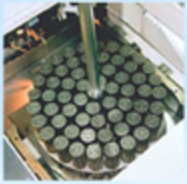




Natural Resources  
Canada

Ressources naturelles  
Canada

# Energy Fact Book 2016–2017







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# **Energy Fact Book 2016–2017**

Canada

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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 2016. 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.



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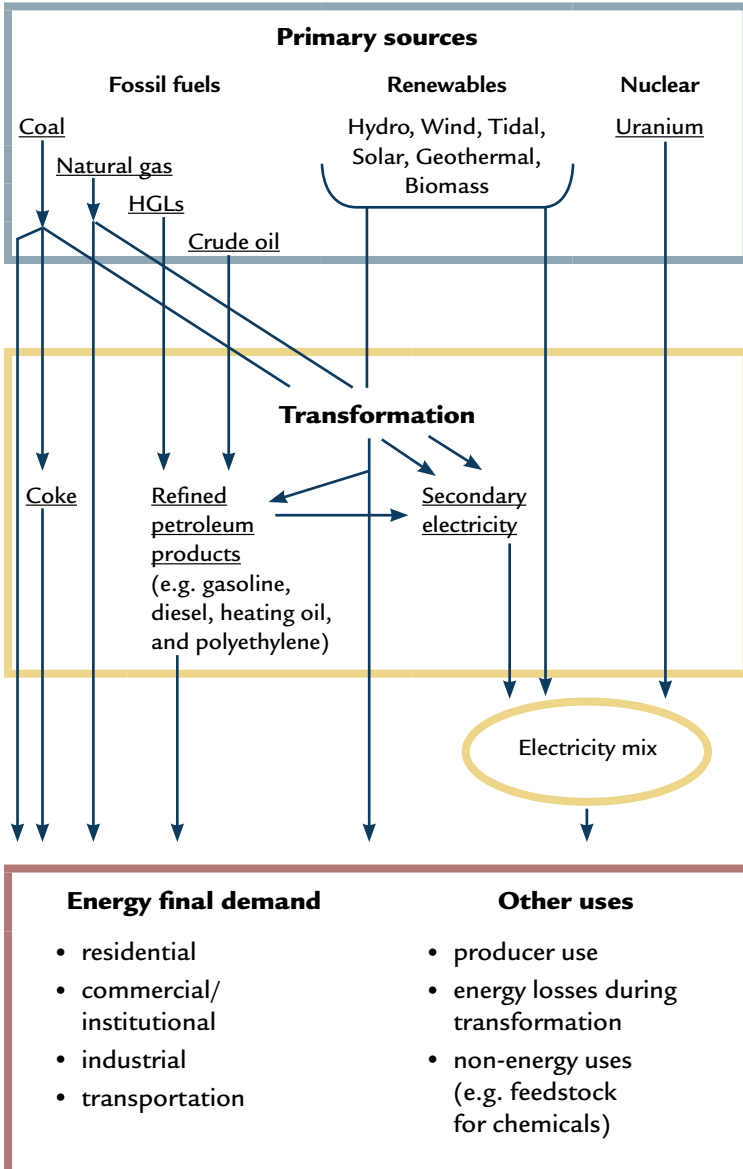
## Definition

In this publication, the following industries are considered to be energy industries:

- oil and gas extraction
- coal mining
- uranium mining
- support activities for oil and gas extraction
- electric power generation, transmission and distribution
- pipeline transportation
- natural gas distribution
- biofuels production
- petroleum refineries

Clean energy industries such as renewable and nuclear electricity generation, biofuels production and carbon capture and storage (CCS) 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.

## Energy flow



## Canada's position in the world (2015)

Resource	Proved reserve/ capacity	Production	Exports
Crude oil	3rd	4th	3rd
Natural gas	17th	5th	4th
Coal	15th	12th	8th
Uranium	4th	2nd	2nd
Electricity	7th	6th	3rd
Renewable energy	–	7th	–
Hydroelectricity	4th	2nd	–
Wind	7th	–	–
Biofuels	–	5th	–

Note: Rankings are based on proved reserves for oil, natural gas, coal and uranium, and capacity for the other energy sources.

## North American Cooperation on Energy Information (NACEI)

As part of the trilateral memorandum of understanding (MoU) concerning climate change and energy collaboration, the Energy Ministers from Canada, Mexico and the United States (U.S.) have created an institutional framework for consultation and sharing publicly available energy information among the countries.

The areas of focus as they relate to collaboration on energy information include:

- **Energy trade statistics:** Comparing, validating and improving respective energy import and export information;
- **Geographical energy information:** Sharing publicly available geospatial information related to energy infrastructure;
- **Outlooks for energy supply and demand:** Exchanging views and information on projections of cross-border energy flows; and
- **Cross reference for energy terminology:** Harmonizing terminology, concepts and definitions of energy products.

To access related products, visit the NACEI web portal at [www.nacei.org](http://www.nacei.org), where you will find:

- **Data tables** for trade flows of energy products and a methodological guide explaining the various sources of data;
- **Static and dynamic maps** of North America's energy infrastructure and renewable energy resource potential;
- **A report** on the framework required to develop more harmonized **North American energy outlooks**; and
- **A cross-referenced guide of terms** relevant to each of the above three areas of analysis.

Note that the product offering from this trilateral collaboration will continue to be developed and updated on a regular basis.

## Energy in the Canadian economy (2015)

### Nominal gross domestic product (in 2015 prices)

Industry	Nominal GDP* (\$ billions)	% of Canadian GDP
Energy (Direct)	136	7.3
• Oil and gas**	98	5.3
• Electricity	35	1.9
Energy (Indirect)***	64	3.5
• Oil and gas	45	2.4
Total (Direct + Indirect)	200	10.8
• Oil and gas	142	7.7

### Employment

Industry	Employment (jobs)	% of total employment
Energy (Direct)	280,365	1.5
• Oil and gas**	191,415	1.0
• Electricity	78,270	0.4
Energy (Indirect)***	625,033	3.4
• Oil and gas	518,133	2.8
• Oil and gas construction	203,065	1.1
Total (Direct + Indirect)	905,398	5.0
• Oil and gas	709,548	3.9

\* Natural Resources Canada (NRCan) estimates

\*\* Oil and gas includes oil and gas extraction, support activities for oil and gas extraction, natural gas distribution, petroleum refineries, and pipeline transportation.

\*\*\* These NRCan estimates include industries that supply goods and services to the energy industry, such as equipment manufacturing, construction and financial services.

Revised Statistics Canada data shows that direct and indirect employment in the oil and gas sector has declined by 47,225 (6.2%) since 2014, as a result of the low oil price environment.

About 16,200 Aboriginal people living off-reserve are directly employed in the energy sector.

## Provincial/territorial nominal gross domestic product (in 2015 prices)

Province/territory	Energy sector nominal GDP (\$ millions)	% of total GDP
British Columbia	9,201	4.4
Alberta	64,007	21.7
Saskatchewan	10,456	17.9
Manitoba	3,178	5.8
Ontario	15,383	2.5
Quebec	13,028	4.2
New Brunswick	1,968	7.4
Nova Scotia	–	–
Prince Edward Island	159	3.4
Newfoundland and Labrador	5,018	19.7
Yukon	39	1.8
Northwest Territories	260	6.8
Nunavut	–	–

## Provincial/territorial employment

Province/territory	Energy sector employment (jobs)	% of total employment
British Columbia	20,400	0.9
Alberta	162,280	6.9
Saskatchewan	19,910	3.3
Manitoba	8,425	1.3
Ontario	37,290	0.5
Quebec	18,880	0.5
New Brunswick	3,300	0.9
Nova Scotia	2,645	0.6
Prince Edward Island	–	–
Newfoundland and Labrador	5,630	2.4
Yukon	215	0.8
Northwest Territories	835	2.6
Nunavut	–	–

## Energy trade

Resource/ product	Exports*				Imports
	% of Canadian production	% to U.S.	% of U.S. imports	% of U.S. consumption	% of Canadian consumption
Crude oil	78	99	43	20	33
Refined petroleum products	26	95	29	3	13
Natural gas	51	100	97	10	21
Coal	49	4	10	0.1	19
Uranium	86	33	18	17	–
Electricity	9	100	89	2	2

### Exports\*

- \$102 billion
- 21% of Canadian domestic merchandise exports
- 94% (\$96 billion) of total Canadian energy exports are to the U.S.
- Oil and gas domestic exports totaled \$93 billion, of which 98% were to the U.S.

### Imports

- \$40 billion
- 8% of Canadian merchandise imports
- 69% (\$28 billion) of total energy imports are from the U.S.

\* Exports refers to domestic exports, which exclude the re-export of goods that have previously entered Canada and exit in the same condition.

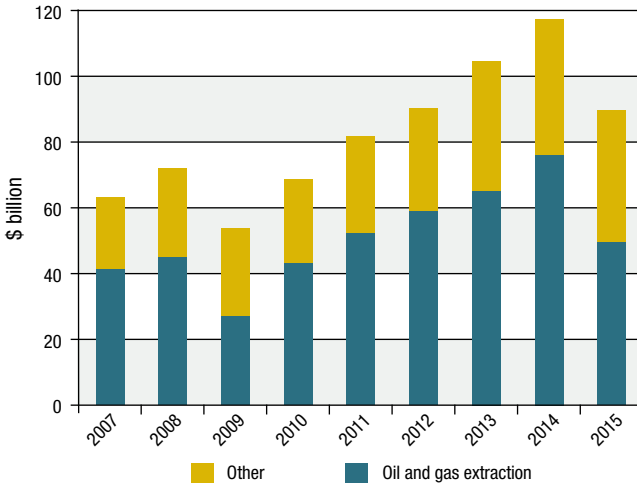


## Capital expenditures\*

- \$90 billion, a decrease of over \$27 billion or 23% from 2014.
- 36% of total investments in non-residential and machinery and equipment in Canada.
- Oil and gas industries accounted for \$65 billion or 26% of the Canadian total.
- Oil and gas companies spent an additional \$5.2 billion on exploration in 2014.

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

### Capital expenditures in the energy industry



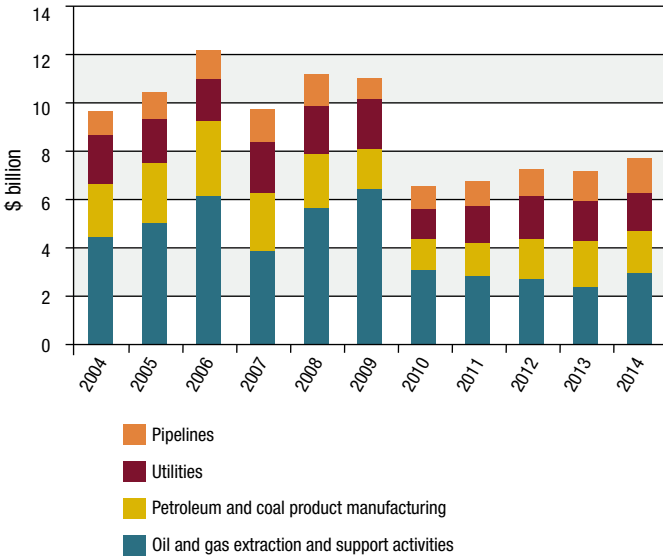
## Government revenues

- Federal and provincial and territorial (P/T) 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
  - Crown land sales, which are paid to the Crown in order to acquire the resource use for specific properties

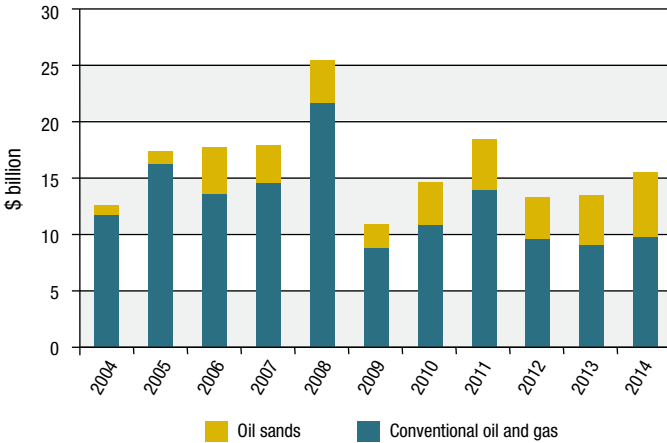
Source	2010–2014 average (\$ billions)
Income tax	4.9
Indirect taxes	2.2
Royalties	12.3
Land sales	2.8
<b>Total</b>	<b>22.2</b>

- The largest share of government revenues is collected from the oil and gas industry, which averaged \$20.3 billion over the last five years, including \$17.7 billion from upstream oil and gas extraction and its support activities.
- Between 2010 and 2014, the energy sector’s share of total taxes paid was 9.1% and its share of operating revenues was 13.0%.

**Total taxes paid by energy industries**

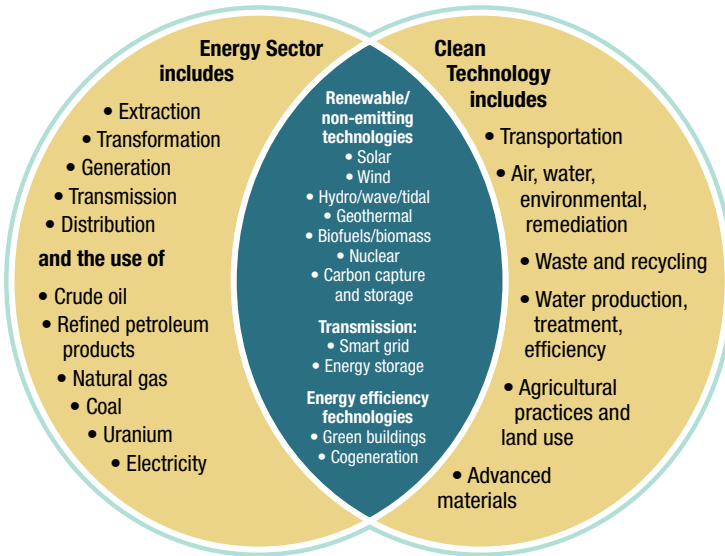


**Total oil and gas Crown royalties and land sales in Canada**



## Energy and clean technology (Cleantech)

- There is no generally accepted definition of the Cleantech sector, nationally or internationally. NRCan is leading work with Statistics Canada and Innovation, Science and Economic Development to better define the sector and enhance data collection.
- Most definitions include a number of different industry sub-sectors, some of which overlap with the energy sector.



## Market structure

- The majority of Cleantech companies are early-stage firms and small and medium-sized enterprises (SMEs), with a small number of firms large enough to be listed on stock exchanges.
- The TSX and TSX-Venture exchanges list 110 companies in the Cleantech\* sector, with a total market capitalization of \$31 billion. Ninety-six of those companies are headquartered in Canada, with a total market cap of \$27 billion (as of April 30, 2016).

## Key facts

- Canada ranked sixth in the world for investment in new domestic clean energy generation projects in 2014. From 2010 to 2014, Canada's cumulative national investment in the clean technology sector amounted to over \$31 billion.
- According to industry estimates, Canadian pure play\*\* Cleantech companies generated over \$11 billion of revenues and employed over 50,000 people in 2014.
- Estimated R&D spending of Canadian pure play Cleantech companies was over \$1.2 billion in 2014, 70% of which came from SMEs.

\* The TSX/TSXV defines Cleantech companies as companies whose operations fall under one of five environmental categories: Energy Efficiency; LowImpact Material and Products; Renewable Energy Equipment Manufacturing and Technology; Renewable Energy Production and Distribution; and Waste Reduction and Water Management.

\*\* A pure play company solely operates in one line of business. In this case, a pure play Cleantech company solely operates under one of the five environmental categories listed above.

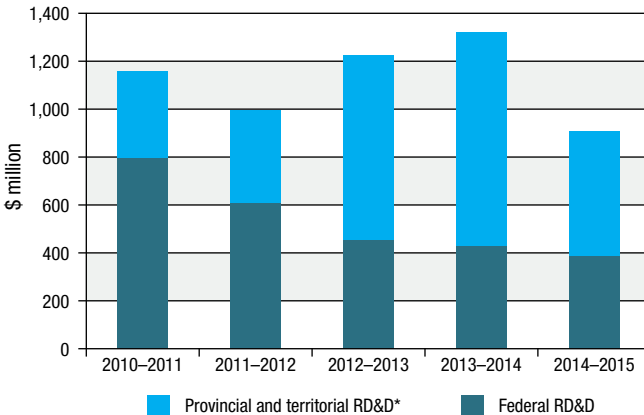
- As depicted in a new on-line map of Clean Energy Resources and Projects (CERP) in Canada (<http://atlas.gc.ca/cerp-rpep/en/>), Canada has 42 clean energy test centres and 57 research development & demonstration (RD&D) projects. Canada also has a large number of renewable energy projects, which are described in more detail in the “Renewable energy” chapter.
- Canada is home to 3 of the world’s 15 large-scale operational CCS projects: Boundary Dam, Quest and Weyburn-Midale. In total, Canada’s key CCS projects include:
  - SaskPower’s Boundary Dam project, launched in October 2014, is the first commercial CCS project at a coal-fired power plant.
  - The Shell Quest Project, launched in November 2015, is the first industrial CCS project designed to capture and store over 1 million tonnes of CO<sub>2</sub> per year.
  - The Weyburn-Midale Project is the largest ongoing CO<sub>2</sub>-enhanced oil recovery (EOR) project with over 30 million tonnes of stored CO<sub>2</sub> since 2000.
  - The PTRC’s Aquistore project is the largest CO<sub>2</sub> monitoring and storage infrastructure, with investments of \$40 million in installed monitoring equipment.
  - The North West Redwater Sturgeon Refinery in Alberta is the only refinery being constructed with CCS integrated.
  - Nova Scotia-based CarbonCure’s CO<sub>2</sub> recycling technology was used by concrete manufacturer Argos in the first delivery of ready-mixed concrete manufactured with recycled CO<sub>2</sub>.
  - The Field Research Station in Alberta is the only site to study CO<sub>2</sub> injected at intermediate subsurface depths.

