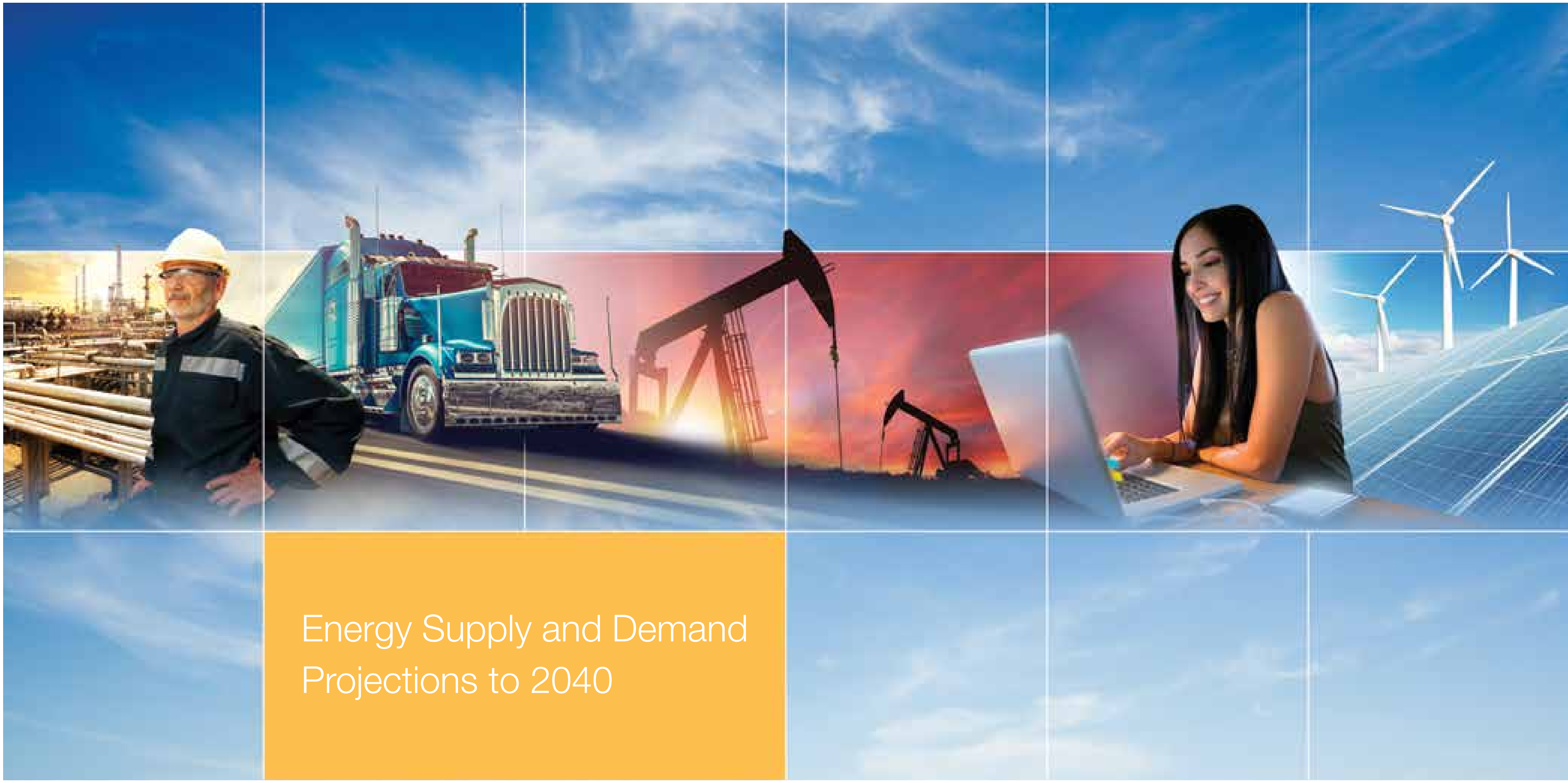
Canada Energy
Regulator

Régie de l'énergie
du Canada

Canada

Canada's Energy Future 2019



Energy Supply and Demand Projections to 2040

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Introduction

Canada's Energy Future 2019: Energy Supply and Demand Projections to 2040 (EF2019) is the first long-term energy outlook from the Canada Energy Regulator (CER). Like many activities of the CER, it builds on the 60 year history of the National Energy Board, which began releasing long term projections in 1967.

The Energy Futures series explores how possible energy futures might unfold for Canadians over the long term. Energy Futures uses economic and energy models to make these projections. They are based on assumptions about future trends in technology, energy and climate policies, energy markets, human behaviour and the structure of the economy.

EF2019 provides an update to the baseline projection in the Energy Futures series, the Reference Case. The Reference Case is based on a current economic outlook, a moderate view of energy prices and technological improvements, and climate and energy policies announced and sufficiently detailed for modeling at the time of analysis.

The "Assumptions" section outlines the specific assumptions behind the Reference Case supply and demand projections, including future oil and natural gas prices. The "Results" section provides an overview of the projections for various parts of the Canadian energy system. Finally, the "Access and Explore Energy Futures Data" section provides links on how to access data and tools to further use and explore the datasets behind the Energy Futures analysis.

Executive Summary

Energy Futures 2019
Key Findings:

1. Energy use grows slowly in the next 20 years. The mix of energy sources that Canadians use continues to change.
2. Oil and natural gas production grows steadily over the projection period. Assumptions on short-term infrastructure developments and long-term energy prices underlie this growth.
3. Technologies enabling Canada's transition to a low carbon economy make inroads across the energy system.
4. Canada is making progress in transitioning towards a low carbon future.

Overview and Background

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EF2019 provides an update to the baseline projection in the Energy Futures series, the Reference Case. The Reference Case is based on a current economic outlook, a moderate view of energy prices and technological improvements, and climate and energy policies announced and sufficiently detailed for modeling at the time of analysis. The Reference Case is based on several important assumptions and caveats. Please see the "Assumptions" section for more details.

Energy Futures continues to evolve to meet Canadians' needs

This first Energy Futures report from the Canada Energy Regulator includes an update to the baseline Reference Case projection and a new look and feel. Energy Futures data is accessible in many different platforms including interactive data tables, machine readable files on OpenGov, and as part of online learning tools. See the "Access and Explore Energy Futures Data" section to access various data sets and tools.

For the 2020 report, we will produce meaningful and useful scenario and sensitivity cases, as well as extend the projection period beyond 2040. Any comments or views on what types of analysis you would like to see in future CER Energy Futures reports can be sent to: energyfutures@cer-rec.gc.ca

Key Findings

1. Energy use grows slowly in the next 20 years. The mix of energy sources that Canadians use continues to change.

Canadian energy use grows slowly in the outlook. This is due to many factors, including improving energy efficiency. From 2018 to 2040, energy use increases by less than 5%. Over the same time, Canada's population increases over 20%. The size of economy (measured as gross domestic product) increases over 40%. This means that energy use per person and per dollar of economic activity falls (See Figure ES1).

The types of energy that meet Canadians' needs are also changing. Canadians use more natural gas and renewable energy, and less oil and coal (See Figure ES2).

Figure ES1

Energy per Person and Energy per $ GDP

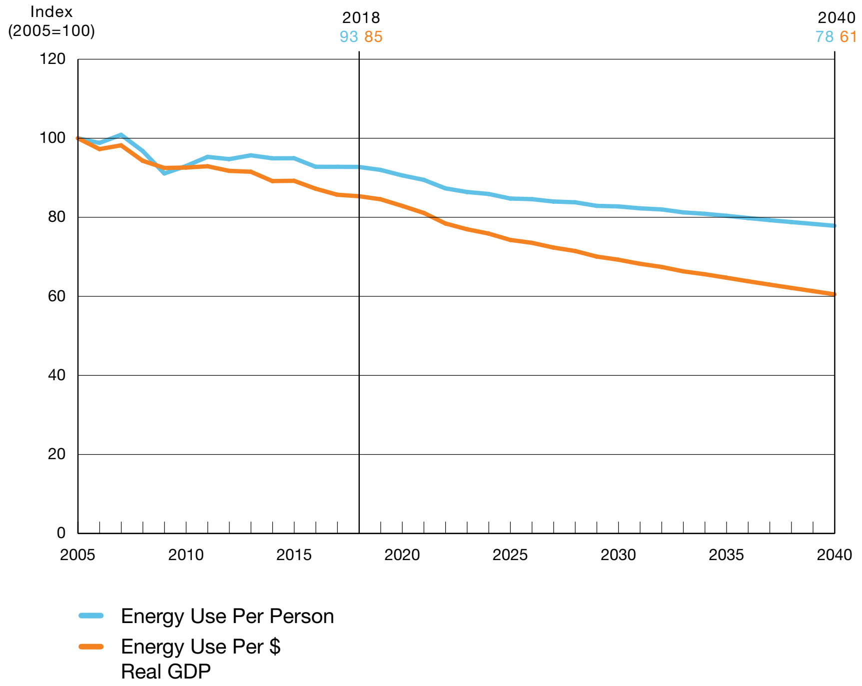
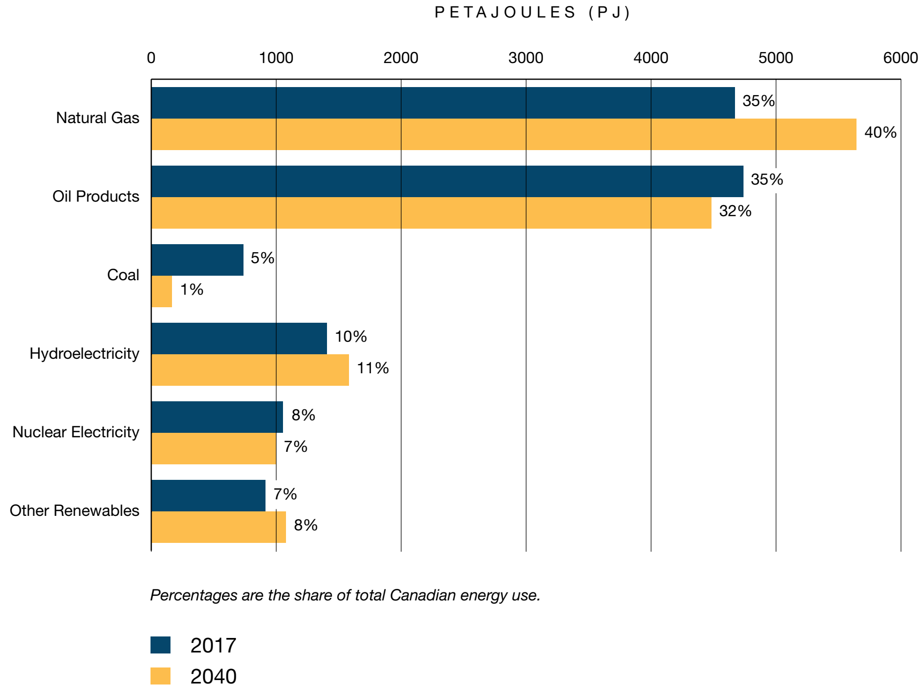


Figure ES2

Total Primary Energy Use in Canada by Fuel Type, 2017 vs 2040



Percentages are the share of total Canadian energy use.

2. Oil and natural gas production grows steadily over the projection period. Assumptions on short-term infrastructure developments and long-term energy prices underlie this growth.

Production of crude oil and natural gas increases in the outlook period. From 2018 to 2040, crude oil production grows by nearly 50%, to around seven million barrels per day (See Figure ES3). Natural gas increases by over 30%, to over 20 billion cubic feet per day (See Figure ES4). Almost all of this growth comes from sources that were a small portion of production just a decade ago. In situ oil sands production leads crude oil growth. Natural gas production is led by growth from tight and shale resources.

Figure ES3

Crude Oil Production by Type

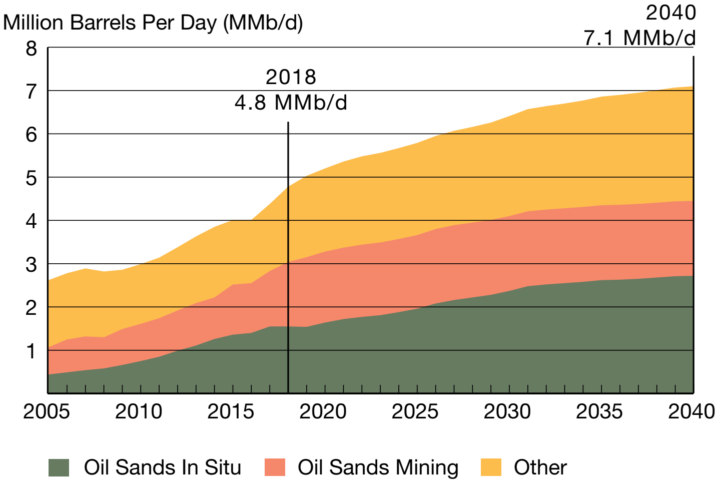
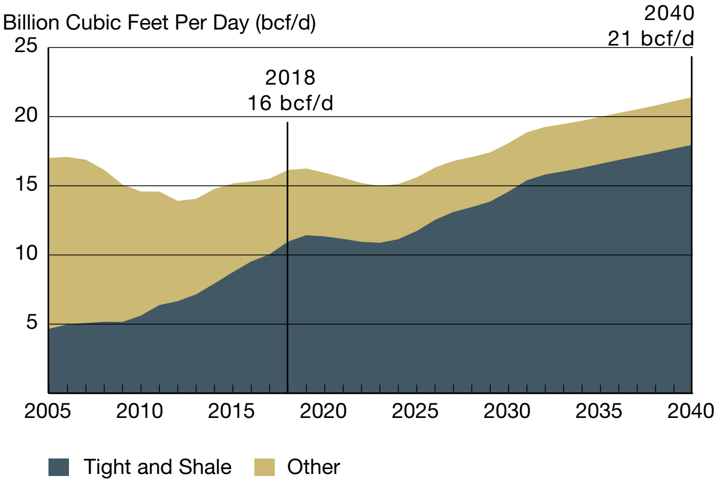


Figure ES4

Natural Gas Production by Type



Projections are based on underlying assumptions about the future. These include:

Infrastructure developments: In the short term, EF2019 assumes that major pipeline projects proceed in line with announced in-service dates. This reduces constraints on take away capacity for both oil and natural gas. As a result, Canadian benchmark prices for crude oil (such as Western Canadian Select (WCS)) and natural gas (such as Nova Inventory Transfer (NIT)) improve relative to international prices.

Liquefied natural gas (LNG) exports: Potential for LNG exports is an important driver of natural gas production. EF2019 includes growing levels of LNG export volumes from British Columbia (B.C.) over the projection period. Large scale LNG exports begin in 2024, rising to 3.7 billion cubic feet per day (Bcf/d) by 2040.

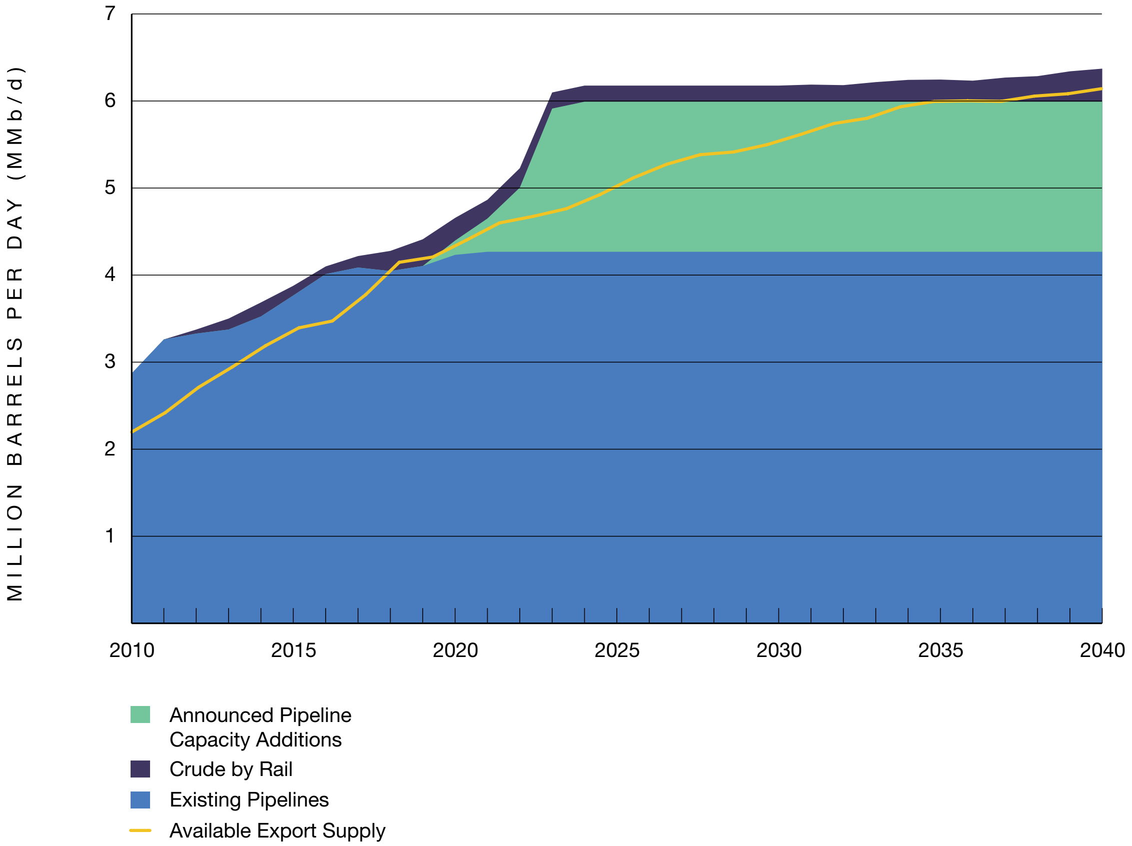
Policy: Alberta's crude oil production curtailment policy is scheduled to continue through 2020. Based on the infrastructure assumptions, in EF2019 the policy does not continue beyond what is currently planned.

Long-term increasing prices: For crude oil, global oil prices increase to 2018 US$75 per barrel (US$/bbl) in the long term. North American natural gas prices increase steadily to 2018 US$4.00 per million British thermal units (US$/MMBtu). These price assumptions are based on consensus views from other agencies, as well as CER analysis. Many factors could influence future price trends. These include use of new technologies, and the impact of climate change policies around the world on long-term oil and natural gas demand.

