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# ENERGY FACT BOOK 2017–2018

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# PREFACE

The purpose of the *Energy Fact Book* is to provide key information on energy markets in Canada in a format that is easy to consult.

This edition is based on data and information available as of June 2017. All data is subject to revisions by statistical sources. In some instances, more than one source may be available and discrepancies in numbers may occur because of conceptual or methodological differences. In addition, some numbers may not add up precisely due to rounding.

This publication was assembled by the Energy and Economic Analysis division of the Energy Policy branch with the help of subject experts from across the Energy sector, the Minerals and Metals sector, the Innovation and Energy Technology sector and other sectors of Natural Resources Canada.

Questions or comments, contact NRCan at
**nrcan.energyfacts-faitsenergetiques.rncan@canada.ca**

[i] In this publication, energy industries are generally considered to include oil and gas extraction; coal mining; uranium mining; electric power generation, transmission and distribution; pipeline transportation; natural gas distribution; biofuels production; petroleum refineries; and support activities for oil and gas extraction. Clean energy industries such as renewable and nuclear electricity generation, biofuels production and carbon capture and storage facilities are contained within the definition of energy industries. Some energy-related industries (e.g. petroleum product wholesaler-distributors and coal product manufacturing) are excluded because of a lack of data.

## CONTENTS

# INTRODUCTION

From an energy perspective, Canada is very fortunate. We have a large land mass, small population and one of the largest and most diverse supplies of energy in the world. Our rivers discharge close to 7% of the world's renewable water – a tremendous source of hydroelectric power. We have the third-largest global supply of proven oil reserves and third-largest supply of uranium; our energy resources are a source of strength that continues to shape our economy and society.

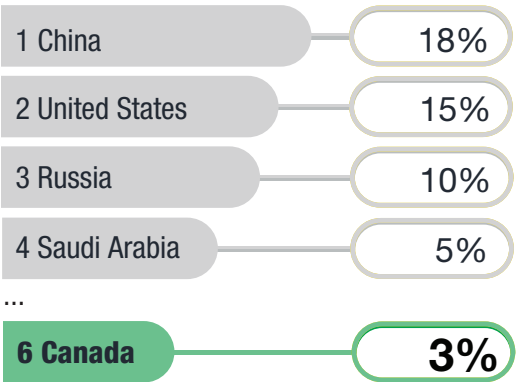
Canada is at the forefront of innovative technologies for how we produce and use energy. For example, low-or non-emitting forms of energy are growing in significance as part of our evolving electricity mix. In fact, wind and solar photovoltaic energy are the fastest-growing sources of electricity generation in Canada. In addition, technological advancements, such as co-generation, have resulted in an increase in energy-efficient practices and a reduction in GHG emissions in areas such as the oil sands. Ongoing developments in areas such as grid-scale electricity storage, carbon capture and storage, and electric and alternative fuel vehicles have the potential to further transform the energy system.

# ENERGY AND THE ECONOMY

# CANADA: A GLOBAL ENERGY LEADER

The amount of primary energy produced by Canada in 2014 is **25% more** than in 2000. The world, on average, has increased energy production by **over 37%** in the same period.

**TOTAL PRIMARY ENERGY PRODUCTION**
**TOP ENERGY PRODUCERS, 2014**




**GLOBAL ENERGY RANKINGS FOR CANADA**

| | Proved Reserve / Capacity | Production | Exports |
|---|---|---|---|
| Crude Oil | 3 | 4 | 3 |
| Uranium | 3 | 2 | 2 |
| Hydroelectricity | 4 | 2 | - |
| Electricity | 7 | 6 | 3 |
| Coal | 15 | 12 | 8 |
| Natural Gas | 17 | 4 | 4 |

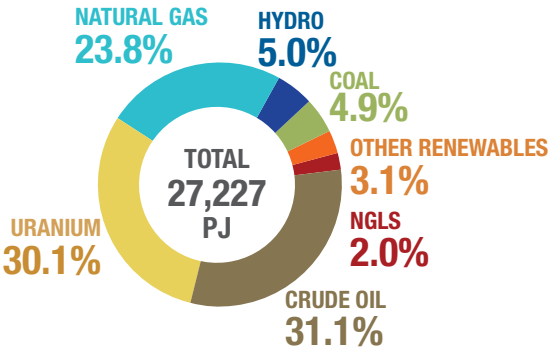
# CANADIAN ENERGY PRODUCTION

Primary energy is energy that is found in nature before any processing or conversion. The *Energy Fact Book* calculates primary energy production using two methods. Method one treats the energy embodied in uranium as primary energy, thereby capturing the uranium Canada produces and then exports. Method two—also employed by the IEA, EIA and others—treats domestic electricity production from nuclear energy as primary energy. Uranium is energy-dense, and Canada exports most of its uranium production, which explains why the two methods produce such different results.

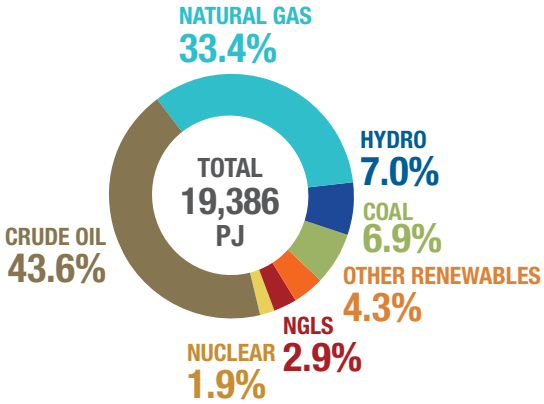
Previous editions of the *Energy Fact Book* have only presented method two, but method one provides a more accurate picture of energy production in Canada.

## PRIMARY ENERGY PRODUCTION BY SOURCE (2015)

### METHOD 1

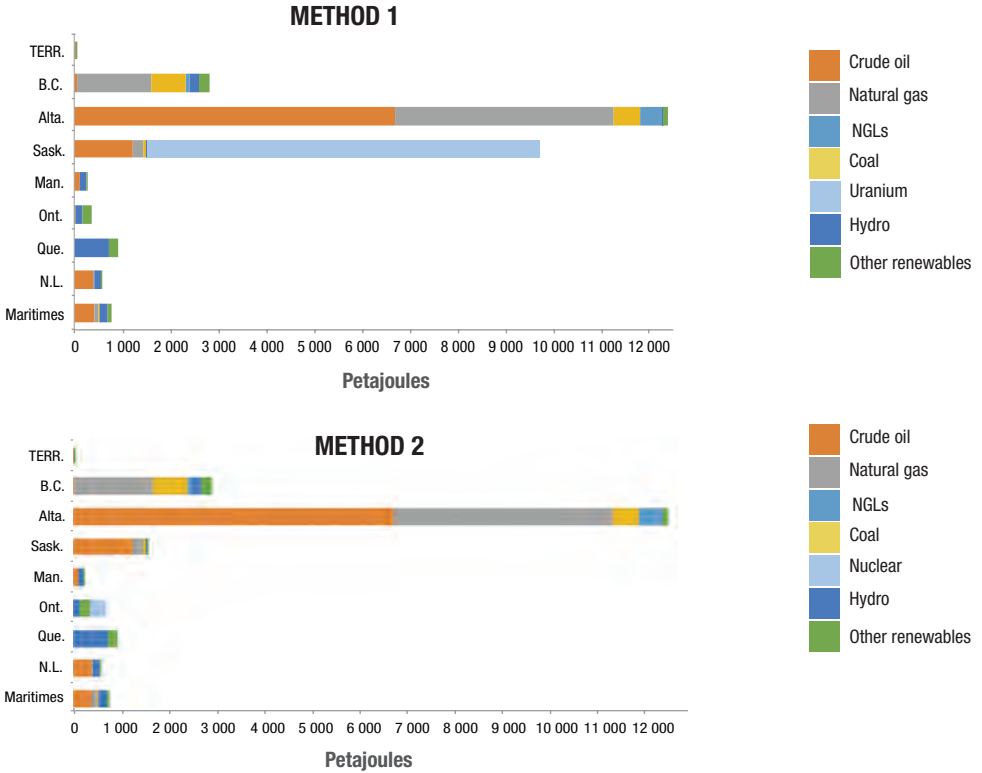



### METHOD 2




"Other renewables" includes wind, solar, wood/wood waste, biofuels and municipal waste.

## PRIMARY ENERGY PRODUCTION BY REGION AND SOURCE (2015)



## EXPORTS IN 2016

**$85.7 billion**

**18%**
of Canadian domestic merchandise

Oil and gas domestic exports totaled
**over $75 billion**

of which
**97%** were to the U.S.

exports energy products to
**144** countries

The U.S. accounts for
**92%**
of energy exports by value ($78.5 billion)

## IMPORTS IN 2016

**$35.9 billion**

**7%**
of Canadian merchandise

imported energy products from
**107** countries

The U.S. accounts for
**65%**
of energy imports by value ($23.2 billion)

# CANADA – U.S. ENERGY TRADE IN 2016

**Exports to U.S.**
**(% of Canadian production)**

| | |
|---|---|
| Crude oil | 79 |
| Natural gas | 53 |
| Uranium | 31 |
| Petroleum products | 21 |
| Electricity | 11 |
| Coal | 2 |

**Exports to U.S.**
**(% of U.S. consumption)**

| | |
|---|---|
| Crude oil | 20 |
| Natural gas | 11 |
| Uranium | 22 |
| Petroleum products | 2 |
| Electricity | 2 |
| Coal | 0.1 |

**Imports from U.S.**
**(% of Canadian consumption)**

| | |
|---|---|
| 27 | Crude oil |
| 19 | Natural gas |
| 9 | Petroleum products |
| 2 | Electricity |
| 17 | Coal |

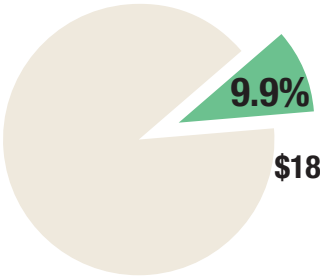
**Exports to U.S.**
**(% of U.S. imports)**

| | |
|---|---|
| 41 | Crude oil |
| 97 | Natural gas |
| 25 | Uranium |
| 25 | Petroleum products |
| 90 | Electricity |
| 11 | Coal |

## NOMINAL GROSS DOMESTIC PRODUCT

### ENERGY'S NOMINAL GDP CONTRIBUTION FOR CANADA

**NOMINAL GDP (% OF CURRENT DOLLARS), 2016**




**or**
**$187 billion**

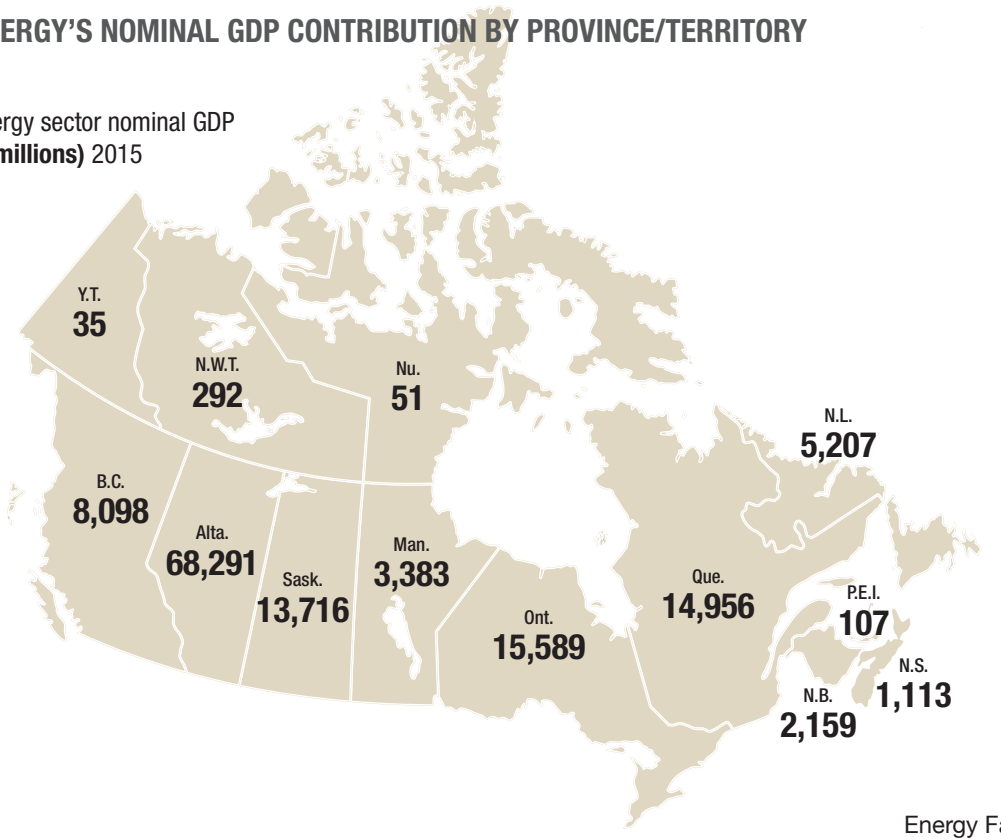
**CANADIAN GDP**

**ENERGY DIRECT 6.7% ($127 billion)**
- CRUDE OIL 2.2%
- ELECTRICITY 1.8%
- OTHER 2.7%

**ENERGY INDIRECT 3.2% ($61 billion)**
- CONSTRUCTION 1.7%
- OTHER 2.5%

## ENERGY'S NOMINAL GDP CONTRIBUTION BY PROVINCE/TERRITORY

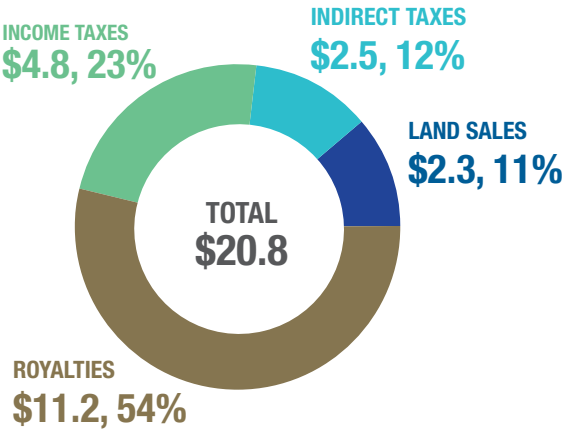
Energy sector nominal GDP
**($ millions)** 2015



## GOVERNMENT REVENUES

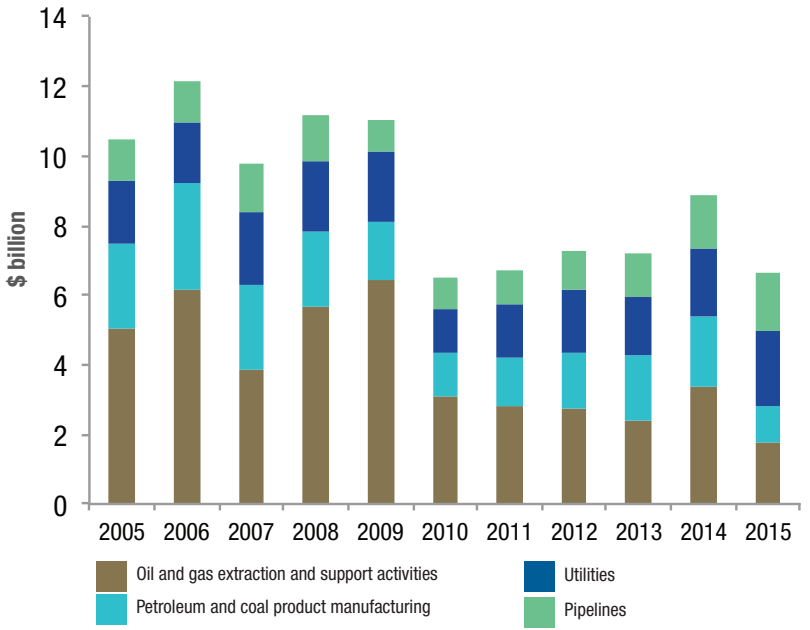
Federal and provincial/territorial governments in Canada receive direct revenues from energy industries through corporate income taxes, indirect taxes (such as sales and payroll taxes), crown royalties – which are the share of the value of oil and gas extracted that is paid to the Crown as the resource owner – and crown land sales, which are paid to the Crown in order to acquire the resource use for specific properties.

**GOVERNMENT ENERGY REVENUE, 2011–2015 AVERAGE ($ BILLIONS)**




- The largest share of government revenues is collected from the oil and gas industry, which averaged **$19.0 billion** over the last five years, including **$16.1 billion** from upstream oil and gas extraction and its support activities.
- Between 2011 and 2015, the energy sector's share of total taxes paid by all industries was **9%** and brought in **over 12%** of all operating revenues earned in Canada.

## TOTAL TAXES PAID BY ENERGY INDUSTRIES

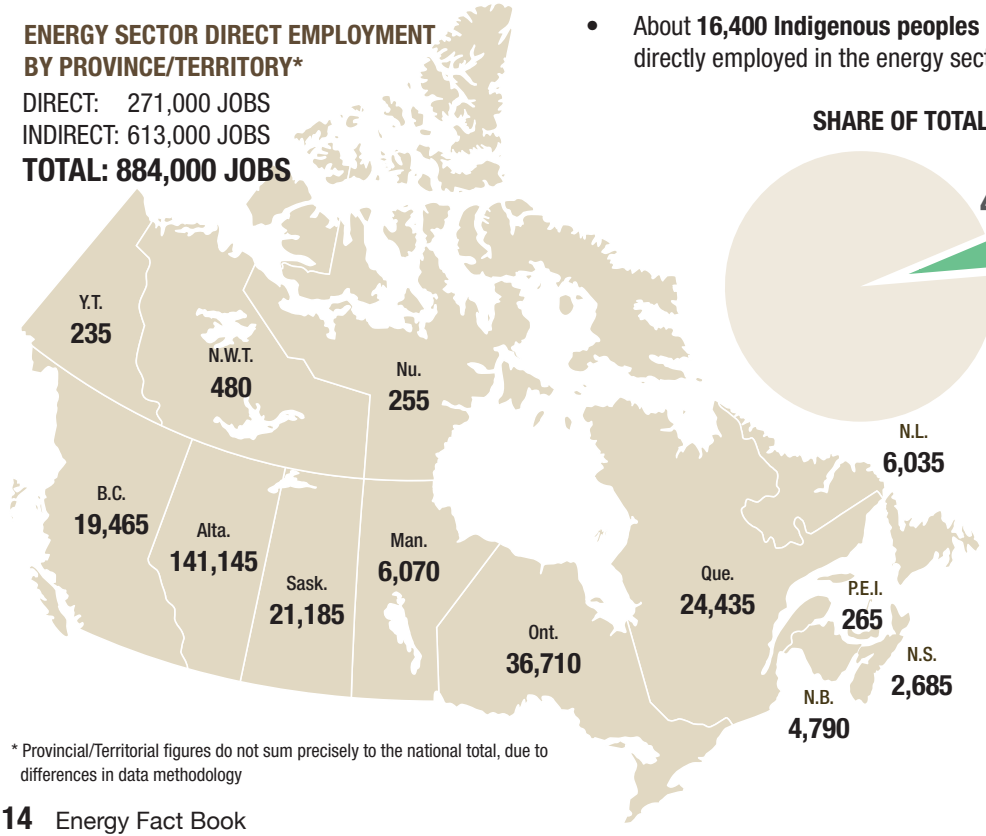



The amount of taxes paid by oil and gas companies fell by around **50%** in 2010 and again in 2015 as a result of declines in oil and gas prices.

# EMPLOYMENT IN CANADA'S ENERGY SECTOR

## ENERGY SECTOR DIRECT EMPLOYMENT BY PROVINCE/TERRITORY*

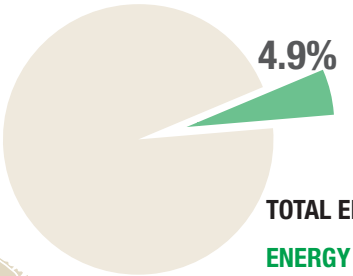
DIRECT: 271,000 JOBS
INDIRECT: 613,000 JOBS
**TOTAL: 884,000 JOBS**




* Provincial/Territorial figures do not sum precisely to the national total, due to differences in data methodology

- About **16,400 Indigenous peoples** living off-reserve are directly employed in the energy sector.

**SHARE OF TOTAL EMPLOYMENT, 2016**



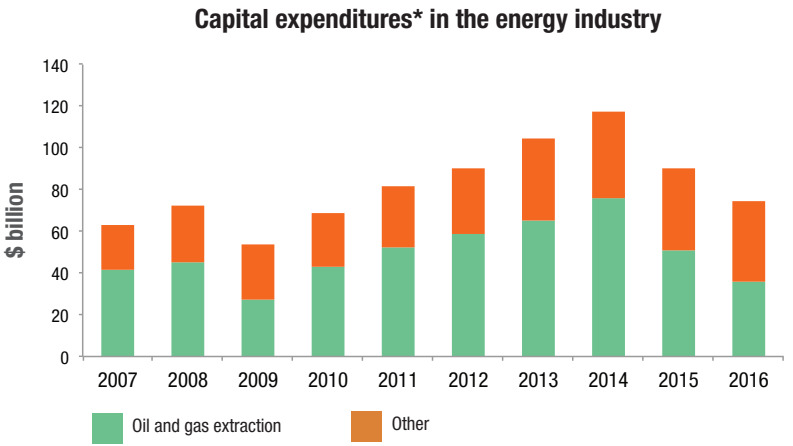

**TOTAL EMPLOYMENT**

**ENERGY DIRECT 1.5%**
- CRUDE OIL 0.4%
- ELECTRICITY 0.4%
- OTHER 0.7%

**ENERGY INDIRECT 3.4%**
- CONSTRUCTION 1.8%
- OTHER 1.6%

# INVESTMENT

## CAPITAL EXPENDITURES

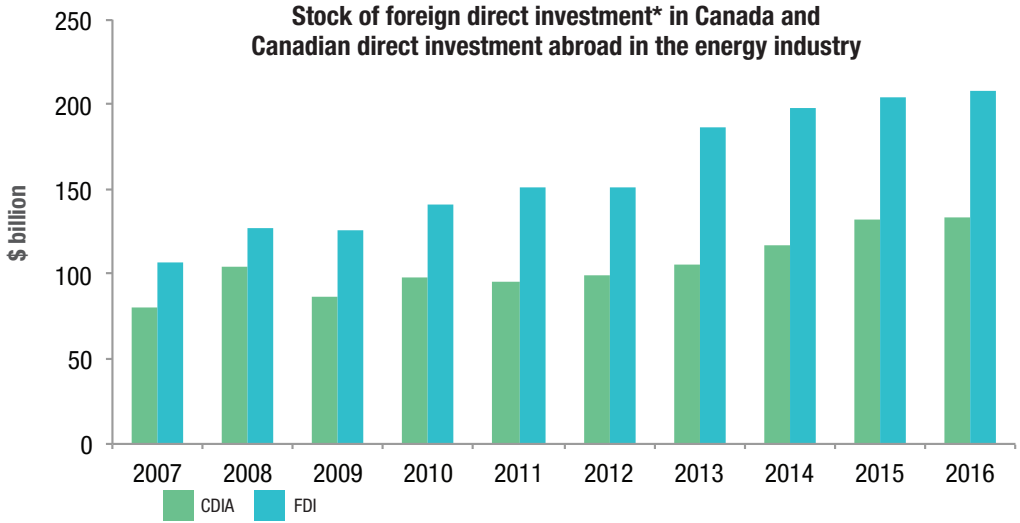



- Capital expenditures in Canada's energy sector totalled **$75 billion** in 2016, a decrease of **36%** from their peak in 2014.
- Energy accounted for **29%** of total investments of **non-residential machinery and equipment** in Canada.
- Oil companies cut back investment in 2015 and 2016 to deal with the short-term financial impact of lower oil prices.

*excludes residential expenditures and intellectual property investments such as exploration expenses

## INTERNATIONAL INVESTMENTS AND INVESTORS

Canada's energy industries operate in free markets, where investments by both Canadian and foreign companies ensure an efficient, competitive and innovative energy system.



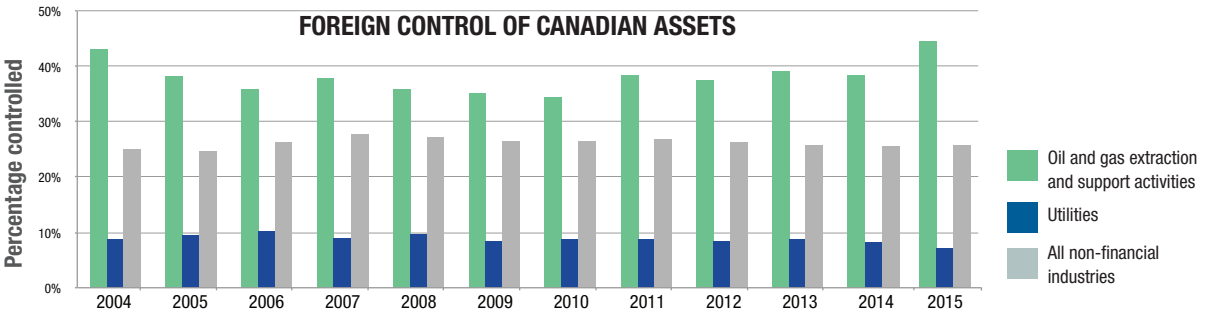

* Direct investment is defined as a company owning voting equity interest in a foreign enterprise and is measured as the total equity value at the time of acquisition.

## STOCK OF FOREIGN DIRECT INVESTMENT IN CANADA AND CANADIAN DIRECT INVESTMENT ABROAD

- The stock of **foreign direct investment** (FDI) in the energy sector reached **$208 billion** in 2016, up from **$107 billion** in 2007.
- The energy industry's share of overall FDI in Canada was **25%** in 2016, up from **21%** in 2007.
- The stock of Canadian direct investment abroad (CDIA) reached **$134 billion** in 2016, up from **$80 billion** in 2007.
- Investment in oil and gas extraction accounted for **$63 billion** of the CDIA stock in 2016.