## Energy research, development and demonstration

### Canadian public expenditures on total energy RD&D

- Combined federal/provincial/territorial energy RD&D expenditures of about \$936 million in 2014/15, down from \$1.3 billion in 2013/14.
  - Due largely to a decrease in provincial spending on carbon, capture and storage projects transitioning to commercial operation.
- Federal energy RD&D expenditures of \$416 million in 2014/15.
  - Key organizations: AECL (\$100 million), NRCan (\$99 million), NSERC (\$88 million), and SDTC (\$57 million).
  - Accounted for approximately 6.2% of federal R&D expenditures in all economic sectors (\$6,758 million).
- P/T government energy RD&D expenditures of \$520 million in 2014/15.
  - Includes expenditures of \$424 million by utilities and other publicly owned entities.
- The Canadian industry spent about \$2 billion on energy R&D in 2013.

### Canadian public expenditures on total energy RD&D



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

## Expenditures on total energy RD&D by technology area

	Federal (2014/15)	Provincial and territorial (2014/15)	Industry (2013)
	(\$ millions)		
Fossil fuels supply (including carbon capture and storage)	99	274	1,532
Renewable and clean energy supply	217	167	273
Energy end use	100	79	197
<b>Total energy RD&amp;D</b>	<b>416</b>	<b>520</b>	<b>2,001</b>

### Mission Innovation – Clean energy RD&D

- Through Mission Innovation (<http://mission-innovation.net/>), Canada, along with 19 other countries and the European Union, have expressed a shared desire to accelerate global clean energy innovation.
- All Mission Innovation members intend on doubling clean energy R&D investment over five years.
- Through Mission Innovation, the Government of Canada established Canada's energy RD&D baseline level at \$387 million\* for 2014/2015, and intends to increase spending to \$775 million by 2019/2020.

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



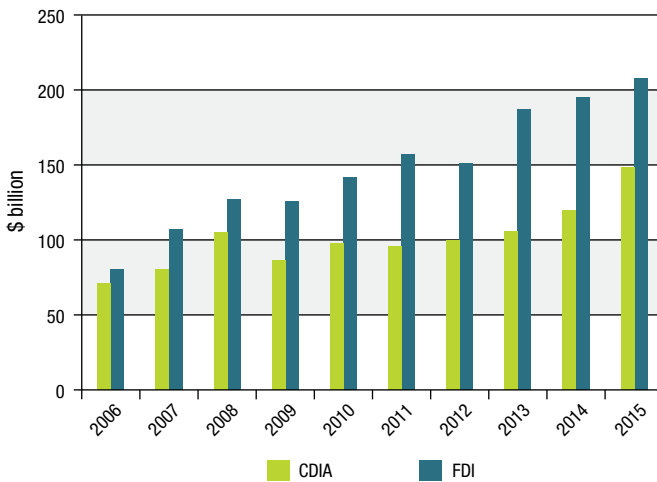
## Investment in Canadian energy industries

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

### Direct investment in Canada and abroad

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 in the energy industry



### Stock of foreign direct investment in Canada

- The stock of foreign direct investment (FDI) in the energy sector is estimated to have reached \$208 billion in 2015, up from \$81 billion in 2006.
- The energy industry's share of overall FDI in Canada has also been steadily increasing, reaching more than 27% in 2015, up from 18% in 2006.
- The stock of FDI from the U.S. in Canada's oil and gas extraction industry, including support services, more than tripled from \$18.9 billion in 2000 to \$69.4 billion in 2015.

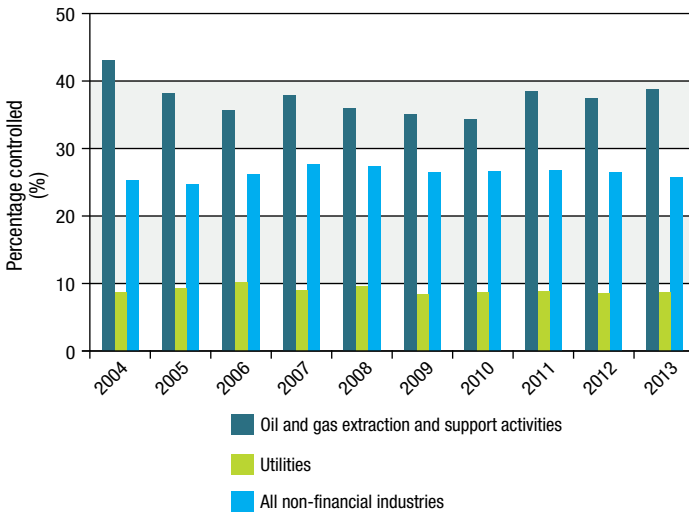
## Stock of Canadian direct investment abroad

- The stock of Canadian direct investment abroad (CDIA) from the energy sector is estimated to have reached \$148 billion in 2015, up from \$71 billion in 2006.
- Investment in oil and gas extraction accounted for \$80 billion of the CDIA stock in 2015.
- Investment by Canada’s energy companies in the U.S. accounts for 48% of the stock of energy CDIA and has grown from \$26 billion in 2000 to \$71 billion in 2015.

## 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.

### Foreign control of Canadian assets

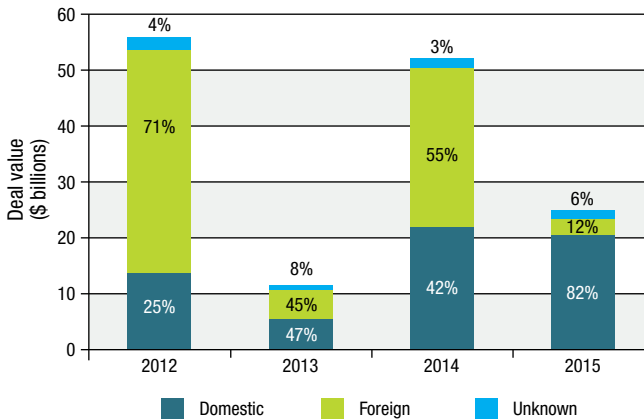


## Mergers and acquisitions

In 2015, Canadian energy companies and assets were involved in 247 merger and acquisition\* (M&A) transactions worth \$24.9 billion, a 50% decline from 2014 M&A activity (\$50.1 billion).

Canadian companies were the most active buyers of Canadian energy companies and assets, accounting for 9 of the top 10 M&A transactions by value. Canadian buyers represented 82% of total M&A activity in Canada's energy sector, as compared to 42% of transaction value in 2014 and 25% of transaction value in 2012.

### M&A activity in Canada's energy sector



\* Merger and acquisition deals are attributed to the year during which they were announced and are valued on a net transaction basis.

## Energy industries

There were 186 oil and gas deals (75% of total) at a transaction value of \$21.9 billion (88% of total value).

Electricity and renewables transactions accounted for \$2.5 billion from 32 deals.

Coal and uranium deals were valued at just under \$400 million from 29 deals.

	Value (millions)	Count
Oil and gas	\$21,940.3	186
Electricity and renewables	\$2,530.6	32
Uranium	\$245.8	20
Coal	\$133.7	9
<b>Total</b>	<b>\$24,850.4</b>	<b>247</b>

## Mergers and Acquisitions – Major Recent Deals

January 2016: Irving Infrastructure Corporation (United Kingdom) acquired Capstone Infrastructure Corporation for \$2.1 billion.

November 2015: Suncor Energy Inc. (Canada) acquired 84.2% of Canadian Oil Sands Limited for \$6 billion.

November 2015: PrairieSky Royalty Ltd. (Canada) acquired a portion of Royalty Assets from Canadian Natural Resources Limited for \$1.7 billion.

June 2015: Natural Resources Group (Canada) acquired Heritage Royalty Limited Partnership from Cenovus Energy Inc. for \$3.3 billion.

May 2015: Crescent Point Energy Corp. (U.S.) acquired Legacy Oil + Gas Inc. for \$1.5 billion.

May 2015: Berkshire Hathaway Energy (U.S.) acquired AltaLink from SNC-Lavalin Transmission Ltd. for \$3.1 billion.

December 2014: Repsol S.A. (Spain) acquired Talisman Energy Inc. for \$16.3 billion.

May 2014: Crescent Point Energy Corp. (U.S.) acquired Canera Energy Corp. for \$1 billion.

April 2014: PetroChina (China), through its wholly owned subsidiary Phoenix Energy Holdings Limited (China), acquired the remaining 40% stake in Dover Commercial Project from Athabasca Oil Corporation for \$1.23 billion.

March 2014: Progress Energy Resources Corp. (Malaysia) acquired a stake in Montney acreage in northeast British Columbia from Talisman Energy Inc. for \$1.5 billion.

February 2014: Canadian Natural Resources Limited (Canada) acquired certain Canadian conventional assets of Devon Canada Corporation for \$3.1 billion.

January 2014: Indian Oil Corp. (India) purchased Canadian shale gas assets from Progress Energy Resources Corp. (Malaysia) for \$1 billion.

January 2014: Compañía Española de Petróleos, S.A.U. (CEPSA) (Spain) acquired Coastal Energy Company for \$2.3 billion.

## Canadian energy assets

In 2014, 435 Canadian energy companies\* were identified as having energy assets either in Canada or abroad:

- 59 companies (14%) had energy assets with a value in excess of \$1 billion.
- 214 companies (49%) had interests outside of Canada (in 75 countries).
- 166 companies (38%) had energy assets in at least two countries.

Canadian energy assets grew to \$543.9 billion in 2014, an increase of 12% from \$484.9 billion in 2013. Canadian energy assets abroad totaled \$149.7 billion in 2014, an increase of 28% over the 2013 value of \$116.9 billion.

In 2014, Canadian energy companies were present in 75 countries, with the majority (70%) of Canadian energy assets abroad value located in the U.S.

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

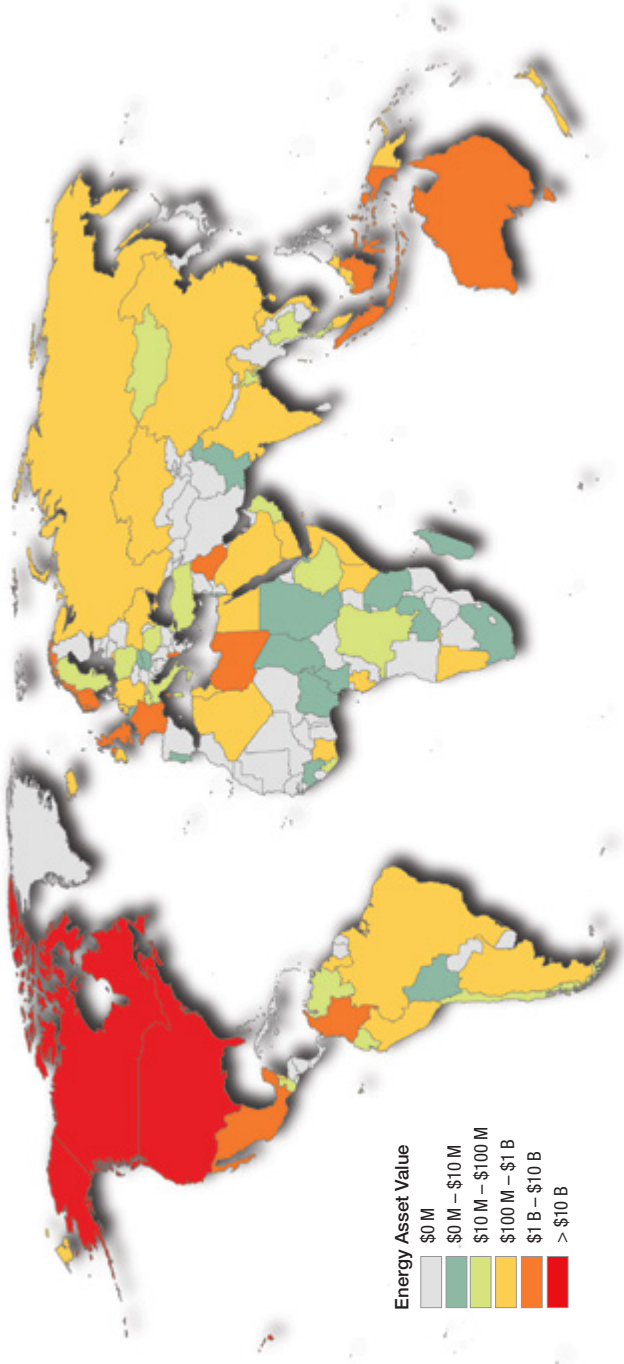
## Canadian energy assets by region, 2013 and 2014

Region	Canadian energy assets (\$ billions)**		Variation in percentage
	2013r	2014	
Africa	4.47	4.93	10%
North America (U.S. and Mexico)	77.84	107.03	38%
Americas (South and Central America, Caribbean)	13.31	14.41	8%
Asia	5.45	5.21	-4%
Europe	11.83	13.99	18%
Oceania	4.00	4.10	2%
<b>Total Canadian energy assets abroad</b>	<b>116.90</b>	<b>149.66</b>	<b>28%</b>
Canada	368.00	394.21	7%
<b>Total Canadian energy assets</b>	<b>484.89</b>	<b>543.88</b>	<b>12%</b>

\*\* Source: NRCan; Values may not sum due to rounding.

2013r: 2013 figures were revised using 2014 company filings.

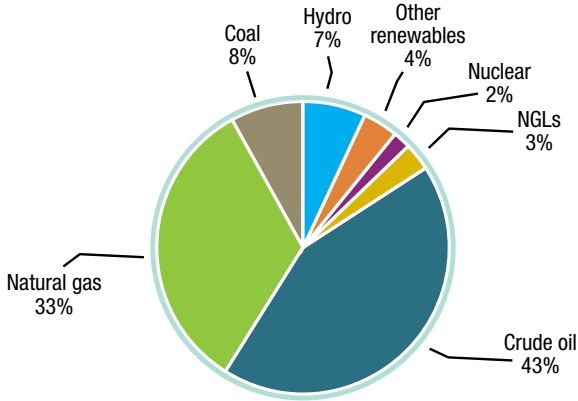
**Global distribution of Canadian energy assets**





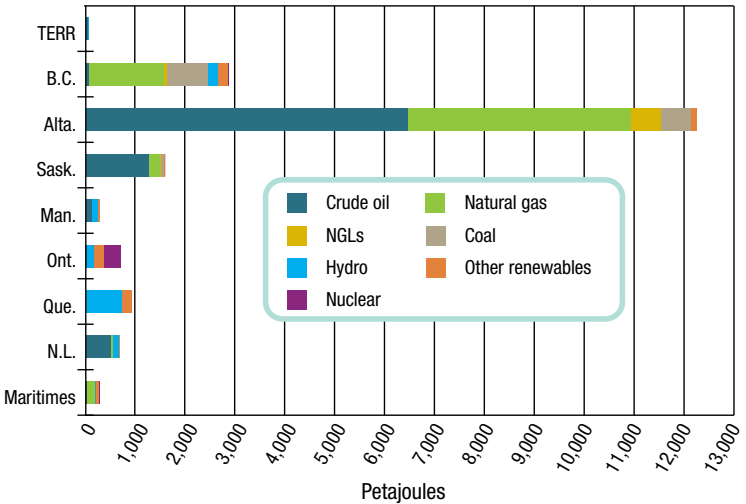
## Canadian energy production

Primary energy production\*, by source, 2014



\*“Other renewables” includes wind, solar, wood/wood waste, biofuels and municipal waste.

Primary energy production by region and source, 2014



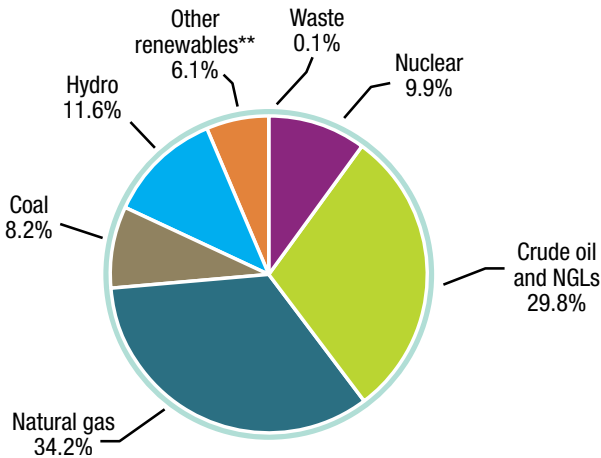
\* The primary energy equivalent of hydroelectricity is calculated using the physical energy content method, as applied by the International Energy Agency and Statistics Canada, in which hydroelectricity is defined as a primary energy form. This differs from the partial substitution method applied by the Energy Information Administration (U.S.), where the primary energy equivalent of hydroelectricity is calculated as the amount of fossil fuel required to generate the same volume of electricity in a thermal power station.

## Canadian primary energy supply

Total primary energy supply (TPES) is calculated as production plus imports, less exports and +/- stock changes.

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 million tonnes of oil equivalent (Mtoe)), with the exception of nuclear electricity, which is calculated assuming a 33% conversion efficiency factor increase (i.e. 1 TWh =  $(0.086 \div 0.33)$  Mtoe). This conversion factor explains the difference in the share of nuclear energy between primary energy production and TPES.

### Total primary energy supply\*, by source, 2014



Renewable energy sources made up 17.7% of Canada's TPES in 2014.

\* Not including electricity trade.

\*\* "Other renewables" includes wind, solar, wood/wood waste, biofuels and geothermal.

### **Canadian industry structure**

- The upstream oil and gas industry comprises several hundred companies that engage in activities such as exploration, drilling, production and field processing.
- The 5 largest companies are responsible for over half of oil production in Canada.
- A variety of firms provide support services to oil extraction operations such as contract drilling and maintenance.
- Oil pipelines, as well as trucks, tanker ships and railways, transport crude oil between production areas, refineries, and export/import border points.

