate the phase-out of conventional coal-fired electricity across Canada to 2030. The amendments require all units to meet the performance standard of 420 t CO_2/GWh at the end of their useful life or by 31 December 2029, whichever comes first.

Ways to expand a plant's lifetime beyond 2030 include carbon capture, utilisation and storage (CCUS) and fuel switching to natural gas. For example, the Boundary Dam coal plant in Saskatchewan will remain open as it has successfully applied CCUS technology to capture CO_2. Nova Scotia and New Brunswick have signed equivalency agreements with the federal government that allow the federal coal regulations to stand down until 31 December 2024. Nova Scotia has announced that it will phase out coal by 2030.

In 2018, Canada enacted the Regulations Limiting Carbon Dioxide Emissions from Natural Gas-fired Generation of Electricity (under the Canadian Environmental Protection Act, 1999) to complement the coal regulations by requiring new natural gas-fired electricity generation to meet emissions limits. The regulation covers natural gas plants that have a minimum installed capacity of 25 MW, sell or distribute more than 33% of their average annual potential electricity output to the grid, and receive more than 30% of their heat input from natural gas. The standards are set at 420 t/GWh for units with capacity of at least 150 MW or 550 t CO_2/GWh for units with capacity between 25 MW and 150 MW. This regulation helps to ensure that natural gas units replacing coal-fired units are higher performing (top-performing natural gas units can achieve 370 t CO_2/GWh). The regulation also includes provisions for the economic life extension of coal units converted to natural gas (based on the initial emissions performance of the converted units, ranging from 480 t CO_2/GWh to 600 t CO_2/GWh).

Moreover, Canada has a carbon price in place that also covers electricity generation. The Greenhouse Gas Pollution Pricing Act sets minimum stringency criteria for carbon pricing across Canada, known as the benchmark. Jurisdictions that do not meet its level of stringency with their own policies are subject to the federal backstop. The backstop has two components: a regulatory charge on fossil fuels and an Output-Based Pricing System (OBPS) for large industrial emitters (including power plants). The OBPS puts a price on carbon pollution for industrial facilities that emit 50 000 tonnes or more per year (or voluntary participation for certain facilities that emit over 10 000 tonnes per year).

The OBPS is designed to help fight climate change by reducing carbon pollution from electricity generation while minimising competitiveness impacts for industrial sectors and

reducing costs for businesses and households. The OBPS assigns different standards to electricity generation according to the type of fuel used.

Natural Resources Canada (NRCan) is also leading a number of initiatives to develop and deploy zero-emission technologies within the electricity sector and in rural and remote communities, including technologies that create carbon-free heat and electricity.

- The Smart Grids Program is modernising electricity grids and storage facilities to make it easier to integrate renewable energy sources.
- The Emerging Renewables Program funds the deployment of innovative renewable technologies, including tidal and geothermal.
- The Clean Energy for Rural and Remote Communities Program is helping communities shift from a reliance on diesel fuel to more renewable energy sources.
- The Energy Innovation Program funds the demonstration of innovative renewable technologies, including tidal and geothermal.

More recently, Canada's net zero legislation, the Canadian Net-Zero Emissions Accountability Act, requires Canada to set emissions reduction targets at five-year intervals from 2030 to 2050. In particular, the Strengthened Climate Plan, *A Healthy Environment and a Healthy Economy*, introduced by the government in December 2020 commits the government to work with provinces, territories and stakeholders to reach net zero emissions from electricity generation before 2050; provides support for clean power projects, including transmission interconnectors, renewable energy installations and grid modernisation; launches the SMR Action Plan (see below); and considers the need for a clean electricity performance standard to ensure that investments in electricity generation are consistent with the goal of net zero emissions by 2050. Specifically, the government plans to commit an additional CAD 964 million over four years toward renewable energy and grid modernisation projects.

In December 2020, the government also released its Small Modular Reactor (SMR) Action Plan to outline progress and ongoing efforts across Canada to develop this emerging nuclear technology. The action plan responds to the 2018 SMR Roadmap and is a multi-stakeholder collection of submissions outlining concrete actions each partner is taking to seize the SMR opportunity for Canada (see Chapter 8).

Canada also provides two tax incentives to promote business investment in clean energy generation equipment that uses renewable energy (e.g. wind, solar, geothermal) or energy from waste (e.g. landfill gas, wood waste), or conserves energy (including in the use of fossil fuels). Since the IEA's last in-depth review, the scope of these provisions has been expanded, including most recently in the government's Budget 2021 (see Chapter 5).

As part of its Budget 2021 announcements, Canada proposed to expand these two incentives to include equipment used in pumped hydroelectric energy storage, renewable fuel production, hydrogen production by electrolysis of water, and hydrogen refuelling while also removing certain restrictions on water-current, wave and tidal energy; active solar heating; and geothermal energy technologies. It was also proposed to update eligibility criteria so that certain fossil-fuelled and low efficiency waste-fuelled electrical generation equipment will no longer be eligible after 2024.

Fuel mix changes toward net zero emissions

Though the near-term focus for Canada's decarbonisation of the electricity sector is on a phase-out of coal-fired generation, the government's target to achieve net zero emissions by 2050 will require stronger growth in low-carbon electricity to enable high levels of electrification.

Canada is well-positioned with a solid foundation of hydro and nuclear power capacity as well as strong growth in wind and solar capacity. However, in a number of currently coal-dependent provinces, the most readily available option to switch from coal is (unabated) natural gas-fired generation, which has seen strong growth in recent years driven by low prices and regulations, and which is expected to see continued growth in the coming years. The government estimates that 45 TWh of 2019 electricity generation from coal will need to be replaced by 2030, and the balance between variable renewables and natural gas (including renewable natural gas) to fill the gap remains unclear. New nuclear builds, and SMRs in particular, are unlikely to play a large role by 2030, but may afterwards. It therefore announced that it is exploring the need for a clean electricity performance standard over the coming months to ensure that Canada's electricity generation achieves net zero emissions before 2050.

Most significantly, plans to decarbonise other sectors of the economy, including heating/cooling, transport, and upstream oil and gas production, will also lean heavily on electrification, which will require a more substantial growth in clean electricity sources in the coming years.

Electrification of transportation, in particular, will play an essential role in a net zero future. The government of Canada has announced the intention to set a mandatory target for all new light-duty cars and passenger trucks sales to be zero-emission by 2035, accelerating Canada's previous goal of 100% sales by 2040. Consumers are starting to demand zero-emission vehicles (ZEVs), automakers and other manufacturers are expanding EV options, and major corporations in Canada and around the world are beginning to electrify their fleets. All levels of government are also bringing in ambitious regulatory and fiscal measures to stimulate the ZEV roll-out. The trajectory would require optimising the country's existing hydro capacity to provide storage and flexibility; identifying new flexibility options in generation capacity; and increasing inter-regional trade, smart grids and load balancing, as well as flexible and responsive demand.

The Canada Energy Regulator's *Energy Futures 2020* report includes a scenario "Towards Net Zero" that outlines total emissions implied to achieve 30% reductions from 2005 levels by 2030, 60% reductions by 2040 and 90% reductions by 2050, but does not provide sectoral emissions reductions required in electricity toward 2050 or fuel pathways (CER, 2020). In the segments assessed under the scenario, namely personal passenger transportation, oil sands production, and remote and northern communities, the assessment notes the significant role that electrification will play in decarbonising all of these sectors.

Nuclear

Nuclear power, which contributes around 15% to Canada's electricity supply, is an important component in Canada's current clean energy mix as the second-largest source of emissions-free electricity after hydro. In nuclear provinces, the technology plays an outsized role in generation, namely in Ontario, where it accounts for 60% of electricity generation, and in New Brunswick, where it accounts for 36%. However, the footprint of

the nuclear industry extends well beyond these provinces, including to Saskatchewan and Ontario, where mining, refining and fuel fabrication take place, and to Ontario and Quebec, where research reactors are housed.

As a significant economic and energy sector driver, Canada has taken active steps to ensure that nuclear remains a mainstay of its future clean electricity sector, both through an ambitious refurbishment of Ontario's CANDU nuclear reactor fleet as well as the development of SMRs (see Chapter 8). The government also notes the role SMRs could play to replace coal and avoid a dash to gas in some jurisdictions.

Hydro

The dominant source of electricity in many Canadian provinces is hydroelectricity, which places them well on track toward net zero emissions targets. Canada is well-endowed with a natural resource advantage of hydro, making it the fourth-largest hydropower producer in the world by capacity (IHA, 2021). Notably, Canada's hydropower technical potential is more than double its current capacity, spread across all its regions (Waterpower Canada, 2020).

Several new large-scale hydro projects are being constructed and are all expected to be in service by 2025, including: the Site C project in British Columbia (1 100 MW); the Muskrat Falls project in Labrador (824 MW); the Keeyask project in Manitoba (695 MW); and the La Romaine 4 project in Quebec (245 MW) (IEA, 2020a). In addition, several small hydro projects are also progressing. Though there are a number of additional promising sites for new hydro projects from a technical perspective, it remains an open question whether these would be developed given the high costs associated with recent projects. For example, recent increases in the cost of the Muskrat Falls hydroelectricity project led the government of Canada to sign a CAD 2 billion financial restructuring deal with the province of Newfoundland and Labrador to help reduce project financing costs.

Instead, more recent investments have been moving toward variable renewables and storage. Nevertheless, hydroelectricity will play a critical role in further electrification and decarbonisation efforts both in Canada and across North America. When combined with transmission capacity, hydroelectricity resources, such as those in British Columbia, Manitoba, Quebec, and Newfoundland and Labrador, enable cost-effective integration of increasing shares of variable renewable energy both in Canada and the United States, as well as the emissions reductions that come from replacing fossil fuel-generated electricity with low-carbon alternatives.

Variable renewables

While variable renewables (i.e. wind and solar) account for a relatively small share of total electricity generation in Canada (6% in 2020), they are the fastest growing sources of electricity generation in the country (solar is the fastest, followed by wind). Variable renewable energy capacity is expected to continue growing in the future, as a number of projects will be commissioned in the coming years and as provinces and territories invest to decarbonise their electricity systems and electrify their economies. The Canada Energy Regulator forecasts that wind capacity will triple over the next 20 years, driven by favourable market conditions and an abundant, high-quality wind resource. Solar is mostly located in Ontario currently, but British Columbia, Saskatchewan and Alberta are also seeing strong growth. In contrast, rooftop solar has not seen much uptake in Canada compared to other countries; existing access to affordable electricity for ratepayers is a key impediment.

Almost all wind and solar capacity in Canada is the result of provincial procurement processes, such as requests for proposals, standard offer contracts, feed-in tariffs, renewable portfolio standards, small equipment rebates and tax credits, among other measures (see Chapter 5).

Future procurements will be supported by provincial renewable energy targets, which include: 93% renewable or clean electricity in British Columbia (already exceeded); 30% renewable electricity in Alberta by 2030; 50% renewable electricity in Saskatchewan by 2030; and a 25% increase in renewable energy production by 2030 from 2013 in Quebec (already 99% in electricity).

Federal government support also has a role. Main support programmes for renewable electricity, the ecoENERGY for Renewable Power (ecoERP) and the ecoENERGY for Renewable Heat (ecoERH) programmes, ended their authority to enter into new contribution agreements on 31 March 2011, although payments for existing agreements continued until March 2021. EcoERP, a 14-year long programme, supports 4 458 MW of renewable energy capacity, such as hydro, wind, solar PV and biomass, by providing a production incentive of 1 cent per kilowatt hour for up to ten years for electricity generated from eligible renewable energy projects (see Chapter 5).

In recent years, Canada has also taken concrete actions to develop its offshore renewable energy potential, and improve market and regulatory certainty for industry, investors and stakeholders. For instance, the Canadian Energy Regulator Act (which replaced the National Energy Board Act) came into force in 2019. It establishes a legislative framework for the construction and operation of offshore renewable projects and their associated power lines in federal offshore areas.

The government of Canada is investing in a number of projects through several programmes and data collected from their operation provide an evidence base that will inform provinces and territories over the long term as they elaborate policies to support the deployment of renewable energy technologies. Notably, the government is investing:

- CAD 200 million to support renewable energy technologies not yet established in Canada, such as tidal and geothermal energy, thus broadening the portfolio of renewable energy technologies available to provinces and territories.

- CAD 520 million to reduce the reliance of northern and remote communities on diesel fuel by supporting clean, renewable energy infrastructure.

- CAD 100 million for smart grid deployment and demonstration, which will enable greater variable renewable energy integration by increasing system flexibility and maximising asset utilisation.

- CAD 450 million to deploy infrastructure for EV charging and natural gas and hydrogen refuelling stations, as well as to support technology demonstration projects.

- CAD 964 million to deploy renewable energy and electric grid modernisation projects that aim to reduce GHG emissions by encouraging the replacement of fossil fuel-generated electricity with renewables as well as providing essential grid services.

The government also collaborated with provinces and territories through the Regional Electricity Cooperation and Strategic Infrastructure Initiative, which examined the most

promising electricity infrastructure projects in the Western and Atlantic provinces with the potential to transition to a sustainable non-emitting electricity generation portfolio. The resulting reports will inform provinces' and territories' future investment decisions around electricity infrastructure.

System integration of variable renewables

Canada's penetration of variable renewables is around 10%, which is manageable for existing provincial grids, though expected future growth in wind and solar will increase the importance of variable renewable integration.

To start, Canada plans to promote a reliable and flexible grid by bolstering regional interconnections, increasing the flexibility of existing power plants and deploying more flexible non-emitting technologies. It will also move toward a distributed model of electricity through the deployment of smart grid technologies and fostering regulatory innovations, and by deploying storage technologies and developing local supply chains.

The dominant role that hydroelectricity plays in several Canadian provinces, along with the fact that many hydro projects in Canada are large and have sizeable reservoirs, will significantly assist with the integration of variable generation, particularly at the energy management or network-wide level. In this regard, hydro is expected to evolve from a baseload role toward one that offers multiple contributions to the grid across Canadian jurisdictions and the North American continental grid, including ancillary services and large-scale storage.

In other Canadian provinces, in the absence of further policy action, natural gas is expected to become an increasingly important fuel in electricity generation, particularly given the planned phase-out of coal-fired generation. Natural gas turbines can complement variable generation given their fast-ramping capabilities.

The government also sees nuclear as playing an important role in providing flexibility and versatility to the grid. Ontario and New Brunswick have developed knowledge on the flexible operation of existing nuclear plants, especially the Bruce nuclear power plant in Ontario. Nuclear innovation is also under development to provide more opportunities for flexibility in nuclear systems, for example with advanced and small modular reactors.

Within Canada, the province of Ontario is the jurisdiction that experienced the most rapid growth in variable generation up to 2016, largely in response to its feed-in-tariff programme for renewable electricity. Ontario has a diverse electricity supply mix with significant nuclear and hydroelectric resources, and is also well-connected to neighbouring US states and the broader Canada-US Eastern Interconnection. These attributes aid significantly in managing variable generation. An issue in Ontario has been managing must-run nuclear plants during periods of very low demand. Ontario has dealt with this issue by utilising export capacity. It has also implemented centralised variable generation forecasting at the system operator level and, more recently, introduced rules enabling the system operator to curtail wind during periods of oversupply. In fact, Ontario has among the highest rates of dispatched-down wind and solar generation in the world (IEA, 2020b).

NRCan's CanmetENERGY labs conduct fundamental R&D related to the integration of distributed generation. This programme addresses technical, institutional and regulatory

barriers to the grid integration of variable renewable generation, focusing on network optimisation, improving power quality, ensuring network integrity and optimising electricity production.

With respect to load management/shifting, utility-led energy efficiency programmes are often primarily directed at peak demand reduction as opposed to an overall reduction in energy use. There are load-shifting initiatives, such as the use of load control devices, in most jurisdictions with energy efficiency programmes. In Canada, most provinces offer time-of-use (TOU) pricing plans only for industrial customers, with the exception of Alberta, where TOU rates are mandatory for residential customers, and Ontario, which offered tiered rates in addition to TOU rates. Ontario has the most focus on peak load reduction and also leads in the deployment of smart meters (a prerequisite for TOU pricing).

Smart grids are expected to play a role in facilitating greater integration of wind and solar power into Canada's electricity systems. Across Canada, more than 82% of installed meters are smart. Although every province and territory in Canada has begun the deployment of advance metering infrastructure, levels of development vary from province to province. British Columbia and Ontario have fully deployed smart meters.

Additionally, there are various levels of smart grid applications deployed across Canada beyond advanced metering infrastructure, including: new markets and rate options, demand response, distributed energy storage, grid automation, microgrid, and advanced inverter functions. Many provinces are actively pursuing the deployment at advanced levels. Future updates to the National Energy Code of Canada for Buildings will include energy performance improvements that maintain Canada's collective progress to net zero energy buildings. As more buildings incorporate renewable energy generation into their design, further demands will be placed on the smart grid to efficiently manage the transmission of electricity from buildings generating electricity to buildings consuming electricity.

Canada's Budget 2017 funded five national programmes, including smart grids, under the Green Infrastructure category of the Investing in Canada Plan. The Smart Grid Program will fund CAD 100 million over four years, starting in 2018/19, to support the demonstration (CAD 35 million) of promising, near-commercial smart grid technologies and the deployment (CAD 65 million) of integrated smart grid systems.

In addition, the public sector supports R&D to better understand the technical and non-technical elements of the smart grid for broader deployment. Canada has invested CAD 261 million to fund CAD 758 million in total project value since 2003 in 135 projects. A significant amount of this funding has been invested in distributed energy resource management (NRCan, 2019).

Last, as part of their planning responsibilities, independent system operators often undertake market and regulatory reviews. Currently, both the Alberta Electric System Operator and the Independent Electricity System Operator (IESO) are undertaking market and regulatory reviews aimed at reliably integrating energy storage and distributed energy resource assets into their respective grids.

Regional integration plans

Given the varied energy profiles and endowments of Canada's jurisdictions, the government has identified regional integration as a key strategy of the clean energy

transition. In particular, the coal phase-out will disproportionately affect those regions with heavy coal usage. These are also the same jurisdictions in which unabated gas generation is the most readily available substitute, but this is not aligned with a longer term net zero future.

In this regard, Canada identifies a significant opportunity to leverage regional advantages to increase the penetration of both hydro and variable renewables through the buildout of interprovincial interconnections.

The Regional Electricity Cooperation and Strategic Infrastructure (RECSI) initiative represented an important step in advancing this objective. Under the RECSI initiative, the federal government collaborated with provinces and utilities to identify the most promising electricity infrastructure projects with the potential to achieve significant GHG reductions. RECSI resulted in two reports: one for Western Canada, which includes the Northwest Territories, British Columbia, Alberta, Manitoba and Saskatchewan; and another for Atlantic Canada, including Newfoundland and Labrador, Nova Scotia, New Brunswick, and Prince Edward Island.

The federal government is working with the premiers of all four Atlantic provinces through a dialogue on the Clean Power Roadmap for Atlantic Canada. This represents an opportunity to improve the transmission system in the Atlantic provinces and use electricity more efficiently in the future. The plan aims to transport clean electricity from Quebec and Newfoundland and Labrador to New Brunswick and Nova Scotia to displace coal usage. This work would build on the impacts of the Lower Churchill Projects, which will will move electricity onto the island of Newfoundland across the Labrador-Island Link (connecting Newfoundland to the continental grid for the first time) and will continue on to Nova Scotia across the Maritime Link. These two subsea connections demonstrate the potential for collaborative transmission projects to make significant contributions toward the region's energy resource options and emissions reduction targets. The so-called Atlantic Loop project has an estimated capital cost of CAD 3 billion and estimated GHG reduction potential of around 2.65 Mt/year, though the project presents financing challenges given the small rate base in the receiving regions.

In Western Canada, in August 2019, the federal and British Columbia governments signed a memorandum of understanding to support the electrification of the natural gas sector in British Columbia. The memorandum of understanding builds on a joint investment by the governments, announced in April 2019 to expand the existing transmission infrastructure in the South Peace Region to meet increasing electricity demand due to natural gas exploration and development. Once complete, industries and businesses in the Peace Region will have access to a cleaner supply of energy to power their operations, reducing GHG emissions by up to 2.6 megatonnes per year.

Nonetheless, federal jurisdiction is limited to pre-development work, funding, and the establishment of dialogue and co-operation among involved provinces and stakeholders.

Internationally, Canada continues to collaborate with its neighbours on regional integration under the North American Renewable Integration Study. The study will analyse the benefits and challenges of achieving a clean energy grid across North America by 2050, focusing on long-term pathways to grid modernisation, high renewable energy penetration scenarios, weather variability, enabling technologies, and operating and planning practices. In doing so, the study will analyse the opportunity for clean

energy; develop state-of-the-art methodologies, datasets and scenarios; and assess co-ordinated grid planning and operation (NREL, 2021).

Covid-19 responses

In its 2020 Fall Economic Statement, the government provided details on a large economic stimulus package to recover from the Covid-19 pandemic, which included: CAD 2.6 billion in grants to improve energy efficiency in homes that will lower electricity demand; CAD 150 million to accelerate electric vehicle infrastructure; and CAD 25 million to support projects that improve Canada's electricity transmission infrastructure.

In response to the pandemic, the province of Ontario provided electricity customers with rate relief by offering a flat electricity rate from 1 June 2020 to 31 October 2020. The province of Alberta similarly developed a Utility Payment Deferral Program to defer the payment of electricity costs, giving Albertans a full calendar year to repay deferred payments for the 18 March-18 June 2020 period.

Electricity security

Overall, Canada's electricity reliability is in line with OECD averages. In 2018, its system average interruption duration index (SAIDI) was 0.9, below the OECD average of 1.3, while its system average interruption frequency index (SAIFI) was 1.3, above the OECD average of 0.9.

With transmission systems that are interconnected at multiple points from east to west, Canada and the United States are able to benefit from a significant electricity trading relationship. This relationship allows for efficient use of resources, especially between summer and winter peaking regions; commercial opportunities for both countries; and a more reliable electric system.

In Canada, recognition of the North American Reliability Corporation (NERC) and its regional entities as the Electric Reliability Organization, adoption of NERC Reliability Standards, and the establishment of measures to monitor and enforce the standards are done at the provincial level. While the process for approving NERC Reliability Standards varies among Canadian jurisdictions, the standards (occasionally modified based on a jurisdiction's reliability regime) are mandatory and enforceable in British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick and Nova Scotia (NERC, 2021). Enforcement varies among the provinces, with monitoring and enforcement authority ultimately resting with provincial regulators.

NERC reliability standards include those pertaining to emergency management. Its regional entities oversee the day-to-day operation of the North American Bulk Electric System and would be the first to work with electric generation and transmission owner/operators to resolve an energy and production emergency in the electricity sector. NERC's role in a blackout or other major bulk electric system disturbance or emergency is to provide leadership, co-ordination, technical expertise and assistance in the prompt and safe restoration of the bulk electric system. Working closely with its regional councils and reliability co-ordinators, NERC would co-ordinate efforts among industry participants, and with state, federal and provincial governments in the United States and Canada to support response to major events.

NERC conducts long-term reliability assessments annually, which assess the adequacy of the Bulk Electric System in the United States and Canada over a ten-year period. The reports project electricity supply and demand, evaluate transmission system adequacy, and discuss key issues and trends that could affect reliability. NERC also prepares summer and winter assessments, which assess the adequacy of electricity supplies in the United States and Canada for the upcoming summer and winter peak demand periods.

NERC expects that overall electricity generation capacity in Canada will be sufficient to maintain reliability, provided new generation is added as planned. However, a number of issues may affect the long-term reliability and effectiveness of the system:

- figures indicate some improvement in capacity margins, but certain areas will need additional supply or demand-side resources to ensure adequate long-term margins
- integration of wind, solar and nuclear resources must be properly managed
- increased reliance on natural gas in some regions
- an ageing workforce and shortage of skilled workers.

In the short and medium term, Canada does not face generation adequacy concerns. With its installed capacities of electricity generation from hydro, nuclear and natural gas, the country as a whole enjoys comfortable capacity margins to meet domestic demand at all times, even after the phase-out of conventional coal-fired electricity by 2030.

One of the most significant issues driving energy security concerns in the Canadian electricity market is the need for new investments in both generation and transmission beyond 2030. While the situation varies from province to province, certain markets will face shortfalls in generation capacity in the next 10-15 years based on required replacements, refurbishments and new build requirements to meet increasing demand.

Total transmission miles are projected to increase substantially over the coming years as electrical interconnections (both inter-provincially and internationally) are increasingly being seen as a low-cost solution to meet both power demand and reduce GHG emissions. However, siting of interprovincial and international interconnections remains challenging due to the various permits required from each province (or US state) that a line crosses.

Canada has implemented a comprehensive approach to critical energy infrastructure security, framed under three pillars: prevention, preparedness, and response and recovery, with international co-operation at the heart of all three. As part of their efforts to protect critical infrastructure in North America, Canada and the United States will implement a Framework for Collaboration on Cybersecurity in the Energy Sector to enhance the security and resiliency of cross-border energy infrastructure.

The government of Canada committed CAD 507.7 million over five years in 2018, and CAD 108.8 million annually thereafter to develop a new National Cyber Security Strategy and established the Canadian Centre for Cyber Security. This includes CAD 10 million specifically to help strengthen the cybersecurity and resilience of Canada's domestic and cross-border energy infrastructure. The Cyber Centre collaborates closely with NRCan in its approach to energy sector cybersecurity, which includes gathering and distributing actionable cyberthreat intelligence to energy sector stakeholders. NRCan engages with energy sector owners and operators to improve the sector's cybersecurity and resilience, including: designing and conducting exercises; co-chairing the Energy and Utilities Sector Network, a public-private forum to share intelligence and best practices to increase the

sector's resilience; and through its Cyber Security and Critical Energy Infrastructure Program, which aims to strengthen the capability of the energy sector to prevent, prepare, respond to and recover from cyberthreats by funding research projects.

Assessment

Canada has one of the cleanest electricity systems in the world. In 2020, 83% of its electricity generation came from non-emitting sources, including hydro (60%); nuclear (15%); and non-hydro renewables such as wind, solar and bioenergy (8%). Coal-fired electricity generation has been on a steady decline since 2010, contributing 6.2% to overall generation in 2020, while natural gas and remaining combustibles accounted for 12%.

While the provinces of British Columbia, Manitoba, Quebec, and Newfoundland and Labrador cover their electricity demand almost entirely with hydro generation, provinces that are less abundant in hydro energy – like Alberta, Saskatchewan and Nova Scotia – rely more heavily on coal and natural gas. Meanwhile, Ontario and New Brunswick rely heavily on nuclear power, while the territories depend more on diesel electricity generation.

In 2019, electricity generation accounted for 15% of Canada's energy-related CO_2 emissions, with 49% of sectoral emissions stemming from coal-fired electricity. Over the last decade, the sector's emissions have significantly dropped, from 109 Mt CO_2 in 2009 to 85 Mt CO_2 in 2019, representing a 22% decline in ten years. Provisional data for 2020 indicate that emissions from electricity and heat generation dropped to 74 Mt CO_2, as less electricity was generated due to the Covid-19 pandemic. Given Canada's strong carbon price trajectory, it is likely that the carbon intensity of its electricity sector will remain low. Still, some additional reductions will be needed. Further GHG emissions reductions in electricity generation of an estimated 47 Mt CO_2-eq are needed to reach Canada's GHG targets for 2030; even deeper cuts are needed to reach net zero emissions in 2050. Perhaps more significantly, however, Canada will need to ensure sufficient new clean generation capacity to meet the sizeable levels of electrification that its net zero targets imply.

Canada has already taken some steps that will help it meet its 2030 targets. After Canada became the first country to introduce federal coal-fired GHG regulations in 2012, it opted for an accelerated phase-out in 2018. Coal-fired power plants at the end of their useful life or before 2030, whichever comes first, need to meet the "clean-as-gas" emissions performance standard of 420 t CO_2/GWh or shut down. Ways to expand a plant's lifetime beyond 2030 include CCUS and fuel switching to natural gas.

In order to maintain the current level of overall generation capacity, the accelerated coal phase-out will make it necessary to replace most of today's coal-fired generation (31 TWh in 2020) with other generation options. Coal-to-gas conversion of existing plants is widely considered a cost-effective option that would circumvent the more challenging option of installing new hydro and wind/solar capacity along with massively expanding inter-provincial grid connections. Coal-to-gas conversions are regulated for their CO_2 emissions, though under current regulations, units converted from coal to gas will be allowed to operate without meeting a performance standard for a fixed period of time after their end-of-life, after which they will have to meet the same performance standard of 420 t CO_2/GWh as new units.

While natural gas is likely to be part of Canada's near-term energy mix, the current trend toward coal-to-gas fuel switching and new builds of gas-fired plants can lead to a risk of stranded investments if future abatement costs are found to be higher than the alternatives. While escalating carbon prices will erode the competitiveness of gas plants, the government should also give due consideration to electricity security concerns if large amounts of gas capacity exits the market in short order. Given its ambitious climate targets for 2050 and the decarbonisation of the electricity sector, as well as electricity security considerations, the federal government is working towards more clearly outlining the role of natural gas in a net zero future, namely through its commitments under the Strengthened Climate Plan. As part of these efforts, the government should model pathways to net zero by 2050 for Canada's electricity system, specifying the roles for each power source as well as implications for transmission capacity and storage.

Canada also recognises the important role that hydropower will continue to play in its energy mix. Four new large hydro generation projects are under construction and several other smaller projects are in the planning phase, which could add up to an additional 21 GW of installed capacity in the future, compared to today's 81 GW. Nonetheless, notwithstanding several additional sites that hold promise for new hydro generation, recent hydro projects have faced hefty price tags. As such, focus has shifted toward variable renewables and storage.

Canada has also wisely opted to keep nuclear as an integral component in its future clean electricity mix, particularly in a net zero future. The country's nuclear fleet is situated in Ontario and New Brunswick and accounted for 15% of Canada's total generation in 2019. Utilities in Ontario have embarked on one of the largest infrastructure projects (CAD 26 billion) with the refurbishment of 8.3 GW of the province's CANDU nuclear power plants by 2033. This measure will extend the plants' lifetimes past mid-century, which will ensure continued supply of emissions-free energy.

Installed capacities of wind and solar electricity generation have displayed substantial growth rates over the last decade, but growth has slowed in recent years and their contribution to overall electricity supply remains small, accounting for less than 6% in 2019. Capacity additions still depend on provincial and federal support programmes, some of which have terminated. While federal tax incentives exist for business investment in clean energy generation equipment, most federal support is targeted in more narrow areas, such as programmes for emerging renewable technologies and for providing clean power to diesel-reliant rural and remote communities. A comprehensive pan-Canadian approach to integrating large shares of non-hydro renewable electricity into the grid is neither in place nor planned.

Harnessing offshore wind energy potential, both on the Atlantic and Pacific coasts, is still in a premature stage, with discussions on how to regulate offshore installations ongoing.

Canada's longer term emissions trajectory calls for more structural changes. In order to reach its net zero targets by 2050, Canada will need to electrify large parts of its fossil dominated sectors, such as transportation, buildings, industry, and remaining oil and gas production. According to government estimates, increased electrification in 2050 will double today's demand for electricity, and the net zero imperative will require a doubling or tripling of power generated from non-emitting sources compared to today. Such a shift will require significant regulatory action.