A key issue in Canada's energy system is the availability of crude oil export pipeline and rail capacity. This has implications for Canadian oil pricing and production trends. The EF2019 projections suggest that if announced pipeline projects proceed as planned[1], along with continued volumes of crude by rail, there would be adequate takeaway capacity to accommodate production growth over the next 20 years (See Figure ES5).

Figure ES5

Current and Announced Crude Oil Export Pipeline Capacity vs. Projected Crude Oil Supply Available For Export



3. Technologies enabling Canada's transition to a low carbon economy make inroads across the energy system.

New technologies are a key factor behind slow growth in energy use and the rising share of renewable energy. In recent years, costs for wind and solar power have fallen. In 2005, wind and solar made up 0.2% of Canada's total generation. Combined they now make up 5%, and that share grows to nearly 10% by 2040 (See Figure ES6). Over the outlook period, installed capacity of wind nearly doubles, while solar more than doubles (See Figure ES7). This depends on many factors, including costs of wind and solar power continuing to fall. EF2019 assumes that the cost of wind power falls by 20% and solar by 40% from 2018 to 2040.

Increasing use of renewables makes Canada's energy mix even more diverse. The wind and solar additions also help increase the already high share of non-emitting electricity generation. By 2040, the share of renewable and nuclear generation increases to 83% from 81%.

Figure ES6

Electricity Generation by Fuel

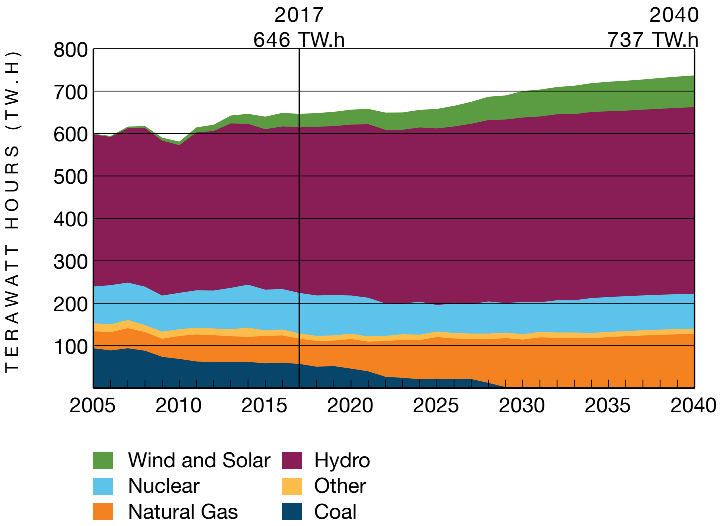
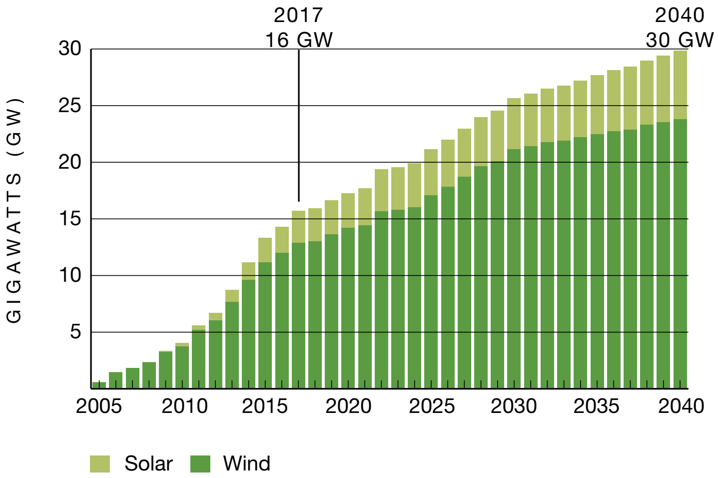


Figure ES7

Installed Capacity of Wind and Solar



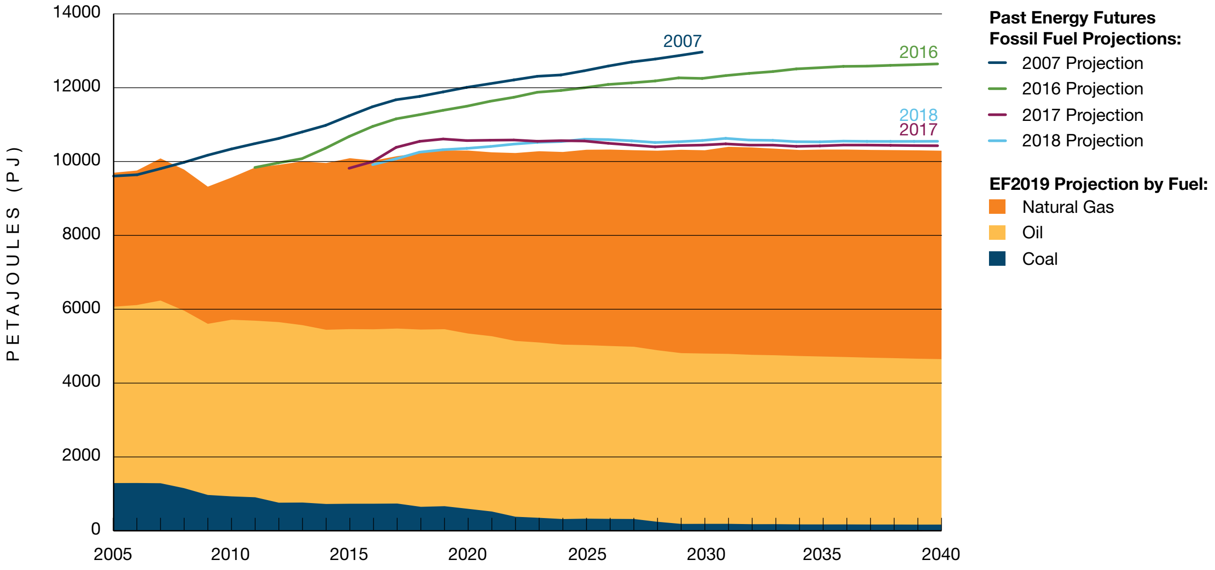
4. Canada is making progress in transitioning towards a low carbon future.

EF2019 includes programs and policies currently in place. These programs and policies have influenced Canada's fossil fuel use trajectory. Comparing fossil fuel use levels in past Energy Futures projections shows this change in trend (See Figure ES8). Those projections saw significant growth in fossil fuel demand under the Reference Case assumptions. In the EF2019 Reference Case, fossil fuel demand growth is limited. It is also led by natural gas, which has the lowest GHG emission intensity. Coal use, which has higher GHG emissions, declines over the outlook period.

In order to meet Canada's climate commitments[2], policy measures are being developed beyond those included in the Reference Case. This includes those planned as part of the Pan-Canadian Framework on Clean Growth and Climate Change, and various emerging provincial and territorial initiatives. As new and in-development measures become law, they will impact trends in Canada's energy system and future Reference Case projections.

Figure ES8

EF2019 Fossil Fuel Use Projections by Fuel
vs. Total Fossil Fuel Use Projections from Past Energy Futures Reports



Assumptions

EF2019 includes an update to the Reference Case projection. The Reference Case is based on a current economic outlook, a moderate view of energy prices and technological improvements, and climate and energy policies announced and sufficiently detailed for modeling at the time of analysis.

The outlook makes a variety of assumptions about future trends that are necessary to make long-term projections. These are factors such as included climate policies and regulations, rate of technological change, crude oil and natural gas markets (both domestic and global), infrastructure, major electricity projects and future costs of new generation capacity. Additional detail on the specific assumptions is below.

General Reference Case Assumptions

Infrastructure and markets: In the short term, infrastructure assumptions are based on existing pipeline projects and announced completion dates. This analysis should not be taken as an endorsement of, or prediction about, any particular project. Rather, these assumptions are necessary for the analysis. After 2025, infrastructure is assumed to be in place to move energy production and markets are found.

Energy Prices: These price assumptions are based on consensus views from other forecasting agencies, as well as CER analysis. Many factors could influence future price trends. These include development of new technologies, and the impact of international climate change policies on long-term global oil and natural gas demand.

Goals and targets: Unless provided with a definitive policy or regulatory framework for achieving them, climate and other related goals and targets are not explicitly modelled.

Policies: Climate and other related goals and targets are not explicitly modelled. Rather, policies currently in place are included in the Reference Case. Climate and other relevant policies with sufficient detail to model or make assumptions on are also included. This includes various simplifying assumptions to reflect carbon pricing systems.

Technological change: The Reference Case assumes moderate improvement in technology. This includes efficiency and cost reductions of renewables in line with current trends.

EF2019 is a baseline for discussion

It is important to note that the projections presented in EF2019 are a baseline for discussing Canada's energy future today and do not represent the CER's predictions of what will take place in the future. EF2019 projections are based on assumptions which allow for analysis of possible outcomes. **Any assumptions made about current or future energy infrastructure or market developments are theoretical and have no bearing on any regulatory proceeding that is, or will be, before the CER.**

Over the projection period, it is likely that developments beyond normal expectations, such as geopolitical events or technological breakthroughs, will occur. Also, new information will become available and trends, policies, and technologies will continue to evolve. This report should not be taken as an official or definitive impact analysis of any specific policy initiative, nor does it aim to show how specific goals, such as Canada's climate targets, will be achieved.

Climate Policy

EF2019 includes many recently announced and implemented climate policies. In order to determine whether a policy was included in the analysis, the following criteria were applied:

- The policy was publically announced prior to 1 August 2019.
- Sufficient details exist to model the policy.[3]
- Goals and targets, including Canada's international climate targets, are not explicitly modelled. Rather, policies that are announced, and in place, to address those targets are included in the modelling and analysis.

Climate policy continues to evolve. Various policies, regulations and standards are being developed by all levels of government. Several policy initiatives that are intended to support Canada's transition to a low carbon economy are still under development and not included in the EF2019 projections. These include the Clean Fuel Standard[4], net zero building codes, and other future federal, provincial, and territorial measures. ECCC provides information on planned policies and how they impact future emissions projections.

Key policies and regulations included in the EF2019 projections:

Carbon pricing: EF2019 includes provincial and territorial carbon pricing systems, as well as the Federal Carbon Pricing Backstop (Backstop). Implementation of carbon pricing systems currently vary across the country, and details on each region's approach are available from Environment and Climate Change Canada. For provinces that have not declared their own carbon pricing system, or have priced carbon at a level below the Backstop schedule, the Backstop schedule is used. For these regions, the carbon price reaches $50 per tonne in 2022 and stays at that level for the remainder of the outlook. For provinces such as Quebec and Nova Scotia that have adopted a cap-and-trade program, the price of carbon is market-based, determined by the supply and demand of emission permits. Like crude oil and natural gas prices, EF2019 makes simplifying assumptions for the future outlook of carbon pricing. EF2019 assumes the carbon price in these provinces remains below the Federal Backstop in the early 2020s, before converging to $50 per tonne in 2025 and remaining at the level for the remainder of the outlook.

Coal-phase out: As per Federal regulations, coal is phased out of electricity generation by 2030. Remaining capacity is due to assumed equivalency agreements in certain provinces, or units equipped with carbon capture and storage (CCS).

Efficiency regulations: A variety of policies and regulations influence energy efficiency. Key regulations include current transportation vehicle emission standards for passenger vehicles and heavy duty freight vehicles, appliance standards, and building codes.

Support for electric vehicles: Many provinces have policies and initiatives to support low and zero emission vehicles (ZEV). This includes Quebec's ZEV mandate, as well as B.C.'s Zero-Emission Vehicles Act. Federal action includes subsidies for electric vehicles, as well as support for charging infrastructure through the zero emission vehicle infrastructure program.

Support for renewable energy: Several provinces and territories provide support for renewable energy in various ways. This includes broad energy strategies and targeted renewable energy goals carried out by utilities. This has also been a dynamic area in the last couple of years. EF2019 incorporates the recent cancellation of the Renewable Electricity Program (REP) program in Alberta, as well as renewable contract terminations in Ontario.

Technology

Technological changes can have large impacts on energy systems. Over the past decade, technological advancements have unlocked fossil fuel resources, dramatically reduced the cost of wind and solar power, and led to improvements in efficiency of energy use and production.

The EF2019 projections assume moderate technological progress, including incremental efficiency improvements and cost reductions for well-established technologies. However, there is a high degree of potential for further technological progress across the energy system. This includes improving performance and economics of all types of energy production, and development of new technologies to support the transition to a low carbon economy. Which emerging technologies will achieve widespread use is difficult to predict. Likewise, the nature of future breakthroughs is unknown. The adoption rate of emerging technologies is a key uncertainty to the projections in EF2019.

KEY TECHNOLOGY DEVELOPMENTS

- Falling costs of renewable energy.
- Improved productivity of oil and gas resource extraction.
- Falling costs of battery electric vehicles and battery storage.
- End-use efficiency improvements such as improving fuel economy in vehicles and efficiency of heating technologies.
- Growth in alternative fuels such as renewable natural gas and hydrogen.

Crude Oil and Natural Gas Markets and Infrastructure

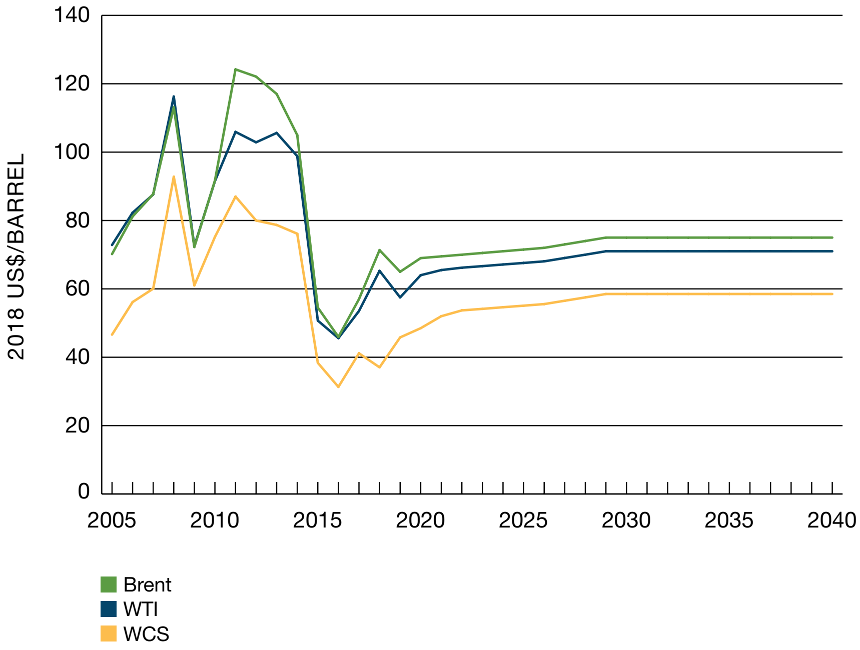
Canada is a major crude oil and natural gas producer and prices are an important driver of future production growth. International crude oil and natural gas prices are a key driver of the Canadian energy system and are determined by supply and demand factors beyond Canada's borders.

Recently, Canadian crude oil and natural gas benchmark prices (such as WCS for heavy crude oil and NIT for natural gas) have been influenced by transportation constraints. These constraints are a result of production growth that has outpaced the growth in pipeline capacity. This has led to Canadian benchmark prices facing higher than normal differentials to global benchmarks. In addition to planned pipeline projects currently underway, wider Canadian benchmark differentials have led to provincial policy responses. This includes Alberta's crude oil production curtailment, which began in 2019 and has recently been extended through 2020.

Figure 1 shows the EF2019 crude oil assumptions for Brent, West Texas Intermediate (WTI), and WCS. Brent and WTI gradually increase over the projection period, as the global market is expected to increasingly require higher cost resources to meet demand. Growth in prices is gradual due to a robust supply of low cost tight oil putting downward pressure on prices, largely a result of rapid development in the Permian Basin located in the southern United States (U.S.). In the longer term, the Brent price assumption of around 2018 US$75/bbl reflects a level that should adequately balance supply and demand given the baseline Reference Case assumptions of current policy action and moderate technological progress.

Figure 1

Crude oil price assumptions to 2040



EF2019 assumes that Canadian heavy benchmark price is discounted to WTI at a level that is consistent with the historical average. In the near term, this is driven by Alberta's curtailment policy, the impact of the International Maritime Organization's (IMO) 2020 standards[5], and upward pressure on heavy oil prices due to recent outages in Venezuela and U.S. sanctions on Iran. EF2019 assumes that adequate pipeline capacity will become available in western Canada in the early 2020s, based on announced online dates for Enbridge's Line 3, the TransMountain Expansion (TMX), and Keystone XL projects. The detail for these projects are listed in Table 1 below. The WTI-WCS differential is 2018 US$12.50 for most of the projection.

Table 1: **Assumed announced crude oil capacity additions**

	Enbridge Line 3	**Keystone XL**	**TransMountain Expansion**
Announced in-service date	2020	2022	2023
Expected date at full capacity	2021	2023	2024
Full capacity (Mb/d)	382	813	528

As discussed in the crude oil results section, additional export capacity could be required as 2040 approaches. Although EF2019 assumes a constant WTI-WCS differential in the latter years of the projection, this additional requirement could put pressure on the differential for reasons discussed in that section.

Factors Currently Affecting Oil Markets

- Global crude oil supply and demand.
- Incremental pipeline and rail capacity in western Canada.
- Government regulations.
- IMO's 0.5% sulphur content regulation.