### **Main associations**

- Canadian Association of Petroleum Producers (CAPP)
- Explorers and Producers Association of Canada (EPAC)
- Canadian Association of Oilwell Drilling Contractors (CAODC)
- Canadian Energy Pipeline Association (CEPA)
- Petroleum Services Association of Canada (PSAC)
- The Explorers and Producers Association of Canada (EPAC)

### **Regulatory authority**

- Primarily with provincial governments, e.g. Alberta Energy Regulator.
- The National Energy Board (NEB) has federal jurisdiction over interprovincial and international oil pipelines and trade.
- The Canada-Newfoundland and Labrador Offshore Petroleum Board and Canada-Nova Scotia Offshore Petroleum Board are responsible for the regulation of oil and gas activities in their corresponding offshore areas.

## International context

### World production\* – 93.9 MMb/d (2015, preliminary)

1) United States .....	14%
2) Saudi Arabia .....	13%
3) Russia.....	12%
<b>4) Canada .....</b>	<b>5%</b>
5) China .....	5%

### World exports\* – 44.5 MMb/d (2014)

1) Saudi Arabia .....	17%
2) Russia.....	11%
<b>3) Canada .....</b>	<b>7%</b>
4) United Arab Emirates.....	6%
5) Iraq .....	6%

### World proved reserves – 1,656 billion barrels (at the end of 2015)

1) Venezuela .....	18%
2) Saudi Arabia** .....	16%
<b>3) Canada .....</b>	<b>10%</b>
(97% of which is oil sands)	
4) Iran .....	10%
5) Iraq .....	9%

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

\*\* 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 May 2016)

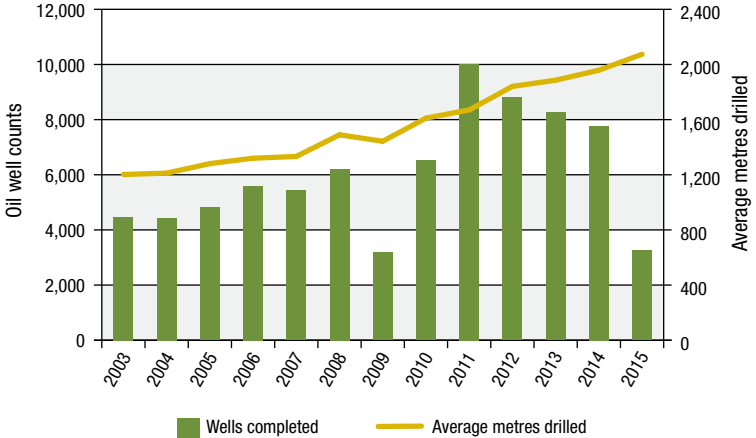
*reserves known to exist and are recoverable under current technological and economic conditions*

**Billion barrels**

<b>Canada total</b> .....	<b>169.9</b>
• conventional* .....	4.5
• oil sands .....	165.4
• mining.....	32.1
• in situ.....	133.3

\* 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

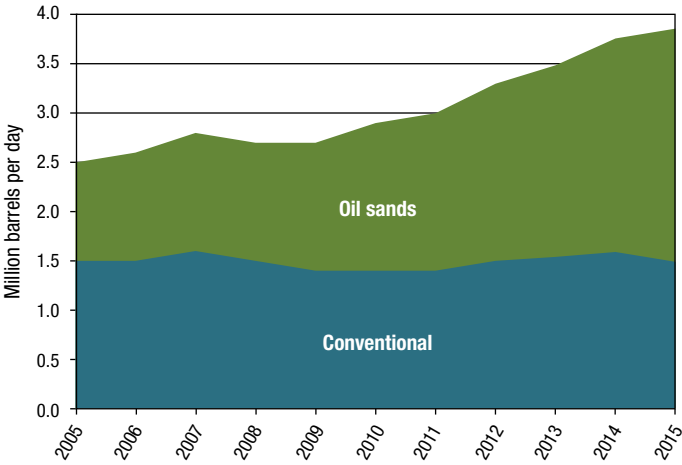


## Canadian production

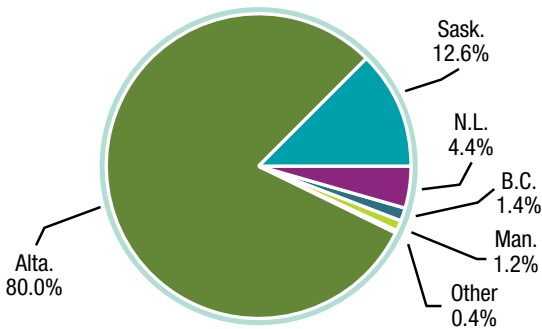
Oil sands production has exceeded conventional production since 2010.

In 2015, oil sands production was 2.4 MMb/d compared to 1.5 MMb/d of conventional oil.

### Production by type



### Production by province, 2015



“Other”: Nova Scotia, Ontario and the Northwest Territories

## Canadian supply and demand\* (2015)

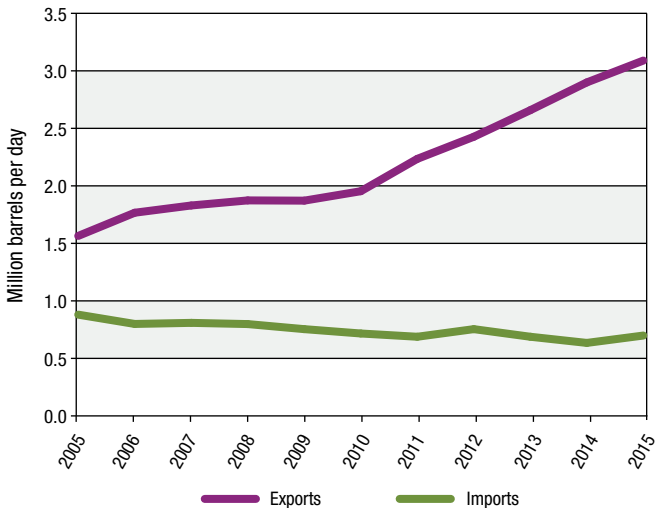
Canadian production .....	3.9 MMb/d
Imports** .....	0.9 MMb/d
Exports .....	3.0 MMb/d
Crude oil shipped to domestic refineries .....	1.7 MMb/d

\* 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

## Trade

### Canadian trade of crude oil



## Key facts

- 99% of Canadian crude oil exports are to the U.S.
- Canada was the largest foreign supplier of crude oil to the U.S., accounting for 43% of total U.S. crude oil imports and for 20% of U.S. refinery crude oil intake.
- Imports of crude oil and equivalents come from a wide range of countries, including the U.S. (69%), Saudi Arabia (9%), Nigeria (4%), Algeria (4%), and Norway (4%).

## 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

### Brent

- Reference price for light crude oil delivered at the Sullom Voe terminal in the U.K.
- Used as a benchmark price for North Sea crudes, as well as for many other crudes around the world
- During the 2000s, Brent and WTI traded within a few dollars of each other.

### Canadian Light Sweet

- Reference price for light crude oil (similar quality to WTI) delivered at Edmonton

### Western Canada Select (WCS)

- Reference price for heavy crude oil (e.g. blended bitumen) delivered at Hardisty, Alta.
- It takes more energy to produce refined products (e.g. gasoline) from heavy crudes, therefore WCS trades at a discount to lighter crudes.

### Maya

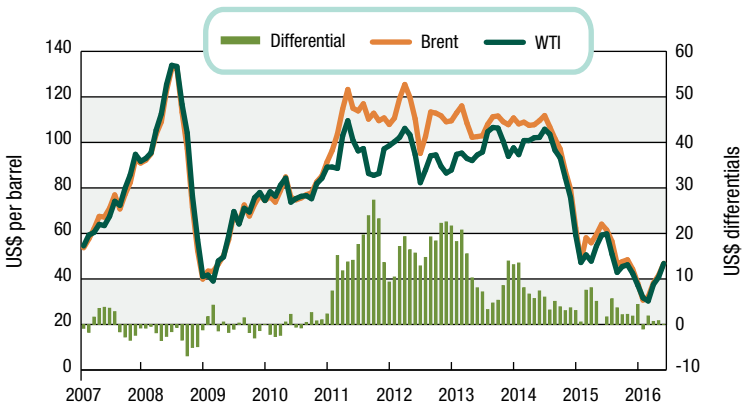
- Reference price for heavy oil produced in Mexico (similar quality to WCS)



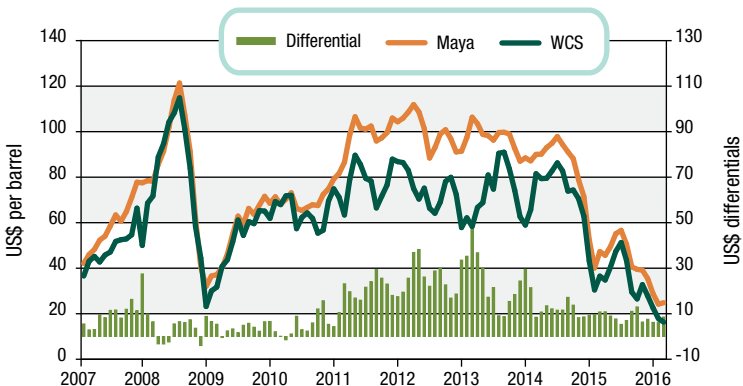
## Highlights for WTI

Peak on July 11, 2008 ..... US\$147 per barrel  
 Average: 2012 ..... US\$94 per barrel  
 Average: 2013 ..... US\$98 per barrel  
 Average: 2014 ..... US\$93 per barrel  
 Peak on June 20, 2014 ..... US\$107 per barrel  
 Average: 2015 ..... US\$49 per barrel  
 Low on February 11, 2016 ..... US\$26 per barrel  
 Average: 2016 (first 5 months) ..... US\$37 per barrel

### Brent versus WTI monthly average prices



### Maya versus WCS monthly average prices



## Oil sands

### Strategic importance

- 97% of Canada's proved reserves
- 61% of Canada's oil production in 2015 or 2.4 MMb/d
- An estimated \$271 billion of capital investment to date, including \$22.5 billion in 2015

### Mining method

- For shallow formations of 75 m or less
- 46% of current production, 19% of oil sand resources
- Process: remove overburden, extract oil sands ore, separate oil from sand using steam, pump tailings into settling basins
- Six large projects in Alberta: Syncrude Mining Project, Suncor Base Mine, CNRL Horizon Mine, Athabasca Oil Sands Project – Muskeg River and Jackpine Mine, and Imperial's Kearl Mine

### In situ method

- For formations deeper than 75 m
- 54% of current production, 81% of resources
- 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) and Firebag (Suncor)

### Bitumen upgrading

- Crude bitumen from oil sands may be transported to upgraders for processing to make it lighter – “synthetic crude oil.”
- Bitumen may also be blended and sold directly to refineries capable of processing heavier oils.
- Major companies with upgrading capacity: Syncrude, Suncor, Shell, Canadian Natural Resources, Husky and Nexen-CNOOC
- Total upgrading capacity in Canada of 1,428,000 b/d (facilities are listed in the Petroleum products section)

## Oil sands: environmental challenges

### Water

- mining method: 3 to 4 barrels of new water required per barrel of bitumen
- in situ method: an average of 0.4 barrels of fresh water required per barrel of bitumen
- Oil sands producers recycle around 80% of the water used in established mines and approximately 94% for in situ production.

### Greenhouse gases

- 9.3% of Canada's total GHG emissions
- GHG emissions per barrel of oil produced in the oil sands in 2014 were 31% below 1990 levels.

### Land

- area of oil sand resources .....142,200 km<sup>2</sup>
- total mineable area ..... 4,800 km<sup>2</sup>
- total area being mined..... 904 km<sup>2</sup>
- tailings ponds ..... 220 km<sup>2</sup>

For comparison:

- Canada's total area .....10,000,000 km<sup>2</sup>
- Canadian boreal forest.....3,200,000 km<sup>2</sup>
- 22% of the Lower Athabasca Region is comprised of conservation areas

## Key existing pipelines

- The current crude oil pipeline capacity exiting in Western Canada is estimated at about 3.9 million barrels per day.

### Enbridge

- World's largest pipeline system for crude oil and petroleum products, serving Canada and the U.S. with an estimated capacity to transport 2,621,000 barrels of oil per day
  - Mainline: Alberta to the U.S. Midwest and Ontario
  - Norman Wells Pipeline: from the Northwest Territories to Alberta
  - Line 9: from Sarnia to Montréal, returned to eastward flow and capacity expanded to 300,000 barrels per day in 2015
  - Southern Lights: diluent from Chicago to Edmonton

### Kinder Morgan

- North America's largest pipeline company and largest transporter of refined products.
  - Trans Mountain Line: has the capacity to transport 300,000 barrels per day from Edmonton to British Columbia (crude oil and petroleum products).
  - Puget Sound System: via the Trans Mountain Line ships crude oil from Abbotsford, B.C., to Washington State with a capacity of 180,000 barrels per day.
  - Cochin Pipeline: transports diluents from Illinois to Fort Saskatchewan with a capacity of 95,000 barrels per day.

### Pembina

- Second-largest oil pipeline system in western Canada
  - 9 pipelines for conventional and unconventional oil
  - Bitumen Line: from Fort McMurray to Edmonton

### **Portland-Montreal Pipe Line**

- Crude oil ships from Portland, Maine to Montréal

### **TransCanada Pipeline**

- Keystone Pipeline (2010): has the capacity to transport 591,000 barrels of oil per day from Hardisty, Alta. to the U.S. Midwest

### **Spectra Energy**

- Express-Platte: has the capacity to transport 280,000 barrels of oil per day from Hardisty, Alta. to the U.S. Midwest

## Rail transportation

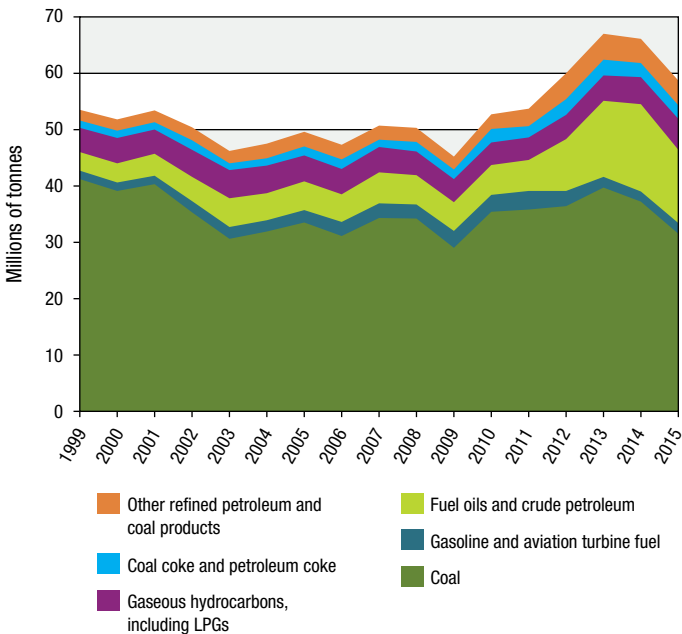
Energy-related products accounted for 17% of the total tonnage transported by rail in Canada in 2015, which is consistent with the average of 17% between 1999 and 2014.

In 2015, coal accounted for 54% of all energy products transported by rail in Canada, a decrease from 77% in 1999.

The tonnage of fuel oils and crude petroleum transported by rail almost tripled between 2011 and 2014; however, it decreased by 16% from 2014 to 2015 because of poorer economics in the current low oil price environment.

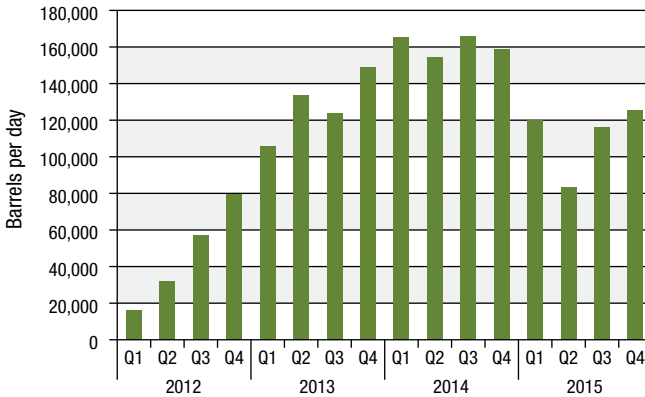
The estimated rail loading capacity out of western Canada in 2015 is approximately 1.0 MMB/d.

### Railway carloads for energy commodities in Canada



## Exports

### Quarterly volumes of crude oil exported to the U.S. by rail



### Major western Canada crude by rail on-loading facilities in operation, 2015 (>30,000 b/d)

Operator	Location	Province	Capacity (b/d)
Cenovus Energy	Bruderheim	Alberta	100,000
Keyera/Enbridge	Cheecham	Alberta	32,000
Kinder Morgan/Imperial	Strathcona County	Alberta	210,000
Pembina	Edmonton	Alberta	40,000
Keyera/Kinder Morgan	Edmonton	Alberta	40,000
Gibson/USDG	Hardisty	Alberta	120,000
Altex	Lashburn	Saskatchewan	88,000
Crescent Point	Stoughton	Saskatchewan	45,000
Tundra	Cromer	Manitoba	30,000

## Light tight oil/Shale oil

### Definition

- Light oil found in sedimentary rock characterized by very low permeability – typically shale.
- The oil is extracted by using horizontal drilling combined with multi-stage hydraulic fracturing – the same techniques used for shale gas extraction.

Note: “Shale oil” should not be confused with “oil shale,” which are shale rocks rich in decomposed matter still in a solid state.

### Potential in Canada and the U.S.

- Tight oil resources are largely found in a belt ranging from central Alberta to southern Texas.
- The Bakken (North Dakota, Montana, Saskatchewan, Manitoba) and Eagle Ford (south Texas) tight oil formations are the largest sources of tight oil production in North America.
- Prospective resources have also been identified throughout the Rocky Mountain region, the U.S. Gulf Coast and the northeastern U.S./eastern Canada (including Anticosti Island and western Newfoundland and Labrador).