The path is not straightforward. Jurisdiction over electricity is mostly held by the provinces and territories. The federal role in electricity is limited to federal lands and international transmission lines and, to a certain extent, interprovincial electricity trade. The federal government exerts significant influence, however, in the area of environmental performance, through tools such as taxation, emissions performance standards and carbon pricing. Moreover, it engages intensively with jurisdictions and stakeholders through various forms of co-operation and dialogue.

Under Canada's federal approach to regulation, electricity market design and levels of competition vary significantly across provincial jurisdictions. While Alberta has fully liberalised wholesale and retail markets and Ontario allows for competition in the wholesale segment, electricity in all other jurisdictions is supplied in regulated markets. In jurisdictions with regulated markets, there is no immediate impetus to shift to greater competition in generation or to empower end-users by offering retail choice.

Potential drivers for future regulatory reform will be innovative technologies and a new electricity sector paradigm, which will include optimising flexible generation, distributed supply, demand response, storage and smart grid operations. To complement these drivers for regulatory reform, guide price regulation and enhance transparency for consumers, the federal government may consider introducing a voluntary system of performance benchmarking for incumbent utilities across jurisdictions.

Strengthening interprovincial connectivity offers considerable upside to allow fossil fuel-dependent provinces to decarbonise and electrify their economies. It is a natural match that all provinces with heavy consumption of oil and natural gas neighbour hydro-rich provinces (such as British Columbia and Alberta). This yields opportunities to create a win-win situation through cross-border trade. However, this prospect may not be a priority for some provincial utilities, as the overall impetus for constructing and using interconnectors does not reflect their potential welfare gains. One barrier may be the common practice of utilities on both sides of the border to bilaterally agree on long-term (often seasonal) capacity commitments, deterring optimised utilisation of interconnectors across shorter time frames, driven by demand and supply and cross-border price differences.

In recent years, the government has increasingly engaged with provinces and territories to help build key interconnections and electrification projects, with funding from the Canada Infrastructure Bank. Successfully practiced formats were the RESCI and the Clean Power Roadmap for Atlantic Canada, which have facilitated progress in projects like Peace Region Electricity Supply in British Columbia and the "Atlantic Loop" in the Atlantic provinces. However, federal jurisdiction is limited to pre-development work, funding, and the establishment of dialogue and co-operation among the involved provinces and stakeholders.

The Canadian government acknowledges that the current regulations on phasing out coal and coal-to-gas conversions, combined with the proposed increase in ambition on the carbon price outlined in the Strengthened Climate Plan, may be insufficient to achieve the required massive expansion in clean energy generation. It therefore announced that it is exploring the need for a clean electricity performance standard over the coming months, which would aim to reduce the CO_2-equivalent emissions intensity of electricity production and help support increased investment in cleaner sources of electricity generation. Clean

fuels are expected to play an essential role in reaching the net zero goal in areas where electrification will be more challenging.

Given the tremendous challenge to electrify Canada's economy, the federal government should develop a comprehensive electrification strategy in line with net zero modelling, complementing the Hydrogen Strategy (see Chapter 3), which would provide guidance to the provinces and territories for establishing their own strategies and offer formats for dialogue and co-operation across jurisdictions and with stakeholders. Such a strategy should include an assessment of provincial market rules and regulatory frameworks that are currently barriers to the deployment and integration of distributed generation, the participation of "prosumers", the use of storage, the incentivisation of demand-side response and the application of smart grid technologies.

Canada's electricity reliability is overall in line with the OECD average. The country's clean and reliable supply comes at comparatively low consumer prices. For industry, Canada's electricity prices were the eighth-lowest among IEA countries, while its household electricity prices were the fourth-lowest. Nonetheless, competitiveness can remain a concern, especially *vis-à-vis* the United States, where industrial prices are lower.

The Canadian-US electricity grid is deeply integrated, with 37 transmission lines connecting the majority of Canadian provinces with neighbouring US states. This allows Canada to export generation surplus in the range of 50-60 TWh yearly, representing 10% of the country's generation, and worth about CAD 2.5 billion of revenues annually. The degree of east-west interprovincial interconnection is significantly lower. Hence, domestic trade across jurisdictions plays a subordinate role compared to international trade with the United States.

Canada does not face generation adequacy concerns in the short or medium term. With its installed capacities of electricity generation from hydro, nuclear and natural gas, the country as a whole enjoys comfortable capacity margins to meet domestic demand at all times, even after the phase-out of conventional coal-fired electricity by 2030. However, the situation varies from one jurisdiction to another, with certain markets potentially facing shortfalls in generation capacity in the next 10-15 years due to replacement, refurbishments and new build requirements to meet demand. New investments in both generation and transmission will be needed in the longer term due to increased electrification, limited interprovincial interconnections and the uneven impact of decarbonising the power system between the hydro-rich provinces and those with nuclear generation on the one side, and provinces that rely heavily on coal and natural gas power generation on the other. Notably, the provinces that rely heavily on coal and natural gas have to create new low-carbon generation capacity, with wind and solar PV as low-cost options. Once the shares of these variable renewable generation capacities start to rise, new challenges will emerge to maintain secure electricity supply at times of low wind or solar availability. The government should carefully study whether special market arrangements (time-of-use pricing, balancing market, ancillary services markets) are necessary to ensure system security at all times.

Recommendations

The government of Canada should:

- Model pathways to net zero by 2050 for its electricity system, specifying the roles for each power source as well as implications for transmission capacity and storage.
- Develop a national electrification strategy in line with net zero modelling, complementing the Hydrogen Strategy, to provide guidance to the provinces and territories for shaping their own strategies on how to electrify fossil heavy sectors like transportation, buildings, industry, and oil and gas production.
- Help provinces and territories address market and regulatory barriers to the deployment and integration of distributed generation, the participation of "prosumers", the use of storage, the incentivisation of demand-side response and the application of smart grid technologies.
- Explore ways to enhance the federal government's role in strengthening inter-provincial connectivity, optimising the use of interconnectors across shorter time frames, and accelerating key projects of grid modernisation and electrification.
- Consider introducing a system of voluntary performance benchmarking for incumbent utilities across jurisdictions to provide guidance for price regulation to regulatory bodies and enhance transparency for consumers.
- Monitor the evolution of generation adequacy across the various jurisdictions and create a regulatory environment that rewards low-carbon replacements, refurbishments and new builds of generation capacity as plans for decarbonisation of the power sector take form.
- Closely monitor the development of variable renewables like wind and solar as they replace fossil fuel generation in some provinces, and assist relevant jurisdictions in developing an electricity market design that facilitates their smooth integration while preserving system security and reliability at all times.

Annex 7.1 Provincial electricity systems

British Columbia

In British Columbia, BC Hydro, the publicly owned utility, owns and operates the majority of the province's electricity generation assets and is the supplier for most residential and commercial customers. Wholesale access and free choice of electricity supplier are available to large industrial users, while smaller consumers are restricted to BC Hydro or their local distributor.

In 2003, the British Columbia Transmission Corporation was created to manage BC Hydro's core transmission assets as an independent transmission entity to ensure non-discriminatory access to the transmission system for all market participants. In June 2010, it became part of BC Hydro as prescribed by the 2010 Clean Energy Act.

The British Columbia Utilities Commission is an independent regulatory agency of the provincial government.

Alberta

In Alberta, electricity generation is organised into a competitive market while transmission and distribution functions are regulated. Retail for industrial and large commercial consumers is competitive. More than 20 companies currently compete to sell power to the province's larger commercial and industrial users, who account for roughly two-thirds of all electricity usage in the province. Although the retail market for residential, farm, and small and medium commercial consumers is open to competition, these consumers have the option to remain on a regulated rate tariff (though the regulated rate option is planned to be phased out).

The Alberta Electric System Operator is responsible for the safe, reliable and economic planning and operation of the Alberta Interconnected Electric System. It also develops and administers transmission tariffs, procures ancillary services to ensure system reliability, and manages settlement of the hourly wholesale market and transmission system services.

The Alberta electricity market is regulated by the Alberta Utilities Commission, which is an independent, quasi-judicial agency charged with balancing the needs of consumers and utilities to ensure safe and reliable utility service at reasonable and competitive rates.

Saskatchewan

Electricity generation, transmission and distribution services in Saskatchewan are primarily provided by the monopoly Crown entity Saskatchewan Power Corporation (SaskPower). SaskPower's proposed rate increases are reviewed by the Saskatchewan Rate Review Panel at the request of the Minister of Crown Management Board. However, the Rate Review Panel does not have the authority to implement any of its recommendations and the final decision on any action is left to the provincial Cabinet.

Manitoba

Manitoba Hydro owns and operates virtually all segments of the electricity industry in Manitoba. Retail electricity rates are regulated by the Manitoba Public Utilities Board, a quasi-judicial administrative tribunal that takes decisions independently of government

direction. However, the Manitoba Public Utilities Board does not regulate Manitoba Hydro's transmission tariff, which is unregulated.

Ontario

Ontario has combined elements of regulation and competition into a unique hybrid market. Wholesale prices created through the market are tempered by contract guarantees and fixed prices provided to a majority of generators in the province. The price customers pay is determined by the Hourly Ontario Energy Price set in the market, which is subsequently adjusted to take into account the various types of contract prices paid to certain generators. Generators offer into the market and are paid the market price. Those with contracts receive fixed prices, monthly revenue guarantees or guaranteed floor prices.

The Independent Electricity System Operator (IESO) was established in 1998 by the Electricity Act of Ontario. In 2015, it was merged with the Ontario Power Authority. The IESO directs the operation of, and maintains the reliability of, the IESO-controlled grid and operates the wholesale electricity market. It operates a real-time energy market in which electricity demand and supply are balanced and instructions are issued to dispatchable generators and loads every five minutes.

The Ontario Energy Board regulates Ontario's electricity industry, including determining electricity transmission and distribution tariffs and approval of the IESO's budget and fees.

Quebec

Hydro-Québec is a fully integrated Crown corporation responsible for the generation, transmission and distribution of most of the electricity sold in Quebec. Generation is not regulated in Quebec. However, Hydro-Québec has pursued the development of larger hydro facilities, leaving applications under 50 megawatts for the private sector and renewable energy developers. Additionally, by law, Hydro-Québec's production arm is required to supply its distribution arm a maximum of 165 million megawatt hours/year (the "heritage pool") for customers in Quebec at a price fixed by regulation. Competition exists in the wholesale market for all distribution needs in excess of the heritage pool.

Transmission and distribution are regulated by the Régie de l'énergie, an independent agency.

New Brunswick

The generation, transmission and distribution of electricity in New Brunswick is dominated by NB Power, a provincially owned utility. Almost all the residential and industrial power consumers in the province are serviced by NB Power, which functions as a regulated monopoly. The New Brunswick Energy and Utilities Board regulates the rates set by the NB Power Distribution Branch.

Nova Scotia

Nova Scotia Power Incorporated, a vertically integrated public utility and subsidiary of Halifax-based Emera, produces and distributes nearly all of the electricity in Nova Scotia. Six municipally owned independent utilities supply electricity to consumers within their territory and own and operate their own distribution systems. The Nova Scotia Utility and Review Board is responsible for overseeing the regulation of the electricity sector and has a mandate to ensure universal access for all Nova Scotians to public utility services at "just and reasonable" rates.

Prince Edward Island

Around 90% of Prince Edward Island's electricity customers are serviced by the fully integrated, regulated private utility Maritime Electric Co. Ltd. The remaining electricity customers are serviced by the municipally owned utility Summerside Electric. Both Maritime and Summerside Electric are regulated by the Island Regulatory and Appeals Commission on a cost-of-service basis.

Newfoundland and Labrador

Newfoundland and Labrador Hydro (NLH), a Crown corporation, dominates generation and transmission services in the province. NLH sells electricity wholesale to Newfoundland Power Inc., a regulated private subsidiary of Fortis Inc., for distribution to customers in urban areas. Both NLH and Newfoundland Power Inc. are regulated by the Board of Commissioners of Public Utilities.

Yukon

Yukon Energy Corporation, a subsidiary of the Crown-owned Yukon Development Corporation, is the dominant power generator with almost 90% of capacity, including all major hydro facilities. Yukon Electric Company Limited, a subsidiary of ATCO Electric, owns and operates the remaining generation capacity in most of the Yukon's other rural communities. These utilities are regulated by the Yukon Utilities Board.

Northwest Territories

The Northwest Territories Power Corporation, a Crown corporation, is the main producer of electric power. Power distribution is handled by Northland Utilities Ltd. (a subsidiary of ATCO Electric). The NWT Public Utilities Board is an independent, quasi-judicial agency of the government of the Northwest Territories.

Nunavut

The Nunavut electrical system consists of isolated diesel generators with no interconnections with neighbouring provinces. All aspects of Qulliq Energy Corporation, the sole utility, are regulated by the Ministry of Energy.

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8. Nuclear

Key data (2020 provisional)

Number of reactors: 19

Installed capacity: 14 GW

Electricity generation: 98.2 TWh, +8% since 2010

Share of nuclear in electricity production: 15.3% of total electricity generation, 15.0% in 2010

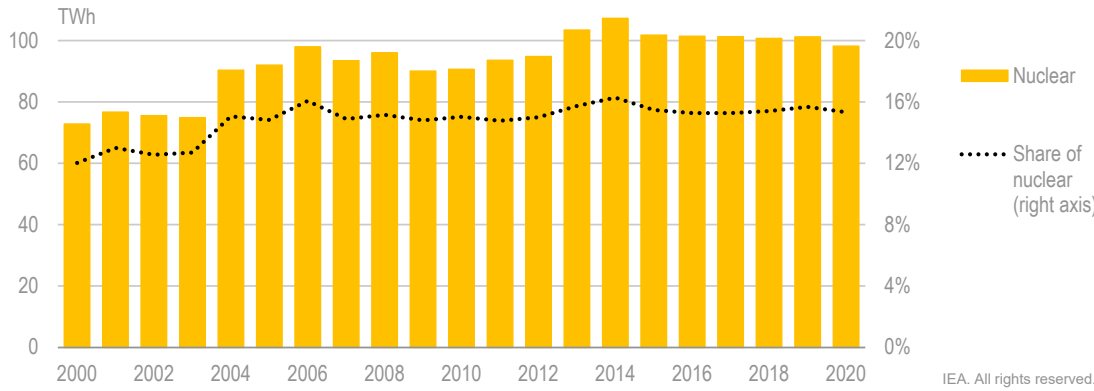
Overview

Nuclear is the second-highest source for electricity generation in Canada after hydropower, and contributed 8.9% of total energy supply (TES) in 2020. Canada has 4 nuclear power plants with 19 operational reactors, located in Ontario and New Brunswick, with a total installed capacity of 14 gigawatts (GW), including the largest operating nuclear plant in the world in terms of capacity (Bruce Power in Ontario, with an annual net output of about 48 terawatt hours [TWh]).

Nuclear generated 98 TWh of electricity in 2020, accounting for 15% of Canada's total electricity generation (Figure 8.1). Electricity production from nuclear energy grew slightly from 2000 to peak in 2014, with moderate fluctuations, and was relatively stable at around 101 TWh/year between 2015 and 2019. In 2020, as a consequence of an overall decrease of electricity demand, electricity generation from nuclear decreased to 98 TWh.

Today, Canada is also at the forefront of the development of advanced nuclear reactors, with a number of demonstration projects under consideration. These projects benefit from strong public-private partnerships and target a number of new market opportunities to support the decarbonisation of hard-to-abate sectors such as coal replacement in industry, electrification of remote mining operations and industrial heat applications. Canada has also advanced a number of policy initiatives, most notably the 2018 Small Modular Reactor (SMR) Roadmap; the 2020 SMR Action Plan; and a provincial memorandum of understanding (MOU) to advance SMRs signed by Alberta, New Brunswick, Ontario and Saskatchewan.

Figure 8.1 Canada's nuclear power generation, 2000-20



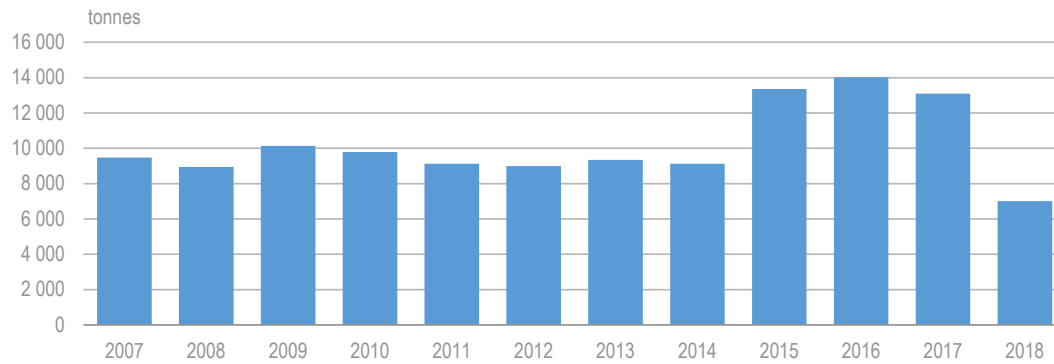
Nuclear accounts for 15% of total electricity generation in Canada. It was stable at around 101 TWh between 2015 and 2019, and decreased to 98 TWh in 2020.

Note: TWh = terawatt hour.
Source: IEA (2021), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

The pressurised heavy-water reactor design known as CANDU (Canada Deuterium Uranium) was developed in Canada in the late 1950s. Canada has exported CANDU reactor systems as a world leader in nuclear energy technology. To date, CANDU reactors have been exported to Argentina, the People's Republic of China, India, Korea, Pakistan and Romania. CANDU reactors are capable of using spent fuels from the light water reactors. There is ongoing work regarding the use of recycled uranium, thorium and mixed oxide fuels as feedstock for the next generation of CANDU reactors.

The government continues to expand the nuclear sector with an eye to a low-carbon future, by supporting research of CANDU technology and implementing Canada's SMR Action Plan (Government of Canada, 2021).

Figure 8.2 Uranium production in Canada, 2007-18



Canada is the second-largest uranium producer in the world, with 7 000 tonnes in 2018.

Source: NRCan (2021) Uranium and nuclear power facts, https://www.nrcan.gc.ca/science-data/data-analysis/energy-data-analysis/energy-facts/uranium-and-nuclear-power-facts/20070.

In 2019, Canada was the second-largest uranium producer in the world, accounting for 13% of the world's production (NRCan, 2021). Canada exports 85% of its uranium production (IAEA, 2018). Uranium is concentrated in the province of Saskatchewan and

increased significantly in 2015 due to increased output from the Cigar Lake mine, then decreased in 2018 as production was suspended at the McArthur River mine and Key Lake mill (Figure 8.2).

Nuclear policy overview

Constitutionally, responsibility for nuclear energy falls within the jurisdiction of the federal government. Its role encompasses certain research and development (R&D) activities, as well as the regulation of all nuclear materials and activities in Canada. Canada only conducts nuclear trade with countries that uphold the highest International Atomic Energy Agency standards for nuclear safety and security.

While the federal government has important responsibilities related to nuclear energy – particularly in the area of nuclear safety, security and non-proliferation – the development and management of resources fall within provincial jurisdiction. Accordingly, the decision to invest in electricity generation, including the refurbishment of existing nuclear plants and the construction of new ones, rests with the provinces, which make this determination in conjunction with relevant provincial energy organisations and power utilities. Similarly, territories have some responsibilities with respect to the management of resources and are responsible for electricity systems within their borders.

Table 8.1 Nuclear power plants in operation in Canada as of January 2021

Nuclear station	Province	MW_e	Commissioning	Operator
PICKERING A	Ontario	2 x 515	1971-73	OPG
PICKERING B	Ontario	4 x 516	1983-86	OPG
DARLINGTON	Ontario	4 x 881	1990-93	OPG
BRUCE A	Ontario	4 x 750	1977-79	Bruce Power
BRUCE B	Ontario	4 x 860	1984-87	Bruce Power
POINT LEPREAU	New Brunswick	1 x 635	1983	NB Power

Note: Mw_e = megawatts electric. OPG = Ontario Power Generation.

Source: IAEA Power Reactor Information System (PRIS).

Nuclear energy is an important part of Canada's current clean energy mix. After hydropower, it is the second-largest source in Canada's 83% non-emitting electricity mix. However, the role of nuclear varies greatly across provinces. Most of the nuclear fleet is located in Ontario, which was the first jurisdiction in North America to phase-out coal power, largely thanks to its substantial nuclear fleet. New Brunswick hosts one nuclear reactor at Point Lepreau where the potential for nuclear new build has been discussed periodically in recent years. Conversely, Quebec, which operated one nuclear reactor (Gentilly-2) for several decades, decided in 2012 not to refurbish this reactor, in effect phasing out nuclear power. While the remaining provinces and territories do not have nuclear power, several of them have previously expressed a strong interest in the technology, in particular Alberta, and more recently, Saskatchewan. In 2019, the provinces

of Ontario, New Brunswick and Saskatchewan signed a provincial MOU to advance SMRs; Alberta signed in April 2021.

The government recognises the role of nuclear energy as fundamental to achieving and sustaining Canada's climate change goals, and sees nuclear as a long-term source of baseload electricity supply. In 2018, SMRs were identified in the Generation Energy report as key to the sustainable development of Canada's energy and natural resources. SMRs were further highlighted in Canada's Strengthened Climate Plan, *A Healthy Environment and a Healthy Economy,* released in December 2020, as a tool to reduce emissions at home and abroad.

In 2018, Natural Resources Canada (NRCan) convened the SMR Roadmap project with interested provinces and territories, industry, indigenous communities, and civil society to chart a path forward for this technology in Canada. The SMR Roadmap was released in November 2018 and contains 53 recommendations for a number of partners, including recommendations for the federal government. More recently, in December 2020, Canada's Minister of Natural Resources announced the release of Canada's SMR Action Plan, which was developed in partnership with more than 100 organisations, including provincial and territorial governments, municipalities, utilities, industry, civil society, academia, and some indigenous voices. Participating organisations have committed to over 500 actions to advance SMRs in Canada.

Canada's nuclear energy sector is currently focused on five key priorities: 1) CANDU refurbishments and new build prospects; 2) leadership on SMRs; 3) uranium markets; 4) responsible management of waste; and 5) domestic and international nuclear liability frameworks. All these areas are further underpinned by strong international collaboration.

The average age of Canada's current fleet of 19 reactors is 38 years, with the oldest being Pickering-1 (50 years) and the youngest Darlington-4 (28 years). Maintaining nuclear as a key component of Canada's baseload electricity supply will be an important part of realising Canada's climate change goals. In the province of Ontario, utilities are investing CAD 26 billion over the period 2016-31 to extend the lifespan of 10 nuclear reactors by approximately 30 years to maintain the province's nuclear power capacity at 9.9 gigawatts electric (GW_e) in the long run, when Pickering retires in 2024-25.

CANDU refurbishments and nuclear new builds

The refurbishment of the existing CANDU nuclear fleet is the first priority of the Canadian nuclear sector. Compared to light water reactors, CANDU reactors have an initial design lifetime of 30 years and require significantly more refurbishment to extend their operation by another 30 years. In 2013, the government of Ontario decided to refurbish ten nuclear reactors at the Bruce and Darlington nuclear power plants as part of the Ontario Long Term Energy Plan. The provincial government announced its intent to end operation of the six Pickering reactors by the end of 2025.

This operation will allow the province to secure long-term supply of electricity generation and help to meet its long-term climate objectives. These projects build on the lessons learnt from previous CANDU refurbishment projects (in particular at Pickering) that faced challenges in terms of costs and delays. As of 2021, ongoing reactor refurbishments are progressing according to plan, and are both on time and on budget, with two units currently offline (Darlington-3 and Bruce-6).

The Bruce and Darlington refurbishments are supported and financed by different policy frameworks. While both nuclear power plants are owned by Ontario Power Generation (OPG), the Bruce nuclear power plant is operated by a private company, Bruce Power, which receives payments for generating and selling electricity on the Ontario market. The province of Ontario estimates that the refurbishment project will provide ratepayers with a long-term supply of relatively low-cost, low emissions electricity. The levelised costs of nuclear electricity post-refurbishment are estimated at about 80 CAD/MWh on average over the next 30 years, below the 112.5 CAD/MWh price of electricity for residential and small business ratepayers as of 2017 (FAO, 2017).

Bruce nuclear power plant refurbishment

In 2005, Bruce Power entered into the Bruce Power Refurbishment Implementation Agreement with Ontario's Independent Electricity System Operator (IESO), which led to the refurbishments of the first two units. The project cost CAD 4.8 billion and was successfully completed in October 2012. In December 2015, Bruce Power and IESO amended the agreement to enact the Major Component Replacement project of the six remaining units at Bruce. This programme will run between 2020 and 2033 for an estimated total cost of CAD 13 billion, which will be financed through a public-private partnership with the Ontario Municipal Employees Retirement System, TransCanada Corporation, the Power Workers' Union and the Society of Energy Professionals.

Darlington nuclear power plant refurbishment

The Darlington refurbishment project is operated by OPG and aims to replace key reactor components in Units 1-4. OPG will invest CAD 12.8 billion in the project. The project began in October 2016 and will last until 2026 to ensure safe plant operation through 2055. The programme is financed through OPG's balance sheet and is backed by Ontario's rate-base regulatory framework. The first unit at Darlington, Unit 2, started its refurbishment outage in October 2016, and was returned to commercial operation in June 2020.

Nuclear new builds

The potential for nuclear new builds has been periodically discussed over the last two decades. Until the last IEA review, these discussions primarily focused on large reactors with both new CANDU designs and Gen-III light water reactors (EPR, AP1000) proposed for Ontario, New Brunswick and Alberta. However, at the time of the previous review, such proposals had already either lapsed or been cancelled, with priority given instead to CANDU refurbishments. Today, as discussed below, strong momentum is emerging around SMRs.

SMR Roadmap and Action Plan

SMRs are generally defined as nuclear reactors with power outputs up to about 300 MW_e. SMRs present several technical features that support inherent safety, improved construction predictability, and potential reductions in construction costs and delivery times. The energy output from SMRs can be used not only for electricity generation, but also heat supply, including generating high-quality heat required for industrial process (NEA, 2021).

In 2018, the government of Canada released its SMR Roadmap (NRCan, 2018), which identified a significant potential for these innovative reactors to address a range of energy

needs, along with opportunities for the Canadian nuclear industry to meet the international demand for these innovative nuclear reactors.

The road map is based on an extensive engagement process that convened all relevant stakeholders, with strong inputs from several provinces, territories and power utilities. It is to be the focal point for developing a policy framework to support near-term technology development and deployment.

The road map identifies several distinct market opportunities for SMRs in Canada that are now moving forward through several provincial initiatives. These different markets would require different reactor design characteristics, for instance in terms of reactor size or heat temperature.

- **On-grid power (150-300 MW_e):** This market especially identifies coal replacement as a key near-term opportunity for SMRs, and several projects are under consideration at the provincial level. Both Ontario and Saskatchewan are targeting SMRs to support such a replacement of coal-fired plants. A potential deployment is under consideration in Ontario by the late 2020s to demonstrate the technology at an existing nuclear site (Darlington). Saskatchewan is also considering on-grid SMRs in the early 2030s as part of its plans to phase out several coal power plants. In parallel, New Brunswick is pursuing innovative next-generation SMRs for its Point Lepreau site and the export market. A key objective would be to deploy a Gen-IV SMR that would enable spent fuel recycling in the early 2030s.

- **Extractive and heavy industries (10-80 MW_e):** This market focuses primarily on off-grid SMRs for extractive industries (mining and oil sands). For a number of years, extractive industries in Canada have maintained a keen interest in high-temperature reactors to replace diesel generators. High-temperature reactors offer a significant long-term potential to decarbonise these hard-to-abate industrial sectors and could reduce greenhouse gas emissions in the heavy industrial sector by 18% by 2050 (EnviroEconomics and Navius Research, 2021). Recently, the Oil Sands Pathways to Net Zero initiative included SMRs as part of a range of emissions-reducing technologies (WNN, 2021).

- **Remote communities (1-10 MW_e):** Last, but not least, remote communities that currently rely primarily on off-grid diesel generators have also been identified as a longer term market opportunity through the development of micro-modular reactors. These reactors have a capacity range of 1-10 MW_e. Global First Power, a joint venture between OPG and USNC Power Ltd., has submitted an application to prepare a site to build a micro-modular reactor at the Atomic Energy of Canada Limited's (AECL) Chalk River Laboratories. This project is currently undergoing an environmental assessment.

In December 2020, the government of Canada released its SMR Action Plan (NRCan, 2020), which responds to the 53 recommendations in the SMR Roadmap and lays out the steps for the development, demonstration and deployment of SMRs at home and abroad. The plan envisages the first units to come online in the late 2020s. In particular, several provincial and federal initiatives, including funding support for SMR vendors, have recently been announced. Among them:

- In June 2018, the province of New Brunswick committed CAD 10 million to support the New Brunswick Energy Solutions Corporation to develop a nuclear research cluster in the province.

- In December 2019, building on this federal initiative, the provinces of New Brunswick, Saskatchewan and Ontario announced plans to collaborate in the field of SMRs to address climate change, regional energy demand, economic development, and research and innovation opportunities. Alberta signed the MOU in April 2021. The MOU provides a clear policy statement that nuclear is a clean and indispensable technology for these provinces to

- meet their climate goals. It calls on the federal government to provide funding for SMR demonstration projects along with dedicated risk-sharing mechanisms such as loan guarantees.

- In June 2020, the province of Saskatchewan announced the establishment of a secretariat to help in the planning and development of SMRs. The new office will co-ordinate nuclear policy and programme work.

- In October 2020, Canada's Strategic Innovation Fund announced CAD 20 million investment in Terrestrial Energy to accelerate development of the company's Integral Molten Salt Reactor.

- In December 2020, the Hydrogen Strategy for Canada was launched, which identified synergies with nuclear energy. A Nuclear Working Group is being established to foster co-ordination and collaboration among participants and to make recommendations for the implementation of the Hydrogen Strategy.

- In February 2021, New Brunswick announced CAD 20 million of industry-matched funding for the development of the Canadian ARC-100 sodium-cooled SMR.

- In March 2021, the federal government announced over CAD 56 million in funding to support the development of SMRs, through the Strategic Innovation Fund and the Atlantic Canada Opportunities Agency's Regional Economic Growth through Innovation programme. The announcement included CAD 50.5 million to Moltex Energy molten salt SMR, CAD 5 million to NB Power to support SMR site preparation at Point Lepreau, and CAD 562 000 to the University of New Brunswick's capacity to support SMR technology development.

- In addition, Canadian Nuclear Laboratories (CNL) received almost 20 expressions of interest for siting an SMR at a CNL-managed site. CNL aims to have a new SMR at its Chalk River site by 2026.

Nuclear regulation

In Canada, the regulation of nuclear facilities is a federal jurisdiction under the Nuclear Safety and Control Act. Environmental assessments for nuclear projects under the Canadian Environmental Assessment Act 2012 are conducted by the Canadian Nuclear Safety Commission (CNSC). However, in 2019, the government of Canada introduced new rules to protect the environment, recognise and respect indigenous rights, and strengthen the economy through the new Impact Assessment Act, which is led by the Impact Assessment Agency of Canada.

The key legislative instruments in place in Canada are:

1. Nuclear Safety and Control Act
2. Nuclear Energy Act
3. Nuclear Fuel Waste Act
4. Nuclear Liability and Compensation Act.

Additional legislation that covers nuclear energy and materials are also relevant:

5. Impact Assessment Act (2019)
6. Canadian Environment Assessment Act (2012)
7. Transportation of Dangerous Goods Acts
8. Export and Import Permits Act.