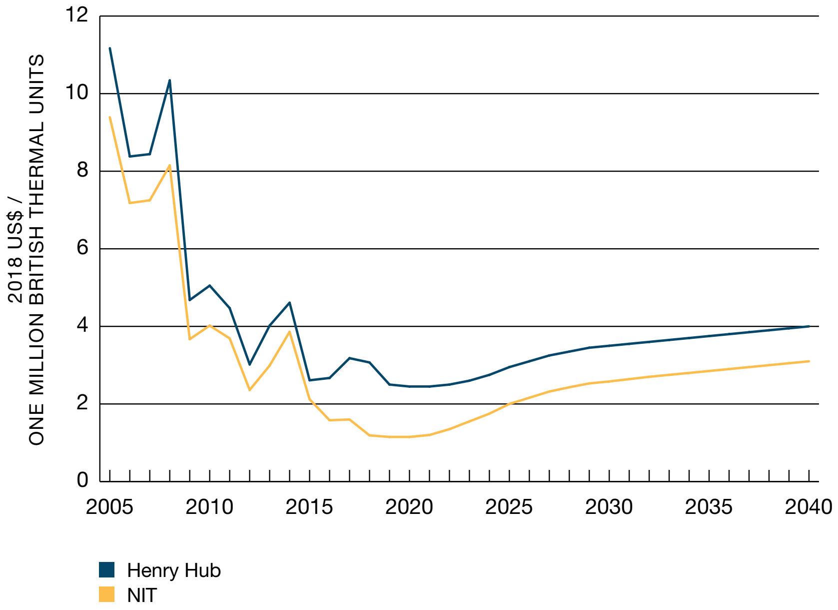
Factors Currently Affecting Natural Gas Markets

- Increased North American production.
- U.S. LNG exports.
- WCSB and export pipeline capacity.
- Oil sands demand for natural gas and condensate.
- Potential Canadian LNG and liquefied petroleum gas (LPG) exports.

Figure 2 shows the EF2019 natural gas price assumptions. Henry Hub, the North American benchmark price, declines in the near term, as the market continues to be in a state of over supply that has kept prices low in recent years. A rising long-term price is based on the assumption that demand for North American natural gas–for both domestic use and LNG exports–will bring demand and supply growth into balance. The long-term price assumption gradually rising to 2018 US$4/MMBtu reflects the large gas resources that can be produced around that level across North America.

Figure 2

Natural gas price assumptions to 2040

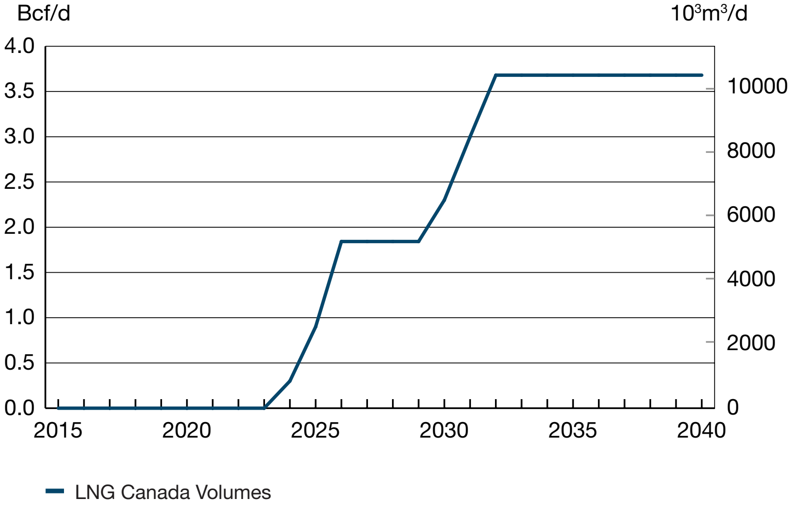


EF2019 assumes the current wide differentials for Canadian natural gas, measured by the difference between Henry Hub and NIT, continues in the short term. This differential narrows as price signals put downward pressure on production, and capacity constraints are reduced, including potential expansions to the NOVA Gas Transmission (NGTL) system. Over the long term, the Henry Hub-NIT differential remains around 2018 US$0.90/MMBtu as the large resource of low cost natural gas in the Western Canada Sedimentary Basin (WCSB) continues to put downward pressure on prices over the projection.

EF2019 assumes LNG export volumes as shown in Figure 3. These volumes are consistent with the LNG Canada project, which announced a positive final investment decision in October 2018. Other LNG projects have been proposed for Canada, and could be included in future EF reports if more concrete plans develop.

Figure 3

Canadian LNG export volume assumptions to 2040



Electricity

EF2019 analysis reflects current utility and system operator expectations of future electricity developments in their respective regions, especially for major planned projects. It is also based on assumptions of the cost to add new electricity generating capacity in the future. Table 2 shows assumptions for natural gas, solar, and wind costs, including their capacity factors. The timing and magnitude of other forms of generation added over the projection period (such as hydroelectric and nuclear refurbishments) are based on current schedules and plans from utilities, companies, and system operators.

Table 2: **Electricity cost assumptions for natural gas, wind, and solar to 2040**

Real, US$	**Capital Cost (2018US$/kilowatt(kW))**	**Fixed Operating and Maintenance Costs (2018US$/kW)**	**Variable Operating and Maintenance Costs (2018US$/megawatt hour(MW.h))**	**Capacity Factor (%)[6]**
Gas (Combined Cycle)	1,100-1,450	16	4	70
Gas Peaking	800-1,100	14	4	20
Wind (2020)	1 284	20-45	0	35-50
Wind (2030)	1 133	20-45	0	35-50
Wind (2040)	1 000	20-45	0	35-50
Solar (2020)	1 312	16-20	0	10-20
Solar (2030)	1 000	16-20	0	10-20
Solar (2040)	800	16-20	0	10-20

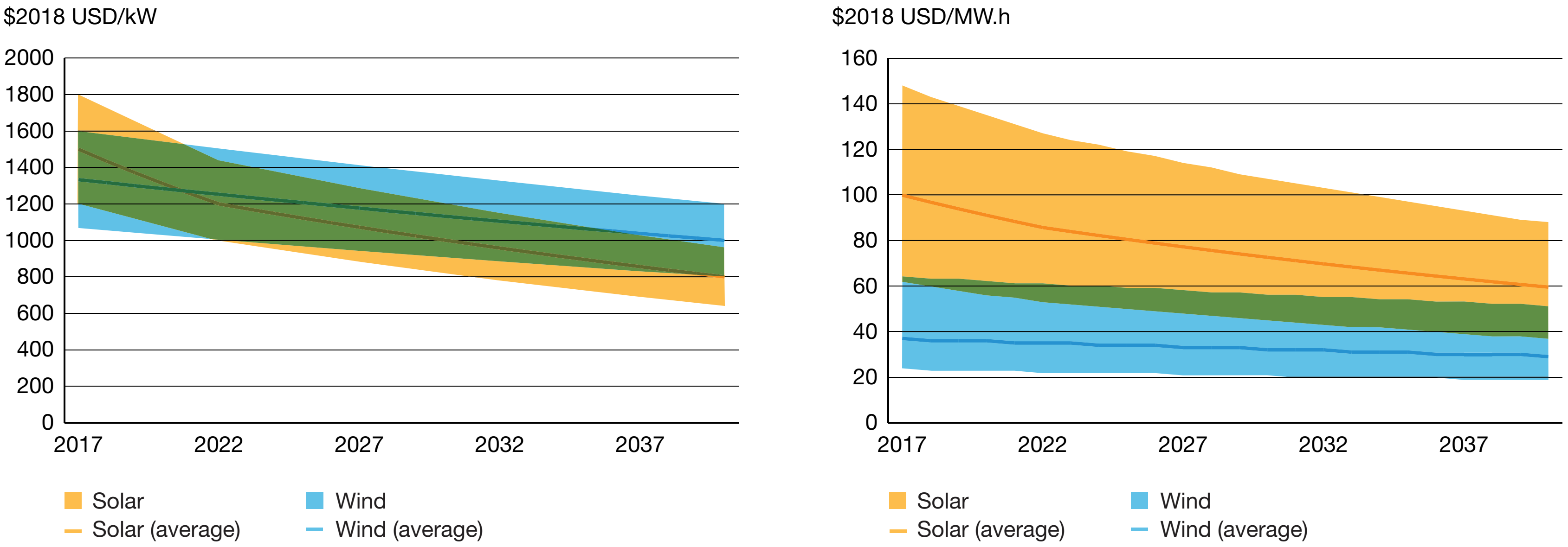
Factors Currently Affecting Electricity Markets

- Moderate electricity demand growth in Canada and U.S.
- Electricity pricing in export markets.
- Federal and regional climate policies such as coal retirement and carbon pricing systems.
- Decline in cost for non-hydro renewables, particularly for solar and wind technologies.
- Aging infrastructure and reliance on diesel in remote communities.

Figure 4 shows additional detail on average wind and solar capital costs, as well as average levelized costs. The levelized cost includes all project costs over its lifetime (operating, fuel, financing, capital costs etc.) along with assumptions about capacity factor and project life. The ranges around the wind and solar figures highlight the variability and importance of these other factors in determining the ultimate cost of the resources.

Figure 4

Wind and solar capital costs and levelized cost[7] assumptions to 2040



Results

This section presents results of the EF2019 Reference Case projection. This projection should not be viewed as a prediction, but as a possible future based on the assumptions described in the Assumptions section. It is important to note that although these figures only show the results from one projection, there are many factors and uncertainties that will influence future trends. Key uncertainties are included for each section.

For a description of the various ways to access the data supporting this discussion, see the Access and Explore Energy Futures Data section later in the report.

Macroeconomics

The economy is a key driver of the energy system. Economic growth, industrial output, inflation, exchange rates, and population growth all influence energy supply and demand trends.

Key economic variables are shown in Table 3[8]. Economic growth averages about 1.7% per year over the projection period in the Reference Case. Economic growth over the projection is generally slower than the 1990-2017 historical period for a variety of reasons, including an aging population and slower global economic growth.

Table 3: **Historical economic indicators compared to the outlook**

Economic Indicator	1990-2017	Reference Case 2018-2040
Real Gross Domestic Product	2.7%	1.7%
Population	1.0%	0.9%
Inflation	1.7%	2.05%
Exchange Rate (average)	$0.81	$0.78
Residential Floor space	2.0%	1.2%
Commercial Floor space	1.8%	1.9%

KEY UNCERTAINTIES:
Macroeconomics

International demand for Canadian goods: International demand for Canadian goods impacts export-oriented industries. Faster or slower economic growth in the U.S., Canada's largest trading partner, would affect the economic and energy demand projections.

Global economic growth: Global economic growth affects many factors that are important for Canada's economy, including commodity prices, and demand for Canadian energy and non-energy exports.

Large infrastructure projects: Projects in the mining, oil, natural gas, and electricity sectors affect the macroeconomic projections in a number of provinces. The pace of these developments is uncertain and could lead to higher or lower economic growth, and impact energy trends.

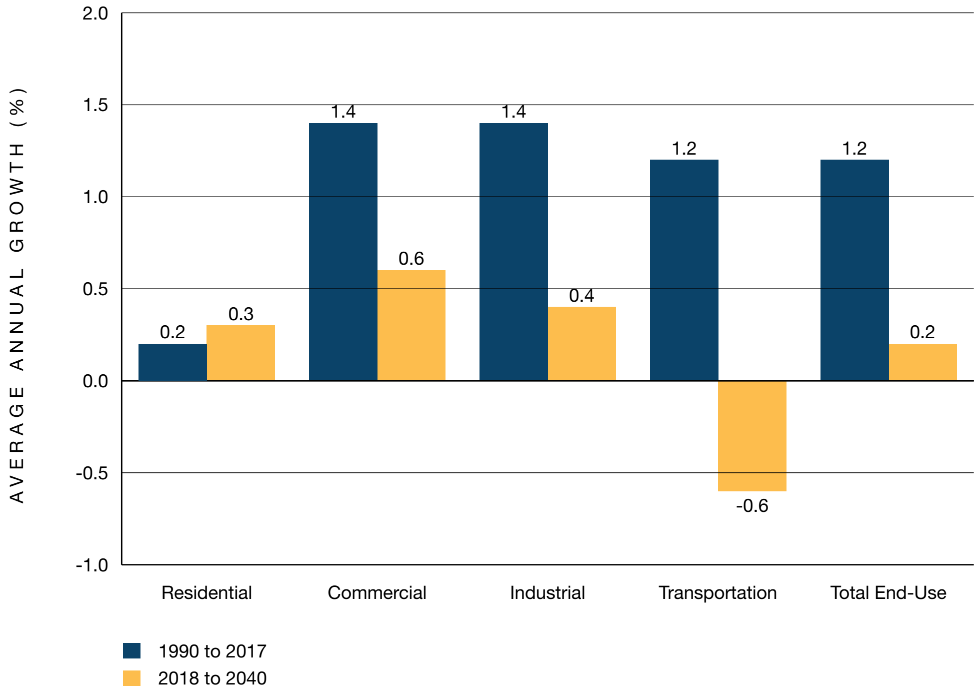
Energy Demand

This section focuses mainly on end-use, or secondary energy demand, by sector of the economy. End-use demand includes electricity, while the fuel used in generating electricity is accounted for in primary demand. Historical data is sourced primarily from Statistics Canada's Report on Energy Supply and Demand in Canada. That data is supplemented with additional details from ECCC, Natural Resources Canada, and various provincial data sources.

Overall, EF2019 projects Canadian end-use energy demand to grow moderately from now until 2040. Figure 5 breaks this down by sector, showing moderate growth in residential, commercial, and industrial demand, and a decline in transportation demand. Projected growth is slower than historical. This is due to a variety of factors, including slower economic growth, improved energy efficiency, and various policies and programs such as transportation emission standards and carbon pricing.

Figure 5

Total end-use demand grows slower in the projection than history



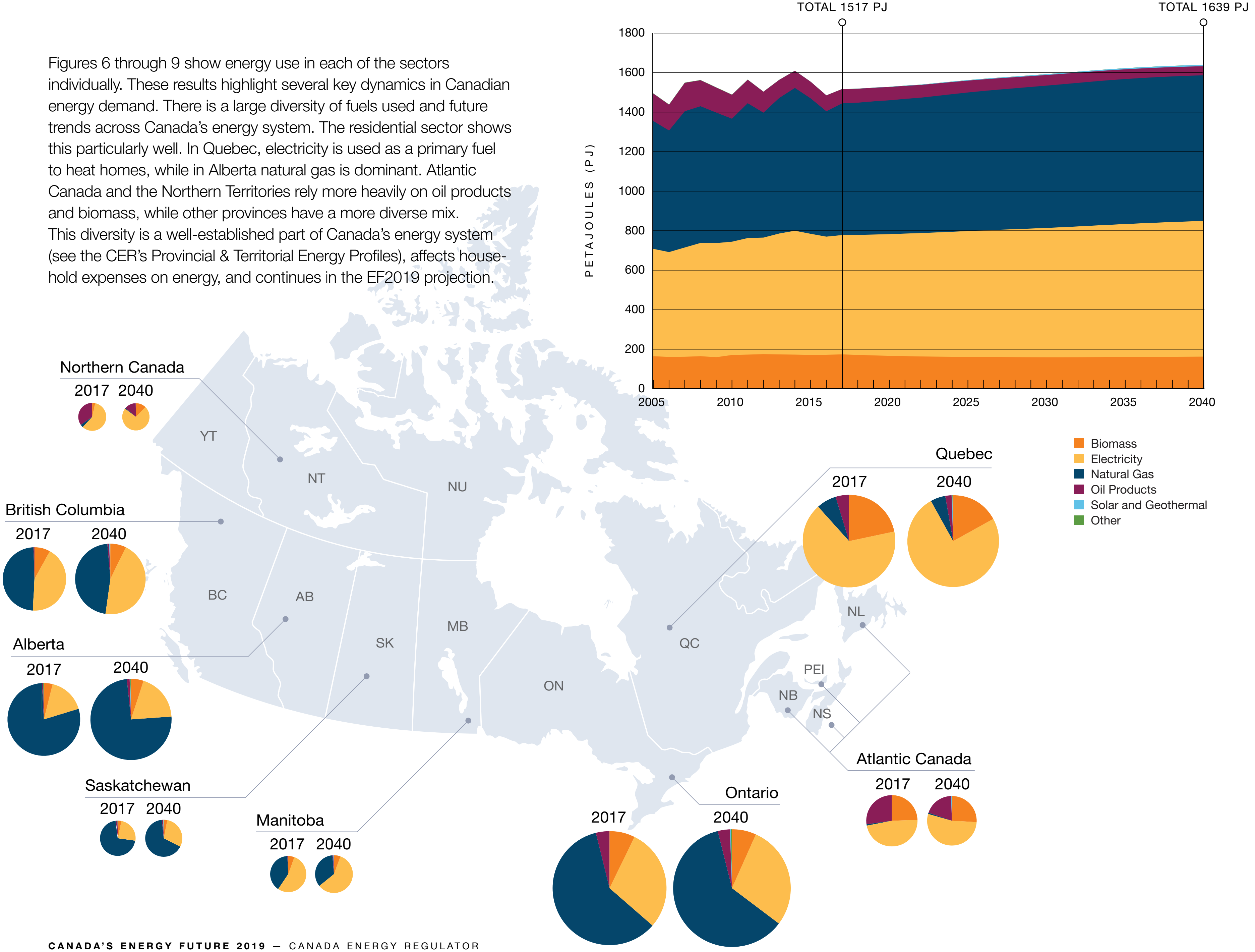
KEY TRENDS:
Energy Demand

- Energy use grows slowly in the next 20 years.
- Annual growth rates are lower than recent history.
- The mix of energy sources that Canadians use continues to change. Use of natural gas and renewables increases; coal and oil product use declines.
- Energy use grows slower than population and GDP, implying a decline in energy use per person and per dollar of economic activity.

Figures 6 through 9 show energy use in each of the sectors individually. These results highlight several key dynamics in Canadian energy demand. There is a large diversity of fuels used and future trends across Canada's energy system. The residential sector shows this particularly well. In Quebec, electricity is used as a primary fuel to heat homes, while in Alberta natural gas is dominant. Atlantic Canada and the Northern Territories rely more heavily on oil products and biomass, while other provinces have a more diverse mix. This diversity is a well-established part of Canada's energy system (see the CER's Provincial & Territorial Energy Profiles), affects household expenses on energy, and continues in the EF2019 projection.

Figure 6

Residential energy use is diverse across the country



Heating and cooling strategies in the clean energy transition

In May 2019, the International Energy Agency (IEA) and the NEB released the outcomes of their collaborative research on Canada's buildings sector. Heating and cooling strategies in the clean energy transition: Outlooks and lessons from Canada's provinces and territories provides estimates of how Canada's buildings sector could evolve in the IEA's Reference Technology Scenario and lower-carbon Clean Technology Scenario.

Energy use and emissions from Canada's building sector could decline significantly between now and 2050 using known technology solutions. Reduced energy expenditures provide incentive to improve energy efficiency and adopt new technologies. However, these alone will not be enough to achieve the Clean Technology Scenario, and additional policy action would be necessary.

