

Country Reports

IEA Bioenergy: 10 2021



This report was prepared from the 2021 IEA World Energy Balances and Renewables Information, combined with data and information provided by the IEA Bioenergy Executive Committee and Task members¹. Reference is also made to FAOstat data as well as data from national statistics. All individual country reports were reviewed by the national delegates to the IEA Bioenergy Executive Committee, who have approved the content. General background on the approach and definitions can be found in the central introductory report for all country reports.

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HIGHLIGHTS

- Renewables make up 16% of Canada’s *total energy supply* in 2019. The renewable energy share in *final energy consumption* is 25%². Two thirds of renewable energy is from hydropower and a quarter from biomass.
- The consumption of fossil fuels – particularly natural gas – is still growing in Canada, while the amount of renewable energy has been fairly stable in the past decade.
- Hydropower is dominant in electricity production and the role of bioelectricity is marginal. Most bioenergy is used for thermal energy purposes, particularly in the forest industry.
- Canada has a high use of transport fuels per capita. Previous government initiatives have helped to grow Canada’s biofuel sector which now represents around 3% of transport energy use in Canada. Nevertheless, the use of fossil fuels for transport is still growing.
- Canada is a large country with low population density and a significant forested area. The use of bioenergy is quite small in relation to its domestic potential. A lot of progress is still possible to deploy bioenergy, particularly in connection to forest industries, as energy from municipal solid waste, and as renewable gas.

¹ While data for 2020 are starting to become available at national level, it was decided to consider trends up to 2019 for good comparability and benchmarking between the different IEA Bioenergy member countries. Care should also be taken when using 2020 data for analysing trends as these data are distorted by the COVID19 Pandemic.

² The difference between the share of renewables in supply and consumption relates to unused heat from power plants (which is counted in energy supply, but not in final consumption).

- Canada has set targets of 40-45% reduction in GHG emissions by 2030 (benchmarked against 2005) and net zero emissions by 2050. These targets are supported by numerous policies and programs related to bioenergy, including the Clean Fuel Regulations (to be implemented in 2022) and the recently announced \$1.5B Clean Fuels Fund, which will support the build-out of new domestic clean fuel production capacity, establish biomass supply chains for feedstock, and develop enabling codes and standards.

COUNTRY PROFILE

Population and land use

Canada is a large country, with a total land area of 8.97 million km² and a population of 37.4 million, which represents a very low population density of 4.2 persons per km². Boreal forests prevail throughout the country, ice is prominent in northern Arctic regions and through the Rocky Mountains, and the relatively flat Canadian Prairies in the southwest facilitate productive agriculture.

More than half of the land area is qualified as 'other land use', particularly arctic regions. The rest of the land is mostly covered with forest. Agriculture takes place on 6% of total land area.

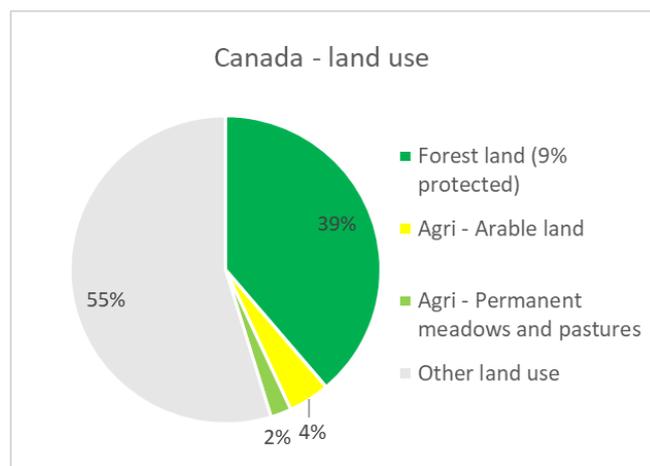


Figure 1: Land use in Canada (2018 figures - Source: FAOstat)

Final energy consumption

Overall final annual energy consumption in Canada (also including non-energy use of oil, natural gas, and coal in industry) equates to 5.5 tonnes of oil equivalent (toe) per capita, which is the highest of all IEA Bioenergy member countries.

Industry, transport, and residential/services each represent around one third of Canada's energy consumption. Energy use in transport is very high (*more than double compared to the average of IEA Bioenergy member countries*), which to some extent can be explained by the low population density and long distances travelled within the country. Residential energy use is also high compared to other countries, which is likely related to Canada's northern climate (higher domestic heating requirements). Energy use in industries is also high compared to other countries.

Table 1: Distribution of the final consumption of energy carriers by sector in Canada (2019 figures - Source: IEA (2021) World Energy Balances and Renewables Information)

| Final consumption energy carriers | Toe/capita (2019) | % of total | Median* (toe/capita) |
|-----------------------------------|-------------------|------------|----------------------|
| Industry (energy use) | 1.26 | 23% | 0.67 |
| Industry (non-energy use) | 0.52 | 10% | 0.21 |
| Transport | 1.82 | 33% | 0.69 |
| Residential | 0.95 | 17% | 0.57 |
| Commercial & public services | 0.76 | 14% | 0.34 |
| other | 0.19 | 3% | |
| Total | 5.49 | | 2.34 |

* Median of the 25 member countries of IEA Bioenergy³

NATIONAL POLICY FRAMEWORK IN CANADA

TARGETS AND STRATEGIES

In recent years, the Government of Canada has made several commitments to meet greenhouse gas (GHG) emissions reduction targets while growing the economy and building resilience to climate change. The *Pan-Canadian Framework (PCF) on Clean Growth and Climate Change* was Canada’s first-ever national climate plan and was developed jointly with provinces and territories, and in consultation with Indigenous Peoples. It was endorsed on December 9, 2016, and was 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 measures in the PCF are projected to make significant progress in helping Canada reach its target of reducing GHG emissions by 30% below 2005 levels by 2030, as committed under the 2015 Paris Agreement.

In December 2020, the federal government proposed Canada’s strengthened climate plan, *A Healthy Environment, and a Healthy Economy*, which will build a stronger, cleaner, more resilient and inclusive economy. Building on the PCF, the plan includes 64 new measures and CAD\$15B in investments. This complements Canada’s proposed *Net-Zero Emissions Accountability Act*, introduced in Parliament in November 2020, which will formalize Canada’s target to achieve net-zero emissions by the year 2050 and establish a series of interim emissions reduction targets at 5-year milestones towards that goal.

The *Hydrogen Strategy for Canada* was also announced in December 2020 to position Canada as a world-leading producer, user and exporter of clean hydrogen, and associated technologies. In a net-zero future, Canada’s economy will be powered by electricity and low carbon fuels – with low carbon fuels expected to provide up to 60% or more of our energy needs. Hydrogen is expected to play an integral role in the modernization of Canada’s energy systems towards a low-carbon economy, delivering up to 30% of Canada’s end-use energy by 2050.

Most recently, 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

³ Comparative figures of the different IEA Bioenergy member countries are discussed in the central Countries’ Report.

Agreement to 40-45% below 2005 levels by 2030. As such, Canada's current GHG reduction targets are (1) a 40-45% reduction in GHG emissions by 2030 (benchmarked against 2005) and (2) net zero emissions by 2050.

In the following sections of this report, policies and programs aimed at achieving these targets through renewable electricity, renewable heat, transport biofuels and renewable gases will be highlighted.

THE CONTRIBUTION OF BIOENERGY IN NATIONAL ENERGY SUPPLY

TOTAL ENERGY SUPPLY

The total energy supply (TES) of Canada in 2019 amounted to 12,795 petajoule (PJ) with fossil fuels (oil, coal, gas) contributing more than 75%. Natural gas (4894 PJ) represents 38%, followed by oil products at 34% (4309 PJ). Coal products have a TES share of 4.5% (580 PJ) and nuclear energy 9% (1104 PJ). Renewable energy sources represent 16% of total energy supply totalling 2067 PJ, of which 1367 PJ comes from hydropower, 566 PJ from bioenergy and 118 PJ from wind energy. The bioenergy values include energy from bio-based solids, liquids, and gases.