Since the IEA's last review, the Nuclear Liability and Compensation Act has been fully implemented (NEA/IAEA, 2018). This legislation introduced a stronger compensation and civil liability regime to address damages in the unlikely event of an incident at a nuclear installation or when nuclear material is transported. This regime makes operators of nuclear installations liable for damage caused by the release of ionising radiation with the liability limit increased from CAD 75 million in the previous legislation to CAD 1 billion. Canada is also undertaking its first five-year review of this liability limit and has begun analysis on the prospective liability limits for SMRs.

For nuclear safety regulation, the CNSC regulates the use of nuclear energy and materials to ensure the health, safety and protection of the public and the workforce involved in the nuclear sector, and the protection of the environment. It implements Canada's international commitments on the peaceful use of nuclear energy. The CNSC reports to parliament through the Minister of Natural Resources.

Since the IEA's last review, one of the CNSC's focus areas has been the development of an enabling framework for the licensing of SMRs. A pre-licensing review process has been introduced to assess vendor designs. The key objective of this staged process is to enable the CNSC to provide feedback early in the design process. Table 8.2 presents a list of SMR vendors that have entered this review process.

Internationally, in 2019 and 2020, the CNSC signed a memoranda of co-operation with the US Nuclear Regulatory Commission and the UK Office for Nuclear Regulation, respectively, to strengthen the regulation of nuclear safety. Signing of the memoranda of co-operation provides a framework to further expand co-operation on nuclear safety related matters to ensuring that the development and deployment of innovative SMR and advanced reactor technologies are done safely and efficiently.

Table 8.2 Vendor design review service agreements in force between vendors and the Canadian Nuclear Safety Commission

Vendor	Design (coolant)	Capacity (MW_e)	Phase applied for	Review start	Status
Terrestrial Energy Inc.	IMSR Integral Molten Salt Reactor (molten salt)	200	Phase 1	April 2016	Complete
			Phase 2	Dec 2018	In progress
Ultra Safe Nuclear Corporation	MMR-5 and MMR-10 (high-temperature gas)	5-10	Phase 1	Dec 2016	Complete
			Phase 2	Pending	Pending
LeadCold Nuclear Inc.	SEALER (molten lead)	3	Phase 1	Jan 2017	On hold at vendor's request
ARC Nuclear Canada Inc.	ARC-100 (liquid sodium)	100	Phase 1	Sept 2017	Complete
Moltex Energy	Moltex Energy Stable Salt Reactor (molten salt)	300	Series Phases 1 and 2	Dec 2017	Phase 1 complete
SMR, LLC (Holtec)	SMR-160 (PWR)	160	Phase 1	July 2018	Complete
NuScale Power, LLC	NuScale (integral PWR)	60	Phase 2*	Jan 2020	In progress
GE Hitachi Nuclear Energy	BWRX-300 (high-temperature gas)	300	Phase 2*	Jan 2020	In progress
X-energy, LLC	Xe-100 (high-temperature gas)	75	Phase 2*	July 2020	In progress
U-Battery Canada Ltd.	U-Battery (high-temperature gas)	4	Phase 1	Pending end 2019	Pending

Notes: MMR = micro-modular reactor. PWR = pressurised water reactor. MW_e = megawatt electrical. There are also two additional vendor design review service agreements under development with Westinghouse Electric Company and StarCore Nuclear.
Source: CNSC (last reviewed June 2021).

Uranium and nuclear fuel

In 2019, Canada was the world's second-largest uranium producer, with production totalling 6 944 tonnes of uranium metal (tU), representing about 13% of total world production. Over 85% of the production is exported. With about 564 900 tU of identified resources, recoverable at a cost of less than 130 USD/kgU (NEA/IAEA, 2020), Canada has the world's third-largest low-cost uranium resources, at about 9% of the world total.

All current Canadian uranium mines are located in Saskatchewan, which hosts the two largest and highest grade mines in the world. Since the IEA's last review, Canada's uranium industry has experienced significant changes, with suspension of operations at the Eagle Point mine and Rabbit Lake mill in 2016 and at the McArthur River mine and Key Lake mill in January 2018. The Cigar Lake mine, which began production in 2014, reached full production in 2017 to become the world's largest uranium-producing mine, exceeding annual production from the McArthur River mine. Nearly all Canadian production since 2018 has been from the Cigar Lake mine. These changes were primarily due to unfavourable market conditions, with international uranium spot prices at about USD 25 per pound as of 2020.

The McArthur River mine, which has the world's largest high-grade uranium deposit, and the Key Lake mill, the world's largest uranium mill, are operated by Cameco Corporation. Production has been suspended since 2018 due to the aforementioned market conditions.

Cameco's Cigar Lake mine, which began operation in 2014, was the world's largest uranium producer in 2019. Cigar Lake has the world's third-largest high-grade uranium deposit, with an average grade above 15% U, compared to a world average of about 0.2% U. The ore is transported for processing to the McClean Lake mill, operated by Orano, located 70 kilometres north-east of the mine site.

Several exploration projects in Saskatchewan have recently discovered large high-grade uranium deposits, which are being proposed for development. Two of these proposals are currently in the environmental assessment phase. Despite low uranium prices, exploration in Saskatchewan continues to be active.

Lastly, uranium oxide concentrate (U_3O_8, also known as "yellow cake") that is produced at the milling facilities is either shipped to customers overseas or transported to Cameco's refinery in Blind River, Ontario, where it is converted into uranium trioxide (UO_3). The UO_3 is then shipped to Cameco's conversion facility in Port Hope, Ontario, where it is converted into either uranium dioxide (UO_2) to supply CANDU reactors domestically and internationally, or uranium hexafluoride (UF_6), which is exported and enriched for use as fuel in light water reactors.

Nuclear waste management and decommissioning

In Canada, nuclear waste management and decommissioning activities operate under the polluter-pays principle, meaning that nuclear waste producers are responsible for the life cycle management of their wastes, including disposal.

Since the IEA's last review, efforts are ongoing to modernise Canada's radioactive waste policy. The objectives of this reform are to ensure that policies continue to meet international practices, are based on the best available science, and reflect the values and principals of Canadians.

Nuclear waste owners are making progress on implementing a safe and secure plan for long-term management of nuclear fuel waste. Regarding uranium mining activities, the resulting wastes are well-managed and disposed on-site using state-of-the-art engineered tailings management facilities that permanently isolate wastes from the environment. For low-level, intermediate and high-level (used nuclear fuel) radioactive wastes, there are several projects across Canada to design and implement long-term storage solutions:

- **Nuclear Waste Management Organization's (NWMO) deep geological repository:** The NWMO, in accordance with the Nuclear Fuel Waste Act, 2002, is responsible for implementing a plan for the long-term management of used nuclear fuel. A stepwise approach foresees the implementation of a deep geological repository for used fuel in a willing informed host area. Between November 2019 and January 2020, the NWMO narrowed the number of communities involved from the remaining 5 potential siting areas (of the original 22 in the siting process) to 2. A final site for the facility is expected to be chosen by 2023.

- **CNL's Port Hope Area Initiative:** This involves the cleanup of approximately 1.2 million cubic metres of historic low-level radioactive waste from various sites in Port Hope, the

construction of an engineered aboveground mound where the waste will be safely contained, and the long-term monitoring and maintenance of the new waste management facility.

- **CNL's proposed near surface disposal facility:** This proposed disposal facility for low-level radioactive waste is planned for the Chalk River Laboratories site to manage the waste from its facilities.

- **CNL's proposals to decommission two research/prototype reactors:** CNL is proposing to decommission and leave the reactor in place (*in situ*) at the Whiteshell and Rolphton sites. All fuel and liquids have been removed, and what remains are the structural components of the reactor, such as the vessel and piping.

Nine nuclear reactors have been permanently shut down in Canada (Table 8.3). These plants are at various stages of decommissioning. These activities will most likely take place over several decades. The funding of decommissioning activities is covered by dedicated provisions of the reactors' owners (the AECL and OPG).

Table 8.3 Nuclear reactors under decommissioning or shut down in Canada

Name	Location	Owner	Capacity (MWe)	In-service date	Shutdown year
DOUGLAS POINT	Ontario	AECL	200	1968	1984
NRX	Ontario	AECL	42	1947	1992
NRU	Ontario	AECL	135	1949	2018
GENTILLY-2	Quebec	Hydro-Québec	675	1983	2012
GENTILLY-1	Quebec	AECL	250	1972	1986
ROLPHTON NPD	Ontario	AECL	22	1962	1987
PICKERING-2	Ontario	OPG	515	1971	2007
PICKERING-3	Ontario	OPG	515	1972	2008
WHITESHELL REACTOR 1	Manitoba	AECL	60	1965	1985

Note: AECL = Atomic Energy of Canada Limited. OPG = Ontario Power Generation.
Source: IAEA (PRIS).

Nuclear research and development and radioisotopes production

Historically, the development of CANDU technology and the supporting R&D infrastructures were managed by the AECL, a Crown corporation. Over the last decade, these activities have been restructured.

In 2011, the AECL's CANDU reactor division was sold to Candu Energy. Candu Energy is owned by SNC-Lavalin and the Canadian government retains the intellectual property rights of the CANDU technology.

In 2015, the AECL's Nuclear Laboratories were restructured under a government-owned and contractor-operated model that resulted in the creation of CNL. CNL delivers the AECL's mandate. It is owned by the Canadian National Energy Alliance, which is a partnership of Jacobs, Fluor and SNC-Lavalin.

Since 2015, the AECL's mandate has been to enable nuclear science and technology and protect the environment by fulfilling the government of Canada's radioactive waste and decommissioning responsibilities.

CNL is responsible for the operation of the Chalk River Laboratories in Ontario, where key R&D facilities are located. The AECL is investing CAD 1.2 billion over ten years at the Chalk River Laboratories to renew and modernise the infrastructure. In addition, there is CAD 76 million per year for the ten-year period 2015-25 for the Federal Nuclear Science and Technology Work Plan to fund nuclear-related science and technology to support core federal roles, responsibilities and priorities, while maintaining necessary capabilities and expertise at CNL.

Canada plays an important role internationally in the production of medical radioisotopes. However, capabilities in this field were reduced by the permanent shutdown in 2018 of the AECL's National Research Universal reactor after 60 years of operation. This removed a large source of production of Mo-99 (the precursor to TC-99). Since then, OPG and BWXT have been making progress toward producing Mo-99 at the Darlington nuclear power plant. This project is currently undergoing regulatory approval with the CNSC and would offer a reliable supply of this radioisotope for the international community. In addition, Canada is the world's largest supplier of Cobalt-60 (about 50%), which is used for cancer radiation treatments, sterilising medical devices, and the treatment of food and consumer products. Also, Canada is major supplier of Iodine-125, whose uses include diagnostic procedures. The CNL is working to advance the availability and scientific understanding of Actinium-225, as a next-generation cancer treatment.

The TRIUMF Canadian particle accelerator centre received government funding to develop cyclotron methods to produce the medical imaging tracer isotope technetium-99m. This resulted in a spinoff company, ARTMS Inc., which was developed to commercialise this isotope production technology. In December 2020, ARTMS received Health Canada's marketing approval of cyclotron produced technetium-99m for clinical use. The ARTMS technology will help alleviate widespread shortages when those reactors experience scheduled and unscheduled interruptions in their operations.

Assessment

Nuclear energy is an important part of the Canadian electricity mix. Nuclear is the second-largest source for electricity generation after hydropower and with 98 TWh of electricity produced in 2020, nuclear contributed to 15% of final electricity consumption. Canada has 4 nuclear power plants with 19 operational reactors, located in Ontario (Bruce, Darlington and Pickering) and New Brunswick (Point Lepreau). The Gentilly 2 nuclear reactor in Quebec was permanently shut down in 2012 without undertaking refurbishment.

The provincial government of Ontario has announced its intent to end operation of the six Pickering reactors by the end of 2025.

The government fully recognises the role of nuclear power as a low-carbon and sustainable technology essential for Canada's transition to a low-carbon energy mix. The government's Fall 2020 Economic Statement recognised the potential for SMRs to contribute to carbon-free electricity, and in December 2020, SMRs were further highlighted in Canada's Strengthened Climate Plan as a potential tool to reduce emissions at home and abroad. Achieving ambitious climate targets, and potentially net zero emissions by 2050, will require both long-term operation of the existing nuclear fleet and the development of nuclear new builds. However, decisions on electricity generation in Canada, sources and mixes are the authority of provinces and territories. The expected role of federal funding for nuclear new builds, and specifically SMRs, has yet to be explicitly assessed by the Canadian government. Assessing the role of federal funding will be of central importance to offer the required visibility to the Canadian nuclear supply chain to invest in these innovative nuclear technologies and to support the public engagement processes at the provincial and local levels.

The pressurised heavy-water reactor design known as CANDU was developed in Canada in the late 1950s. Canada has exported CANDU reactor systems as a world leader in nuclear energy technology. Since the IEA's last in-depth review, a major development has been the decision to refurbish a large share of the nuclear fleet with some undergoing refurbishment. Darlington 2 was completed in 2020 and Darlington 3 and Bruce 6 are currently undergoing refurbishment. The cumulative capacity of 8.3 GW from these ten units represents about 60% of the 14 GW total cumulative capacity of the entire Canadian nuclear fleet. Once completed, these refurbished CANDU reactors will be able to operate for at least another 30 years.

The refurbishment of CANDU reactors is currently Canada's first nuclear energy priority and stands as one of the largest ongoing infrastructure undertakings in the country. The projects represent CAD 26 billion of investment over 17 years to extend the life of Ontario's nuclear fleet past mid-century, with significant local economic and job spillovers estimated from both refurbishment activities and continued operations. Ontario, where both nuclear power plants are located, estimates that the refurbishment project will provide ratepayers with a long-term supply of relatively low-cost, low emissions electricity. The levelised costs of nuclear electricity post-refurbishment are estimated at about 80 CAD/MWh on average over the next 30 years, below the 112.5 CAD/MWh price of electricity for residential and small business ratepayers as of 2017. So far, the two major projects are progressing on time and on budget, and the refurbishment of the first unit at Darlington was completed in 2020. The Darlington and Bruce refurbishment projects are expected to be completed by 2026 and 2033, respectively. The Pickering nuclear power plant is planned to operate until 2025 subject to nuclear regulatory approvals, providing electricity during the Darlington and Bruce refurbishments.

Canada continues to promote the export of new CANDU reactors internationally and to support refurbishment projects in countries that currently operate this technology. Ongoing new build prospects include Cernavoda Units 3 and 4 in Romania that present significant export opportunities for the Canadian nuclear supply chain. At home, plans for new CANDU reactors remain a long-term option. However, such plans had already been deferred at the time of the previous review and have not since been reconsidered further.

Another major achievement since the previous review has been the publication in 2018 of *A Canadian Roadmap for SMRs*, a comprehensive road map regarding the development of SMRs. The IEA commends the government of Canada for conducting an extensive stakeholder engagement process in order to identify the most promising market opportunities at home and abroad. The SMR Roadmap currently serves as the focal point for developing Canada's SMR policy framework at the federal, provincial and territorial levels. Three emerging streams have been identified and are matched with active interest by several provinces. First, near-term on-grid SMRs for the replacement of coal power plants, primarily in Ontario and then Saskatchewan. This would rely on the most mature SMR designs, with potential construction of a demonstration plant at the Darlington nuclear power plant by the late 2020s, followed by Saskatchewan in the early 2030s. Second, New Brunswick is pursuing innovative next-generation on-grid SMRs for its Point Lepreau site as well as the export market, including the potential for technologies to recycle used nuclear fuel for use as fuel for SMRs. Third is SMRs for off-grid applications, with several mining companies having signalled potential interest and carrying out feasibility studies for SMRs to replace diesel generators.

Since the publication of the Canadian SMR Roadmap in 2018, four provinces (Alberta, Ontario, New Brunswick and Saskatchewan) have signed an Interprovincial SMR MOU, agreeing to collaborate on SMR development and deployment. The MOU commits the provinces and their utilities to prepare a feasibility study and business case for SMRs in their respective jurisdictions. Following the feasibility study and business case, the provinces will prepare a strategic plan for SMRs to be delivered to provincial premiers. The MOU calls on the federal government to provide funding for SMR projects as well as risk-sharing mechanisms.

At the federal level, NRCan convened the launch of Canada's SMR Action Plan, which was published in late 2020, building upon the work of the SMR Roadmap. The SMR Action Plan acknowledged the role that the government of Canada has to play in supporting the advancement of SMR technology in Canada. For instance, since the launch of the SMR Action Plan, the government of Canada has announced over CAD 56 million in funding to support the development of SMRs in Atlantic Canada by Moltex Energy. So far, financial support decisions appear to be taken on a project-by-project basis. Given the scale of financial support needed to move SMRs to commercial deployment, the next steps of the Canadian SMR policy would certainly benefit from a more integrated approach that develops a clear long-term industrial strategy for the sector. Similarly, Canada's Strengthened Climate Plan underlines SMRs' potential to reduce CO_2 emissions, decarbonise heavy industry and spur economic development. Further including SMRs explicitly in long-term energy and climate scenarios would also support policy makers to better reflect the potential for SMRs across energy and climate policies. In parallel, taking advantage of some of SMRs' unique technological features, regulatory and licensing processes may need to be reviewed to ensure that they are commensurate with the risks presented and do not result in any unnecessary delays or inefficiencies. The availability of sufficient financial support at the federal and provincial levels for the different project development phases should also remain a key priority.

In addition, bilateral and multilateral international collaboration is a key priority for the government to foster the deployment of SMRs, in particular for the licensing of these innovative nuclear reactor designs. In August 2019, the CNSC and the United States' Nuclear Regulatory Commission signed a memorandum of co-operation to expand

co-operation on advanced reactor and SMR technologies, with the objective to increase regulatory effectiveness though collaboration between the two agencies.

Canada is also a major player in the front end of the nuclear fuel cycle. In 2019, it was the world's second-largest uranium producer, with 6 944 tU, accounting for 13% of the world's production. About 85% of Canada's uranium production is exported to be used for nuclear power. With 564 900 tU of identified recoverable resources below 130 USD/kgU, Canada ranks third in the world, with about 9% of global uranium resources, after Australia and Kazakhstan. Most uranium produced in 2019 came from the Cigar Lake mine (Saskatchewan), the largest and highest grade uranium mine in the world. New uranium projects have been mothballed in recent years due to low uranium prices; however, a potential recovery of the market in the current decade could see extension of existing mining projects and/or new developments, two of which are currently in the environmental assessment process. In addition to uranium mining, Canada is a key player through Cameco in the areas of uranium refining and conversion. CANDU fuel fabrication for the domestic and international markets are also located in Canada.

For the back-end of the nuclear fuel cycle, Canada is making progress in the area of waste management. Nuclear operators are responsible for the full life cycle management of the waste they produce and those operators set financial guarantees aside for decommissioning and long-term waste management. The NWMO, in accordance with the Nuclear Fuel Waste Act, 2002, is responsible for implementing a plan for the long-term management of used nuclear fuel. A stepwise approach foresees the implementation of a deep geological repository for used fuel in a willing and well-informed host area. The NWMO is currently engaging with local communities that have expressed an interest in hosting the deep geological repository. Initially, 22 communities expressed interest in hosting the project and based on technical and social evaluations, the NWMO reduced the number of potential siting areas to 2. The selection of a preferred site is planned by 2023, and it is expected that the facility will become operational between 2040 and 2045.

The AECL is also in the process of implementing waste management and disposal solutions for historic and legacy waste, including two near surface disposal facilities which are currently in operation in Ontario for historic low-level radioactive waste, a proposed near surface disposal facility for legacy low-level radioactive waste at the Chalk River Laboratories, and two proposed projects for the *in situ* disposal of legacy research and prototype reactors.

Recommendations

The government of Canada should:

- Assess the long-term contribution that the existing CANDU nuclear fleet and nuclear new builds (in particular small modular reactors [SMRs]) could play to meet Canada's net zero climate goals for 2050 through both low-carbon electricity and heat.
- Building on the momentum of the Canadian SMR Roadmap and Action Plan, offer timely federal support for ongoing SMR projects under discussion at the provincial level. A key priority should be to ensure that the required policy reforms are in place to allow for the licensing and construction of the first demonstration projects expected in the late 2020s.
- Foster international collaboration, notably for international licensing of innovative SMR technologies and for CANDU international prospects, while leveraging its experience in nuclear technologies and first-mover advantage in SMRs.
- Support the Nuclear Waste Management Organization in its mandate to select a site for a deep geological repository by 2023, while continuing strong community engagement and stakeholder involvement. Ensure that options remain open for potential fuel recycling if the need and/or opportunity arises.

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9. Coal

Key data (2020 provisional)

Coal net exports: 26.1 Mt/15.5 Mtoe (3.6 Mtoe imports, 19.1 Mtoe exports), +24% since 2010

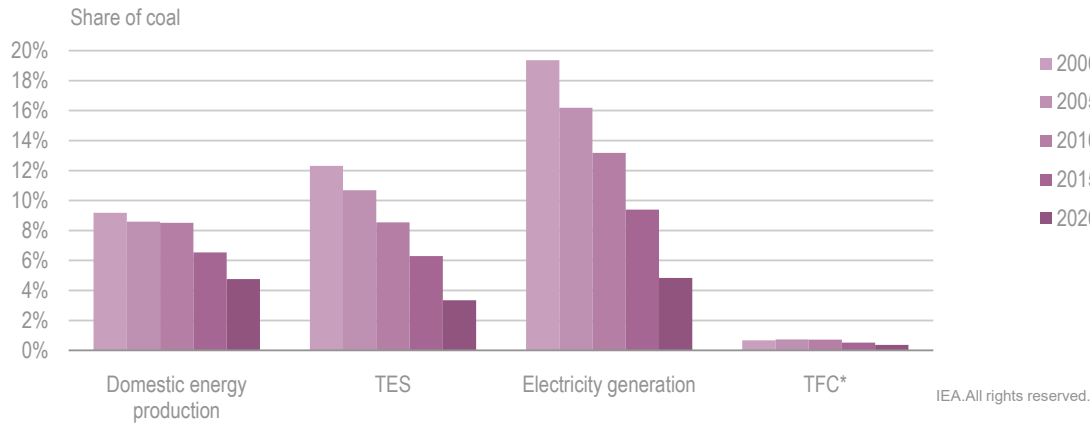
Share of coal: 3.4% of total energy supply and 4.8% of electricity generation

Coal consumption (2019): 13.9 Mtoe (heat and electricity generation 75.6%, industry 24.4%)

Overview

The shares of coal in Canada's energy mix have significantly decreased since 2000 (Figure 9.1). Coal shifted from accounting for 12% of total energy supply (TES) in 2000 to 3.4% in 2020 and from 19% to 4.8% of electricity generation over the same period. In 2016, Canada announced the phase-out of conventional coal-fired power plants by 2030.

Figure 9.1 Share of coal in different energy supplies in Canada, 2000-19



Between 2000 and 2020, the share of coal significantly decreased from 12% to 4% of total energy supply and from 19% to 6% of electricity generation.

* Most recent TFC data are from 2019.
Notes: TES = total energy supply. TFC = total final consumption. 2020 data are estimated.
Source: IEA (2021), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

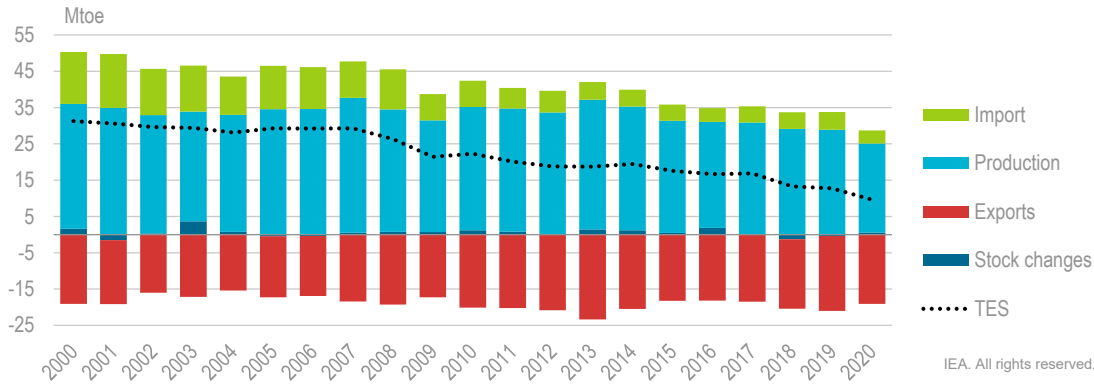
Supply and demand

Total energy supply from coal dropped from 22 million tonnes of oil equivalent (Mtoe) in 2010 to 10 Mtoe in 2020 (Figure 9.2). The decrease of coal in TES corresponded to a 50% drop in imports since 2010 to less than 4 Mtoe in 2020. The production of coal

decreased by 28% between 2010 and 2020. Until 2019, this decrease was exclusively attributable to lower thermal coal production, while metallurgical coal production increased. In 2020, only the production of thermal coal increased, while the production of all other types of coal decreased with respect to 2019. In particular, production of sub-bituminous coal almost halved in 2020 with respect to the previous year. Canada is a net exporter of coal and increased its exports by 20% between 2009 and 2019, when it exported 21 Mtoe. This increase is attributable to metallurgical coal export growth, while thermal coal exports declined during the same period. In 2020, exports of thermal coal increased, while less metallurgical coal was exported with respect to the previous year.

Regionally, in 2020, British Columbia accounted for 52.9% of Canada's coal production, followed by Alberta at 30.5%, Saskatchewan at 16.2% and Nova Scotia at 0.4%.

Figure 9.2 Coal supply by source in Canada, 2000-20



Since 2010, Canada has decreased imports, total energy supply and production of coal, while exports increased until 2019, to decrease in 2020.

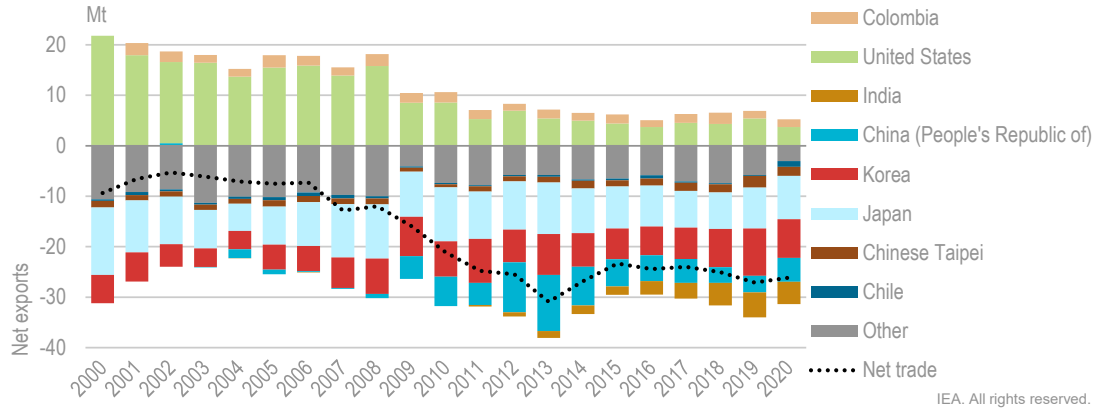
Note: Mtoe = million tonnes of oil equivalent. TES = total energy supply.
Source: IEA (2021), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Just over two-thirds (69%) of coal imports in 2020 came from the United States, followed by Colombia (25%) and the Russian Federation (2%). Coal exports are more diversified (Figure 9.3). In 2019, Canada exported coal mainly to Japan (27%), Korea (24%), the People's Republic of China (15%) and India (14%).

Coal production, imports, exports and TES consist of different types of coal. In 2020, 56% of coal production was metallurgical coal, 17% sub-bituminous coal, 16% lignite and 11% thermal coal, while imports were 55% metallurgical coal, 17% thermal coal and 21% sub-bituminous coal. TES from coal was 42% sub-bituminous coal, 33% lignite, 12% thermal coal and 12% metallurgical coal, while exports consisted of 88% metallurgical coal and 12% thermal coal.

Canada mainly exports metallurgical coal, which accounted for 88% of Canada's total coal exports in 2020. Canada is the world's fourth-largest exporter of metallurgical coal after Australia, the United States and Russia. Most of Canada's metallurgical coal is destined for foreign markets.

Figure 9.3 Coal net trade in Canada by country, 2000-20



Canada imports coal mainly from United States and Colombia, while exports are more diversified, with Korea and Japan accounting for half.

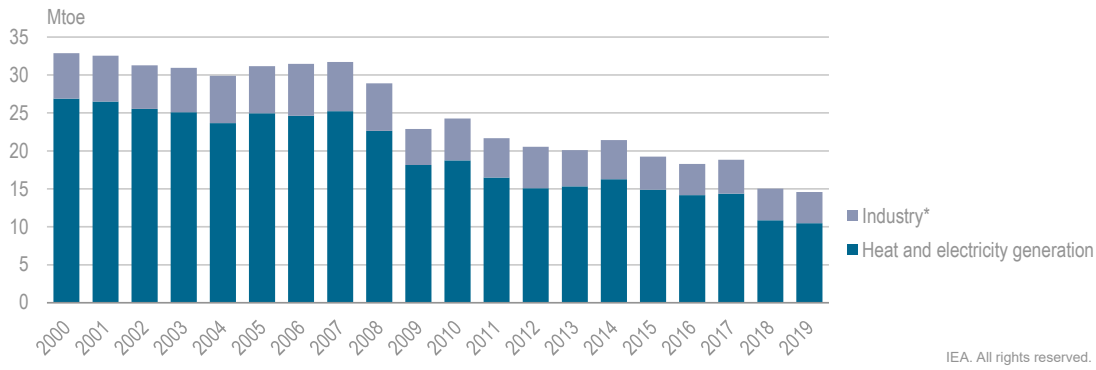
Notes: Mt = million tonnes. Includes only hard coal (metallurgical and thermal coal).

Source: IEA (2020), *Coal Information 2020*, www.iea.org/statistics.

Around three-quarters of coal demand in 2019 (11 Mtoe) came from heat and electricity generation, but coal consumption from this sector has more than halved since 2008, first with a quick drop by 20% between 2008 and 2009, then with a gradual decrease in the following years (Figure 9.4). Coal currently makes up 6.2% of Canada's electricity generation, and in 2019 was concentrated in Alberta (48% of provincial generation), Saskatchewan (42%), Nova Scotia (53%) and New Brunswick (14%).

The industry sector was responsible for remaining coal demand, used mainly in the iron and steel, non-ferrous metals, and non-metallic minerals sectors.

Figure 9.4 Coal consumption in Canada by sector, 2000-19



Coal used for power generation in 2019 accounted for 76% of the total, and has decreased by 54% compared to 2008.

* *Industry* includes energy use in the industry sector and transformation in coke ovens and blast furnaces.

Note: Mtoe = million tonnes of oil equivalent.

Source: IEA (2021), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Coal policy

Thermal coal in electricity generation

In 2012, Canada became the first country to introduce federal coal-fired electricity greenhouse gas (GHG) regulations, requiring coal-fired electricity units to meet a stringent performance standard of 420 tonnes of carbon dioxide emissions per gigawatt hour (t CO_2/GWh) of electricity produced. The regulations developed under the Canadian Environmental Protection Act, 1999 apply to new units built after 1 July 2015, and to existing units once they have reached the end of their useful life (defined as 45-50 years after their commissioning date).