Figure 7

Commercial energy demand grows steadily

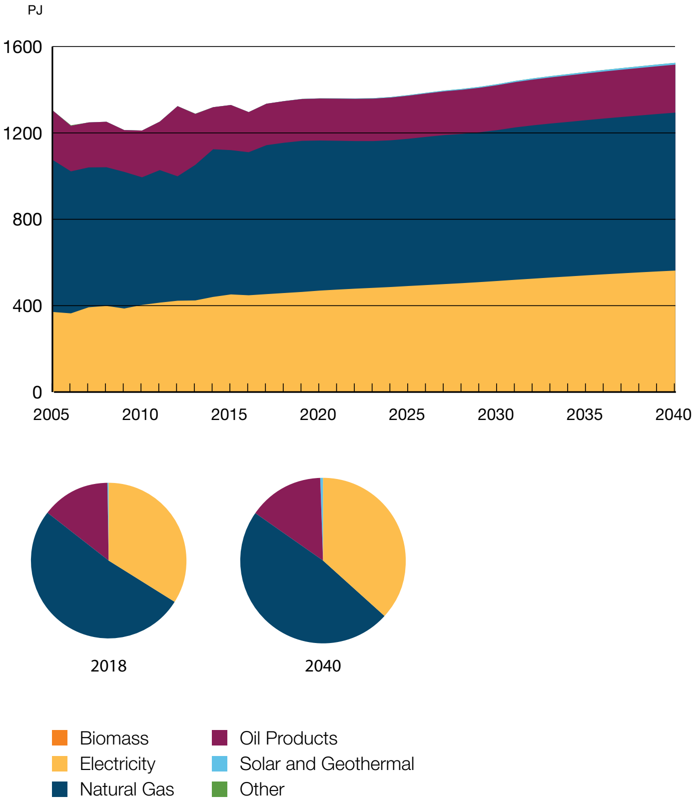
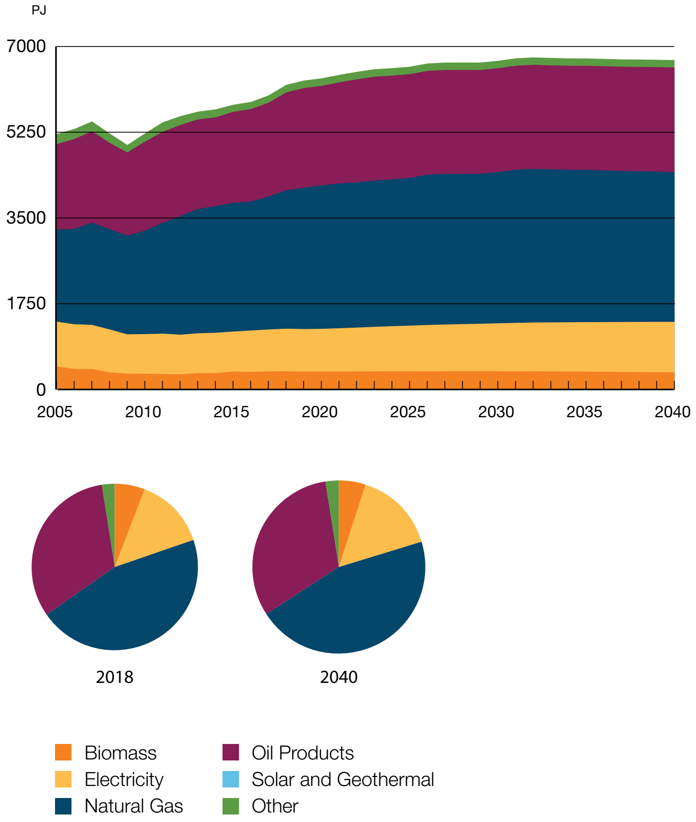


Figure 8

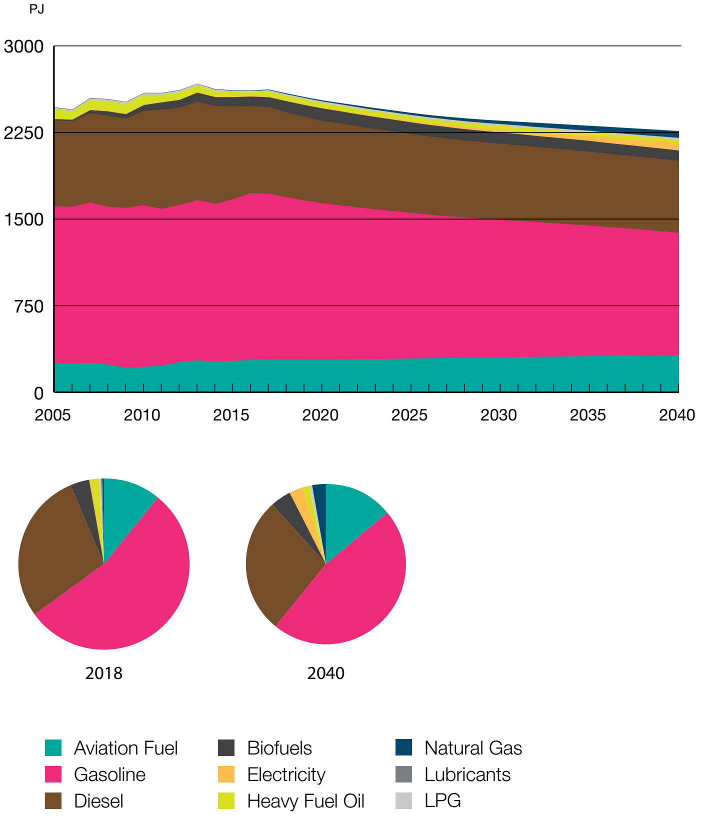
Industrial demand increases, led by natural gas



The transportation sector has been dominated by oil products. Improved fuel economy, as well as electrification, cause transportation energy use to decline over the projection[9]. Commercial and industrial demand is dominated by natural gas and electricity, and show moderate growth. Demand also varies across provinces and territories.

Figure 9

Transportation demand declines as energy efficiency improves steadily

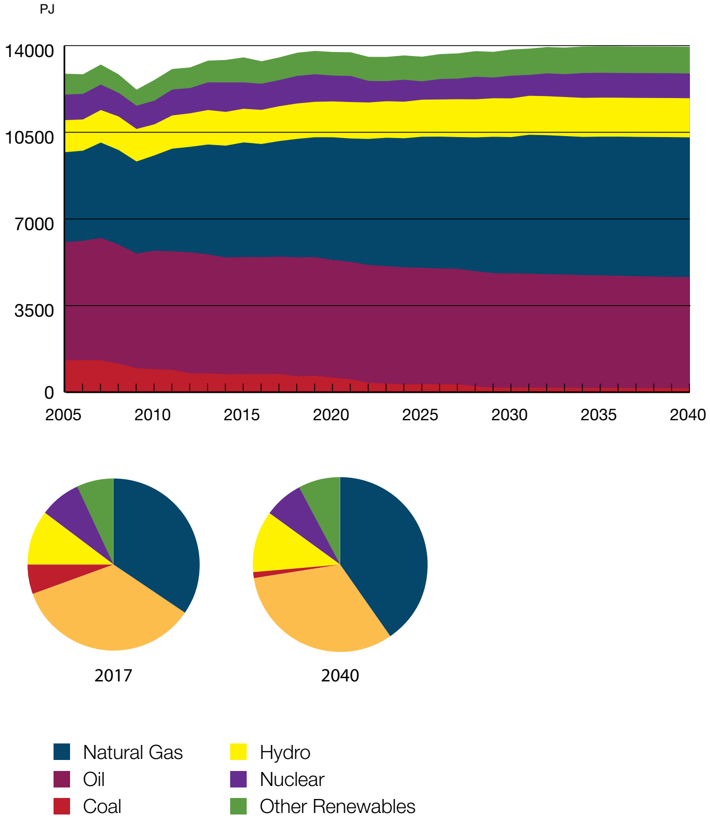


In this analysis, primary demand is the total amount of energy used in Canada. Primary demand is calculated by adding the energy used to generate electricity to total end-use demand, and then subtracting the end-use demand for electricity.

As shown in Figure 10, the share of natural gas increases the most, a result of natural gas use for power generation and for oil sands production. Coal's share of primary demand falls considerably due to declining coal-fired power generation.

Figure 10

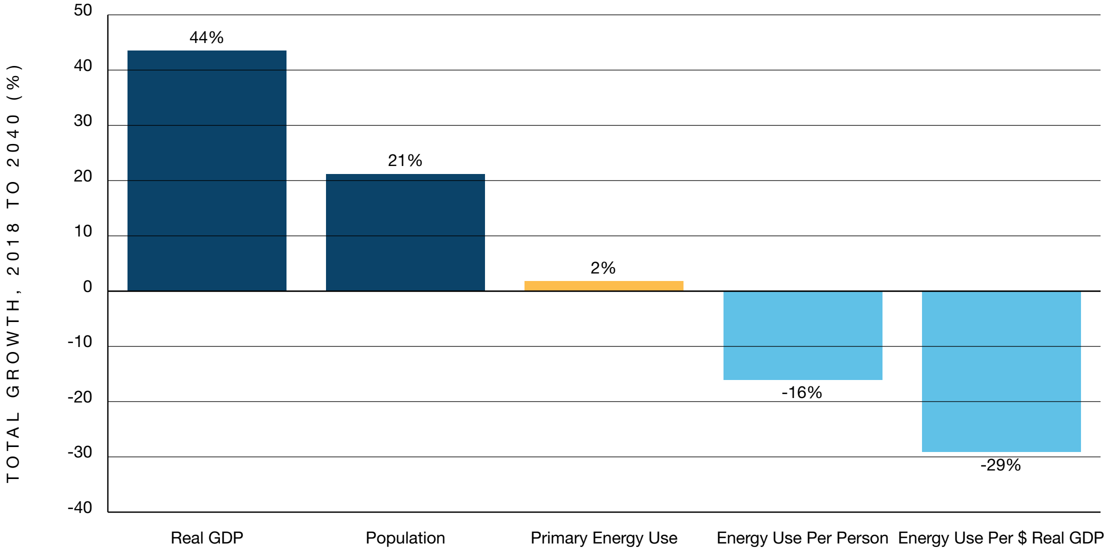
Primary demand grows moderately, led by natural gas



Energy use grows much slower than both the economy and Canada's population, implying energy intensity–measured in energy use per capita or per $ GDP–declines. This is summarized in Figure 11. From 2018 to 2040, real GDP increases over 40%, and population increases over 20%. Primary energy use increases less than 5%. These different trends imply that energy use per $ GDP declines nearly 30% from 2018 to 2040, while energy use per person declines over 15%.

Figure 11

The economy grows faster than energy use, and energy intensity declines



KEY UNCERTAINTIES: Energy Demand

Technological influences: The impacts of technology on the energy system can be substantial and difficult to predict. The Reference Case assumes modest growth of emerging technologies.

Oil and natural gas industry transformations: In the past decade, the oil and natural gas industry has undergone rapid transformations in both the types of resources extracted and the technologies used to extract them. Depending on the future development of these resources and technologies, the energy used in this sector may be higher or lower than this projection. The most notable example of this would be the trend of the steam to oil ratio (SOR) for in situ oil sands development, which will have a substantial effect on future natural gas demand in Alberta.

Electrification: New sources of electricity demand could have large implications for future trends. This includes a shift towards electricity delivering energy services currently provided by other fuels, such as heating and transportation. It also includes new uses, such as cryptocurrency mining.

Climate policies: Several measures are announced but are currently in initial stages of development, such as the proposed Canadian Clean Fuel Standard. These policies are not included in EF2019 and could impact energy trends as they are implemented. Likewise, small or large changes to existing policies, or changes in policy direction, could also impact the trends shown in the Reference Case projections.

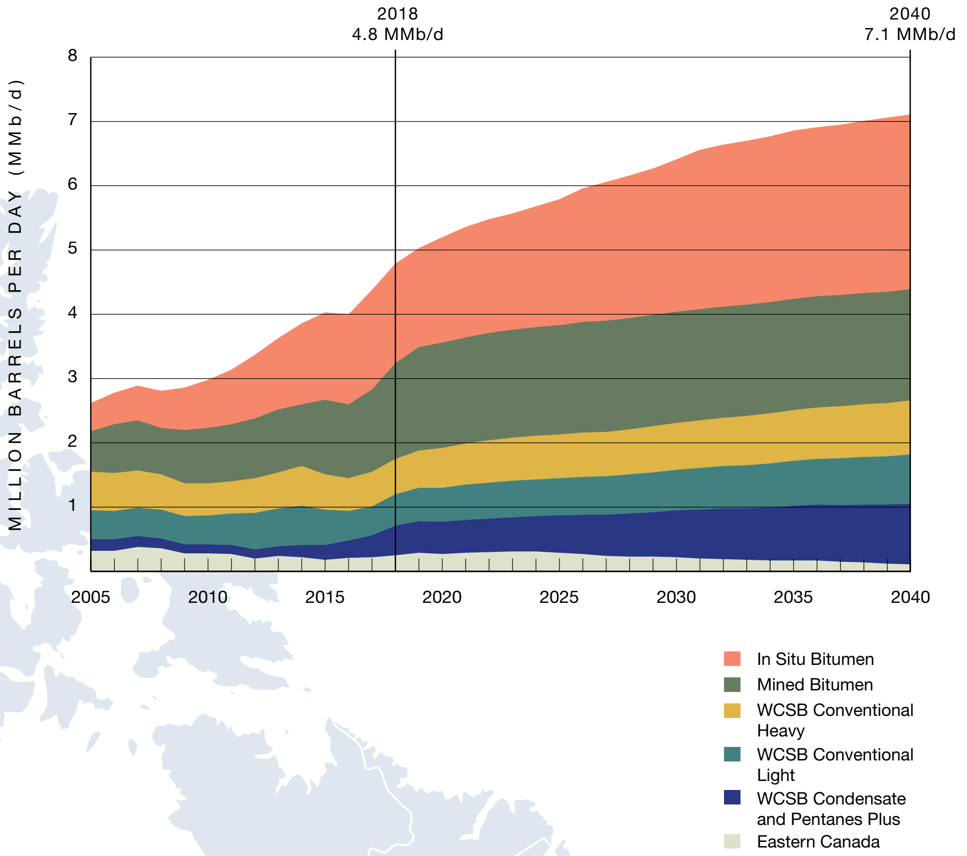
Crude Oil

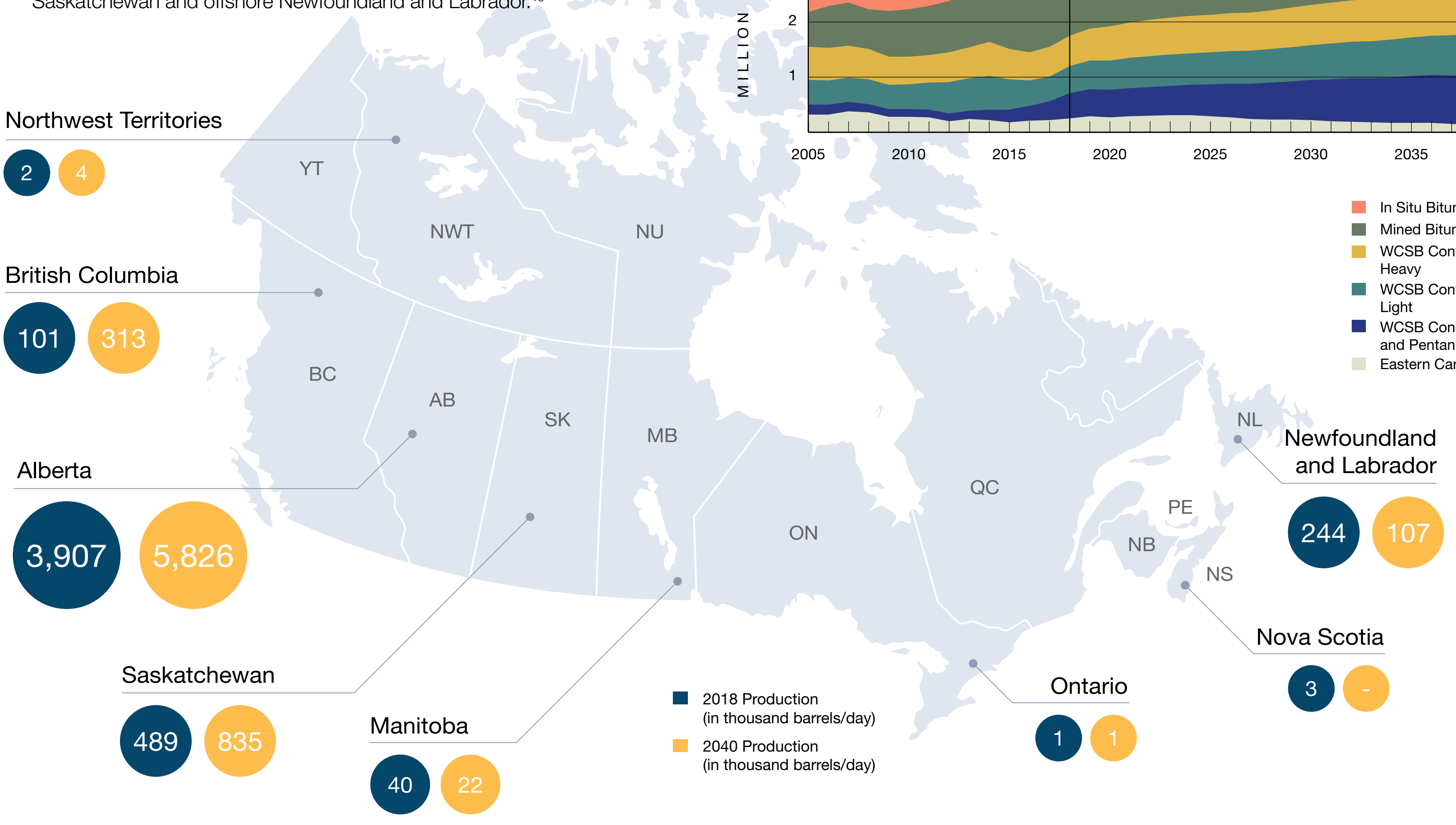
Canada produces crude oil for domestic refining as well as for exports. In 2018, Canadian crude oil production averaged 4.8 million barrels per day (MMb/d) (761 thousand cubic metres per day ($10^3m^3/d$)). Growth in recent years has been dominated by new oil sands facilities coming online.