Since 2010, total energy supply has steadily increased by around 1.5% per year. Compared to 2010, the share of coal has decreased from 9% to 4.5%, and the share of oil slightly decreased from 37% to 34%. On the other hand, there was a substantial increase in the share of natural gas from 29% to 38% of total energy supply.

The share of renewable energy in TES has remained relatively stable over the past 20 years between 16% and 18%. Two thirds of the renewable energy supply come from hydropower, fluctuating between 1370 and 1420 PJ per year. The share of bioenergy slightly decreased in the past 5 years from 600 PJ to 560 PJ. Wind increased from 31 PJ in 2010 to 118 PJ in 2019, still much below bioenergy levels. Solar energy increased from 2 PJ in 2010 to 16 PJ in 2016 and has since stabilized.

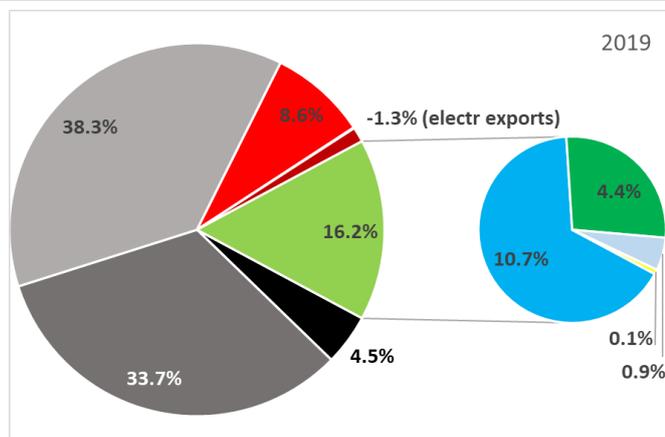
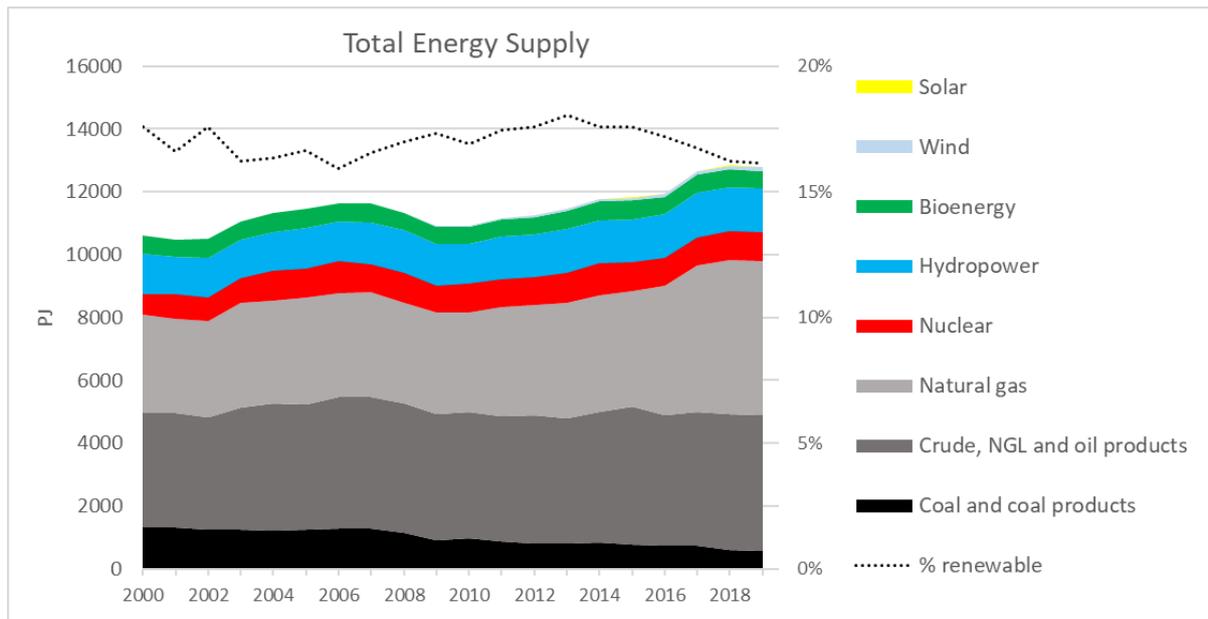


Figure 2: Total energy supply⁴ and the contribution of different energy sources in Canada, with distribution in 2019 (Source: IEA (2021) World Energy Balances and Renewables Information)

Overall bioenergy supply has fluctuated between 550 and 600 PJ in the past decades. As shown in Figure 3, solid biofuels make up the majority (80%) of bioenergy in Canada, however their share of the bioenergy mix has been slowly declining while other types of bioenergy have begun to grow. Most solid biofuels are used in industry, yet this share is steadily decreasing with the contraction of the pulp and paper sector. Canada is the second-largest exporter of wood pellets in the world representing 11.9% of total global exports in 2017. Over 90% of these pellets are exported to Europe and Asia. Spurred by a growing global pellet market, Canadian pellet producers have doubled their production capacities from 2 million tonnes in 2014 to over 4 million tonnes in 2020.

There has been a substantial increase in the supply of transport biofuels (from 7 PJ in 2007 to 93 PJ in 2019), particularly bioethanol and biodiesel. Biogas supply in Canada has not been reported since 2014, at which point it was 17 PJ. Given the recent increase in Canadian anaerobic digestion projects for both electricity production and RNG production, biogas supply in 2019 was likely greater than 17 PJ and is expected to continue to rise in the near future.

⁴ Total energy supply refers to the use of resources. In terms of the role in the energy system this distribution overestimates the role of resources producing electricity with a high share of unused waste heat (like nuclear plants).

Renewable energy from MSW has stabilized around 5 PJ.

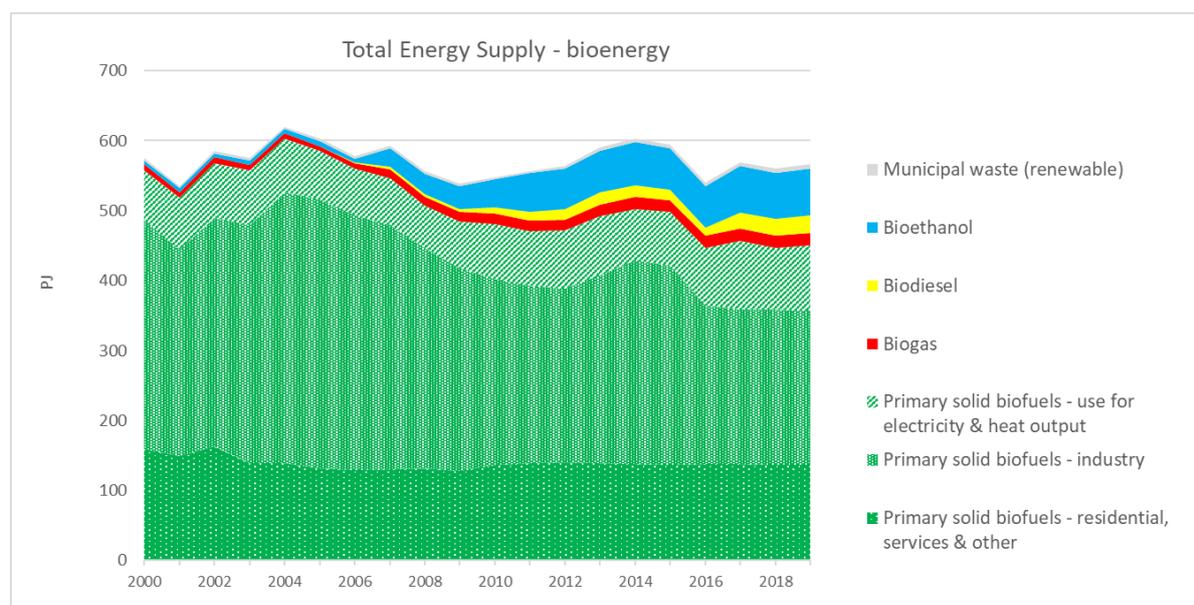


Figure 3: Development of total energy supply from bioenergy in Canada 2000 - 2019 (Source: IEA (2021) World Energy Balances and Renewables Information)

Table 2 displays the 2019 total bioenergy supply values on a per capita basis. Compared to the other 24 member countries of IEA Bioenergy (expressed per capita), Canada ranks at the higher end of solid biofuels and liquid biofuels usage, in the middle for biogas and at the low end for renewable MSW usage.