## FOREIGN CONTROL OF CANADIAN ASSETS

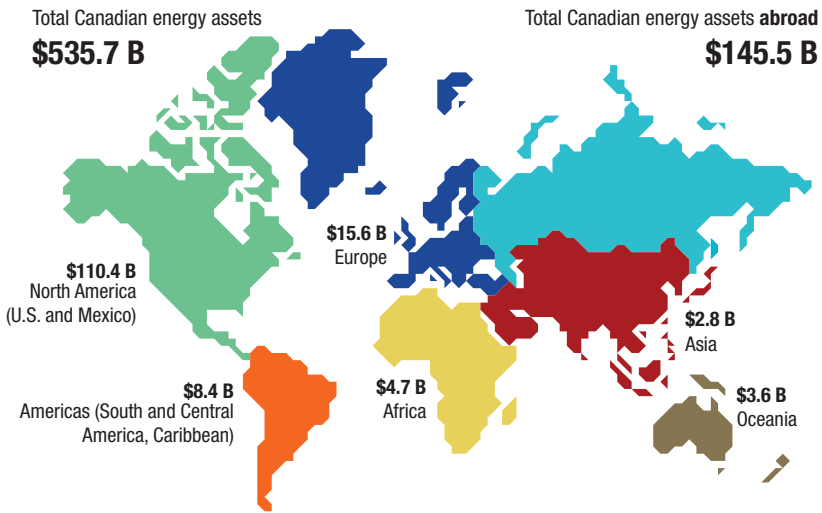
Foreign control is a measure of the extent to which foreign entities operate in Canada. Generally, a corporation is deemed to be foreign-controlled if **more than 50%** of its shares are owned by one or more foreign companies.



## CANADIAN ENERGY ASSETS

The total value of Canadian* energy assets (CEA) fell slightly in 2015 to **$535.7 billion**, a decrease of **2% from $548.4 billion** in 2014. In 2015, domestic CEAs totalled **$390.2 billion**, **down from $397.3 billion** in 2014, while Canadian energy assets abroad totalled **$145.5 billion**, **down from $151.1 billion**. Assets abroad accounted for **27% of total assets.**

### CANADIAN ENERGY ASSETS BY REGION 2015




* A Canadian company is here defined as a publicly traded company headquartered in Canada and not foreign-controlled.

# RESEARCH, DEVELOPMENT AND DEMONSTRATION

## CANADIAN EXPENDITURES ON TOTAL ENERGY RD&D

In 2015/16, federal energy RD&D expenditures were **$500 million** and provincial/territorial* (P/T) government energy RD&D expenditures were **$394 million** for a combined total of **$894 million**, down from **$936 million** in 2014/15:

In 2015/16, an increase in federal spending was more than offset by a decrease in P/T spending.

Canadian federal departments, agencies and organizations increased their Mission Innovation-related expenditures to **$479 million** in 2015/16, or **24% higher** than the baseline level in 2014/15.

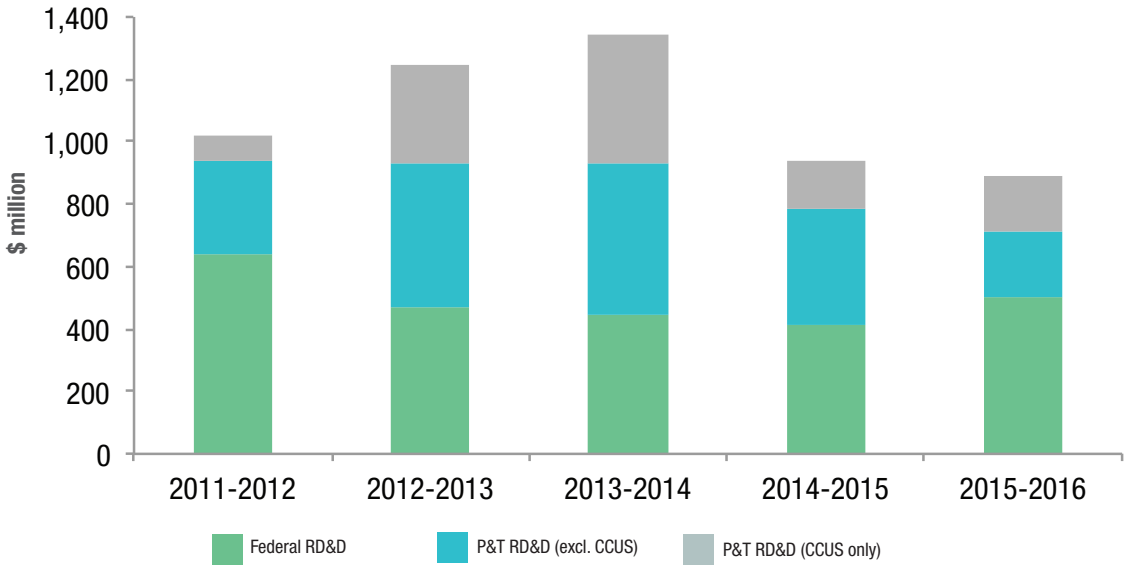
The Canadian industry spent about **$2.1 billion on energy RD&D** in 2014, a slight increase from **$2.0 billion** in 2013.

A subset** of this data is used to report Canada's progress under Mission Innovation, an international initiative of **23 governments** aimed at accelerating global clean energy innovation.

*Provincial and territorial includes utilities and other publicly owned entities.

** Canada's Mission Innovation baseline of $387 million is a subset of Canada's federal energy RD&D spending of $416 million in 2014/15 that excludes nuclear activities not directly related to clean energy RD&D.

## CANADIAN PUBLIC EXPENDITURES ON ENERGY RD&D



## EXPENDITURES ON TOTAL ENERGY RD&D BY TECHNOLOGY AREA ($ MILLIONS)

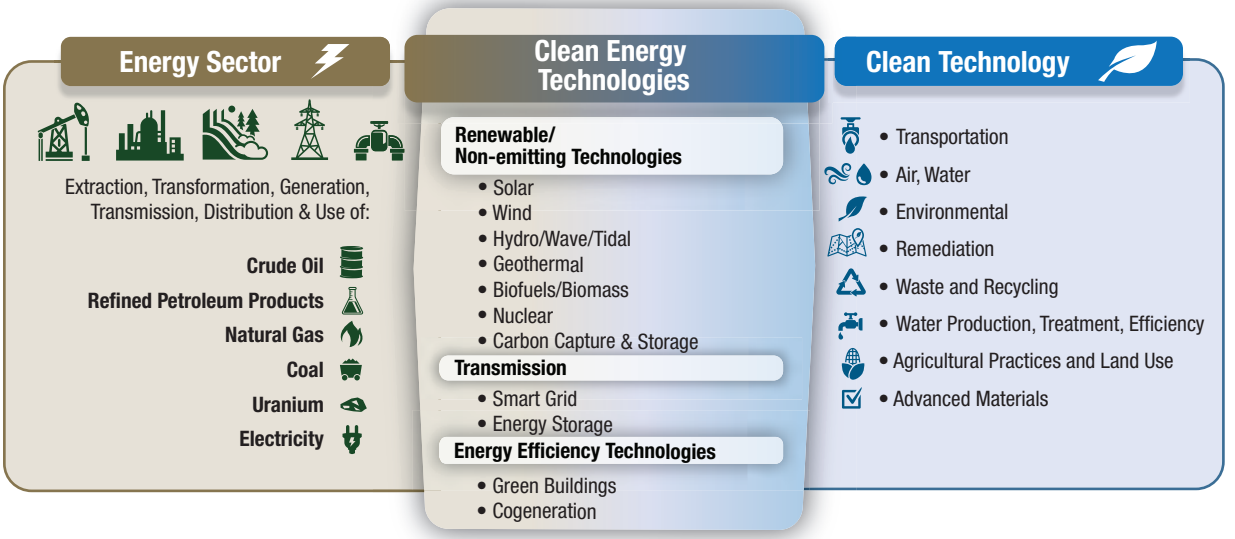
| | Federal (2015/16) | Provincial & Territorial (2015/16) | Industry (2014) |
|---|---|---|---|
| Fossil fuels (including CCUS) | 92 | 228 | 1,392 |
| Renewable and clean energy | 243 | 113 | 509 |
| Energy end use | 165 | 52 | 186 |
| **Total*** | **500** | **394** | **2,087** |

* Totals may not be exact due to rounding.
Renewable and clean energy supply includes renewable and nuclear energy.
Energy end use includes energy efficiency related to transport, industry and buildings and communities.

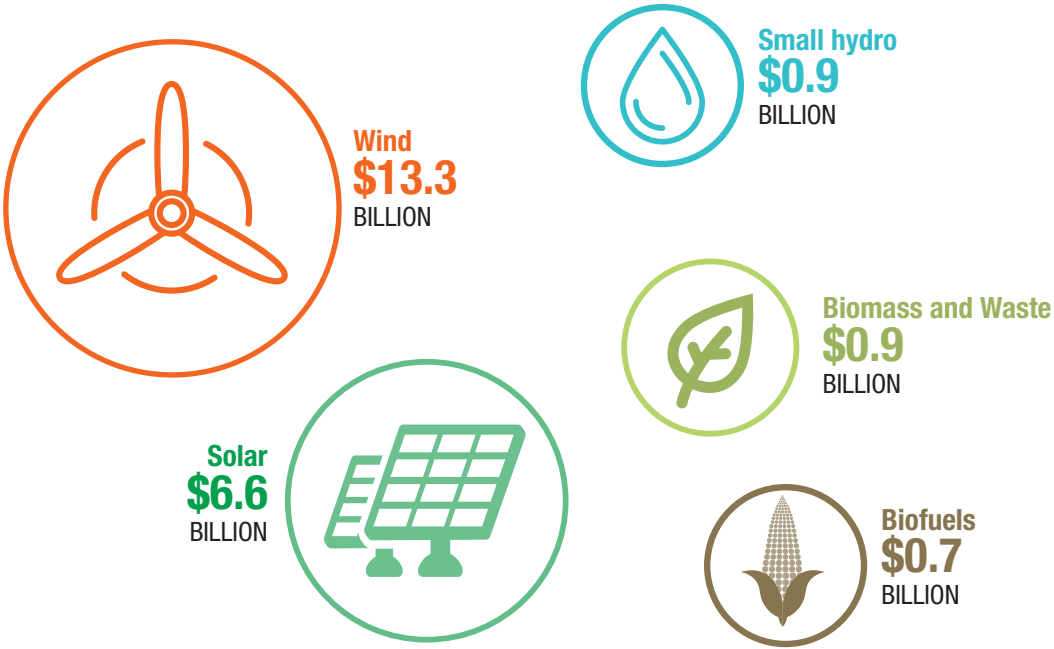
## INVESTMENT IN CLEAN TECHNOLOGY

- Clean technology is an emerging sector, and data that comprehensively captures Canadian clean technology investments—and the clean energy portion of these investments—is not yet available.
- In 2017, the federal government invested in a *Clean Technology Data Strategy,* which broadly defines clean technology as any process, product or service that reduces environmental impacts through environmental protection activities through the sustainable use of natural resources or through the use of goods that have been specifically modified or adapted to be significantly less energy- or resource-intensive than the industry standard.
- The majority of cleantech companies are early stage firms and small- and medium-sized enterprises.
- The TSX and TSX-Venture exchanges list **98 companies** in the **cleantech[1] sector**, with a total market capitalization of **$42 billion**. **Eighty-six of those companies are headquartered in Canada**, with a total market cap of **$38 billion** (as of May 31, 2017).

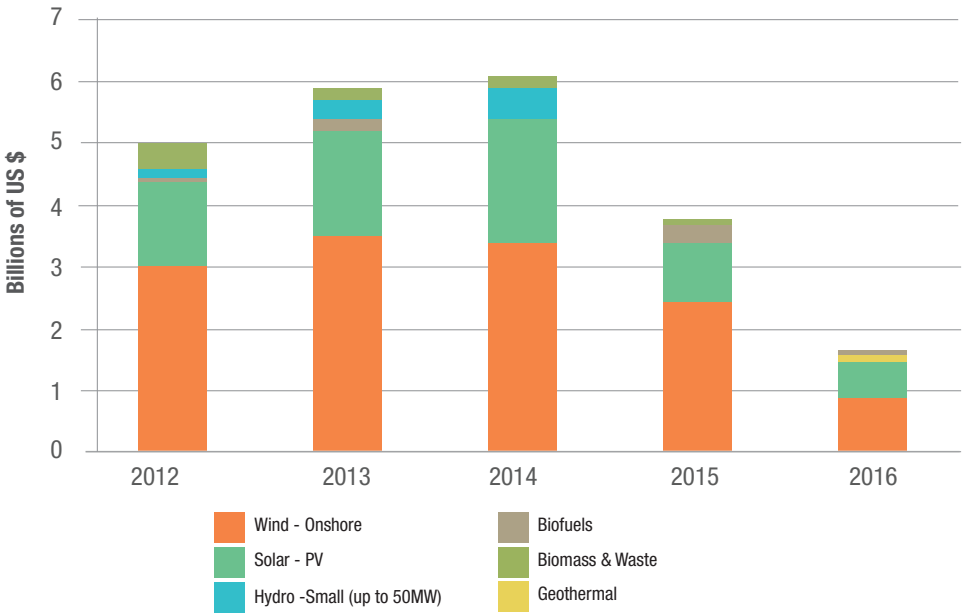
[1] Includes companies whose operations fall under Energy Efficiency, Low-Impact Material and Products, Renewable Energy Equipment.


Energy Sector
Extraction, Transformation, Generation, Transmission, Distribution & Use of:
Crude Oil
Refined Petroleum Products
Natural Gas
Coal
Uranium
Electricity
Clean Energy Technologies
Renewable/ Non-emitting Technologies
• Solar
• Wind
• Hydro/Wave/Tidal
• Geothermal
• Biofuels/Biomass
• Nuclear
• Carbon Capture & Storage
Transmission
• Smart Grid
• Energy Storage
Energy Efficiency Technologies
• Green Buildings
• Cogeneration
Clean Technology
• Transportation
• Air, Water
• Environmental
• Remediation
• Waste and Recycling
• Water Production, Treatment, Efficiency
• Agricultural Practices and Land Use
• Advanced Materials

## SPENDING ON RENEWABLE ENERGY BY TECHNOLOGY IN CANADA, 2012 – 2016



## CLEAN ENERGY INVESTMENTS IN CANADA, 2012 TO 2016 [1]




[1] Not including large hydro

## ENERGY IN OUR DAILY LIVES

Canadian households use energy every day – to power lights and appliances, heat or cool spaces, run personal vehicles, recharge electronics and more.

- **83%** of residential energy consumption is used for space and water heating.
- Residential energy efficiency improved by **47%** between 1990 and 2014, **saving 672 PJ** of energy and **$12 billion in energy costs**.

**Residential energy use increased almost**

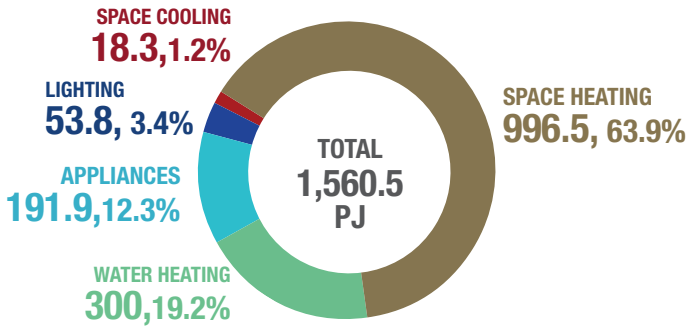
**9.5%** since 1990,

**but would have increased by**

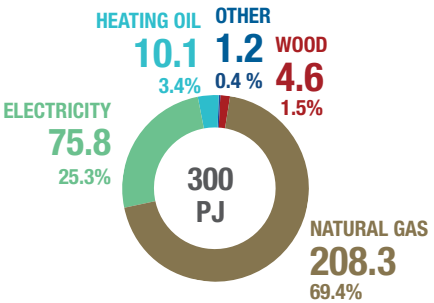
**57%**

without energy efficiency improvements.

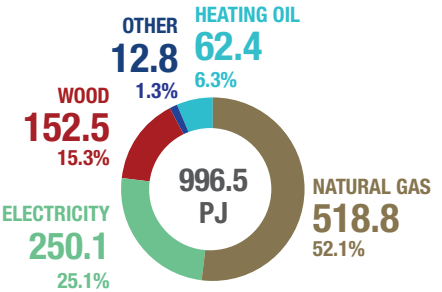
## RESIDENTIAL APPLIANCES ENERGY USE (PJ), 2014




## WATER-HEATING ENERGY USE (PJ), 2014




## SPACE-HEATING ENERGY USE (PJ), 2014

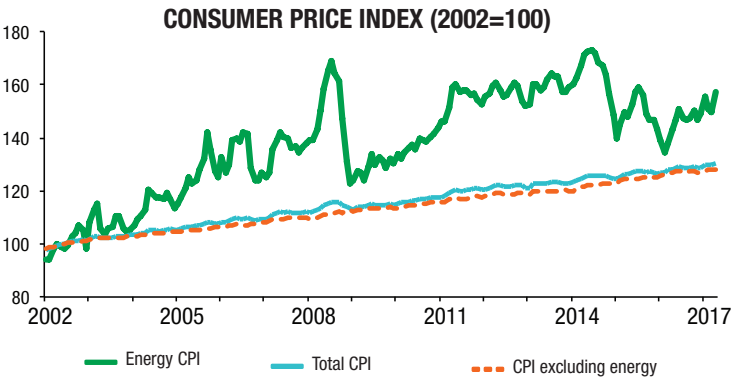


## HOUSEHOLD EXPENDITURES ON RESIDENTIAL AND TRANSPORTATION

- Canadian households **spent $4,198** on average on energy in 2015.
- Residential energy expenditures averaged **$2,105**.
- Transportation energy expenditures averaged **$2,093**.
- Energy accounted for almost **7%** of current household consumption.
- Lower-income households spend a larger share of their disposable income on energy.

## ENERGY RETAIL PRICES

- The “energy” component of the consumer price index (CPI) has been volatile in recent years.
- This volatility reflects mostly the variations of upstream oil and gas prices and their impact on consumer products such as gasoline.



# ENERGY AND GHGs

# ENERGY AND GREENHOUSE GAS (GHG) EMISSIONS

In Canada, and around the world,


**80%** of GHG emissions from human activity comes from energy-consuming activities such as

transportation, energy and electricity production, heating and cooling of buildings, operation of appliances and equipment, production of goods and the provision of services.

Canadians consume more energy than most because of our extreme temperatures, large land mass and dispersed population.

The challenges of **transitioning** to a **lower-carbon energy system** are numerous, but they also present opportunities for **Canada to be a global leader** by **supporting innovative technologies in the energy sector**, including **promoting our growing renewables and clean tech sectors**.

Over the past two decades, there has been a decoupling between the growth of Canada's economy and GHG emissions.

**Between 1990 and 2015, although Canada's GHG emissions increased over**

$CO_2$

**18%**

**GHG emissions decreased**

**33%**

**per dollar of GDP**

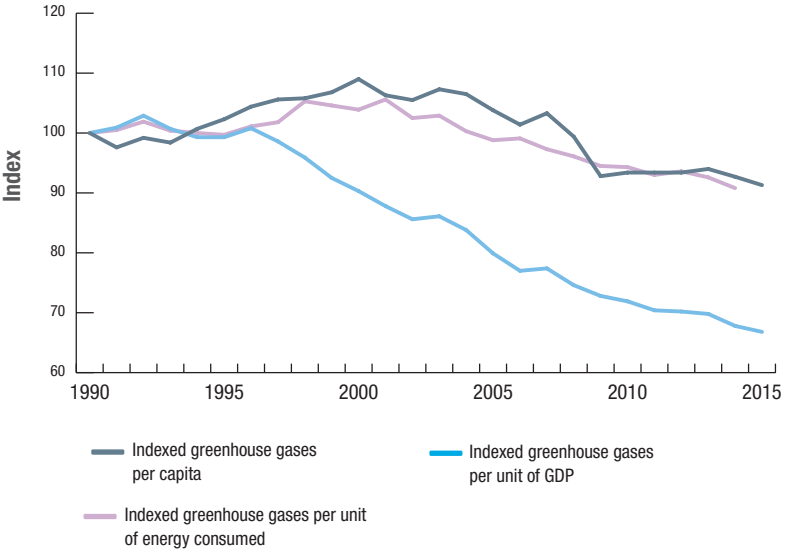
**and**

**9%**

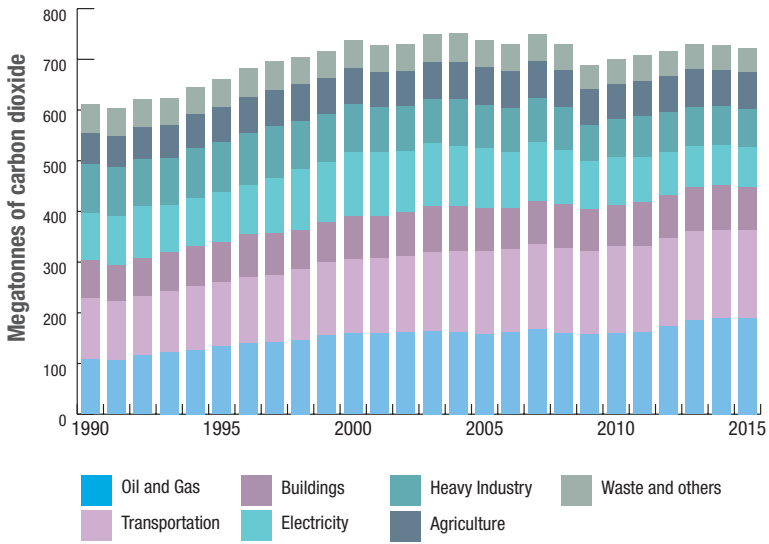
**per capita**

(largely due to technological improvements, regulations, and more efficient practices and equipment)

**INDEXED TREND IN GHG EMISSIONS PER PERSON, PER UNIT OF GDP AND PER UNIT OF ENERGY CONSUMED, 1990 TO 2015**



## GHG EMISSIONS BY CANADIAN ECONOMIC SECTOR, 1990 TO 2015

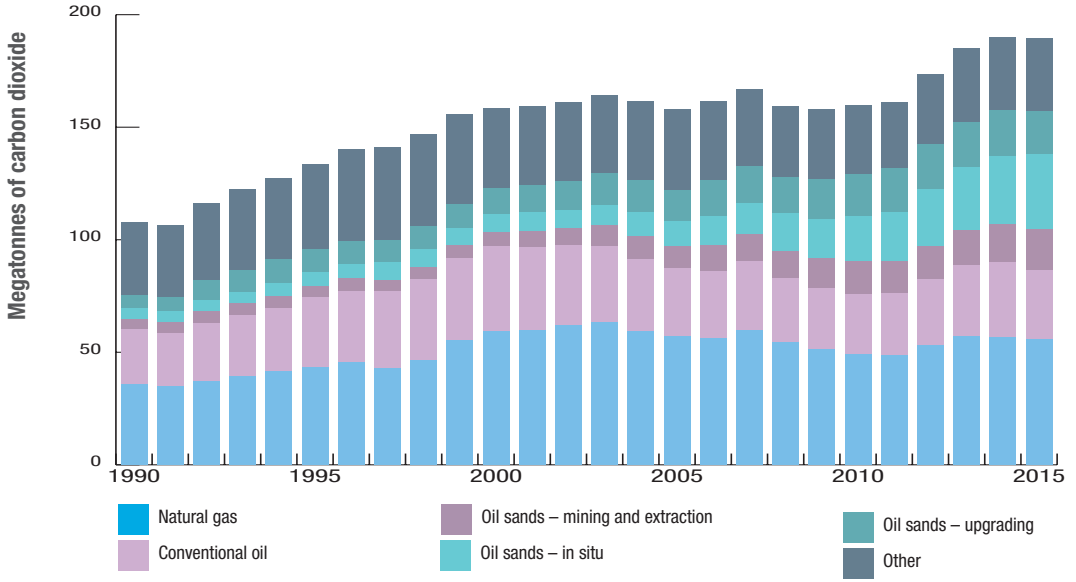



- Between 1990 and 2015, **emissions from electricity** production **decreased 16%**, largely because of an increase in renewable electricity generation and a decrease in coal-fired electricity generation.
- **Emissions from oil and gas production increased 75%**, leading to an **overall 33% increase** in emissions from energy production.
- **Transportation emissions rose 42%** over the same period, because of the increased number of vehicles (especially light trucks and SUVs) and higher emissions from freight trucks.

## SPOTLIGHT: OIL AND GAS

GHG emissions from oil and gas production **have gone up 20% between 2005 and 2015**, largely because of an increase in oil sands production. Oil sands emissions per barrel **have decreased 12% during the same period** because of technological and operational efficiency improvements.

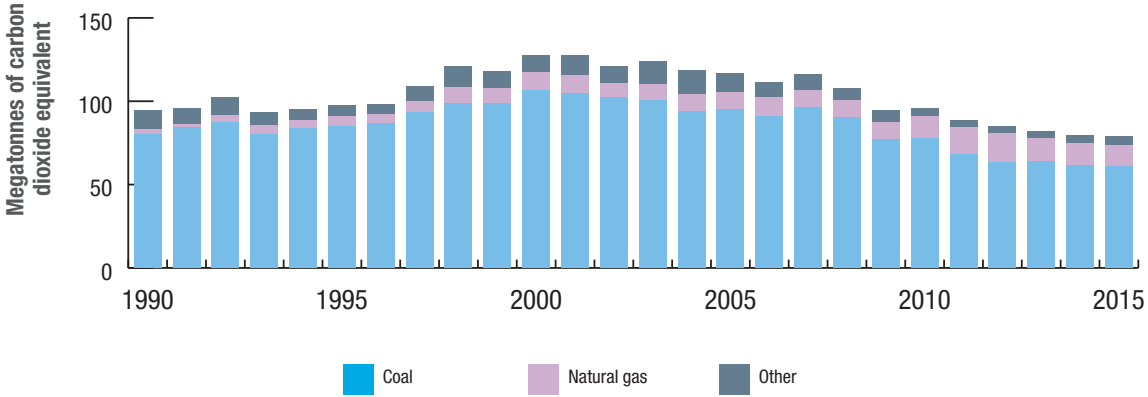
**OIL AND GAS SECTOR GREENHOUSE GAS EMISSIONS FOR CANADA, 1990 TO 2015**



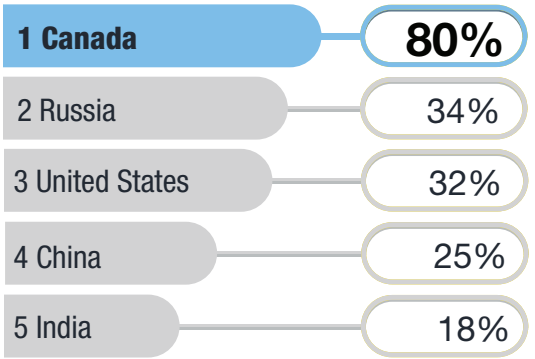
## SPOTLIGHT: ELECTRICITY

Coal-fired electricity generation accounted for **10% of generation** and **77% of electricity-related** GHG emissions in 2015.