Figure 12 shows the outlook for Canadian crude oil production. By 2040, Canadian crude oil production in the Reference Case is around 7 MMb/d (1 130 $10^3m^3/d$), growing by 49% from 2018. Production is largely located in Alberta, with additional volumes in Saskatchewan and offshore Newfoundland and Labrador.[10]

Figure 12

Total crude oil production continues to increase





Figures 13 through 16 show the various forms of crude oil produced in Canada currently, and projected in EF2019. Although oil sands production dominates growth, Canada produces a wide variety of crude oil types across the country.

Production growth in the oil sands continues, led by new phases of existing in situ projects. These additions are economic given Reference Case price levels. Production growth also comes from technology improvements that increase productivity. In the near-term, the Alberta government's curtailment program has led some projects to delay when they were scheduled to come online. This leads to faster growth in the 2027-2033 period.

Conventional production is classified as light or heavy, depending on the API gravity of the oil. In 2018, 48% of western Canadian conventional production was heavy, 52% was light. Growth in non-oil sands production is due primarily to increases in tight light oil production in Alberta along with growing heavy oil production in Saskatchewan. Tight oil growth is based on producers' preference to target wells which have higher initial production rates and a quicker return on investment. Growth in Saskatchewan's heavy oil production is due to the low cost and low decline rates of heavy oil reservoirs in that province.

Figure 13

Oil sands production from in situ continues to increase

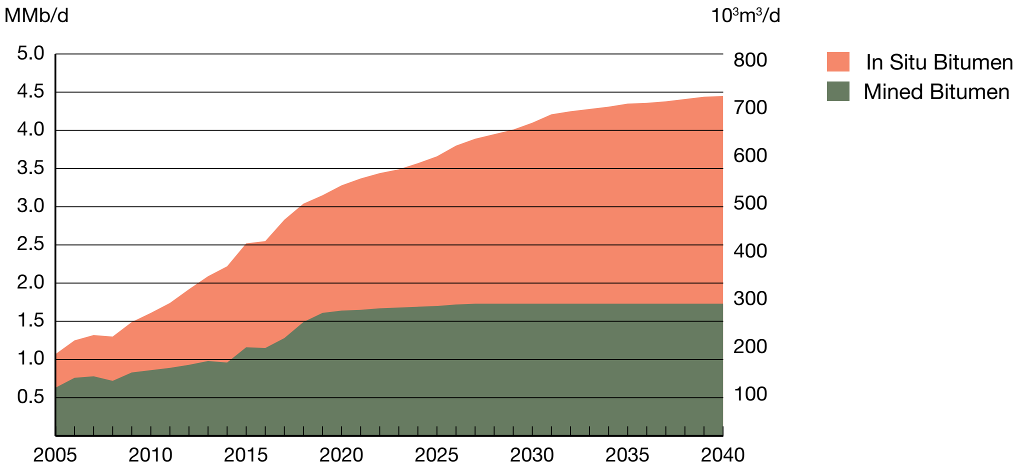


Figure 14

Conventional oil production increases in western Canada, mostly Alberta light and Saskatchewan heavy

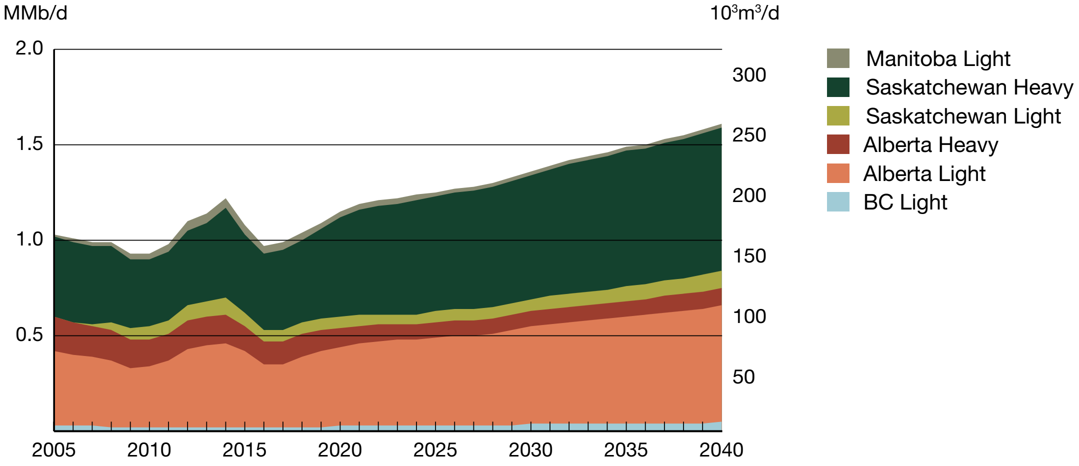


Figure 15

Condensate production follows natural gas production growth and increasing diluent demand

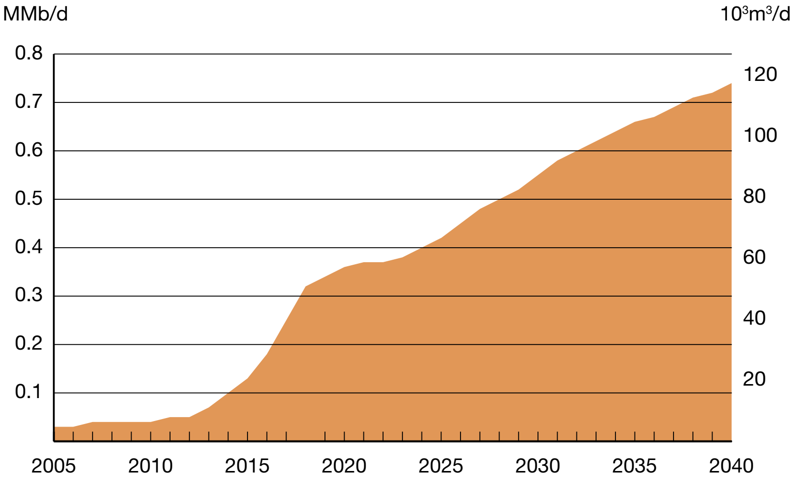
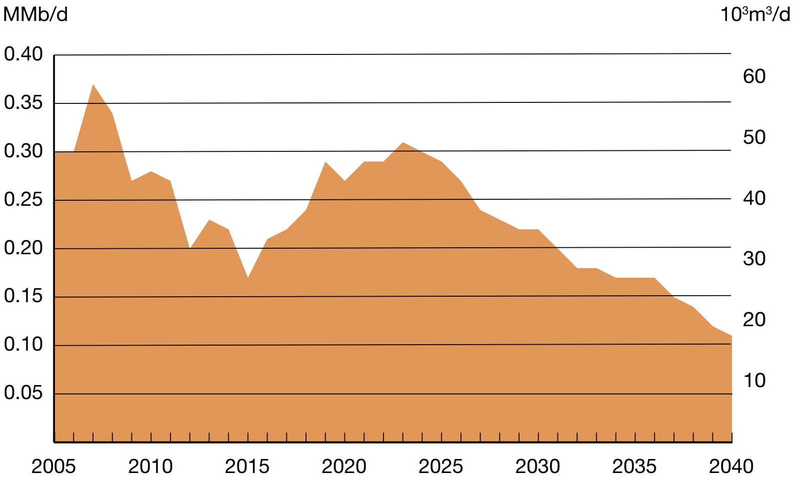


Figure 16

Newfoundland offshore oil production increases in the near term and steadily declines



Condensate comes primarily from natural gas wells and is removed from the gas stream either at the well head or at processing plants before the gas is sent to its intended market. Once removed, the condensate is used in a number of industrial processes, most notably as a diluent for bitumen and heavy oil. Currently, the majority of condensate production comes from Alberta. Much of the growth in condensate production in the projection period occurs in B.C., as producers focus on liquids-rich natural gas plays like the Montney.

Offshore Newfoundland production in the Reference Case increases in the near term as Hebron continues to ramp up and new wells from existing facilities are brought online. A new offshore discovery adds production in 2028, with a second new discovery in 2034. Hebron is the only project in Newfoundland's offshore that produces heavy oil. Other projects produce either light or medium grade oil.

Figure 17

Light balance projects increasing light oil exports

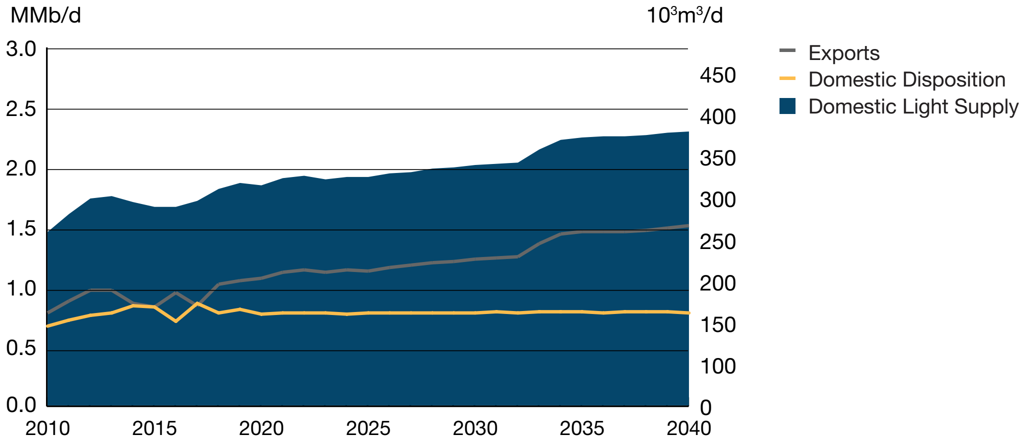
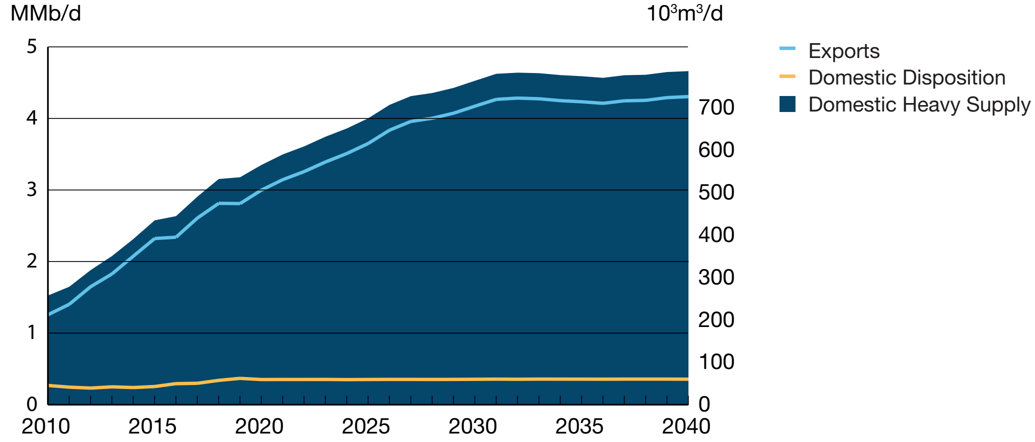


Figure 18

Heavy balance sees flat domestic demand and rising exports



Figures 17 and 18 illustrate the projections for crude oil exports in EF2019. Exports of crude oil are the difference between the net available oil supply[11] and the domestic disposition[12] of crude oil. Given growing supply and slowly declining domestic use of crude oil, crude oil exports increase over the outlook period.

KEY TRENDS:
Crude Oil

- Production grows steadily over the projection period. Assumptions on short-term infrastructure developments and long-term energy prices underlie this growth.
- Crude oil production increases over 49% from 2018 to 2040.
- Growth in oil sands largely due to expansions of existing facilities.
- Offshore Newfoundland production sustained by two new projects in 2028 and 2034.

In recent years, production growth in the WCSB has outpaced growth in pipeline capacity. This has been a key trend in Canadian oil markets[13]. Figure 19 provides a detailed look at available supply from the WCSB and takeaway capacity. The available capacity of a pipeline is the volume of crude oil it can safely transport while considering the type of crude being transported, planned and unplanned outages, downstream constraints and pressure restrictions, among other factors. This capacity is calculated by pipeline operators on a daily basis. The available capacity of existing pipeline systems is estimated by the CER using historical averages. The available capacity of new pipelines is estimated by comparing that pipeline to existing pipelines with similar characteristics.

Crude-by-rail volumes are divided into two types, based on CER estimates: structural and variable. Structural refers to crude oil that is likely to be exported by rail regardless of a given WCS-WTI differential. Variable refers to crude oil rail exports supported by the WCS-WTI differential, and in response to potential pipeline constraints. Variable rail export volumes are minimal for much of the projection period, as new pipeline capacity is added. Post 2035, crude-by-rail export volumes increase, reaching volumes similar to current export levels.[14]

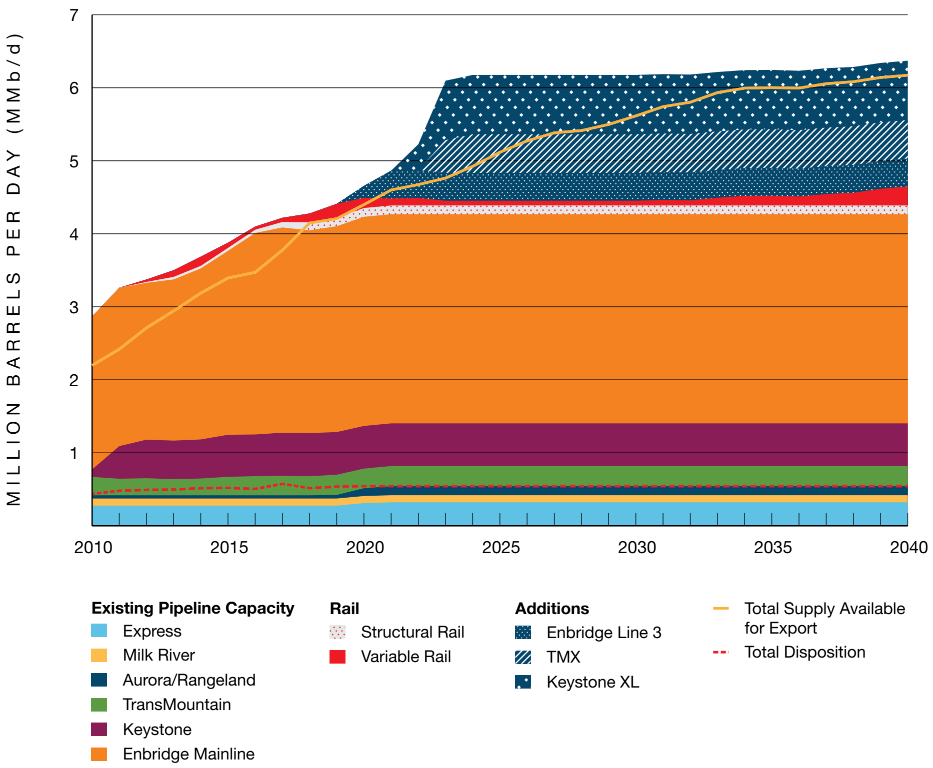
The volumes and timing of capacity additions to existing systems are as announced by the operators of those pipelines. Likewise, capacity and timing of the three pipelines included in Table 4 are as per the announcements of the operators.

Table 4: **Assumed announced crude oil capacity additions**

	Enbridge Line 3	Keystone XL	TransMountain Expansion
Expected in-service date	2020	2022	2023
Expected date at full capacity	2021	2023	2024
Full capacity (Mb/d)	382	813	528

Figure 19

Crude oil pipeline capacity vs. total supply available for export



What happens if assumed pipelines are not built?

The timing and magnitude of capacity additions, whether through the construction of new pipelines or increased utilization of existing ones, is uncertain. A number of other assumptions would be affected if the new pipeline projects assumed in EF2019 were significantly delayed or cancelled.

What could happen in such a scenario is difficult to predict. In fall 2018, production growth beyond available pipeline capacity and refinery maintenance in the U.S. led to a backlog of crude oil in Canada. This led to increasing storage levels, increased crude-by-rail volumes, and widening differentials between WCS and WTI. The differentials were wide enough for the Alberta government to enforce mandated curtailment volumes to reduce production levels, which brought the differential in line with historical norms. (Additional information is available: Western Canadian Crude Oil Supply, Markets, and Pipeline Capacity and Optimizing Oil Pipeline and Rail Capacity out of Western Canada – Advice to the Minister of Natural Resources).

These recent experiences show that Canadian price differentials, production, storage, and crude-by-rail volumes are sensitive to the availability of pipeline capacity. The exact nature of the impact will be related to the current market context, policy responses, and specific events including planned and unplanned outages. There could also be implications on other market factors, such as oil and gas investment, production and the adoption of new technology to increase the capacity of existing systems.

KEY UNCERTAINTIES:
Crude Oil

Future oil prices: Oil prices are a key driver of future Canadian oil production and a key uncertainty to the projections in EF2019. Oil prices could be higher or lower depending on demand and policy trends, technological developments and geopolitical events.

The pace of technological development in the oil sands: EF2019 assumes gradual technological improvement in the sector. Technology development could occur either more or less rapidly than assumed in this analysis and that could impact the oil sands production projection. Potential advances that could change the supply projections include solvent-based processes, other steam reduction technologies, and electrification.

Take away capacity: The existence of take away capacity, and market and policy responses to lack of capacity (such as Alberta's recent and on-going production curtailment) will influence future production growth.

Natural Gas

Canadian natural gas is produced for domestic use, as well as for exports. Canadian marketable natural gas production averaged over 16 Bcf/d or 457 million cubic metres per day ($10^6 m^3$/d) in 2018.

Alberta natural gas production remained steady over the last few years, while B.C. production continued to ramp up. This increase has been driven by a variety of factors including:

- Drilling to evaluate natural gas resources expected to supply LNG exports off of Canada's west coast.
- New natural gas processing plants helping to debottleneck some gas gathering systems.
- Natural gas liquids in some natural gas plays driving drilling and production despite low prices.

KEY TRENDS:
Natural Gas

- Natural gas production declines in the near term due to lower prices.
- Production increases in the long term. Assumptions on LNG export projects, infrastructure developments, and long-term prices underlie this growth.
- Majority of the production growth comes from the Montney Formation.