In 2016, Canada committed to the phase-out of conventional coal-fired electricity across the country by 2030. To this end, in December 2018, under the Pan-Canadian Framework on Clean Growth and Climate Change commitments, Canada published amendments to the 2012 regulations in order to accelerate the phase-out of conventional coal-fired electricity by 2030. These amendments require all units to meet the performance standard of 420 t CO_2/GWh at the end of their useful life or after 31 December 2029, whichever comes first. The regulation is expected to contribute 12.8 Mt to Canada's 2030 Paris Agreement emissions reduction target (Government of Canada, 2018).

The performance standard can be met by shutting down a unit or converting it to use a lower emitting fuel, including natural gas. Some coal units converted to natural gas are granted a life extension for a fixed period of time, up to ten years, after which they must meet the natural gas performance standard. The duration of the life extension is dependent on the emissions performance that the converted unit achieves following its conversion; better performing units can operate longer than poorer performers, with some units having a performance that disqualifies them from receiving any life extension. The amended regulation for coal units, like the original regulation, also contains provisions to account for emissions abatement using carbon capture, utilisation and storage (CCUS) systems, enabling coal-fired units to operate beyond 2030 if they are in regulatory compliance and meet the performance standard. The Boundary Dam 3 coal unit in Saskatchewan, which was the world's first coal plant to apply CCUS in 2014, is designed to capture up to 1 Mt CO_2 per year.

The Canadian Environmental Protection Act, 1999 contains provisions for provinces and territories to negotiate equivalency agreements with the federal government. Equivalency agreements allow federal regulations developed under the Canadian Environmental Protection Act, 1999 to be stood down in provinces and territories that already have regulations in place that are deemed to achieve equivalent or better environmental outcomes than the federal regulations. This mechanism avoids duplication of efforts in controlling GHG emissions and/or air pollutants and ensures that industry does not face two sets of regulations.

Canada entered into two equivalency agreements for the federal coal-fired electricity regulations with the provinces of Saskatchewan and Nova Scotia, which allow these provinces' GHG regulations for their electricity sectors to take the place of federal regulations from 2020 to 2024.

Ontario was the first province to commit to phasing out coal-fired generation in 2003 and closed its last coal unit in 2014. Since the publication of the 2012 federal coal regulations,

seven units have closed outside of Ontario, representing 1 360 megawatts (MW) of generation capacity. Thirty emitting units are still operating without CCUS in four provinces: Alberta, Saskatchewan, Nova Scotia and New Brunswick, for a total of 9 095 MW of generation capacity.

Canada is also active internationally to support the phase-out of thermal coal in electricity generation. In November 2017, Canada and the United Kingdom co-launched the Powering Past Coal Alliance. With more than 125 members (including national and subnational governments and businesses), the Powering Past Coal Alliance is the world's leading initiative seeking to accelerate clean growth and climate protection through the rapid phase-out of unabated coal power.

Canada supports the deployment and financing of clean energy alternatives to coal power internationally through its climate finance. In June 2021, it announced that it would double its climate finance to CAD 5.3 billion over five years, and joined some G7 countries in collectively committing up to CAD 2 billion in the coming year to the Climate Investment Funds' Accelerating the Coal Transition and Integrating Renewable Energy programmes. These resources are expected to mobilise up to CAD 10 billion in co-financing, including from the private sector, to support renewable energy deployment in developing and emerging economies.

Coal mining

Though conventional coal-fired electricity is being phased out in Canada by 2030, coal will continue to be used for metallurgical processes domestically, and thermal coal may continue to be exported to foreign markets.

Proposed new coal mines (thermal and metallurgical) will be evaluated under the appropriate legislative and regulatory framework. Starting in 2016, Canada launched a comprehensive process to review existing environmental assessment laws and regulatory processes and sought public input on improving the system. Following this review, the Impact Assessment Act (IAA) was developed and came into force on 28 August 2019, replacing the Canadian Environmental Assessment Act, 2012.

Coal mines are subject to the requirements of the IAA if they meet certain thresholds, designed to target major projects with the greatest potential for adverse environmental effects in areas of federal jurisdiction. In addition, the Minister of the Environment has the discretion to require an impact assessment for a project that does not meet the IAA threshold requirements if the project may cause adverse effects within federal jurisdiction or adverse direct or incidental effects. Projects that do not require a federal impact assessment are still subject to comprehensive existing federal and provincial legislation and regulatory requirements.

In December 2019, the government announced that Canada would launch a strategic assessment of thermal coal mining to provide guidance on how future thermal coal mine projects will be assessed under the IAA. Draft terms of reference for the strategic assessment were published for public comment in July 2020. In June 2021, the government of Canada released a policy statement on thermal coal mining, stating that the government considers new thermal coal mining or expansion projects likely to cause unacceptable environmental effects within federal jurisdiction and not to be aligned with Canada's domestic and international climate change commitments (Government of Canada, 2021a). It also indicated that the policy statement would inform the Minister of

Environment's discretionary decision whether to designate any proposed new thermal coal project or expansion that does not meet the regulatory threshold for federal review. As a result, the strategic assessment of thermal coal mining is no longer needed and has been cancelled.

In addition, the government of Canada is developing proposed Coal Mining Effluent Regulations under the Fisheries Act to reduce the risks to fish and fish habitat by limiting levels of harmful substances in coal mining effluent. The regulations will implement national effluent quality standards for selenium, nitrate and suspended solids as well as requirements related to pH and toxicity. The regulations will also set requirements for monitoring, reporting and record keeping, including environmental effects monitoring. The proposed regulations are expected to be published in the summer of 2022 and should be final in 2023.

"Just Transition"

The accelerated phase-out of coal power has implications for workers and communities supported by this industry. Nearly 50 communities in 4 provinces still rely on thermal coal mining and coal power for local employment and taxes. As of 2019, these industries directly employed 3 000-3 900 workers, most of which are highly skilled and earn higher-than-average wages in unionised jobs with health and pension benefits.

As such, in 2018, the government established the Task Force on Just Transition for Canadian Coal Power Workers and Communities to engage coal-affected communities in Alberta, Saskatchewan, Nova Scotia and New Brunswick and recommend a path forward. The task force was made up of experts in sustainability, workforce development and the electricity sector, including representatives from labour associations, unions and municipalities.

Throughout 2018, the task force met with workers, communities and key stakeholders in Alberta, Saskatchewan, Nova Scotia and New Brunswick to listen to and learn from those directly affected by the accelerated phase-out of coal.

The task force released its final report in March 2019, including ten recommendations for the government's consideration. The recommendations included calls to increase transparency, research, financial and support for impacted communities; the creation of a labour market inventory for coal workers; skills building programmes; and local infrastructure development (Government of Canada, 2019).

In response, the government has committed CAD 185 million to transition initiatives, including CAD 35 million for the Canada Coal Transition Initiative (CCTI) to support skills development and economic diversification, and CAD 150 million beginning in 2020/21 to support infrastructure projects and economic diversification in the impacted communities.

Under the CAD 35 million CCTI, Western Economic Diversification Canada and the Atlantic Canada Opportunities Agency have overseen a number of skills development and economic diversification activities.

As of May 2021, in Western Canada, this includes 26 projects worth over CAD 15 million that are underway in Saskatchewan and Alberta. In Atlantic Canada, so far 16 projects totalling over CAD 10 million have been approved in New Brunswick and Nova Scotia.

The projects will support business development and re-employment initiatives. Examples include grants to local colleges, research centres and companies. For example, South East College will receive CAD 800 000 to develop and deliver an industry accredited heavy equipment programme in Estevan, Saskatchewan.

In addition, Canada's Budget 2019 allocated CAD 150 million starting in 2020/21 to the Canada Coal Transition Initiative-Infrastructure Fund (CCTI-IF). Activities under this fund will contribute to improving the long-term economic diversity of these communities, through increased access to employment, business opportunities, training and education and increased funding to improve socio-economic outcomes. As of May 2021, four projects have been approved in Atlantic Canada worth over CAD 4 million.

The federal government is actively working with the Atlantic provinces, Alberta and Saskatchewan to identify key projects that can support the transition away from coal in these regions. In March 2019, the Atlantic provinces and the federal government agreed to develop a Clean Power Roadmap for Atlantic Canada. The road map outlines a collective vision for how jurisdictions may collaborate over the coming decades to build a clean power superhighway across the region (see Chapter 7).

With the understanding that good-paying jobs require skilled workers, the Canadian government is making significant investments in training for workers. This training is a critical contribution to help build the net zero ready workforce. These skills and training measures announced in Budget 2021 are projected to deliver almost 500 000 new training and work opportunities for Canadians, which will help workers transition from traditional energy sectors such as coal, and take advantage of new opportunities, such as in clean energy sectors.

Moreover, in July 2021, Canada launched public consultations to gather diverse views on proposed just transition legislation that would include:

- people-centred just transition principles that put workers and communities at the centre of the government's policy and decision-making processes on climate change action
- a Just Transition Advisory Body to provide the government with advice on regional and sectoral just transition strategies that support workers and communities, and increase diversity and inclusion.

Canada is also ensuring that the "just transition" is at the forefront of international discussions, including by:

- spearheading a G7 discussion on preparing the energy workforce of tomorrow during its G7 Presidency in 2018
- supporting the COP24 Solidarity and Just Transition Silesia Declaration
- supporting the G7 discussion on combating inequality through an inclusive ecological transition led by France in May 2019
- chairing two sessions at Canada's CEM10/MI-4 on workers and communities.

Assessment

The role of coal in Canada's energy and power supply has declined over the past two decades. In 2020, coal accounted for 6.2% in Canada's power generation, down from 19%

in 2000. Several provinces still rely on coal-fired power generation, which is the source of 40% of power sector CO_2 emissions and 8% of Canada's total CO_2 emissions in 2020. Conversely, coal mining remained stable at around 60 Mt per year until 2019, with production concentrated in four main provinces: British Columbia, Alberta, Saskatchewan and Nova Scotia. Half of Canada's coal production is metallurgical coal destined for exports, which provided revenue of CAD 5 billion in 2019. In 2020, coal production dropped to 46 Mt.

A rapid transition away from unabated coal use is essential to fulfilling the Paris Agreement's climate goals, and the future of coal-fired power and coal mining should be revisited around the world. Canada was an early leader in this regard. Internationally, Canada and the United Kingdom co-led the international Powering Past Coal Alliance starting in 2017, which was reflected in a federal commitment to end coal use in power generation by 2030. In 2018, the government strengthened the 2012 federal emissions performance standard of 420 t CO_2/GWh, to apply to all coal-fired power generation units at the end of their useful life or at the end of 2029, whichever comes first. Units can run beyond that date if they succeed in reducing their emissions to below the performance standard.

In light of Canada's net zero pledge, the federal government needs to ensure the transition of the power sector to net zero is taking place in a timely, secure and cost-effective way. To address the carbon legacy of Canada's coal-fired power plants, several options are available: early retirements, retrofitting with CCUS, fuel switching (to natural gas or other lower carbon fuels) or repurposing to clean power investment at the same site. In a net zero context, not all of these options will be cost-effective or desirable in the medium to long term.

Coal plays a significant role in the power generation of Alberta (48% in 2019), Saskatchewan (42%) and the Atlantic Provinces (New Brunswick [14%] and Nova Scotia [53%]). Utilities in Alberta plan to convert units to natural gas in the coming years. Saskatchewan led global efforts in the demonstration of CCUS at the Boundary Dam power station, which became the first power plant with carbon sequestration and capture globally – which includes injecting captured CO_2 for enhanced oil recovery at the Weyburn oil field. More power plants are being considered for CCUS systems, but the economics continue to be challenging.

The coal phase-out may have implications for the security of power supply, notably in provinces that rely on it for the bulk of their power generation. International experience shows that coal plants may close well ahead of identified closure times, as carbon prices start to hit and energy markets transition. The repurposing or fuel switching of units can support electricity reliability, avoid stranded assets, and maintain site and grid connection for the installation of clean power investment (battery storage) while meeting environmental regulations.

The pace of the transition to net zero power will depend on how provinces and industry can meet the significant challenges related to unabated coal phase-out decisions. The federal government has an important role to play in accompanying this transition by providing support for coal regions, stimulating investment in technology and innovation hubs (including through federal tax incentives), and guiding regional efforts to strengthen clean power systems.

Under the Canadian Environmental Protection Act, 1999, the federal government may negotiate equivalency agreements that stand down federal regulations for a period five years in provinces or territories that already have regulations that achieve equal or better emissions reduction outcomes compared to the federal regulations. Although it can challenge a transition to net zero emissions, such an agreement can enable a province to manage a reduction in the use of coal on a fleet-wide basis, rather than on a facility basis (which could provide greater flexibility for CCUS), while reducing emissions by other means, such as the instalment of renewable electricity. Though challenging under the existing regulatory structure, if Canada were to create a green certificate scheme, provinces could invest in renewable generation in jurisdictions that have more favourable conditions, or purchase certificates from those regions. A good example of providing creative solutions for provinces with limited renewable power is the Clean Power Roadmap for Atlantic Canada, agreed in 2019 by the Atlantic provinces and the federal government to build on regional power networks.

The transition to net zero power may also mean reduced thermal coal mining, notably in Saskatchewan and Alberta, as investments in coal mines face stronger regulatory and environmental scrutiny by the federal government. The federal government has committed CAD 185 million to the "just transition" of the coal phase-out, including CAD 35 million over five years for the CCTI to support skills development and economic diversification for impacted communities and workers, and CAD 150 million (starting in 2020-21) for the CCTI-IF to support economic diversification in impacted communities. As of May 2021, 46 projects worth over CAD 29 million have been approved under the CCTI and CCTI-IF and are being delivered by two of Canada's regional development agencies (Western Economic Diversification Canada and the Atlantic Canada Opportunities Agency).

Recommendations

The government of Canada should:

- Facilitate the transition of Canada's coal-fired power generation to net zero by helping provinces and utilities identify cost-effective, future-proof solutions, including early retirements, repurposing, conversion to low-carbon fuels or additional renewable electricity.
- Support the just transition in Canada's coal regions by targeting the funding of Canada's Coal Transition Initiative to the most vulnerable regions.

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10. Natural gas

Key data (2020 provisional)

Domestic production: 184 bcm, +18% since 2010

Trade: 47.3 bcm net exports (23.6 bcm imports, 70.9 bcm exports)

Share of gas: 30% of domestic energy production, 39% of total energy supply,[13] 11% of electricity generation, 26% (in 2019) of total final consumption

Gas consumption by sector (2019): 133 bcm total consumption, +41% since 2009, other energy 34%, industry 17%, residential 14%, power generation 14%, commercial 13%, transport 3%

Overview

Canada is one of the world's largest natural gas producers and has over 200 years of reserves at current production levels. Alberta and British Columbia are the main producers of natural gas, accounting for 97% of total Canadian production.

Over the past decade, the natural gas market has shifted both within Canada and globally, causing challenges for Canadian producers. In North America, US shale gas production has increased, reducing North American prices and leading to the displacement of Canadian natural gas that had supplied both the US and Eastern Canadian markets. However, Canadian natural gas and liquefied natural gas (LNG) companies are responding, including by taking strategic actions to improve carbon competitiveness. Canada's efforts to lower the carbon footprint of the upstream gas sector include a commitment to reduce oil and gas sector methane emissions by at least 75% below 2012 levels by 2030 as well as to expand electrification and the deployment of carbon capture, utilisation and storage (CCUS).

While there is only one LNG export project currently under construction, LNG Canada which is expected to begin exporting in 2025, LNG exports are projected to rise steadily in the decade that follows. However, global LNG market conditions in recent years, including the impact of the Covid-19 pandemic, have resulted in a more cautious approach to project development, with many investors announcing they would wait until 2021 to determine how to proceed concerning major LNG projects delayed earlier, in 2020.

Natural gas accounted for 39% of Canada's total energy supply in 2020, compared to 29% in 2000. While the pace of natural gas demand growth may slow or reverse, Canada

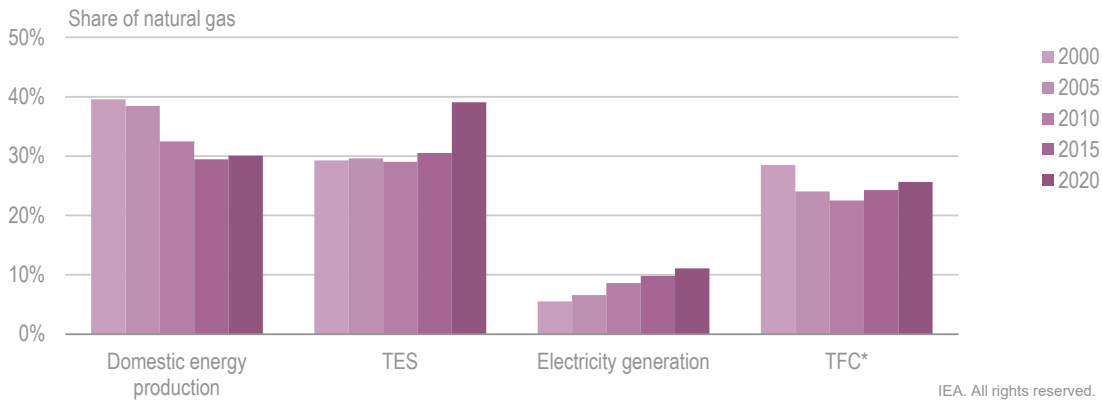
[13] Total energy supply does not include oil used for international bunkering.

expects its role as a transition fuel in the global energy mix to persist in the coming decades as the country itself moves towards its goal of net zero.

The share of natural gas in total electricity generation increased from 6% in 2000 to 11% in 2020, while its share in domestic energy production fell from 40% in 2000 to 30% in 2020 (Figure 10.1).

This chapter draws on the Canada Energy Regulator's (CER) 2020 Energy Futures Report's Evolving Scenario when referencing forecasts for natural gas. While the Evolving Scenario does not reflect Canada's current ambitions of achieving net zero emissions by 2050, the CER is undergoing new analysis to evaluate this new ambition, starting with its implications for the electricity sector and working towards a full net zero energy system scenario.

Figure 10.1 Share of natural gas in the Canadian energy system, 2000-20



Natural gas increased its share in electricity generation and in TES, but decreased in domestic energy production and TFC.

Note: TES = total energy supply. TFC = total final consumption.

Source: IEA (2021a), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Supply and demand

Supply

In 2020, Canada was the fifth-largest natural gas producer in the world after the United States, the Russian Federation, Iran and the People's Republic of China, with total domestic production of 184 billion cubic metres (bcm). Alberta and British Columbia are the main producers of natural gas, accounting for 97% of total Canadian production. Twenty-nine per cent of Canadian natural gas production was conventional while 71% was unconventional, including coal-bed methane, shale and tight gas.

As of 2019, Canada's marketable natural gas reserves are estimated to be 1 383 trillion cubic feet (39 trillion cubic metres), of which 39% is conventional gas and the rest is unconventional. Canada has more than 200 years of natural gas at current production levels.

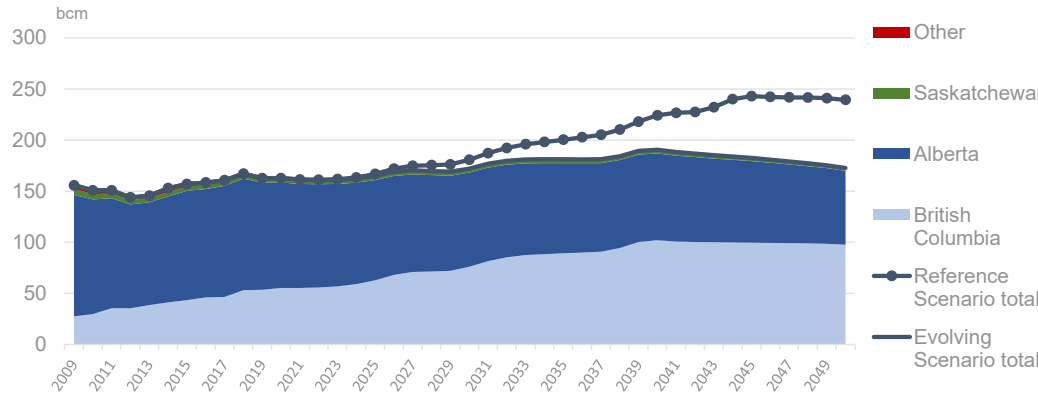
Over the past decade, the natural gas market has shifted both within Canada and globally, causing challenges for Canadian producers. In North America, US shale gas production

has increased, reducing North American prices and leading to the displacement of Canadian supply in both the US and Eastern Canadian markets. Within Canada, natural gas production has shifted from conventional gas production in southern Alberta to liquid-rich tight natural gas production in north-west Alberta and British Colombia, driven by demand for higher value condensates (ethane, propane and butane) and natural gas liquids (pentanes).

Canadian gas production has remained relatively stable, increasing incrementally despite declining gas prices since 2014. While the number of wells drilled has declined, well productivity has increased over time due to improvements in horizontal drilling and hydraulic fracturing.

Natural gas production is forecast to rise in the coming decades. According to the CER, gas production is expected to rise to 190 bcm (18.4 billion cubic feet per day [bcf/d]) by 2040, before declining to 173 bcm (16.75 bcf/d) by 2050 (CER, 2020). However, in the near term, production is projected to decline until 2022 due to lower capital expenditures resulting from low natural gas prices and the impacts of Covid-19, and a lack of an LNG export outlet that is expected to become operational in 2025.

Figure 10.2 Natural gas production, 2009-50: Evolving* and Reference Scenario



Total natural gas production peaks in 2040 then declines through 2050 in the Evolving Scenario.

* The Evolving Energy System Scenario (Evolving Scenario) considers the impact of continuing the historical trend of increasing global action on climate change throughout the projection period.

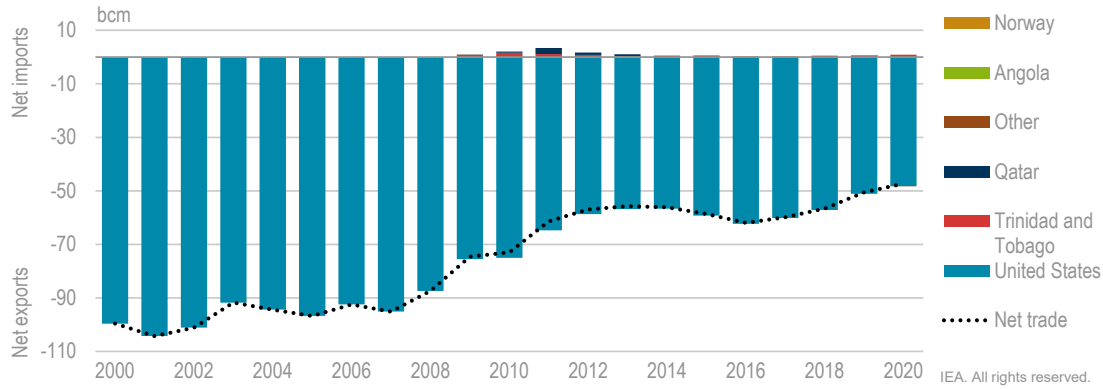
Note: bcm = billion cubic metres.

Source: CER (2020), *Canada's Energy Future 2020*, https://www.cer-rec.gc.ca/en/data-analysis/canada-energy-future/2020/results/index.html.

Trade

Canada's natural gas trade is dominated by net exports to the United States, with only minor overseas imports via the Canaport LNG import terminal in New Brunswick from a few other countries including Trinidad and Tobago, Angola, Qatar, and Norway, among others (Figure 10.3). In 2020, Canada exported 71 bcm to the United States, and imported a total of 24 bcm, almost entirely from the United States. Canada's 2020 net exports of 48 bcm represents approximately 5% of overall US natural gas demand of 869 bcm. Overall gas trade has decreased in recent decades, as Canada's net exports totalled 104 bcm in 2001, 73 bcm in 2010 and 47 bcm in 2020.

Figure 10.3 Canada's natural gas net trade by country, 2000-20



Canada's natural gas trade has steadily declined in recent years.

Notes: The figure only displays net trade with each country, rather than absolute imports and exports. The United States is the only country with which Canada both exports and imports natural gas. bcm = billion cubic metres.
Source: IEA (2021b), *Natural Gas Information 2020* (database), www.iea.org/statistics.

Canadian producers have been seeking overseas markets for their natural gas in the form of LNG exports, incentivised by differentials between North American gas and global LNG prices. While several LNG export facilities have been proposed in Canada, LNG Canada in British Columbia is currently the only project under construction and is expected to begin exporting in 2025. LNG exports are projected to rise steadily in the decade that follows, reaching 50 bcm (4.88 bcf/d) by 2040 (CER, 2020).

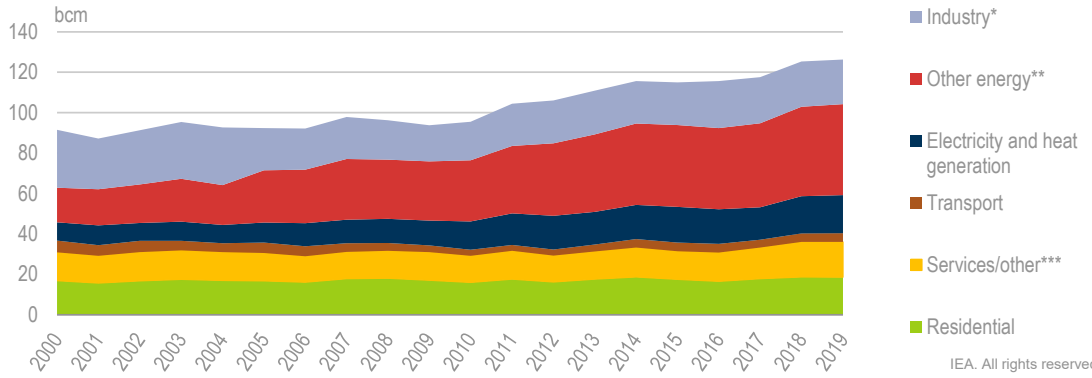
Demand

Natural gas demand was 133 bcm in 2019, up from 92 bcm in 2000. Demand growth has been driven by the notable increase in the energy sector's demand (Figure 10.4), primarily for gas used to create steam needed in some Canadian oil sands production processes, as well as other industrial processes. Demand for gas condensates used as diluent in Canada's oil sands production has also contributed to natural gas production as natural gas is produced alongside condensates. Demand for natural gas from oil and gas production and refineries was 17 bcm (19%) in 2000 and increased to 45 bcm (34%) in 2019. In 2019, the industry sector consumed 22 bcm of natural gas (17%), followed by the residential sector at 19 bcm (14%), electricity and heat generation at 19 bcm (14%), services and others at 18 bcm (13%), with transport consuming only 4 bcm (3%).

Natural gas-powered electricity generation is projected to double between 2019 and 2040, according to the CER's Reference Scenario. Most of this increase is driven by the displacement of coal-fired generation, which is forecast to reduce its electricity generation share from 7% in 2019 to 0.6% by 2040. In a number of currently coal-dependent provinces, the most readily available option to switch from coal is (unabated) natural gas-fired generation, which has seen strong growth in recent years driven by low prices and regulations, and is expected to see continued growth in the coming years. Natural gas is forecast to become the second-largest source of electricity generation by 2040, after hydro, with a share of 18% (CER, 2020). The government has since announced that it is exploring the need for a clean electricity performance standard over the coming months to ensure Canada's electricity generation achieves net zero emissions before 2050.

Overall, domestic primary natural gas demand is projected to peak in 2025 at 135 bcm (13 bcf/d) then to decrease to 102 bcm (9.85 bcf/d) by 2050 (CER, 2020).

Figure 10.4 Natural gas demand in Canada by sector, 2000-19



Gas demand has been driven by demand from the energy sector, primarily for gas condensates used as diluent in oil sands production.

* *Industry* includes non-energy use.

** *Other energy* includes oil and gas extraction and other energy sector use.

*** *Services/other* include commercial and public services, agriculture/forestry, and fishing.

Note: bmc = billion cubic metres.

Source: IEA (2021a), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Demand for natural gas in Canada is very seasonal, with peak consumption occurring in the colder winter months. Seasonality is mainly driven by the residential and commercial sectors, where demand is lowest in the summer months when natural gas is used primarily for cooking and hot water heating. National winter demand is twice that of the summer period, on average, as half of Canadian households rely on natural gas as their primary indoor heating source. During periods of higher winter demand, Canadian gas supply is supplemented by imports and gas storage, which fills during the non-winter months when supply is greater than demand.

Retail prices and taxation

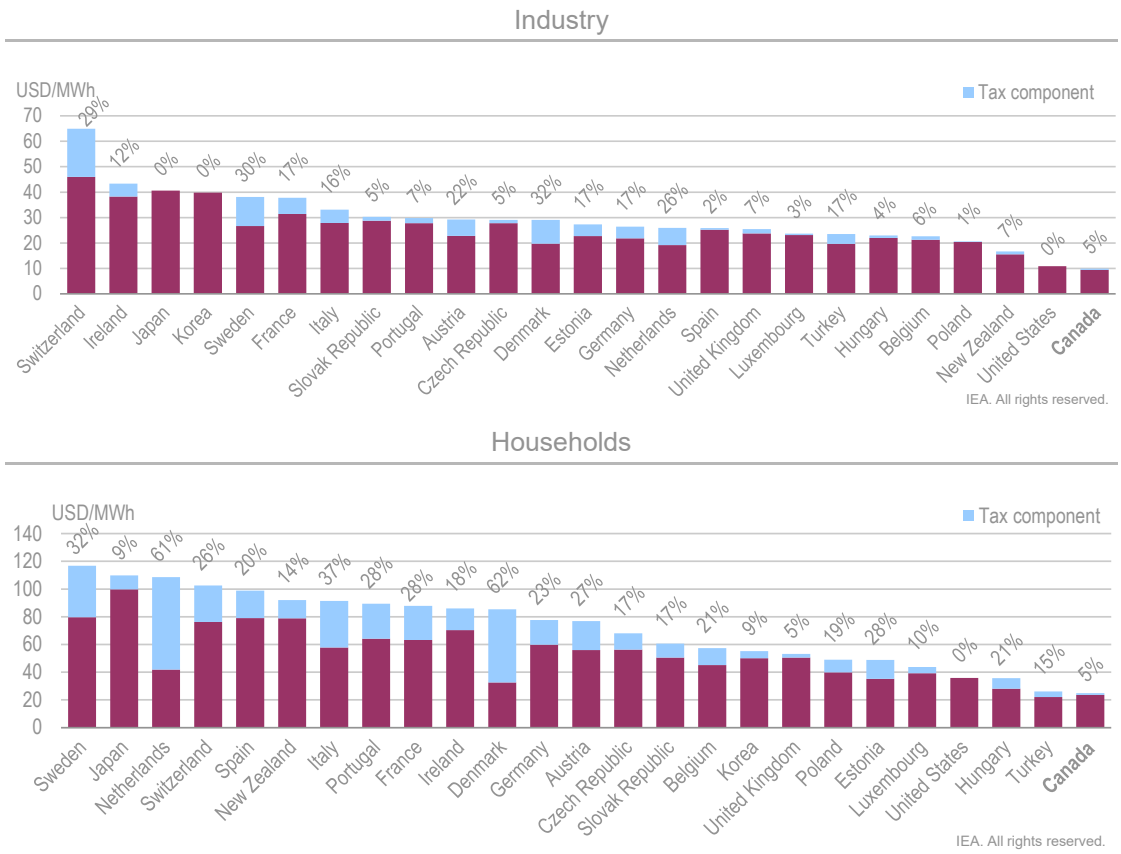
Natural gas prices received by producers have been deregulated in Canada since 1985. However, the transport tariffs charged by transmission and distribution companies remain regulated. The price of natural gas for an end-user is composed of the natural gas commodity cost, the natural gas pipeline transmission costs (for moving gas from the purchase area to the distribution company inlet), distribution company costs and margins (including a rate of return on equity), and taxes.