Table 2: Total energy supply per capita in 2019 for different bioenergy carriers

| | Supply per capita | Median IEA Bioenergy members |
|------------------------|-------------------|------------------------------|
| Bioenergy | 15.1 GJ/cap | 10.6 |
| Solid biofuels | 12.0 GJ/cap | 7.0 |
| Renewable MSW | 0.2 GJ/cap | 0.8 |
| Biogas | 0.5 GJ/cap | 0.7 |
| Liquid biofuels | 2.5 GJ/cap | 1.5 |

Source: IEA (2021) World Energy Balances and Renewables Information

Table 3 shows the amounts of the different bioenergy carriers compared to some relevant reference points, namely the amount of forest in the country (for solid biomass), the amount of generated MSW (for renewable MSW used for energy), the amount of natural gas consumed in the country (for biogas) and the amount of fossil oil products consumed (for liquid biofuels). While most biogas in Canada is currently converted to electricity and heat, comparing the total supply of biogas with the total supply of natural gas provides a basis for comparison across all IEA member countries.

Table 3: Comparison of the supply of different bioenergy carriers in 2019 to specific reference points

| Compared to reference points | | | Median* |
|------------------------------|------------------|--|-------------------|
| Bioenergy | 4.4 % | of total energy supply | 7.2 % |
| Solid biofuels | 1.4 GJ/ha_forest | compared to the domestic hectares of forest land (excl. protected) | 21.3 GJ/ha_forest |
| Renewable MSW | 0.24 GJ/ton_MSW | compared to the total generated MSW in the country | 1.4 GJ/ton_MSW |
| Biogas | 0.003 GJ/GJ_NG | compared to natural gas supply | 0.023 GJ/GJ_NG |
| Liquid biofuels | 0.021 GJ/GJ_oil | compared to oil products supply | 0.028 GJ/GJ_oil |

Source: energy data from IEA (2021) *World Energy Balances and Renewables Information*; forest figures from FAOStat; waste figures from World Bank

* Median of the 25 member countries of IEA Bioenergy⁵

Specific comments in relation to the reference points:

- While Canada does export solid biofuels, the use of these fuels is very low in comparison to other countries given the total area of forested land in Canada.
- Energy production from (the renewable share of) MSW is quite low. However, there remains potential to increase its share of the bioenergy mix.
- Considering the high share of natural gas in total energy supply, the share of biogas is very modest. Most biogas is currently converted to electricity and heat, with only 27 % of biogas currently being upgraded to RNG in Canada (Canadian Biogas Association 2020 Market Report). This is expected to change in the future since the number of RNG projects in Canada has seen a sharp rise in recent years.

⁵ Comparative figures of the different IEA Bioenergy member countries are discussed in the central Countries' Report.

ROLE OF BIOENERGY IN DIFFERENT SECTORS

OVERVIEW

The overall 2019 share of renewables in **final energy consumption** among electricity, transportation and heat sectors is 25%, with bioenergy making up 6% of the energy share (Table 4). The shares of renewables and bioenergy in final energy consumption are higher than their shares in Canada’s total energy supply (16% for renewables and 4% specifically for bioenergy, as discussed above) since the latter includes unused waste heat, e.g., in fossil or nuclear power production.

Table 4: Role of bioenergy and renewable energy in Canadian electricity, transport energy and fuel/heat consumption in 2019

| Sector | Share of bioenergy | Share of renewable energy | Overall consumption |
|--|--------------------|---------------------------|---------------------|
| Electricity ⁶ | 1.8% | 71.4% (63.5% hydro) | 598 TWh (2153 PJ) |
| Transport energy (final consumption) | 3.2% | 3.9% | 2847 PJ |
| Overall fuel and heat consumption ⁷ | 11.8% | 12.0% | 3059 PJ |
| TOTAL FINAL ENERGY CONSUMPTION | 6.2% | 24.9% | 8032 PJ |

Source: IEA (2021) *World Energy Balances and Renewables Information*

The following sections will consider the evolution of renewable energy, with a particular focus on bioenergy, in Canada’s electricity, transportation and heat sectors.

ELECTRICITY

Hydropower makes up around 60% of Canada’s electricity generation, followed by fossil fuels (18%) and nuclear energy (16%). Coal has traditionally made up the largest share of fossil fuel use in electricity generation; however, it is slowly being phased out across Canada.

Electricity generation from other renewable energy sources includes wind, solar and biomass-based generation. Wind-based electricity generation has seen a significant increase in deployment since 2008 and makes up 5% of the total electricity supply. Biomass-based electricity makes up 1.7% and has remained relatively stable for the last decade (*ca.* 10 TWh). Most of this electricity is from the combustion of residual woody biomass and spent pulping liquor, with biogas-generated electricity contributing < 1 TWh. There is some growth in solar energy, but at very modest levels (0.6% or 4 TWh).

⁶ Renewable electricity production compared to final consumption. Potential renewable shares of imported electricity are not included.

⁷ This includes final consumption of fuels and heat in industry, the residential sector, commercial and public services and agriculture/forestry. Transport fuels are excluded. Energy used for transformation and for own use of energy producing industries is also excluded.

Electric heating (direct or through heat pumps) is not included in these figures as this is not separately reported.

Net electricity exports, i.e., the difference between consumption and production in the Figure 4, are significant. Around 7% of generated electricity is exported to the United States.