### World technically recoverable shale oil\* resources

419 billion barrels (2015)

1) United States .....	19%
2) Russia.....	18%
3) China .....	8%
4) Argentina.....	6%
5) Libya .....	6%
...	
<b>13) Canada .....</b>	<b>2%</b>

\* Shale formations are a subset of low permeability tight oil formations.



# 3

## Petroleum products

### Canadian industry structure

- 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.
- A variety of firms, including integrated oil companies, refiners and independent fuel retailers, distribute refined petroleum products at the wholesale and retail levels.
- Pipelines and tanker ships are commonly used to transport products over long distances, while tanker trucks and trains are more often used for regional and local distribution.
- Liquefied petroleum gas (LPG) produced by refineries is included in this chapter and in the “Hydrocarbon gas liquids” chapter.

### Main associations

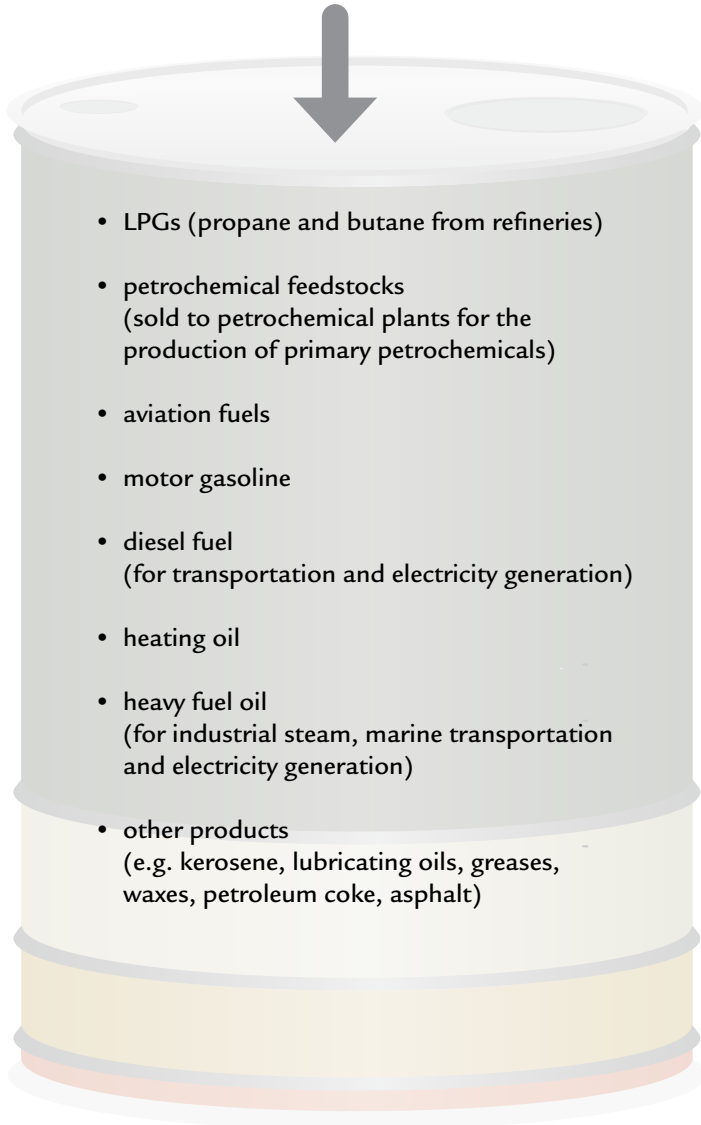
- Canadian Fuels Association (CFA)
- Canadian Independent Petroleum Marketers Association (CIPMA)

### Regulatory authority

- Primarily with provincial governments

## Petroleum refineries

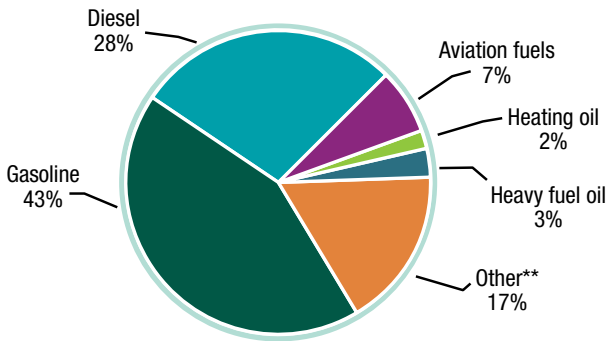
- crude oil distillation
- additional processing (e.g. catalytic cracking and reforming)
- product blending



## Canadian supply and demand (2015)

Crude oil shipped to domestic refineries.....	1.7 MMb/d (98 billion L)
Canadian production .....	1.9 MMb/d (108 billion L)
Imports.....	0.2 MMb/d (14 billion L)
Exports .....	0.5 MMb/d (28 billion L)
Domestic sales .....	1.8 MMb/d (104 billion L)

### Sales by product, 2015\*

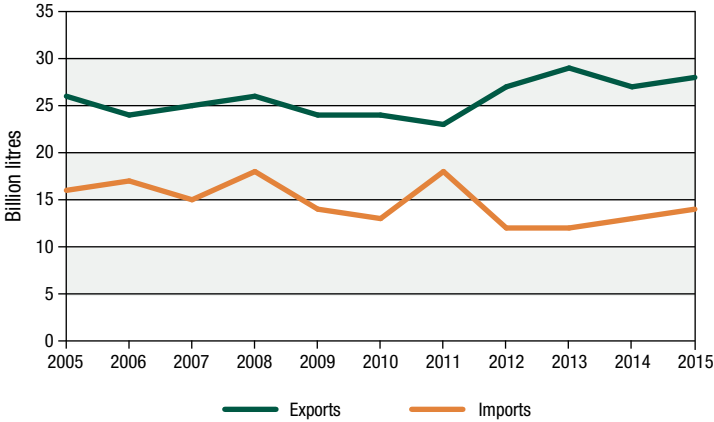


\* Certain product shares are based on NRCan estimates.

\*\* "Other" includes LPGs, petro-chemical feedstocks, lubricating oils, petroleum coke, asphalt, etc.

## Trade (2015)

### Canadian trade of refined petroleum products



### Key facts

- 26% of Canadian production of refined petroleum products is exported:
  - 95% of Canadian refined petroleum product exports are to the U.S.
  - 24% of U.S. imports come from Canada.
- 13% of Canadian consumption of refined petroleum products is imported:
  - 75% of Canadian imports come from the U.S.
  - Other Canadian imports come from a wide range of countries, including the Netherlands (10%), the U.K. (2%) and Russia (2%).

## Retail prices (in cents per litre)

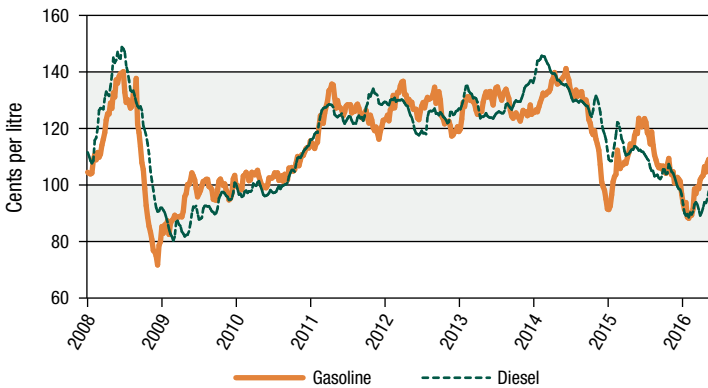
	Gasoline	Diesel
2015		
average Canadian pump price	108.9	109.2
estimated crude cost	38.8	38.8
refining and marketing	31.8	38.8
federal taxes*	15.5	9.1
provincial taxes**	22.9	22.4
2016		
average Canadian pump price (first five months)	98.3	92.7

\* includes the GST and federal excise tax

\*\* includes the provincial portion of the HST

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

### Weekly retail gasoline and diesel prices



## Canadian petroleum refineries

Location	Refinery	Capacity
<b>British Columbia</b>		
Prince George	Husky Energy	12,000 b/d
Burnaby	Chevron Canada	57,000 b/d
<b>Alberta</b>		
Edmonton	Imperial Oil	187,000 b/d
Edmonton	Suncor Energy	142,000 b/d
Fort Saskatchewan	Shell Canada	100,000 b/d
<b>Saskatchewan</b>		
Regina	Federated Co-operatives	130,000 b/d
<b>Ontario</b>		
Sarnia	Imperial Oil	121,000 b/d
Nanticoke	Imperial Oil	112,000 b/d
Sarnia	Suncor Energy	85,000 b/d
Corunna	Shell Canada	75,000 b/d
<b>Quebec</b>		
Levis	Valero (formerly Ultramar)	265,000 b/d
Montréal	Suncor Energy	137,000 b/d
<b>New Brunswick</b>		
Saint John	Irving Oil	318,000 b/d
<b>Newfoundland and Labrador</b>		
Come by Chance	North Atlantic	115,000 b/d
<b>Total refining capacity</b>		<b>1,856,000 b/d</b>

## Other plants with crude oil processing

Location	Plant	Capacity
<b>Asphalt plants</b>		
<b>Saskatchewan</b>		
Lloydminster	Husky Energy	29,000 b/d
Moose Jaw	Moose Jaw Refinery	16,000 b/d
<b>Total processing capacity</b>		<b>45,000 b/d</b>
<b>Lubricant plants (currently using crude oil as feedstock)</b>		
<b>Ontario</b>		
Mississauga	Suncor Energy	17,000 b/d
<b>Total processing capacity</b>		<b>17,000 b/d</b>
<b>Upgraders*</b>		
<b>Alberta</b>		
Fort McMurray	Syncrude	465,000 b/d
Fort McMurray	Suncor Base U1/ U2/Millennium	438,000 b/d
Fort Saskatchewan	Shell Scotford	240,000 b/d
Fort McKay	CNRL Horizon	135,000 b/d
Wood Buffalo	Nexen-CNOOC	72,000 b/d
<b>Saskatchewan</b>		
Lloydminster	Husky Energy	78,000 b/d
<b>Total upgrading capacity</b>		<b>1,428,000 b/d</b>

\* Although upgraders primarily transform heavy crudes into lighter crudes, they also produce some refined products, such as diesel. The capacities reported are with regard to inputs of heavy crude oil or bitumen.





# 4

## Hydrocarbon gas liquids

### Definition

- Hydrocarbon gas liquids (HGLs) include natural gas liquids (NGLs) (propane, butane, and ethane) and olefins produced by natural gas processing plants and upstream processing or by crude oil refineries.
- Propane and butane, which are produced from natural gas processing plants or from refining crude oil, can be liquefied and sold as liquefied petroleum gas (LPG).
- Condensates and pentanes plus are also HGLs obtained directly from the field or from a natural gas processing plant. However, because these HGLs are considered to be a crude oil equivalent, they are included in the “Crude oil” chapter.

### Notes

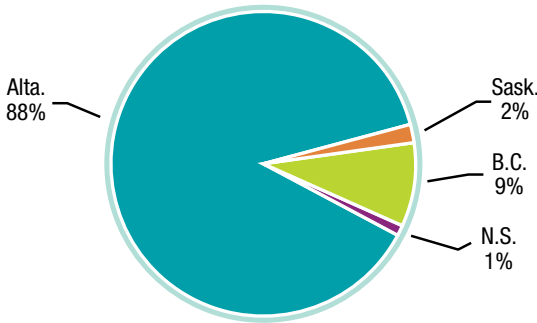
- These gases can be easily liquefied, and therefore are commonly referred to as “liquids.”
- When these liquids are present in natural gas, it is called “wet” gas; when they are not present or have been extracted, the natural gas is called “dry” gas.

### Canadian supply\* (2015)

Canadian production .....	562.4 Mb/d
– propane .....	191.4 Mb/d
– butane .....	130.0 Mb/d
– ethane .....	241.0 Mb/d
Exports .....	136.8 Mb/d
Imports.....	70.6 Mb/d

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

### Production of NGLs by province\*, 2015



\* includes only gas processing plant production

## Canadian industry structure

- The upstream oil and gas industry comprises several hundred companies that engage in activities such as exploration, drilling and production of raw natural gas. Some upstream companies also own and operate gathering pipelines and field processing facilities.
- The midstream natural gas industry operates natural gas processing plants, which remove impurities and natural gas liquids (NGLs), natural gas storage facilities, gathering pipelines and NGL facilities. Pipeline-quality natural gas is then transported through pipelines from processing plants to transmission pipelines or consuming areas.
- The downstream natural gas industry comprises long-haul transmission pipelines and distribution companies, also called local distribution companies (LDCs). LDCs receive gas from pipelines and then distribute it to end-use consumers via extensive networks of local distribution pipelines.

## Main associations

- Canadian Association of Oilwell Drilling Contractors (CAODC)
- Canadian Association of Petroleum Producers (CAPP)
- Petroleum Services Association of Canada (PSAC)
- Canadian Energy Pipeline Association (CEPA)
- Canadian Gas Association (CGA)
- Canadian Society for Unconventional Resources (CSUR)
- Explorers and Producers Association of Canada (EPAC)
- Industrial Gas Users Association (IGUA)

## Regulatory authority

- Primarily with provincial and territorial governments
- The National Energy Board (NEB) has federal jurisdiction over interprovincial and international natural gas pipelines and trade.
- The Canada-Nova Scotia Offshore Petroleum Board and Canada-Newfoundland and Labrador Offshore Petroleum Board are responsible for regulations of oil and gas activities in their corresponding offshore areas.

## International context

**World production** – 347 Bcf/d (9.8 Bcm/d)  
(2015, preliminary)

1) United States .....	21%
2) Russia.....	18%
3) Iran .....	5%
4) Qatar .....	5%
<b>5) Canada .....</b>	<b>5%</b>

**World exports** – 102 Bcf/d (2.9 Bcm/d)  
(2015, preliminary)

1) Russia.....	19%
2) Qatar .....	11%
3) Norway.....	11%
<b>4) Canada .....</b>	<b>7%</b>
5) Netherlands .....	5%

**World proved reserves** – 6,950 Tcf (197 Tcm)  
(beginning of 2016)

1) Russia.....	24%
2) Iran .....	17%
3) Qatar .....	12%
4) United States .....	5%
5) Saudi Arabia.....	4%
...	
<b>17) Canada .....</b>	<b>1%</b>

## Canada-U.S. resources

- The natural gas markets in Canada and the U.S. are highly integrated.
- Canadian marketable resources could sustain current production levels for up to 300 years.

### Proved reserves\* (at the end of 2014)

Canada.....	70 Tcf
U.S. ....	369 Tcf
Total .....	439 Tcf

### Marketable/technically recoverable resources\*\*

Canada total.....	879–1,560 Tcf
Canadian conventional.....	299–305 Tcf
Canadian unconventional.....	580–1,255 Tcf
	(coal-bed methane, shale and tight gas)
U.S. total .....	2,431 Tcf
portion that is shale and tight gas.....	664 Tcf
portion that is other.....	1,766 Tcf
World total .....	28,499 Tcf
portion that is conventional .....	16,421 Tcf
portion that is unconventional.....	12,078 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).

## Shale and tight gas

### Features of shale

- Ultra-low permeability sedimentary rock containing natural gas
- Gas is extracted by using horizontal drilling and hydraulic fracturing.

### Hydraulic fracturing (fracking)

- Creates fractures in sedimentary rock formations by using pressurized water, mixed with small amounts of sand and additives, to release the natural gas

### Potential in Canada

- Shale gas resources are found in British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia and the territories.
- Technological advancements in drilling (long-reach horizontal well bores) and completion techniques (multistage hydraulic fracturing) enable commercial production of shale gas.
- These advancements have increased the long-term prospects for the supply of natural gas in North America.

### Global potential

- A 2012 U.S. Energy Information Administration assessment of 137 shale formations in 41 countries, in addition to the U.S. basins, found a total of 7,299 Tcf (207 Tcm) of technically recoverable shale gas resources.

### World technically recoverable shale resources – 7,299 Tcf (2012)

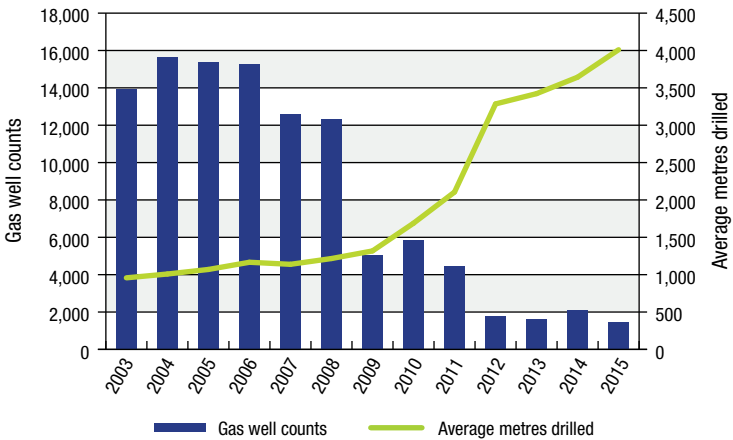
1) China .....	15%
2) Argentina.....	11%
3) Algeria.....	10%
4) United States .....	9%
<b>5) Canada .....</b>	<b>8%</b>
6) Mexico.....	7%
7) Australia.....	6%

## Canada-U.S. market (2015)

Canada-U.S. market .....	89.0 Bcf/d
	(2.5 Bcm/d)
Canadian average marketable production .....	14.4 Bcf/d
	(0.4 Bcm/d)
conventional .....	26%
unconventional* .....	74%
U.S. average marketable production.....	74.2 Bcf/d
	(2.1 Bcm/d)
conventional .....	27%
unconventional* .....	73%
North American LNG imports.....	0.31 Bcf/d
	(0.01 Bcm/d)

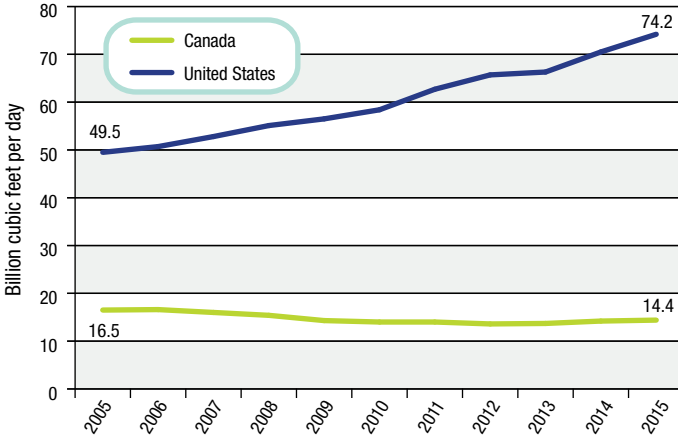
\* Unconventional gas includes tight gas, coalbed methane and shale gas.