In the near-term, natural gas production declines, given less drilling capital expenditures due to lower natural gas prices. Production from new wells won't be able to keep pace with the declining production from existing wells. As a result, total production declines until 2023. In the longer term, rising prices and the onset of LNG exports leads to production growth. Exploration and development spending associated with LNG exports support higher capital expenditure. This leads to more natural gas wells and production in the WCSB. By 2040, natural gas production reaches 21 Bcf/d (606 $10^6m^3/d$) (See Figure 20).

Figure 20

Total natural gas production by region continues to be dominated by Alberta and B.C.

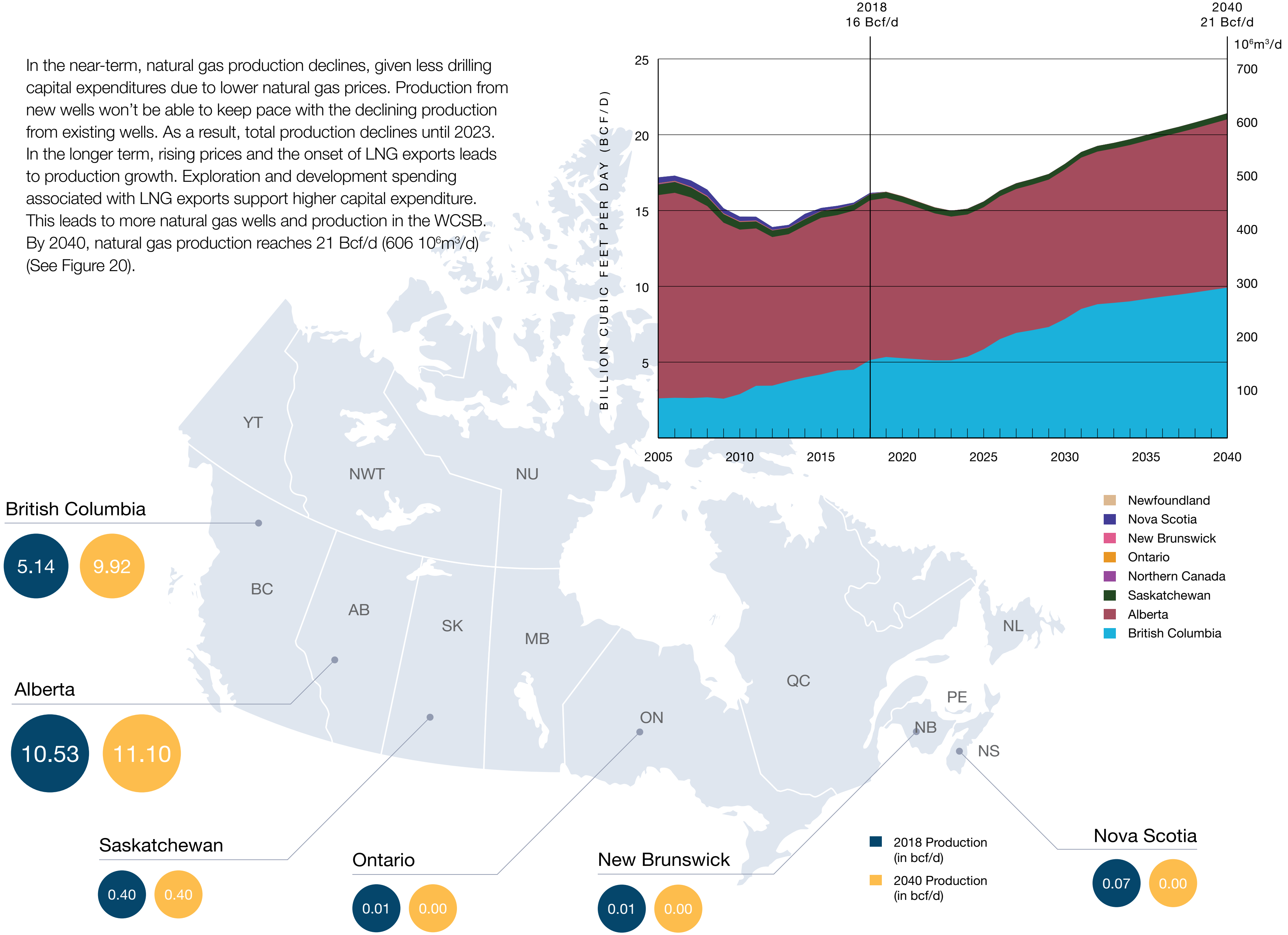
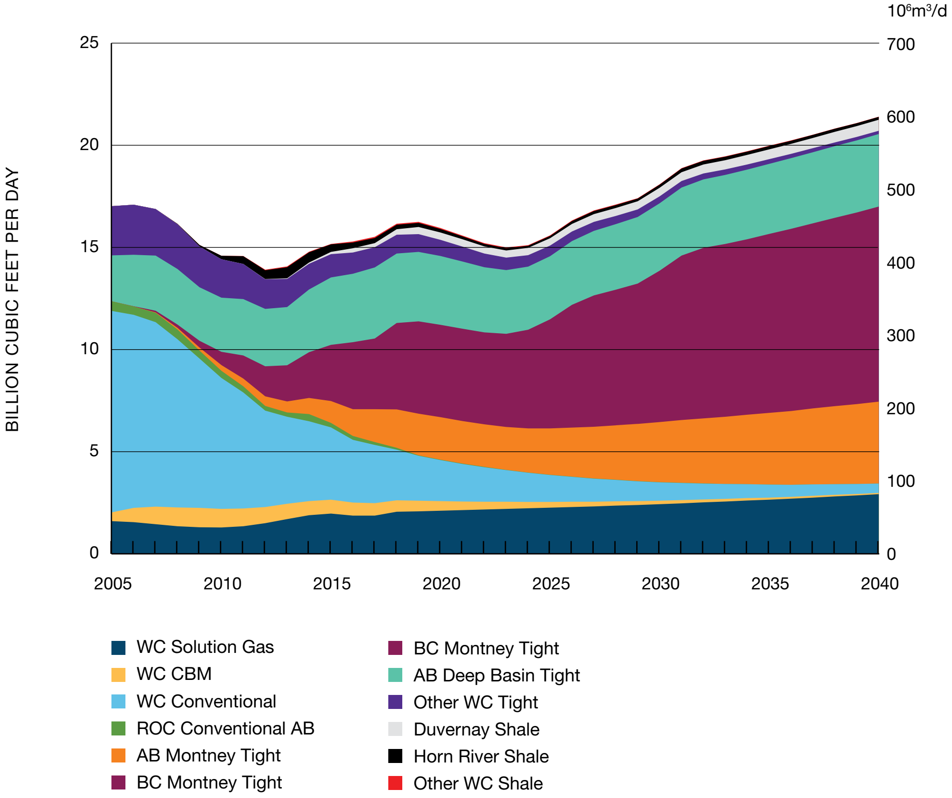


Figure 21 shows production by type of natural gas. Production growth is led by tight natural gas produced from the Montney Formation. Tight natural gas production from the Montney formation has grown significantly over the past five years. Alberta Deep Basin tight natural gas production grows moderately, as well as some small shale gas growth from the Duvernay and Horn River shales, and solution gas. Conventional and coal bed methane production declines over the projection period.

Natural gas exports have increased over the last few years, mostly due to increasing exports to the Western U.S. Imports of natural gas have been stable over the last decade, hovering between 2-3 Bcf/d (55 $10^6m^3/d$). Imports could potentially rise as pipeline capacity increases from the Appalachian Basin in northeastern U.S. to Dawn, Ontario. Net natural gas exports have increased slightly over the past few years.

Figure 21

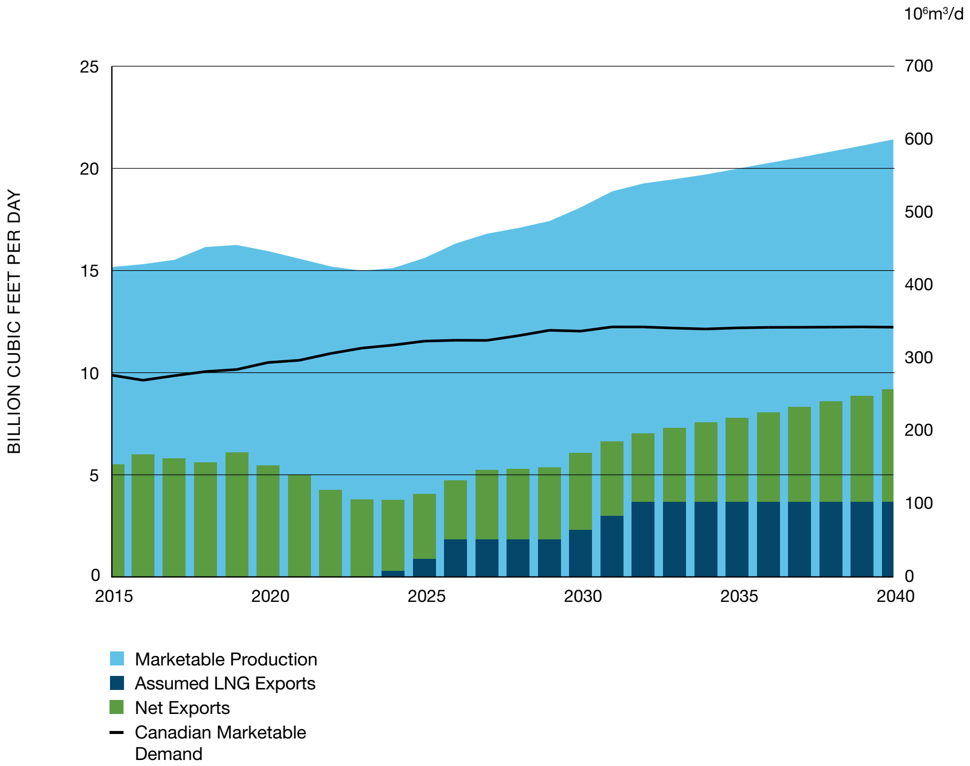
Natural gas production by type increases led by production from the Montney Formation



Projected net pipeline exports, which is calculated as Canadian natural gas production less Canadian demand, is shown in Figure 22[15]. In the early 2020's, declining production and Canadian natural gas demand growth leads to shrinking net exports. As production ramps up after 2023, production growth starts to outpace demand growth and net exports rise. By 2025, LNG exports begin to contribute to the growth in net exports.

Figure 22

Natural gas supply and demand balance sees net exports increasing in the longer term



KEY UNCERTAINTIES:
Natural Gas

Future natural gas prices: Prices could be higher or lower, which would lead to different production results.

Canadian natural gas price discounts: This analysis assumes that over the long term, all energy production will find markets and infrastructure will be built as needed. Extended differentials for Canadian natural gas relative to Henry Hub could reduce gas production in the longer term.

LNG exports: It is possible that global market conditions and the costs of commissioning a new LNG export facility or phase may change in the future, influencing future volumes of LNG exports in Canada.

Natural Gas Liquids

Natural gas liquids (NGLs) are present with most natural gas production, and is the main source of NGL production in Canada. Demand for certain NGLs, like oil sands demand for condensate or the petrochemical demand for ethane, propane, and butanes, add value to natural gas production and drive its increase. Raw natural gas at a wellhead is comprised primarily of methane, but often contains ethane, propane, butane, condensate and other pentanes. In 2018, 1 158 Mb/d (184 10^3m^3/d) of NGLs were produced in Canada.

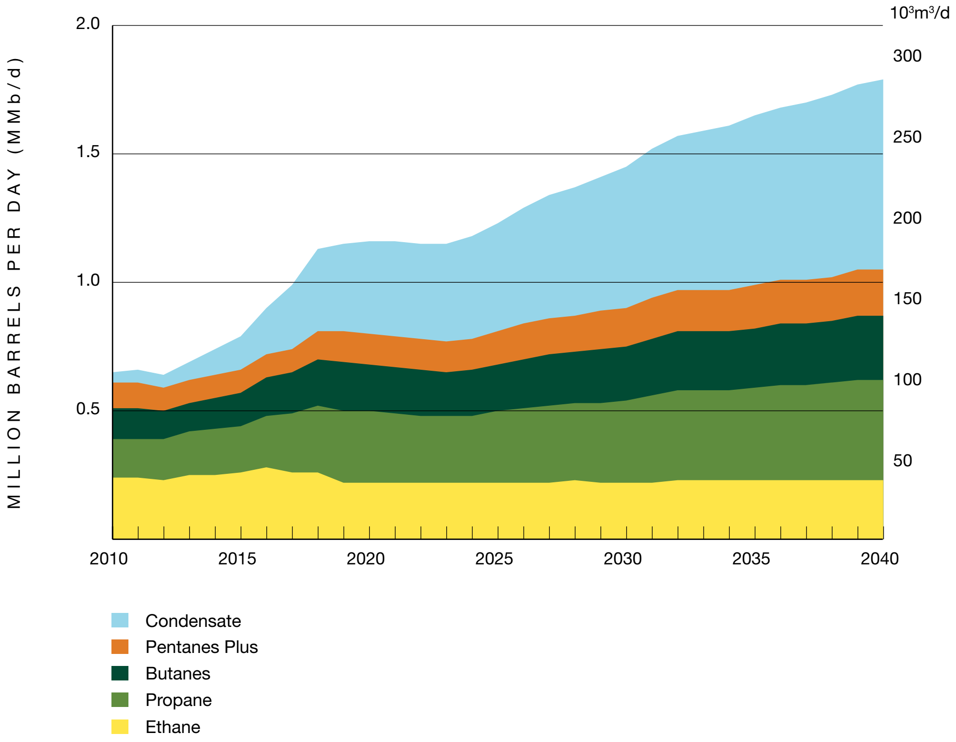
Figure 23 shows that NGL production grows over 80% over the projection period. Growth is dominated by condensate, which more than doubles to 2040. Condensate demand and prices have influenced natural gas drilling to focus on NGL-rich plays. Condensate is added to bitumen as a diluent to enable it to flow in pipelines and rail cars.

Propane and butane production follows natural gas production, and increases over the projection period. Demand for these NGLs increases in the mid-term as petrochemical use in Alberta and propane and butane exports rise.

Ethane, the majority of which is extracted at large natural gas processing facilities located on major natural gas pipelines in Alberta and B.C., made up 22% of NGL production in 2018. Ethane production increases slowly over the projection to 2040, as its recovery from the natural gas stream is essentially constrained related to the capacity of the petrochemical facilities in Alberta. Ethane produced in excess of this capacity is reinjected back into the pipeline system to be consumed by end users as natural gas.

Figure 23

Condensate and pentanes plus lead natural gas liquids production increase



Additional Detail on Crude Oil, Natural Gas, and NGL Projections

For additional data on crude oil, natural gas and NGL production, see the EF2019 supplemental tables. These datasets include additional geographical and monthly detail on production and drilling trends.

Further information about these and other data sets is available in the "Access and Explore Energy Futures Data" section later in this report.

KEY UNCERTAINTIES: Natural Gas Liquids

Natural Gas: NGLs are a by-product of natural gas production, and as such, any uncertainty discussed in the Natural Gas section applies for NGL projections.

Oil Sands: The rate of oil sands and other heavy oil production growth, and the amount of blending, will affect the demand for condensate and butanes required for diluent. Likewise, the use of solvents to reduce steam requirements in the oil sands could impact demand and prices for propane and butanes and influence the degree they are targeted by future natural gas drilling.

LNG composition: The amount of NGLs that remain in natural gas to be liquefied for LNG varies throughout the world. This can be specified in the contracts underpinning a liquefaction facility, the energy content required by the LNG importer, and the gas composition of the feedstock gas used by the LNG exporter.

Petrochemical development: There is potential for ethane and propane recovery to increase further if there is an uptick in incremental petrochemical capacity requiring either as feedstock. This includes incentives captured in the second phase of the Petrochemicals Diversification Program.

Global LPG export market: Canada has approved several large-scale facilities to export LPG from B.C.'s coast. Propane will likely be the dominant liquid exported. However, these facilities would have the potential to ship butanes and future market developments could present a scenario where butanes is a viable export product. The composition of the LPG stream exported at these terminals could impact domestic NGL prices and the attractiveness of drilling for NGL-rich natural gas.

Electricity

Canada's diverse electricity generation mix varies significantly among provinces and territories, reflecting the type of energy available, economic viability, and policy choices. Over the past decade, there have been significant changes in Canadian electricity, and it continues to evolve in the EF2019 projection. From 2017 to 2040, electric capacity grows by 16%, driven by increases in renewables and natural gas to meet new demand growth and replace retiring units, mainly coal. Total Canadian electricity demand increases nearly 1% per year over the projection period. Nuclear power is a key part of Ontario and New Brunswick's electricity systems, and over the projection period nuclear units in Ontario are refurbished, according to provincial plans. Figure 24 provides an overview of the electricity capacity mix across Canada in 2017 and projected to 2040.