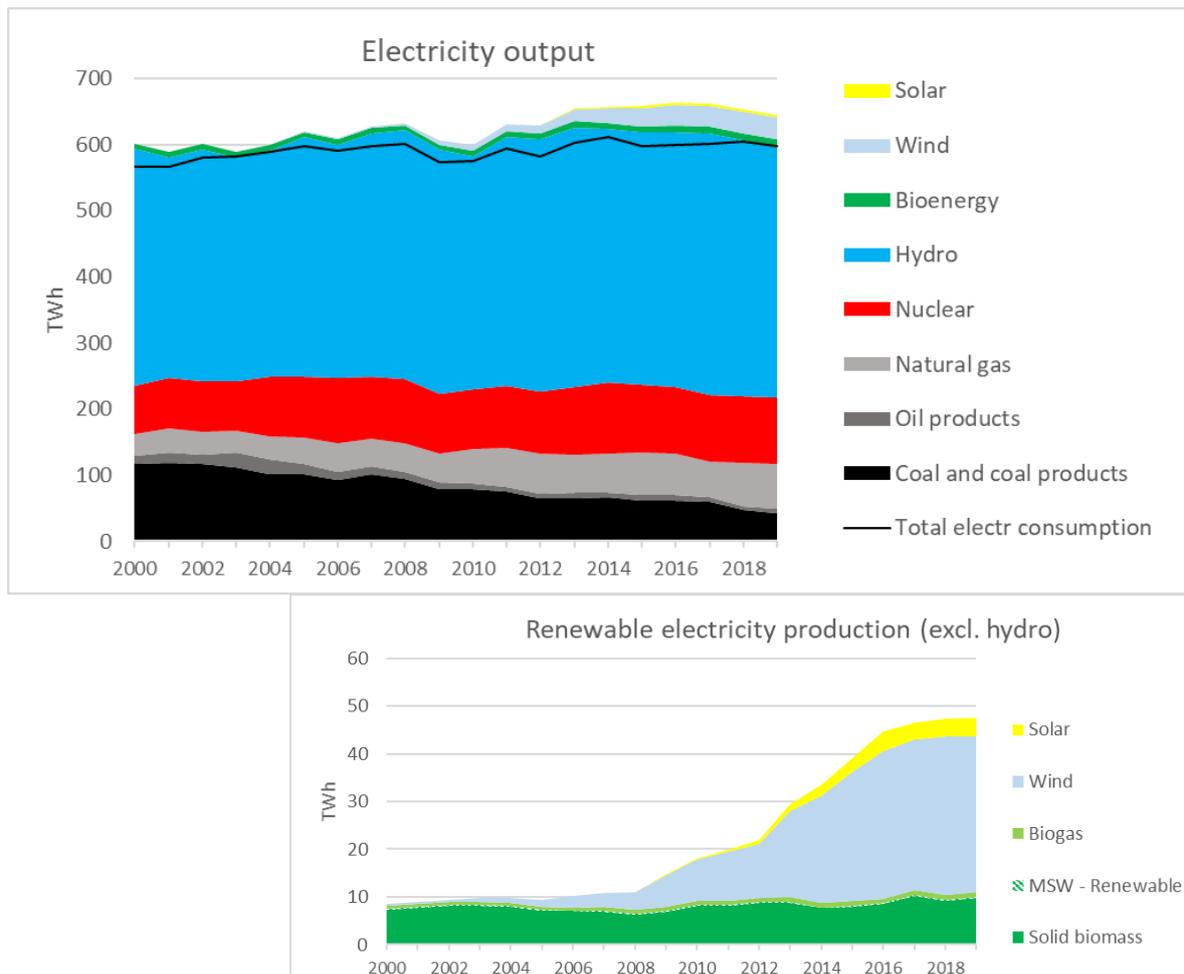


Figure 4: Evolution of the electricity mix in Canada 2000 - 2019 (Source: IEA (2021) World Energy Balances and Renewables Information)

Policy framework

Previous growth in electricity from biogas came about due to provincial renewable energy policies, in particular feed-in-tariff (FIT) programs that provided a premium for electricity generated from biogas. This resulted in the construction of anaerobic digesters in the agriculture, industrial and wastewater treatment sectors. In most provinces, these FIT programs have ended and there has been very little new development. As renewable natural gas (RNG) policies established in the provinces of British Columbia and Quebec are incentivizing the conversion of biogas to RNG (biomethane), most new developments in biogas energy are expected to produce RNG and not electricity.

Renewable energy for electricity is expected to expand over the coming years as a result of the following programs and policy instruments:

- The *Pan Canadian Framework on Clean Growth and Climate Change* was amended in 2018 to phase out conventional coal-fired electricity by 2030 and set a GHG emission limit of 420 t CO₂/GWh for coal-fired electricity units by December 31, 2029 (or end of unit life if sooner).

- The *Greenhouse Gas Pollution Pricing Act*, adopted on June 21, 2018, establishes the framework for the federal carbon pollution pricing backstop system consisting of two main parts: a regulatory charge on fossil fuels and a regulatory trading system for industry (known as the *Output-Based Pricing System* or OBPS).
 - The OBPS is designed to help fight climate change by reducing carbon pollution from electricity generation while minimizing 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. This approach works with other policies to reduce emissions from electricity generation, including the federal regulations to phase out coal across Canada by 2030.
- Canada's *Strengthened Climate Plan*, which was released in December 2020 and aims to expand Canada's clean electricity supply, continue to progress in grid modernisation, and support clean transportation.
 - CAD\$964M towards renewable energy and grid modernisation projects

HEAT/FUEL

Figure 5 shows the role of different fuels/energy carriers for providing heat in different sectors (industry, residential sector, commercial and public services and other). It also includes heat sold to customers, e.g., through district heating. Fuel use by energy producing industries for transformation and for own use is excluded. Mind that electric heating (direct or through heat pumps) is not included in these figures as this is not separately reported in the IEA database.

The provision of heat is still mostly based on fossil fuels, predominantly from natural gas. The use of natural gas for heating has increased from 1540 PJ in 2010 to 1945 PJ in 2019. Direct use of biomass for heat represents around 12% of Canada's total heat supply, however it has been steadily declining (was 17% in 2007). About two thirds of heat supplied from biomass combustion is for industrial purposes, with the other one third used for residential heat (primarily wood stoves and fireplaces).

The use of biomass for heating using modern biomass boilers in commercial and institutional buildings and community district heating clusters has increased from less than 100 MW installed capacity in 2007 to over 450 MW in 2020. Community scale biomass heat projects are increasingly being seen as an opportunity for rural, remote and Indigenous communities in Canada to gain energy sovereignty, generate local economic development opportunities and reduce reliance on diesel fuel and heating oil. Since 2010, 92 community-owned bioenergy projects have been developed across Canada, more than 70% of which were developed since 2015. Biogas energy can also be directly used for process energy, as has been done in 24 food processing facilities and 2 pulp mills.

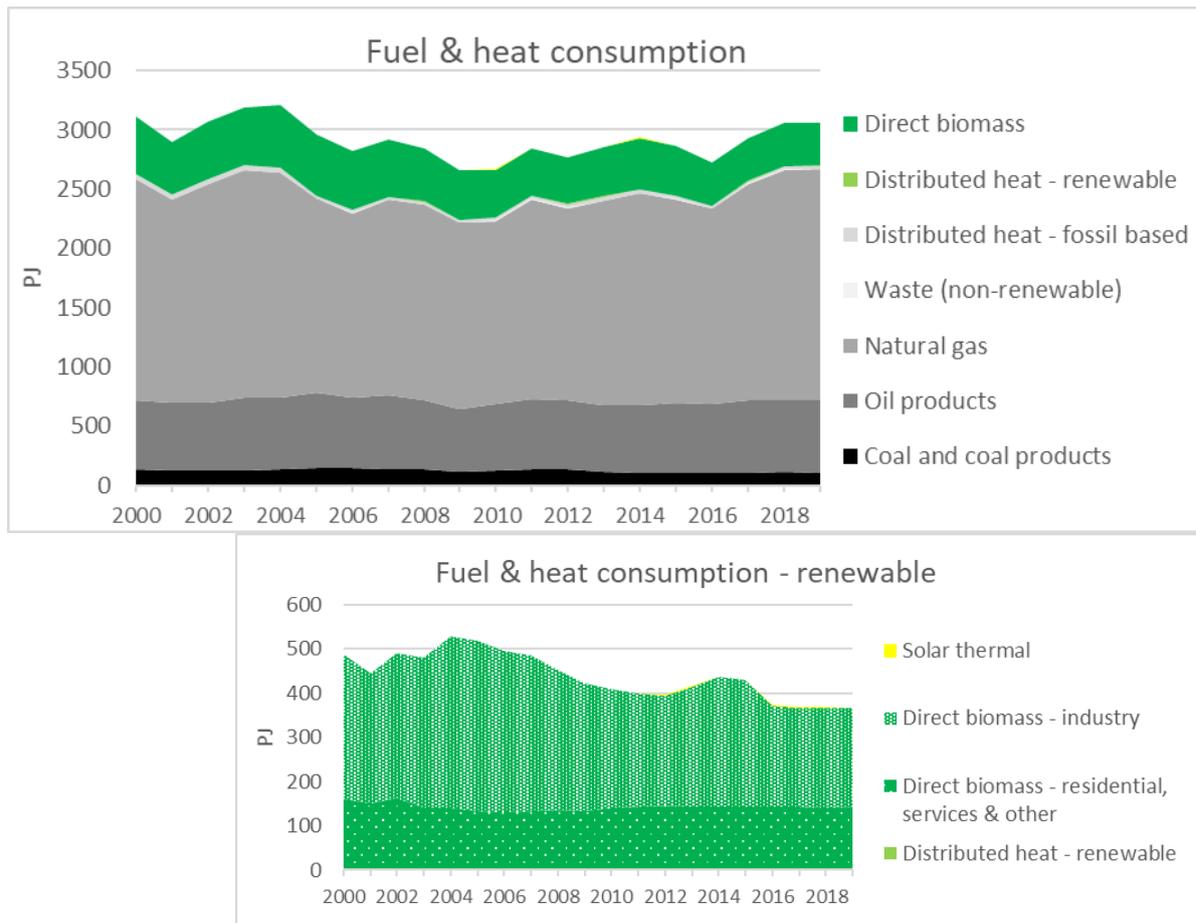


Figure 5: Evolution of fuel and heat consumption in Canada 2000 - 2019 (Source: IEA (2021) World Energy Balances and Renewables Information)

Policy framework

Past programs have delivered support to increase renewable energy capacity, including Canada’s *ecoENERGY for Renewable Power (ecoERP)* program, which ended on March 31, 2021, after running for 14 years, supporting 4458 MW of renewable energy capacity and delivering CAD\$1.4B of funding. *ecoERP* increased renewable energy capacity from sources such as wind, low-impact hydro, biomass, photovoltaic and geothermal energy.