## Natural gas wells completed and average metres drilled in western Canada

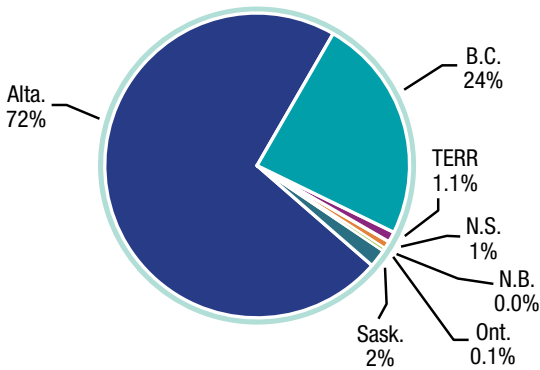


## Canadian production (2015)

### Canadian and U.S. marketable production of natural gas



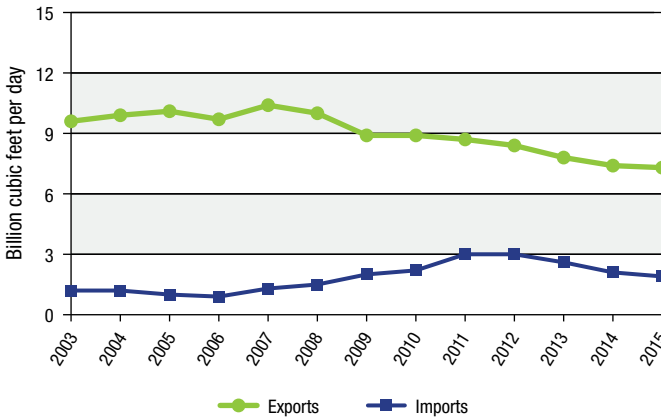
### Marketable production by province, 2015





## Trade (2015)

### Canadian trade of natural gas



Canadian exports .....	7.3 Bcf/d (0.21 Bcm/d)
Canadian imports .....	1.9 Bcf/d (0.05 Bcm/d)

### Key facts

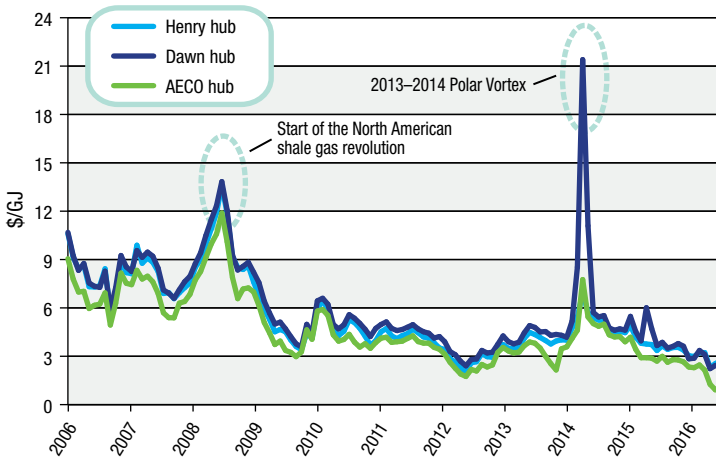
- 51% of Canadian production is exported
  - All Canadian exports go to the U.S.
  - 97% of U.S. imports and 10% of U.S. consumption come from Canada.
  - The value of Canadian net exports (exports minus imports) was \$7.2 billion in 2015.
- 20% of Canadian consumption is imported from the U.S.
- Since 2009, Canada has also imported small amounts of natural gas liquids from other countries through the Canaport LNG terminal in Saint John, N.B.

## Upstream prices (AECO hub\* average prices)

Average: 2005–2013 .....	\$5.54/GJ
Average: 2014.....	\$4.74/GJ
Average: 2015.....	\$2.69/GJ
Average: 2016.....	\$1.36/GJ
(first four months)	

\* 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.

## Monthly average natural gas spot prices



## Key existing pipelines

### TransCanada Pipelines

- Canada's leading natural gas pipeline company serving markets in Canada, the U.S. and Mexico, tapping into virtually all natural gas basins in North America
- Nova Gas Transmission Ltd (NGTL) System: serving Alberta and British Columbia
- Canadian Mainline: several pipelines in the same corridor from the Alberta/Saskatchewan border to Québec (city) with several interconnections to the U.S. along the way
- Foothills: from Alberta to Idaho via British Columbia and from Alberta to Montana via Saskatchewan

### Spectra Energy

- Canada's second-largest gas pipeline company
- Maritimes & Northeast Pipeline: Nova Scotia and New Brunswick to the U.S.
- Union Gas: gas distribution and transmission in Ontario and eastern U.S.
- West Coast Energy: a pipeline in British Columbia

### Enbridge Inc.

- Third-largest gas pipeline company in Canada (and largest oil pipeline)
- Largest local gas distribution company in Canada (Enbridge Gas Distribution of Toronto)
- Alliance Line (50% owner): British Columbia through Alberta; and Saskatchewan to Chicago
- Vector Line (60% owner): Chicago to Ontario

### ATCO Pipeline

- Gathering and distribution lines within Alberta

### TransGas Ltd.

- Gathering, transmission and storage facilities in Saskatchewan
- Owned by SaskEnergy Inc. (provincial distributor)

## Liquefied natural gas

Twenty-six liquefied natural gas (LNG) export facilities have been proposed for Canada – 20 in British Columbia, 2 in Quebec, 1 in New Brunswick and 3 in Nova Scotia – with a total proposed export capacity of 355 mtpa of LNG (or approximately 48 Bcf/d of natural gas). Since 2011, 24 LNG projects have been issued long-term export licenses.

### Proposed Canadian LNG export terminals (as of June 1, 2016)

Project	Location	Export license	Total capacity	
			Natural gas (Bcf/d)	LNG (mtpa)
<b>British Columbia</b>				
Kitimat LNG	Kitimat	√	1.30	10.00
LNG Canada	Kitimat	√	3.47	26.00
Cedar LNG Project	Kitimat	√	0.83	6.40
Pacific Northwest LNG	Prince Rupert	√	2.74	19.68
Prince Rupert LNG	Prince Rupert	√	2.91	21.60
Woodfibre LNG	Squamish	√	0.33	2.10
WCC LNG	Prince Rupert	√	4.00	30.00
Triton LNG	Kitimat or Prince Rupert	√	0.32	2.30
Aurora LNG	Prince Rupert	√	3.10	24.00
Kitsault Energy Project	Kitsault	√	2.70	20.00
WesPac Marine Terminal	Delta	√	0.50	3.00
Steelhead LNG	Sarita Bay	√	4.30	30.00
Grassy Point LNG	Grassy Point	√	2.70	20.00

Project status:

Project on hold

Application not yet filed

**Proposed Canadian LNG export terminals  
(as of June 1, 2016) (continued)**

Project	Location	Export license	Total capacity	
			Natural gas (Bcf/d)	LNG (mtpa)
Discovery LNG	Campbell River	√	2.63	20.00
Orca LNG	Prince Rupert	√	3.20	24.00
Stewart LNG	Stewart	√	3.99	30.00
NewTimes Energy	Prince Rupert	√	1.60	12.00
Malahat LNG	Mill Bay	√	0.85	6.00
Watson Island LNG	Prince Rupert	Not applied	Unknown	Unknown
Nisga'a LNG	Nasoga Gulf	Not applied	Unknown	Unknown
<b>East Coast</b>				
Énergie Saguenay	La Baie, Que.	√	1.56	11.00
Stolt LNGaz	Becancour, Que.	√	0.07	0.50
Saint John LNG	Saint John, N.B.	√	0.68	5.00
Goldboro LNG	Guysborough County, N.S.	√	1.40	10.00
Bear Head LNG	Richmond County, N.S.	√	1.59	12.00
A C LNG	Middle Melford, N.S.	√	2.07	15.50

Project status:

- Project on hold
- Application not yet filed



**Canadian industry structure**

- The Canadian coal industry produces coal for use in:
  - metallurgical applications
  - thermal applications (e.g. electricity generation)
- Numerous firms provide services to coal producers such as exploration, equipment supply, engineering services and transportation.
- Some power-generating companies not only use coal for electricity generation but also own coal mines or are involved in coal production. Other companies generate electricity from purchased coal.

**Main association**

- Coal Association of Canada

**Regulatory authority**

- Primarily with provincial governments

## International context

### World production – 7.7 billion t (2015, preliminary)

1) China .....	46%
2) United States .....	11%
3) India.....	9%
4) Australia.....	7%
5) Indonesia.....	6%
...	
<b>12) Canada .....</b>	<b>1%</b>

### World exports – 1.3 billion t (2015, preliminary)

1) Australia.....	30%
2) Indonesia.....	28%
3) Russia.....	12%
4) Columbia.....	6%
5) South Africa.....	6%
...	
<b>8) Canada .....</b>	<b>2%</b>

### World proved reserves – 892 billion t (at the end of 2011)

1) United States .....	27%
2) Russia.....	18%
3) China .....	13%
4) Australia.....	9%
5) India.....	7%
...	
<b>15) Canada .....</b>	<b>1%</b>

The above data excludes coal products such as coke.



## Canadian supply and demand (2015)

Canadian production ..... 62 Mt

Exports ..... 30 Mt

- major export destinations (by \$ value):

1) Japan ..... 28%

2) South Korea ..... 20%

3) China ..... 16%

- 4% of Canadian exports are to the U.S., representing 10% of U.S. coal imports

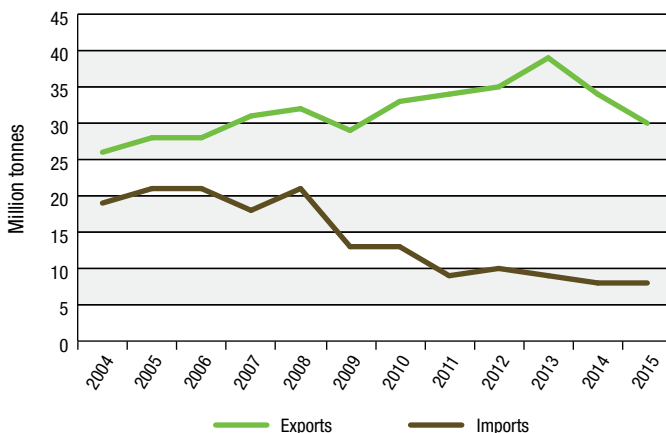
Imports ..... 8 Mt

- 75% of Canadian imports are from the U.S.
- Close to half of imports are destined for use in steel manufacturing (metallurgical coal); the rest are for electricity generation (thermal coal).

Domestic availability ..... 39 Mt

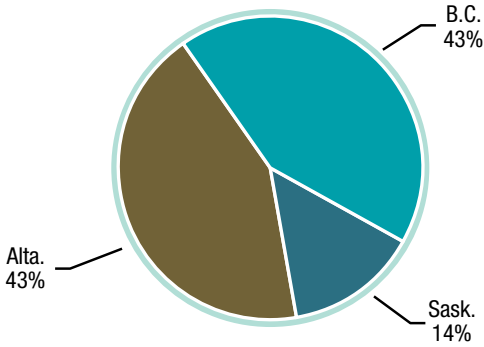
- mostly for electricity generation in Alberta and Saskatchewan
- also for metallurgical applications

## Canadian trade of coal



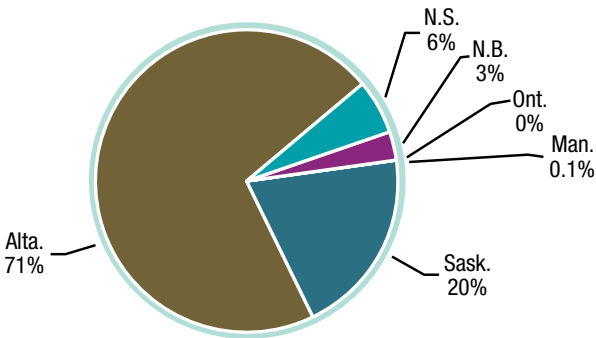
## Production and use, by province

Production by province, 2015\*



\* NRCan estimate

Coal used for electricity generation by province, 2014



## Coal-fueled power plants in Canada >500 MW (2016)

Facility	Province	Total capacity (MW)
Sundance	Alberta	2,141
Genesee	Alberta	1,376
Keephills	Alberta	1,285
Sheerness	Alberta	816
Battle River	Alberta	689
Boundary Dam*	Saskatchewan	672
Lingan	Nova Scotia	620
Poplar River	Saskatchewan	582

\* As of October 2014, SaskPower's Boundary Dam (unit 3 – 120 MW electricity production) became the world's first commercial-scale coal-fired power station equipped with CCS technology.

Data includes facilities that burn petroleum coke as their primary fuel.

## Coal-fired generating capacity by province (2016)

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	5.0
Manitoba**	105	1.1
<b>TOTAL</b>	<b>9,834</b>	<b>100</b>

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



## Canadian uranium industry structure

- Canada has an abundant supply of uranium, including large high-grade deposits in northern Saskatchewan.
- Key producers are Cameco Corporation and AREVA Resources Canada Inc. – two of the world’s largest uranium mining companies.
- Once mined, uranium ore is milled to produce a uranium oxide concentrate ( $U_3O_8$ ) commonly known as “yellowcake.”
- A large portion of the uranium concentrates from Canada and around the world is shipped to a refinery in Blind River, Ontario, to produce high-purity uranium trioxide ( $UO_3$ ), an intermediate product.
- The  $UO_3$  from Blind River is transported to a uranium conversion facility in Port Hope, Ontario, to produce:
  - uranium dioxide ( $UO_2$ ) to supply CANDU-type heavy water reactors
  - uranium hexafluoride ( $UF_6$ ), which is exported to be enriched and used as fuel in light water reactors (LWR)
- Key users in Canada are power generators with nuclear reactors (e.g. Ontario Power Generation (OPG)).

## Regulatory authority

- Mining in Canada is generally governed by provincial regulations, but uranium mining is also under federal jurisdiction.
- The Canadian Nuclear Safety Commission regulates mines and mills and all subsequent stages of the nuclear-fuel cycle, including conversion, refining, fuel fabrication, nuclear reactor operation and nuclear fuel waste management.

## Uranium – international context

### World production – 60.5 kt (2015, preliminary)

1) Kazakhstan .....	39%
2) <b>Canada</b> .....	<b>22%</b>
3) Australia .....	9%
4) Niger .....	7%
5) Russia.....	5%

### World exports – 51.3 kt (2015, preliminary)

1) Kazakhstan .....	46%
2) <b>Canada</b> .....	<b>23%</b>
3) Australia .....	11%
4) Niger .....	8%
5) Namibia .....	6%

### World known recoverable resources – 5.9 Mt (at the beginning of 2013)

1) Australia.....	29%
2) Kazakhstan .....	12%
3) Russia.....	9%
4) <b>Canada</b> .....	<b>8%</b>
5) Niger .....	7%

## Uranium – Canadian supply and demand (2015)

Canadian production ..... 13.3 kt

- All uranium comes from mines in Saskatchewan.
- Annual value ≈ \$2 billion

Exports ..... ≈ 86% 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%
- 30% of uranium purchased by U.S. nuclear reactors in 2015 came from Canada, making Canada the largest foreign supplier of uranium to the U.S.

Domestic use ..... ≈14% of production

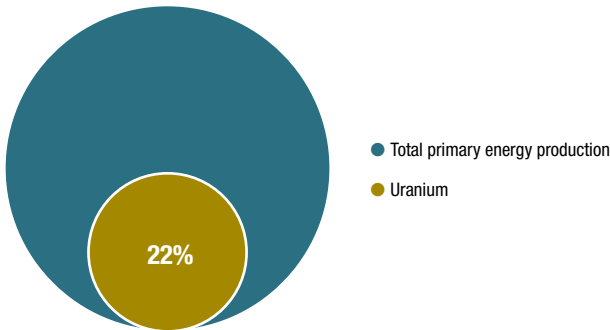
- to Canada's CANDU reactors (Ontario and New Brunswick)

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

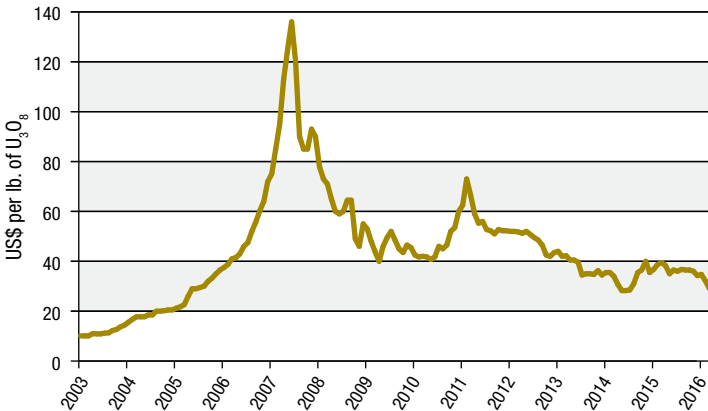
### Primary energy production

The primary energy equivalent of nuclear energy is defined by the International Energy Agency as the amount of heat produced in a reactor. Following this method and including both domestic use and exports, the primary energy equivalent for Canada’s total uranium production is estimated by NRCan at over 5.5 million TJ in 2014, or 22% of Canada’s total primary energy production.