Provincial energy regulators regulate final end-user natural gas prices. However, this does not mean consumers are protected from market-driven changes in natural gas commodity prices. In all provinces, distribution companies simply pass on the unregulated, market-driven prices of natural gas to consumers, as well as the regulated pipeline transmission costs.

Provincial energy regulators protect consumers by ensuring that market purchases are done on a prudent basis, with no mark-up of the price. Some regulators also smooth the day-to-day volatility of the unregulated commodity natural gas price by requiring distributors to charge consumers on an average quarterly or monthly price basis. Provincial regulators also regulate distribution company costs, rates and return on equity.

In 2020, Canada's natural gas industry and household prices were both the lowest among IEA member countries, at 9.9 USD/MWh for industry prices and 24.9 USD/MWh for household prices (Figure 10.5). Tax shares were also among the lowest in the comparison, at 5% in both cases. Prices for natural gas in Canada followed similar trends as the United States, having fallen significantly since a peak in 2008 for industry and households (Figure 10.6).

Figure 10.5 Industry and household natural gas prices in IEA countries, 2020

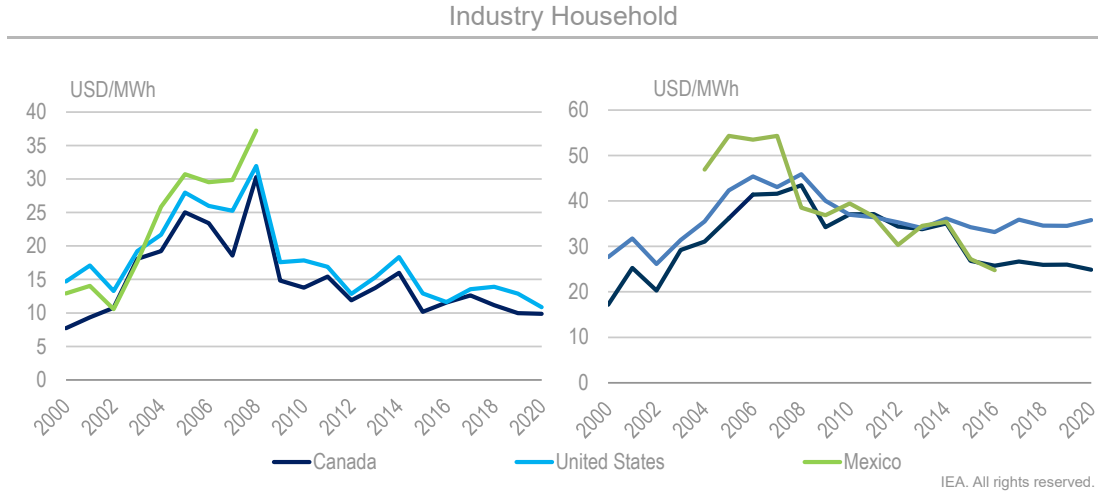


Canada's industry and household natural gas prices are the lowest among IEA countries.

Notes: USD = United States dollar. MWh = megawatt hour. Tax information is not available for Korea (industry) or the United States (industry and households). Data are not available for Australia, Finland, Greece or Mexico. Japan's tax is nil for industry natural gas prices.

Source: IEA (2021c), *Energy Prices and Taxes 2019* (database), www.iea.org/statistics.

Figure 10.6 Industrial and household gas prices in selected IEA countries, 2000-20



Canada's natural gas prices have followed similar trends as the United States over the past years.

Notes: USD = United States dollar. MWh = megawatt hour. Data are missing for some years for Mexico (industrial prices, 2009-20; and household prices, 2000-03 and 2017-20).

Source: IEA (2021c), *Energy Prices and Taxes 2019* (database), www.iea.org/statistics.

Institutions

Under the Canadian Constitution, provinces own all natural gas resource rights that lie within their provincial boundaries, with the government of Canada owning resource rights in certain frontier areas and offshore. The provinces, as the resource owners, are responsible for managing their resources and for upstream regulation (exploration, production, intra-provincial gathering and transmission). Provinces also have jurisdiction over downstream activities, such as retail markets, local distribution, storage, marketing and regulation of energy.

The CER, an independent energy regulatory body established in 2019 to replace the National Energy Board, regulates natural gas imports and exports; the construction and operation, including tolls and tariffs, of interprovincial and international pipelines; and the exploration and development of gas resources in frontier areas not covered by provincial/federal accords (i.e. Nunavut, a portion of the Northwest Territories, the Arctic Offshore, Hudson Bay, part of the Gulf of St. Lawrence, a portion of the Bay of Fundy and Sable Island, and off the British Columbia coast).

The CER reports to parliament through the Minister of Natural Resources. The minister is responsible for making recommendations to the Governor in Council (Cabinet) regarding the issuance of certificates for new energy facilities.

Natural gas market structure

The Canadian natural gas market is fully liberalised. Investment in Canada's natural gas sector is open to both private and foreign capital, and the commodity price of natural gas is determined by market supply and demand since gas pricing was deregulated in Canada in 1985. North America has an integrated natural gas market, with interconnected gas transmission networks transporting gas freely in both directions across the US-Canadian border.

Natural gas transmission pipeline flows are determined by the outcome of commercial negotiations between buyers (e.g. the local distribution companies) and sellers (e.g. production companies), and are governed by regulator approved pipeline tariffs. The tariff "rules of operation" for the pipeline cover issues such as shipper input and off-take requirements, daily balancing, and gas quality. The individual pipeline companies are responsible for load balancing on their networks, and pipeline load balancing is forced by rules for shippers, including non-discriminatory third-party access and penalties for non-compliance. Shippers must therefore arrange for storage or other balancing services if these are needed to ensure they stay in balance (pipeline input must equal output for each shipper).

Natural gas distribution in Canada is managed by private companies who have exclusive rights to distribute gas in a given region. Distribution companies are provincially regulated. The upstream industry is highly competitive in Canada, with hundreds of production companies. However, the top 10 companies accounted for 47% of total natural gas production in Canada at the end of 2019. The industry is also undergoing a wave of consolidation as a result of Covid-19 impacts.

Some natural gas producers sell gas directly to large end-users, including gas utilities and industrial users. Many producers sell their gas production to gas marketing and trading companies who are middlemen in selling gas on the wholesale gas market. Major marketers and traders of gas in Canada include BP Canada Energy, Shell Energy North America, Navicomm and Direct Energy, as well as some financial institutions.

Natural gas is mainly transported within extensive networks of pipelines. Five main companies operate natural gas pipelines in Canada: 1) Enbridge Inc.; 2) TC Energy; 3) ATCO Pipeline; 4) TransGas Ltd.; and 5) Brookfield Infrastructure Partners.

Natural gas policies and regulations

Canadian natural gas policy consists of three fundamental elements: 1) market orientation; 2) respect for provincial jurisdiction over natural resources; and 3) targeted interventions.

Canadian natural gas policy falls under the more general Canadian energy policy framework, which establishes that investments are made in a competitive and freely functioning energy market. Long-term security is provided by a robust energy sector that has open access to both product and capital markets. Investment in the natural gas sector is open to private and foreign capital. Under Canada's market-based energy framework, companies take business decisions on where new pipeline infrastructure is required based on a project's economic feasibility and expressed interests in open seasons.

Federal powers, with regard to market regulation, in natural gas are primarily associated with the interprovincial and international pipeline transportation of natural gas, and with works extending beyond a province's boundaries. This allows the federal government to develop policies and regulate interprovincial and international natural gas trade and pipelines, codified in the Canadian Energy Regulator Act (CER Act) of 2019.

Legislated timelines for all interprovincial pipelines are included in both the CER Act and the Impact Assessment Act. The CER has 450 days to conduct the review and to issue a report with a recommendation on the project to the Minister of Natural Resources. The Integrated Review Panel has up to 6 months for an early engagement phase, and up to 600 days to conduct the review and to issue a report with a recommendation to both the Minister of the Environment and the Minister of Natural Resources. Additionally, Bill C-69 was passed in 2018 to improve environmental protection rules while helping to attract infrastructure investment by providing companies greater predictability and certainty for the approval process.

Section 236 of the CER Act provides the CER the discretion to ensure that open, non-discriminatory access is provided to all shippers on interprovincial gas pipelines. Firm service is typically contracted (usually on auction) for a minimum term of one year directly between the shipper and the pipeline company. Shippers have the option to assign their capacity to other shippers, either temporarily or permanently. Some pipelines offer short-term firm service, but generally lack the flexibility (e.g. no diversion, renewal or assignment rights) of a longer term contract, while maintaining the guarantee of delivery.

Emissions reduction policies

In order to achieve Canada's Paris Agreement commitments and domestic net zero 2050 objectives, the government of Canada has introduced successive climate measures, aiming to reduce emissions in Canada and increase technological advancement, which have implications on the natural gas industry.

The Clean Fuel Regulations will provide economic opportunities for producing and using clean fuels through the generation of credits. While the regulation requires a reduction in carbon intensity of liquid fossil fuels, they will create incentives for clean gaseous fuels including biogas, renewable natural gas and hydrogen. There are various ways credits can be generated from clean gaseous fuels, including through the use of low-carbon intensity hydrogen as a feedstock in the production of fossil fuels or low-carbon intensity fuels and through the supply of renewable natural gas and hydrogen to the transportation sector (via fuel cell vehicles and natural gas vehicles). The final regulations are expected to be published in late 2021 and come into effect in December 2022.

Canada's methane regulations address emissions from unintentional fugitive equipment leaks and intentional venting and flaring from the oil and gas sector. Canada has committed under the Pan-Canadian Framework on Clean Growth and Climate Change (PCF) to reduce methane emissions from the oil and gas sector by 40-45% below 2012 levels by 2025. Final methane regulations were published on 26 April 2018 and started to come into effect on 1 January 2020. The remaining regulations are anticipated to come into force by 2023 and will apply to new and existing sources of emissions, such as oil and gas wells and batteries, natural gas processing plants, compressor stations, supporting pipelines, storage tanks, pneumatic devices, and compressors.

In October of 2021, the government of Canada committed to an increased oil and gas methane emissions reduction target to at least 75% below 2012 levels by 2030. Current methane regulations will be revisited to support this increased ambition.

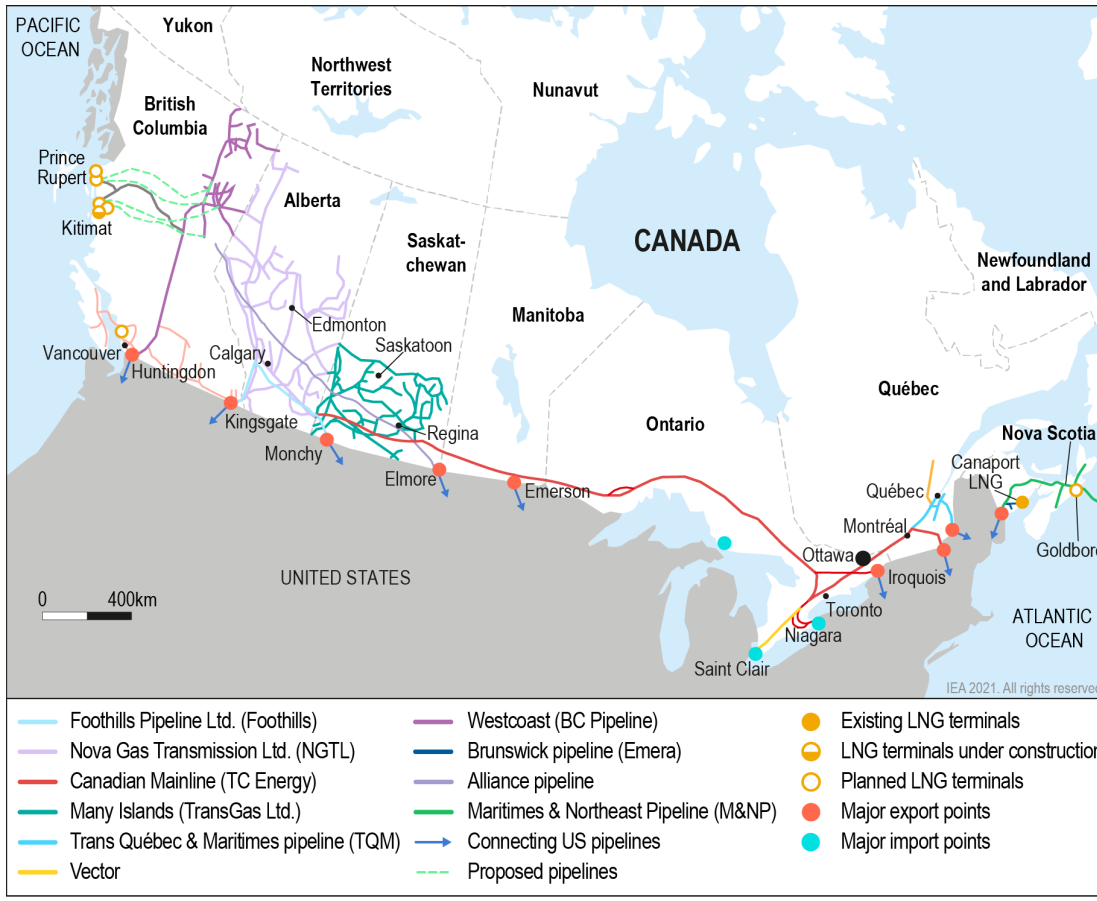
The CAD 750 million Emissions Reduction Fund supports capital investments and research to reduce GHG emissions, with a focus on methane, from onshore and offshore oil and gas. Up to CAD 675 million of this fund is available to onshore upstream/midstream conventional, tight and shale oil and gas companies to reduce or eliminate unintentional fugitive equipment leaks and intentional venting and flaring. The remaining CAD 75 million is for the deployment of emissions-reducing technologies and related research, development and demonstration (RD&D) in the offshore sector.

The federal government is working with the government of British Columbia to advance electrification of upstream natural gas operations and downstream LNG facilities to reduce emissions from the natural gas value chain. The initiative will support the development of proposed fully electrified LNG export projects, including Woodfibre LNG and Cedar LNG, which would lead the world in the production of low emissions LNG powered by clean, renewable hydroelectric sources. In addition, it would support the potential expansion of Tilbury LNG – a facility mainly used for domestic security of supply – for bunkering and export, and the potential electrification of Phase 2 of the LNG Canada facility.

In June 2021, Canada passed Bill C-12, the Canadian Net-Zero Emissions Accountability Act, to require current and future federal governments to set binding climate targets to help Canada achieve net zero carbon emissions by 2050, as well as to plan, report on and course correct on those targets. The bill requires the federal government to set five-year interim GHG emissions reduction targets covering the next 30 years to ensure progress towards the net zero goal. Net zero means remaining emissions produced will be fully absorbed by nature (e.g. tree plantation) or technology (e.g. carbon capture and storage systems), or offset via GHG trading regimes. The legislation also requires the Minister of Environment and Climate Change Canada to table in parliament and publish a plan outlining how the federal government plans to meet the environmental targets, a progress report and an assessment report with respect to each target. The act also established an independent Net-Zero Advisory Body and provides for public participation when setting or amending targets.

Natural gas infrastructure

Figure 10.7 Map of Canadian natural gas pipeline infrastructure



Pipeline networks

The Canadian natural gas network consists of a 77 579 kilometre (km) transmission network, 298 953 km of distribution networks and 190 404 km of service networks.

Canada's transmission pipeline system consists of nine major pipeline networks over two distinct geographical regions – Western Canada and Eastern Canada (Figure 10.7 and Table 10.1). As Western Canada is where most of the country's natural gas production is located, the local pipeline network is extensive and well supplied, but there are only a few large pipelines linking the two regions. Historically, the supply of natural gas to customers in Eastern Canada used to flow predominantly from Western Canada through transmission pipelines that constitute the TransCanada Canadian Mainline. This extends from the Alberta/Saskatchewan border to the Quebec/Vermont (United States) border, and has interconnections with other natural gas pipeline networks in both Canada and the United States.

The existing gas transportation infrastructure was built for a market where the United States was reliant on conventional Canadian gas. The change in gas production from conventional to liquids-rich gas has led to the crowding out of natural gas from conventional producers in both Alberta and the United States, creating regional bottlenecks on both sides of the border, as new sources of supply strain existing infrastructure.

Significant investments have been made in the past five years in natural gas infrastructure, reflecting the growth in the Montney basin in north-east British Columbia and north-western Alberta, as well as other shale basins in Western Canada, which are among the most cost-competitive in the world. These were primarily focused on expansions of one of Canada's main pipeline systems, TC Energy's Nova Gas Transmission Limited (NGTL). The NGTL System, which delivers 75% of Alberta's and British Columbia's natural gas production to national and export markets, is currently undergoing a CAD 9.9 billion expansion programme to address bottlenecks and capacity constraints in the long term. Despite significant buildout, challenges remain in securing sufficient takeaway capacity for producers.

Table 10.1 Main Canadian natural gas pipeline networks

Pipeline system	Capacity (million m^3/d)	Description
Western Canada		
Alliance Pipeline	42.8 at the US border 13.3 Zone 2	Draws from fields in north-eastern British Columbia (BC) and north-western Alberta (AB), flows south-east through Saskatchewan (SK) to demand centres in the area of Chicago, United States.
Foothills System	61.5 Monchy (SK) 81.2 Kingsgate (BC)	The AB system includes the export interconnection at the US border near Monchy (SK), which supplies mid-US and Chicago; and the export interconnect at the US border near Kingsgate (BC) supplies the US Pacific north west, California and Nevada.
Westcoast (BC Pipeline)	43.7 at the US border	Extends from points in Yukon, the Northwest Territories, AB and BC; flows south to the Vancouver (BC) area and the Canada-US border near Huntingdon (BC), to supply the US Pacific north-west. It also has eastbound flow connecting to the Nova Gas Transmission Limited System.
Nova Gas Transmission Ltd. (NGTL System)	302.2 Upstream of James River 132.7 north and east flows	The AB system flows in multiple directions, mostly south to market delivery points in AB and BC. The system is expanding at a rapid pace to accommodate growing production from new supply entering the system, particularly from the Montney formation in the north west.
TC Energy Canadian Mainline	171.7 Prairies Segment 95.7 N. Ontario Line 229.3 Eastern Triangle	Eastward flow from the AB/SK border across SK, Manitoba and Ontario, and through a portion of Quebec. Would carry gas from AB toward liquefied natural gas (LNG) projects in Eastern Canada (Quebec and Novia Scotia).
Eastern Canada		
Maritimes and Northeast Pipeline	13.3 import/export	Bidirectional flow from offshore Deep Panuke platform near Nova Scotia (flow for export is minimal) and imports from the United States. Additional supply enters from the Canaport LNG import terminal via the Brunswick Pipeline or from the US Portland Natural Gas Transmission System. Would transport gas to proposed LNG projects in Nova Scotia.

Pipeline system	Capacity (million m^3/d)	Description
Trans Quebec and Maritimes Pipeline	24.4 to Saint Lazare 8.3 at the US border	Quebec City is supplied by TC Energy's Canadian Mainline connection near Saint Lazare. It also extends from Terrebonne, Quebec, north of Montreal, to a point on the Canadian-US border near East Hereford, Quebec.
Vector	36.8	Transports gas between Illinois (United States) and Ontario. The US pipeline system has been expanded in recent years into Ontario's Dawn storage hub and is used to import natural gas from the Joliette Illinois hub connecting both US and Canadian gas pipelines.
Brunswick Pipeline Company Ltd.	23.2	Connects the Canaport LNG import facility to the Maritimes and Northeast pipeline near St. Stephen, New Brunswick.

Sources: CER (2021), *Pipeline Profiles*, https://www.cer-rec.gc.ca/en/data-analysis/canada-energy-future/2020/results/index.html; IEA.

Due to bottlenecks on the NGTL System, the natural gas price of AECO, Alberta's natural gas trading price benchmark, has seen increased volatility. These bottlenecks have drawn further attention to upstream infrastructure constraints and recent instances of a widening price differential with the United States.

In September 2019, the CER approved a Temporary Service Protocol for the NGTL System until 31 October 2020 (the CER denied a request to extend this by an additional year). The protocol changed the approach to curtailment on the system during times of maintenance. Although it was never used, the protocol, along with small incremental expansions on the NGTL System, are credited with reducing price volatility and narrowing the differential with the United States. However, pipeline transportation capacity is required to permanently address price volatility, and some new capacity expansions are proposed and already underway. On 19 October 2020, the government of Canada approved the 2021 NGTL System expansion with a capacity of 1.45 bcf/d (41 million m^3/d), but the company has indicated it will not be in full operation until April 2022. More recently in 2021, the NGTL's North Corridor and Edson Mainline expansion projects were also approved to address bottlenecking.

Liquefied natural gas

Canada has one operational LNG import terminal: the Canaport facility in Saint John, New Brunswick on the country's east coast. The facility has a maximum send out capacity of 28 million m^3/d (1.2 bcf/d) (CLNG, 2021). LNG imported through this facility serves markets in Atlantic Canada and the north-eastern United States.

LNG Canada, in Kitimat, British Columbia, is currently the only project under construction. Phase 1 of the CAD 40 billion LNG Canada liquefaction and export terminal is under construction and due to begin to export 14 million tonnes of LNG per year (mtpa) by 2025, with an option to expand to 28 mtpa in a future second phase (BCOGC, 2020). The Coastal GasLink pipeline project (2.1 bcf/d capacity) will supply natural gas to the LNG Canada facility and is due for completion by 2023.

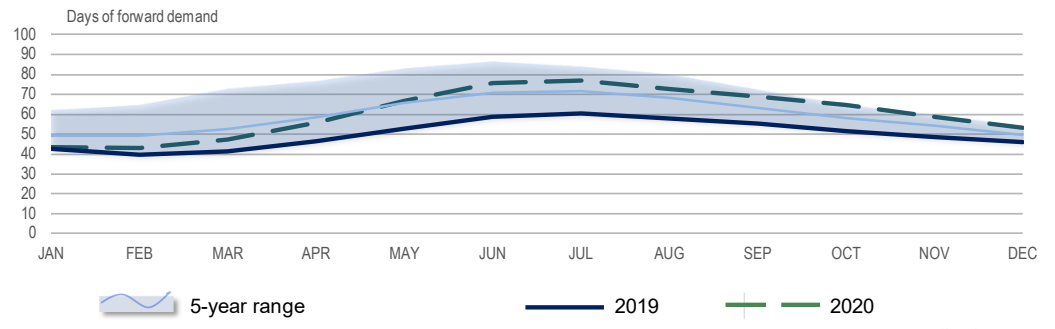
A number of initiatives for new LNG facilities and pipelines to deliver natural gas to these facilities have been proposed over the last decade, as Canadian producers have been seeking overseas markets for their natural gas. The vast majority of these projects are in British Columbia, linked to shale and tight gas developments in Alberta and British Columbia. There are also east coast proposals in Quebec, Nova Scotia, and Newfoundland and Labrador. However, global LNG market conditions in recent years, including the impact of the Covid-19 pandemic, have resulted in a more cautious approach to project development, with many investors announcing they would wait until 2021 to determine how to proceed on major LNG projects delayed earlier in 2020. Woodfibre LNG and Goldboro LNG both cited market conditions as part of their respective rationale for delaying a final investment decision from 2020 to 2021. This has created uncertainty around the LNG portion of future net exports.

In line with the Canadian government's plans to realise net zero emissions by 2050, Canada's LNG export projects aim to be world leaders in low-carbon supplies. The LNG Canada plant intends to have the lowest carbon emissions intensity of any large LNG facility currently operating in the world, with a 60% lower emissions rate than the global average. Other LNG projects in Canada plan to use clean, renewable hydroelectricity to power operations, resulting in emissions profiles up to 90% lower than global competitors. In response to Canada's Strengthened Climate Plan, Canadian LNG project proponents are working to develop pathways to domestic net zero supply chain emissions. Canadian LNG exports would aim to leverage those low emissions profiles to respond to anticipated demand growth for LNG – and greater attention on life cycle emissions – as a part of global decarbonisation efforts (e.g. focusing on reducing coal use) and energy security objectives.

Storage

Canada has a number of commercial natural gas storage facilities located across the country. There is no public or strategic natural gas storage in Canada. In all cases, underground natural gas storage facilities are an essential tool for allowing operators to balance their systems and optimise their gas use. Storage facilities are used to manage pipeline flows, production levels, seasonal demand swings and to capture price arbitrage opportunities. Total commercial stocks in Canada during the winter months over the last five years have ranged from 40 to 70 days of demand (average daily demand of the forward three months) (Figure 10.8).

Figure 10.8 Commercial natural gas stock levels in Canada in recent years



Natural gas stocks held by industry in Canada range from 40 to 80 days of forward demand.

Note: Days of forward demand is total stock level divided by the forward three month's average daily demand (gross inland deliveries).
Source: IEA (2021d), *Monthly Gas Statistics, March 2021,* www.iea.org/statistics.

As of 2020, Canada had 27 bcm in natural gas storage capacity, with total peak output capacity of 322 million m^3/d. Roughly two-thirds of the storage facilities are located in Western Canada, mostly in Alberta, and are typically owned by pipeline companies or producers (except in Saskatchewan, where all storage facilities are owned by the Crown corporation TransGas).

Most underground storage facilities in Canada are depleted oil and gas fields that have been repurposed to store natural gas. Gas is also stored in underground salt caverns, but this only accounts for 2% of the underground storage capacity in Canada.

The remainder of the natural gas storage facilities are in Eastern Canada, primarily in Southern Ontario, and are typically owned by local distribution companies to meet seasonal demand fluctuations. Distribution is handled by private companies that have exclusive rights to distribute gas in a given regional or local area. Distribution companies are provincially regulated.

Natural gas security

Canadian natural gas emergency response policy is generally geared towards short-term rather than long-term supply disruptions. The reason for this is that the government does not consider long-term risks particularly relevant for North America, as the North American natural gas market is resource-rich and is an open, well interconnected competitive commodity market.

During a natural gas supply disruption (or potential disruption), the natural gas industry is responsible for the initial response – including co-ordinating emergency response activities and performing all the remedial work. Natural gas pipelines are monitored continuously by industry players from centralised control centres that collect real-time data on pressure, volume and other variables.

As is the case with an oil supply disruption, the second level of response to an emergency is the responsibility of the provincial government. The third level – in the event of a declared national emergency – is the responsibility of the federal government. Canada's federal government has considerable powers to control natural gas flows in a declared natural gas emergency under the Emergencies Act.

The CER is the lead regulatory agency on federally regulated facilities or operations and has its own Emergency Management Program in place to establish a prompt and co-ordinated response to an incident. The Strategic Petroleum Policy and Investment Office within Natural Resources Canada (NRCan) is responsible for providing policy advice and recommendations for natural gas security-related issues.

Emergency response measures

In the case of a natural gas supply disruption, Canada has a number of options for ensuring that natural gas demand will continue to be met.

- Although there are no government-owned strategic reserves of natural gas in Canada and no government-imposed compulsory stockholding obligations on market participants, the country's natural gas industry has significant commercial natural gas storage infrastructure that is primarily used to service peak winter demand. These storage volumes can be drawn down at very short notice to help meet demand or to help address a supply shortfall.

- In the event of a domestic gas supply disruption, Canada could import additional quantities of gas via pipeline from the United States or, in the event of a prolonged disruption, could also bid on LNG spot cargoes via the Canaport LNG terminal. This alternative supply would, however, likely take at least several days to receive.
- Many large industrial natural gas consumers (including some electricity generators) have "interruptible" service contracts, meaning that their natural gas supplies can be diverted elsewhere, if required.

The Canadian government has no policies to encourage or require short-term fuel switching in the natural gas-consuming sectors during a supply disruption, and the country has limited capacity in this regard. While it may currently be possible for some electricity generators to switch to different fuels in a scenario where natural gas is unavailable, a natural gas supply disruption would more likely be handled by using other forms of power generation to meet electricity demand. Canada is not heavily reliant on natural gas for electricity supply, as gas represented 11% of total electricity generation in 2020.

Fuel-switching capacity exists in some industrial facilities, where the alternative fuel is oil, coal or wood. The primary motivation for these natural gas consumers to switch fuels would be the price of gas. There are no government requirements to maintain specific stocks of alternative fuels. There are also no requirements for electricity generation to maintain stocks of alternative fuels.

Assessment

Canadian gas production has remained relatively stable over the past decade, increasing incrementally since 2014, despite declining gas prices for much of the period. Production is projected to rise over the period to 2040, with LNG exports starting in 2025. However, the Covid-19 pandemic resulted in lower natural gas demand in 2020, with the decline most notable in the industry sector. While demand for gas began recovering in 2021, it is projected to return to pre-pandemic levels by 2022. The expected natural gas demand from LNG facilities could also be revised downward due to potential delays in LNG projects. Similarly, the expected natural gas liquids demand from petrochemical facilities and export terminals could also be affected as companies delay investments.

In 2020, Canada had the lowest natural gas industry and retail prices among IEA countries. Due to consistent low sale prices, the upstream Canadian natural gas industry has improved its cost structure to remain competitive. Prices are expected to remain stable at over USD 2 per million BTU. Due to impacts from the Covid-19 pandemic, major Canadian producers made significant reductions in their capital spending in 2020. While this did not have significant impacts on companies' production for 2020, it might have ripple effects on production in the next few years. Nevertheless, Canadian natural gas producers are more optimistic about the future than in recent years because of reduced natural gas price volatility, and prices have settled higher than in recent years, resulting in greater revenues.

Although natural gas-powered electricity generation decreased from 2012 to 2017, it is projected to double between 2019 and 2040 based on current policies. Most of this increase will be driven by the displacement of coal-fired generation, which is forecast to decrease its electricity generation share from 12% in 2018 to 0.6% by 2040. According to the CER's Reference Scenario, natural gas is expected to become the second-largest source of electricity generation by 2040, after hydro, with a share of 18%, as Alberta transitions off coal for power by 2023 (CER, 2020). While coal-to-gas fuel switching will

undoubtedly yield results in terms of lowering GHG emissions, Canada should clarify the role that natural gas plants and transportation networks will play in its trajectory toward a net zero future by 2050. Notably, new natural gas plants built through the 2020s will require emissions abatement in order to become compliant with Canada's net zero ambitions in the 2050 time frame, which will make them increasingly less cost-effective relative to other clean energy technologies. Additionally, there is interest in exploring the possibility to leverage natural gas transportation networks (e.g. pipelines) to support other low-carbon fuels, such as hydrogen.

According to NRCan, domestic demand is forecast to grow in areas that will fuel the energy transition: the Hydrogen Strategy for Canada identifies hydrogen produced from natural gas combined with CCUS as a key low-carbon fuel production pathway; coal-powered electricity is expected to be replaced with natural gas and CCUS in some instances; efforts should continue to displace diesel with LNG and other lower emitting fuels in northern and remote communities; Canada's globally competitive petrochemical industry could provide a value-added outlet for natural gas demand; and fuel switching to LNG and renewable natural gas (RNG) in Canada's transportation sector (marine, medium and heavy-duty trucks, trains) has the potential to achieve further emissions reductions.

Canadian natural gas utilities see the introduction of RNG into their distribution systems as a pathway for decarbonisation, which requires no changes to their infrastructure. Similarly, biogas can be used in the electricity grid and provide emissions reductions, particularly in jurisdictions that have higher emitting electricity systems.

