National Energy Board

Office national de l'énergie

Exploring Canada's Energy Future: Methodology

Exploring Canada's Energy Future is an interactive tool that allows users to visualize, download, and share the data behind the National Energy Board's (NEB) latest outlook, *Canada's Energy Future 2016: Energy Supply and Demand Projections to 2040* (EF 2016). As such, the methodology below refers to the EF 2016 report.

Canada's Energy Future 2016: Energy Supply and Demand Projections to 2040 (EF 2016) report is a continuation of the NEB's *Energy Futures* series. The NEB has been producing long-term supply and demand projections regularly since 1967. The report is the only publicly available Canadian long-term energy outlook that includes all energy commodities in all provinces and territories.

Canada's Energy Future 2016 contains a projection of future energy supply and demand trends in Canada. Given the numerous uncertainties and factors that may affect these trends, the analysis includes six possible future scenarios based on different assumptions.

Canada

Overview

- EF 2016 considers three core cases which are discussed throughout the report:

  o The Reference Case with baseline projections, based on current macroeconomic outlook and a moderate view of energy prices

  o The High and Low Price Cases address uncertainties related to future crude oil and natural gas prices

- Four key assumptions underpin the core cases:

  o All energy production will find markets, and infrastructure will be built as needed

  o Only policies and programs that are law at the time of writing are included in the projections. As a result, any policies under consideration, or new policies developed after the projections were completed in the summer of 2015, are not included in this analysis

  o Environmental and socio-economic considerations beyond the included policies and programs are outside the scope of this analysis

  o Energy markets are constantly evolving. The analysis presented in EF 2016 is based on the best available information at the time of finalizing the analysis and results, which was the summer of 2015

- EF 2016 also introduces three supplemental sensitivity cases which explore issues related to markets and infrastructure:

  o The Constrained Oil Pipeline Capacity Case (Constrained Case) considers the impact on the Canadian energy system if no new major oil pipelines are constructed over the projection period

  o The High Liquefied Natural Gas (LNG) and No LNG Cases consider the uncertainty related to the global LNG market and Canada's ability to compete for market share; considering higher and lower Canadian LNG export volumes than those in the Reference Case

- In developing EF 2016, the NEB met with various energy experts and interested stakeholders, including representatives from industry and industry associations, government, non-governmental organizations, and academia to gather input and feedback on the preliminary projections. The information obtained from these consultations helped shape the key assumptions and final projections.

Model Overview

Energy Futures includes a wide range of projections for Canadian energy supply and demand. These projections are the result of a modeling system consisting of several interactive components (or modules) which produce integrated, future Canadian energy trends. Figure 1 outlines the system in diagram.

Figure 1: Model Flow Chart
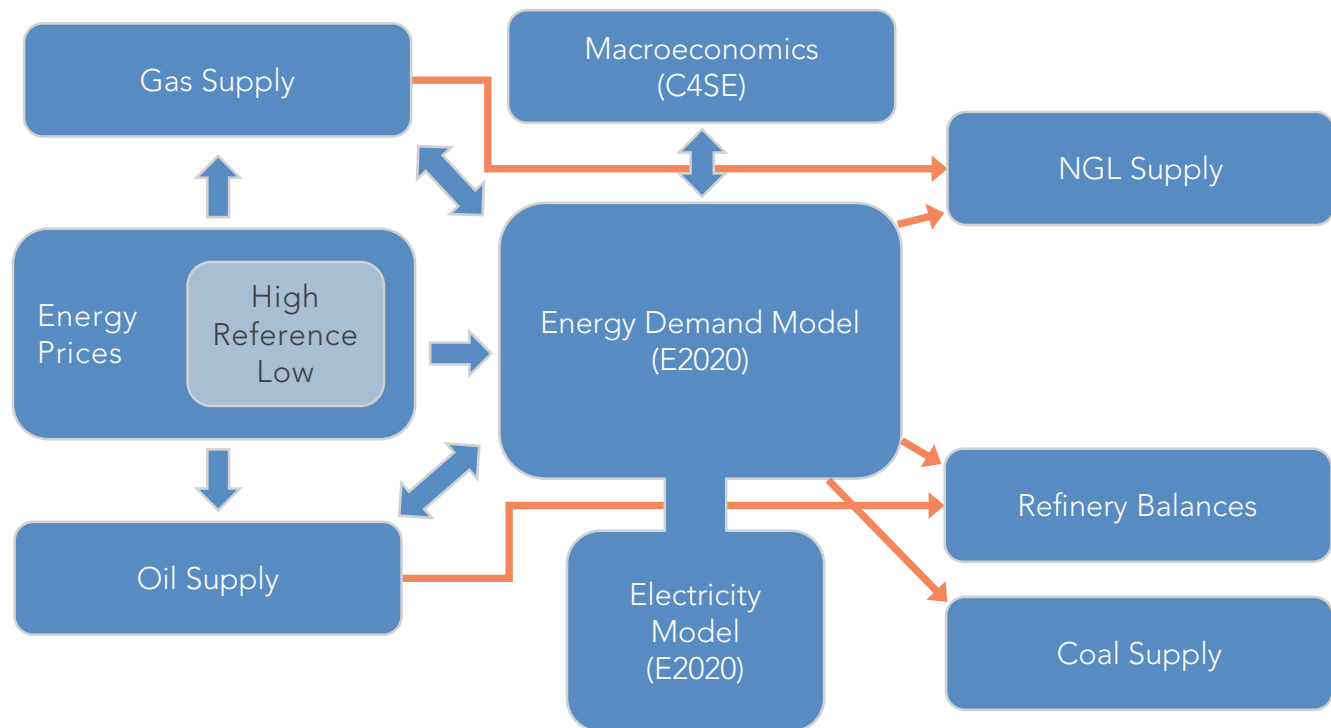
What are the Model's Components?