Uranium’s share of total primary energy production, 2014



### Spot 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.



## Canadian nuclear industry structure

- There are three nuclear power plant operators in Canada:
  - OPG owns and operates the Pickering and Darlington power plants in Ontario.
  - Bruce Power operates the Bruce A and Bruce B power plants in Ontario on a long-term lease from OPG, which owns the site. The Bruce generating station is the largest operating nuclear power plant in the world.
  - New Brunswick Power owns and operates the Point Lepreau power plant.
- In Ontario, planned investments of \$25 billion over the next 15 years will extend the life of 10 nuclear reactors for another 25 to 30 years.
- Nuclear power plant operators are supported by a supply chain of major equipment and component manufacturers and engineering service suppliers.
- Canada has nuclear R&D capabilities that are supported by academic research centres, the private sector, and government laboratories, including Chalk River Laboratories, Canada's largest science and technology facility. Research is focused on existing reactor technologies as well as on next-generation nuclear energy systems and other nuclear science applications.

## Main Associations

- Canadian Nuclear Association (CNA)
- Organization of Canadian Nuclear Industries (OCI)

## Regulatory Authority

- Decisions about the use of nuclear energy to produce electric power falls under provincial and territorial jurisdiction, whereas the development, regulation and licensing of nuclear energy are federal responsibilities.
- The Canadian Nuclear Safety Commission regulates all aspects of nuclear energy, including the development, production and operation of nuclear power and research reactors, and the production, possession and use of nuclear substances.

## Nuclear power – international context

### World generation – 2,364 TWh (2015)

1) United States .....	33%
2) France .....	17%
3) Russia.....	7%
4) China .....	7%
5) South Korea.....	6%
<b>6) Canada .....</b>	<b>4%</b>
7) Germany.....	4%
8) Ukraine.....	3%

### 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 LWRs, which use normal water as the moderator and coolant and enriched uranium for fuel.
- In addition to Canada, CANDU reactors have been sold to India, Pakistan, Argentina, South Korea, Romania and China.
- 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.

## 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





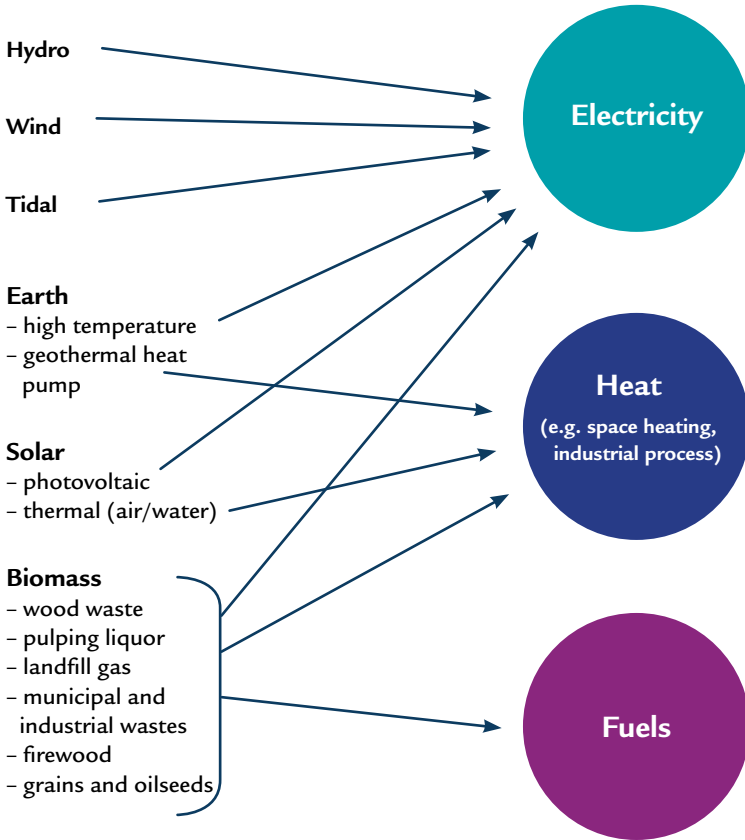
## What is renewable energy?

- Renewable energy is obtained from natural resources that can be naturally replenished or renewed within a human lifespan – that is, the resource is a sustainable source of energy.
- Some natural resources, such as moving water, wind and sunshine, are not at risk of depletion.
- Biomass is a renewable resource only if its rate of consumption does not exceed its rate of production.
- A wide range of energy-producing technologies and equipment has been developed over time to take advantage of these natural resources.
- Usable energy can be produced in the form of electricity, industrial heat, thermal energy for space and water conditioning, and transportation fuels.

## Major associations

- Canadian Hydropower Association
- Canadian Wind Energy Association
- Canadian Solar Industries Association (CanSIA)
- Canadian Geothermal Energy Association (CanGEA)
- Canadian Renewable Fuels Association (CRFA)

## Main sources and uses in Canada



## International context

### World production – 79,299 PJ or 1,894 Mtoe (2014)

1) China .....	18%
2) India.....	11%
3) United States .....	8%
4) Brazil.....	6%
5) Nigeria .....	6%
6) Indonesia.....	4%
7) <i>Canada</i> .....	3%

### Share of energy supply from renewable sources (2014)

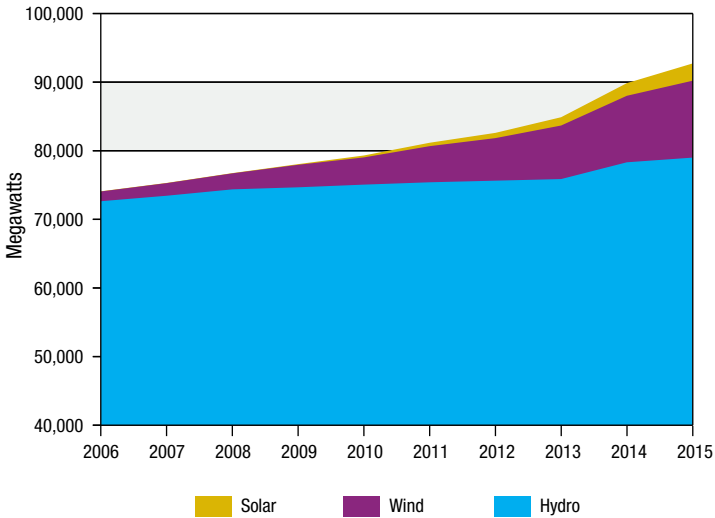
World .....	13.8%
OECD countries only.....	9.4%
<i>Canada</i> .....	17.7%

## Canadian production (2014)

**Total renewable energy** – 2,097 PJ or 50 Mtoe

Hydro .....	65.400%
Solid biomass (e.g. wood/waste) .....	26.700%
Wind .....	3.850%
Biogasoline .....	1.780%
Municipal waste/landfill gas .....	1.110%
Solar photovoltaic .....	0.470%
Biodiesel .....	0.300%
Industrial and other waste .....	0.300%
Solar thermal .....	0.080%
Tidal .....	0.003%

## Canadian renewable energy capacity





## Hydroelectricity – international context

### World generation of hydroelectricity – 3,895 TWh (2014)

1) China .....	27%
2) <b>Canada</b> .....	<b>10%</b>
3) Brazil .....	10%
4) United States .....	7%
5) Russia.....	5%

### Share of hydroelectricity in net electricity generation (2013)

1) Norway.....	96%
2) Brazil.....	69%
3) Venezuela .....	68%
4) <b>Canada</b> .....	<b>63%</b>

By comparison:

China.....	17%
United States .....	7%

## Hydroelectricity

**Hydroelectricity capacity in Canada** – 78,317 MW (2014)

### Major hydro facilities in Canada\* (≥1,000 MW)

Power plant	Province	Total capacity (MW)
Robert-Bourassa	Que.	5,616
Churchill Falls	N.L.	5,428
La Grande 4	Que.	2,779
Gordon M. Shrum	B.C.	2,730
Revelstoke	B.C.	2,480
La Grande 3	Que.	2,417
La Grande 2A	Que.	2,106
Beauharnois	Que.	1,853
Mica	B.C.	1,805
Manic 5	Que.	1,596
Sir Adam Beck 2	Ont.	1,499
La Grande 1	Que.	1,436
Limestone	Man.	1,340
Manic 3	Que.	1,326
Manic 2	Que.	1,229
Kettle	Man.	1,220
Bersimis 1	Que.	1,178
Manic 5 PA	Que.	1,064
Robert H. Saunders	Ont.	1,045
Outardes 3	Que.	1,026
Long Spruce	Man.	1,010
Kemano	B.C.	1,000

\* There are 576 hydro facilities in Canada with a capacity of at least 0.8 MW.

## Hydroelectricity

### Major projects under construction

Project	Province	Total capacity (MW)	Expected in-service
Site C	B.C.	1,100	2024
La Romaine Complex	Que.	1,550	2017–2020
Muskrat Falls	N.L.	824	2018
Keeyask	Man.	695	2021
Lower Mattagami Complex	Ont.	438	2016
Total		4,607	

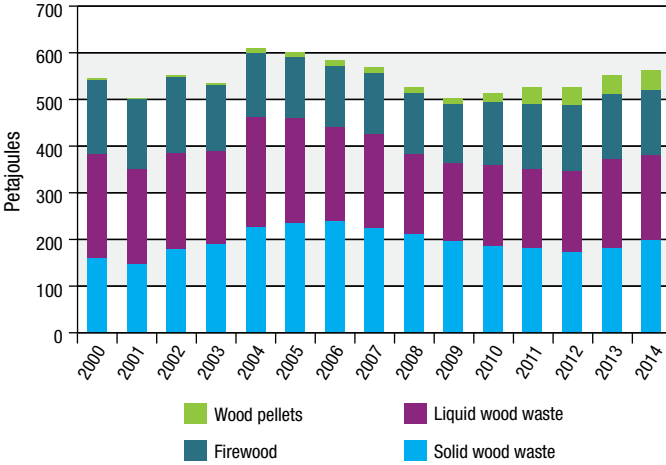
## Tidal

Canada currently has 1 tidal facility in operation. Annapolis Tidal Station, located in Nova Scotia, has a generation capacity of 20 MW.

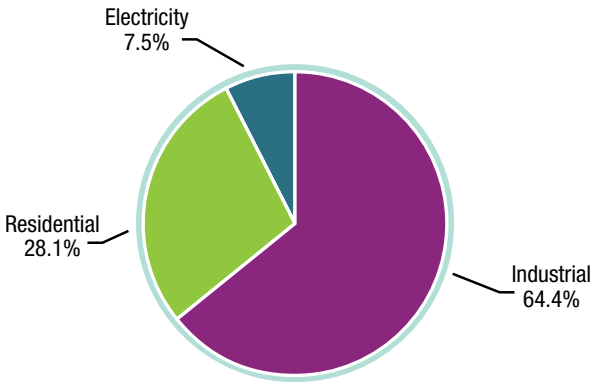
## Wood and wood waste (2014)

Wood and wood waste account for the largest share of renewable energy production in the OECD, at 34.9%. In Canada, that share is 26.7% – the second largest after hydro’s 65.4%.

### Canadian production



### Wood fuel use, by sector (2014)



There are 135 facilities in Canada with a capacity of at least 0.8 MW that use biomass to generate electricity. Together they have an aggregate capacity of about 3,000 MW. Additionally, there are 282 bio-heat facilities.

## Wind power – international context

**World capacity of wind power** – 432,883 MW  
(2015)

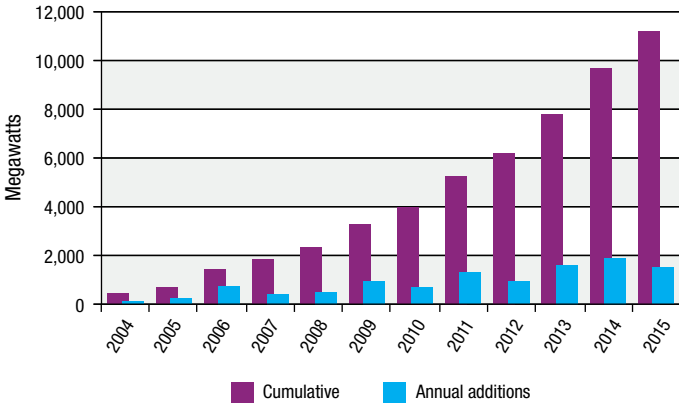
1) China .....	34%
2) United States .....	17%
3) Germany.....	10%
4) Spain.....	5%
5) India.....	6%
6) United Kingdom.....	3%
7) <b>Canada .....</b>	<b>3%</b>

### Wind power in Canada

Generation (2014) – 22.3 TWh, a 25% increase from 2013, representing 3.6% of total electricity

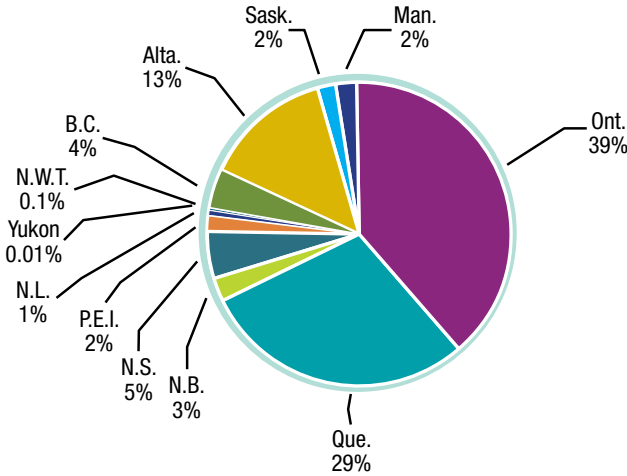
Capacity (at the end of 2015) – 11,205 MW

#### Installed capacity



## Wind power

Capacity by province, 2015



### Selected largest wind farms in Canada\* (≥150 MW)

Facility	Province	Total capacity (MW)
Lac Alfred (I and II)	Que.	300
Blackspring Ridge	Alta.	299
Seigneurie de Beaurpré 2 and 3	Que.	272
South Kent Wind Farm	Ont.	270
K2 Wind Farm	Ont.	270
Riviere du Moulin Phase II	Que.	200
Wolfe Island	Ont.	198
Prince Project	Ont.	189
Kincardine	Ont.	182
Armow Wind Farm	Ont.	180
Comber East and West	Ont.	166
Kent Hills 1 and 2	N.B.	150
Massif du Sud	Que.	150
Riviere du Moulin Phase I	Que.	150

\* There are 217 wind power facilities in Canada with a capacity of at least 0.8 MW.

## Solar photovoltaic – international context

### World capacity of solar PV – 227,000 MW

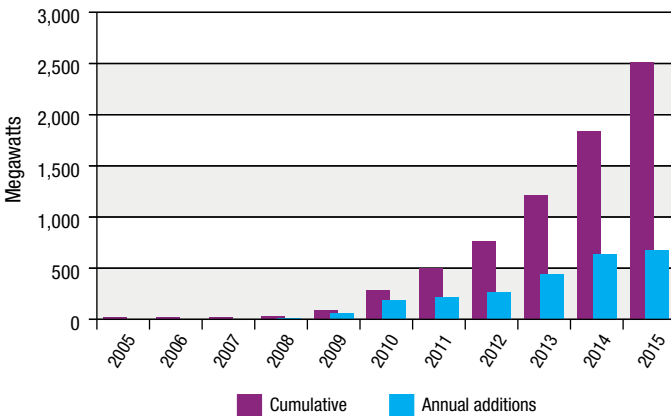
(2015)

1) China .....	19%
2) Germany.....	17%
3) Japan.....	15%
4) United States.....	11%
5) Italy.....	8%
...	
<b>Canada .....</b>	<b>1%</b>

### Solar PV in Canada

Capacity (at the end of 2015) – 2,517 MW, a 37% increase since 2014

#### Installed capacity



## Solar photovoltaic

### Selected largest solar PV farms in Canada \* ( $\geq 20$ MW)

Facility	Province	Total capacity (MW)
Sol-Luce Kingston	Ont.	100
Grand Renewable Energy Park	Ont.	100
Sarnia Solar Project 2	Ont.	60
Sault Ste. Marie 2	Ont.	34
Stardale	Ont.	33
Sault Ste. Marie 1	Ont.	24
Elmsley East/West	Ont.	24
Arnprior	Ont.	23
Sarnia Solar Project 1	Ont.	20
Belmont	Ont.	20
Amherstburg-1	Ont.	20
St. Clair Moore	Ont.	20
St. Clair Sombra	Ont.	20
Walpole	Ont.	20

\* There are 136 solar PV facilities in Canada with a capacity of at least 0.8 MW.

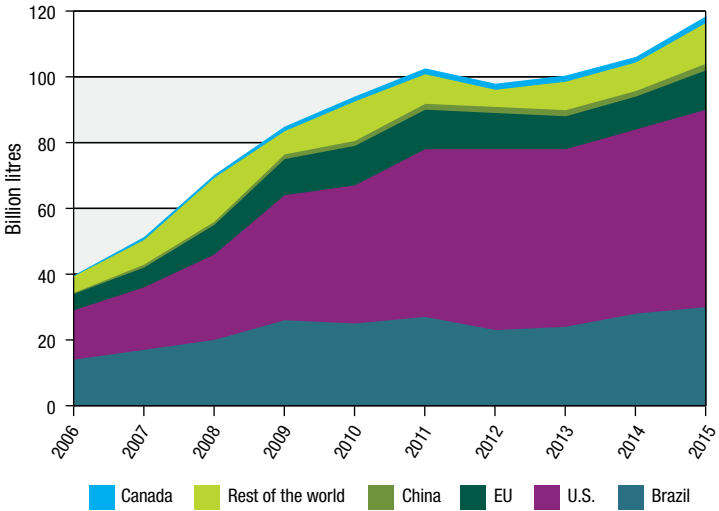


## Biofuels – international context

**World production of biofuels** – 118.5 billion L (2015)

- 1) United States ..... 50%
- 2) Brazil ..... 25%
- 3) European Union ..... 10%
- 4) China ..... 2%
- 5) *Canada* ..... 2%

### World biofuels production



## Biofuels

### Canadian supply and demand

Activity	Ethanol (2015)	Biodiesel (2015)
	Mb/d (million L)	
Canadian production	29.6 (1,720)	5.3 (307)
Imports	19.0 (1,100)	6.6 (383)
Exports	0	4.1 (238)
Domestic use	48.6 (2,820)	7.8 (452)

### Chicago ethanol market price



## Biofuels

### Regulations (2015)

	Gasoline	Diesel
	(% of renewable fuels content)	
Canada	5.0	2
British Columbia	5.0	4
Alberta	5.0	2
Saskatchewan	7.5	2
Manitoba	8.5	2
Ontario	5.0	2
Quebec	5.0*	–

\* Not regulated, target only

- The federal *Renewable Fuels Regulations*, administered by Environment and Climate Change Canada, 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 commencing on December 15, 2010.
- Fuel producers and importers of diesel fuel are also required to have an average annual renewable fuel content of at least 2% of the volume of diesel fuel that they produce and import commencing July 1, 2011 (heating distillate oil volumes for space heating purposes were excluded from the diesel regulations starting January 1, 2013).