Canada has a significant and untapped renewable gas opportunity. Its current domestic RNG production capacity of approximately 7 petajoules (PJ) represents 0.18% of the total natural gas energy demand. As indicated in a 2010 report, RNG from wastes alone could account for 130% of Canada's residential natural gas demand. At present, there are over 270 operating biogas facilities, approximately 13 RNG projects, and 1 active power to gas hydrogen project in Canada.

In terms of energy trade, in 2019, 55% of Canadian natural gas production was exported, primarily to the United States via pipeline. Canada imported some natural gas from the United States, which met 22% of Canadian consumption, and small amounts of LNG from Trinidad and Tobago, Qatar, Norway, and Angola through the Canaport LNG terminal in New Brunswick. The change in gas production from conventional to liquids-rich has led to the crowding out of natural gas from conventional producers in both Alberta and the United States, creating regional bottlenecks on both sides of the border, as new sources of supply strain existing infrastructure. In response, and to ensure the continued viability of its natural gas sector, Canadian producers have been, and need to continue, seeking overseas markets for their natural gas in the form of LNG and propane exports. Propane exports from Canada's west coast to Japan began in May 2019 with the completion of the first export-oriented propane terminal, providing Canada's natural gas sector access for the first time to markets beyond North America. A second terminal began operations in 2021.

Price differentials between North American gas and global LNG have also been large enough to justify the facility development, liquefaction and long-range transportation costs related to LNG trade. Proposed Canadian LNG projects on the west and east coasts are closer to prime Asian and European markets than potentially competing facilities in the United States, Australia, Russia and Qatar. The construction of LNG Canada is underway

and is expected to begin exporting in 2025, and several other LNG export facilities are proposed on both coasts in Canada. LNG projects that were delayed in 2020 due to the pandemic, like many other projects around the world, may begin to move forward to meet the increasing global demand. Moreover, Canada will face increasing competition in a more crowded global LNG market, especially as low-cost producers such as Qatar undertake large new expansion projects.

Canada continues to work with oil and gas companies to enhance performance and reduce environmental impacts, recognising that global markets will progressively demand cleaner fuels and will discriminate in favour of more carbon-competitive products. New regulatory requirements are establishing the conditions for Canada to be a long-term sustainable, competitive energy producer, and global investors are increasingly linking access to capital to environmental, social, and governance (ESG) performance. The LNG Canada plant is designed to be one of the lowest CO_2 intensity LNG facilities currently operating in the world, with a 60% lower emissions rate than the global average. Other LNG projects in Canada plan to use clean, renewable hydroelectricity to power operations, with emissions profiles up to 90% lower than global competitors. Canadian industry is talking to international partners about their specific commodity needs, and they are confident in their ability to retain customers who value high ESG performance. However, while the global investment climate rewards companies with high ESG performance, Canadian industry continues to ensure that it can offer cost-competitive LNG, understanding that this will remain an important factor for LNG buyers.

A key factor in Canada's EG performance is that federal, provincial and territorial governments, along with industry, continue to advance reconciliation with Indigenous peoples by building meaningful relationships and partnerships, and increasing opportunities for participation in the energy sector. Indigenous partnerships in the clean energy sector continue to contribute to Canada's ambitious emissions reduction targets. Some indigenous communities are taking active roles in project development, with the intent to support the development of sustainable projects that create economic opportunities for their communities, especially through natural gas pipelines and export facilities. Others are voicing concerns or opposing increased development. The government of Canada views economic self-determination as a key contributor to sustainable and equitable development for Indigenous peoples. Going forward, implementation of the United Nations Declaration on the Rights of Indigenous Peoples can contribute to the sustainable development of natural resources while also supporting Indigenous peoples in exercising their right to self-determination.

Perhaps the most important priority for Canada's natural gas sector is what actions will be taken to achieve Canada's 2030 and 2050 climate goals. Canada is to be commended for progress made since the IEA's last review in 2015. This includes:

- the establishment of an Emissions Reduction Fund for Canada's oil and natural gas sector, with a focus on methane
- a commitment to reduce methane emissions from the oil and gas sector by 75% below 2012 levels by 2030 and the adoption of a new regulatory framework
- a requirement that hydraulically fractured well completions must conserve or burn gas in most circumstances instead of venting it

- advancing the Hydrogen Strategy for Canada and electrification with renewables to support energy competitiveness and drive down emissions in resource extraction and processing, including for oil and gas
- working with provinces and territories through the Energy and Mines Ministers' Conference to provide scientific and policy advice to ensure any hydrocarbon development occurs in a safe and environmentally responsible manner, among other initiatives
- the passage of the Canadian Net-Zero Emissions Accountability Act and Strengthened Climate Plan.

Looking forward, NRCan's mandate to promote RD&D is to focus on influencing the pace and direction of energy system transformation. NRCan is targeting the most impactful technologies to maximise environmental and economic outcomes. The private sector has quickly reacted to Canada's climate policies and is positioned to work towards net zero objectives. Oil and gas account for one of the largest RD&D investments in Canada, including in the areas that are considered clean technology. Although the pace of energy technology innovation is accelerating, government and industry acknowledge that many of the technologies needed to achieve net zero goals are not yet ready.

Canada's emergency gas response policy, similar to that of oil, reflects its role as a major producer and net exporter, with vast volumes of gas supplies in a well-integrated market connected by extensive pipeline networks both within Canada and across the border with the United States. In this context, Canada's gas emergency policy is generally geared towards short-term regional or local disruptions rather than a more widespread or long-lasting supply outage.

Industry has the primary responsibility for ensuring security of supply and responding in an emergency, while local, municipal and provincial authorities would respond when the industry is unable to adequately resolve the disruption in a timely manner. The federal government would take direct action to manage crisis response at the request of the provincial authorities or in the case where a national emergency is declared.

Given Canada's robust natural gas market, a national disruption is unlikely; however, a regional or localised disruption could have significant consequences for vulnerable consumers, such as households or public buildings like hospitals using gas for winter heating. While the use of natural gas varies across Canada's territories and provinces, roughly 14% of overall gas consumption in Canada is in the residential sector, while another 13% is accounted for in the services/other sector, which includes hospitals and other essential services. While gas used for power generation represents only about 10% of total electricity generation in Canada overall, in instances where it is used for power generation, supplies should be prioritised in a gas supply crisis to avoid knock-on effects in electricity supply. The share of gas used in the transformation sector (14%) is forecast to grow in the coming decade as natural gas replaces coal in power generation.

In the case of a natural gas supply crisis where industry is unable to adequately respond, either provincial or federal authorities would intervene, depending on the scope and magnitude of the situation, and potentially need to (re)allocate limited supplies. Determining such allocation during a crisis could be sufficient to ensure priority consumers are protected if the disruption is short term. However, a prolonged or wider spread supply shortage could result in inequities because of increased competition for reduced supplies, and this could potentially become acute if a national disruption were to occur. Particularly

in such instances, pre-determined priority users and plans for ensuring their continued supply should be maintained.

Recommendations

The government of Canada should:

- Intensify work with stakeholders on the RD&D of technologies for the sustainable exploration, production and transport of natural gas resources, to contribute toward 2030 greenhouse gas targets and 2050 net zero goals.
- Clearly outline the role of natural gas in a net zero future and the pathway for how this can be achieved.
- Strengthen support for the development of clean hydrocarbon and renewable fuels pathways in the transition to globally competitive cleaner and renewable fuels, with robust funding and collaborative activities, including energy innovation initiatives in partnership with provinces, territories and industry under the Energy and Mines Ministers' Conference.
- Promote ongoing collaboration and consultation with provincial and territorial governments and industry to strengthen relationships and establish partnerships with Indigenous peoples to build consensus and increase opportunities for their participation in the energy sector and natural gas projects.
- Ensure measures are in place to protect vulnerable residential consumers in the event of natural gas supply shortages, especially during cold temperatures. To this end, the federal government should provide guidance to provincial and territorial authorities in establishing priority user plans and developing metrics relevant to protecting vulnerable consumers.

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11. Oil

Key data (2020 provisional)

Domestic crude oil production: 5 220 thousand barrels per day (kb/d), +55% since 2010

Net exports of crude oil:* 3 026 kb/d (total imports 788 kb/d, total exports 3 814 kb/d), +152% since 2010

Domestic oil products production (2019): 2 097 kb/d, +6% since 2009

Net exports of oil products: 234 kb/d, +52% since 2010

Share of oil: 33% total energy supply,** 1% in electricity generation, 50% of domestic energy production, 45% (in 2019) in total final consumption

Oil consumption by sectors (2019): 2 277 kb/d (domestic transport 56%, international bunkering 1%, industry including non-energy consumption 23%, services and agriculture 9%, other energy 9%, energy sector including power generation 1%, and residential 1%)

* Imports of crude oil includes crude oil, natural gas liquids and feedstock.

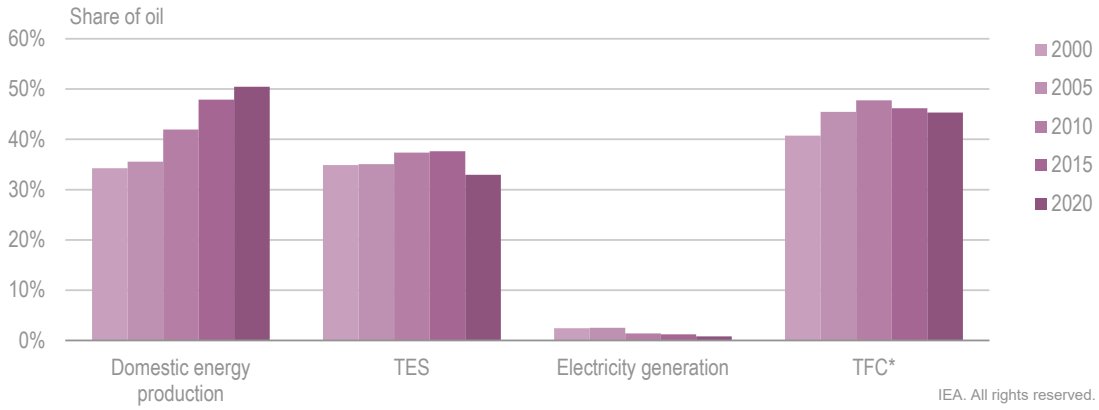
** Total energy supply does not include oil used for international bunkering.

Overview

Canada has continued to grow as a major oil producer, solidifying its role as a leading exporter of crude oil. Major new oil sands projects have contributed to most of the production increases, as have light condensates, which are used to blend with bitumen to make it transportable by pipeline. At the same time, Canada's domestic consumption of refined petroleum products has held steady, resulting in incremental crude oil production being available for export. Nearly all of Canada's oil exports go to the United States, where refineries have the technology to process heavy crude grades.

Oil's share in domestic energy production has increased over the past decades, from 34% in 2000 to 42% in 2010 and 50% in 2020 (Figure 11.1). The share of oil in total domestic supply decreased from 37% in 2010 to 34% in 2020, while oil's share in electricity production decreased from 2.4% in 2000 to 0.9% in 2020. Oil's contribution in total final consumption increased from 41% in 2000 to 45% in 2020, after peaking in 2010 at 48%.

Figure 11.1 Share of oil in domestic energy production, total supply, electricity generation and total final consumption in Canada, 2000-20



Canada's share of oil increased in domestic energy production, but decreased in total supply and in electricity generation.

Note: TES = total energy supply. TFC = total final consumption.

Source: IEA (2021a), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Oil will continue to be a significant fuel for the Canadian economy in the decades to come, with continued domestic production coupled with policies to reduce domestic oil use resulting in a growing amount of Canadian oil being available for exports. Canada has made a series of international and domestic commitments towards a balanced approach to resource development to promote economic growth and strengthen environmental performance to set Canada on a path to achieve a net zero emissions future by 2050. These include Canada's Strengthened Climate Plan, the Greenhouse Gas Pollution Pricing Act, the Clean Fuel Regulations and measures to decarbonise the transport sector.

Supply and demand

Crude oil production

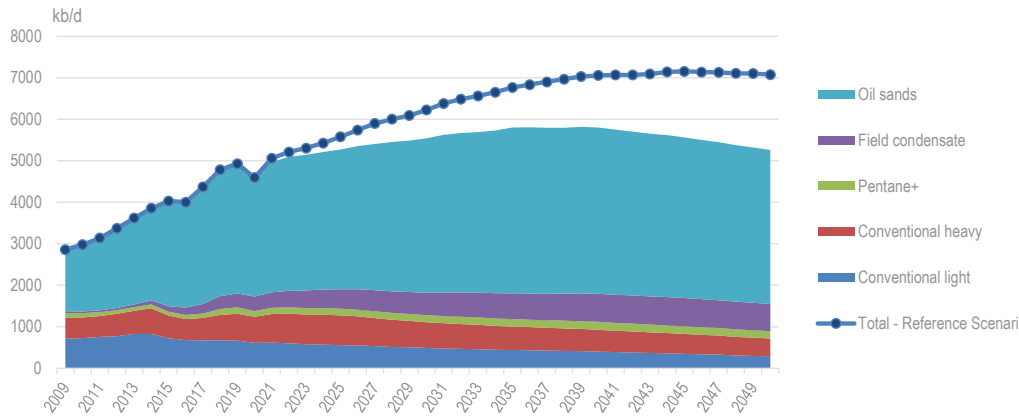
Canada is among the world's main crude oil producers and exporters, with proven oil reserves (166.7 billion barrels), ranking the third-largest in the world. Roughly 97% of its reserves are oil sands,[1] while conventional reserves, including tight oil and offshore reserves, account for the remaining 3%. Production is mostly in Alberta, with additional volumes in Saskatchewan and off the coast of Newfoundland and Labrador. The incremental cost of production for oil sands is low relative to upfront costs, with most projects able to generate positive cash flows at a West Texas Intermediate (WTI) oil price just above USD 40 per barrel.

[1] The oil sands consist of crude bitumen suspended in an ore that is a mixture of sand, clay and water. Bitumen can be extracted using either surface mining or *in situ* methods, depending on how deep the reserves are below the surface. Once extracted, raw bitumen is either diluted with lighter hydrocarbons to allow it to flow through pipelines to suitably equipped refineries or upgraded on site. Upgraders are similar to refineries and specialise in transforming bitumen into synthetic crude oil. Raw bitumen can also be shipped using heated rail cars.

Crude oil production in Canada has increased substantially over the past decade, with total production, including crude oil and equivalent liquids,[2] reaching 5.54 million barrels per day (mb/d) in 2019, compared to 3.32 mb/d in 2009. Oil sands bitumen accounted for most of this growth, doubling in output over the decade to reach 3.13 mb/d in 2019. Condensate production also grew substantially over the period, increasingly in demand from oil sands projects as it is used as a diluent to blend with bitumen to make it pipeline transportable. Other areas of growth include conventional heavy oil and pentanes plus, while the production of conventional light oil has remained relatively flat over the past decade.

Production in 2020 was impacted by the Covid-19 pandemic. During the second quarter of 2020, Canadian producers shut in approximately 1 mb/d of production, more than half of which was from oil sands projects. Most of the oil sands production was progressively brought back online over the second half of 2020, while conventional oil production continued to lag, resulting in an overall 4.2% decline in production for the year. Production reached pre-pandemic levels by the end of 2020. Canada is expected to post the highest oil production growth among non-OPEC countries in 2021 that supports high demand in US refineries.

Figure 11.2 Canada's crude oil production, 2009-50: Evolving* and Reference Scenarios



Total crude oil production peaks in 2039, then declines through 2050 in the Evolving Scenario.

* The Evolving Scenario considers the impact of continuing the historical trend of increasing global action on climate change throughout the projection period.

Note: kb/d = thousand barrels per day.

Source: CER (2020), *Canada's Energy Future 2020*, https://www.cer-rec.gc.ca/en/data-analysis/canada-energy-future/2020/results/index.html.

[2] Includes crude, natural gas liquids (NGLs) and non-conventional/synthetic oil. National Canadian data for crude oil production differs from that of the IEA due to discrepancies in categorising. For example, the IEA's crude oil data include condensate recovered from associated and non-associated gas, whereas Canadian crude oil production data do not.

Canada's domestic oil production is forecast to grow to a peak of 5.8 mb/d in 2039, according to the Canada Energy Regulator's Evolving Scenario, which assumes increasing climate action continues in both Canada and the world), compared to the Reference Scenario (assuming no new climate actions) where production peaks at 7.2 mb/d in 2045 (Figure 11.2) (CER, 2020). Under the Evolving Scenario, oil sands production is expected to grow, primarily from expansions of existing oil sands *in situ* projects, from 3.13 mb/d in 2019 to 4 mb/d in 2035 where it plateaus for five years before declining slightly to 3.7 mb/d in 2050.

Future Canadian oil production and exports will depend in part on the premium that oil consumers will put on oil production with low emissions intensity; Canada is seeking to position itself as a world leader in offering the "cleanest barrel" through enhanced electrification of the upstream sector. According to independent analysis (IHS Markit, 2020), the upstream greenhouse gas (GHG) intensity of the Canadian oil sands (calculated as the overall weighted average of the intensity of the oil sands production) has declined over the past decade, averaging 70 kilograms of carbon dioxide equivalent per barrel (kg CO_2-e/bbl) in 2018, compared to 72 kg CO_2-e/bbl in 2017, and representing a 20% decline from 2009, placing Canadian crude emissions only 6% higher compared to the average barrel refined in the United States. This same analysis projects that the GHG intensity of oil sands will decline by at least another 17-27% by 2030, to a level 30% below 2009 levels.

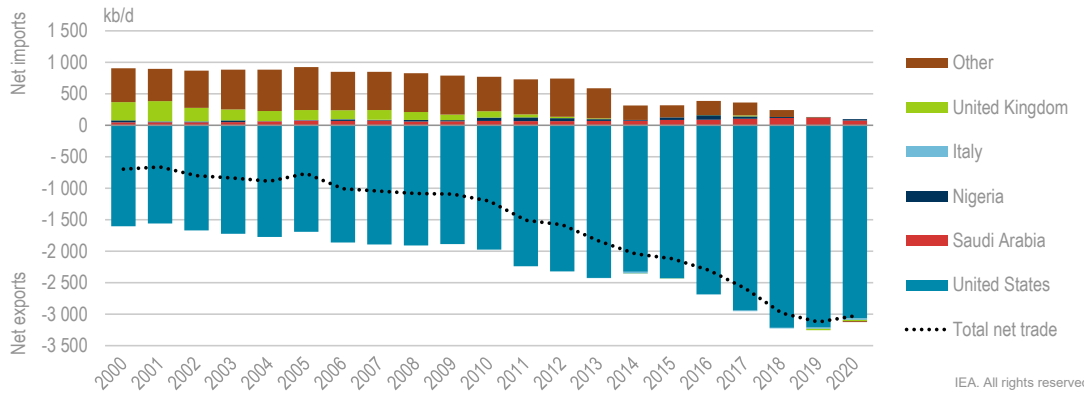
Crude oil trade

Despite the large growth in domestic oil production, eastern refineries in Canada still rely on imports of crude oil to meet their demands. Ontario refineries import oil exclusively from the United States, while Quebec and New Brunswick refineries have the ability to import oil from overseas by marine tankers; in recent years those in Quebec have imported exclusively from the United States thanks to expansions of pipeline capacity that provide connections with North American crude sources. In 2020, Canada imported a total of 788 kb/d, including crude, natural gas liquids (NGLs) and feedstocks. Most of Canada's crude imports in 2020 (80%) came from the United States, with the remainder from overseas (Saudi Arabia 10% and Nigeria 3%).

Canada's exports of crude oil have nearly doubled over the past decade, mostly due to the expansion in oil sands production. In 2020, its exports of crude, NGLs and feedstocks totalled 3.7 mb/d, of which approximately 75% was heavy crude (bitumen). Nearly all of Canada's oil exports go to the United States, where refineries in the US Midwest and Gulf Coast have residual coking units that allow them to process heavy crude grades. Over 90% of Canada's crude oil exports to the United States are transported via pipeline, although in recent years there has been an increased reliance on rail to bridge the gap as supply growth has outpaced additions to pipeline takeaway capacity.

In terms of net trade, Canada's total net exports of crude oil (including NGLs and feedstocks), have grown substantially in recent years (Figure 11.3). In 2020, Canada's net exports were 3.03 mb/d, compared to 1.20 mb/d in 2010.

Figure 11.3 Canada's crude oil net trade by country, 2000-20



Crude oil in Canada is predominantly exported to the United States and has increased in recent years.

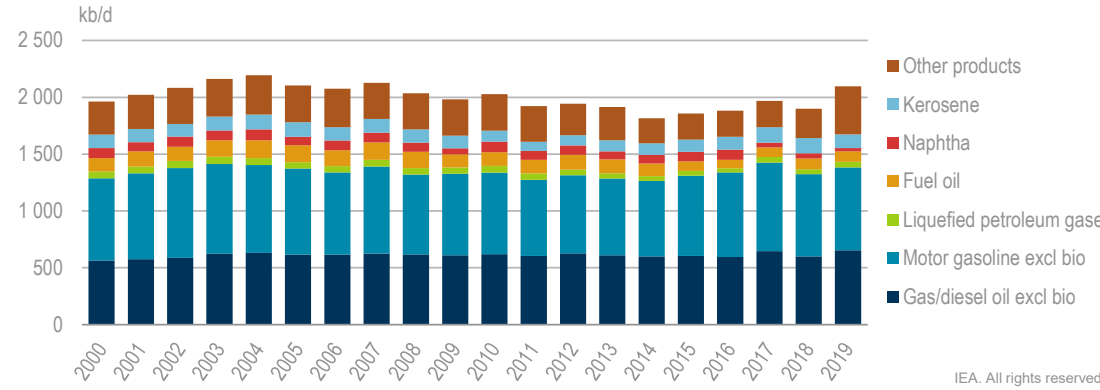
Notes: kb/d = thousand barrels per day. Net trade: crude oil trade includes crude oil, natural gas liquids and feedstocks.

Source: IEA (2021a), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Oil products supply and trade

In 2019, a total of 2.1 mb/d of refined oil products were produced in Canada, with motor gasoline (730 kb/d) and gas/diesel (653 kb/d) together accounting for 66% of the total. The remainder of refined product production in 2019 consisted of kerosene (121 kb/d), fuel oil (92 kb/d), liquefied petroleum gases (50 kb/d), naphtha (27 kb/d) and other products (425 kb/d, including ethane and petroleum coke) (Figure 11.4).

Figure 11.4 Canada's oil products production, 2000-19



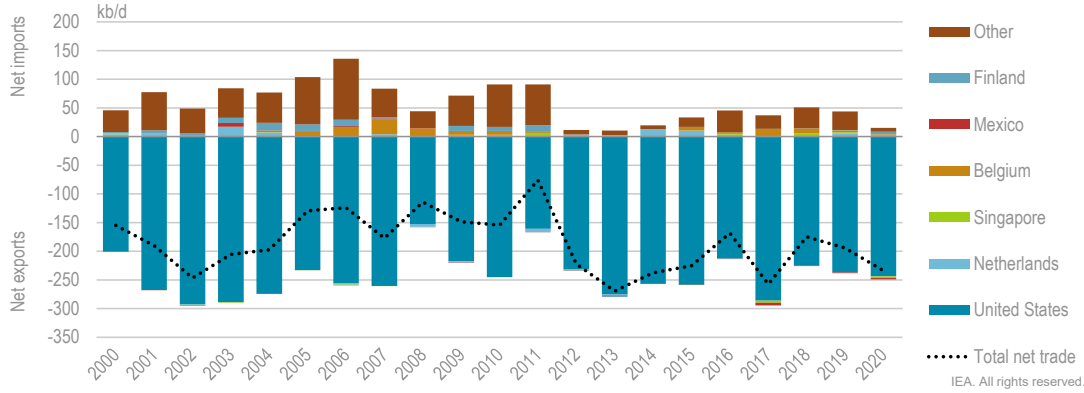
Motor gasoline and gas/diesel oil together account for two-thirds of oil products domestic production.

Note: kb/d = thousand barrels per day.

Source: IEA (2021a), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Canada's oil products trade is predominantly composed of exports to the United States, with imports to a lesser extent from a handful of countries (the Netherlands, Slovenia, the Russian Federation, Belgium) (Figure 11.5). In 2020, Canada exported a total of 413 kb/d of refined oil products while importing a total of 179 kb/d, resulting in 234 kb/d of net exports. These net exports consisted predominantly of diesel (130 kb/d) and gasoline (96 kb/d), while at the same time Canada was a net importer of kerosene (18 kb/d) and petroleum coke (25 kb/d).

Figure 11.5 Canada's oil products net trade by country, 2000-20



Canada is a net exporter of oil products, predominantly motor gasoline and diesel to the United States, but also imports oil products from further abroad.

Notes: kb/d = thousand barrels per day.

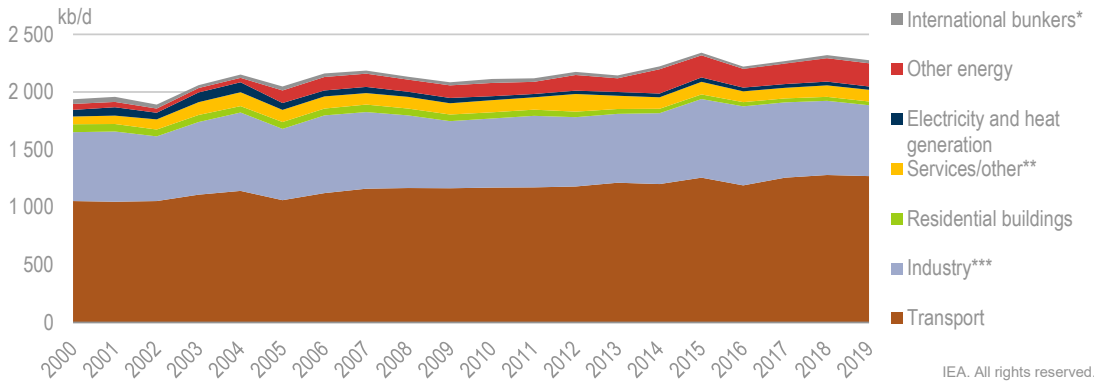
Source: IEA (2021a), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Oil demand

Oil demand in Canada was 2.38 mb/d in 2019, with motor gasoline (833 kb/d) and gas/diesel (599 kb/d) accounting for the majority.

Oil in Canada is mainly used in domestic transport (1 270 kb/d in 2019) and the industry sector (624 kb/d), which together represented 79% of total oil demand, compared to 81% in 2009. The remaining oil use was accounted for in the services sector (200 kb/d) and "other energy" (201 kb/d), and to a much lesser degree, residential (32 kb/d), electricity and heat generation (29 kb/d), and international bunkers (28 kb/d) (Figure 11.6). Consumption by "other energy" increased by 84% compared to 2009, services increased 19% and domestic transport 9%, while the residential sector decreased by 45%, electricity and heat generation by 36%, and industry by only 1%.

Figure 11.6 Canada's oil demand by sector, 2000-19



Domestic transport and industry sectors have together accounted for around 80% of oil consumption in recent decades.

* *International bunkers* includes bunker fuels for international aviation and navigation.

** *Services/other* includes commercial and public services, agriculture, forestry, and fishing.

*** *Industry* includes demand from oil refineries.

Note: kb/d = thousand barrels per day.

Source: IEA (2021a), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Oil demand fell in all sectors in 2020 as a result of the Covid-19 pandemic, resulting in a decline in overall oil product demand of 9.5% from the 2019 level (to around 2.13 mb/d). In terms of specific oil products, this consisted of a decline in demand for motor gasoline (10%), diesel (8%) and aviation fuels (46%).

Biofuel blending

The Renewable Fuels Regulations, which came into force in 2010, require blending 5% renewable fuel in gasoline and 2% renewable fuel in diesel fuel and heating distillate oil. As a result of amendments in 2013, heating distillate oil was exempted from the requirements. The regulations include provisions that govern a trading system of compliance units and require record keeping and reporting to assist in verifying compliance. With the development of the new Clean Fuel Regulations, which will come into effect in 2022 (see below), the Renewable Fuels Regulations will be repealed in 2024 with the last compliance period in 2022 (see Chapter 5).

There are also provincial renewable fuel mandates in effect in the provinces of British Columbia, Alberta, Saskatchewan, Manitoba and Ontario, while new regulations have been proposed for Quebec (Table 11.1). The Clean Fuel Regulations will require further reductions in the emissions intensity of liquid fuels in Canada (see below).

Table 11.1 Canada's provincial low-carbon and Renewable Fuel Regulations

Jurisdiction	Ethanol blend mandate (% vol)	Biomass-based diesel blend mandate (% vol)	Low-Carbon Fuel Standard
British Columbia	5%	4%	Reduce fuel carbon intensity by 20% by 2030 (from 2010)
Alberta	5%	2%	n.a.
Saskatchewan	7.5%	2%	n.a.

Jurisdiction	Ethanol blend mandate (% vol)	Biomass-based diesel blend mandate (% vol)	Low-Carbon Fuel Standard
Manitoba	8.5% (pledged to increase to 10%)	2% (pledged to increase to 5%)	n.a.
Ontario	10% (will increase to 15% between 2025 and 2030)	4%	n.a.
Quebec*	10% (will increase to 15% in 2025)	2% (will increase to 4% by 2025)	n.a.

* Proposed regulations; if approved, they would come into effect in 2023.

Source: Canadian government.

Oil market policies and regulations

Under the Canadian Constitution, the provinces own the vast majority of resource rights that fall within their territory. Regulation of oil and gas resource development is the responsibility of the provinces that also oversee the development of oil and gas infrastructure projects (i.e. pipelines, gas plants) within their territory. The federal government regulates pipelines that cross provincial and international borders, while the downstream and refining sector is regulated by both the federal and provincial governments.

Emissions reduction policies

In December 2016, the federal government, along with the provinces and territories, released the Pan-Canadian Framework on Clean Growth and Climate Change (PCF), a comprehensive plan with over 60 new policies and measures, including a price on carbon. Since then, Canada has introduced in parliament the Net-Zero Emissions Accountability Act (Bill C-12) to help achieve net zero emissions by 2050 with five-year targets beginning in 2030. It has also announced a Strengthened Climate Plan to further reduce emissions by 32-40% below 2005 levels by 2030 (see Chapter 3). When taken together, Canada's climate plans will have a direct impact on future oil and gas developments in Canada, in addition to the federal carbon price, which is proposed to increase annually from CAD 50 per tonne in 2022 to CAD 170 per tonne in 2030.

Greenhouse gas emissions from the oil and gas sector are expected to be held to 194 million tonnes (Mt) by 2030, compared to 213 Mt if unmitigated, effectively decoupling emissions growth from the growing production over the period. An additional reduction of 56 Mt/year in the oil and gas sector by 2030 is required to reach Canada's enhanced 2030 Paris Agreement target.

The Greenhouse Gas Pollution Pricing Act, which received Royal Assent in June 2018, implements the federal carbon pollution pricing system. The federal system is composed of two parts: 1) a regulatory charge on fossil fuels ("fuel charge"); and 2) an output-based pricing system for industrial facilities. Under the act, provinces have the flexibility to implement their own carbon pricing systems aligned with minimum national stringency standards (the "federal benchmark"). A "federal backstop" carbon pollution pricing system applies (in part or in full) in any jurisdiction that requests it or that does not implement its own system that meets the federal benchmark (see Chapter 3 for more details).