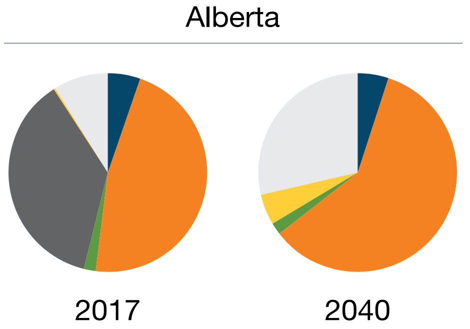
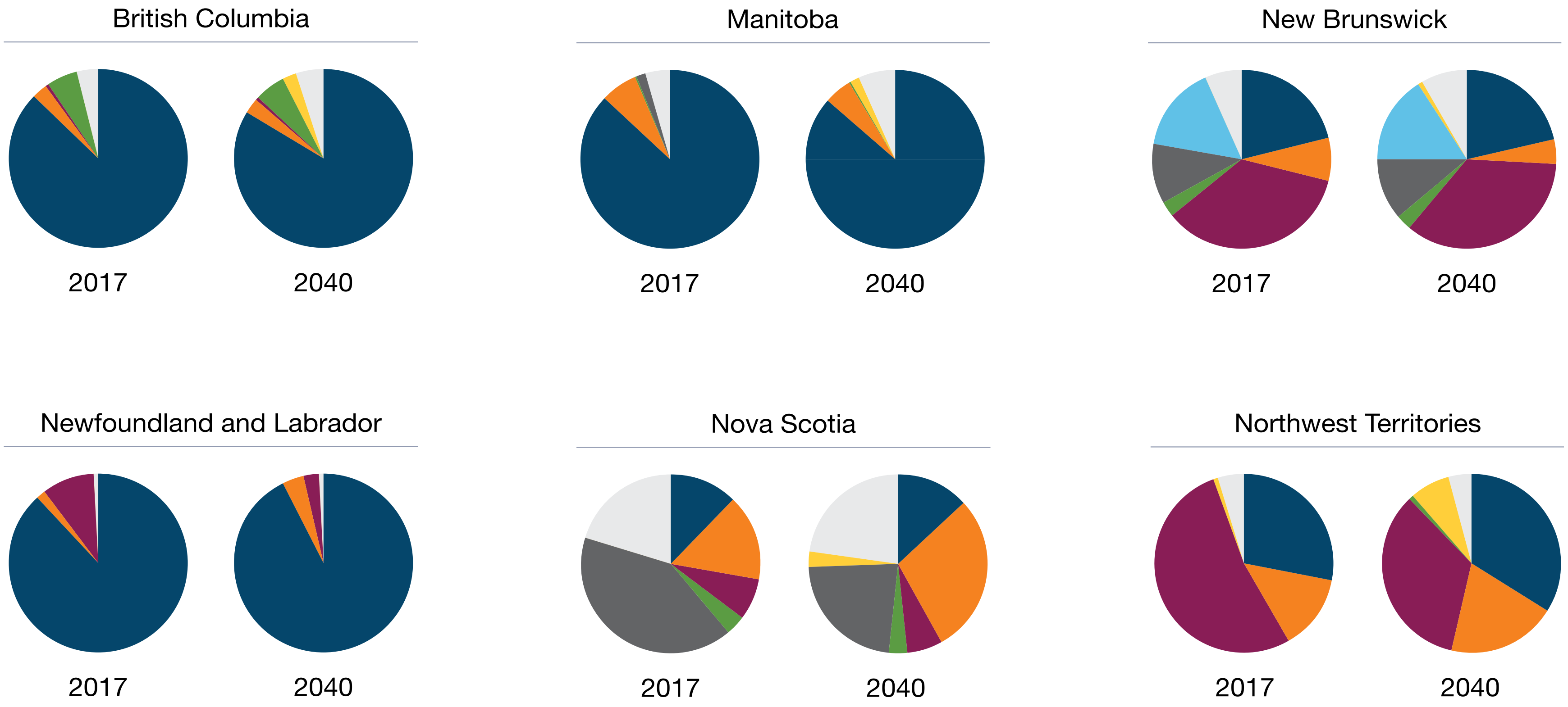
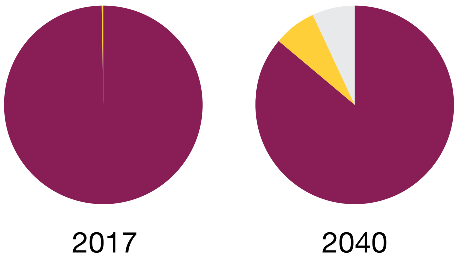


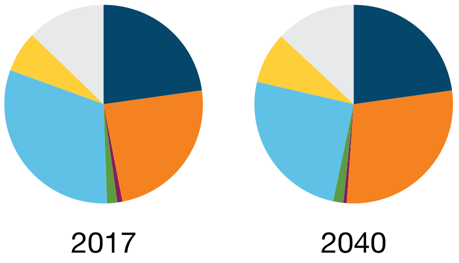
Figure 24
Electric capacity mix varies by region



Nunavut

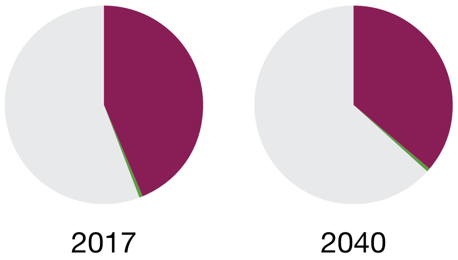


Ontario

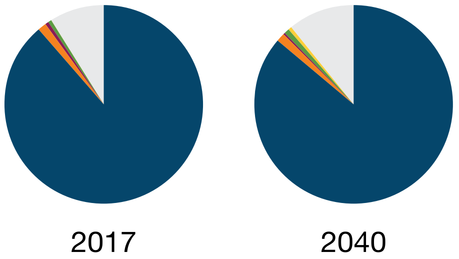


- ⬜ Wind
- 🟨 Solar
- 🟦 Nuclear
- ⬛ Coal
- 🟩 Biomass and Geothermal
- 🟪 Oil
- 🟧 Natural Gas
- 🟦 Hydro

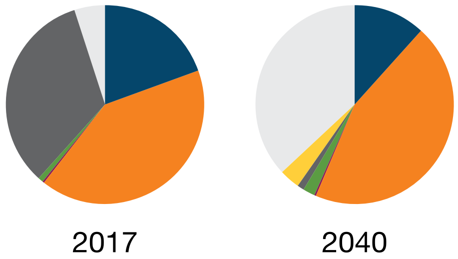
Prince Edward Island



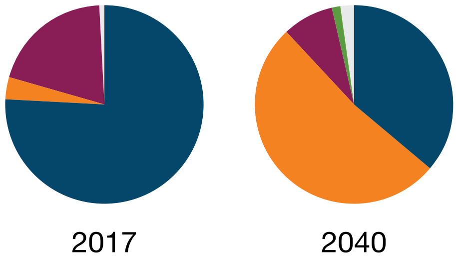
Quebec



Saskatchewan



Yukon

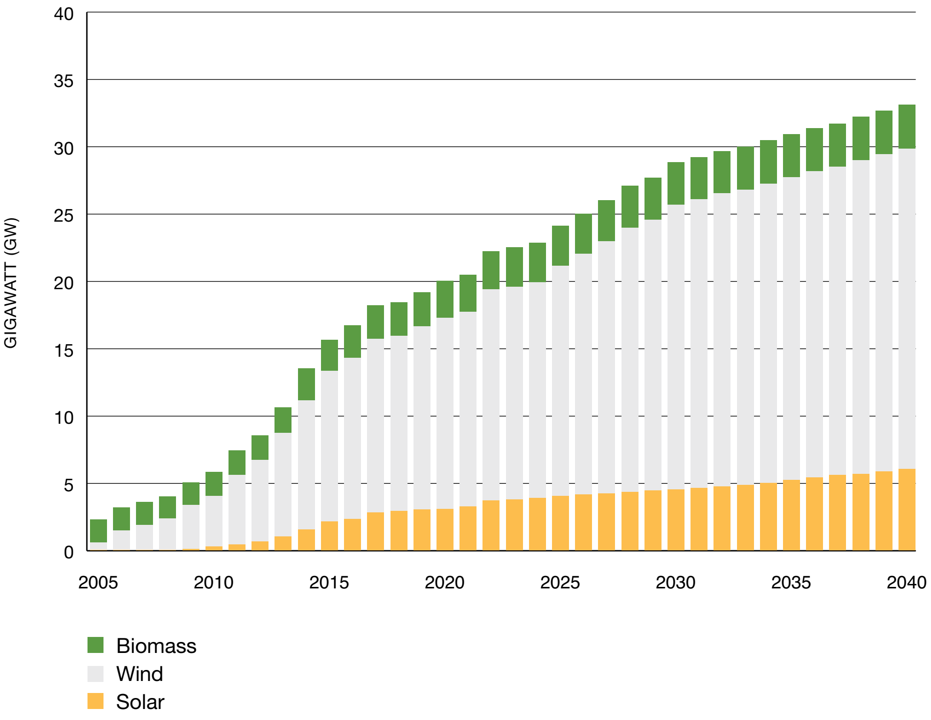


Canada has a relatively low emitting electricity grid. In 2017, 81% of its generation was from non-emitting sources. This is primarily due to its Canada's large base of hydro power, which makes up the majority of electricity produced in B.C., Manitoba, Quebec, and Newfoundland and Labrador. There has also been a significant increase in non-hydro renewables. In 2005, wind and solar made up 0.2% of the electricity generation mix. By 2017 this share increased to 5%, and by 2040 increases to 10%.

Figure 25 shows projected growth in non-hydro renewables. This growth is supported by policy development, as well as improved economics. Over the outlook, installed capacity of wind nearly doubles, while solar more than doubles. Over the last several years, there have been some key policy changes in several provinces regarding renewable development. Alberta has recently terminated the former Renewable Energy Procurement program, which would have led to an additional 3 600 MW of guaranteed renewable additions[16]. Ontario also recently terminated feed-in-tariff and procurements of large renewable projects. These policy changes do not mean renewable development will stop in these regions, however. EF2019 assumptions on declining wind and solar costs support growth in renewable development, despite fewer direct policy initiatives.

Figure 25

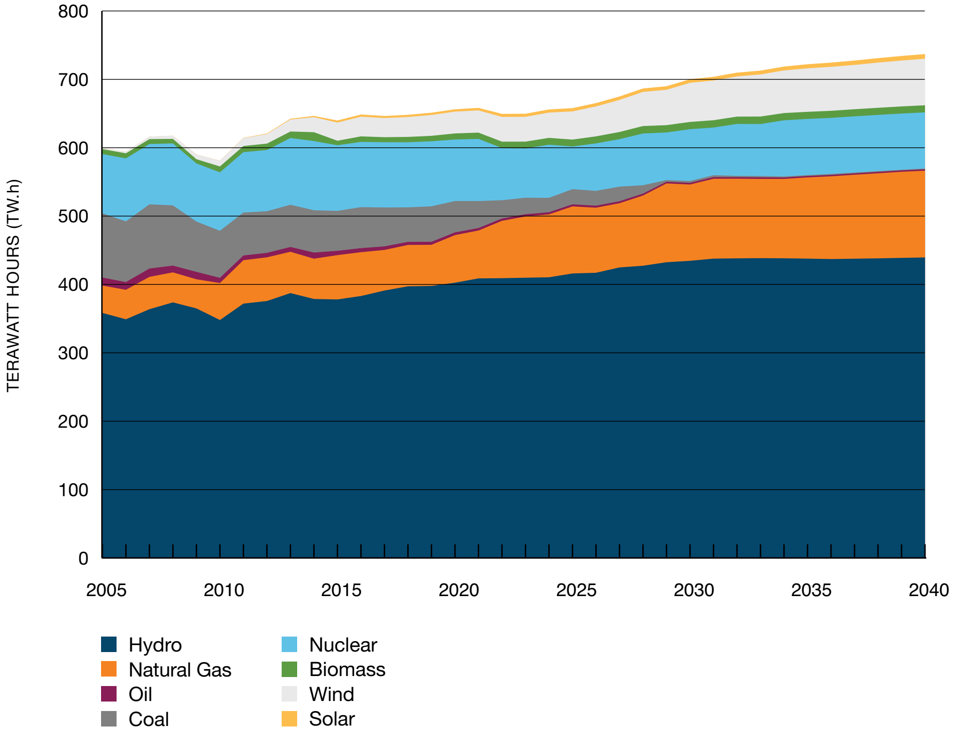
Renewable capacity increases over the projection



In the Reference Case, total Canadian electricity generation increases by over 90 terawatt hours (TW.h) from 2017 to 2040, an increase of about 14%. Hydro, other renewables, and natural gas lead this growth, while coal and nuclear generation decline. Figure 26 shows these trends by fuel type. Additional renewables and decline of coal reduces the overall emission intensity of Canada's electricity mix. In 2017, Canada averaged 130 grams of CO_2 equivalent per kilowatt hour (gCO_2e/kW.h). In 2040, this falls to less than 80 gCO_2e/kW.h, a decrease of about 40%.

Figure 26

Electricity generation by fuel shows coal phasing out, and more renewables and natural gas added



KEY TRENDS:

Electricity Generation

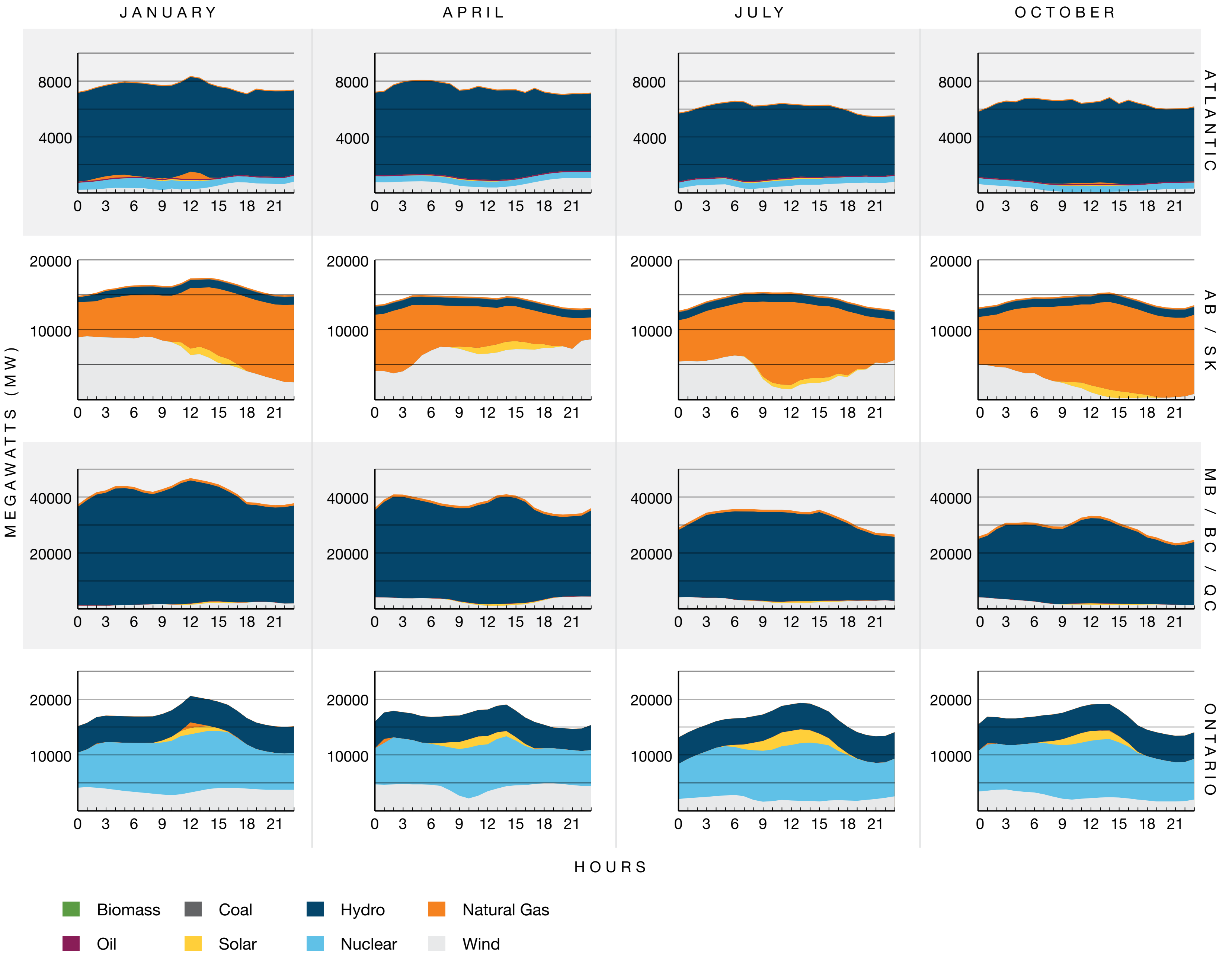
- Technologies enabling Canada's transition to a low carbon economy make inroads across the energy system, particularly in electricity generation.
- Natural gas and renewable generation is added, most nuclear will be refurbished.
- Coal will be largely phased out.
- The share of renewable and nuclear generation increases from 81% currently to 83% in 2040.

As the proportion of variable renewable energy, such as wind and solar, increases, variations in generation from hour-to-hour and minute-to-minute become increasingly important in balancing electricity production and use. Figure 27 illustrates simulated generation, which includes interprovincial and international trade, for 24 hours in the four seasons across various regions in Canada in 2040. As wind and solar generation vary throughout the day, other generation sources fill in to meet load requirements. In addition, there is variability in the output of variable renewables across the seasons. For regions that have low shares of non-hydro renewables, the generation mix remains fairly constant and non-hydro renewables are integrated in the system without significant changes to system operation.

The hourly generation projections presented here are simulations and represent one particular sample from many different outcomes. They are not a definitive statement on what will happen in the future, but rather an illustration of one potential outcome. Electricity demand, solar irradiation and wind speed can show great variability hour-to-hour and day-to-day. This results in many different ways electricity demand and renewable generation can fall on any given day. The graphs below illustrate one way these variables could line up.

Figure 27

Hourly electricity generation by fuel source for a simulated day for various Canadian regions in 2040

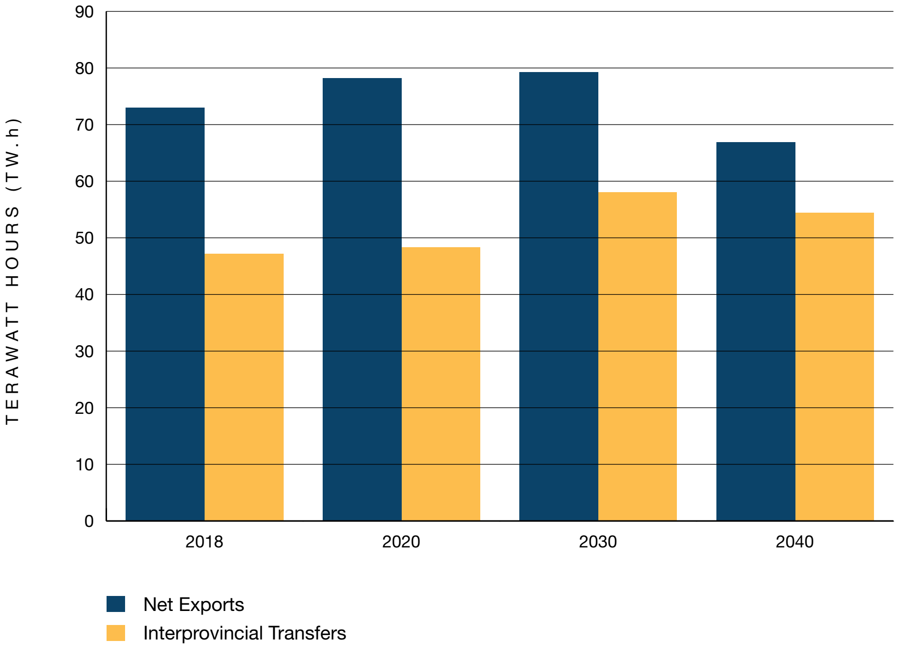


Canada is a net exporter of electricity to the U.S., and large amounts of electricity are also traded between provinces, mainly in eastern Canada. By connecting the electricity grids of different regions, grid operators can take advantage of regional differences in periods of peak electricity demand.