- **Energy Prices:** The starting point for *Energy Futures* analysis is the development of benchmark crude oil and natural gas price assumptions. These assumptions are based on a survey of projections by other forecasting agencies like the International Energy Agency and the U.S. Energy Information Administration, complemented by internal analysis. It is important to note that these assumptions are not predictions of future crude oil and natural gas prices, but necessary inputs for the analytical process.

- **Oil Supply:** This module provides crude oil production projections for the various regions and crude types in Canada, based on the price assumptions. It includes an oil sands module, and non-oil sands deliverability module for western Canada, and analysis of other regions in Canada.

- **Gas Production:** This module estimates the production of natural gas throughout Canada. The module relies upon the oil and natural gas price assumptions as well as the crude oil production estimate from the oil supply module. The module includes the Western Canadian Sedimentary Basin natural gas deliverability model, as well as project specific analysis for other producing regions ex., off-shore Nova Scotia.

- **Macroeconomics:** EF 2016 macroeconomic projections for each of the scenarios were provided by Centre for Spatial Economics (C4SE). C4SE developed unique projections of key macroeconomic indicators such as gross domestic product, exchange rate, and industry gross output for each of the EF 2016 scenarios, based on the price assumptions and output of the NEB's supply and demand models.

- **Demand and Electricity:** The demand and electricity projections are developed using ENERGY2020: a detailed energy model created by Systematic Solutions Incorporated. It creates projections for energy demand and electricity generation based on historical energy data for parameters such as supply, demand, economic growth, efficiency, prices, and investment.

- **Natural Gas Liquids:** This module provides a modeling framework with estimates of NGL supply and demand in Canada. The module simulates four categories of liquids: ethane, butane, propane, and pentane plus. For each liquid, the module provides estimates of production, supply and demand at the individual provincial/territorial level.

- **Refinery Balances:** This module estimates the disposition of crude oil throughout Canada. Specifically, it reconciles estimates of supply with demand and exports of heavy and light crude oil. It also tracks refinery feedstock requirements and sources within Canada's major refining regions.

- **Coal:** This module estimates the production and disposition of coal in Canada. The module relies upon energy demand data from ENERGY 2020, historical production data from NRCan, and information on proposed coal mining projects.

Additional Information

For additional information on the Energy Futures series, see:

- *The NEB Energy Futures Index*

- *Canada's Energy Future 2016: Energy Supply and Demand Projections to 2040*

- *Canada's Energy Future 2016: Energy Supply and Demand Projections to 2040 Detailed Data Appendices*

- *Canada's Energy Future 2016: Province and Territory Outlooks (pending)*

Definitions and indicators

Canada's Provinces and Territories

All four visualizations display data at the provincial and territorial level. The table below defines the provincial and territorial acronyms and provides some key indicators for the provinces and territories.

Acronym	Full Name	Key Indicators		
		Population (thousands, 2015)	GDP (millions of dollars at current prices, 2014)	Area (km²)
CN	Canada	35 851.8	1 973 043	9 984 670
NL	Newfoundland and Labrador	527.8	33 514	405 212
PE	Prince Edward Island	146.4	6 003	5 660
NS	Nova Scotia	943.0	39 077	55 284
NB	New Brunswick	753.9	32 056	72 908
QC	Quebec	8 263.6	370 064	1 542 056
ON	Ontario	13 792.1	721 970	1 076 395
MB	Manitoba	1 293.4	64 077	647 797
SK	Saskatchewan	1 133.6	82 780	651 036
AB	Alberta	4 196.5	375 756	661 848
BC	British Columbia	4 683.1	237 188	944 735
YK	Yukon	37.4	2 603	482 443
NT	Northwest Territories	44.1	4 731	1 346 106
NU	Nunavut	36.9	2 487	2 093 190

Sources: **Population:** Statistics Canada   **GDP:** Statistics Canada   **Land Mass:** Natural Resources Canada, GeoAccess Division

Supply and Demand Categories

- **Total Demand:** The total energy used in the four sectors of Canada's economy: residential, commercial, industrial and transportation. Includes the use of electricity, natural gas, petroleum products such as gasoline, coal, and renewable fuels. Also referred to as end-use or secondary demand, it does not include the energy used to generate electricity.