**ELECTRICITY SECTOR GHG EMISSIONS FOR CANADA, 1990 TO 2015**

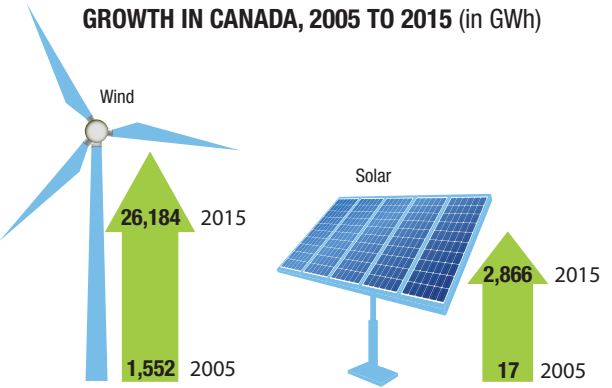


## PERCENTAGE OF TOTAL ELECTRICITY FROM NON-EMITTING SOURCES FOR TOP 4 ELECTRICITY GENERATING COUNTRIES AND CANADA



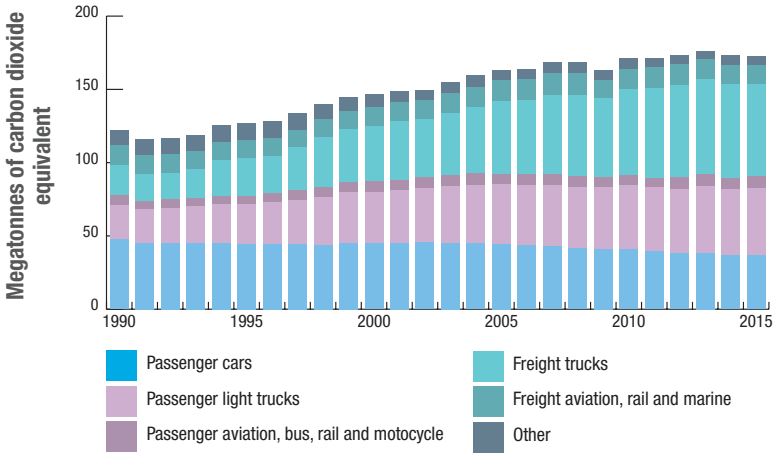

- In 2015, **80% of electricity in Canada** came from non-GHG emitting sources. **Hydro** made up almost **59%**, **nuclear 15%**, and other renewables the remaining **6%**.
- Net renewable electricity generation has increased **15%** since 2010, with solar and wind having the most relative growth.

## WIND AND SOLAR NET ELECTRICITY GENERATION GROWTH IN CANADA, 2005 TO 2015 (in GWh)



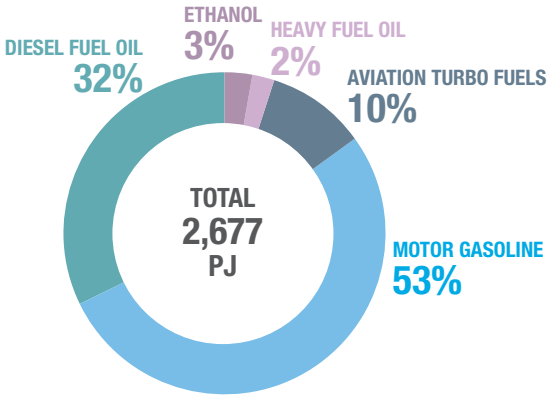
## SPOTLIGHT: TRANSPORTATION

### TRANSPORTATION SECTOR GHG EMISSIONS IN CANADA, 1990 TO 2015



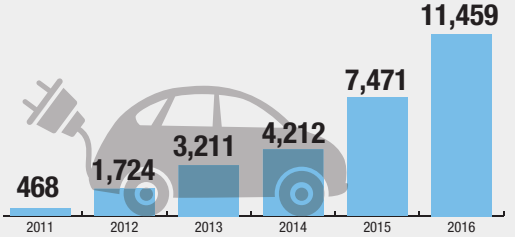

- **Transportation GHG emissions** have **increased 42%** since 1990. Emissions from passenger light trucks and freight trucks have doubled and tripled, respectively, because of an increased number of vehicles (especially light trucks and SUVs) and higher emissions from freight trucks.

## FUEL MIX OF TRANSPORTATION SECTOR, 2014




- Transportation emissions are split almost half and half between freight and passenger transportation.
- Energy efficiency improvements in the transportation sector saved Canadians **574 PJ** of energy and over **$19 billion** in energy costs in 2014.
- Total transportation energy use **increased 43%** between 1990 and 2014.

## ELECTRIC VEHICLE SALES IN CANADA, 2011–2016

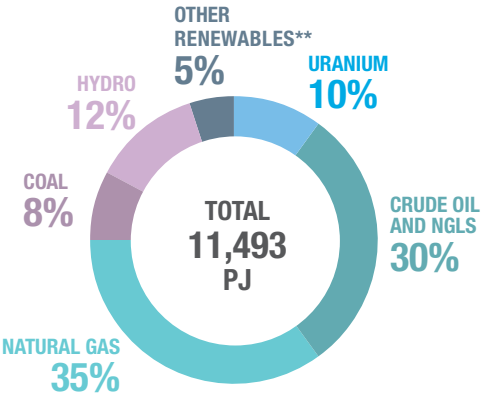



- In 2014, electricity powered less than **0.2%** of all transportation.
- Sales of electric vehicles have been on the rise in recent years. Over **11,000 vehicles** were **sold** in 2016, **up 53%** from 2015. Vehicle sales are highest in the provinces of Quebec, Ontario and British Columbia.
- To ensure continued uptake in electric vehicles and other lower-carbon transportation options, the federal government is making **investments in green infrastructure and clean technologies** and has committed **$182.5 million** to support electric vehicle and alternative fuel infrastructure and demonstration projects.

A look at Canada's total primary energy supply (TPES) helps to better understand the impact of energy sources on greenhouse gas emissions. The TPES[1] is calculated as:

**TPES = PRODUCTION + IMPORTS - EXPORTS + STOCK CHANGES**

**CANADA TOTAL PRIMARY ENERGY SUPPLY*, BY SOURCE, 2015**




- Fossil fuels made up **73%** of Canada's TPES in 2015.
- Renewable energy sources made up **over 17%** of Canada's TPES in 2015.

Comparatively, the global TPES is made up of

**81%** **Fossil fuel**
oil **31%**, coal **29%**, natural gas **21%**

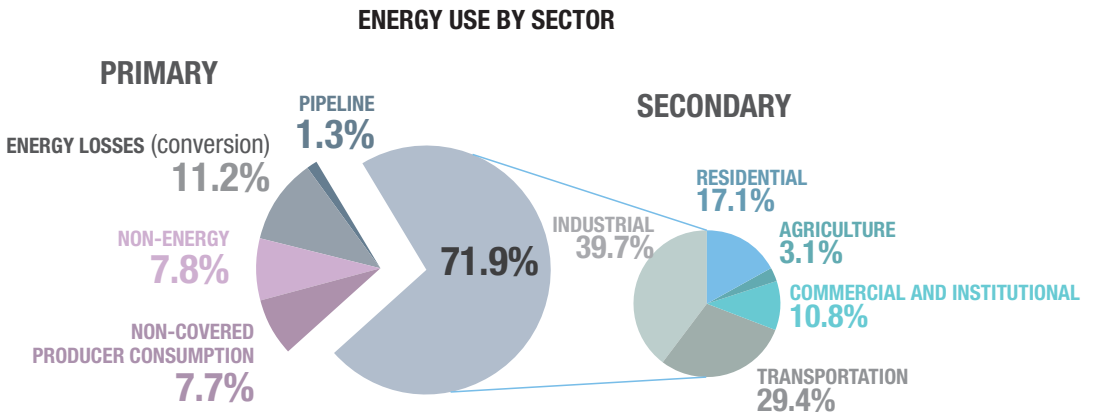
**14%** **Renewables**

**5%** **Uranium**

* not including electricity trade
**"Other renewables" includes wind, solar, wood/wood waste, biofuels and geothermal.
[1] For the purposes of TPES, electricity production and trade are calculated using the energy content of the electricity (i.e. at a rate of 1 TWh = 0.086 Mtoe), with the exception of nuclear electricity, which is calculated assuming a 33% conversion efficiency factor increase (i.e. 1 TWh = (0.086 ÷ 0.33) Mtoe).

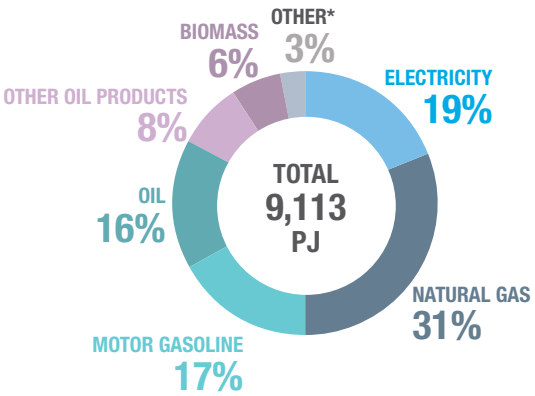
## PRIMARY AND SECONDARY ENERGY USE BY SECTOR, 2014

- Primary energy use measures the total energy requirements of all users of energy.
- Secondary energy use accounts for the energy used by final consumers in the economy.
- Primary energy use includes secondary energy use. Additionally, primary energy use includes the energy required to transform one form of energy into another (e.g. coal to electricity); the energy used to bring energy supplies to the consumer (e.g. pipeline); and the energy used to feed industrial production processes.
- Canada's primary energy consumed was estimated at **12,678.2 PJ.**



- Secondary energy use includes the energy used to run vehicles; the energy used to heat and cool buildings; and the energy required to run machinery.
- Canada's secondary energy use in 2014 was **9,112.5 PJ**.
- Not every fuel is consumed predominantly as secondary energy. For example, about **68% of the hydrocarbon gas liquid** supply in Canada is used as a non-energy feedstock in the petrochemical industry.

**CANADA'S SECONDARY ENERGY USE BY FUEL TYPE**

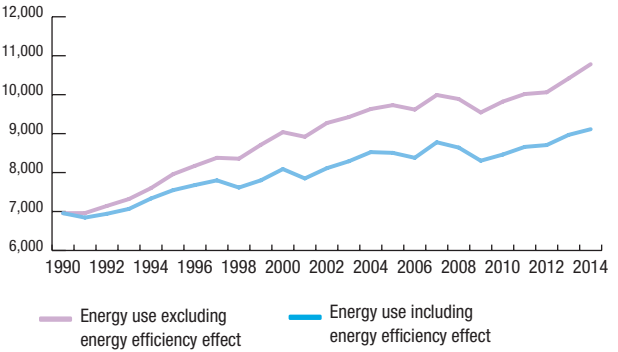



* "Other" includes coal, coke, coke oven gas, NGLs and steam and waste.

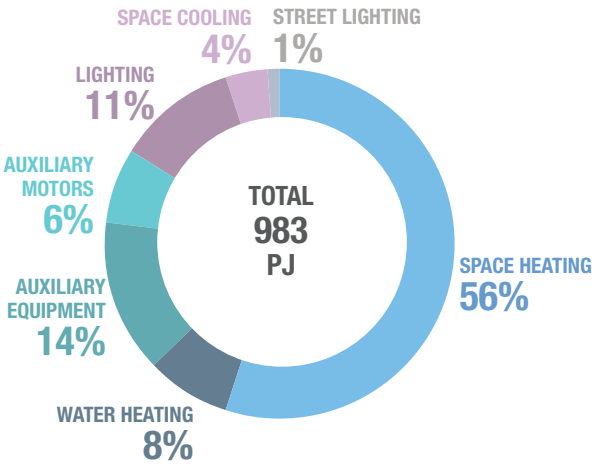
# HISTORICAL ENERGY EFFICIENCY / ENERGY INTENSITY

- **Energy intensity** is the ratio of energy use per unit of activity (such as floor space and GDP).
- **Energy efficiency** is a measure of how effectively energy is used for a given purpose and is one of the paths toward decarbonization.
- **Efficiency improvements** slow the rate of growth in energy use.
- **Energy efficiency** in Canada improved by **25%** between 1990 and 2014.
- **Energy use grew** by **31%** between 1990 and 2014. Without energy efficiency improvements, energy use would have **grown by 55%**.
- **Energy efficiency savings** of **1,669 PJ** in 2014 were equivalent to end-user savings of **$38.5 billion**.

**SECONDARY ENERGY USE WITH AND WITHOUT ENERGY EFFICIENCY IMPROVEMENTS, 1990–2014**



## COMMERCIAL AND INSTITUTIONAL ENERGY USE BY END USE, 2014




Commercial and institutional **energy use increased between 1990 and 2014 but would have increased**

**32%**

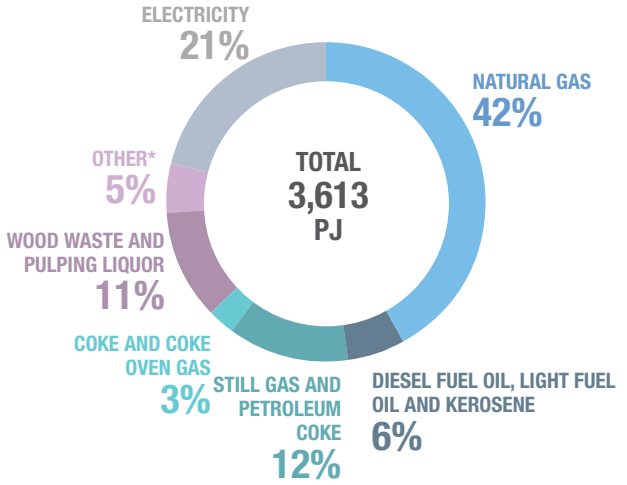
**61%** **without energy efficiency improvements**

**Energy intensity (GJ/m²) decreased**

**11%**

Energy efficiency in the commercial and institutional sector improved **29%**, saving Canadians 213 PJ of energy and **$4.4 billion** in energy costs in 2014.

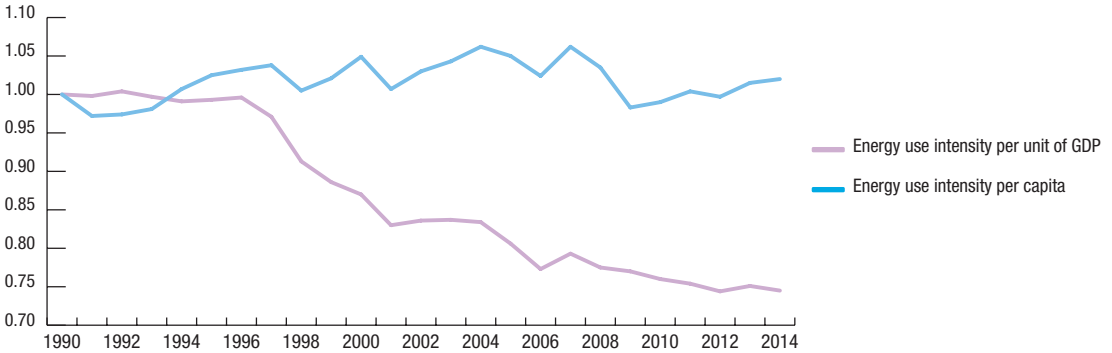
## INDUSTRIAL SECTOR ENERGY USE BY FUEL TYPE, 2014




* "Other" includes HFO, coal, LPGs, NGLs, steam and waste.

- The **industrial sector** includes all manufacturing, mining (including oil and gas extraction), forestry and construction activities, and in 2014, these industries **spent $47.6 billion** on energy.
- **Canadian industry saved $2.7 billion** in energy costs because of a 7.8% energy efficiency improvement in 2014, saving 210 PJ of energy.
- **Energy intensity** (MJ/$ of GDP) decreased **10%**.
- **Industrial energy use increased 33%**. It would have **increased 41%** without energy efficiency improvements.

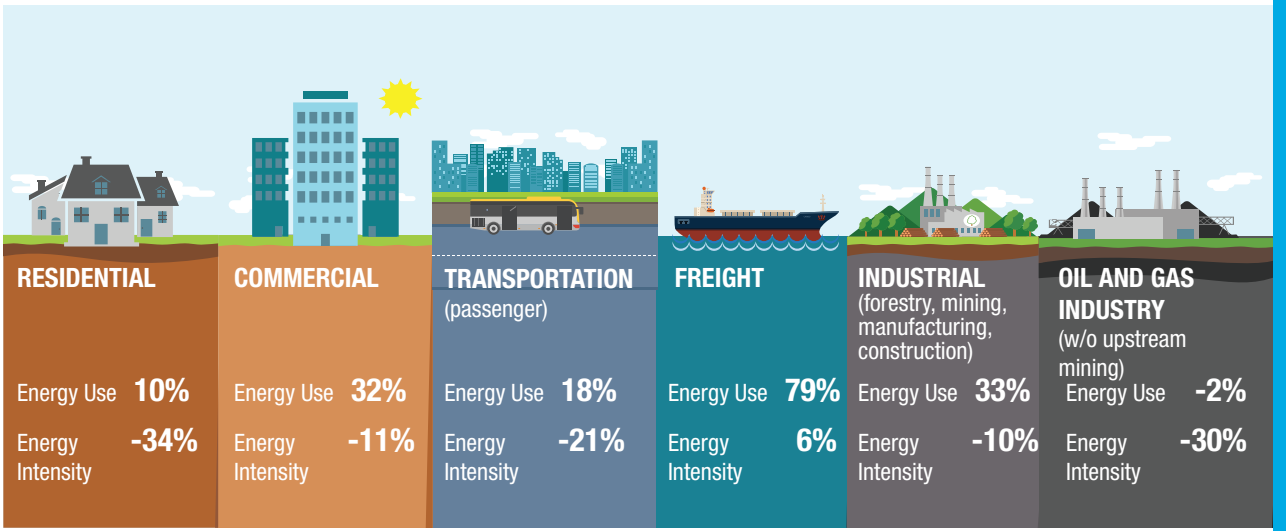
## INDEXED TOTAL SECONDARY ENERGY USE INTENSITY PER CAPITA AND PER UNIT OF GDP, 1990 – 2014 (1990 = 1)




**Per capita energy consumption is 2% higher than in 1990**

**Canada used 25% less energy per dollar of GDP in 2014 than in 1990**

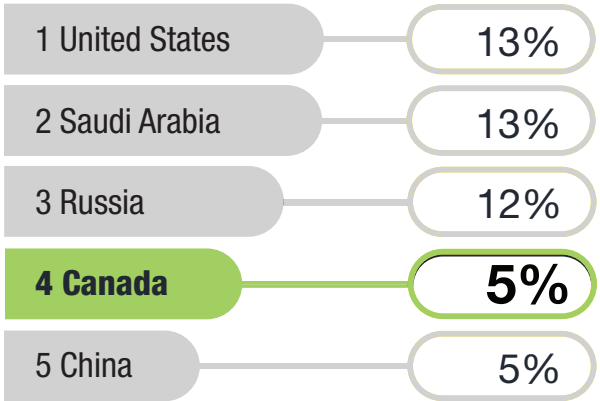
## TRENDS IN ENERGY USE AND INTENSITY BY SUBSECTOR, 1990–2014



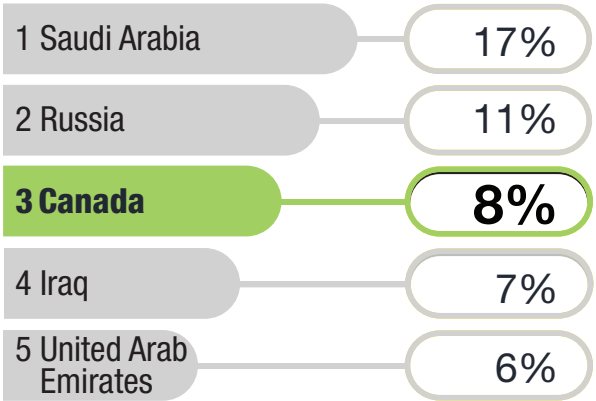
# CRUDE OIL

## CRUDE OIL

**World production* – 93.6 MMb/d** (2016, preliminary)




**World exports* – 46.6 MMb/d** (2015)

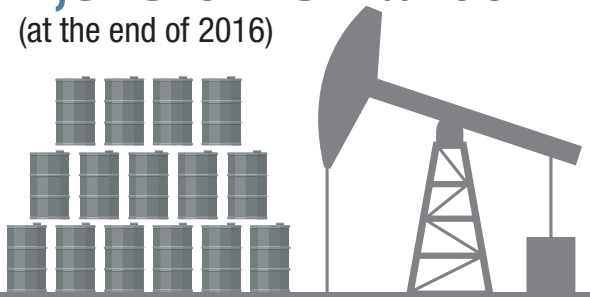



* includes crude oil, NGL, additives and other hydrocarbons (including the receipts of additives).

**World proved reserves**

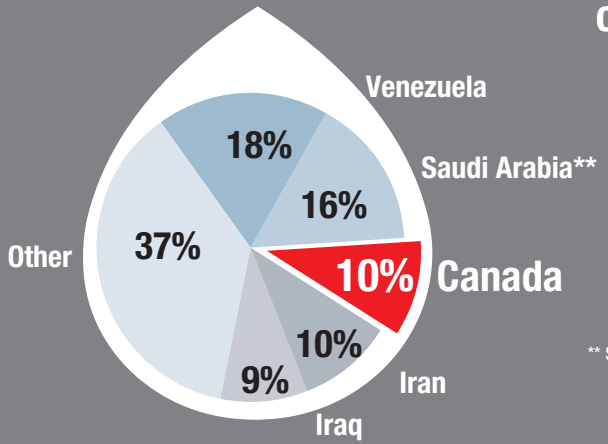
# 1,646 billion barrels

(at the end of 2016)



# 97%

## of Canada's proven oil reserves are located in the oil sands

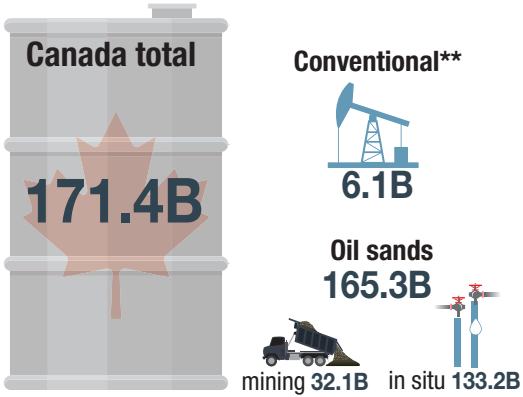



** Saudi Arabia and Kuwait reserves include the Saudi-Kuwaiti "neutral zone," with total proved reserves of 5 billion barrels.

## CANADIAN RESOURCES

### REMAINING ESTABLISHED RESERVES*

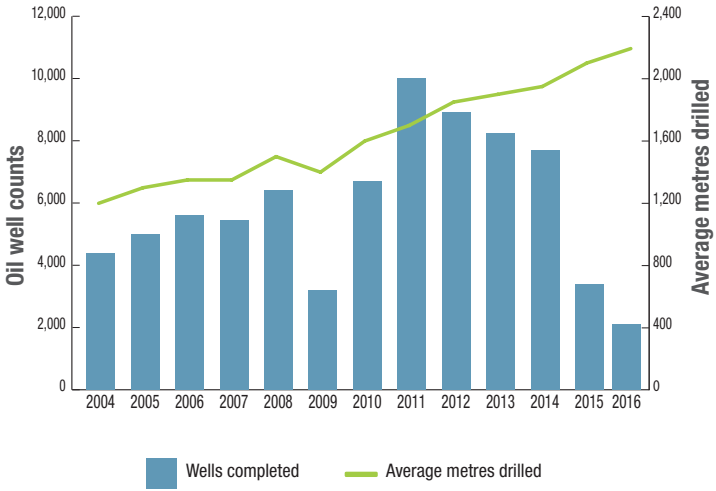
(latest available data as of December 2016)




* Reserves known to exist and recoverable under current technological and economic conditions.

** Reserves also include proved reserves of pentanes plus (a crude-oil equivalent that is associated with oil production).

### OIL WELLS COMPLETED AND AVERAGE METRES DRILLED IN WESTERN CANADA

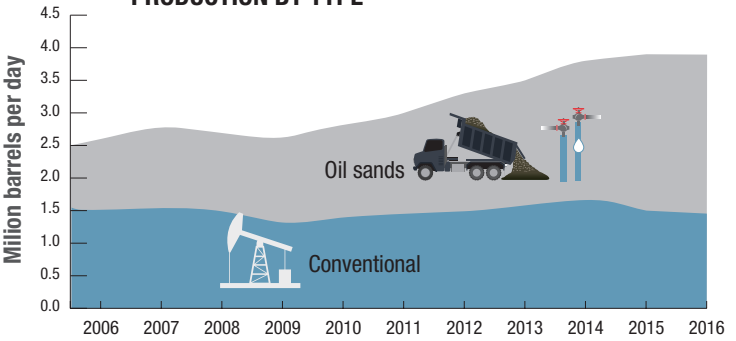


## CANADIAN PRODUCTION

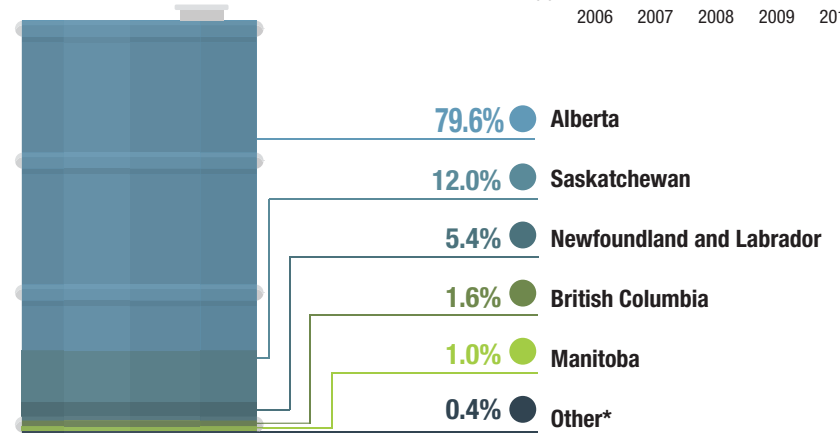
Oil sands production has exceeded conventional production since 2010.

In 2016, oil sands production was **2.4 MMb/d** compared with **1.5 MMb/d** of conventional oil production (including tight oil).