Renewable energy for heat is expected to expand over the coming years as a result of the following programs:

- The *Clean Energy for Rural and Remote Communities (CERRC)* program, which is investing CAD\$220M until 2026 to reduce the reliance of rural, remote, and northern communities on diesel by supporting renewable energy solutions such as solar, smart grids, bioheat and district energy networks.
- Canada’s *Clean Fuels Fund*, which will invest CAD\$1.5B over five years to support the build-out of new domestic clean fuel production capacity, establish biomass supply chains, and develop enabling codes and standards. The program will support a suite of clean fuels including renewable natural gas, hydrogen, renewable diesel, and ethanol.
- The *Investments in Forest Industry Transformation* program has supported innovative projects in the Canadian forest sector since 2010 and will invest an additional CAD\$54.8M

over two years (2021-2023) to further support the development of Canada's forest-based bioeconomy, including advanced biofuels.

- The *Indigenous Forestry Initiative* will invest CAD\$15.6M over three years to provide financial support for Indigenous-led economic development projects in Canada's forest sector, which include the development of clean technology and low-carbon biofuels such as community bioheat systems and solid biofuel supply chains.
- The *Low Carbon Economy Fund* is investing CAD\$2B in projects that generate clean growth and reduce greenhouse gas emissions, helping Canada meet or exceed its commitments under the Paris Agreement.
- The Strategic Innovation Fund's *Net Zero Accelerator* will invest CAD\$8B over 5 years to rapidly expedite decarbonisation projects with large emitters, scale-up clean technology and accelerate Canada's industrial transformation across all sectors.

TRANSPORT

Figure 6 shows an overview of the energy used in transport in Canada, split up by different fuels/energy carriers. Gasoline is the dominant fuel, and its consumption is in fact still increasing. Other oil-based fuels make up 11% of transport energy and represent aviation fuel for domestic flights. Natural gas is also used as a transport fuel and makes up around 5% of transport energy.

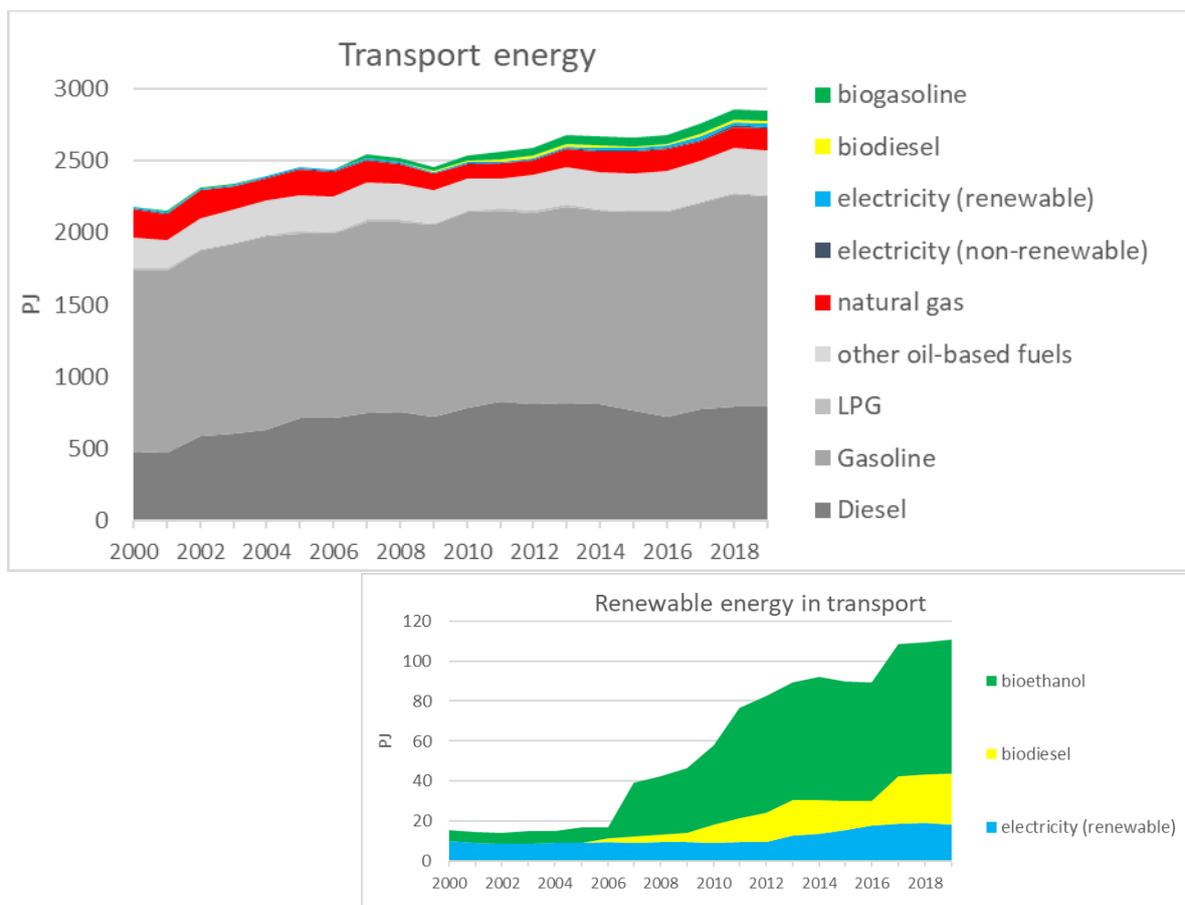


Figure 6: Evolution of transport fuel consumption in Canada 2000 - 2019 (Source: IEA (2021) World Energy Balances and Renewables Information)

Biofuels currently make up 3.2% of Canada’s transport energy use, however, there has been strong growth in both bioethanol (from 7 PJ in 2005 to 67 PJ in 2019) and biodiesel (from 5 PJ in 2009 to 26 PJ in 2019). It is worth noting that biodiesel energy values include hydrogenation-derived renewable diesel (HDRD), which is expected to become the dominant biofuel in the diesel pool in the coming years.

Electricity makes up 1.0% of Canada’s total transport energy use, with electric cars only making up 0.16% of Canada’s total energy consumption in transport. The use of electricity in road vehicles can be expected to grow in the coming years because of the recently announced zero-emission mandate (100% of car sales to be zero-emission by 2035).

Policy framework

The main relevant programs and policy instruments behind the evolution of renewable transport fuels in Canada are:

- Canada’s *Renewable Fuels Regulations*, which require fuel producers and importers to have an average renewable fuel content of at least 5% based on the volume of gasoline that they produce or import into Canada and of at least 2% based on the volume of diesel fuel and heating distillate oil that they produce or import into Canada. Many provinces have more aggressive targets (see Figure 7), for example, Ontario and Quebec require a 10% renewable content in gasoline, which will be raised to 15% in 2030 (Ontario) and 2025 (Quebec).