Figure 28 shows potential for growth in net exports out of Canada, as well as aggregate interprovincial trade volumes. One of the reasons for increased interprovincial trade is the Maritime Link, which is a new energy loop for Atlantic Canada. This new transmission corridor will create stability and reduce reliance on fossil fuel generation in the region. The project will allow Nova Scotia to import more power from Newfoundland and Labrador, reducing the province's coal generation. This link could also facilitate more renewable energy development in the region.

Figure 28

Net exports of electricity decrease by 2040 while interprovincial transfers remain steady



KEY UNCERTAINTIES:
Electricity Generation

Future capital cost declines of generating facilities: The capital costs associated with different generating technologies is an important factor in determining what type of facilities are built. This is especially true with less commercially mature technologies like wind, solar, and coal with CCS.

Electricity demand growth: This is important in determining future electricity supply. As a result, the uncertainties identified in the energy demand section are uncertainties that also apply to the electricity supply projections.

Future projects and developments: Climate policies, fuel prices, electrification and power sector decarbonization in export markets could impact future projects and transmission intertie developments.

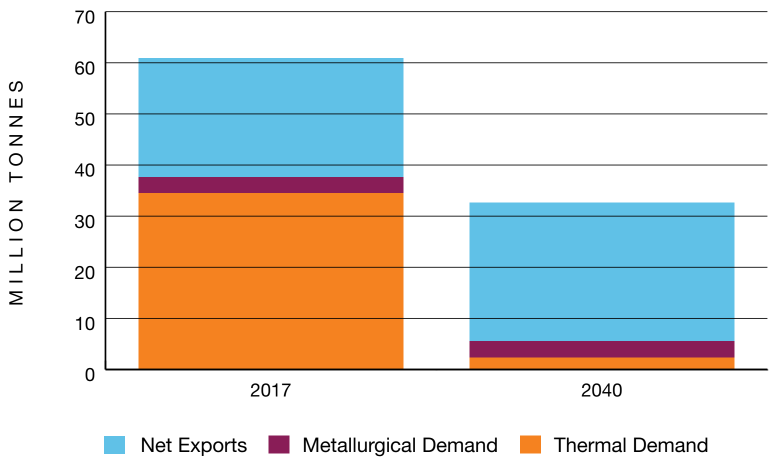
Changes to capacity mix in export markets: Planned nuclear and coal retirement, and growing renewables, could impact capacity expansion plans, generation and flows between trading jurisdictions.

Coal

There are two main types of coal produced in Canada: thermal and metallurgical. Canadian thermal coal production is linked to the use of coal in the electricity sector, particularly in Alberta, Saskatchewan, and Nova Scotia. Metallurgical coal is primarily used for steel manufacturing domestically and internationally. Much of Canada's metallurgical coal production is exported and future production trends are linked to global metallurgical coal demand and prices.

Figure 29 shows Canadian production and consumption of coal in Canada in 2017. Thermal coal accounted for 88% of total Canadian coal consumption in 2017. In the Reference Case, demand for thermal coal declines by 89% over the projection period, falling from 30 million tonnes in 2017 to just over 3 million tonnes in 2040. This declining trend is driven primarily by retirements of coal-fired generation capacity resulting from regulations to phase out traditional coal-fired power plants by 2030.

Figure 29:
Canadian coal production and disposition trends driven by falling thermal demand



Domestic demand for metallurgical coal used in steel manufacturing declines from 4.4 million tonnes in 2017 to just under 4 million tonnes by 2040. Global demand for metallurgical coal grows moderately over the projection period, resulting in steady growth in net exports from Canada. Total metallurgical coal production in Canada increases from about 30 million tonnes in 2017 to 30.5 million tonnes by 2040. Total production declines from about 61 million tonnes in 2017 to 38 million tonnes in 2040.

KEY UNCERTAINTIES:
Coal

Prices: Future price movements in the global coal markets are a key uncertainty for Canadian coal exports.

Climate policies: Canadian climate policies, and the climate policies of coal importing countries, could have a significant impact on both Canadian thermal and metallurgical coal production.

Greenhouse Gas Emissions

Currently, energy use and greenhouse gas (GHG) emissions in Canada are closely related. ECCC prepares and annually updates greenhouse gas emissions projections to 2030.[17]

The majority of GHGs emitted in Canada are a result of fossil fuel combustion. Fossil fuels provide the vast majority of energy used to heat homes and businesses, transport goods and people, and power industrial equipment. Emissions from fossil fuels, including those used for the production of energy, accounted for 81% of Canadian GHG emissions in 2017. The remaining emissions are from non-energy sources such as agricultural and industrial processes, and waste.

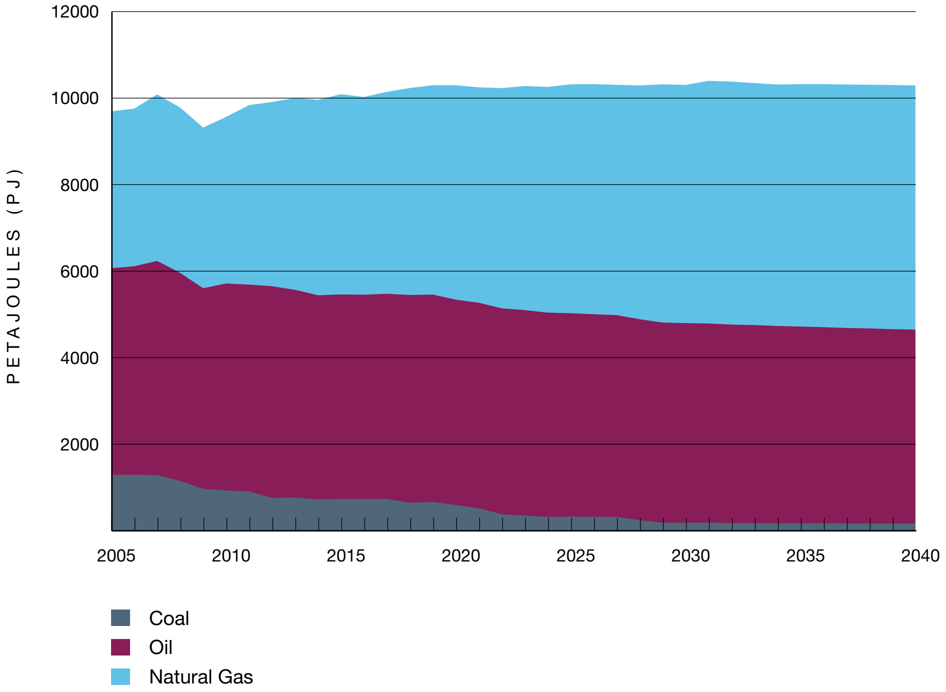
KEY TRENDS:
Fossil Fuel Use and GHG Emissions

- Canada is making progress in transitioning towards a low carbon future.
- Fossil fuel use grows 1% from 2018 to 2040, lower than growth in total energy use.
- Growth is driven by increased natural gas use, which makes up an increasing share of fossil fuel use.
- More GHG emission-intensive sources, oil products and coal, decline over the projection period.

Figure 30 shows the total demand for fossil fuels in the Reference Case. From 2018 to 2040, total fossil fuel use grows less than 1%, but growth varies significantly across the different fuel types. Natural gas use, the least GHG-intensive fossil fuel, increases by 18%. Oil product use declines by 7%, while coal use declines by nearly 75%.

Figure 30

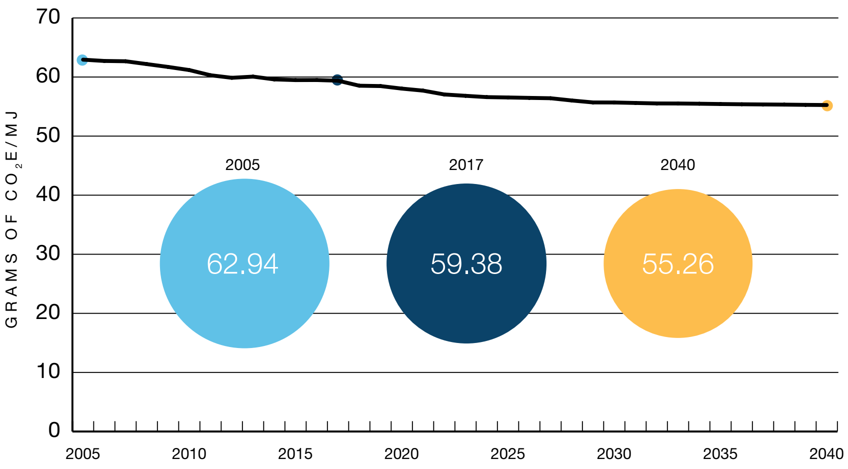
Total demand for fossil fuels increases slowly, with rising natural gas and falling oil and coal use



While total fossil fuel consumption grows in the Reference Case, changing proportions of fossil fuels consumed leads to declining GHGs per unit of fossil fuel energy used, as shown in Figure 31. Deployment of CCS technology in power and industrial facilities also reduces the GHG intensity of fossil fuel use. In 2040, fossil fuel emission intensity is 7% lower than 2017, and 12% lower than 2005. Accounting for reductions in non-combustion emissions, such as reducing methane leaks, as well as including emission credits purchased through international trading mechanisms (like Quebec's emission trading with California) could further decrease emission intensity.

Figure 31

Fossil Fuel Emission Intensity falls due to higher shares of natural gas and less coal



KEY UNCERTAINTIES:
GHG Emissions

Technology development: Future adoption of low carbon technologies could alter the course of fossil fuel demands shown here. Increased deployment of technologies such as carbon capture, use and storage, could weaken the link between fossil fuel use and future emission trends.

Future climate policies: The evolution of climate policies in Canada will be an important factor in fossil fuel combustion and GHG emission trends. Future developments in policies such as carbon pricing, energy and emission regulations, and support for emerging technologies could all alter these fossil fuel projections.

Footnotes

Executive Summary

[1] Additional details on project timing and assumptions can be found in the main report.

[2] Under the Paris Agreement Canada has committed to an economy-wide target to reduce GHG emissions to 30% below 2005 levels by 2030.

Assumptions

[3] For example, the proposed Clean Fuel Standard has been announced, but is not included as proposed regulations are currently under development.

[4] In June 2019, ECCC released the *Proposed Regulatory Approach for the Clean Fuel Standard.* Proposed regulations for the liquid fuel class of the Clean Fuel Standard are expected to be published for consultation in early 2020. Further details on next steps for gaseous and solid fuel class regulations are available from ECCC.

[5] In 2020, EF2019 assumes that the International Maritime Organizations (IMO) sulfur regulations lead to a temporary widening of the WTI-WCS differential at an additional US or C$4/bbl. This represents a global discount for all heavy sour crudes. We assume that this differential shrinks in 2021 to US or C$2/bbl, and US or C$0.5/bbl by 2022.

[6] Capacity factors are the actual energy produced by a generator divided by the maximum possible generation over a given period.

[7] The range around the capital costs is +/- 20%, which reflects the variability across different estimates of current and future wind and solar costs. The ranges around the levelized costs include the variation in capital costs shown in the figure, ranges in other costs and capacity factors shown in Table 2, as well as higher and lower project financing costs.

Results

[8] Macroeconomic projections are developed by Stokes Economics.

[9] On an energy equivalent basis, electric vehicles use less energy to travel a given distance than conventional vehicles, all else being equal. This implies that as electric vehicles gain market share, the offsetting reduction in gasoline demand will be larger than the electricity added, leading to a net reduction. Additional details on electric vehicle efficiency and economics can be found in a recent CER Market Snapshot: *Levelized Costs of driving EVs and conventional vehicles*.

[10] Information on crude oil ultimate potential and remaining reserves is available in the EF2019 Data Appendices.

[11] All non-upgraded bitumen and nearly all conventional heavy oil must be blended with lighter hydrocarbons to reduce its viscosity and allow it to flow on pipelines. Bitumen that is transported by rail is generally blended as well, although sometimes at lower levels than for pipelines. The resulting blend of produced crude oil or bitumen, after accounting for production losses and any diluent recycling, is the net oil supply available for domestic and foreign markets.

[12] This is the volume of Canadian crude oil that is required for feedstock at Canadian refineries. This volume is influenced by a number of factors such as refined product demand and the amount of foreign oil that is processed within Canada. Economics at any particular refinery dictate whether that facility uses Canadian or foreign oil to produce the refined petroleum products needed to meet Canadian and foreign demand.

[13] For more information see *Western Canadian Crude Oil Supply, Markets, and Pipeline Capacity* and *Optimizing Oil Pipeline and Rail Capacity out of Western Canada – Advice to the Minister of Natural Resources*.

[14] Efficiency improvements, improved rail economics, and policy action are all potential uncertainties that could affect rail export volumes and the WCS-WTI differential. Given the many uncertainties, EF2019 assumes a constant WCS-WTI differential in the long term, as shown in Figure 1. However, additional rail volumes could require a wider differential to support them.

[15] This value of natural gas demand is lower than the primary natural gas demand value discussed earlier because it does not include non-marketed natural gas used directly by those that produce it. Examples of this include flared gas, natural gas produced and then consumed by in situ oil sands producers, and natural gas produced and consumed by offshore oil production.

[16] The Renewable Energy Procurement program was originally for 5 000 MW. Of that, 1 400 MW were previously awarded in 3 phases. These contracts remain in place and are included in the projections.

[17] Data sets are available through the Government of Canada's Open Government Portal.

Access and Explore Energy Futures Data

Datasets related to EF2019 are available in a variety of formats and styles at: www.cer-rec.gc.ca/energyfutures

- → **Data behind the figures:**
  All data behind the EF2019 figures is available in a downloadable excel file.
- → **Interactive Data Appendix:**
  The Energy Futures Data Appendix contains downloadable tables arranged by appendix type (macroeconomic drivers, end-use demand, crude oil production, etc.) and report version.
- → **Machine Readable Files:**
  The EF 2019 data can be downloaded all at the same time from Open Gov.

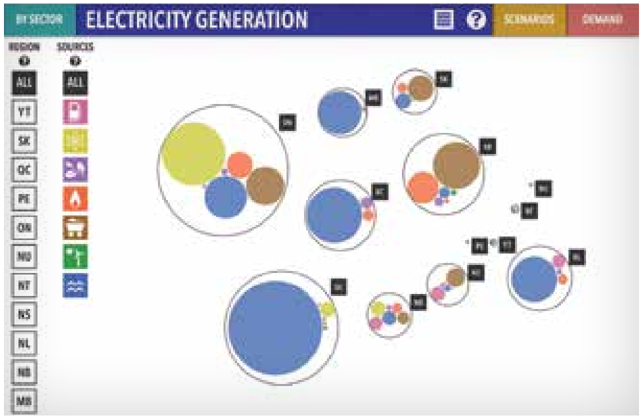
Energy Futures Supplement Datasets

- → Deep dive into the projections with more detailed datasets, including monthly projections, for natural gas and oil production projections:

  NATURAL GAS | NATURAL GAS LIQUIDS | CONVENTIONAL OIL | OIL SANDS
- → Methodology and description for each of these datasets can be found in the EF2018 Supplements.

Explore energy futures – interactive data visualization tool:

Explore Canada's Energy Future with an interactive tool that allows users to visualize, download, and share the data behind the long-term energy outlooks.



Student resources:

The CER, together with Ingenium, developed educational activities based on Canada's forecasted energy demand and supply.

Targeted at high school students between the grades of 9 and 11, the activities encourage students and educators to explore Canada's energy ecosystem using an interactive tool. This tool allows users explore how the future of energy in Canada over the long term. The material and student resources are available.

Data science with open data:

Partnered with Fireside Analytics, this course is an introduction to Data Science with Open Data sets and R Studio. Learners will learn common buzzwords used in Data Science and they will do hands on labs visualizing and analyzing Open Data from the Energy Futures series. This course is designed for learners who are new to computer programming and data science.

About the CER

The Canada Energy Regulator is Canada's independent national energy regulator. The CER's main responsibilities include regulating:

- the construction, operation, and abandonment of pipelines that cross international borders or provincial/territorial boundaries;
- associated pipeline tolls and tariffs;
- the construction and operation of international power lines and designated interprovincial power lines;
- imports of natural gas and exports of crude oil, natural gas, natural gas liquids, refined petroleum products, and electricity; and
- oil and gas exploration and production activities in specified northern and offshore areas.

As part of our Energy System Information Program, the CER is also charged with ensuring Canadians have access to and use energy information for knowledge, research and decision making, community-specific CER-regulated infrastructure information, and opportunities to collaborate and provide feedback on CER information products.

We study market trends, energy transportation, and emerging technologies to better understand the energy landscape in which we work; to provide Canadians with energy information of interest and relevance, and to identify and respond to emerging issues. We provide transparent information about pipeline safety performance, and use tools like interactive pipeline maps and visualizations of our data to make complex pipeline and energy market data user-friendly and accessible.

About this Report

The CER's Energy System Information Program is closely linked to its regulatory responsibilities as defined in the Canadian Energy Regulator. Under Part VI of the Act, the CER regulates the export and import of natural gas as well as the export of natural gas liquids, crude oil and petroleum products, and electricity. The Act requires the CER to ensure that oil and gas exports are surplus to Canadian requirements. The CER monitors energy markets and assesses Canadian energy requirements and trends to support its regulatory responsibilities.
This report, Canada's Energy Future 2019: Energy Supply and Demand Projections to 2040, is the continuation of the Energy Futures series, and projects long-term Canadian energy supply and demand trends.

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If a party wishes to rely on material from this report in any regulatory proceeding before the CER, it may submit the material, just as it may submit any public document. Under these circumstances, the submitting party in effect adopts the material and that party could be required to answer questions pertaining to the material.

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