### PRODUCTION BY TYPE

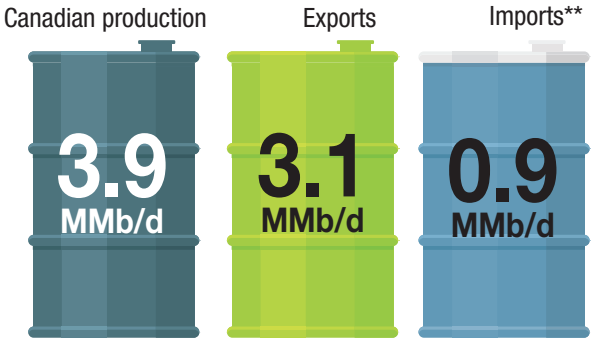


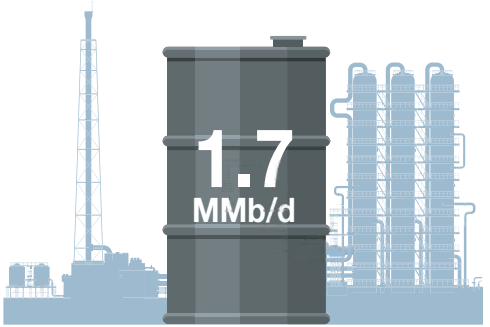

### PRODUCTION BY PROVINCE, 2016




*Other: Nova Scotia, Ontario and the Northwest Territories includes crude oil, condensates and pentanes plus

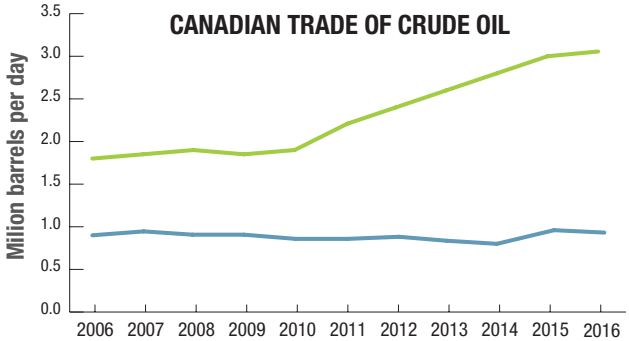
## CANADIAN SUPPLY AND DEMAND* (2016)




**CRUDE OIL SHIPPED TO DOMESTIC REFINERIES**

## TRADE



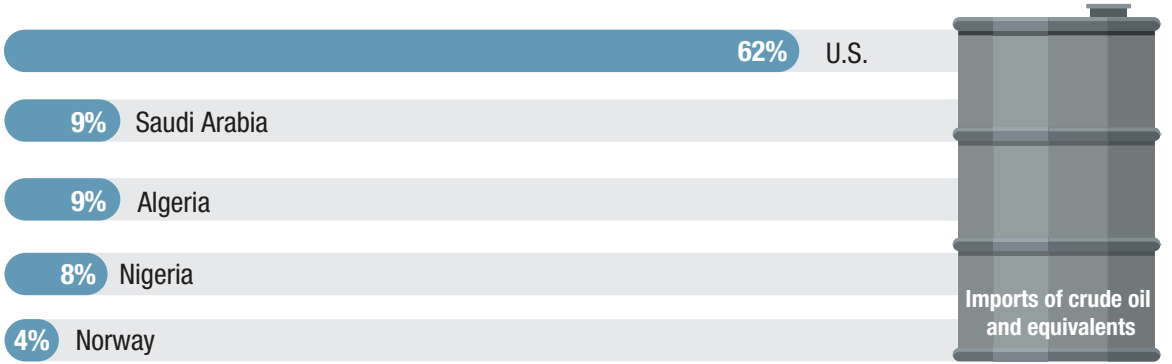

Exports

Imports**

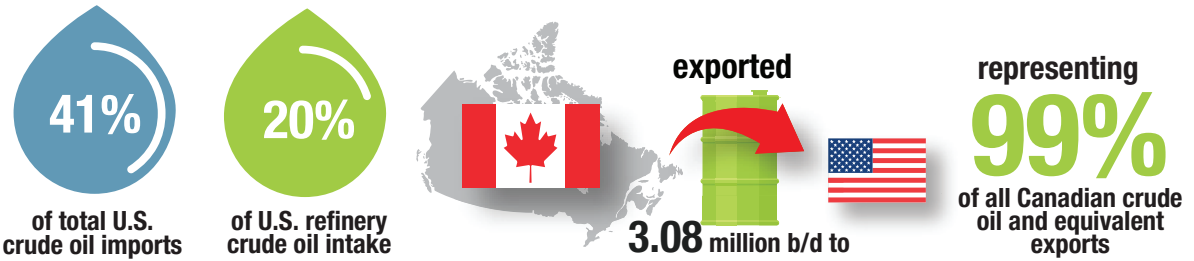
* includes condensates and pentanes plus

** includes both imports to refineries (0.6 MMb/d) and those delivered to upgraders or fields for use as diluent

**Imports of crude oil** and equivalents into Canada come from a wide range of countries, including



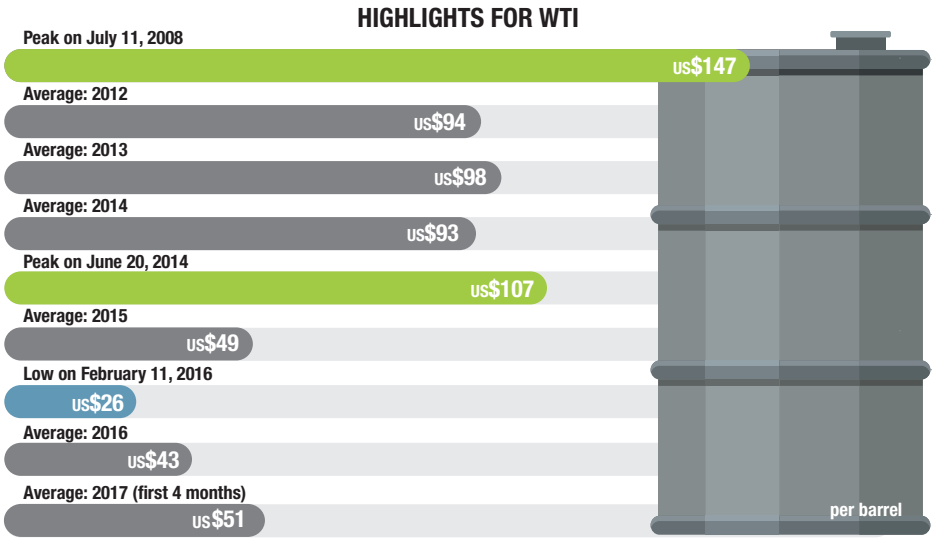

In 2016, Canada was the **largest foreign supplier of crude oil** to the U.S., accounting for



# PRICES

## WEST TEXAS INTERMEDIATE (WTI)

- Reference price for light crude oil delivered at Cushing, Oklahoma (a major pipeline hub)
- Used as the benchmark price for North American crudes
- Underlies oil futures contracts on the NYMEX



## OIL SANDS

An estimated **$288 billion** of capital investment to date, including **$16.6 billion** in 2016

**97%**

**OF CANADA'S PROVED RESERVES**

**62%**

**OF CANADA'S OIL PRODUCTION IN 2016 OR 2.4 MMb/d**

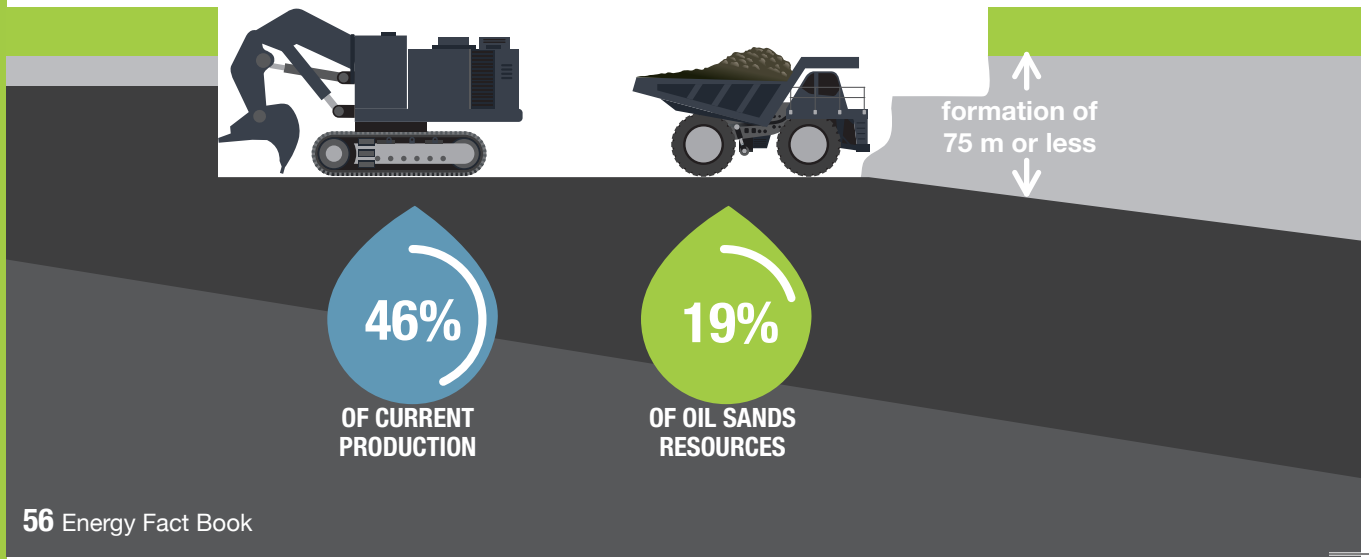
### BITUMEN UPGRADING

- Crude bitumen from oil sands may be transported to upgraders for processing to make it lighter – "synthetic crude oil."
- In 2016, **42%** of the raw bitumen produced was sent for upgrading in Alberta.
- Bitumen may also be blended with diluent (e.g. condensates) and sold directly to refineries capable of processing heavier oils.
- Major companies with upgrading capacity include Syncrude, Suncor, Shell, Canadian Natural Resources, Husky and Nexen-CNOOC.
- Total upgrading capacity in Canada of **1,363,000 b/d** (more information on upgrading in the *Petroleum Products* section).

## MINING METHOD

**Process:** remove overburden, extract oil sands ore, separate oil from sand using steam, pump tailings into settling basins.

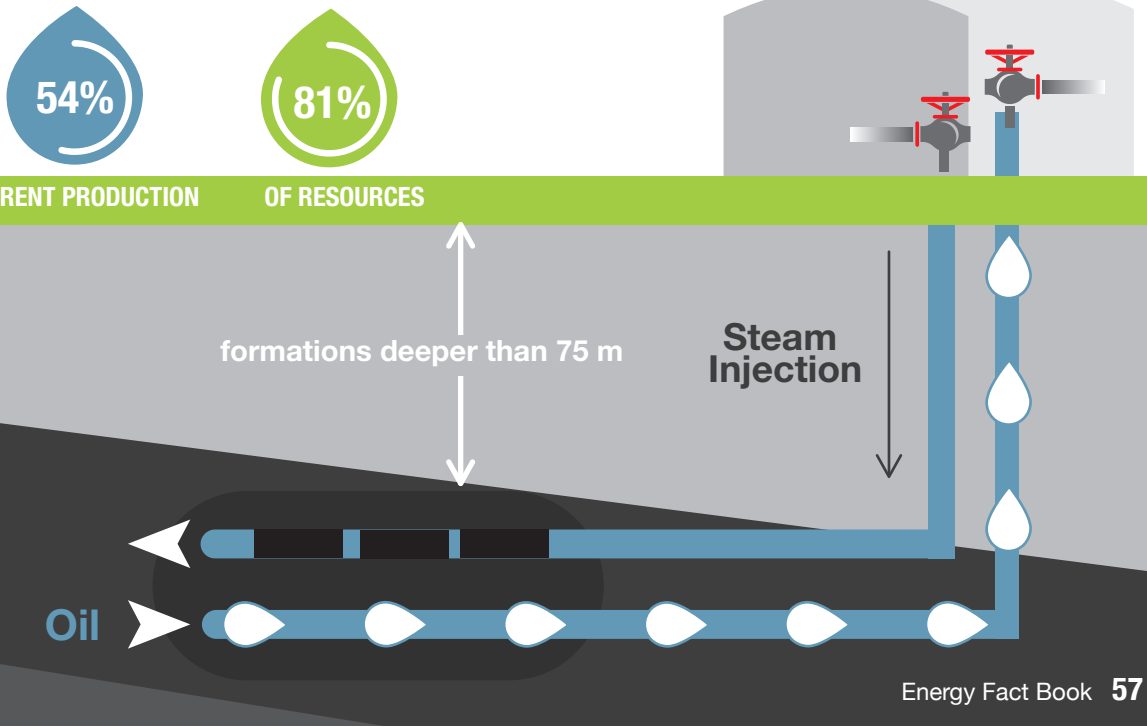
In 2016, **six large projects in Alberta** produced over **100,000 barrels** a day: Syncrude Mining Project **(321 Mb/d)**, Suncor Base Mine **(238 Mb/d)**, CNRL Horizon Mine **(146 Mb/d)**, Athabasca Oil Sands Project – Muskeg River **(142 Mb/d)** and Jackpine Mine **(114 Mb/d)**, and Imperial's Kearl Mine **(185 Mb/d)**.



## IN SITU METHOD

**Process:** drill vertical and/or horizontal wells, inject steam to facilitate the flow of oil

**More than 20 projects in Alberta** – largest are Cold Lake (Imperial Oil), Christina Lake (Cenovus) and Firebag (Suncor)

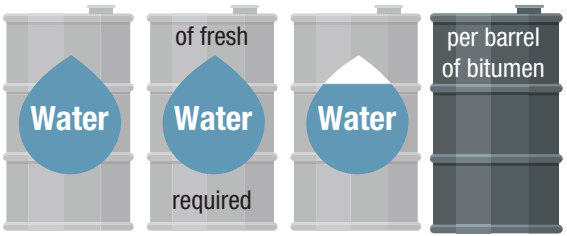


## OIL SANDS: ENVIRONMENTAL CONSIDERATIONS

### WATER

**Mining method:**

**2.8 barrels**

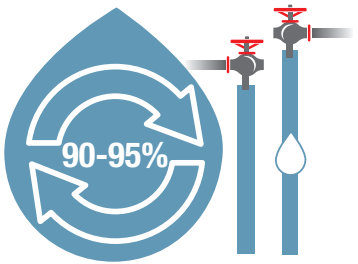



**In situ method:** an average of

**0.3 barrels**


**Oil sands producers recycle around**


**OF THE WATER USED IN ESTABLISHED MINES**

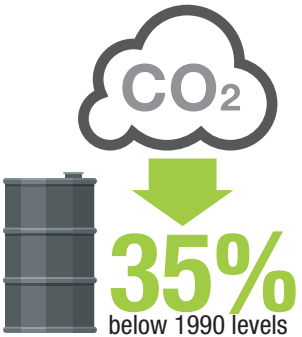


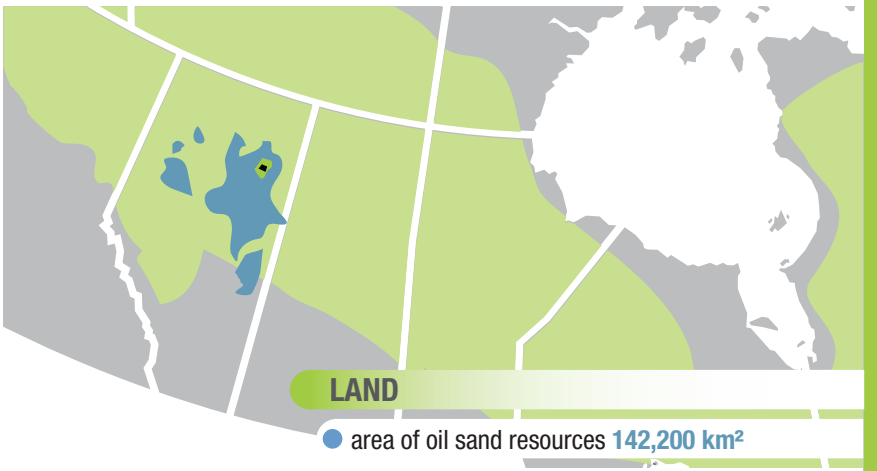

**OF THE WATER USED IN SITU PRODUCTION**

## GREENHOUSE GASES

**9.8%** of Canada's total **GHG emissions** and **0.1%** of **global emissions**

**GHG emissions per barrel of oil produced**
in the oil sands in 2015



## LAND

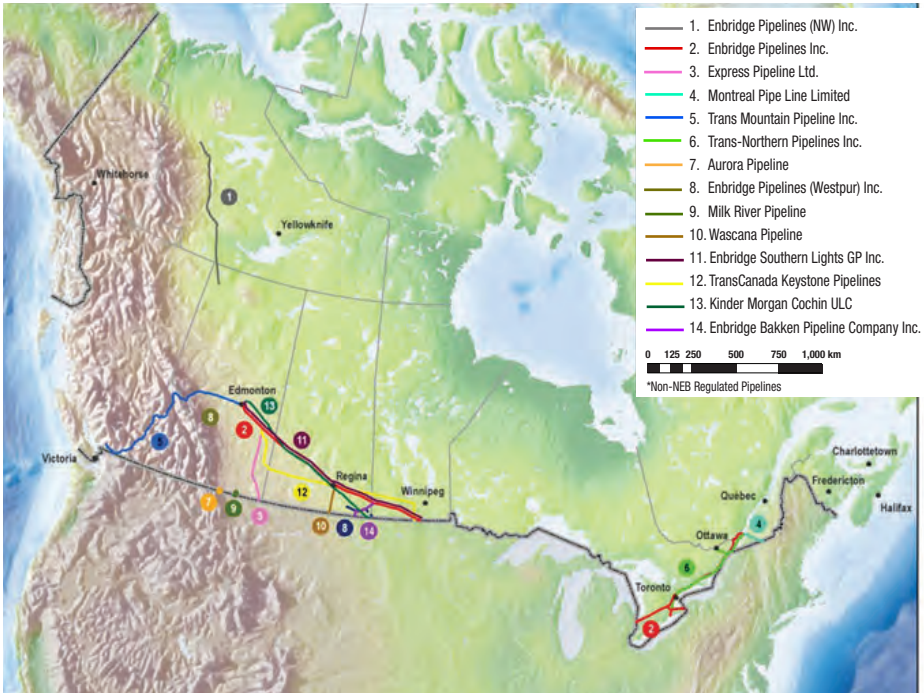
- area of oil sand resources **142,200 km²**
- total mineable area **4,800 km²**
- total area being mined **904 km²**
  tailings ponds **220 km²**

For comparison:

- Canada's total area **10,000,000 km²**
- Canadian boreal forest **2,700,000 km²**

# TRANSPORTATION

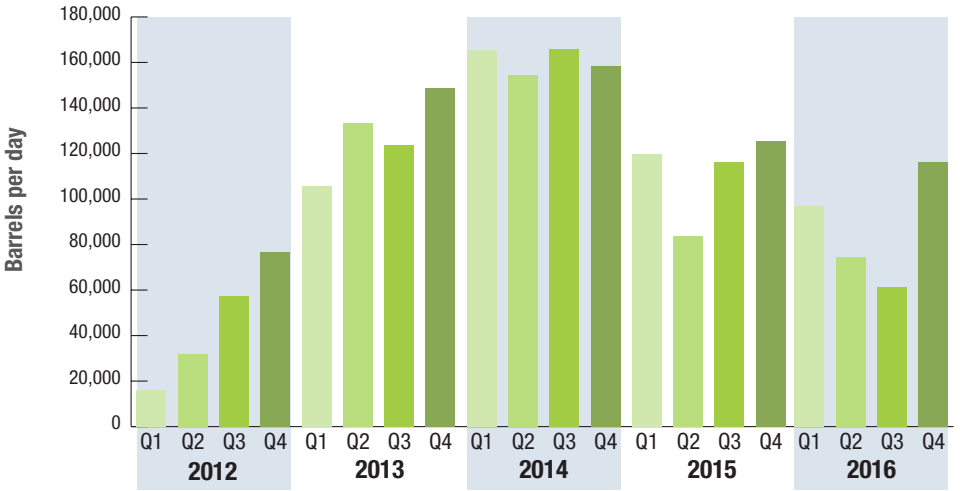
## BY PIPELINE

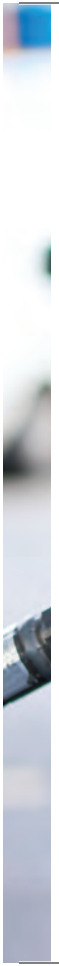


## BY RAIL

Although crude oil is primarily transported by pipeline, some is transported by rail. The tonnage of fuel oils and crude petroleum transported by rail almost tripled between 2011 and 2014, but subsequently decreased by **16%** from 2014 to 2015, due to low oil prices. The estimated rail loading capacity out of Western Canada in 2016 is approximately **1.0 MMb/d**.

**QUARTERLY VOLUMES OF CRUDE OIL EXPORTED TO THE U.S. BY RAIL**





# PETROLEUM PRODUCTS

# PETROLEUM REFINERIES

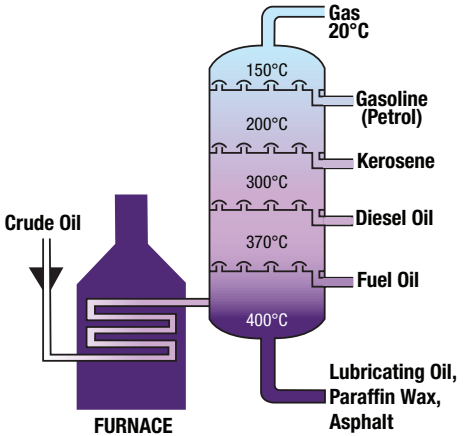
Petroleum refineries transform crude oil into a wide range of refined petroleum products (e.g. gasoline, diesel). Other facilities such as asphalt plants, lubricant plants, upgraders and some petrochemical plants also process crude oil to produce a limited range of products.

## REFINERY ACTIVITIES:

- **crude oil distillation:** separating products from crude oil by heating
- **additional processing** (e.g. catalytic cracking, reforming, coking)
- **product blending:** end-use RPPs are usually blended with additives or renewable fuels

## REFINERY OUTPUTS:

- transportation fuels – gasoline, diesel, aviation fuels, heavy fuel oil
- heating oil
- liquid petroleum gases (propane and butane from refineries)
- petrochemical feedstock
- other products (e.g. kerosene, lubricating oils, greases, waxes, asphalt)



## SUPPLY AND DEMAND* (2016)

Canadian production

**1.9**
**MMb/d**
(109 billion L)

Exports

**0.4**
**MMb/d**
(25 billion L)

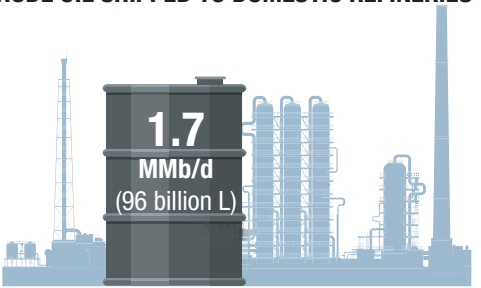
Imports

**0.2**
**MMb/d**
(14 billion L)

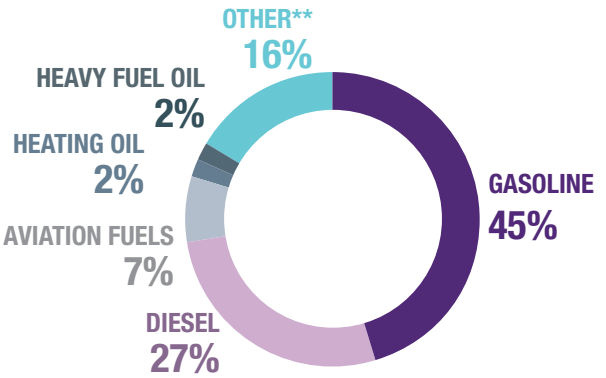
Domestic sales

**1.8**
**MMb/d**
(105 billion L)

### CRUDE OIL SHIPPED TO DOMESTIC REFINERIES

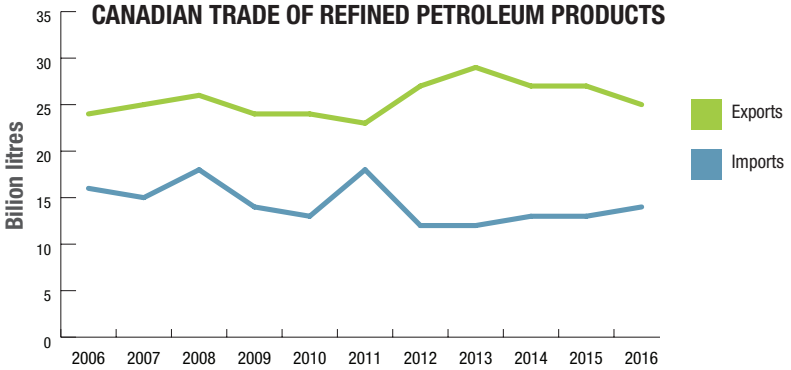


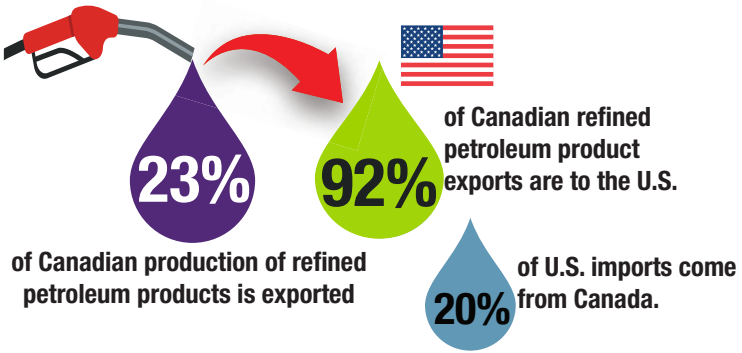

### SALES BY PRODUCT*

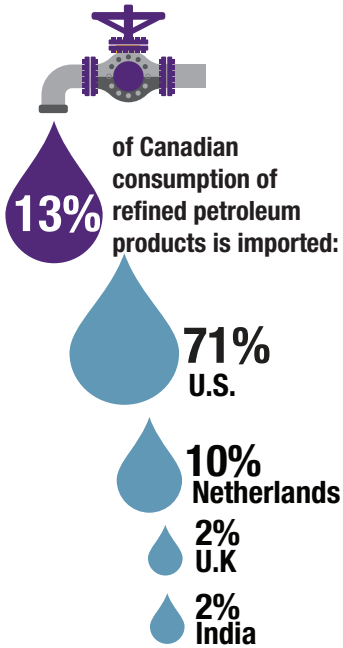



* Certain product shares are based on NRCan estimates.
** "Other" includes LPGs, petrochemical feedstock, lubricating oils, petroleum coke, asphalt, etc.