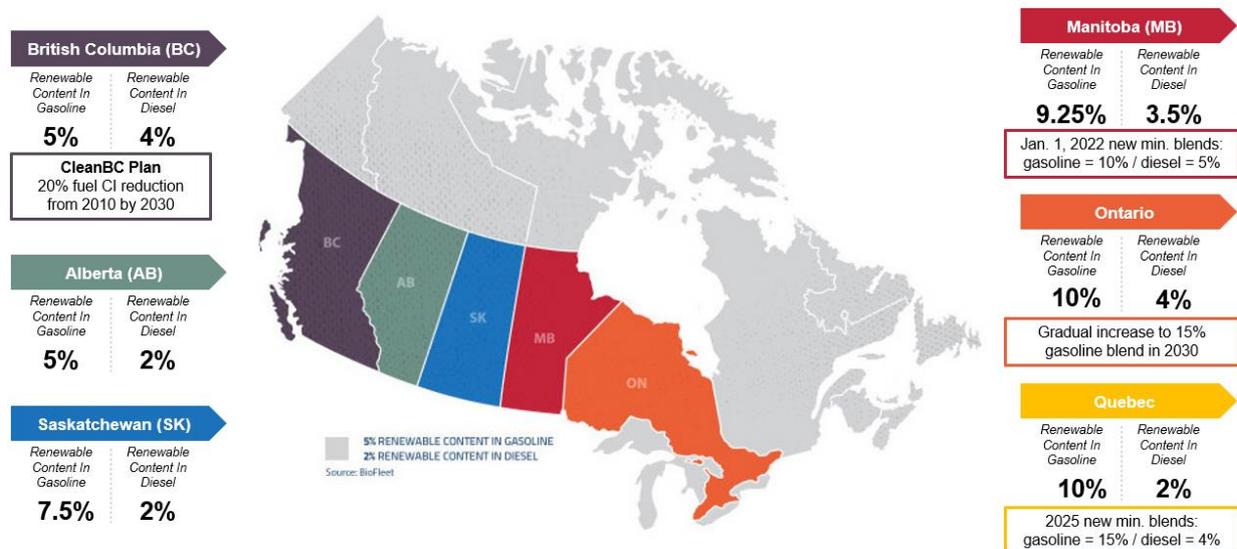


Figure 7: Renewable Fuels Regulations in Canada (Natural Resources Canada, 2021)

- The *Pan-Canadian Approach to Pricing Carbon Pollution*, which set a benchmark on carbon pricing in October 2016 that applied for any province that did not implement its own equally stringent carbon pricing system. Currently, the carbon price is CAD\$40 per tonne of CO₂e and will increase to CAD\$50 in 2022.
 - Canada’s strengthened climate plan (*A Healthy Environment and a Healthy Economy*) was proposed in 2020 and would see the carbon price further increase by CAD\$15 per year until it reaches CAD\$170 in 2030.

- Canada also has policies in place to reduce emissions for passenger cars and light trucks, whereby emissions performance must improve by 5% per year from 2017 to 2025 (except for light trucks between 2017 and 2021, which must improve by 3.5% per year)

Renewable energy for transport is expected to expand over the coming years as a result of the following programs and policies:

- The *Clean Fuel Regulations* (CFR), previously Clean Fuel Standard, draft regulations were published in December 2020. The CFR will require liquid fuel (gasoline, diesel) suppliers 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 our liquid fuels used in Canada by 2030. The CFR will introduce a credit system whereby the regulation can be met by purchasing credits or through other actions. The CFR will create economic opportunities for voluntary parties like biofuel producers and other lower carbon fuel producers to create and sell credits. In turn, this will create opportunities for feedstock providers like farmers and foresters supporting lower carbon fuel production.
 - The CFR will reduce the carbon intensity of liquid fuels by 2.4 g CO₂e/MJ in 2022 and will eventually progress to a reduction of 12 g CO₂e/MJ by 2030.
 - Credits can be created by directly reducing the carbon intensity of liquid fuels at the source (e.g., through process improvements), by supplying low carbon fuels (e.g., biodiesel), or by end-use fuel switching in vehicles.
- As previously stated, the *Clean Fuels Fund* will de-risk the capital investment required to build new or expand existing clean fuel production facilities and supports the implementation of the CFR.
- Canada's zero emission vehicle (ZEV) sales targets which stipulate that 10% of light-duty vehicle sales per year should be ZEVs by 2025 and 100% by 2035.
- The *Incentives for Zero-Emission Vehicles* (iZEV) program will provide CAD\$287M to support the adoption of ZEVs as well as CAD\$150M over three years under the *Zero Emission Vehicle Infrastructure Program* to support the build out of necessary charging and refuelling infrastructure across Canada.

RESEARCH, DEMONSTRATION, AND DEPLOYMENT FOCUS RELATED TO BIOENERGY

In 2018-19, federal energy RD&D expenditures were CAD\$678M and provincial and territorial government energy RD&D expenditures were CAD\$481M, for a combined total of CAD\$1159M. This represents an increase of CAD\$360M from 2017-18. Recent increases in federal spending align with Canada's Mission Innovation objectives. Federal energy RD&D expenditures support numerous bioenergy related research projects across Canada in universities and colleges, federal and provincial laboratories, and industry. Herein, federal programs which support research and development of bioenergy are listed; please note that this list is not exhaustive.

The Canadian Forest Service (CFS) of Natural Resources Canada has identified the emerging circular forest bioeconomy as an important contributor to Canada's transition to a net-zero economy. In 2018, *The Forest Bioeconomy Framework for Canada*, was adopted by the Canadian Council of Forest Ministers, a consortium of provincial, territorial and federal forestry Ministers, and outlines four pillars for enhanced policy coherence and collaboration across the country. The Framework is intended to support increasing the use of forest biomass for long-lived wood products, and advanced bioproducts, biochemicals and biofuels.

The CFS has a number of programs designed to support the development and growth of Canada's circular forest bioeconomy such as the *Forest Innovation Program (FIP)*, which supports research, development and technology transfer activities across Canada's forest sector, and the *Investments in Forest Industry Transformation (IFIT)* program, which provides funding to advance innovation and support capital projects by offering non-repayable contributions to stakeholders in the Canadian forestry industry to implement innovative, first-in-kind technologies in their facilities, including for the production of liquid or gaseous biofuels. IFIT also recently received an additional CAD\$54M in funding over two years to specifically support the growth of Canada's forest bioeconomy under the federal government's 2021 budget. The IFIT program also focuses on funding pilot projects to support steps towards commercialization and moving products to the market-ready stage. The *Indigenous Forestry Initiative (IFI)* program is investing CAD \$15.6M over three years to provide financial support to Indigenous-led economic development project in Canada's forest sector which includes funding for clean technology and participation in Canada's circular forest bioeconomy and has funded bioheat and biomass supply chain development projects.

The CFS also conducts research to evaluate and assess biomass availability in Canada as well as techno-economic and market research on bioenergy, bioproducts, and biochemicals to identify and assess opportunities for the Canadian circular forest bioeconomy. Also, CFS scientists are conducting research to refine on an ongoing basis estimates of biomass availability, to characterize various types of forest biomass and to identify conversion pathways best suited to the biomass available.

The Office of Energy Research and Development (OERD) of Natural Resources Canada manages a suite of programs that include support for the advancement of bioenergy. In 2019-2020, OERD invested over CAD\$500 million in 300 energy innovation and clean technology RD&D projects, with project partners tripling this impact by investing \$3 for every \$1 invested by OERD. OERD's programs include the *Program of Energy Research and Development (PERD)*, which operated until 2019 and provided funding to federal departments and agencies for internal R&D as well as collaborative Grants and Contributions to outside organizations working with federal departments or agencies to support the development of sustainable energy. The *Energy Innovation Program (EIP)* supports clean energy innovation, including renewable energy. The *Clean Growth Program (CGP)* funds clean technology research and development (R&D) and demonstration projects in Canada's energy, mining, and forestry sectors. The *Clean Energy for Rural and Remote Communities (CERRC): BioHeat, Demonstration & Deployment Program Streams* are focused on reducing the reliance of rural and remote communities on diesel fuel for heat and power. As well, the Impact Canada Initiative has launched *The Sky's the Limit Challenge* with a Green Aviation Fuels Innovation Competition and a Cross-Canada Flight Competition.