The Clean Fuel Regulations will require suppliers of liquid fuel (gasoline, diesel, home heating oil) to gradually reduce the carbon intensity of the fuels they produce and sell for

use in Canada over time, leading to a decrease of approximately 13% (below 2016 levels) in the carbon intensity of liquid fuels used in Canada by 2030. The Ministry of Environment and Climate Change estimates that the regulations will reduce GHG emissions by more than 20 Mt in 2030 – equivalent to taking 5 million cars off the road. Final regulations are due to be published in late 2021 and will come into effect in December 2022 (see more details in Chapter 5).

Under the PCF, Canada has committed to reduce methane emissions from the oil and gas sector by 40-45% below 2012 levels by 2025. Final methane regulations were published on 26 April 2018, as a new regulatory framework under the Canadian Environmental Protection Act, and came into effect on 1 January 2020. As of October 2021, the government of Canada committed to increase its oil and gas methane emissions target to at least a 75% reduction below 2012 levels by 2030.

The CAD 750 million Emissions Reduction Fund supports the reduction of GHGs with a focus on methane. The CAD 675 million onshore portion of the fund supports oil and gas companies to reduce methane and associated GHGs emissions through the deployment of infrastructure and technology, while the CAD 75 million offshore portion of the fund provides support for research, development and demonstration of technologies and solutions that reduce GHG emissions.

In addition to upstream methane regulations, the Emissions Reduction Fund and emissions intensity benchmarks, technology can play an important role in reducing emissions, notably carbon capture, utilisation and storage (CCUS) and electrification from low-carbon sources. To this end, Canada's Strengthened Climate Plan proposed the development of a comprehensive strategy for CCUS that reflects opportunities across regions and sectors in Canada. The strategy will be developed by Natural Resources Canada (NRCan), with an initial expectation that CCUS could, among others, be fundamental in creating new business models for cleaner oil and gas in addition to low-carbon industrial and negative emissions pathways.

To decarbonise the transportation sector, the government is setting ambitious targets to be achieved at the national level and encompassing battery electric vehicles, hydrogen fuel cell electric vehicles and plug-in hybrid electric vehicles. Canada announced its intention to set a mandatory target for all new light-duty cars and passenger trucks sales to be zero-emission by 2035, accelerating Canada’s previous goal of 100% sales by 2040.

Alberta emissions policy

Alberta’s Technology Innovation and Emissions Reduction (TIER) regulations, which replaced the Carbon Competitiveness Incentive Regulation, came into effect on 1 January 2020. The TIER regulations apply to facilities that have emitted 100 000 tonnes or more of CO_2 equivalent in 2016, or any subsequent year. The regulations set GHG emissions intensity benchmarks for oil sands operations. These benchmarks are either facility specific or can be based on the industry average. Facility-specific standards are initially set at 10% below 2013-15 emissions intensity. The stringency of the benchmarks increases for each subsequent year by 1%. Facilities with emissions above the benchmark are expected to pay a carbon price of 40 CAD/tonne into the TIER Compliance Fund for each additional tonne emitted. Discussions between the federal and provincial governments may result in changes to the price level. The Alberta TIER regulation meets federal carbon pricing benchmark criteria and sets out the requirements for the oil sector

in that province. Oil sands operations are expected to deploy energy efficiency and low-cost mitigation technologies to meet their respective benchmarks.

In June 2021, NRCan, Cenovus Energy, Imperial, MEG Energy and Suncor Energy formally announced the Oil Sands Pathways to Net Zero initiative. These companies operate approximately 90% of Canada's oil sands production. The goal of this unique alliance, working collectively with the federal and Alberta governments, is to achieve net zero GHG emissions from oil sands operations by 2050.

Production curtailments

Canadian heavy crude is typically priced at a discount to international light crude grades. This is due to both quality factors and transportation costs to move the oil from Alberta to key refining markets in the United States. In October 2018, as production growth exceeded pipeline takeaway capacity and utilisation rates on the main pipeline systems in Western Canada reached 98%, the heavy oil discount widened to a high of CAD 52 per barrel. New oil sands projects coming online added to the excess supply, which by some estimates was 400 kb/d above pipeline takeaway capacity in late 2018. Producers who could not secure takeaway capacity through the pipelines nomination process had to make alternative arrangements, including transporting crude by rail, which costs CAD 15-22 per barrel from Alberta to the US Gulf Coast.

In response to these extreme market conditions, the government of Alberta took exceptional measures to reign in supply levels so that they would be in line with available pipeline takeaway capacity. A curtailment order was put in place in 2019 which reduced supply by 325 kb/d, with exceptions given to small producers and those who could demonstrate that they had sufficient rail capacity. In December 2020, with production still recovering from shut-ins, and more space being available on pipelines, the government of Alberta announced that it would suspend the curtailment order until further notice. There is still the option to reinstate the curtailment order should the circumstances warrant.

Moratorium area for oil tankers

The Oil Tanker Moratorium Act prohibits oil tankers carrying more than 12 500 metric tonnes (92 kb) of crude oil or persistent oil products as cargo from stopping, loading or unloading at ports or marine installations in the moratorium area. The moratorium covers the area from the Canadian-Alaskan border in the north down to the point on British Columbia's mainland across from the northern tip of Vancouver Island. This measure complements the existing voluntary Tanker Exclusion Zone, which has been in place since 1985. The moratorium area has gained attention in recent years as a potential launching point for crude oil exports, given its proximity to Asian markets. The act would prohibit future exports of crude oil from this area.

Inactive and orphan wells

There are a great number of inactive and legacy wells in the oil-producing regions of Canada. Inactive wells are the responsibility of the individual owner, while orphan wells have no legally responsible or financially able owner and are managed by provincial orphan well associations funded by industry, primarily through annual levies. Due to the significant decline in oil prices since 2014 and the competitiveness issues faced by the industry, which have been exacerbated by the Covid-19 pandemic, the inventory of

inactive and orphan wells has experienced significant growth. This was addressed by the Canadian government's responses to the Covid-19 pandemic (see below).

Infrastructure project approval process

In order to ensure more timely and predictable decisions regarding the review and approval of major infrastructure projects, the government enacted Bill C-69 to modernise the National Energy Board and the Canadian Environmental Assessment Agency. Bill C-69, which created the Canada Energy Regulator and the Impact Assessment Agency of Canada, is intended to put better rules in place to protect the environment, while providing greater certainty and predictable project reviews to attract investment. Engaging with Indigenous peoples both through consultation processes and job creation has also been a major goal of this overhaul. For more details on this engagement process, see Chapters 2 and 10.

Covid-19 support measures

Recognising Covid-19's impacts on the petroleum sector, the government of Canada targeted CAD 2.8 billion to support petroleum sector workers while improving environmental performance, covering the following programmes:

- **Orphan and inactive wells** (CAD 1.72 billion): Funding to the governments of Alberta, British Columbia and Saskatchewan, along with Alberta's Orphan Wells Association, to remediate orphan and inactive wells, helping sustain employment while addressing an environmental liability. Up to 8 600 jobs in the oil field services sector are projected to be created through this programme. As part of the funding agreements with Alberta and Saskatchewan, these provinces are required to strengthen the regulatory regime to significantly reduce the future prospect of inactive and orphan wells and ensure a sustainably funded system by industry. The funding agreement with British Columbia did not require regulatory changes as British Columbia had recently introduced regulatory improvements to its oil and gas liability regime, including the introduction of legislated timelines for the restoration of oil and gas wells.

- **Emissions Reduction Fund** (CAD 750 million): Funding to support capital investments and research to reduce GHG emissions, with a focus on methane, from onshore and offshore oil and gas. Up to CAD 675 million of this fund is available to onshore upstream/midstream conventional, tight and shale oil and gas companies to reduce or eliminate the routine flaring or venting of methane-rich natural gas. The remaining CAD 75 million is for the deployment of emissions-reducing technologies and related research, development and demonstration (RD&D) in the offshore sector.

- **Newfoundland and Labrador Offshore Worker Support** (CAD 320 million): Funding to the government of Newfoundland and Labrador to support workers in the offshore energy sector through activities that advance environmental benefits and co-benefits. Eligible projects include activities such as safety improvements, maintenance and upgrades of existing facilities, and R&D. CAD 41.5 million has already been committed to Husky's White Rose West extension project, which had been put on hold following the Covid-19 price collapse.

Oil market structure

Canada has a market-based oil industry that relies on private sector companies to take investment decisions and develop oil resources.

Canada's oil industry can be separated into the following key segments: exploration and production, refining, midstream transportation and storage, and wholesale and retail operations. Some larger companies are active in all of these areas, while most companies prefer to focus only on one or two of these segments.

The oil sands sector is a concentrated, specialised sector comprised mainly of large and profitable Canadian producers. Four major companies are primarily focused on oil sands: Suncor Energy, Imperial Ltd, Cenovus Energy and Canadian Natural Resources Ltd (CNRL). These four companies control over 85% of oil sands production and over 70% of total oil production in Canada. The remaining 15% of oil sands production is owned by a combination of smaller domestic companies and international oil companies.

Suncor, Imperial and Cenovus (following completion of its merger with Husky in January 2021) have fully integrated business models with upstream production, downstream refining and marketing, while CNRL is solely focused on upstream production.

Imperial Oil is the largest of ten refinery companies in Canada, providing around a quarter of the oil products used in the country, through its industrial and wholesale businesses and retail brands, Esso and Mobil. In addition to Imperial, Suncor, Irving Oil, Valero and Shell round out the top 5 list of refining companies, which together represent 80% of Canada's refining capacity.

There were 67 companies operating 11 937 retail stations in Canada in 2019 under 93 retail brands, with the top retail fuel brands consisting of Esso (15% of total stations), Suncor (12%) and Shell (11%) (Kent, 2020).

Prices and taxation

The government of Canada has no jurisdiction to regulate retail prices, outside of an emergency situation, although it does have a role in monitoring markets through the Competition Bureau. Provinces have the authority to regulate petroleum product pricing, and some provinces have put in place measures to regulate prices at the wholesale and retail levels. In most instances, local rack prices are set by free market forces through interaction between buyers and sellers.

All of the provinces in Eastern Canada − Newfoundland and Labrador, Prince Edward Island, Nova Scotia, New Brunswick, and Quebec − have chosen to regulate petroleum product prices in some manner in order to ensure that prices are predictable and fair for consumers and fuel providers in both urban and rural regions. In 2019, following record high prices for gasoline and diesel, the province of British Columbia introduced a new Fuel Price Transparency Act that requires wholesale companies to provide detailed information on fuel pricing and volumes to the provincial regulator.

Prices in Canada for automotive diesel in 2Q 2020 were the second-lowest among IEA countries, at 0.7 USD/litre, with a tax rate of 38% (Figure 11.7). Likewise, Canada's unleaded gasoline price in the same comparison group is second-lowest, at 0.8 USD/litre,

above only the United States, with a tax rate at 40%. Prices of light fuel in Canada for 2Q 2020 were tenth-lowest, at 0.6 USD/litre, with a tax rate of 13%.

Figure 11.7 Price comparison for automotive diesel, unleaded gasoline (RON 95) and light fuel oil in IEA countries, 2Q 2020

Canada's oil prices figure among the lowest in an IEA commparison.

Notes: USD = United States dollar/ L = litre. Automotive diesel does not include Mexico. Premium unleaded gasoline data are not available for Japan or Mexico. Light fuel data are not available for Australia, Hungary, Mexico, New Zealand, Norway, the Slovak Republic or Sweden.

Source: IEA (2021b), *Energy Prices and Taxes – Third Quarter 2020* (database), www.iea.org/statistics.

Oil infrastructure

Figure 11.8 Map of Canadian oil infrastructure

Sources: CER (2021), *Pipeline Profiles*, https://www.cer-rec.gc.ca/en/data-analysis/canada-energy-future/2020/results/index.html; IEA.

Refineries

There are 15 refineries in Canada, with a combined crude processing capacity of 1.95 mb/d (Table 11.2). Canadian refineries are divided into three main market orbits: 1) Western Canada, where the majority of Canadian crude oil is produced; 2) Southern Ontario, which has access to domestic and Bakken crude from North Dakota (North American mid-continental) and where significant refined product consumption occurs; and 3) Quebec and the Atlantic provinces, where crude supplies are largely imported and a significant share of refinery output is exported.

Table 11.2 Overview of refining capacity in Canada

Location		Owner	Capacity (kb/d)	Nelson Complexity
Quebec and the Atlantic provinces			**850**	
Come by Chance	Come by Chance, Newfoundland	North Atlantic Refining LP	130	7.8
St. John	St. John, New Brunswick	Irving Oil	318	7.92
Jean Gaulin	Levis, Quebec	Valero Energy	265	7.95
Montreal Suncor	Montreal, Quebec	Suncor Energy	137	11.54
Southern Ontario			**392**	
Nanticoke Imperial	Nanticoke, Ontario	Imperial Oil	112	9.49
Sarnia Imperial	Sarnia, Ontario	Imperial Oil	120	14.88
Corunna Shell	Corunna, Ontario	Shell Canada	75	7.71
Sarnia Suncor	Sarnia, Ontario	Suncor Energy	85	13.41
Western Canada			**706**	
Edmonton Imperial	Edmonton, Alberta	Imperial Oil	187	8.46
Edmonton Suncor	Edmonton, Alberta	Suncor Energy	142	9.84
Scotford	Scotford, Alberta	Shell Canada	100	11.88
Sturgeon Refinery	Redwater, Alberta	North West Redwater Partnership	80	8.42
Regina	Regina, Saskatchewan	Fedrative Co-operative	130	9.98
Burnaby	Burnaby, British Columbia	Parkland Fuels	55	7.29
Prince George	Prince George, British Columbia	Tidewater Midstream	12	NA
Total			**1948**	

Source: Canadian government.

The Sturgeon Refinery Project in Alberta is the first refinery built in Canada in over 30 years. This refinery is configured to process diluted bitumen into ultra-low sulphur diesel. The refinery also has integrated carbon capture and storage. This will result in 1.2 Mt CO_2 being captured and sequestered each year, which will lower the carbon intensity of fuels produced at the refinery.

No other major refining projects are planned in Canada, as refined product demand is expected to decline slightly over the coming years. The Come by Chance refinery in Newfoundland has been idle since March 2020, with no imminent date for restart. News reports in January 2021 indicate that the provincial government of Newfoundland will provide the refinery, as it seeks new owners, with financial assistance (CAD 16.6 million) to maintain the refinery warm in case of a future restart.

Alberta's upgraders

An "upgrader" is a facility that processes heavy crude or bitumen into synthetic crude oil, a lighter, lower sulphur content crude oil that is easier to transport. About 35% of bitumen produced from the oil sands is upgraded into synthetic crude oil before being sold to market. Upgraders can also produce some refined products such as refinery fuel, diesel and petroleum coke. Where upgraders are co-located at bitumen mines, most of the products are consumed on site to power heavy equipment and mine vehicles or as own-use for the upgrader.

There are currently five operational bitumen upgraders in Alberta with a total combined capacity of 1.36 mb/d (Table 11.3): three are north of Fort McMurray (Suncor, Syncrude and CNRL Horizon), one is north-east of Edmonton (Shell Scotford) and one is on the Alberta-Saskatchewan border (Husky's Lloydminster). Except for the Shell and Husky

upgraders, the other upgraders are located adjacent to mining operations and are integrated with bitumen production.

Table 11.3 Upgraders in Canada

Operator	Facility	Feedstock	SCO Capacity (kb/d)
Canadian Natural Resources Ltd.	Horizon	Bitumen	250 000
Husky Energy	Lloydminster	Heavy oil + bitumen	80 000
Shell Canada	Scotford	Bitumen	320 000
Suncor Energy	Upgrader 1&2	Bitumen	357 000
Syncrude	Mildred Lake & UE1	Bitumen	350 000

Note: kb/d = thousand barrels per day.

Source: Canadian government.

Pipelines

In Canada, crude oil is predominantly transported by pipeline through a network consisting of four major crude oil pipeline systems: Enbridge (3.96 mb/d capacity), Express (0.31 mb/d), Keystone (0.57 mb/d) and Trans Mountain (0.31 mb/d), and a refined product pipeline system, the Trans-Northern (0.13 mb/d), from Montreal to Toronto.

In recent years, crude oil production has grown faster than pipeline capacity. Between 2013 and 2016, about 1 mb/d of nameplate pipeline capacity was added in Canada. No significant incremental nameplate capacity has since been added and several expansion projects have been terminated. In addition to the recent termination of the Keystone XL project, the Energy East project was cancelled by the proponent in 2017 and the Northern Gateway project was dismissed by the government in 2016. However, in 2019, the federal government approved the Trans Mountain Expansion project, a twinning of the existing 1 150 km Trans Mountain Pipeline between Edmonton (Alberta) and Burnaby (British Columbia) that will triple the pipeline's current capacity. Construction is underway and is expected to be in service as early as December 2022 (Table 11.4).

Several optimisations and capacity increases, notably on the Enbridge Mainline system, have been completed. This includes the Enbridge Line 67 capacity increase to 800 kb/d, which has alleviated some of the pressure for oil transportation, particularly the need to ship crude by rail as an alternative to pipeline takeaway capacity. In recent years, pipeline companies have also steadily increased capacity and throughputs on their pipeline systems through the addition of drag reducing agents and pumping power.

In 2019, Enbridge completed the Canadian segment of its Line 3 Replacement Program. Enbridge's Line 3 pipeline is a 1 660 kilometre-long oil pipeline running from Hardisty, Alberta to Superior, Wisconsin (United States). It is part of the Enbridge Mainline system of pipelines. Line 3 had been running at a reduced pressure since 2008 due to integrity issues and had a maximum capacity of 390 kb/d. The Line 3 Replacement Program fully replaced the original line with a new pipeline, built to modern safety standards, and allows the pipeline to operate at its full capacity of 760 kb/d. Work on the US components of the Line 3 Replacement Program are nearing completion, with the potential to enter service in late 2021 (although the project remains the subject of litigation).

Table 11.4 Oil pipeline projects in Canada

Pipeline system	Description	Incremental export capacity (kb/d)	Expected in-service date
Enbridge Line 3	Replacement of existing pipeline from Hardisty, Alberta (section completed) to Superior, Wisconsin (United States)	370	Q4 2021
Trans Mountain Expansion Project	New pipeline in parallel to existing line between Edmonton, Alberta, to the Westridge Marine Terminal in Burnaby, British Columbia that will expand capacity from 300 kb/d to 890 kb/d	590	End-2022
Keystone XL Pipeline Project	New line from Hardisty, Alberta, extending south to Steele City, Nebraska (United States)	830	2023 (cancelled)

Note: kb/d = thousand barrels per day.

Source: Canadian government.

The Trans Mountain Pipeline Expansion (TMX) Project was originally approved in 2016. In the spring of 2018, the government of Canada purchased the Trans Mountain system, including the TMX expansion project. Construction on the TMX project resumed in the fall of 2019 after the project was reapproved in 2019, following additional review of the marine shipping aspects of the project and further consultation with potentially impacted indigenous groups. Trans Mountain has indicated the project can be completed by late 2022. When completed, the project would unlock large-scale access to offshore markets, including in Asia and the US west coast.

Construction on the long-delayed Keystone XL project restarted in 2020, after the company reaapplied for a permit to US authorities and received all major state and federal permits. Full construction was progressing in Alberta; however, the permit was revoked by the US administration in January 2021, leading to the project's suspension by the pipeline's owner, TC Energy. The project was officially cancelled in June 2021.

Enbridge Line 5 is a significant crude oil and natural gas liquids supply source for the entire Great Lakes region. It serves industry and consumers in both Canada and the United States, including the Sarnia refinery and petrochemical complex; refineries in Quebec; and refineries in Michigan, Ohio and Pennsylvania. Feedstock from Line 5 is used in the production of propane in Ontario that is the source of the majority of propane consumed in Michigan, Ontario and Quebec.

In November 2020, Michigan Governor Gretchen Whitmer announced the state is seeking court approval to revoke Enbridge's 1953 authorisation ("easement") to operate Line 5 through the Straits of Mackinac by 12 May 2021. While the matter is currently before US courts, the pipeline continues to operate safely.

Storage

Western Canada has five major hubs, where the majority of Canada's crude oil stocks are held, including Edmonton, Fort Saskatchewan and two in Hardisty in Alberta, and Kerrobert in Saskatchewan. These hubs are connected with major intra-provincial and international pipeline networks, allowing for the flow of crude into the facilities and export

to markets in the Midwest US and Eastern Canada. Total crude storage capacity in these hubs is estimated at 118 mb.

Canada currently does not collect official statistics on storage capacities for crude oil and refined products. Statistics Canada is evaluating the possibility of incorporating an annual or biannual question on storage capacity to existing refinery and midstream surveys. NRCan put in place a voluntary survey in June 2020 for upstream and refining companies in Canada. A total of 10 out of 14 queried companies voluntarily submitted data on storage capacities for crude oil and refined products. When supplemented with public data sources, this information indicates a total of at least 135 mb of crude storage capacity and 56 mb of refined product storage capacity throughout Canada.

Oil emergency policies

The Canadian federal government's oil emergency response policy, as a major oil producer and significant net exporter, is primarily based on the ongoing ability of the market to meet demand. In general terms, this translates into a reliance on the market to continuously enhance the growth, flexibility and diversity of the oil supply system in order to reduce the risks, and potential impacts, of oil supply disruptions. The policy therefore places primary reliance on the use of market instruments to achieve energy objectives, but the government also has the authority to take direct action in the event of a market failure.

In circumstances where the market cannot adequately respond to a supply disruption and government intervention is required, Canada has an emergency legislative and regulatory framework in place that grants it powers of response to a fuel supply disruption. Prior to its activation, however, the federal government would look to work with municipal and provincial governments to solve disruptions in a co-operative manner with industry. Failing this, and typically once provinces have exhausted their own response efforts, an energy supply emergency would be declared.

Legislation and national emergency strategy organisation

The Energy Supplies Emergency Act (ESEA) and the Emergencies Act provide the legislative basis for Canada to take broad-reaching measures in a nationally declared emergency. The ESEA, which was passed to allow Canada to fulfil its IEA treaty obligations, establishes the Energy Supplies Allocation Board (ESAB). When activated, the ESAB would have broad-ranging authority to direct the flow of petroleum-based energy resources in an emergency. While not specific to the oil sector, the Emergencies Act further provides the government of Canada broad powers to respond to emergencies in specific circumstances (i.e. emergencies related to public welfare, public order, international crisis and war).

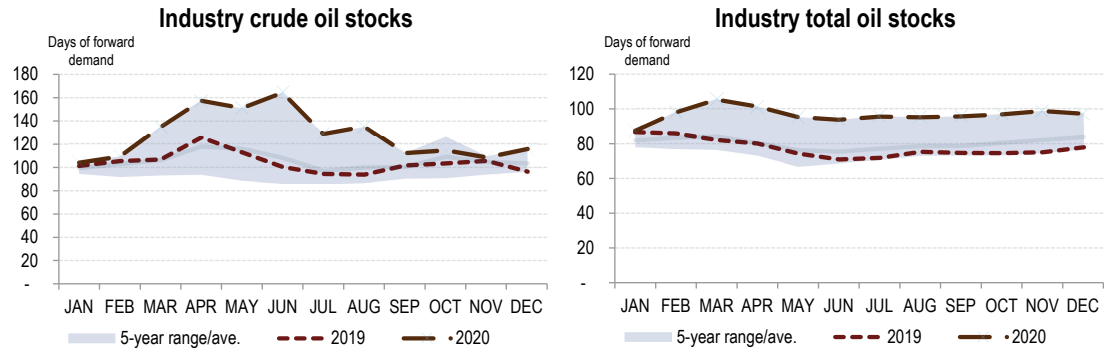
In non-emergency times, the Strategic Petroleum Policy and Investment Office within NRCan serves as the core national emergency strategy organisation (NESO) staff. In an emergency, when enabling legislation is activated (i.e. Energy Supplies Emergency Act), a much larger emergency organisation can be mobilised under the ESAB. This group comprises a chairperson and not more than six other members. The ESAB is chaired by the Deputy Minister of NRCan. The other members of the board are appointed by the Governor in Council. The board reports to the Minister of NRCan. The board is supported by core NESO staff who consult with industry and provincial counterparts on a regular basis.

Since coming into effect in 1985, the ESEA has never been invoked, and the ESAB remains a dormant body. Past crisis responses, including measures activated during the 2016 Alberta wildfires and the 2005 IEA collective action, did not meet the threshold for activating ESEA powers. The government of Canada reviews its emergency oil policies and legislation on an ongoing basis to assess their effectiveness, also in light of Canada's transformation over the period into one of the world's leading oil exporters.

Emergency response measures

As Canada is a net oil exporter, it is not subject to the IEA's emergency stockholding obligation (90 days of net import cover) and Canada does not have any publicly held emergency oil stocks nor set a compulsory stockholding obligation on industry. All oil stocks in Canada are industry stocks held for commercial/operational purposes. Based on days of forward demand, total oil stock levels in recent years have averaged between 75 and 85 days (Figure 11.9).

Figure 11.9 Commercial oil stock levels in Canada in recent years



Over the last five years, total oil stocks held by industry in Canada have averaged 75-85 days of forward demand.

Notes: Days of forward demand are stock levels divided by the forward quarter average daily demand. Stocks are inventories held on national territory, excluding utility stocks and including pipeline and entrepot stocks where known. Stock levels of 2020 measured in days of forward demand are exceptionally high due to the low oil demand related to the Covid-19 pandemic.

Source: IEA (2021c), *Monthly Oil Data Service*, www.iea.org/statistics.

Voluntary demand restraint measures are the administration's stated preferred contribution in the event of an IEA collective action. The government of Canada, through a robust federal/provincial/territorial emergency management system, underpinned by the Federal Emergency Response Protocol, has various overlapping systems for co-ordinating government responses in an emergency.

In implementing demand restraint measures, the federal government would lead on actions taken at the national level, such as public communications programmes and telecommuting measures targeting federally regulated employees, and would co-ordinate with provincial governments to encourage the roll-out of demand restraint measures *vis-à-vis* the powers available to the provinces and territories (provincially regulated employees, road and traffic regulations, transit programmes, etc.). If such efforts are found to be insufficient to reduce demand enough to meet Canada's international obligations, the government of Canada could implement more specific and/or compulsory demand

restraint measures under a declared national emergency. As indicated above, the government has never declared a national emergency in response to a petroleum supply crisis.

Based on data provided in the IEA's *Saving Oil in a Hurry*, the Canadian administration has commissioned a study to model the volumetric savings from potential demand restraint measures (Table 11.5). This includes several light-handed demand restraint mechanisms available that apply to daily road transportation, such as eco-driving measures, carpooling, telecommuting and increased use of public transport systems, which are estimated to each save 0.1-1.5%, depending on the intensity and variety of the methods used. More severe measures, only applicable under a declared national emergency, such as odd/even driving bans, are estimated to be able to save around 20-30% in road fuel usage (approximately 220-330 kb/d, equivalent to 9-14% of Canada's total oil demand).

Table 11.5 Potential demand restraint measures in Canada

Package of demand restraint measures	Potential savings (kb/d)	Share of 2019 oil demand
Basic (telecommuting, compressed workweek, eco-driving)	117.6	5%
Moderate (basic + 1/10 driving ban)	156.1	7%
Strong (basic + odd/even driving ban)	457.6	19%

Note: kb/d = thousand barrels per day.

Source: Estimates from the government of Canada.

With regards to supply-side emergency response, under Canada's federal system, the provinces have jurisdiction over oil resource rights and are responsible for regulating oil production. In the event of a major oil disruption that would prompt an IEA collective action, the federal government would communicate with the provinces to encourage them to lift or raise rate limitations on wells. Only Alberta would have some capacity to surge production in the short term (i.e. one to three months) and most of this would be through market-based supply response. According to the Alberta Energy Regulator, given the technical challenges involved with achieving nameplate capacity at oil sands facilities, temporary suspension of the maximum rate limitation would not result in significant surge production for the purposes of collective action.

Assessment

Since the IEA's last review in 2015, Canada has made a series of international and domestic commitments that strive toward a balanced approach to resource development, promoting economic growth while strengthening environmental performance. Thus, Canada aims to continue to be a long-term, sustainable and competitive energy producer and exporter. To achieve its ambitious climate plans, the leaders of all provinces and territories and the federal government endorsed the PCF in 2016.[3]

The Greenhouse Gas Pollution Pricing Act, which received Royal Assent in June 2018, implements the federal carbon pollution pricing system. The act is composed of two parts:

[3] Saskatchewan and Manitoba did not adopt the PCF at that time. Manitoba has since joined. Although Saskatchewan did not adopt the PCF, it continues to contribute to the annual PCF Synthesis Report.

a fuel regulatory charge on fossil fuels ("fuel charge") and an output-based pricing system for industrial facilities. Alberta's carbon pricing system for industry meets federal benchmark criteria and sets the requirements for the oil sector in that province.

Specifically, Alberta's TIER regulations apply to facilities that have emitted 100 000 t CO_2-eq or more in 2016, or any subsequent year. The stringency of these regulations increases by 1% per year.

In December 2020, through the release of the Strengthened Climate Plan, the federal government committed to the continued implementation of the PCF, while strengthening existing and introducing new GHG reduction measures to exceed Canada's 2030 emissions reduction goal and set Canada on a path to achieve net zero emissions by 2050. As a result, the oil sands sector could face more stringent GHG regulations.

Due to technological and operational efficiency improvements, oil sands emissions per barrel have already decreased by roughly 20% in the last decade. Despite this improvement in intensity, absolute emissions have increased due to expanding production. GHG emissions from oil and gas production went up by 26% between 2000 and 2019, largely from increased oil sands production, particularly *in situ* extraction. Canada will need to reconcile future growth in oil sands production with increasingly strict GHG requirements. Significantly, Canada has joined together with Norway, Qatar, Saudi Arabia and the United States in the establishment in April 2021 of a Net-Zero Producers Forum. As more and more countries state net zero targets, the emissions intensity of oil production will come into the spotlight. When global oil demand starts to decline, this intensity – combined with Canada's stability and broader environmental, social and governance performance – may become a factor in consumer preferences. Canada intends to continue its oil production and exports well beyond 2050 and should therefore prepare for a situation in which such preferences impact demand for its products.

The PCF also includes a policy to reduce methane emissions from the oil and gas sector by 40-45% below 2012 levels by 2025. The government committed to an increased target for the sector in October 2021 to at least a 75% reduction below 2012 levels by 2030. In addition, programmes such as the Emissions Reductions Fund play an important role in reducing emissions from intentional venting and flaring (methane, volatile organic compounds) during oil and gas production and supporting current and strengthened methane reduction targets.

Overall, Canada will need to find a way to further reduce the environmental impact of oil sands development in order to balance ambitious environmental targets with the economic benefits of resource development. In addition to upstream methane regulations and emissions intensity benchmarks, technology can play an important role, notably CCUS and electrification from low-carbon sources.

To this end, Canada's Strengthened Climate Plan proposed the development of a comprehensive strategy for CCUS. The strategy will be developed by NRCan and could, among others, be fundamental in creating new business models for cleaner oil and gas in addition to low-carbon industrial and negative emissions pathways. The IEA also notes efforts by some large oil sands producers to pursue net zero emissions pledges, underpinned by investments in technology.