# TRADE (2016)

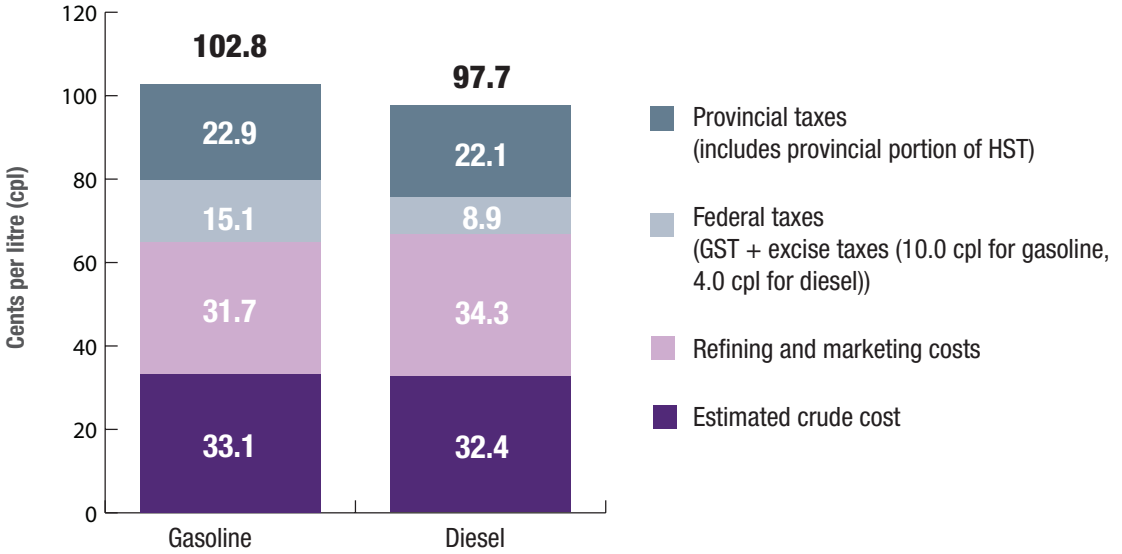

CANADIAN TRADE OF REFINED PETROLEUM PRODUCTS
Billion litres
35
30
25
20
15
10
5
0
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Exports
Imports


23%
of Canadian production of refined petroleum products is exported
92%
of Canadian refined petroleum product exports are to the U.S.
20%
of U.S. imports come from Canada.


13%
of Canadian consumption of refined petroleum products is imported:
71%
U.S.
10%
Netherlands
2%
U.K
2%
India

# RETAIL PRICES

## AVERAGE CANADIAN GASOLINE AND DIESEL PRICE, 2016




Changes in retail prices for fuel tend to follow those for crude oil.

## REFINERY CAPACITY

### CANADIAN PETROLEUM REFINERIES BY COUNT AND CAPACITY*, 2016

| Province | Petroleum Refinery | | Asphalt Plants | | Petrochemical Plants (using crude oil as feedstock) | | Upgraders** | |
|---|---|---|---|---|---|---|---|---|
| | Count | Capacity | Count | Capacity | Count | Capacity | Count | Capacity |
| Alberta | 3 | 429 | - | - | - | - | 5 | 1,285 |
| British Columbia | 2 | 69 | - | - | - | - | - | - |
| New Brunswick | 1 | 318 | - | - | - | - | - | - |
| Newfoundland and Labrador | 1 | 115 | - | - | - | - | - | - |
| Ontario | 4 | 393 | - | - | 1 | 17 | - | - |
| Quebec | 2 | 402 | - | - | - | - | - | - |
| Saskatchewan | 1 | 130 | 2 | 48 | - | - | 1 | 78 |
| **Total** | **14** | **1,856** | **2** | **48** | **1** | **17** | **6** | **1,363** |

*Capacities are in Mb/d.

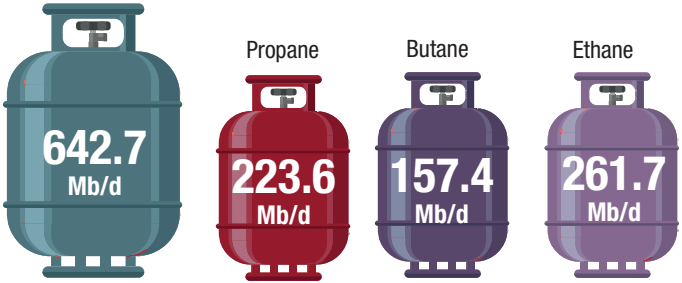
**Capacities reported are for inputs of heavy crude oil or bitumen.

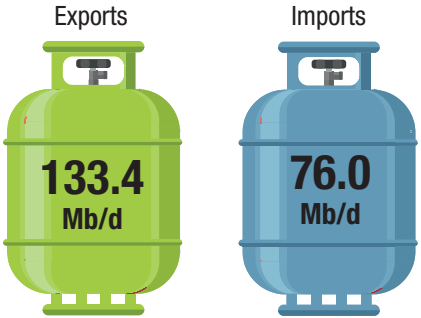


# HYDROCARBON GAS LIQUIDS

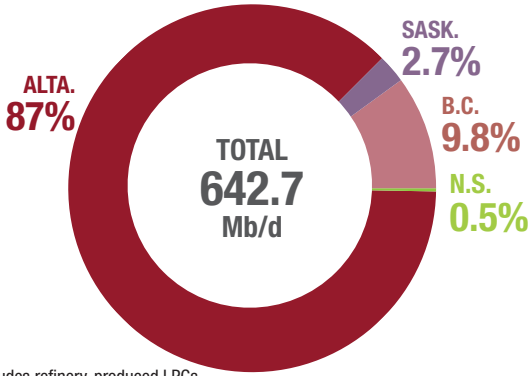
## SUPPLY AND DEMAND* (2016)

Canadian production




### GAS PROCESSING PLANT PRODUCTION OF NGLS BY PROVINCE




* excludes condensates and pentanes plus, which are included as part of crude oil, and includes refinery-produced LPGs

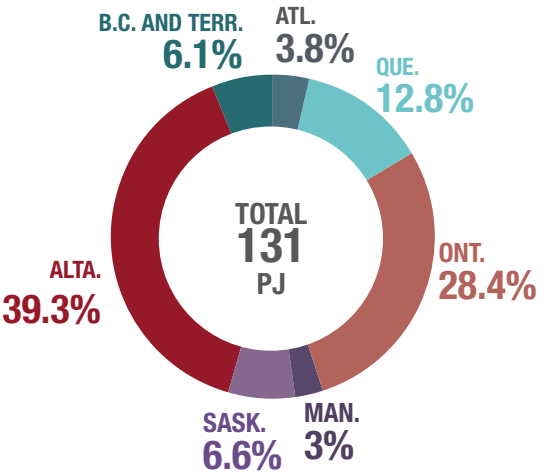
# NATURAL GAS LIQUIDS ENERGY USE

## TOTAL NATURAL GAS LIQUIDS ENERGY USE WAS 131 PJ IN 2014

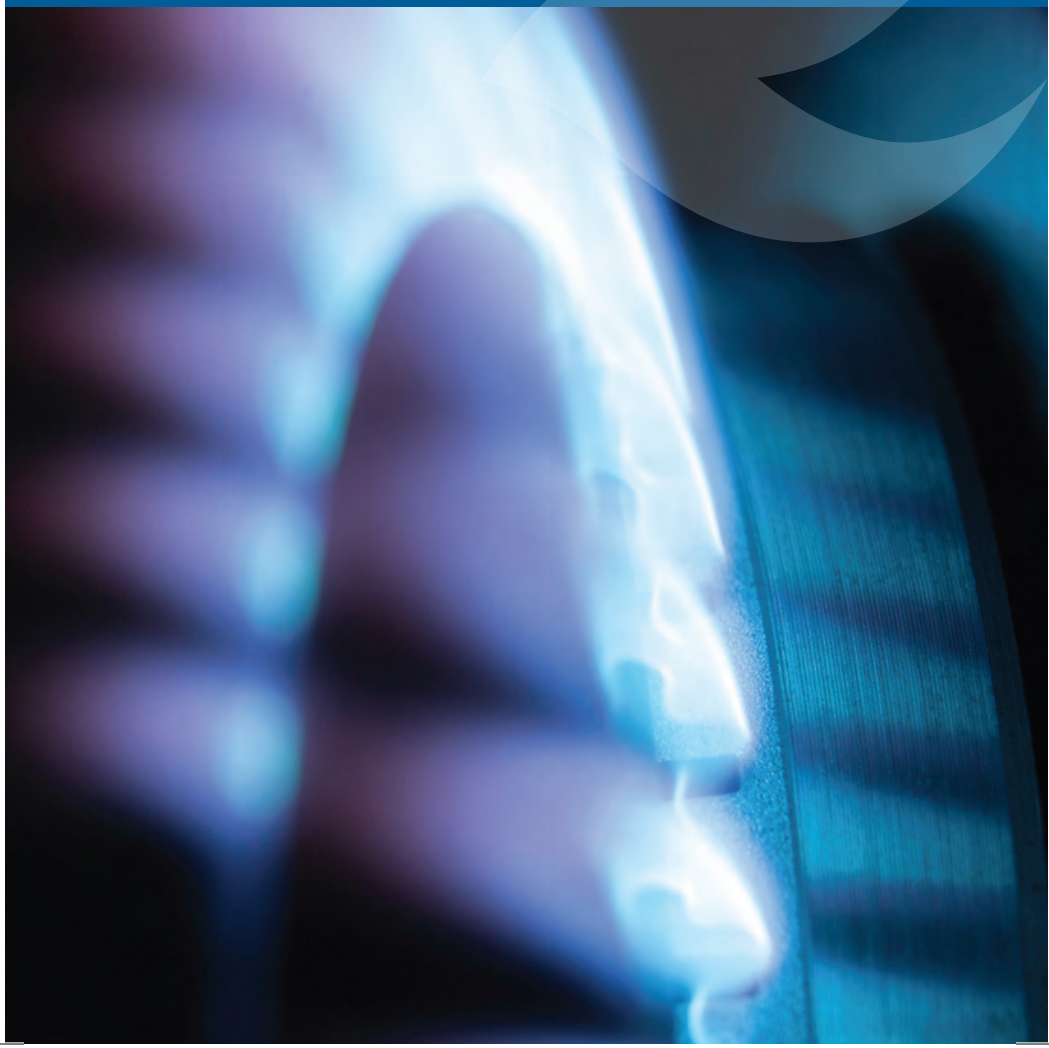
| Sector | Energy use* (PJ) | % of the total |
|---|---|---|
| Residential | 13.4 | 10.2% |
| Commercial | 31.9 | 24.4% |
| Industrial | 68.4 | 52.2% |
| Transportation | 9.5 | 7.3% |
| Agriculture | 7.7 | 5.9% |
| **Total** | **131.0** | **100%** |

*secondary energy use

## NATURAL GAS LIQUIDS ENERGY USE BY PROVINCE, 2014



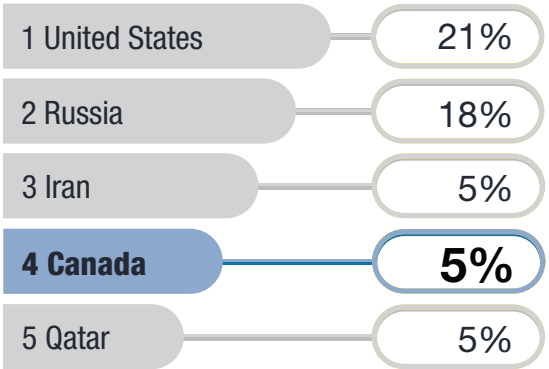
# NATURAL GAS



# NATURAL GAS

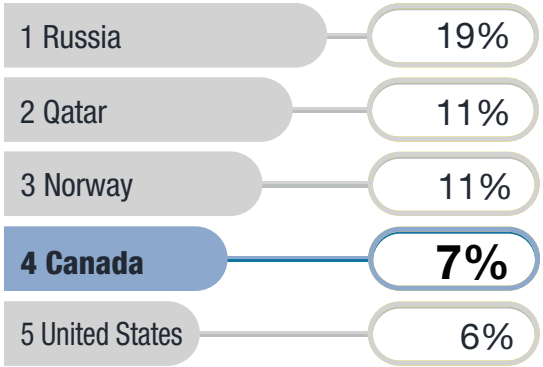
## World production – 350 Bcf/d (9.9 Bcm/d)

(2016, PRELIMINARY)

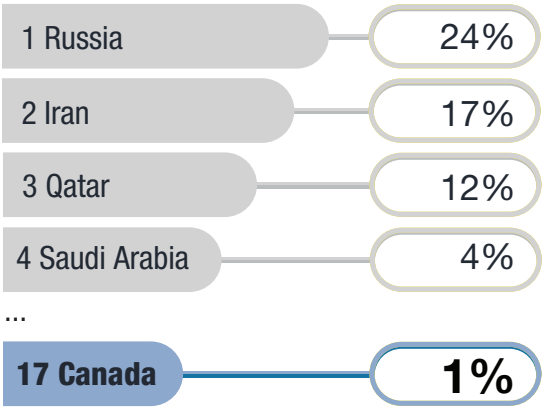



## World exports – 106 Bcf/d (3.0 Bcm/d)

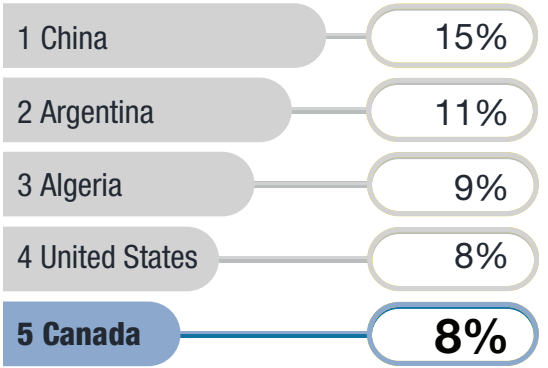
(2016, PRELIMINARY)



**World proved reserves – 6,896 Tcf/d (195 Tcm/d)** (BEGINNING OF 2017)




**World technically recoverable shale resources – 7,577 Tcf/d** (2012)



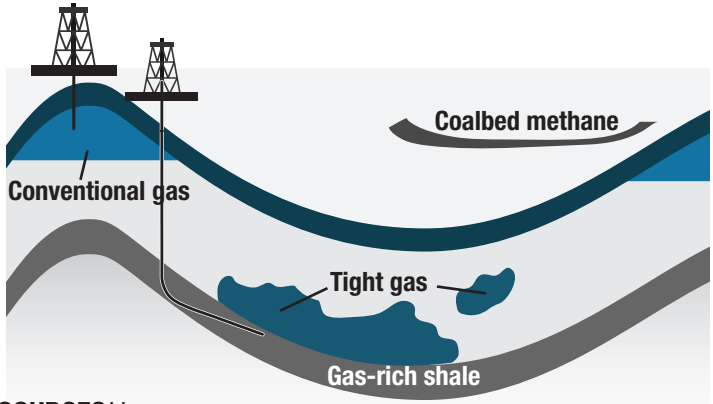
# CANADA – U.S. RESOURCES

## PROVED RESERVES* (AT THE END OF 2016)

77 Tcf

293 Tcf

TOTAL **370** Tcf




## MARKETABLE/TECHNICALLY RECOVERABLE RESOURCES**

**Canada total 864–1,773** Tcf

conventional **281–323** Tcf

unconventional **584–1,451** Tcf

(coal-bed methane, shale and tight gas)

**World total 27,581** Tcf

portion that is conventional **15,433** Tcf

portion that is unconventional **12,148** Tcf

**U.S. total 2,431** Tcf

portion that is shale and tight gas **664** Tcf

portion that is other **1,766** Tcf

* Proved reserves are known to exist and are recoverable under current technological and economic conditions.

** Canadian marketable resources: natural gas that is in a marketable condition, after the removal of impurities and after accounting for any volumes used to fuel surface facilities. Marketable resources are recoverable using existing technologies, based on geological information, but much of the drilling necessary to produce the natural gas has not yet been performed.
U.S. technically recoverable resources: gas estimated to be recoverable as drilling and infrastructure expands (similar to Canadian marketable resources)

## CANADA – U.S. MARKET (2016)

Canada's natural gas market is heavily integrated with that of the U.S. largely because of the location of supply basins, demand centres, and the availability of transportation infrastructure, as well as existing Canada-U.S. trade agreements. These factors allow for consumers and distributors on either side of the border to freely access natural gas from the lowest cost supplier.

Canada – U.S. production

**87.7** Bcf/d (2.5 Bcm/d)

**Canadian average marketable production**

**15.4** Bcf/d (0.4 Bcm/d)

**25%** conventional

**75%** unconventional*

**U.S. average marketable production**

**72.3** Bcf/d (2.0 Bcm/d)

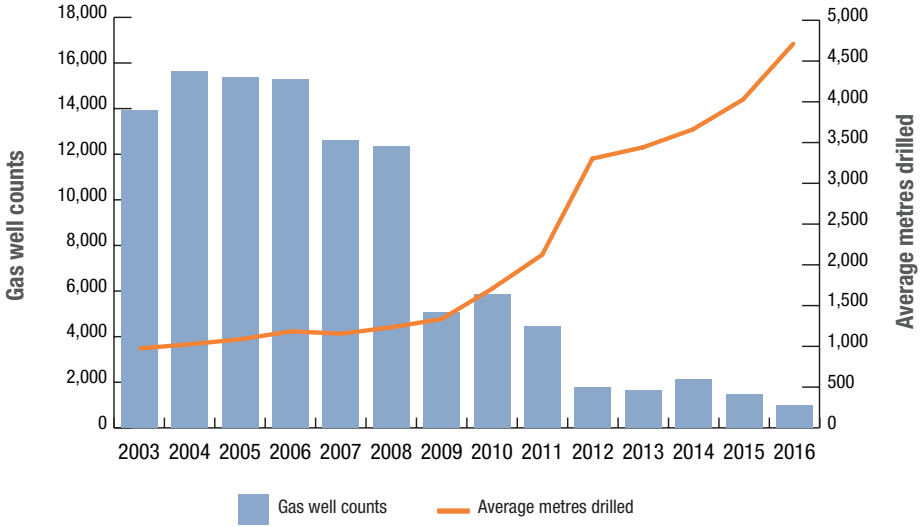
**25%** conventional

**75%** unconventional*

**North American LNG imports 0.27** Bcf/d (0.01 Bcm/d)

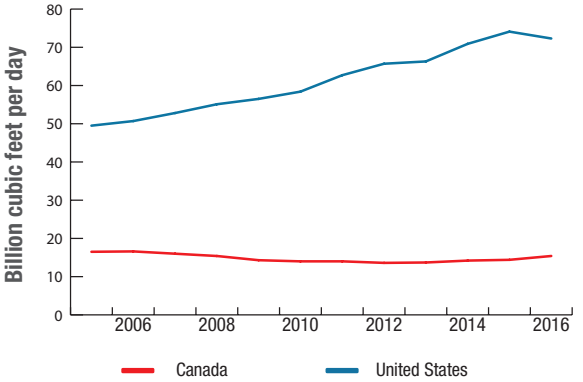
* Unconventional gas includes tight gas, coalbed methane and shale gas.

## NATURAL GAS WELLS COMPLETED AND AVERAGE METRES DRILLED IN WESTERN CANADA

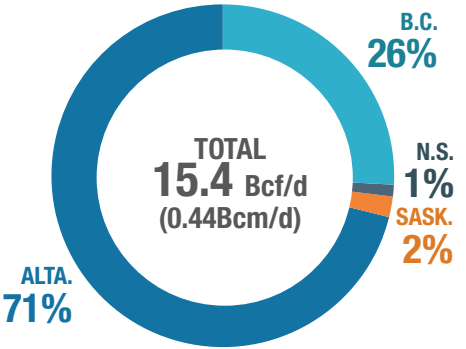



While Canadian natural gas production remained relatively flat and the number of wells drilled declined, the well productivity has increased over time. This reflects the increased use of horizontal drilling and increased well length.

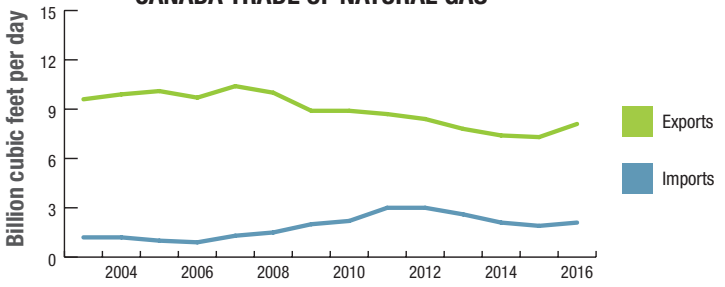
## CANADIAN AND U.S. MARKETABLE PRODUCTION OF NATURAL GAS




## MARKETABLE PRODUCTION BY PROVINCE, 2016




## CANADA TRADE OF NATURAL GAS




Canadian exports to U.S.

**8.1** Bcf/d (0.23 Bcm/d)

Canadian imports from U.S.

**2.1** Bcf/d (0.06 Bcm/d)

- While the share of exports is declining, more Canadian gas was exported than consumed domestically.
- Natural gas imports from the U.S. into Eastern Canada are on the rise because of higher supplies in the U.S. Northeast and shorter transportation distances from these U.S. natural gas basins.
- Canadian natural gas exports to the Western U.S. and U.S. Midwest remain strong.
- U.S. LNG exports and exports of natural gas to Mexico may create additional opportunities for Canadian natural gas producers to address gaps in U.S. domestic supply.
- Since 2009, Canada has also imported small amounts of natural gas liquids from other countries through the Canaport LNG terminal in Saint John, N.B.

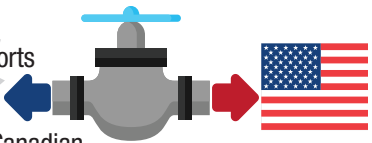
**53%** of Canadian production is exported

**All Canadian exports go to the U.S.**

**97% of U.S. imports and 11% of U.S. consumption come from Canada.**

**The value of Canadian net exports** (exports minus imports) was **$6.1 billion** in 2016.

**99%** of Canada's imports and **19%** of Canadian consumption comes from the U.S.



# UPSTREAM PRICES

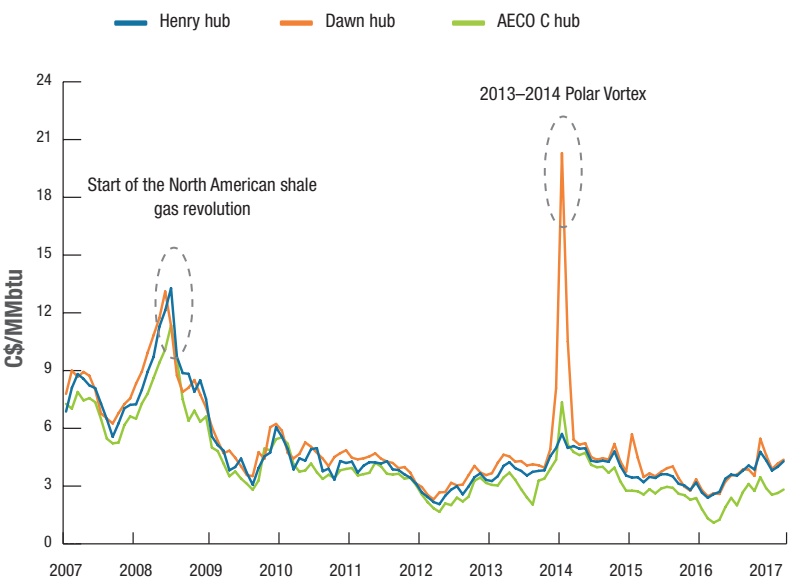
The AECO hub is Canada's largest natural gas trading hub, and the AECO price serves as a benchmark for Alberta wholesale natural gas transactions.