The bioenergy research conducted by the **CanmetENERGY Laboratories of Natural Resources Canada** focuses on the pretreatment and conversion of biomass to bioenergy and renewable fuels. Through collaborations with industry, academia, other government organizations, and in-house research, these national laboratories are exploring the optimization of biomass supply chain, the conversion of biomass resources (gasification, anaerobic digestion, densification, pyrolysis,

hydrothermal liquefaction, catalytic conversion, etc.), the production of renewable natural gas (RNG), hydrogen and liquid biofuels, using advanced biorefinery and co-refining processes, the generation of combined heat and power, the mitigation of equipment corrosion, and the reduction of air emissions.

The National Research Council of Canada conducts bioenergy research within the low carbon fuels pillar of the *Advanced Clean Energy (ACE)* program that seeks to enable fuel switching through the use of residual and waste biogenic feedstocks. The program has a focus on feedstock characterization, biological and thermochemical production technologies for low carbon fuels and also supports and demonstrates the efficient utilization of biofuels in various applications such as transportation and power generation.

The Natural Sciences and Engineering Research Council of Canada (NSERC) is a federal granting council which funds research and training in Canadian postsecondary institutions. The agency supports university students in their advanced studies, promotes and supports discovery research, and fosters innovation by encouraging Canadian private, public, and not-for-profit organizations to participate and invest in postsecondary research projects. NSERC has funded several large bioenergy initiatives including the *BiofuelNet Network of Centres of Excellence (2012 to 2017)*, the *NSERC Bioconversion Network (2010-2015)*, the *NSERC Biomaterials and Chemicals Strategic Network (2010-2015)* and the *NSERC Industrial Biocatalysis Network (2014-2019)*.

Agriculture and Agri-Food Canada (AAFC) manages several innovation and clean technology programs that support bioenergy projects, including the *Agricultural Clean Technology (ACT)*, *AgriInnovate*, and *AgriScience* programs. The ACT aims to create an enabling environment for the development and adoption of clean technology that will help drive the changes required to achieve a low-carbon economy and promote sustainable growth in Canada's agricultural and agri-food sector. This includes supporting the development of transformative clean technologies and the expansion of current technologies in green energy and bioeconomy research areas.

Environment and Climate Change Canada (ECCC) manages programming associated with the Pan-Canadian Framework on Clean Growth and Climate Change, including the *Climate Action Incentive Fund (CAIF)* and the *Low Carbon Economy Fund (LCEF)*. CAIF supports initiatives undertaken by small and medium-sized businesses and schools in Saskatchewan, Manitoba, New Brunswick and Ontario that reduce energy use, energy-related costs and greenhouse gas emissions. No further intakes are currently planned under CAIF, which was returning a portion of 2019-20 federal fuel charge proceeds. A new delivery approach for the return of federal fuel charge proceeds is under development. LCEF leverages investment in projects that generate clean growth and reduce greenhouse gas emissions, helping Canada meet or exceed its commitments under the Paris Agreement.

Innovation, Science, and Economic Development (ISED) manages *Canada's Regional Development Agencies (RDA)*, supports Sustainable Development Technology Canada's *Sustainable Development Technology Fund (SD Tech Fund)*, and manages the *Strategic Innovation Fund*, which will invest CAD\$8B over 5 years through its *Net Zero Accelerator* to rapidly expedite decarbonisation projects with large emitters, scale-up clean technology and accelerate Canada's industrial transformation across all sectors. *Canada's Strengthened Climate Plan* continued support to Sustainable Development Technology Canada with an additional \$750M over five years, to support startups and to scale-up companies to enable pre-commercial clean technologies to successfully demonstrate feasibility as well as to support early commercialization efforts. To support large-scale clean technology projects, Budget 2021 proposes to make up to \$1B available starting in 2021-22 (to be

delivered via ISED), to help draw in private sector investment for these projects. These resources would fuel the growth of innovative Canadian companies, create jobs for highly skilled workers, and bring important environmental and climate solutions to the world.

Global Affairs Canada's (GAC's) Trade Commissioner Service (TCS) helps Canadian businesses grow by connecting them with its funding and support programs, international opportunities, and its network of Trade Commissioners in more than 160 cities worldwide. The TCS is committed to supporting Canadian companies that have meaningful economic ties to Canada, the potential to contribute significantly to Canada's economic growth, and the capacity and commitment to internationalization. The TCS helps qualified companies to prepare for international markets, assess potential markets, find qualified contacts, and resolve business problems. The *Canadian Technology Accelerators* initiative is a global business development program that supports the international scale-up of high-growth, high-potential Canadian firms in the sectors of cleantech, life sciences and digital and information communication technology. Canadian businesses looking to expand their international footprints should apply for *CanExport* funding, which covers up to 75% of project costs and provides up to \$75,000 for a range of export development activities for exporters, innovators, associations and communities. The *Canadian International Innovation Program* fosters and supports collaborative industrial research and development projects that have a high potential for commercialization by connecting Canadian companies with foreign partners to develop, adapt, or validate technologies. Partner countries in the program are Brazil, China, India, Israel, and South Korea.

Additional programs which support research, demonstration, and deployment related to bioenergy include:

- Business Development Bank of Canada's *Cleantech Practice*
- Canada Infrastructure Bank's *Clean Power Sector*
- Export Development Canada's *Risk Management and Financing*
- *Biofuture Platform*, a government-led international effort to promote accelerated development of advanced low carbon fuels, biochemical and biomaterials
- *Global Bioenergy Partnership*, which supports biomass and biofuel deployment, particularly in developing countries where biomass use is prevalent
- *International Renewable Energy Agency (IRENA)*, an intergovernmental organisation that supports countries in their transition to a sustainable energy future, and serves as the principal platform for international cooperation, a centre of excellence, and a repository of policy, technology, resource, and financial knowledge on renewable energy.

RECENT MAJOR BIOENERGY DEVELOPMENTS

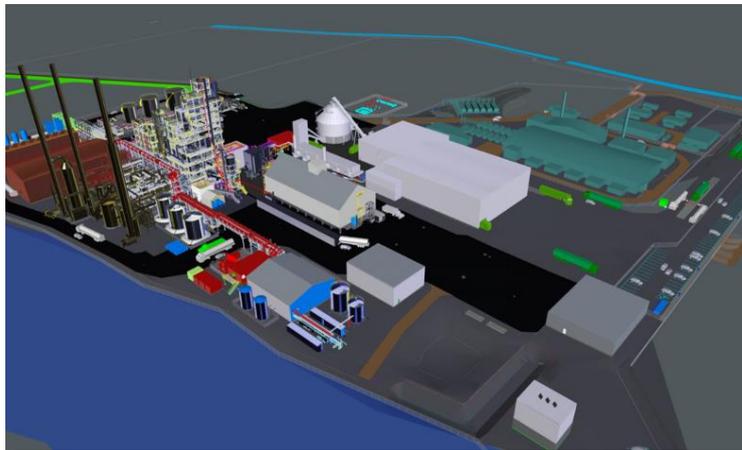
Featured projects

The **Kwadacha First Nation**, located in Fort Ware, B.C., is an off-the-grid remote community more than 570 kilometres north of Prince George. The community, with an estimated population of 380, and approximately 80 homes, has traditionally relied on costly diesel generators to provide electricity, and on trucked-in propane for heat.



Since 2017, Kwadacha FN is operating Canada's first off-grid, utility standard, biomass gasification, combined heat and power (CHP) system. The CHP plant is comprised of three linked CHP generators, each at a capacity of 45 kWe / 100 kWth. The CHP plant runs on wood chips produced locally from an abundant supply of pine beetle kill timber. It is estimated that the wood chip CHP plant replaces 20 - 25% of the diesel-based electricity and provides heat for the local school and greenhouses. In addition to supplying the community with renewable heat and electrical energy, the CHP plant has also created 5 – 6 full-time jobs in the areas of chipping and supplying biomass to operate the plant.