## Canadian industry structure

The electricity industry performs three main activities:

- generating electricity by using various energy sources and technologies
- high-voltage transmission of electricity, usually over long distances, from power plants to end-use markets
- distributing electricity to end users, usually through low-voltage, local power distribution lines

In some provinces, electricity is provided by vertically integrated electric utilities that are often provincial Crown corporations.

## Major associations

- Canadian Electricity Association
- Provincially focused independent power producers' societies
- Source-specific associations (e.g. Canadian Hydropower Association and Canadian Wind Energy Association)

## Regulatory authority

- Primarily under provincial jurisdiction
- Provincial governments exercise their jurisdiction through provincial Crown utilities and regulatory agencies.
- The NEB regulates international power lines and electricity exports.

## International context

### World generation – 23,903 TWh (2014)

1) China .....	24%
2) United States .....	18%
3) India.....	5%
4) Russia.....	4%
5) Japan.....	4%
<b>6) Canada .....</b>	<b>3%</b>
7) Germany.....	3%
8) Brazil.....	2%

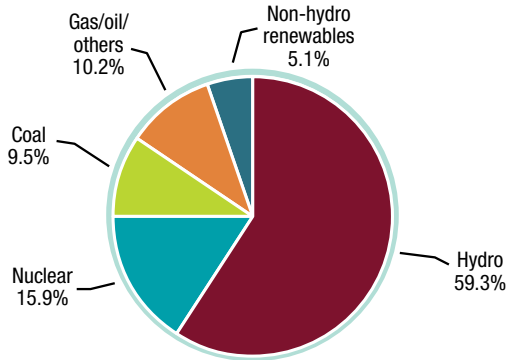
### World exports – 690 TWh (2014)

1) France .....	11%
2) Germany.....	11%
<b>3) Canada .....</b>	<b>8%</b>
4) Paraguay .....	6%
5) Switzerland .....	5%
6) Sweden.....	4%

## Canadian supply

### Generation in Canada – 639 TWh (2014)

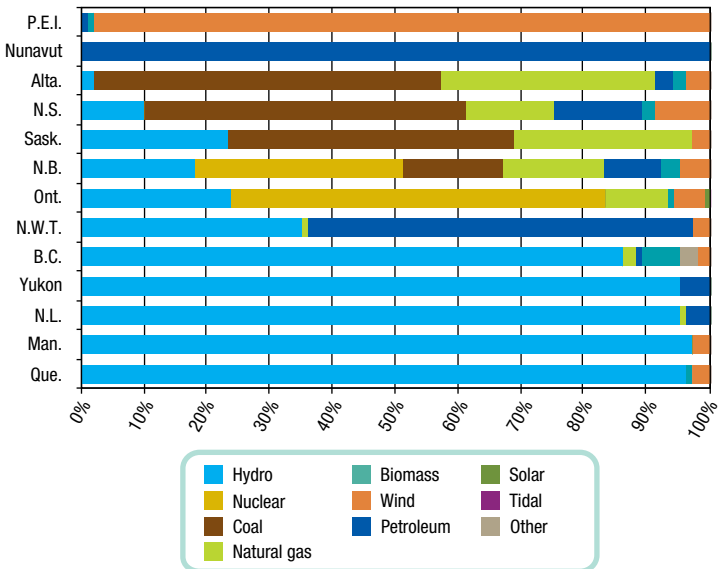
#### Generation by source, 2014



Generation from renewable sources: 64%, first in the G7

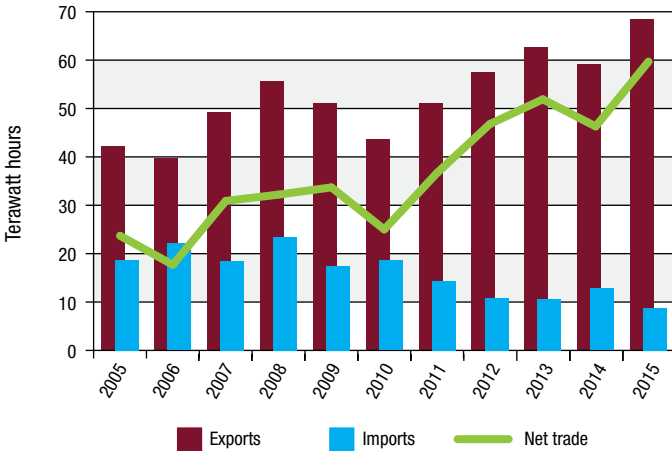
Generation from non-GHG emitting sources: 80%, second in the G7 after France

### Provincial characteristics



## Trade (2015)

### 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)

Exports ..... 68 TWh

Imports..... 9 TWh

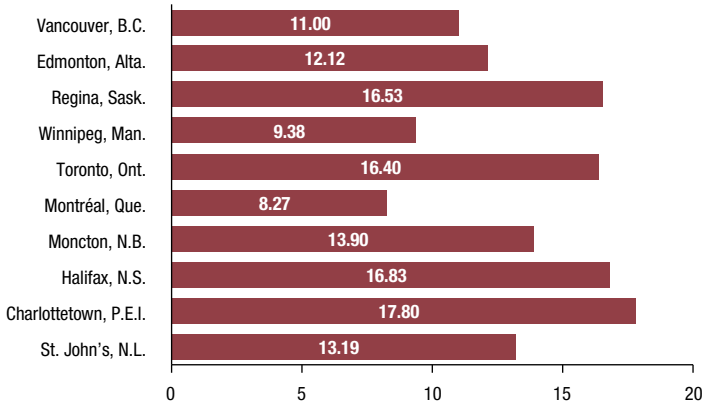
### Key facts (2015)

- All Canadian electricity trade is with the U.S.
- Canada exports 9% of its electricity to the U.S., which meets 2% of U.S. consumption.

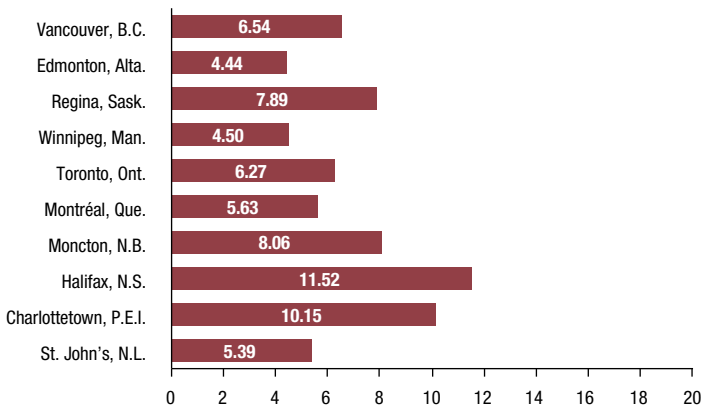


## Retail prices

### Average residential electricity prices, including taxes, April 2015 (cents/kWh)



### Average large industrial electricity prices, including taxes, April 2015 (cents/kWh)





### Primary energy use

- Primary energy use measures the total energy requirements of all users of energy.
- 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 (e.g. NGLs used as feedstock by the chemical industries).
- In 2013, the total amount of primary energy consumed was estimated at 12,681.4 PJ.

### Secondary energy use

- Secondary energy use accounts for the energy used by final consumers in various sectors of the economy.
- Secondary energy use includes the energy used to run vehicles in the transportation sector; the energy used to heat and cool buildings in the residential and commercial/institutional sectors; and the energy required to run machinery in the industrial and agricultural sectors.
- In 2013, secondary energy use accounted for about 70% of primary energy use, or 8,924.0 PJ.

All subsequent use of the phrase “energy use” in this section refers to secondary energy use, unless otherwise stated.

### **Factors affecting energy use**

- level of activity – the number of households and the floor space of residences; short-term variations in industrial output
- sectoral structure (e.g. growth and decline of industries with varied energy intensity)
- weather – leading to changes in heating and cooling requirements
- service level (i.e. the penetration rate of devices and equipment, such as residential air conditioners)
- capacity utilization rate – the proportion of the installed production capacity that is in use
- energy efficiency

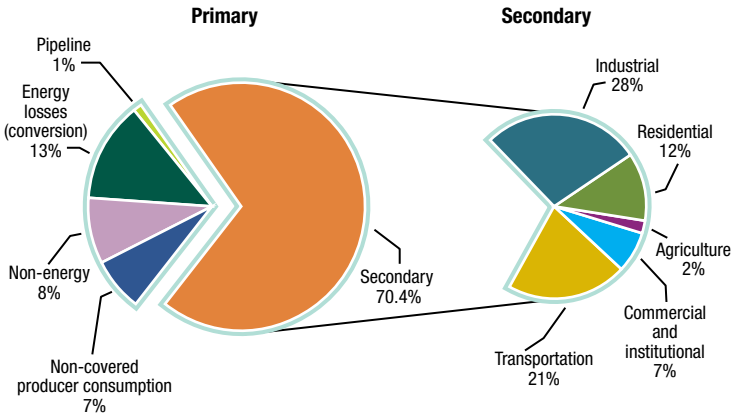
### **Energy efficiency**

- a measure of how effectively energy is used for a given purpose
- providing a similar (or better) level of service with less energy consumption on a per-unit basis is considered an improvement in energy efficiency

### **Energy intensity**

- the ratio of energy use per unit of activity (such as floor space, GDP, Pkm, Tkm, etc.)

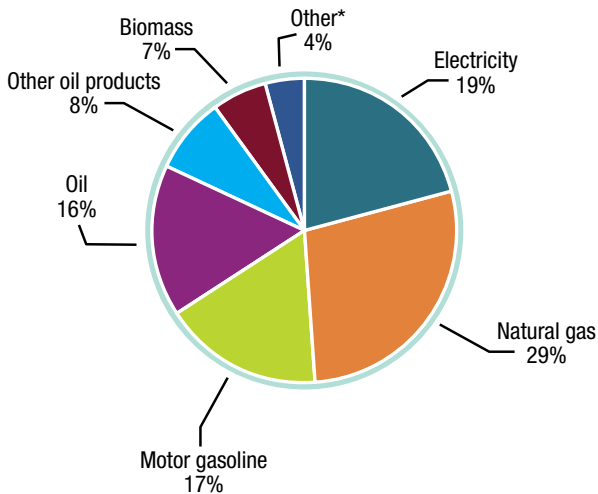
Primary and secondary energy use by sector, 2013



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 – 8,924 PJ (2013)

Energy use by fuel type, 2013



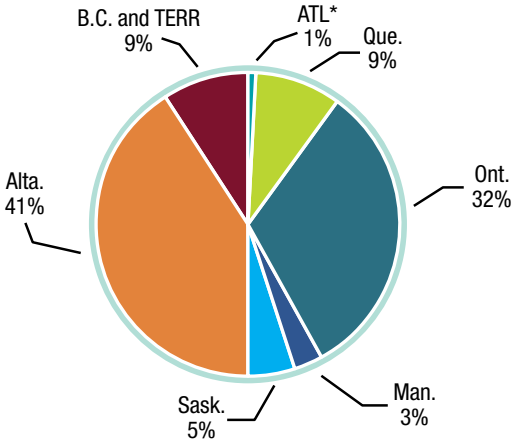
\* "Other" includes coal, coke, coke oven gas, NGLs and steam and waste.

### Natural gas energy use (2013)

Total natural gas energy use was 2,573.9 PJ in 2013.

Sector	Energy use (PJ)	% of the total
Residential	685.3	26.6%
Commercial	496.7	19.3%
Industrial	1,351.9	52.5%
Transportation	1.5	0.1%
Agriculture	38.5	1.5%
<b>Total</b>	<b>2,573.9</b>	<b>100%</b>

### Natural gas energy use by province, 2013



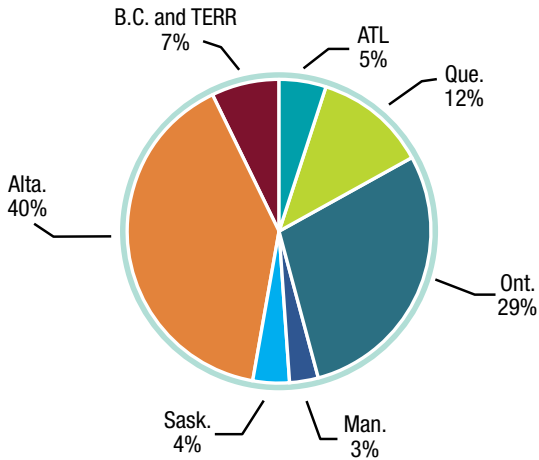
\* Atlantic provinces.

## Natural gas liquids energy use (2013)

Total natural gas liquids energy use was 139.0 PJ in 2013.

Sector	Energy use (PJ)	% of the total
Residential	14.6	10.5%
Commercial	35.0	25.2%
Industrial	70.7	50.9%
Transportation	10.4	7.5%
Agriculture	8.2	5.9%
<b>Total</b>	<b>139.0</b>	<b>100%</b>

## Natural gas liquids energy use by province, 2013

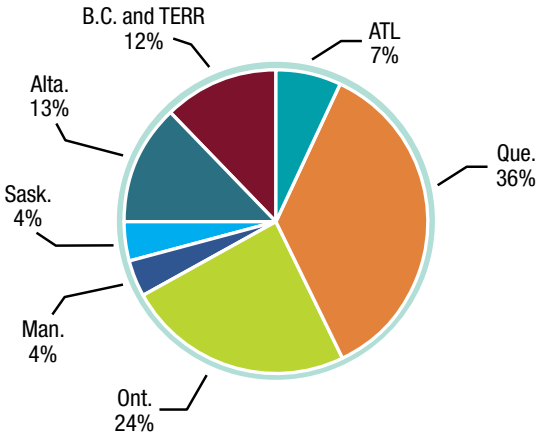


### Electricity energy use (2013)

Total electricity energy use was 1,720.9 PJ in 2013.

Sector	Energy use (PJ)	% of the total
Residential	566.4	32.9%
Commercial	359.2	20.9%
Industrial	755.1	43.9%
Transportation	4.4	0.3%
Agriculture	35.9	2.1%
<b>Total</b>	<b>1,720.9</b>	<b>100%</b>

### Electricity energy use by province, 2013

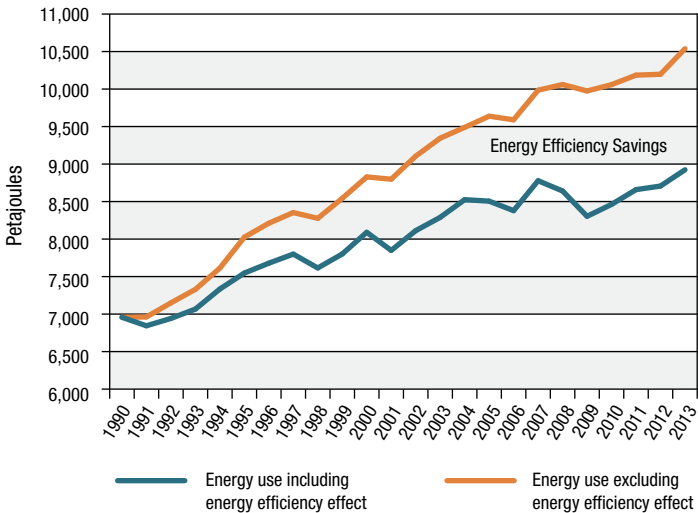




## Energy efficiency

- Energy efficiency in Canada improved by 24.2% between 1990 and 2013.
- Efficiency improvements slow the rate of growth in energy use:
  - Energy use grew by 28% between 1990 and 2013.
  - Without energy efficiency improvements, energy use would have grown by 51%.
- Energy efficiency savings of 1,613 PJ in 2013:
  - equivalent to end-user savings of \$37.6 billion

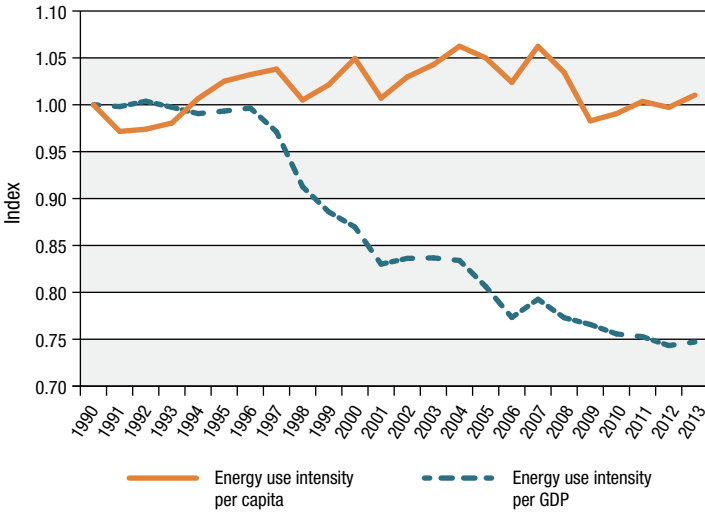
### Secondary energy use with and without energy efficiency improvements 1990–2013



## Energy intensity

- Canada used 25% less energy per dollar of GDP in 2013 than in 1990.