## AECO PRICE

| | |
|---|---|
| Average: 2007–2014 | **$4.62**/MMbtu |
| Average: 2015 | **$2.70**/MMbtu |
| Average: 2016 | **$2.18**/MMbtu |
| Average: 2017** | **$2.72**/MMbtu |

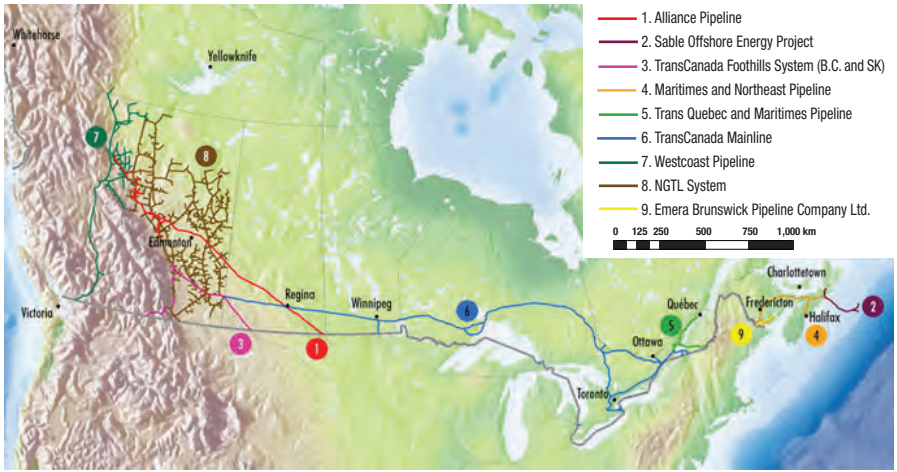
** First four months

**MONTHLY AVERAGE NATURAL GAS SPOT PRICES**



# TRANSPORTATION

## BY PIPELINE



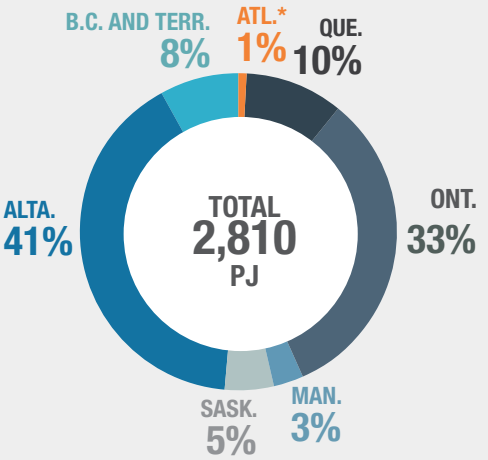
# NATURAL GAS ENERGY USE

**TOTAL NATURAL GAS ENERGY USE* WAS 2,810 PJ IN 2014.**

| Sector | Energy use (PJ) | Energy use (bcf/d) | % of the total |
|---|---|---|---|
| Residential | 735.3 | 1.82 | 26.2% |
| Commercial | 536.2 | 1.33 | 19.1% |
| Industrial | 1,496.3 | 3.71 | 53.2% |
| Transportation | 3.9 | 0.01 | 0.1% |
| Agriculture | 38.8 | 0.10 | 1.4% |
| **Total** | **2,810.4** | **6.97** | **100%** |

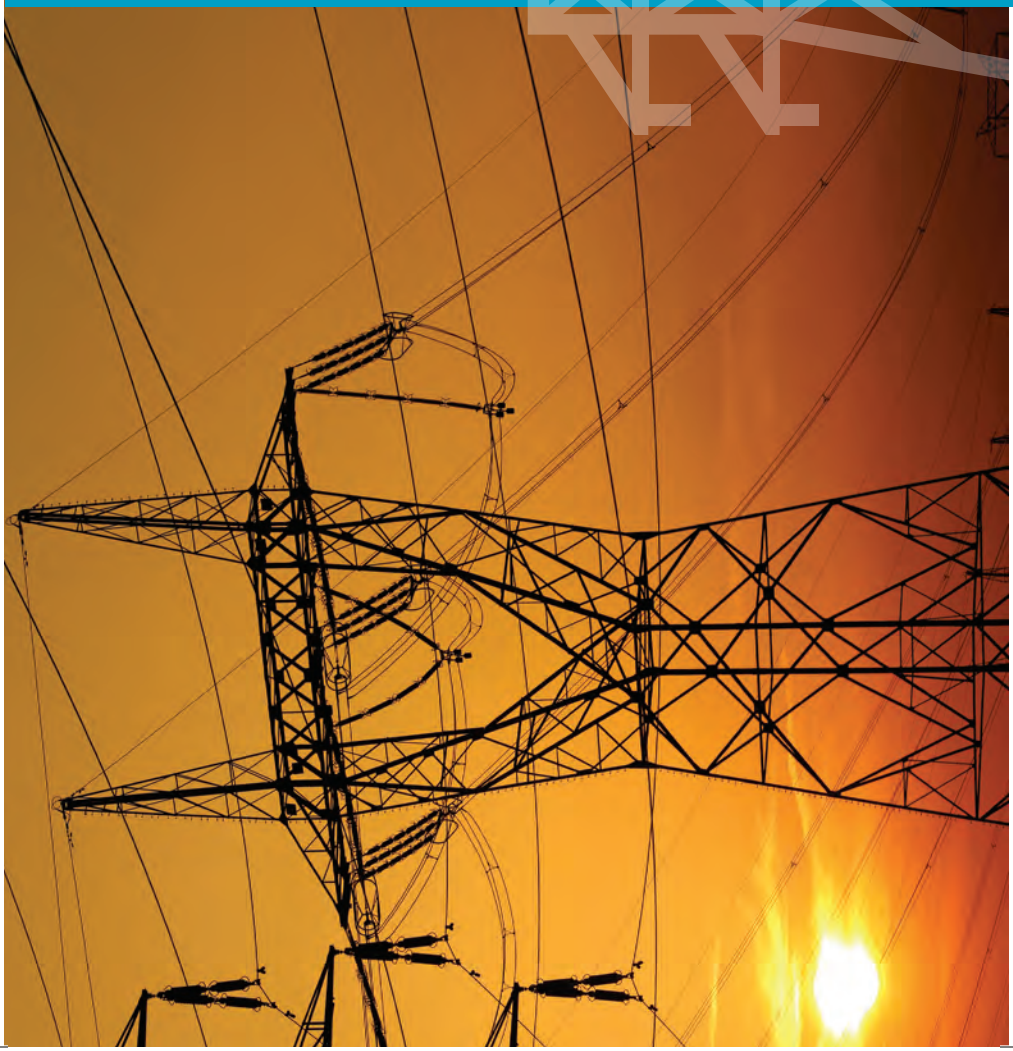
*secondary energy use

**NATURAL GAS ENERGY USE BY PROVINCE, 2014**



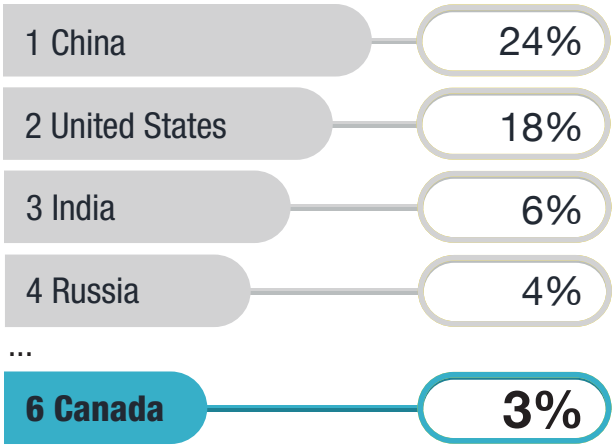

* Atlantic provinces

# ELECTRICITY

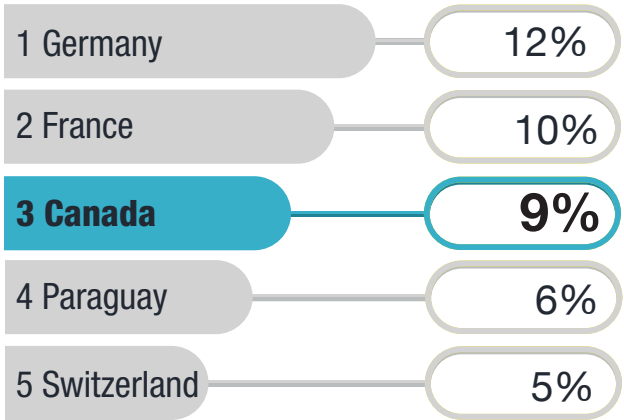


# ELECTRICITY

**World production – 24,345 TWh** (2015)




**World exports – 725 TWh** (2015)



# TRADE 2016

All Canadian electricity trade is with the U.S.

EXPORTS

**73 TWh**

IMPORTS

**9 TWh**

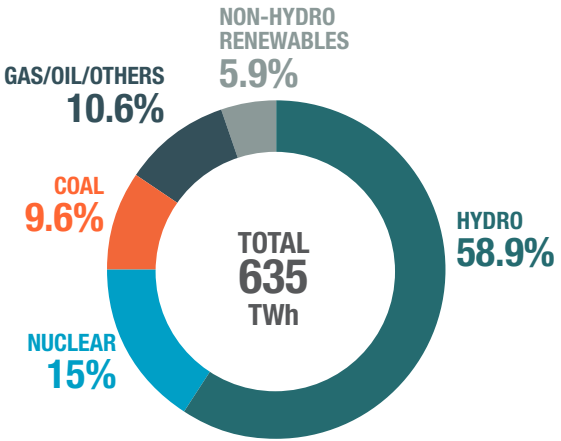
**CANADA'S ELECTRICITY TRADE WITH THE U.S.***

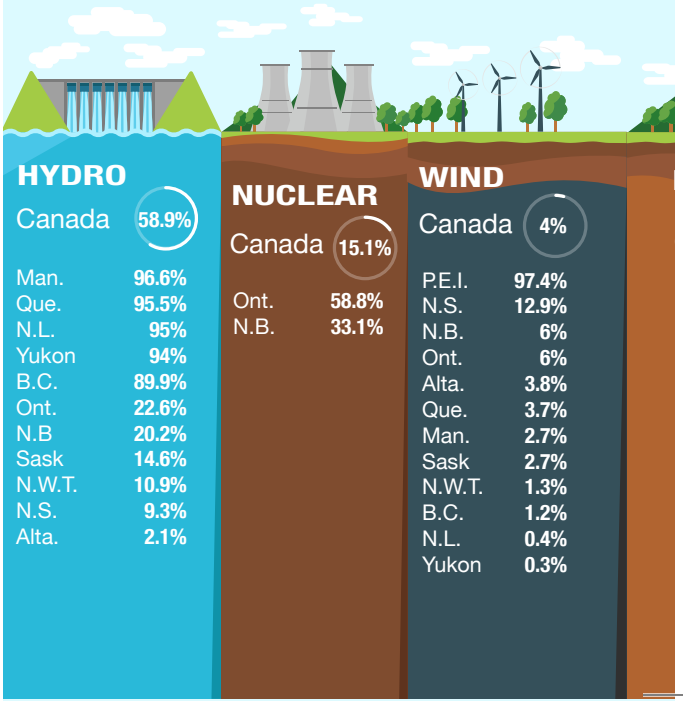

* includes only electricity traded under purchased contracts; excludes electricity transferred under non-financial agreements (e.g. under treaty obligations)

# CANADIAN SUPPLY

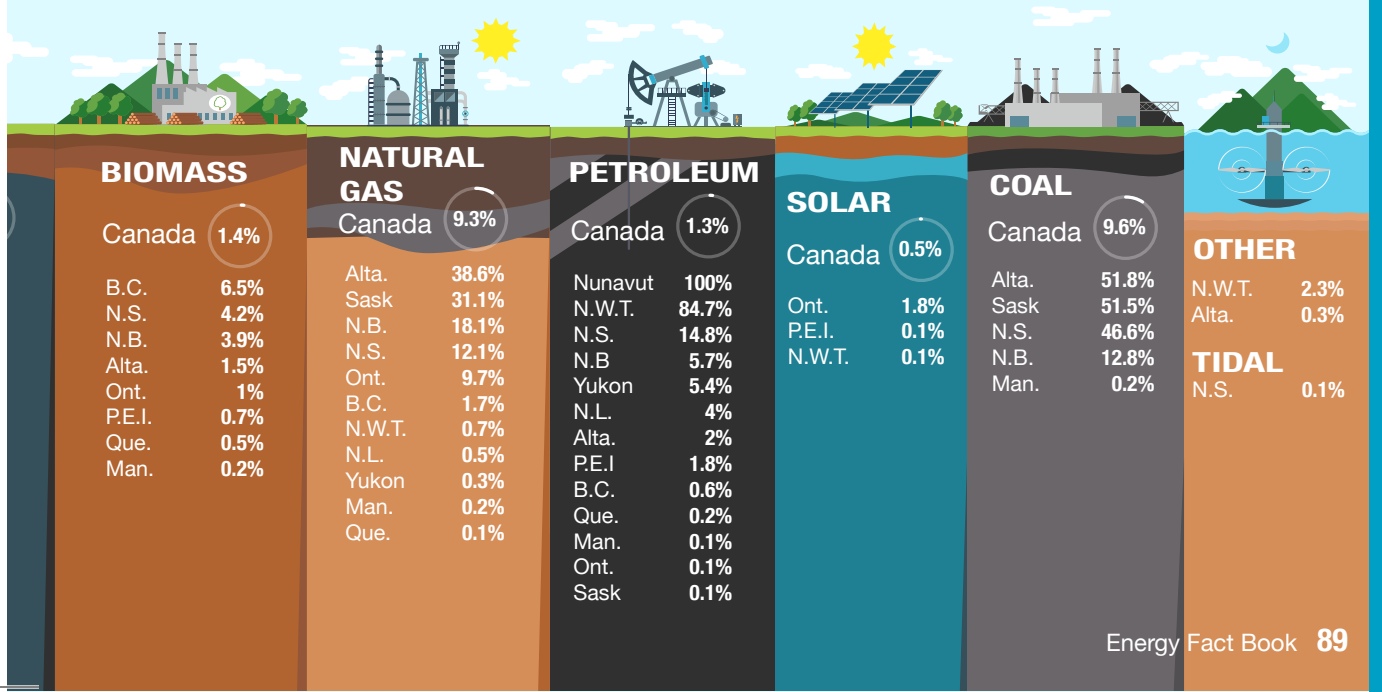
## GENERATION IN CANADA – 635 TWh

### GENERATION BY SOURCE, 2015



## PROVINCIAL ELECTRICITY GENERATION BY SOURCE, 2015



### BIOMASS

Canada 1.4%

| | |
|---|---|
| B.C. | 6.5% |
| N.S. | 4.2% |
| N.B. | 3.9% |
| Alta. | 1.5% |
| Ont. | 1% |
| P.E.I. | 0.7% |
| Que. | 0.5% |
| Man. | 0.2% |

### NATURAL GAS

Canada 9.3%

| | |
|---|---|
| Alta. | 38.6% |
| Sask | 31.1% |
| N.B. | 18.1% |
| N.S. | 12.1% |
| Ont. | 9.7% |
| B.C. | 1.7% |
| N.W.T. | 0.7% |
| N.L. | 0.5% |
| Yukon | 0.3% |
| Man. | 0.2% |
| Que. | 0.1% |

### PETROLEUM

Canada 1.3%

| | |
|---|---|
| Nunavut | 100% |
| N.W.T. | 84.7% |
| N.S. | 14.8% |
| N.B | 5.7% |
| Yukon | 5.4% |
| N.L. | 4% |
| Alta. | 2% |
| P.E.I | 1.8% |
| B.C. | 0.6% |
| Que. | 0.2% |
| Man. | 0.1% |
| Ont. | 0.1% |
| Sask | 0.1% |

### SOLAR

Canada 0.5%

| | |
|---|---|
| Ont. | 1.8% |
| P.E.I. | 0.1% |
| N.W.T. | 0.1% |

### COAL

Canada 9.6%

| | |
|---|---|
| Alta. | 51.8% |
| Sask | 51.5% |
| N.S. | 46.6% |
| N.B. | 12.8% |
| Man. | 0.2% |

### OTHER

| | |
|---|---|
| N.W.T. | 2.3% |
| Alta. | 0.3% |

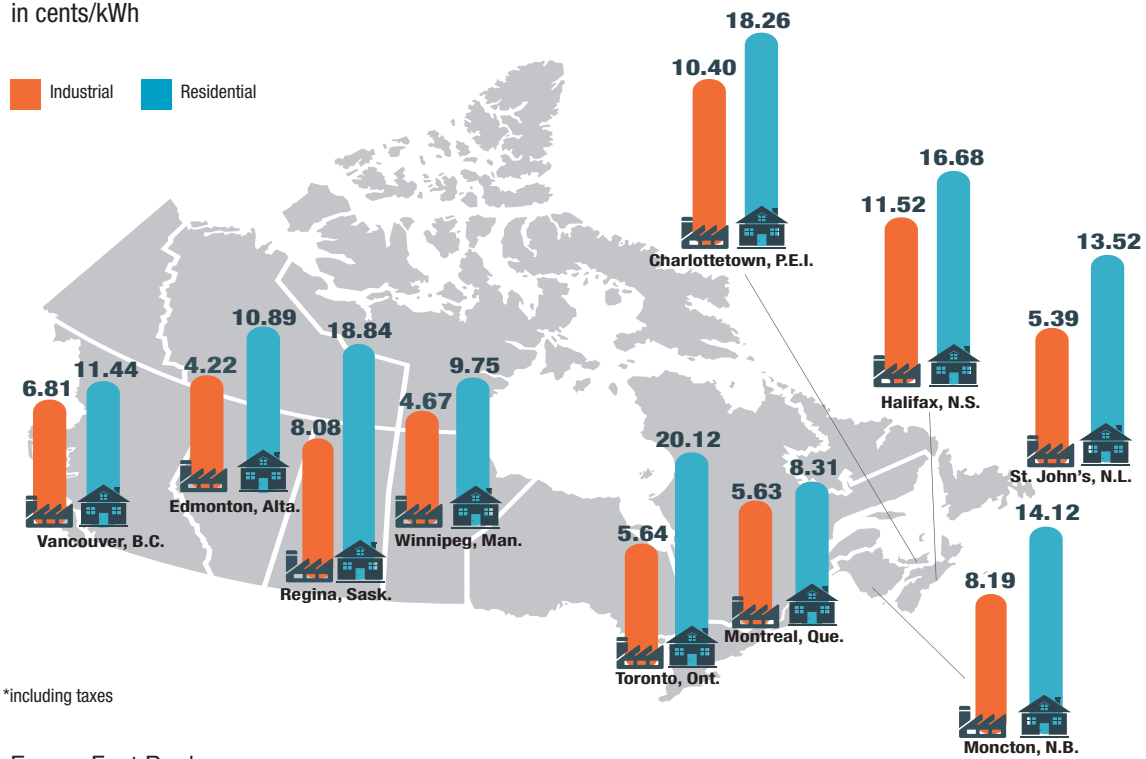
### TIDAL

| | |
|---|---|
| N.S. | 0.1% |

# ELECTRICITY PRICES

## AVERAGE LARGE INDUSTRIAL AND RESIDENTIAL ELECTRICITY PRICES*, APRIL 2016

in cents/kWh




*including taxes

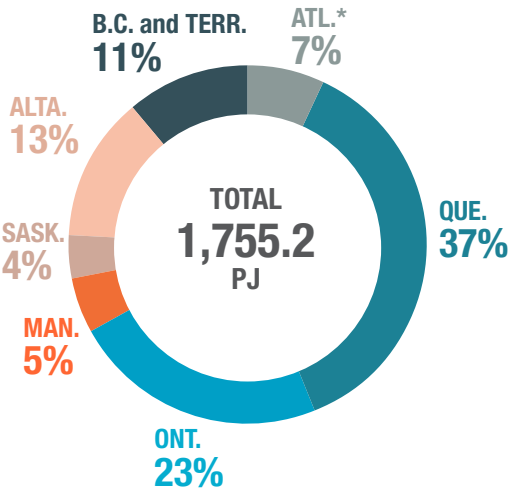
# ELECTRICAL ENERGY USE

## TOTAL ELECTRICAL ENERGY USE* WAS 1,755 PJ IN 2014

| Sector | Energy use (PJ) | % of the total |
|---|---|---|
| Residential | 581.6 | 33.1% |
| Commercial | 375.5 | 21.4% |
| Industrial | 759.7 | 43.3% |
| Transportation | 4.5 | 0.3% |
| Agriculture | 33.8 | 1.9% |
| **Total** | **1,755.1** | **100%** |

*secondary energy use

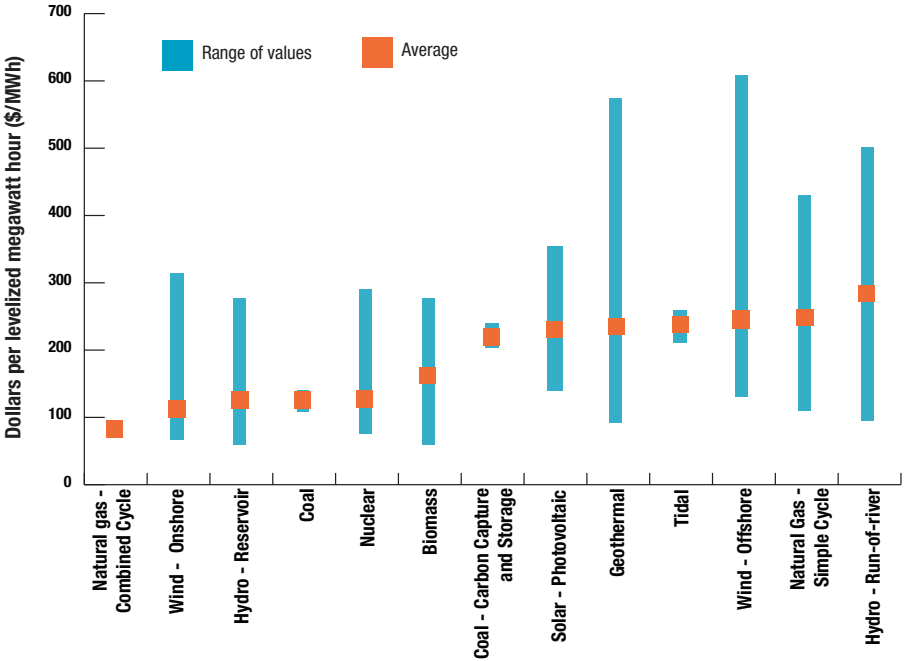
## ELECTRICAL ENERGY USE BY PROVINCE, 2014




* Atlantic provinces

## LEVELIZED COST OF ELECTRICITY

One measure used to directly compare costs between generation technologies is the levelized cost of electricity (LCOE). This is the average price an electricity generator must receive for each unit it generates over its lifetime to financially break even.



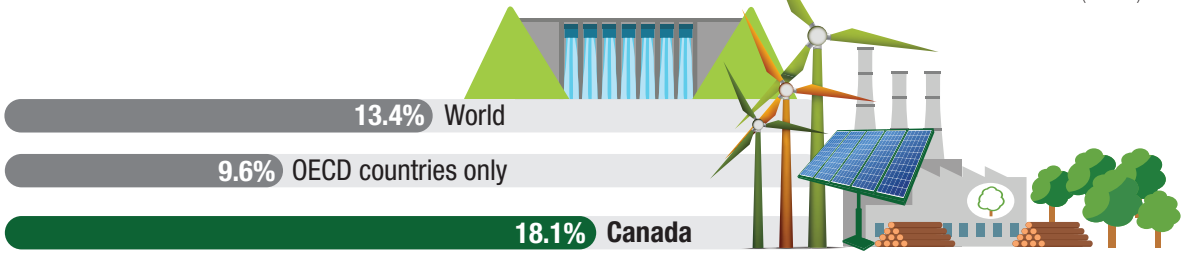
# RENEWABLE ENERGY

## RENEWABLE ENERGY

**World production – 76,144 PJ OR 1,823 MTOE** (2015)

| | |
|---|---|
| 1 China | 14% |
| 2 India | 12% |
| 3 United States | 8% |
| 4 Brazil | 7% |
| ... | |
| **7 Canada** | **3%** |

**Share of energy supply from renewable sources** (2015)



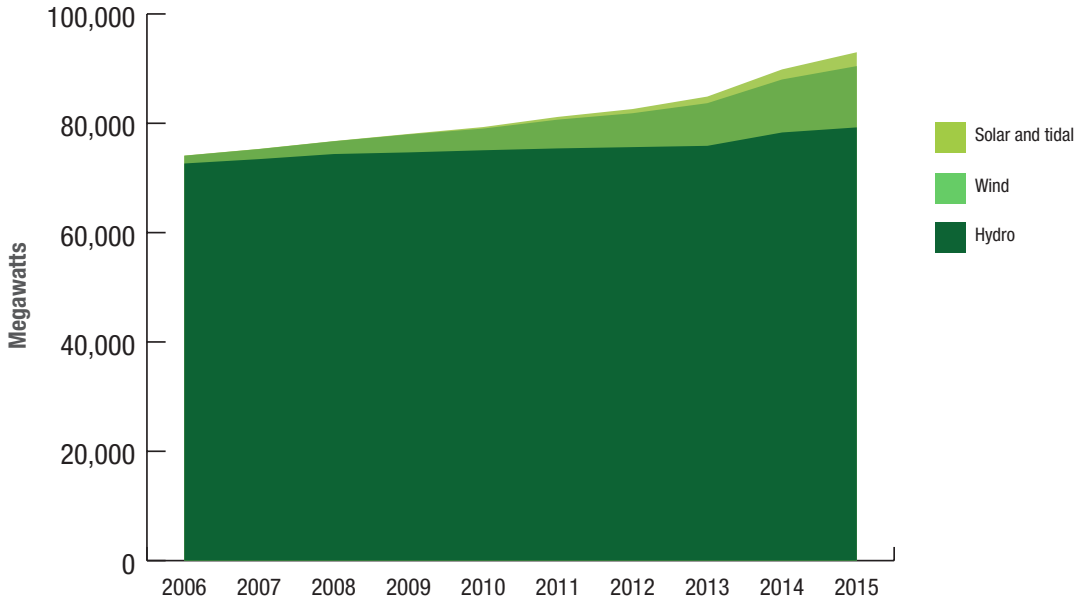
## CANADIAN PRODUCTION (2015)

### Total renewable energy* – 2,049 PJ OR 49 MTOE

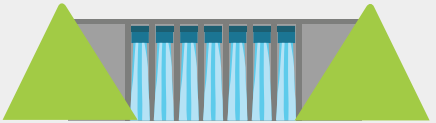
| | |
|---|---|
| 66.9% | Hydro |
| 24.1% | Solid biomass (e.g. wood/waste) |
| 4.6% | Wind |
| 1.8% | Ethanol** |
| 1.2% | Municipal waste/landfill gas |
| 0.51% | Solar photovoltaic |
| 0.49% | Biodiesel |
| 0.31% | Industrial and other waste |
| 0.09% | Solar thermal |
| 0.002% | Tidal |

*includes energy consumed for electricity and heat production and for biofuels in the transportation sector
**is a biogasoline

## CANADIAN HYDRO, WIND, SOLAR ELECTRICITY GENERATING CAPACITY



## HYDROELECTRICITY

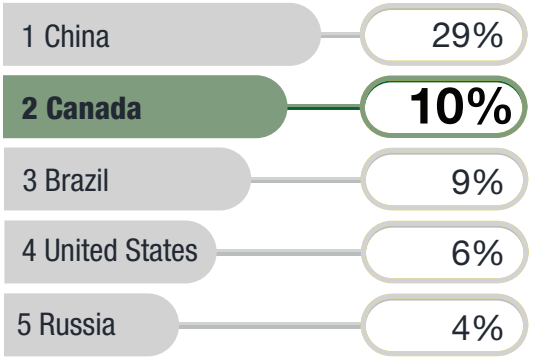


Moving water is the most important renewable energy source in Canada, providing **59%** of Canada's electricity generation. In fact, in 2015, Canada was the second-largest producer of hydroelectricity in the world.

INTERNATIONAL CONTEXT

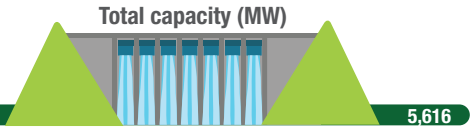
## HYDROELECTRICITY

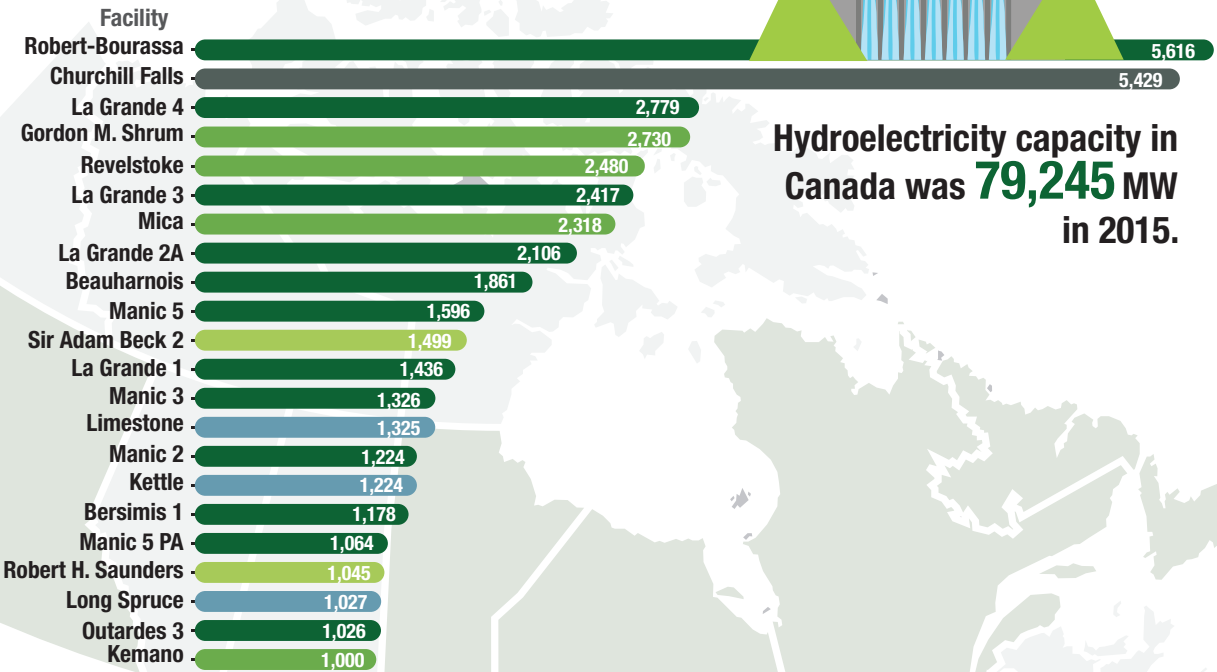
**World generation of hydroelectricity – 3,888 TWh**
(2015)



# HYDROELECTRICITY CAPACITY IN CANADA

## MAJOR HYDRO FACILITIES IN CANADA* (≥1,000 MW)




**Hydroelectricity capacity in Canada was 79,245 MW in 2015.**

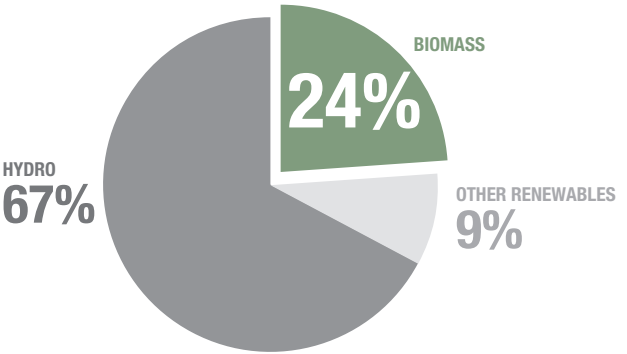
*There are 492 hydro facilities in Canada with a capacity of at least 1 MW.