Enerkem, which currently operates a commercial waste-to-fuels facility in Edmonton, announced the construction of a new Varennes Carbon Recycling facility in December 2020 (schematic right). Enerkem estimates the plant will produce nearly 125 million litres/year of advanced biofuels from non-recyclable waste and wood waste. The plant will employ Enerkem's proprietary thermochemical technology to produce methanol as an intermediary product with potential applications in ground and marine transportation, power generation, and industry.



<http://biomassmagazine.com/articles/17576/enerkem-proposes-to-develop-advanced-biorefinery-in-quebec>

The facility will be built in collaboration with Shell, Suncor, Proman, and Hydro-Québec, as well as with support from the Québec and Canadian governments. The facility, which has an anticipated commissioning year of 2023, will be accompanied by a 90 MW electrolyzer to supply green hydrogen and oxygen.

Additional projects

La Coop Carbone and Coop-Energie Warwick started up a centralized digester in Warwick, Quebec in March 2021. The project takes in manure from 6 farms, waste from a local cheese manufacturer as well as municipal biosolids. The generated biogas is upgraded to 83,500 GJ of RNG (biomethane) that is injected into the gas pipeline, and the nutrients are returned to local farms as fertilizer.

<http://coopcarbone.coop/fr/activites/biomethanisation>

H2V Energies has announced a new hydrogen plant expected to begin production in 2022. This project will utilize a plasma gasification technology to convert raw residual biomass into syngas to produce 49,000 tonnes/year of hydrogen. <https://renewablesnow.com/news/h2v-energies-to-build-green-hydrogen-plant-in-quebec-opens-order-book-684374/>

Covenant Energy Ltd. and Haldor Topsoe have announced a renewable diesel and sustainable aviation fuel facility projected to begin production in Saskatchewan in 2024. The plant will produce 6,500 barrels/day of renewable diesel. <https://blog.topsoe.com/covenant-energy-chooses-haldor-topsoes-hydroflex-and-h2bridge-solution-to-produce-renewable-diesel-with-low-carbon-footprint>

Forge Hydrocarbons Corp. will produce 7.5 million gallons/year of renewable fuels in Sombra, Ontario. This facility, which expects to begin operations in 2021, will utilize a patented lipid-to-hydrogen technology to produce renewable jet fuel, diesel and naphtha fuel from waste fats and oils. <https://www.canadianbiomassmagazine.ca/forge-hydrocarbons-to-build-30m-biofuel-plant-in-ontario/>

The **Dufferin Organics Processing Facility** in Toronto, ON is set to upgrade the biogas produced from processing food waste into renewable natural gas. This project, which began construction in 2018, has an anticipated production of 3.2 million cubic metres/year of renewable natural gas.

<https://www.canadianbiomassmagazine.ca/toronto-organics-processing-facility-to-convert-food-waste-to-rng/>

Parkland Fuel Corp. is expanding the volume of canola and tallow feedstock co-processed at BC's Parkland Refining refinery in North Burnaby. The 2021 expansion will see current feedstock volumes increase from 44 million litres/year to 100 million litres/year, allowing the company to deliver low carbon fuels with up to 15% renewable content. <https://www.ogi.com/refining-processing/refining/optimization/article/14197850/parkland-fuels-burnaby-refinery-to-expand-renewables-coprocessing>

Expander Energy Inc. is looking to build a 22 million litres/year biomass/gas to liquids plant in Slave Lake, AB. The plant will produce net-zero carbon intensity fuels including diesel fuel, jet fuel, and blue hydrogen. The fuels are expected to be commercially available by 2024.

<https://www.newswire.ca/news-releases/expander-energy-to-produce-net-zero-carbon-fuels-by-2024-860261771.html>

Bioénergie La Tuque recently received funding from the government of Québec to design and develop an advanced biofuels facility which will make use of locally sourced forest residues in collaboration with the Council of the Atikamekw Nation and Neste.

<https://www.neste.com/releases-and-news/renewable-solutions/government-quebec-announces-its-support-advanced-biofuel-project-carried-out-jointly-bioenergie-la>

Greenfield Global announced an expansion to its Johnstown, Ontario facility, which will produce an additional 100M litres/year of high purity alcohols before then end of 2021.

<https://greenfield.com/news/2020/greenfield-global-announces-a-100-million-litre-high-purity-alcohol-expansion-in-ontario/>

Carbon Engineering has partnered with LanzaTech to produce sustainable aviation fuel in an air-to-jet facility based in the UK. The facility expects to produce over 100 million litres/year of sustainable aviation fuel from captured atmospheric carbon dioxide. <https://carbonengineering.com/news-updates/ce-lanzatech-jet-fuel/>

SAF+ Consortium has signed a memorandum of understanding with Airbus for the construction of a power-to-liquid pilot plant near Montreal. Production is expected to begin as early as 2021 and a commercial scale plant is planned for 2025. <https://safplusconsortium.com/blog/airbus-joins-canadas-saf-consortium-to-accelerate-the-development-of-a-new-sustainable-aviation-fuel-technology/>

Steeper Energy Canada Ltd. has signed an agreement with the city of Calgary to construct a demonstration plant at the Pine Creek Wastewater treatment plant. The demonstration plant will produce sustainable biofuels from the city's sewage sludge and waste using Steeper's proprietary Hydrofaction® technology. <https://www.renewableenergymagazine.com/biofuels/calgary-signs-mou-with-steeper-energy-canada-20200807>

Genifuel Corp. and Metro Vancouver are collaborating on a demonstration plant to produce bio-crude oil from sewage. Operation is expected to begin in 2022. <https://canada.constructconnect.com/joc/news/projects/2021/02/tender-for-worlds-first-wastewater-sludge-bio-crude-pilot-coming>

Woodland Biofuels has announced plans to build a commercial facility in Sarnia which will produce 80 million litres/year of ethanol from forestry waste and construction and demolition wood waste. <https://blackburnnews.com/sarnia/sarnia-news/2019/08/27/new-biofuels-plant-planned-sarnia/>

Surrey Biofuel facility opened in 2018 and processes 115,000 tonnes/year of organic waste to produce 120,000 GJ/year of renewable natural gas and 45,000 tonnes/year of compost. <https://www.surrey.ca/services-payments/waste-collection/surrey-biofuel-facility>

G4 Insights Inc. is building a demonstration plant to produce renewable natural gas from forestry biomass via a proprietary pyrocatalytic hydrogenation process. <https://www.ngif.ca/portfolio-item/g4-insights-inc/>

CRB Innovations announced a pilot plant project in the fall of 2020 which will convert forestry residuals into biofuels and co-bioproducts. The plant will be located in Sherbrooke, Québec. <https://www.canadianbiomassmagazine.ca/crb-innovations-receives-8-575m-to-convert-wood-waste-into-biofuels/>

LINKS TO SOURCES OF INFORMATION

Pan-Canadian Framework (PCF) on Clean Growth and Climate Change:

<https://www.canada.ca/en/services/environment/weather/climatechange/pan-canadian-framework.html>

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>

Canada Energy Facts:

<https://www.nrcan.gc.ca/science-data/data-analysis/energy-data-analysis/energy-facts/20061>

Bioenergy Research, Bioheat Survey and Biomass Standards:

<https://www.nrcan.gc.ca/our-natural-resources/energy-sources-distribution/renewable-energy/bioenergy-systems/7311>

A description of renewable energy and climate policies and measures in Canada is available at the IEA's Policies and Measures Database: <https://www.iea.org/policies?country=Canada>

Office of Energy Research and Development (OERD):

<https://www.nrcan.gc.ca/science-and-data/funding-partnerships/funding-opportunities/office-energy-research-development-oerd/5711>

Clean Fuels Fund:

<https://www.nrcan.gc.ca/climate-change/canadas-green-future/clean-fuels-fund/23734>

Clean Fuel Regulations:

<https://www.canada.ca/en/environment-climate-change/services/managing-pollution/energy-production/fuel-regulations/clean-fuel-standard.html>

Agricultural Clean Technologies:

<https://agriculture.canada.ca/en/agricultural-programs-and-services/agricultural-clean-technology-program-adoption-stream>