Beyond reducing upstream emissions, Canada also has a range of policies in place to reduce domestic oil consumption which are still to be quantified in future oil demand

projections. The Clean Fuel Regulations, expected to come into force in December 2022, will require suppliers of liquid fuels that are mainly used in transport to gradually reduce the carbon intensity of the fuels. This measure is estimated to result in a 13% reduction of carbon intensity in liquid fuels by 2030 compared to 2016. In its efforts to decarbonise the transportation sector, the government is also setting ambitious intentions to reach 100% zero-emission vehicle sales by 2035, to be achieved at the national level encompassing battery electric vehicles, hydrogen fuel cell electric vehicles and plug-in hybrid electric vehicles. Furthermore, Canada's plans for hydrogen production coupled with CCUS technology could help reduce the carbon footprint of this resource while helping to reduce emissions in the transportation sector.

In addition to reducing its GHG footprint in line with climate targets, Canada's oil sector also faces challenges in getting its products to market. Pipelines play an important role in the shipping of oil across Canada and to the United States. There are four main pipelines for shipping crude oil to the United States, and more than 90% of Canada's crude oil exports to the United States are transported via these pipelines. Pipelines have lower operating costs and better safety compared to shipping by rail, and further oil sands development will require an increase in takeaway capacity. In recent years, however, crude oil production has outpaced pipeline capacity, leading to an increased reliance on rail to bridge the gap.

With the vast majority of Canadian crude exports going to the United States, Canada's export infrastructure is heavily focused on moving oil to the US market. However, Canada will need to substantially diversify its export destinations as Canadian and US production increases while at the same time oil consumption in both countries will decline. The Trans Mountain Pipeline Expansion Project will be a significant step in diversifying export potential, expanding access to overseas markets in Asia and further afield.

Several pipeline optimisations and capacity increases have been completed in recent years. Efforts to improve the approval process, such as Bill C-69, should help to facilitate infrastructure development, including pipeline capacity expansions. With further deployment of emissions mitigation technologies, and the importance of the industry to Canada's economic recovery, the industry should increase the sharing of information to help advance public acceptance of oil infrastructure projects. At the same time, acceptability of oil sector infrastructure projects can be enhanced by demonstrating responsibility in taking care of infrastructure which has passed its operating lifespan, and Canada should continue efforts to remediate the inactive and legacy wells in the nation's oil-producing regions.

Canada's oil emergency response policy reflects its role as a major oil producer and net exporter. With a robust oil industry and supply infrastructure, Canada's emergency policy places primary reliance on a well-functioning market to ensure supply security, while at the same time reflecting the jurisdictional authority of provinces and territories over energy resources. In a major disruption, where the oil industry is unable to adequately respond, the provinces would lead on crisis response with federal government support, and with direct federal co-ordination as a last resort.

While Canada is a major oil producer and exporter, it is not immune to risks in security of supply. With an extensive system of pipelines moving large volumes of oil from the west towards domestic and US markets across the continent, a significant disruption to any of these pipelines could pose a serious challenge to emergency response. At the same time,

as crude oil production is concentrated in the west of the country, oil supplies to the populous eastern part of Canada relies on oil imports and can have the same vulnerabilities as net-importing IEA countries in meeting oil demand. Moreover, today's oil supply security concerns extend beyond a country's level of crude oil production and status as a net exporter, including cyberthreats to infrastructure and supply chain security of critical components to oil supply, such as the blending fuels necessary to meet regulatory biofuel requirements and of diluents necessary to transport oil sands production.

As a net exporter, Canada does not have an IEA emergency oil stockholding obligation. At the same time, Canada is also a large oil consumer, and as such is obliged to take a substantial part in any IEA collective action. In order to ensure the ability to contribute effectively to an IEA collective action, Canada will need to periodically assess whether its current emergency response policy is sufficient and ready to be fully implemented as needed.

Recommendations

The government of Canada should:

- ☐ Define clear targets for emissions reductions in Canada's oil sector to align with stated plans to continue oil and gas exports beyond 2050 with net zero ambitions.
- ☐ Incentivise and monitor the reduction of environmental impacts, including greenhouse gas emissions in the oil sector, and promote the research, development and uptake of clean and innovative technologies by industry, including energy efficiency technologies.
- ☐ Ensure transparent information is provided to the public about the oil sector, including on technology developments to enhance production and reduce greenhouse gas emissions in a sustainable manner.
- ☐ Ensure that a regulatory regime is put in place in relevant provinces that requires a strong liability management system for oil-producing companies to plug depleted wells.
- ☐ Ensure the ability to contribute effectively to IEA collective action by periodically assessing the potential of all available emergency response measures to meet Canada's level of contribution, including in larger disruption scenarios; continue to explore possible options for establishing emergency oil stocks.

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ANNEX A: Organisations visited

Review criteria

The Shared Goals, which were adopted by the IEA ministers at their 4 June 1993 meeting in Paris, provide the evaluation criteria for the in-depth reviews conducted by the International Energy Agency (IEA). The Shared Goals are presented in Annex C.

Review team and preparation of the report

The IEA's in-depth review team conducted a virtual review of Canada from 8 to 19 February 2021. The team met with government officials, energy companies, interest groups, research institutions, and other organisations and stakeholders. This report was drafted based on the review team's preliminary assessment of the country's energy policy and information on subsequent policy developments from the government and private sector sources. The members of the team were:

IEA member countries

Ms. Mary Warlick, United States (team leader)

Ms. Martina Berg, Sweden

Ms. Yuliya Blondiau, Switzerland

Ms. Kathleen Deutsch, United States

Ms. Mette Gravdahl Agerup, Norway

Mr. Nils Saniter, Germany

Mr. Simon Sharpe, United Kingdom

OECD Nuclear Energy Agency

Mr. Michel Berthelemy

IEA Secretariat

Mr. Simon Bennett

Mr. Aad van Bohemen

Mr. Jason Elliott

Ms. Divya Reddy

The team is grateful for the co-operation and assistance of the many people it met throughout the visit. Thanks to their kind hospitality, openness and willingness to share information, the virtual visit was highly informative, productive and enjoyable. The team expresses particular gratitude to Natural Resources Canada for organising the visit and for all its support throughout the review process, especially to Jean-François Gagné, Isabel Murray, David Caughey, Mitchel Pennell, Jodi Browne and Dennis Trigylidas. The team is also sincerely grateful to Deputy Minister Jean-François Tremblay and several other senior officials from Natural Resources Canada for meeting with the review team.

Divya Reddy managed the review visit process and drafted the report, except for Chapter 6, which was prepared by Simon Bennett of the IEA; Chapter 8, which was drafted by Michel Berthelemy of the Nuclear Energy Agency; and Chapters 10 and 11, which were prepared by Jason Elliott of the IEA.

The report was prepared under the guidance of Aad van Bohemen, Head of the IEA's Energy Policy and Security Division. Helpful comments and updates were provided by the review team members and IEA staff, including Carlos Fernández Alvarez, Heymi Bahar, Adam Baylin-Stern, Peter Fraser, Sara Moarif, Jeremy Moorhouse and Aleksandra Paciorek.

Clémence Lizé, Alessio Scanziani, Bomi Kim, Myriam Badri, Alan Choi and Eunjin Choe managed the data and prepared the figures. Roberta Quadrelli, Erica Robin, Stève Gervais, Jungyu Park, Arnau Risquez Martin and Alexandre Bizeul provided support on statistics. Isabelle Nonain-Semelin and Therese Walsh managed the editing process, Jennifer Allain copy edited the report, Tanya Dyhin managed the design process and Astrid Dumond managed the production process. Jad Mouawad and Jethro Mullen supported the press launch.

Organisations visited

During its virtual meetings with Canada, the review team met with the following organisations:

7 Generations
Agricuture and Agri-Food Canada
AltaGas
Atlantic Canada Opportunities Agency
Atomic Energy of Canada Limited
Belledune Port Authority (New Brunswick)
Cactus Corridor (Alberta)
Cameco
Canadian Electricity Association
Canadian Fuels Association
Canadian Gas Association
Canadian Labour Congress
Canadian LNG Alliance
Canadian Nuclear Association
Canadian Nuclear Safety Commission
Canadian Renewable Energy Association (CanREA)
Canadian Fuels Association
Candu Owners Group
Canadian Association of Petroleum Producers (CAPP)
CBDC Chaleur
Canadian Energy Pipeline Association (CEPA)
Canada Energy Regulator (CER)
City of Estevan (Saskatchewan)

Coal Association of Canada

Coronach Region (Saskatchewan)

Canada's Oil Sands Innovation Alliance (COSIA)

Environment and Climate Change Canada (ECCC)

Explorers and Producers Association of Canada

Finance Canada

Global Affairs Canada (GAC)

Government of Alberta

Government of Nunavut

Government of Ontario

Ignite Pictou (Nova Scotia)

Impact Assessment Agency of Canada (IAAC)

Imperial Oil

Innovation, Science and Economic Development Canada (ISED)

Mining Association of Canada

Natural Gas Innovation Fund

Natural Resources Canada (NRCan)

NB Power

NWMO

Ontario Power Generation

Organization of Canadian Nuclear Industries

Parkland County (Alberta)

Pembina Institute

Prairies Economic Development Canada

Statistics Canada

Transport Canada

Verschuren Centre (Nova Scotia)

Waterpower Canada

Western Economic Diversification (WD)

ANNEX B: Energy balances and key statistical data

Unit: Mtoe

SUPPLY		1973	1990	2000	2010	2018	2019	2020E
TOTAL PRODUCTION		**198.2**	**276.5**	**374.9**	**398.4**	**537.7**	**535.6**	**515.1**
Coal		11.7	37.9	34.4	33.9	29.1	28.9	24.5
Peat		-	-	-	-	-	-	-
Oil		96.5	94.1	128.4	167.2	267.2	272.4	259.9
Natural gas		61.4	88.6	148.4	129.4	165.1	158.3	155.0
Biofuels and waste[1]		7.8	10.9	13.9	13.2	13.7	13.8	13.6
Nuclear		4.1	19.4	19.0	23.6	26.2	26.4	25.6
Hydro		16.7	25.5	30.8	30.2	33.2	32.6	33.1
Wind		-	-	0.0	0.8	2.9	2.8	3.1
Geothermal		-	-	-	-	-	-	-
Solar/other[2]		-	0.0	0.0	0.1	0.4	0.4	0.4
TOTAL NET IMPORTS[3]		**-37.3**	**-61.1**	**-129.8**	**-145.5**	**-228.1**	**-231.4**	**-226.2**
Coal	Exports	7.6	21.4	19.3	20.2	19.2	20.7	19.1
	Imports	10.5	9.5	15.1	8.2	5.5	6.0	4.7
	Net imports	2.8	-11.9	-4.2	-12.0	-13.7	-14.7	-14.5
Oil	Exports	63.2	49.7	93.3	124.4	218.3	227.0	213.1
	Imports	48.7	34.8	54.3	55.3	57.1	58.5	47.4
	Int'l marine and aviation bunkers	-1.7	-1.8	-2.1	-1.8	-1.3	-1.4	-0.9
	Net imports	-16.1	-16.7	-41.1	-70.9	-162.5	-169.9	-166.6
Natural gas	Exports	23.1	33.0	82.7	79.2	67.3	64.6	59.8
	Imports	0.3	0.5	1.3	18.7	19.5	22.0	19.9
	Net imports	-22.8	-32.5	-81.4	-60.4	-47.7	-42.6	-39.9
Electricity	Exports	1.4	1.6	4.4	3.8	5.3	5.2	5.8
	Imports	0.2	1.5	1.3	1.6	1.1	1.1	0.8
	Net imports	-1.2	-0.0	-3.1	-2.2	-4.1	-4.0	-4.9
TOTAL STOCK CHANGES		**-1.6**	**-4.0**	**8.5**	**7.9**	**-2.8**	**1.4**	**-1.4**
TOTAL SUPPLY (TES)[4]		**159.4**	**211.3**	**253.7**	**260.8**	**306.8**	**305.6**	**287.6**
Coal		15.3	24.3	31.7	23.1	14.3	13.9	10.6
Peat		-	-	-	-	-	-	-
Oil		79.4	76.5	87.1	96.3	103.6	102.9	94.2
Natural gas		37.3	54.7	74.3	75.7	116.8	116.9	112.3
Biofuels and waste[1]		7.8	10.9	13.8	13.2	13.6	13.8	13.3
Nuclear		4.1	19.4	19.0	23.6	26.2	26.4	25.6
Hydro		16.7	25.5	30.8	30.2	33.2	32.6	33.1
Wind		-	-	0.0	0.8	2.9	2.8	3.1
Geothermal		-	-	-	-	-	-	-
Solar/other[2]		-	0.0	0.0	0.1	0.4	0.4	0.4
Electricity trade[5]		-1.2	-0.0	-3.1	-2.2	-4.1	-4.0	-4.9
Shares in TES (%)								
Coal		*9.6*	*11.5*	*12.5*	*8.9*	*4.7*	*4.5*	*3.7*
Peat		-	-	-	-	-	-	-
Oil		*49.8*	*36.2*	*34.3*	*36.9*	*33.8*	*33.7*	*32.7*
Natural gas		*23.4*	*25.9*	*29.3*	*29.0*	*38.1*	*38.3*	*39.1*
Biofuels and waste[1]		*4.9*	*5.1*	*5.5*	*5.1*	*4.4*	*4.5*	*4.6*
Nuclear		*2.6*	*9.2*	*7.5*	*9.1*	*8.6*	*8.6*	*8.9*
Hydro		*10.5*	*12.1*	*12.2*	*11.6*	*10.8*	*10.7*	*11.5*
Wind		-	-	-	*0.3*	*0.9*	*0.9*	*1.1*
Geothermal		-	-	-	-	-	-	-
Solar/other[2]		-	*0.0*	*0.0*	*0.0*	*0.1*	*0.1*	*0.1*
Electricity trade[5]		*-0.8*	-	*-1.2*	*-0.8*	*-1.4*	*-1.3*	*-1.7*

0 is negligible, - is nil, .. is not available, x is not applicable. Please note: rounding may cause totals to differ from the sum of the elements.

Unit: Mtoe

DEMAND							
FINAL CONSUMPTION	**1973**	**1990**	**2000**	**2010**	**2018**	**2019**	**2020E**
TFC	**131.4**	**158.5**	**187.4**	**187.3**	**207.1**	**205.5**	**..**
Coal	5.4	3.2	3.6	3.2	2.7	2.6	..
Peat	-	-	-	-	-	-	..
Oil	75.7	65.5	76.3	89.5	94.8	93.2	..
Natural gas	23.7	43.3	53.4	42.2	52.9	52.7	..
Biofuels and waste[1]	7.6	9.9	11.9	10.9	10.9	11.0	..
Geothermal	-	-	-	-	-	-	..
Solar/other[2]	-	-	-	0.0	0.0	0.0	..
Electricity	18.9	35.9	41.4	41.0	45.1	45.5	..
Heat	0.1	0.6	0.8	0.4	0.7	0.6	..
Shares in TFC (%)							
Coal	*4.1*	*2.0*	*1.9*	*1.7*	*1.3*	*1.2*	..
Peat	-	-	-	-	-	-	..
Oil	*57.6*	*41.3*	*40.7*	*47.8*	*45.8*	*45.3*	..
Natural gas	*18.1*	*27.3*	*28.5*	*22.5*	*25.6*	*25.6*	..
Biofuels and waste[1]	*5.8*	*6.2*	*6.3*	*5.8*	*5.3*	*5.3*	..
Geothermal	-	-	-	-	-	-	..
Solar/other[2]	-	-	-	*0.0*	*0.0*	*0.0*	..
Electricity	*14.4*	*22.7*	*22.1*	*21.9*	*21.8*	*22.2*	..
Heat	*0.1*	*0.4*	*0.4*	*0.2*	*0.3*	*0.3*	..
TOTAL INDUSTRY[6]	**53.0**	**62.3**	**75.3**	**65.3**	**68.1**	**66.6**	**..**
Coal	4.9	3.2	3.6	3.2	2.7	2.6	..
Peat	-	-	-	-	-	-	..
Oil	21.3	18.1	22.1	24.5	24.6	23.1	..
Natural gas	11.9	20.2	23.4	15.7	18.9	18.6	..
Biofuels and waste[1]	5.7	5.7	7.9	6.5	5.5	5.5	..
Geothermal	-	-	-	-	-	-	..
Solar/other[2]	-	-	-	-	-	-	..
Electricity	9.1	14.4	17.5	15.1	15.8	16.3	..
Heat	0.1	0.6	0.8	0.4	0.6	0.5	..
Shares in total industry (%)							
Coal	*9.2*	*5.1*	*4.7*	*4.8*	*4.0*	*3.8*	..
Peat	-	-	-	-	-	-	..
Oil	*40.3*	*29.1*	*29.4*	*37.5*	*36.1*	*34.7*	..
Natural gas	*22.4*	*32.5*	*31.1*	*24.0*	*27.7*	*28.0*	..
Biofuels and waste[1]	*10.8*	*9.1*	*10.5*	*9.9*	*8.1*	*8.2*	..
Geothermal	-	-	-	-	-	-	..
Solar/other[2]	-	-	-	-	-	-	..
Electricity	*17.2*	*23.2*	*23.2*	*23.1*	*23.2*	*24.4*	..
Heat	*0.2*	*1.0*	*1.1*	*0.7*	*0.9*	*0.8*	..
TRANSPORT[4]	**33.6**	**43.1**	**52.1**	**60.6**	**68.2**	**68.0**	**..**
OTHER[7]	**44.8**	**53.1**	**60.0**	**61.4**	**70.8**	**70.9**	**..**
Coal	0.4	0.1	0.0	0.0	0.0	0.0	..
Peat	-	-	-	-	-	-	..
Oil	21.1	7.4	7.4	8.4	8.4	8.5	..
Natural gas	11.9	20.2	25.3	24.1	30.4	30.4	..
Biofuels and waste[1]	1.9	4.2	3.8	3.3	3.3	3.3	..
Geothermal	-	-	-	-	-	-	..
Solar/other[2]	-	-	-	0.0	0.0	0.0	..
Electricity	9.5	21.2	23.5	25.5	28.6	28.6	..
Heat	-	0.0	0.0	0.0	0.1	0.0	..
Shares in other (%)							
Coal	*0.9*	*0.1*	*0.1*	*0.1*	-	-	..
Peat	-	-	-	-	-	-	..
Oil	*47.1*	*14.0*	*12.3*	*13.6*	*11.9*	*12.0*	..
Natural gas	*26.5*	*38.0*	*42.1*	*39.3*	*43.0*	*42.9*	..
Biofuels and waste[1]	*4.3*	*7.9*	*6.4*	*5.3*	*4.6*	*4.6*	..
Geothermal	-	-	-	-	-	-	..
Solar/other[2]	-	-	-	*0.1*	*0.1*	*0.1*	..
Electricity	*21.3*	*40.0*	*39.2*	*41.6*	*40.4*	*40.4*	..
Heat	-	-	-	-	*0.1*	-	..

0 is negligible, - is nil, .. is not available, x is not applicable. Please note: rounding may cause totals to differ from the sum of the elements.

Unit: Mtoe

DEMAND							
ENERGY TRANSFORMATION AND LOSSES	**1973**	**1990**	**2000**	**2010**	**2018**	**2019**	**2020E**
ELECTRICITY GENERATION[8]							
Input (Mtoe)	36.1	71.5	89.1	89.6	93.4	92.3	..
Output (Mtoe)	23.2	41.5	52.1	51.9	56.2	55.5	55.1
Output (TWh)	270.1	482.0	605.6	602.9	653.7	645.3	640.8
Output shares (%)							
Coal	*12.9*	*17.1*	*19.4*	*13.2*	*7.2*	*6.7*	*4.9*
Peat	-	-	-	-	-	-	-
Oil	*3.4*	*3.4*	*2.4*	*1.4*	*0.9*	*0.9*	*0.8*
Natural gas	*6.0*	*2.0*	*5.5*	*8.6*	*10.1*	*10.5*	*11.1*
Biofuels and waste[1]	-	*0.8*	*1.4*	*1.5*	*1.6*	*1.7*	*1.6*
Nuclear	*5.6*	*15.1*	*12.0*	*15.0*	*15.4*	*15.7*	*15.3*
Hydro	*72.1*	*61.6*	*59.2*	*58.3*	*59.0*	*58.8*	*60.0*
Wind	-	-	-	*1.4*	*5.1*	*5.1*	*5.6*
Geothermal	-	-	-	-	-	-	-
Solar/other[2]	-	-	-	*0.5*	*0.6*	*0.7*	*0.7*
TOTAL LOSSES	**31.3**	**49.7**	**62.3**	**81.8**	**103.7**	**101.7**	**-3.3**
of which:							
Electricity and heat generation[9]	12.8	29.4	36.1	37.2	37.0	36.6	..
Other transformation	2.0	-0.9	-1.8	-1.8	1.6	1.4	-3.3
Own use and transmission/distribution losses	16.6	21.2	28.0	46.3	65.2	63.6	..
Statistical differences	**-3.4**	**3.1**	**4.0**	**-8.3**	**-4.1**	**-1.6**	**..**
INDICATORS	**1973**	**1990**	**2000**	**2010**	**2018**	**2019**	**2020E**
GDP (billion 2015 USD)	537.02	878.02	1163.71	1399.51	1659.24	1690.13	1600.33
Population (millions)	22.49	27.69	30.69	34.01	37.07	37.59	38.01
TES/GDP (toe/1000 USD)[10]	0.30	0.24	0.22	0.19	0.18	0.18	0.18
Energy production/TES	1.24	1.31	1.48	1.53	1.75	1.75	1.79
Per capita TES (toe/capita)	7.08	7.63	8.27	7.67	8.28	8.13	7.57
Oil supply/GDP (toe/1000 USD)[10]	0.15	0.09	0.07	0.07	0.06	0.06	0.06
TFC/GDP (toe/1000 USD)[10]	0.24	0.18	0.16	0.13	0.12	0.12	..
Per capita TFC (toe/capita)	5.84	5.72	6.11	5.51	5.59	5.47	..
CO_2 emissions from fuel combustion ($MtCO_2$)[11]	375.7	409.3	503.5	526.2	570.5	571.0	..
CO_2 emissions from bunkers ($MtCO_2$)[11]	5.2	5.6	6.5	5.6	4.1	4.4	..
GROWTH RATES (% per year)	**73-90**	**90-00**	**00-10**	**10-17**	**17-18**	**18-19**	**19-20**
TES	1.7	1.8	0.3	2.1	1.4	-0.4	-5.9
Coal	2.8	2.7	-3.1	-3.5	-20.7	-3.0	-23.8
Peat	-	-	-	-	-	-	-
Oil	-0.2	1.3	1.0	0.7	2.2	-0.7	-8.5
Natural gas	2.3	3.1	0.2	5.7	4.9	0.1	-3.9
Biofuels and waste[1]	2.0	2.4	-0.4	0.6	-1.3	1.1	-3.5
Nuclear	9.6	-0.2	2.2	1.6	-0.6	0.5	-3.0
Hydro	2.5	1.9	-0.2	1.7	-2.2	-1.6	1.3
Wind	-	-	41.7	20.1	5.3	-1.6	10.5
Geothermal	-	-	-	-	-	-	-
Solar/other[2]	-	7.2	31.3	28.4	6.0	5.9	4.3

Footnotes to energy balances and key statistical data

1 Biofuels and waste comprise solid biofuels, liquid biofuels, biogases, industrial waste and municipal waste. Data are often based on partial surveys and may not be comparable between countries.

2 Other includes tide and wave.

3 In addition to coal, oil, natural gas and electricity, total net imports also include biofuels.

4 Excludes international marine bunkers and international aviation bunkers.

5 Total supply of electricity represents net trade. A negative number in the share of total electricity supply indicates that exports are greater than imports.

6 Industry includes non-energy use.

7 Other includes residential, commercial and public services, agriculture/forestry, fishing, and other non-specified.

8 Inputs to electricity generation include inputs to electricity, co-generation and heat plants. Output refers only to electricity generation.

9 Losses arising in the production of electricity and heat at main activity producer utilities and autoproducers. For non-fossil fuel electricity generation, theoretical losses are shown based on plant efficiencies of approximately 33% for nuclear and 100% for hydro, wind and solar photovoltaic.

10 Tonne of oil equivalent per thousand US dollars at 2015 prices and exchange rates.

11 "CO_2 emissions from fuel combustion" have been estimated using the IPCC Tier I Sectoral Approach methodology from the 2006 IPCC Guidelines. Emissions from international marine and aviation bunkers are not included in national totals.

ANNEX C: International Energy Agency's "Shared Goals"

The member countries* of the International Energy Agency (IEA) seek to create conditions in which the energy sectors of their economies can make the fullest possible contribution to sustainable economic development and to the well-being of their people and of the environment. In formulating energy policies, the establishment of free and open markets is a fundamental point of departure, though energy security and environmental protection need to be given particular emphasis by governments. IEA countries recognise the significance of increasing global interdependence in energy. They therefore seek to promote the effective operation of international energy markets and encourage dialogue with all participants. In order to secure their objectives, member countries therefore aim to create a policy framework consistent with the following goals:

1. Diversity, efficiency and flexibility within the energy sector are basic conditions for longer term energy security: the fuels used within and across sectors and the sources of those fuels should be as diverse as practicable. Non-fossil fuels, particularly nuclear and hydro power, make a substantial contribution to the energy supply diversity of IEA countries as a group.

2. Energy systems should have **the ability to respond promptly and flexibly to energy emergencies.** In some cases, this requires collective mechanisms and action: IEA countries co-operate through the Agency in responding jointly to oil supply emergencies.

3. The environmentally sustainable provision and use of energy are central to the achievement of these Shared Goals. Decision makers should seek to minimise the adverse environmental impacts of energy activities, just as environmental decisions should take account of the energy consequences. Government interventions should respect the polluter-pays principle where practicable.

4. More environmentally acceptable energy sources need to be encouraged and developed. Clean and efficient use of fossil fuels is essential. The development of economic non-fossil sources is also a priority. A number of IEA member countries wish to retain and improve the nuclear option for the future, at the highest available safety standards, because nuclear energy does not emit carbon dioxide. Renewable sources will also have an increasingly important contribution to make.

5. Improved energy efficiency can promote both environmental protection and energy security in a cost-effective manner. There are significant opportunities for greater energy efficiency at all stages of the energy cycle, from production to consumption. Strong efforts by governments and all energy users are needed to realise these opportunities.

6. Continued **research, development and market deployment of new and improved energy technologies** make a critical contribution to achieving the objectives outlined above. Energy technology policies should complement broader energy policies. International co-operation in the development and dissemination of energy technologies, including industry participation and co-operation with non-member countries, should be encouraged.

7. Undistorted energy prices enable markets to work efficiently. Energy prices should not be held artificially below the costs of supply to promote social or industrial goals. To the extent necessary and practicable, the environmental costs of energy production and use should be reflected in prices.

8. Free and open trade and a secure framework for investment contribute to efficient energy markets and energy security. Distortions to energy trade and investment should be avoided.

9. Co-operation among all energy market participants helps to improve information and understanding, and encourages the development of efficient, environmentally acceptable and flexible energy systems and markets worldwide. These are needed to help promote the investment, trade and confidence necessary to achieve global energy security and environmental objectives.

(The Shared Goals were adopted by IEA ministers at the meeting of 4 June 1993 in Paris, France.)

* Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, the Slovak Republic, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States.

ANNEX D: Glossary and list of abbreviations

In this report, abbreviations and acronyms are substituted for a number of terms used within the International Energy Agency. While these terms generally have been written out on first mention, this glossary provides a quick and central reference for the abbreviations used.

Acronyms and abbreviations

AECL	Atomic Energy of Canada Limited
CAD	Canadian dollar (currency)
CANDU	Canada Deuterium Uranium
CCA	capital cost allowance
CCTI	Canada Coal Transition Initiative
CCUS	carbon capture, utilisation and storage
CEM	Clean Energy Ministerial
CER	Canada Energy Regulator
CERRC	Clean Energy for Rural and Remote Communities
CFR	Clean Fuel Regulations
CNL	Canadian Nuclear Laboratories
CNRL	Canadian Natural Resources Ltd
CNSC	Canadian Nuclear Safety Commission
ECCC	Environment and Climate Change Canada
EIP	Energy Innovation Program
EOR	enhanced oil recovery
ESAB	Energy Supplies Allocation Board
ESCO	energy service company
ESEA	Energy Supplies Emergency Act
ESG	environmental, social and governance
EV	electric vehicle
GBA+	Gender-Based Analysis Plus
GDP	gross domestic product
GHG	greenhouse gas
IAA	Impact Assessment Act
IEA	International Energy Agency
IESO	Independent Electricity System Operator
LNG	liquefied natural gas
LULUCF	land use, land-use change and forestry
MI	Mission Innovation

MOU	memorandum of understanding
NAFTA	North American Free Trade Agreement
NDC	nationally determined contribution
NECB	National Energy Code of Canada for Buildings
NERC	North American Reliability Corporation
NGL	natural gas liquid
NGTL	Nova Gas Transmission Limited
NLH	Newfoundland and Labrador Hydro
NRCan	Natural Resources Canada
NWMO	Nuclear Waste Management Organization
OBPS	Output-Based Pricing System
OECD	Organisation for Economic Co-operation and Development
OPG	Ontario Power Generation
PCF	Pan-Canadian Framework
PERD	Program of Energy Research and Development
PPA	power purchase agreement
PPP	purchasing power parity
PV	photovoltaic
R&D	research and development
RD&D	research, development and demonstration
RFR	Renewable Fuels Regulation
RNG	renewable natural gas
SAIDI	System average interruption duration index
SAIFI	System average interruption frequency index
SIF	Strategic Innovation Fund
SMR	small modular reactor
STAC	Science and Technology Acceleration for Cleantech
StatCan	Statistics Canada
TES	total energy supply
TFC	total final consumption
TFEC	total final energy consumption
TIER	Technology Innovation and Emissions Reduction
US	United States
US EPA	United States Environmental Protection Agency
USD	United States dollar (currency)
ZEV	zero-emission vehicle

Units of measure

bcf/d	billion cubic feet per day
bcm	billion cubic metres
CO_2	carbon dioxide
GJ	gigajoule
GW	gigawatt
GW_e	gigawatt electrical
GWh	gigawatt hour
kb/d	thousand barrels per day
kg CO_2	kilogramme of carbon dioxide
kV	kilovolt
kw	kilowatt
mb/d	million barrels per day
MJ	megajoule
Mt	million tonnes
Mtoe	million tonnes of oil equivalent
MW	megawatt
MW_e	megawatt electrical
PJ	petajoule
t CO_2-eq	tonne of carbon dioxide equivalent
toe	tonne of oil equivalent
tU	tonnes of uranium metal
TWh	terawatt hour

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Energy Policy Review

The International Energy Agency (IEA) regularly conducts in-depth peer reviews of the energy policies of its member countries. This process supports energy policy development and encourages the exchange of international best practices and experiences.

Since the last IEA review in 2015, Canada has made a series of enterprising international and domestic commitments to put the country on a path towards transforming its energy system, including a target to cut greenhouse gas emissions by 40-45% by 2030 from 2005 levels and to reach net zero emissions by 2050.

Canada's energy transformation presents both challenges and opportunities given its profile as a major producer, consumer and exporter of energy, and its highly decentralised government system. The sizeable weight of fossil fuel production in employment and economic output means strong attention should be placed on ensuring a people-centred approach to Canada's clean energy transition.

Canada has a number of policy measures in place, including an ambitious carbon pricing scheme, clean fuel regulations, a commitment to phase out unabated coal use by 2030, nuclear plant extensions, upstream methane regulations, energy efficiency programmes, and measures to decarbonise the transport sector.

In this report, the IEA provides energy policy recommendations to help Canada effectively manage the transformation of its energy sector in line with its goals.