## BIOMASS

- Biomass is a renewable energy resource derived from living organisms and/or their by products.
- There are **75 facilities** in Canada with an electricity generating capacity of at least **1 MW** that use biomass.
- Together, these facilities have an aggregate capacity of about **2,455 MW**.
- There are also **282 bio-heat facilities** that use biomass to produce heat for largely industrial purposes.

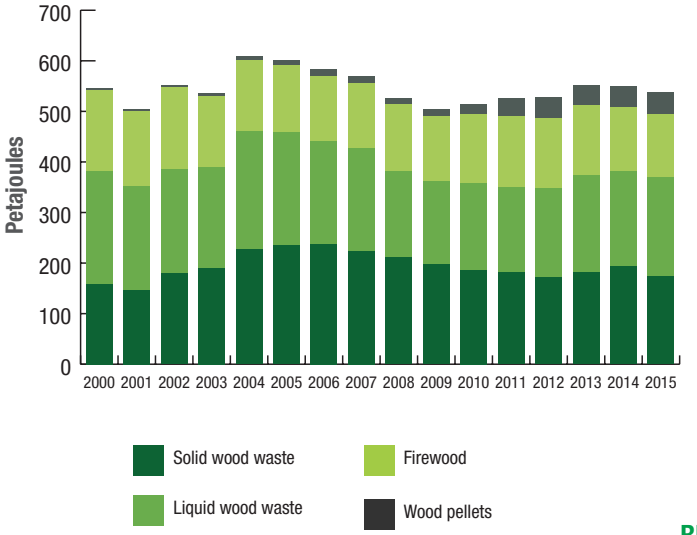
Biomass accounts for the **largest share of renewable energy production** in the OECD, at


**In Canada, that share is**

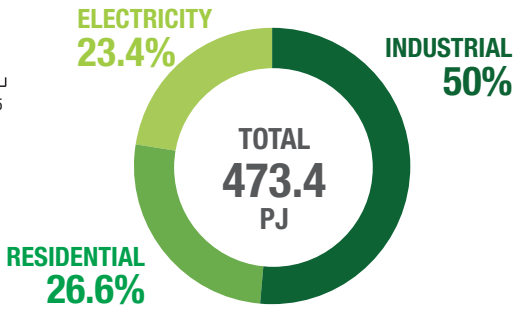


## CANADIAN PRODUCTION

### CANADIAN PRODUCTION OF BIOMASS, 2015




### WOOD FUEL USE BY SECTOR, 2015



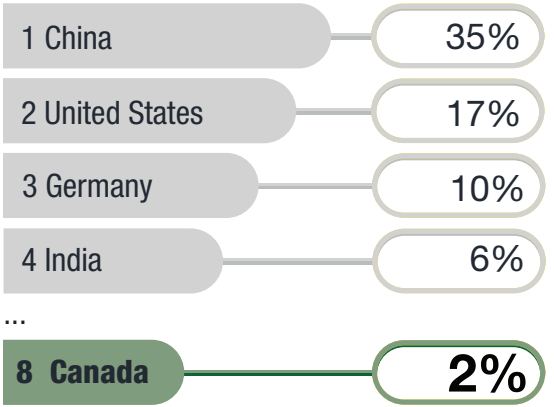
## WIND POWER

- Electricity from wind energy is one of the **fastest growing sources** of electricity in the world and in Canada.
- Wind accounts for **4%** of electricity generation in Canada.

INTERNATIONAL CONTEXT

## WIND POWER

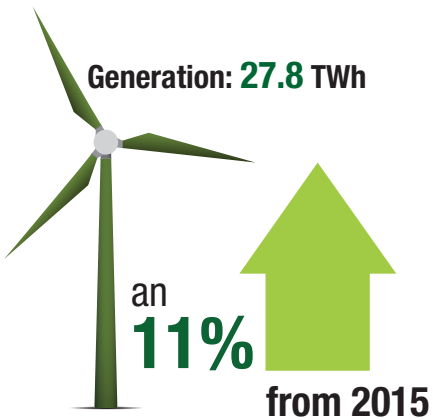
**World capacity of wind power – 486,790 MW**
(2016)



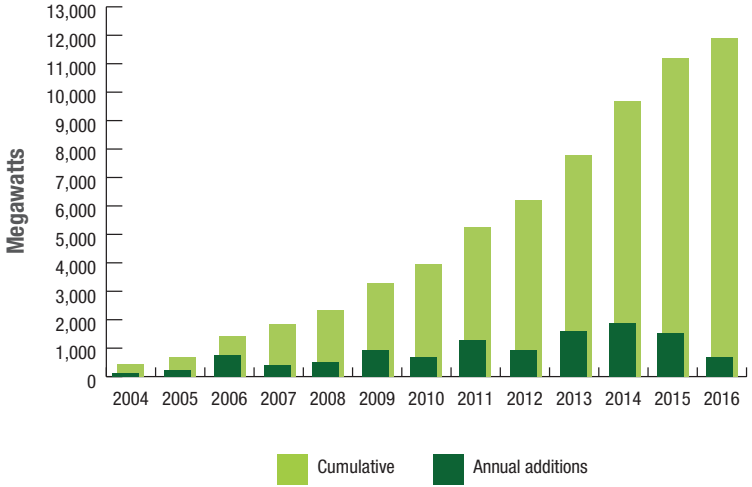
## WIND POWER IN CANADA (2016)

**Capacity: 11,908 MW**

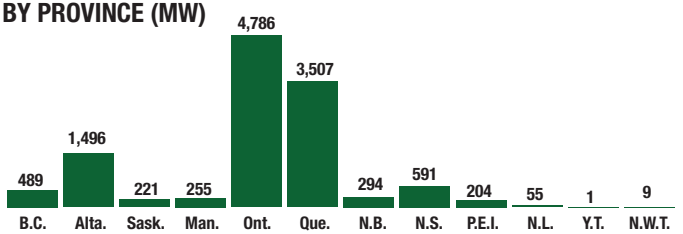
**Generation: 27.8 TWh**



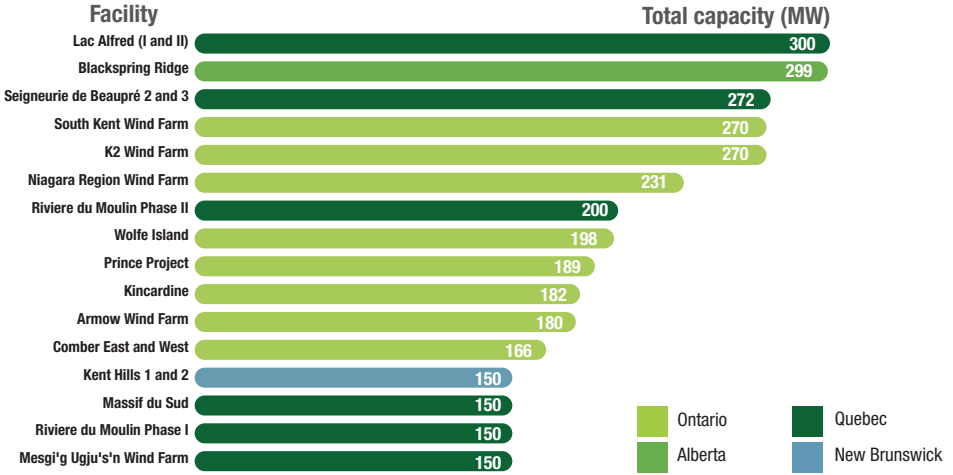

**INSTALLED CAPACITY**



## CAPACITY BY PROVINCE (MW)




## LARGEST WIND FARMS IN CANADA* (≥150 MW)




*There are 255 wind power facilities in Canada with a capacity of at least 1 MW.

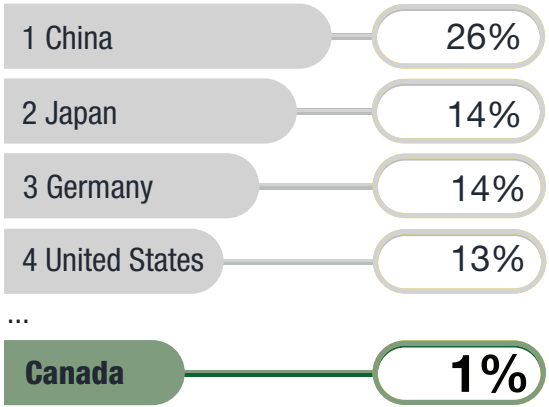
## SOLAR PHOTOVOLTAIC

- Solar power is the conversion of energy from sunlight into electricity. Solar photovoltaics (PV) are rapidly becoming an economical, renewable technology to harness renewable energy from the sun.

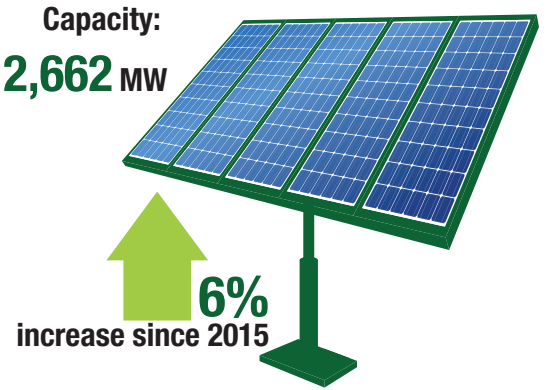
INTERNATIONAL CONTEXT

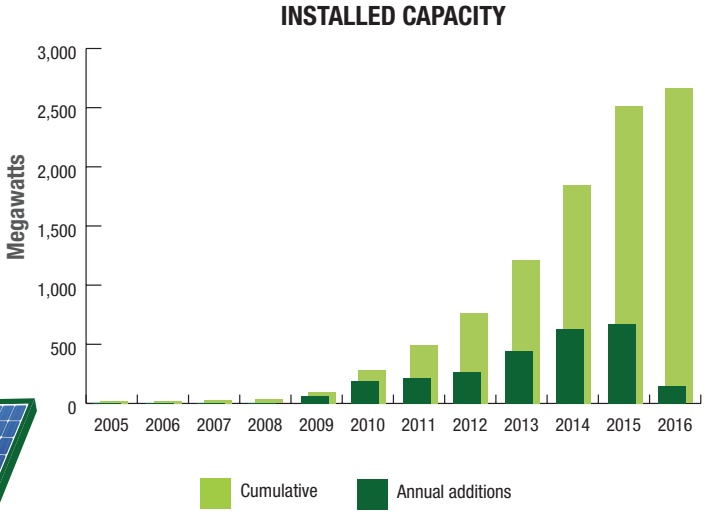
## SOLAR PHOTOVOLTAIC

**World capacity of solar PV – 303,000 MW** (2016)

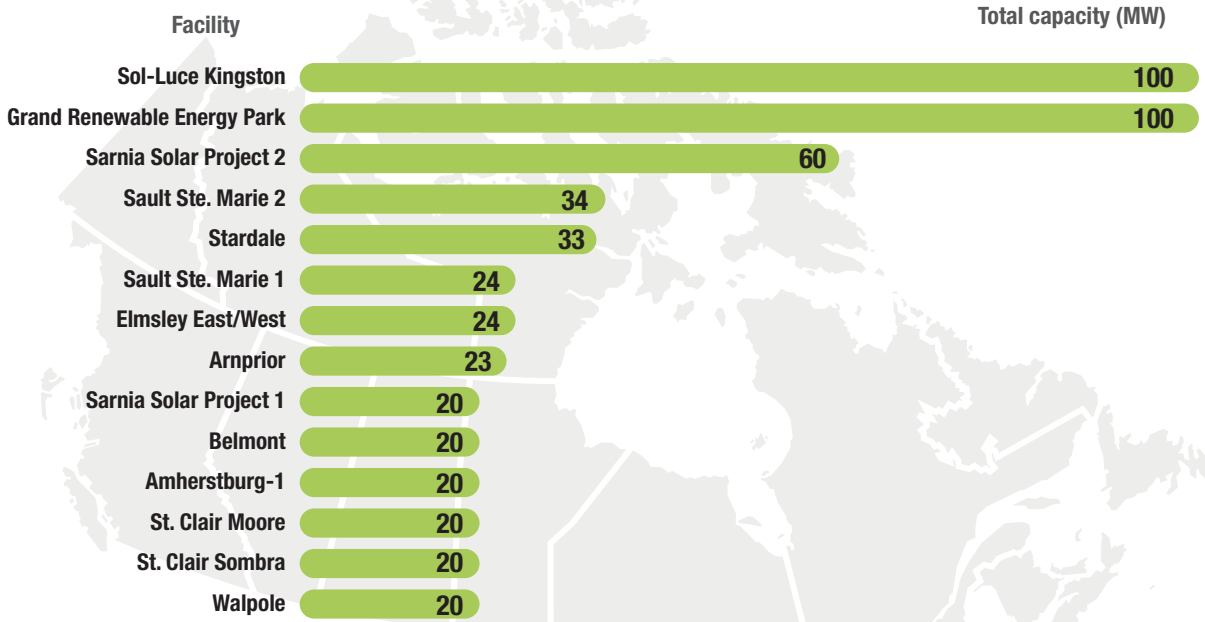


## SOLAR PV IN CANADA (2016)



## SOME OF THE LARGEST SOLAR PV FARMS IN CANADA* (≥20 MW)



## LIQUID BIOFUELS

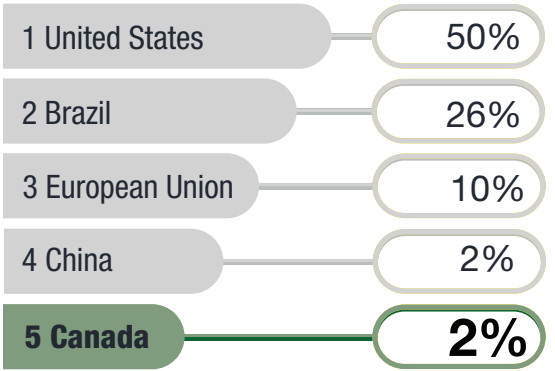
- Liquid biofuels are enhanced biomass-derived fuels that can take the form of a liquid such as ethanol or renewable diesel fuels. The liquid biofuels are mixed with traditional gasoline and diesel to reduce the overall greenhouse gas emissions associated with the blended fuel.
- The federal *Renewable Fuels Regulations* require fuel producers and importers to have an average renewable content of at **least 5%** based on the **volume of gasoline** that they produce or import, and at **least 2%** of the **volume of diesel fuel** that they produce and import.*

* Heating distillate oil volumes for space-heating purposes are excluded from the diesel regulations.

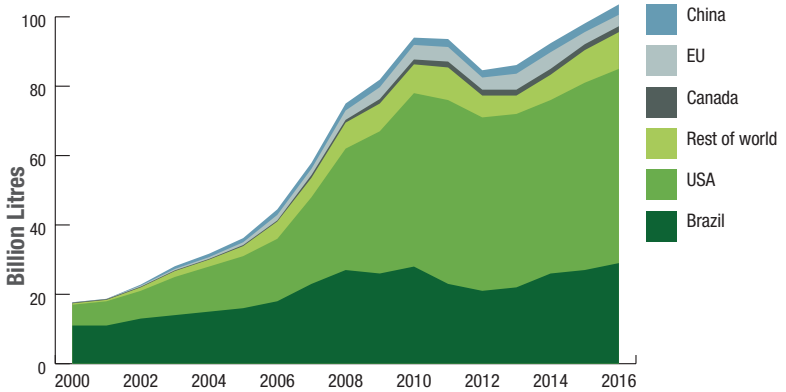
INTERNATIONAL CONTEXT

## LIQUID BIOFUELS

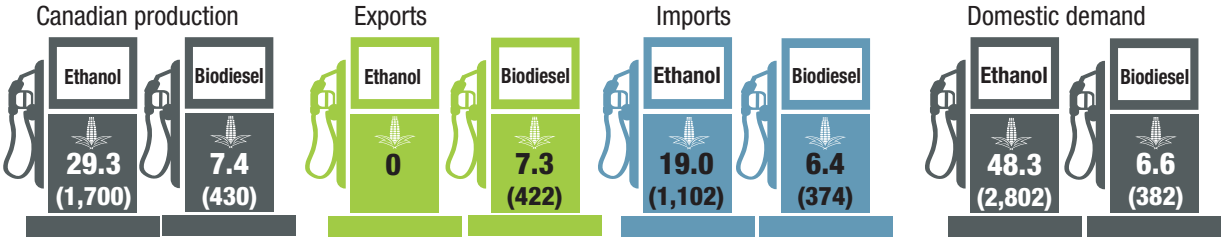
**World capacity of biofuels – 124.0 billion litres**
(2016)



## WORLD BIOFUELS PRODUCTION



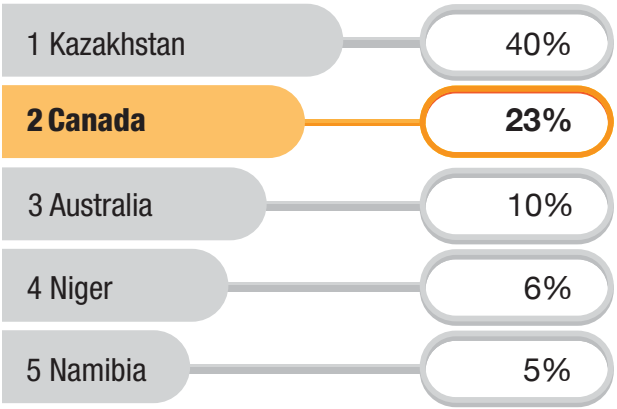

## CANADIAN SUPPLY AND DEMAND, 2016 - Mb/d (Million L)



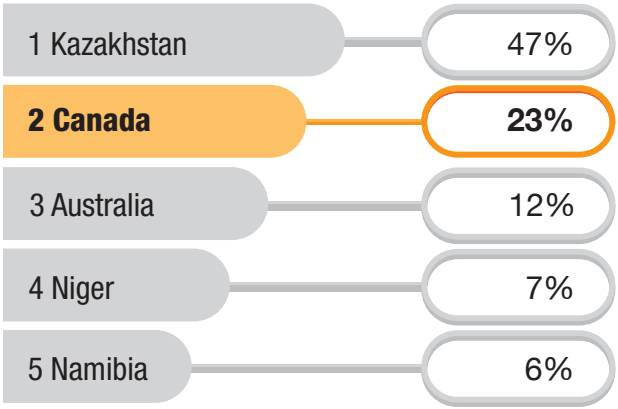
# URANIUM AND NUCLEAR POWER

# URANIUM

**World production – 62.0 kt** (2016, preliminary)

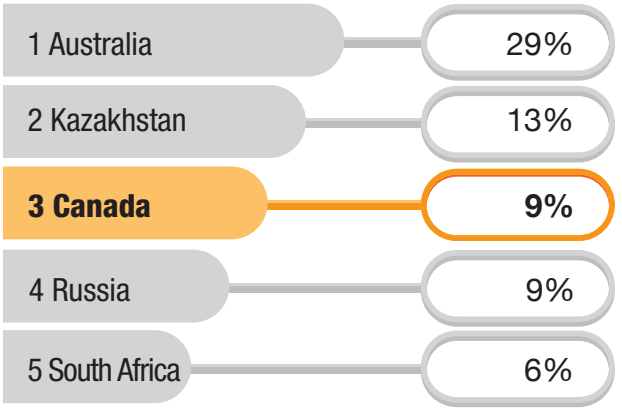



**World exports – 52.8 kt** (2016, preliminary)

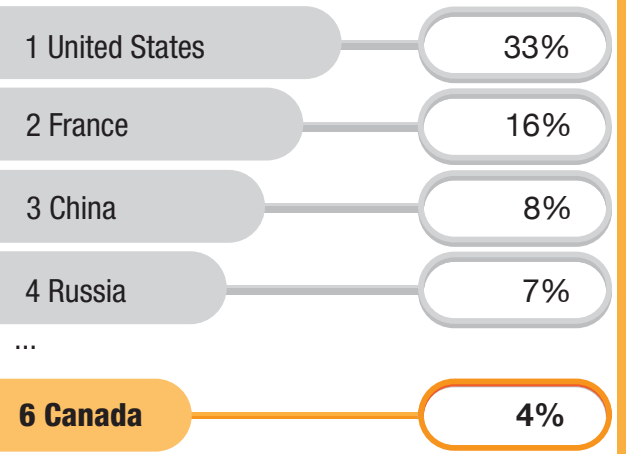


# NUCLEAR POWER

**World known recoverable resources – 5.7 Mt**
(2015)




**World generation – 2,476 TWh** (2016)



## CANADIAN SUPPLY AND DEMAND (2016)

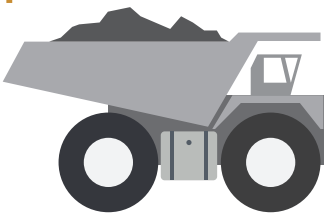
### URANIUM

Canadian production **14.0 kt**

All uranium comes from mines in Saskatchewan.

**ANNUAL VALUE**
is approximately

# $2 billion



**EXPORTS 88%** of production

Based on long-term contracts*, uranium from Canadian mines is generally sold in

| | |
|---|---|
| 1) Asia | **49%** |
| 2) North America/Latin America | **31%** |
| 3) Europe | **20%** |

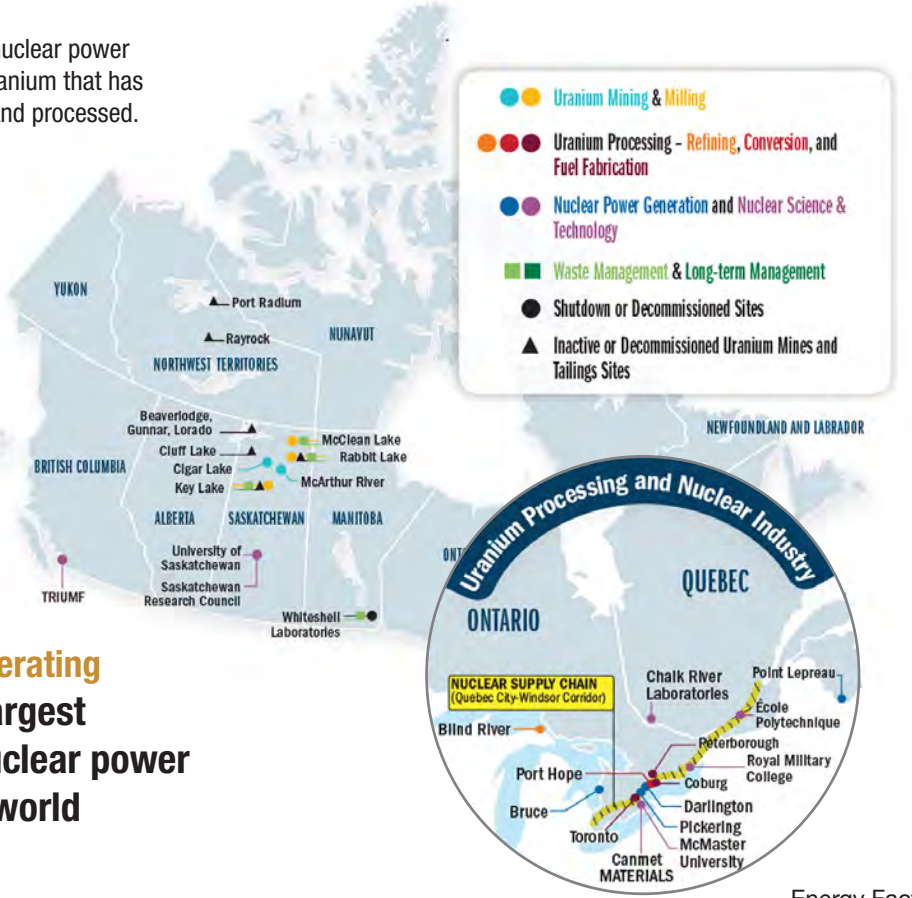
* These values can vary based on changes in regional demand.

**22%** of uranium purchased by U.S. nuclear reactors in 2016 came from Canada, making Canada the largest foreign supplier of uranium to the U.S.

**DOMESTIC USE: 12%** of production

Used in Canada's CANDU reactors (Ontario and New Brunswick), including the Bruce Generating Station, the world's largest operating nuclear facility.

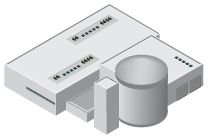
Across the country, nuclear power is generated from uranium that has been mined, milled and processed.




The **Bruce Generating Station** is the **largest operating nuclear power plant in the world**

## CANDU NUCLEAR REACTORS

- **Canada has developed a unique nuclear reactor technology called CANDU**, for CANada Deuterium Uranium. Canada is one of roughly half a dozen countries that offer domestic designed reactors to the open commercial market.
- The CANDU reactor is a pressurized heavy water reactor (PHWR) that uses heavy water (deuterium oxide) as a moderator and coolant and natural uranium for fuel. The majority of power reactors in use in the world are light water reactors (LWRs), which use normal water as the moderator and coolant and enriched uranium for fuel.
- CANDU technology continues to evolve to enable the use of alternative fuels. Work is underway in Chinese CANDU reactors to demonstrate that they can recycle used fuel from other nuclear power plants, reducing the volume of nuclear waste.