- **Electricity Generation:** The amount of electric energy produced by transforming other forms of energy. In Canada, electricity is generated from hydro, other renewables like wind and solar, thermal sources like natural gas and coal, and nuclear power.

- **Oil Production:** The amount of crude oil produced in Canada. Crude oil is produced from various areas using different technologies. This includes mined and in situ bitumen from the oil sands, conventional light and heavy oil produced in the Western Canadian Sedimentary Basin, condensate, and oil produced from off-shore platforms on the east coast.

- **Natural Gas Production:** The amount of marketable natural gas produced in Canada. Natural gas is produced from various areas using different technologies. This includes tight, shale, coal bed methane, conventional, and natural gas produced along with oil from oil wells (also called associated or solution gas).

Energy Sources

For detailed technical definitions for these and other energy terms, see the Definitional Cross Reference created for the North American Cooperation on Energy Information.

Crude Oil: contains conventional light and heavy crude oil, condensate, oil sands bitumen (mined and in situ).

Oil Products: Includes refined petroleum products and natural gas liquids. Specifically this includes: motor gasoline, diesel, aviation fuel, light fuel oil, kerosene, heavy fuel oil, propane, butane, ethane, petroleum coke, still gas, and non-energy products such as lubricants, asphalt, and petrochemical feedstocks.

Natural Gas: Production refers to dry marketable gas production. Total consumption of gas includes some non-marketed producer consumption. In Canada it is produced from conventional, tight, shale, and coal bed methane resources, as well is produced along with crude oil production (also known as solution or associated gas).

Coal: Includes coal, coke, and coke oven gas.

Electricity: End-use electric energy that is generated from a variety of sources and technologies. Includes generation primary electricity sources such as nuclear, hydro, and other renewables, and thermal generation from other fuels such as natural gas, coal, and oil.

Hydro: Amount of electricity generated by hydro power plants.

Nuclear: Amount of electricity generated by nuclear power plants.

Biomass and Biofuels: Includes solid biomass fuels such as wood pellets, as well as liquid biofuels such as ethanol and biodiesel.

Solar/Wind/Geothermal: For electricity generation this includes the electric energy generated from wind, solar, and geothermal sources. At an end-use level, it includes thermal uses such as solar hot water heating and geothermal space heating.

Units

Energy Units

- **Petajoule:** A measure of energy that is a quadrillion (1015) joules. According to Statistics Canada, a petajoule is the approximate amount of energy it takes to run the Montreal Metro for one year.

- **Thousand Barrels of Oil Equaivalent per Day (kBOE/d):** A measure of energy normalized to the equivalent energy content of a barrel of light crude oil. One barrel of oil equivalent is equal to 6.811 joules[1], while one petajoule is equal to 0.4475 kBOE/d.

- **GW.h:** A measure of electric energy that is a billion (109) watt hours of electric energy per year. One GW.h is equal to 0.0036 petajoules and 0.0016 kBOE/d.

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[1]   Consistent with the conversion used in the Inter-America Development Bank Energy Database project.

Volumetric Units

- **Thousand Barrels per Day (kb/d):** Number of barrels of crude oil produced per day.

- **Thousand m3 per day (103m3/d):** Number of cubic metres of crude oil produced per day. One barrel of oil is equal to 0.159 cubic metres.

- **Million Cubic Feet Per Day (Mcf/D):** Number of cubic feet of natural gas produced per day.

- **Million Cubic Metres Per Day (106m3/d):** Number of cubic metres of natural gas produced per day. One cubic foot of natural gas is equal to 0.0283 cubic metres.

Sectors

- **Residential:** This is the energy consumed by Canadian households. It includes energy used for space and water heating, air conditioning, lighting, large appliances, and other energy-using devices like televisions and computers.

- **Commercial:** A broad category including offices, stores, warehouses, government and institutional buildings, utilities, communications, and other service industries. It also includes energy consumed by street lighting and pipelines. Buildings use energy for space and water heating, air conditioning, lighting, appliances and other devices. Pipelines use energy to power pumps or compressors that move oil and natural gas through pipelines.

- **Industrial:** This sector includes manufacturing, forestry, fisheries, agriculture, construction, mining, and oil and natural gas extraction. In 2013, 81 per cent of industrial energy was consumed by a number of energy-intensive industries like iron and steel, aluminum, cement, chemicals and fertilizers, pulp and paper, petroleum refining, mining, and oil and natural gas extraction.