**12 CANDU reactors** are in operation outside of Canada.

## GROSS CAPACITY OF NUCLEAR POWER PLANTS IN CANADA (2015)

| Facility | Province | Total capacity (MW) | Units |
|---|---|---|---|
| Darlington | Ontario | 3,740 | 4 |
| Bruce A | Ontario | 3,220 | 4 |
| Bruce B | Ontario | 3,390 | 4 |
| Pickering A | Ontario | 1,084 | 4 |
| Pickering B | Ontario | 2,160 | 2 |
| Point Lepreau | New Brunswick | 705 | 1 |

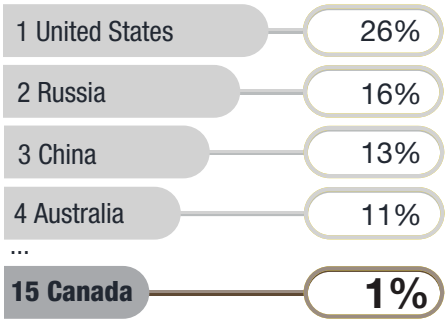
## URANIUM - PRICES


* The majority of Canadian uranium production is sold via long-term contract, as opposed to on the spot market. In the short term, spot prices do not have a significant impact on the annual value of Canada's uranium production.

# COAL

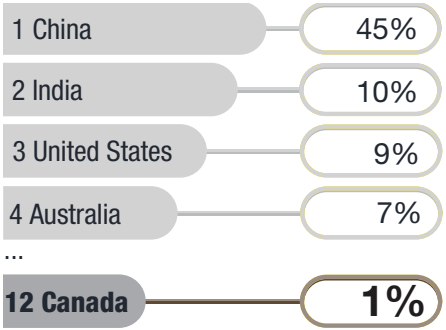
# COAL

## World proved reserves – 985 BILLION TONNES (2014)



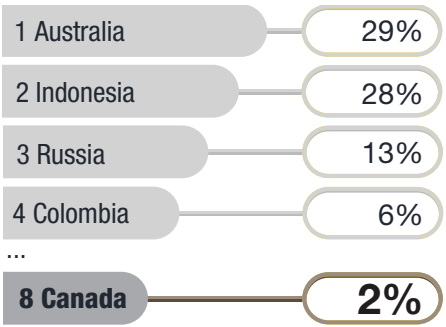

## World production – 7.3 BILLION TONNES

(2016, PRELIMINARY)




## World exports – 1.3 BILLION TONNES

(2016, PRELIMINARY)



## SUPPLY AND DEMAND (2016)

CANADIAN PRODUCTION


EXPORTS


IMPORTS


**major export destinations** (by $ value)
**$4.5 billion**

**24% Japan**
**20% South Korea**
**16% China**

**3%** of Canadian exports are to the

representing **11%** of **U.S. coal imports**

**76%** of Canadian imports are from the

**1/2** of imports are destined for use in steel manufacturing (metallurgical coal); the rest are for electricity generation (thermal coal)

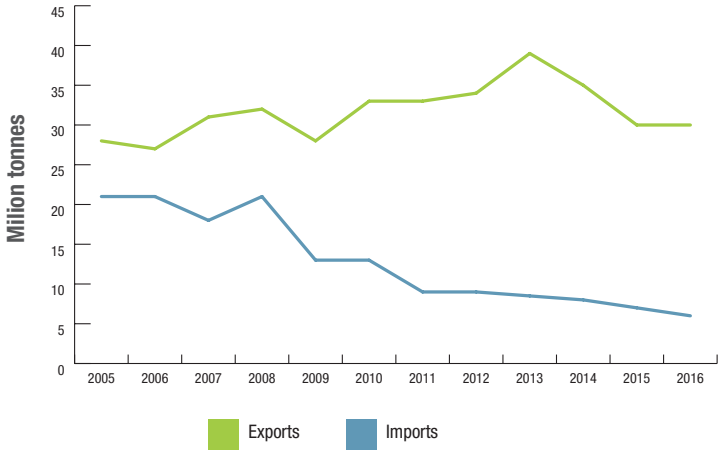
# TRADE

## DOMESTIC DEMAND


Mostly for electricity generation in Alberta and Saskatchewan

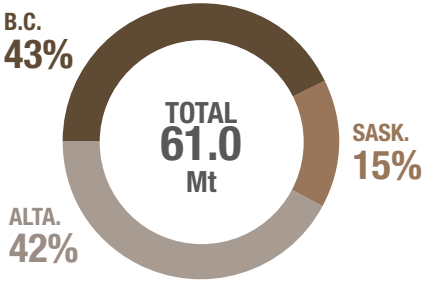
Also for metallurgical applications

## CANADIAN TRADE OF COAL



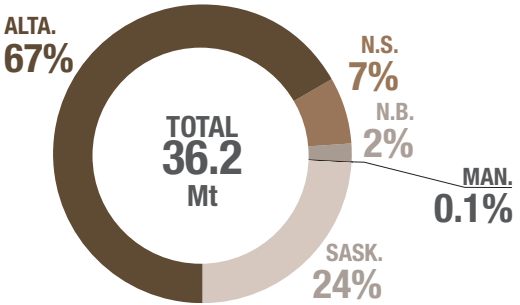
# PRODUCTION AND USE

## PRODUCTION BY PROVINCE, 2016*




* NRCan estimate

## COAL USED FOR ELECTRICITY GENERATION BY PROVINCE, 2015




## COAL-FIRED GENERATING CAPACITY BY PROVINCE, 2017

| Province | Total coal-generating capacity (MW) | Share of total capacity (%) |
|---|---|---|
| Alberta | 6,457 | 65.7% |
| Saskatchewan | 1,530 | 15.6% |
| Nova Scotia | 1,252 | 12.7% |
| New Brunswick | 490 | 5% |
| Manitoba** | 105 | 1.1% |
| **Total** | **9,834** | **100%** |

Note: The government has announced its plan to eliminate the use of traditional coal-fired electricity in Canada by 2030.

** As per provincial regulations, the Brandon coal-fired power plant may be used only in emergency situations.

# ANNEXES

## UNITS AND CONVERSION FACTORS

### PREFIXES AND EQUIVALENTS

| Prefix | | | Equivalent | |
|---|---|---|---|---|
| SI/Metric | | Imperial | | |
| k | kilo | M | thousand | $10^3$ |
| M | mega | MM | million | $10^6$ |
| G | giga | B | billion | $10^9$ |
| T | tera | T | trillion | $10^{12}$ |
| P | peta | - | quadrillion | $10^{15}$ |

Notes

- Tonne may be abbreviated to “t” and is not to be confused with “T” for tera or trillion.
- Roman numerals are sometimes used with imperial units (this can create confusion with the metric “M”).

## CRUDE OIL

### Upstream

- reserves/production usually in barrels or multiples (million barrels)
- production/capacity often in barrels per day or multiples (thousand barrels/day or Mb/d, million barrels/day or MMb/d)
- metric: 1 cubic metre = 6.2898 barrels
- International Energy Agency: uses weight (tonnes) rather than volume

### Downstream

- volumes of refined products usually in litres
- 1,000 litres = 1 cubic metre
- U.S.: 1 U.S. gallon = 3.785 litres

## NATURAL GAS

### Volume

- reserves/production usually in cubic feet or multiples (billion cubic feet or Bcf, trillion cubic feet or Tcf)
- production/capacity often in cubic feet per day or multiples (Bcf/d, Tcf/d)
- metric: 1 cubic metre = 35.3147 cubic feet

### Density

- 1 million t LNG = 48.0279 billion cubic feet

### Pricing

Volume-based:

- cents per cubic metre (¢/$m^3$) (customer level in Canada)
- $ per hundred cubic feet ($/CCF) (customer level in the U.S.)

Energy content – based:

- $ per gigajoule ($/GJ) (company level in Canada)
- $ per million British thermal units ($/MMBTU) (company level in the U.S., LNG)

## URANIUM

- 1 metric tonne = 1,000 kilograms of uranium metal (U)
- U.S.: in pounds of uranium oxide (U3O8)
- 1 lb. U3O8 = 0.84802 lb. U = 0.38465 kg U

## COAL

- 1 metric tonne = 1,000 kilograms
- U.S.: 1 short ton = 2,000 pounds
- 1 metric tonne = 1.10231 short tons

## ELECTRICITY

### Capacity

- maximum rated output that can be supplied at an instant, commonly expressed in megawatts (MW)

### Total capacity

- installed generator nameplate capacity

### Generation/sales

- flow of electricity over time, expressed in watt-hours, or multiples:
  - kilowatt-hours or kWh (e.g. customer level)
  - megawatt-hours or MWh (e.g. plant level)
  - gigawatt-hours or GWh (e.g. utility level)
  - terawatt-hours or TWh (e.g. country level)

### From capacity to generation

- A 1-MW unit operating at full capacity over one hour generates 1 MWh of electricity.
- Over one year, this unit could generate up to 8,760 MWh (1 MW × 24 hr × 365 days).

- Units are rarely used at full capacity over time because of factors such as maintenance requirements, resource limitations and low demand.
- "Capacity factor" is the ratio of actual generation to full capacity potential.

## ENERGY CONTENT

Rather than using "natural" units (e.g. volume, weight), energy sources can be measured according to their energy content – this allows comparison between energy sources.

- metric: joules or multiples (gigajoules or GJ, terajoules or TJ, petajoules or PJ)
- U.S.: 1 British thermal unit (BTU) = 1,055.06 joules
- IEA: energy balances expressed in oil equivalent:
  - thousand tonnes of oil equivalent (ktoe)
  - million tonnes of oil equivalent (Mtoe)

### Typical values

- 1 $m^3$ of crude oil = 39.0 GJ
- 1,000 $m^3$ of natural gas = 38.3 GJ
- 1 MWh of electricity = 3.6 GJ
- 1 metric tonne of coal = 29.3 GJ
- 1 metric tonne of wood waste = 18.0 GJ
- 1 metric tonne of uranium = 420,000 GJ to 672,000 GJ

## ABBREVIATIONS

| | |
|---|---|
| AECO | Alberta Energy Company |
| b/d | barrels per day |
| Bcf/d | billion cubic feet per day |
| Bcm/d | billion cubic metres per day |
| CANDU | Canada Deuterium Uranium |
| CCS | carbon capture and storage |
| CCUS | carbon capture, utilization and storage |
| CDIA | Canadian direct investment abroad\ |
| CEA | Canadian energy assets |
| $CO_2$ equivalent | carbon dioxide equivalent |
| CPI | consumer price index |
| CPL | cents per litre |
| EIA | Energy Information Administration (U.S.) |
| EU | European Union |
| FDI | foreign direct investment |
| G7 | Seven wealthiest major developed nations: Canada, France, Germany, Italy, Japan, U.K. and U.S. |
| GDP | gross domestic product |
| GHG | greenhouse gas |
| GJ | gigajoule |
| GST | Goods and Services tax |
| GWh | gigawatt hours |
| HGL | hydrocarbon gas liquids |
| HST | Harmonized sales tax |
| IEA | International Energy Agency |
| kg | kilogram |
| km | kilometre |
| $km^2$ | square kilometre |
| kt | kilotonne |
| kWh | kilowatt hour |
| lb. | pound |
| L | litre |
| LCOE | levelized cost of electricity |
| LDC | local distribution company |
| LNG | liquefied natural gas |
| LPG | liquefied petroleum gases |
| LWR | light water reactor |
| m | metre |
| $m^2$ | square metre |
| $m^3$ | cubic metre |
| Mb/d | thousand barrels per day |
| MJ | megajoule |
| MMb/d | million barrels per day |
| MMcf/d | million cubic feet per day |
| MMbtu | million British thermal units |
| Mt | million tonnes; megatonne |
| Mtoe | million tons of oil equivalent |
| mtpa | million tonnes per annum |
| MW | megawatt |
| NEB | National Energy Board |
| NGL | natural gas liquids |
| NRCan | Natural Resources Canada |

| | |
|---|---|
| NSERC | National Science and Engineering Research Council of Canada |
| OECD | Organisation for Economic Co-operation and Development |
| PHWR | pressurized heavy water reactor |
| PJ | petajoule |
| Pkm | passenger-kilometre |
| Provinces | Alta. – Alberta |
| | B.C. – British Columbia |
| | Man. – Manitoba |
| | N.B. – New Brunswick |
| | N.L. – Newfoundland and Labrador |
| | N.S. – Nova Scotia |
| | Nu. – Nunavut |
| | N.W.T. – Northwest Territories |
| | Ont. – Ontario |
| | P.E.I. – Prince Edward Island |
| | Que. – Quebec |
| | Sask. – Saskatchewan |
| | Y.T. – Yukon |
| | Atl. – Atlantic provinces |
| | Terr. – Territories |
| P/T | provincial/territorial |
| PV | photovoltaic |
| RD&D | research, development and demonstration |
| R&D | research and development |
| RPP | refined petroleum products |
| SDTC | Sustainable Development Technology Canada |
| SMR | small modular reactor |
| Tcf | trillion cubic feet |
| Tcm | trillion cubic metres |
| Tkm | tonne-kilometre |
| t | tonnes |
| TPES | total primary energy supply |
| TWh | terawatt-hour |
| UAE | United Arab Emirates |
| U.K. | United Kingdom |
| U.S. | United States |
| US$ | United States dollars |
| WCS | Western Canada Select |
| WTI | West Texas Intermediate |

# SOURCES

## 1. ENERGY AND THE ECONOMY

- Global Primary Energy Production: IEA Annual Database
- Global Energy Rankings: IEA Annual Database
- Global Trade: StatCan International Merchandise Trade Database (TRAGS Database) and IEA Annual Database
- CANADA – U.S. Trade: StatCan International Merchandise Trade Database (TRAGS Database) and U.S. EIA, U.S. Imports by Country of Origin Database
- GDP: StatCan CANSIM tables 388-0010, 384-0037, and 379-0028 and NRCan estimates
- Government Revenue: StatCan CANSIM Table 180-0003, StatCan special tabulation (royalties), and Canadian Association of Petroleum Producers, Statistical Handbook, Table 01-01C
- Employment: StatCan CANSIM tables 388-0010 and 383-0029 and NRCan estimates
- Capital expenditures: StatCan CANSIM tables 029-0045, 029-0046, and 029-0051
- Foreign Direct Investment and Canadian Direct Investment Abroad: StatCan CANSIM Table 376-0052
- Foreign control: StatCan CANSIM tables 179-0004, 179-0005, and 180-0003
- Canadian Energy Assets: compiled by NRCan from S&P's Capital IQ
- Canadian Expenditures on Energy RD&D: IEA Data Services, Data analysis performed by NRCan using the IEA Energy RD&D survey results for public expenditures; Statistics Canada, Annual Survey of R&D in Canadian Industry, Energy-related R&D by area of technology for industry expenditures, Industry data analysis performed by NRCan using internal data provided by Statistics Canada
- Database Clean Energy and Tech Investment: Bloomberg New Energy Finance (BNEF), TSX and TYSX-V, Canadian Clean Tech Industry report – Analytica Advisors 2017
- Residential Energy Use: Office of Energy Efficiency's National Energy Use Database based on StatCan data
- Household expenditures: StatCan CANSIM Table 203-0021
- Consumer prices: StatCan CANSIM Table 326-0020
- Canadian Energy Production: StatCan CANSIM tables 127-007, 128-0016, and 128-0007, and NRCan estimates

## 2. ENERGY AND GHGS

- Global Emission Sources: Environment and Climate Change Canada – Drivers and Impacts of Greenhouse Gas Emissions
- GHG Overview: Environment and Climate Change Canada National Inventory Report 1990–2014: Greenhouse Gas Sources and Sinks in Canada, World Resources Institute – CAIT Climate Data Explorer and NRCan analysis
- Oil and Gas emissions intensity: Environment and Climate Change Canada 2017 National Inventory Report as submitted to the United Nations Framework Convention on Climate Change
- Electricity GHG: Environment and Climate Change Canada Environmental Indicators: Greenhouse Gas Emissions by Canadian Economic Sector 1990–2015
- Non-emitting electricity share: World Bank, Sustainable Energy for All (SE4ALL) database from the SE4ALL Global Tracking Framework led jointly by the World Bank, International Energy Agency and the Energy Sector Management Assistance Program
- Solar and Wind Generation: IEA Annual Database

- Transportation GHG: Environment and Climate Change Canada Environmental Indicators: Greenhouse Gas Emissions by Canadian Economic Sector 1990–2015
- Transportation Fuel Mix: Office of Energy Efficiency's National Energy Use Database
- Electric Vehicle Sales: Bloomberg New Energy Finance (BNEF)
- Province and Territory GHG Emissions: Environment and Climate Change Environmental Indicators: Greenhouse Gas Emissions by Province and Territory, StatCan CANSIM Table 051-0001
- Total primary energy supply: IEA Annual Database, World Energy Balances and IEA SLT questionnaire
- Primary and secondary energy use: Office of Energy Efficiency's National Energy Use Database based on StatCan data
- Energy efficiency: Office of Energy Efficiency's National Energy Use Database
- Energy intensity: Office of Energy Efficiency's National Energy Use Database
- Commercial and institutional sector: Office of Energy Efficiency's National Energy Use Database based on StatCan data
- Trends in Energy Use and Intensity: Office of Energy Efficiency Energy Use Database – Efficiency Trends Analysis tables
- Transition to Low Carbon Future: Pan-Canadian Framework on Clean Growth and Climate Change, Environment and Climate Change Canada National Inventory Report
- Coal Phase Out: IEA World Annual Balances
- Carbon Price: The World Bank Carbon Pricing Dashboard

## 3. CRUDE OIL

- Key Facts: CanOils Database
- World production and exports: International Energy Agency (IEA Online Data Services)
- World proved reserves: Oil and Gas Journal, Survey: Worldwide Look at Reserves and Production
- Canadian resources: CAPP, Statistical Handbook for Canada's Upstream Petroleum Industry, March 2017; Alberta Energy Regulator (AER) ST98; National Energy Board (NEB)
- Wells completed and metres drilled in western Canada: JuneWarren-Nickle's Energy Group, Canadian Association of Oilwell Drilling Contractors (CAODC)
- Canadian production: StatCan CANSIM tables 126-0001 and 126-0003 and NRCan analysis
- Canadian supply and demand: StatCan CANSIM tables 126-0001, 126-0003, 134-0001, and 133-0003 and StatCan International Merchandise Trade Database (TRAGS Database)
- Trade: StatCan CANSIM tables 126-0001 and 126-0003 and StatCan International Merchandise Trade Database (TRAGS Database), U.S. Energy Information Administration, Imports by Country of Origin, Refinery and Blender Net Input for Crude Oil
- Prices: U.S. EIA tables on Spot Prices for Crude Oil and Sproule Worldwide Petroleum Consultants
- Pipelines: compiled by NRCan
- Oil sands: CAPP Statistical Handbook for Canada's Upstream Petroleum Industry, Table 4-16B, Statistics Canada CANSIM tables 029-0046, 126-0001, and 126-0003, Alberta Energy Regulator (AER) ST98, Canada's Oil Sands Innovation Alliance (COSIA), CanOils Database and NRCan analysis

- Light tight Oil/Shale Oil: U.S. EIA, Technically Recoverable Shale Oil Resources
- Environmental considerations: NRCan compiled using Environment and Climate Change Canada (ECCC) National Inventory Report 1990-2014: Greenhouse Gas Sources and Sinks in Canada, World Resources Institute – CAIT Climate Data Explorer, Alberta Government Oil Sands Information Portal (OSIP), Alberta Energy Regulator, Statistics Canada, NRCan Boreal forest website, Alberta Government Lower Athabasca Regional Plan (LARP)
- Transportation: CANSIM Table 404-0002, CAPP Crude Oil Forecast, Markets & Transportation, NEB Canadian Crude Oil Exports by Rail – Quarterly Data

## 4. PETROLEUM PRODUCTS

- Canadian refineries: compiled by NRCan from company information and Conference Board of Canada, Canada's Petroleum Refining Sector, including Canadian Fuels Association, Canadian Association of Petroleum Producers and CanOils Database
- Canadian supply and demand: StatCan CANSIM tables 134-0001 and 134-0004 and NRCan analysis
- Sales by Product: StatCan CANSIM Table 134-0004 and NRCan analysis
- Trade: StatCan CANSIM Table 134-0004, U.S. EIA, U.S. Imports by Country of Origin for Petroleum and Other Liquids, and StatCan International Merchandise Trade Database (percentage of dollar value)
- Gasoline prices: Kent Group Ltd, average retail prices for regular gasoline and diesel fuel, and data compiled by NRCan

## 5. HYDROCARBON GAS LIQUIDS

- Canadian supply and demand: StatCan CANSIM tables 134-004 and 131-0002, NEB and StatCan International Merchandise Trade Database (TRAGS Database) for Imports
- Natural gas liquids energy use: NRCan Office of Energy Efficiency's National Energy Use Database based on StatCan data
- Production by province: CAPP Statistical Handbook for Canada's Upstream Petroleum Industry, tables 3.5a, 3.6a, and 3.14a

## 6. NATURAL GAS

- World production and exports: International Energy Agency, IEA Natural Gas Information
- World proved reserves: Oil and Gas Journal
- Canada reserves: CAPP Statistical Handbook for Canada's Upstream Petroleum Industry, Table 02-13B
- Shale gas: U.S. EIA, Technically Recoverable Shale Gas Resources, June 2013, able 6
- U.S. reserves: U.S. EIA, Natural Gas Reserves Summary, dry gas
- Canada resources: NEB, Canada's Energy Future 2016
- U.S. resources: 2013 and U.S. EIA, Technically Recoverable Shale Oil and Shale Gas Resources: An Assessment of 137 Shale Formations in 41 Countries Outside the United States, June 2013
- World resources: International Energy Agency, World Energy Outlook 2015, table 5.3
- Canada-U.S. market: compiled by NRCan from StatCan, U.S. EIA, US Natural Gas Imports by Country, National Energy Board, Natural Gas Imports, Exports and Liquefied Natural Gas Statistics, Commodity Statistics for LNG imports, LNG Shipment Details
- Canadian production: StatCan CANSIM Table 131-0001

- U.S production: U.S. EIA Table Natural Gas Gross Withdrawals and Production
- Trade: NEB, Natural Gas Imports, Exports and Liquefied Natural Gas Statistics, Commodity Statistics for pipeline trade, Gas Monthly Summary for the Year, U.S. EIA, Natural Gas Consumption by End Use, StatCan International Merchandise Trade Database (TRAGS Database) and calculations by NRCan
- Prices: Sproule Price Forecast
- Shale and Tight Gas: NEB, Canada's Energy Future 2016: Energy Supply and Demand Projections to 2040
- Pipelines: compiled by NRCan
- Natural gas energy use: Wells completed and metres drilled in western Canada: JuneWarren-Nickle's Energy Group, Canadian Association of Oilwell Drilling Contractors, and CAPP Statistical Handbook for Canada's Upstream Petroleum Industry, Table 1.2 February 2016

## 7. ELECTRICITY

- World generation and exports: International Energy Agency, IEA Electricity Information (note: IEA production/generation data is expressed on a "gross" basis, i.e. before generating station use)
- Canadian supply: compiled by StatCan and NRCan
- Trade: National Energy Board table Electricity Exports and Imports Statistics, StatCan, and U.S. EIA Table Retail Sales of Electricity to Ultimate Customers
- Domestic demand: StatCan CANSIM Table 128-0017
- Prices: Hydro-Québec report Comparison of Electricity Prices in Major North American Cities
- Electricity energy use: NRCan OEE Comprehensive Energy Use Database.
- Levelized cost of electricity: National Energy Agency, Canada's Adoption of Renewable Power Sources – Energy Market Analysis

## 8. RENEWABLE ENERGY

- International context: International Energy Agency (IEA Renewables Information)
- Domestic production: International Energy Agency (IEA Renewables Information), based on StatCan and NRCan data
- Hydro – international context: International Energy Agency (IEA Electricity Information, Energy Balances of OECD Countries, and Energy Balances of Non-OECD Countries)
- Hydro – capacity in Canada: StatCan CANSIM Table 127-0009 and compiled by NRCan
- Hydro – facilities and projects: compiled by NRCan from StatCan and other public sources
- Wood and wood waste – share of renewables: International Energy Agency (IEA Renewables Information)
- Wood and wood waste – production: StatCan CANSIM Table 128-0018, StatCan International Merchandise Trade Database (TRAGS), NRCan
- Wood and wood waste – wood fuel use by sector: International Energy Agency, IEA Renewables Information
- Wood and wood waste – trade: StatCan International Merchandise Trade Database (TRAGS)
- Wind – international context: Global Wind Energy Council
- Wind – generation in Canada: StatCan CANSIM Table 127-0007
- Wind – capacity in Canada: compiled by NRCan from multiple sources (e.g. Canadian Wind Energy Association, StatCan, NRCan)
- Wind – wind farms: compiled by NRCan from StatCan data and other public sources

- Solar PV – international context: Renewable Energy Policy Network for the 21st Century
- Solar PV – capacity in Canada: Canada's Annual Report to the IEA Implementing Agreement on PV and compiled by NRCan
- Solar PV – solar PV farms: compiled by NRCan from StatCan data and other public sources
- Biofuels – Canadian production of biofuels and World production of biofuels: Bloomberg New Energy Finance, F.O. Licht, FAPRI, NRCan, Environment and Climate Change Canada
- Biofuels – supply and demand and production: Bloomberg New Energy Finance, FO Licht, FAPRI, Environment and Climate Change Canada 2016 Biodiesel Production from Industry Representatives,
- Biofuels – imports/exports: StatCan data
- Biofuels – ethanol prices: Oil Price Information Service, Chicago Ethanol Market Price
- Biofuels – regulations: compiled by NRCan

## 9. URANIUM AND NUCLEAR POWER

- World production and exports: World Nuclear Association
- World known recoverable resources: World Nuclear Association
- Nuclear power world generation: IAEA, International Atomic Energy Agency, (Nuclear Power Reactors in the World)
- Canadian supply and demand: compiled by NRCan from company information; also published by the World Nuclear Association
- Purchases by U.S. nuclear reactors: U.S. EIA Table Uranium Purchases by Owners and Operators of Civilian Nuclear Power Reactors
- Spot prices: Ux Consulting Company
- Nuclear power plants in Canada: compiled by NRCan from StatCan and other public sources

## 10. COAL

- World production and exports: International Energy Agency, IEA Coal Information
- World proved reserves: World Energy Council
- Canadian supply and demand: StatCan CANSIM Table 135-0002 and StatCan International Merchandise Trade Database (TRAGS Database)
- Coal-fueled power plants: compiled by NRCan from StatCan and other public sources

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