- **Transportation:** Includes passenger and freight on-road transportation, as well as air, rail, marine, and non-industrial off-road travel, such as recreational all-terrain vehicles and snowmobiles. Demand in the transportation sector includes foreign energy used on Canadian soil, airspace and waters.

Scenarios

EF 2016 contains a projection of future energy supply and demand trends in Canada. Given the numerous uncertainties and factors that may affect these trends, the analysis includes six future scenarios based on different assumptions. This outlines how future trends can be impacted by different factors, and how current uncertainties might affect long-term outcomes.

The projections in EF 2016 include a Reference Case, two price sensitivity cases and three supplemental sensitivity cases:

- The Reference Case provides a baseline outlook, based on a moderate view of future energy prices and economic growth.

- A price case with higher oil and natural gas prices capture some of the uncertainty related to future energy prices.

- A price case with lower oil and natural gas prices capture some of the uncertainty related to future energy prices.

- Considers a case where no new major oil pipelines are built over the projection period to address uncertainties related to future oil export infrastructure.

- The uncertainty related to eventual volumes of liquefied natural gas (LNG) exports is explored in two additional cases.

An overview of the cases, key assumptions, and drivers are shown in Figure 2.

Figure 2: Overview of EF 2016 Projections and Key Assumptions

Baseline	Reference Case Consensus economic growth and moderate energy price projections	• Crude oil price is $82 in 2020 and $107 in 2040. • Natural gas prices reach $3.85 in 2020 and $4.55 in 2040. • Canadian GDP increases by an average of 1.7%/year, while population grows 0.8%/year. • Markets for Canadian energy exports exist and infrastructure is built a needed. • LNG Exports from B.C. are 2.5 Bcf/d after 2023.
Oil and Natural Gas Price Uncertainty	High Price Case Higher oil and natural gas prices Low Price Case Lower oil and natural gas prices	• In the High Price Case, crude oil prices reach $105 in 2020 and $134 in 2040, while natural gas prices reach $4.53 in 2010 and $5.76 in 2040. Canadian GDP is 2.1 per cent higher than the Reference Case in 2040. • In the Low Price Case, crude oil prices reach $56 in 2020 and $80 in 2040, while natural gas prices reach $3.05 in 2020 and $3.54 in 2040. Canadian GDP is 1.2 per cent lower than the Reference Case in 2040.
Oil Transport Uncertainty	Constrained Oil Pipeline Capacity Case No new major crude oil pipelines	• Canadian crude oil export pipeline capacity is limited to 4.0 MMb/d after 2019. • Rail provides the only additional export capacity, but at a higher cost than pipeline. This reduces Canadian light and heavy crude oil prices relative to North American and international benchmark prices, putting downward pressure on crude oil investment and production in Canada.
LNG Market Uncertainty	High LNG Case Higher LNG exports from Canada No LNG Case No LNG exports from Canada	• In the High LNG Case, Canadian LNG exports from B.C. reach 4.0 Bcf/d in 2022, and increase to 6.0 Bcf/d by 2030. • In the No LNG Case, there are no LNG export facilities built over the projection period. • In all cases, the LNG export volumes do not refer to a specific project and are only assumptions.

Crude Oil Prices: Brent, 2015 US$, **Natural Gas Prices:** Henry Hub, 2015 US$, **Gross Domestic Product (GDP):** 2007$ C$

Data Sources

Energy Demand

The primary source for historical energy demand data is Statistics Canada's Report on Energy Supply and Demand and associated CANSIM data tables. These values are disaggregated at an end-use level using NRCan's National End-use Database. The dataset is also supplemented with data from Environment Canada, and various provincial and territorial sources such as the Alberta Energy Regulator, BC Hydro, Alberta Electric System Operator, and Ontario's Independent Electric System Operator.

Electric Generation

The primary source for electric generation data comes from Statistics Canada. It is supplemented by additional data from provincial governments, utilities, and system operators, as well as industry associations (such as CanWEA and CanSIA).

Crude Oil and Natural Gas Production

Data for crude oil and natural gas production comes from a variety of sources. These include NEB analysis of Divestco well data, provincial and territorial governments, the Alberta Energy Regulator, and Canadian Association of Petroleum Producers.

Access to Data

Data may be downloaded through the Exploring Canada's Energy Futures online tool. As well, the full data sets, in addition to the visualization source code, may be downloaded from the Government of Canada's Open Data site.

The National Energy Board is an independent federal regulator of several parts of Canada's energy industry with the safety of Canadians and protection of the environment as its top priority. Its purpose is to regulate pipelines, energy development and trade in the Canadian public interest. For more information on the NEB and its mandate, please visit www.neb-one.gc.ca.