Total secondary energy use intensity per capita and unit of GDP index 1990–2013 (1990=1)



## Trends in energy use and intensity by subsector, 1990–2013

	Energy use <sup>1</sup>		Energy intensity <sup>2</sup>	
Residential	↑	7%	↓	-35%
Commercial	↑	23%	↓	-15%
Transportation (passenger)	↑	20%	↓	-21%
Freight	↑	78%	↑	11%
Industrial (forestry, mining, manufacturing, construction)	↑	30%	↓	-9%
Industry (w/o upstream mining)	↓	-1%	↓	-31%

<sup>1</sup> energy used by final consumers to deliver energy services in various sectors of the economy (e.g. space heating, process heating and lighting)

<sup>2</sup> the amount of energy used per unit of activity (i.e. floor space – residential, floor space – commercial, Pkm, Tkm and GDP)

- Most industries saw a reduction in their energy intensity due in part to gains in energy efficiency.

## Canadian households

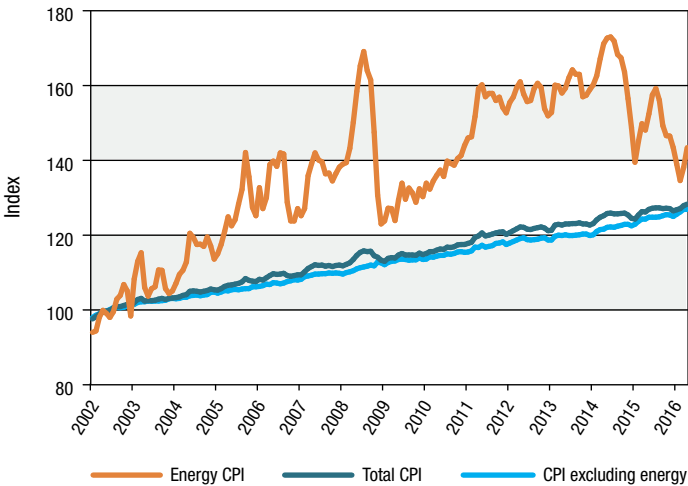
### Household expenditures on residential and transportation

- Canadian households spent \$4,735 on average on energy in 2014.
  - Residential energy expenditures averaged \$2,265.
  - Transportation energy expenditures averaged \$2,470.
- Energy accounted for 8% 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.

Consumer price index (2002=100)

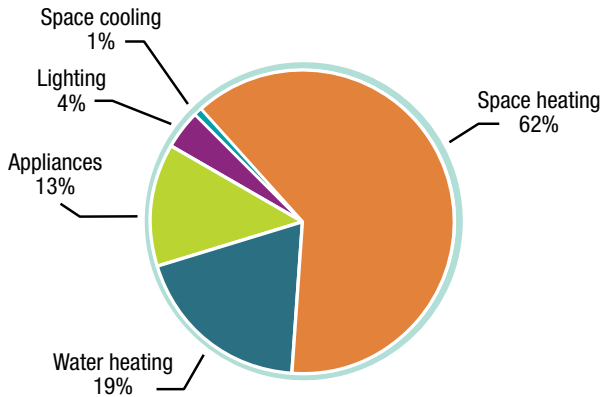


## Residential sector

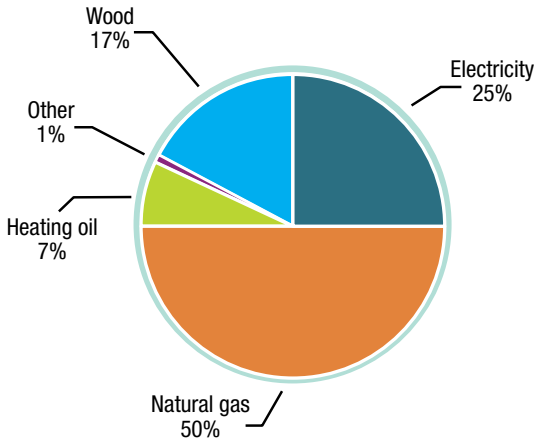
### Overview – 1990–2013 period

- Residential energy efficiency improved by 45%, saving 639 PJ of energy and \$12 billion in energy costs.
- Residential energy use increased by 6.5%, but would have increased by 51% without energy efficiency improvements.
- Energy intensity decreased by 24% per household, while energy use per square metre decreased even more, at 35%.

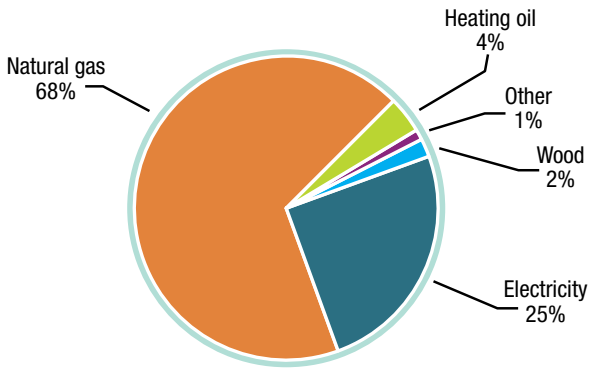
### Energy use by end use, 2013



Residential space heating by fuel type, 2013



Residential water heating by fuel type, 2013

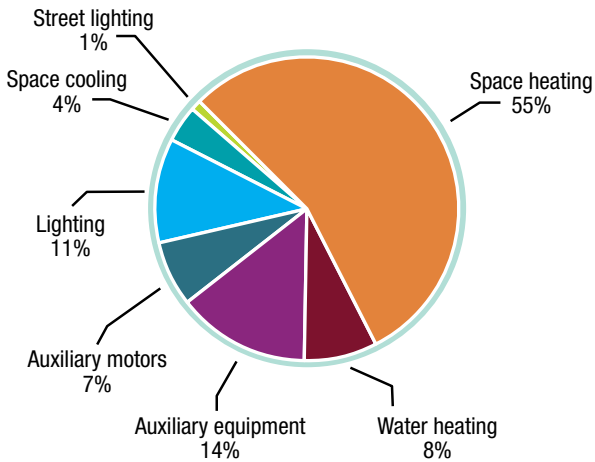


## Commercial and institutional sectors

### Overview – 1990–2013 period

- Energy efficiency in the commercial/institutional sector improved by 33%, saving Canadians 241.8 PJ of energy and \$5.4 billion in energy costs in 2013.
- Energy use increased by 23%, but would have increased by 55% without energy efficiency improvements.
- Energy intensity (GJ/m<sup>2</sup>) decreased by 15%.

### Energy use by end use, 2013



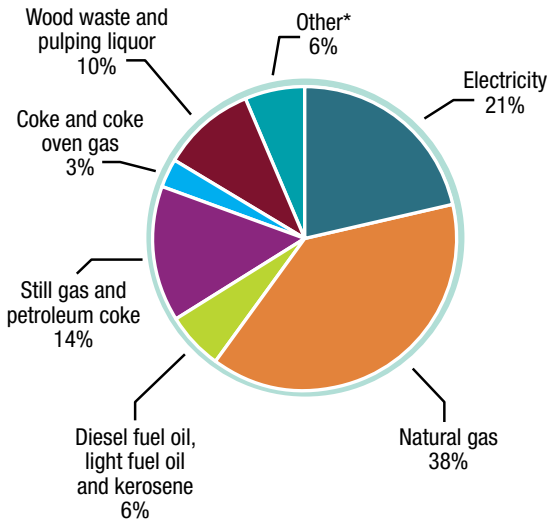
## Industrial sector

### Overview – 1990–2013 period

- The Canadian industry saved \$3.0 billion in energy costs because of an 8.1% energy efficiency improvement, saving 220.1 PJ.
- Industrial energy use increased by 30%, but would have increased by 38% without energy efficiency improvements.
- Energy intensity (MJ/\$ of GDP) decreased by 9%.

The industrial sector includes all manufacturing, mining (including oil and gas extraction), forestry and construction activities, and in 2013, these industries spent \$47.6 billion on energy.

### Energy use by fuel type, 2013



\* “Other” includes HFO, coal, LPGs, NGL, steam and waste.

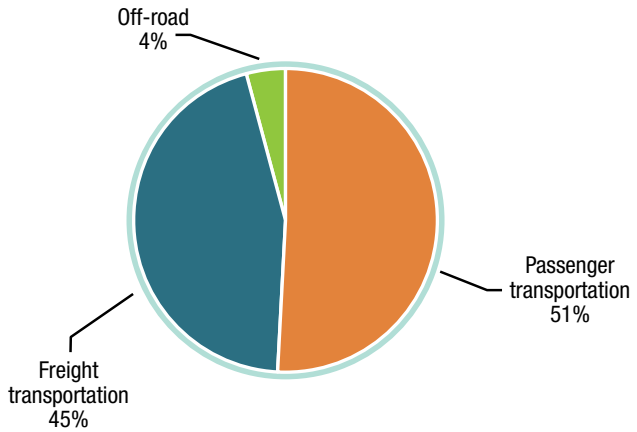


## Transportation sector

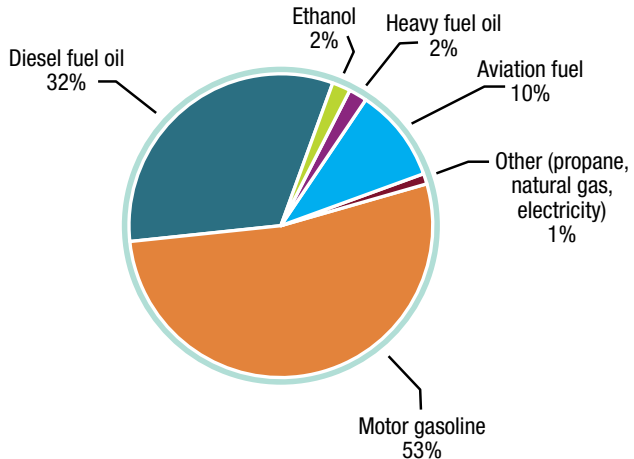
### Over the 1990–2013 period

- Energy efficiency in the transportation sector improved by 29%, saving Canadians 512.1 PJ of energy and \$17.1 billion in energy costs in 2013.
- Total transportation energy use increased by 43%.

### Energy use by transportation type, 2013



### Energy use by fuel type, 2013





## Canadian GHG emissions (2014)

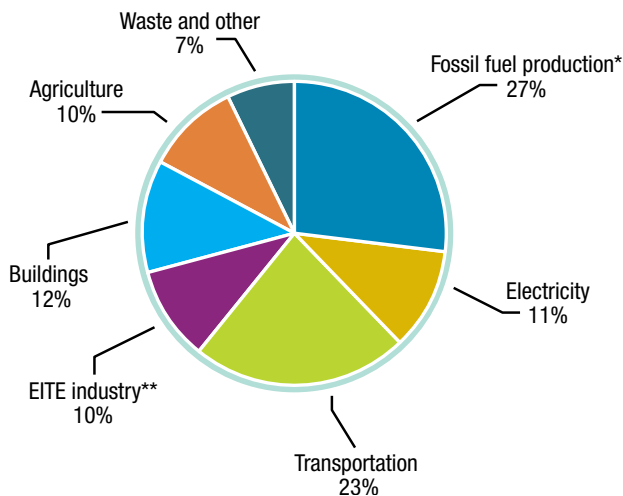
Total\* ..... 732 Mt CO<sub>2</sub> equivalent

\* excludes land use, land-use change and forestry estimates

Between 2005 and 2014, Canada's GHG emissions decreased 2.0% while the economy grew 13.9%.

Over the same period, emissions from electricity production decreased 33.9% and emissions from fossil fuel production increased 21.0%, leading to an overall decrease of 2.1% in emissions from energy production.

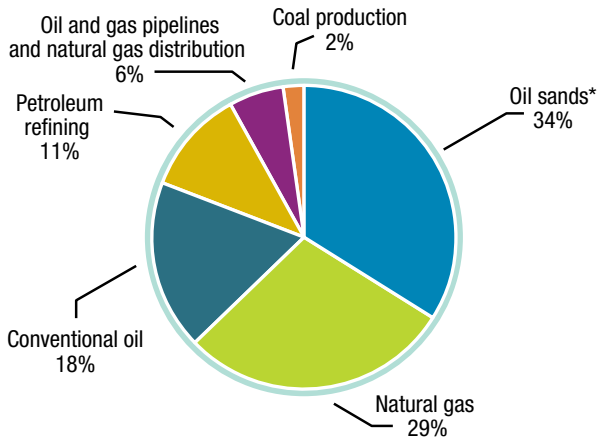
## GHG emissions by economic sector, 2014



\* includes coal production

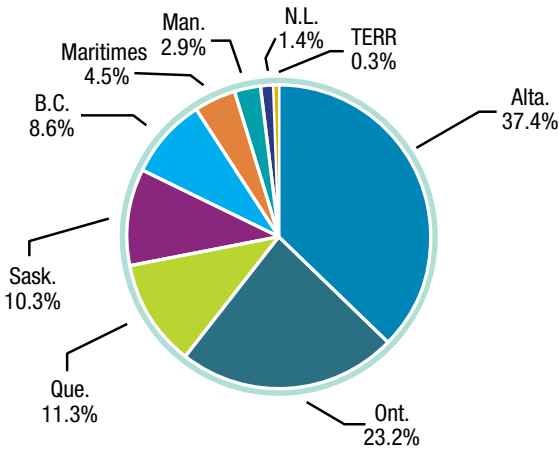
\*\* EITE: emissions intensive, trade exposed (Mining; Smelting and Refining of Non-Ferrous Metals; Pulp and Paper; Iron and Steel; Cement; Lime and Gypsum; Chemicals and Fertilizers)

**GHG emissions by fossil fuel subsector, 2014**

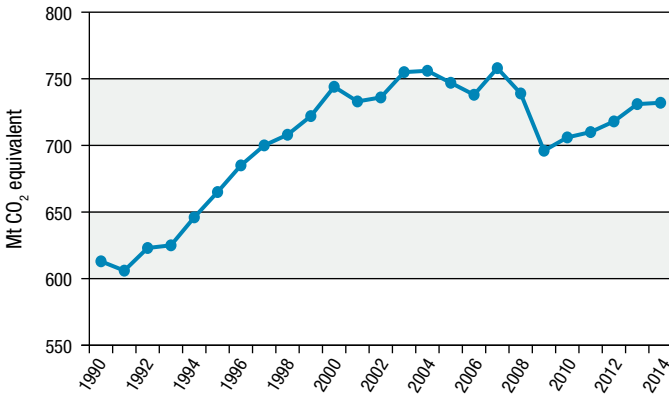


\* See Chapter 2, “Crude oil”, for more information on GHG emissions from the oil sands.

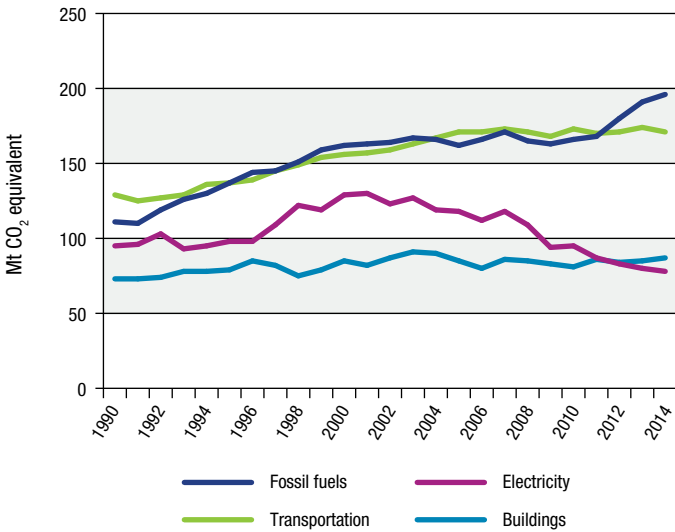
**GHG emissions by province, 2014**



GHG emissions, 1990–2014



GHG emissions, selected economic sectors, 1990–2014





# Annex 1: 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 ( $\text{¢}/\text{m}^3$ ) (customer level in Canada)
- \$ per hundred cubic feet ( $\text{\$/CCF}$ ) (customer level in the U.S.)

energy content based:

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

## Coal

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

## Uranium

- 1 metric tonne = 1,000 kilograms of uranium metal (U)
- U.S.: in pounds of uranium oxide ( $\text{U}_3\text{O}_8$ )
- 1 lb.  $\text{U}_3\text{O}_8$  = 0.84802 lb. U = 0.38465 kg U



## 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 ( $1 \text{ MW} \times 24 \text{ hr} \times 365 \text{ days}$ ).
- 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<sup>3</sup> of crude oil = 39.0 GJ
- 1,000 m<sup>3</sup> 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

## Annex 2: Abbreviations

b/d	barrels per day
Bcf/d	billion cubic feet per day
Bcm/d	billion cubic metres per day
CCS	carbon capture and storage
CDIA	Canadian direct investment abroad
CO <sub>2</sub> equivalent	carbon dioxide equivalent
EIA	Energy Information Administration (U.S.)
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
HGL	hydrocarbon gas liquids
HST	Harmonized Sales tax
IEA	International Energy Agency
kg	kilogram
km	kilometre
km <sup>2</sup>	square kilometre
kt	kilotonne
lb.	pound
L	litre
LNG	liquefied natural gas
LPG	liquefied petroleum gases
m	metre
m <sup>2</sup>	square metre
m <sup>3</sup>	cubic metre
Mb/d	thousand barrels per day
MMb/d	million barrels per day
MMcf/d	million cubic feet per day
Mt	million tonnes; megatonne
Mtoe	million tons of oil equivalent
mtpa	million tonnes per annum
MW	megawatt

## Annex 2: Abbreviations

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
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 N.W.T. – Northwest Territories Ont. – Ontario P.E.I. – Prince Edward Island Que. – Quebec Sask. – Saskatchewan
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
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

# Annex 3: Sources

## 1. Energy industry

**Canada's position in the world:** electricity capacity from the United Nations; for other data, see relevant chapters

**Gross domestic product:** StatCan CANSIM Table 379-0029, nominal values for recent years estimated by NRCan

**Employment:** CANSIM Table 383-0031, StatCan Aboriginal People and the Labour Market Estimates from the Labour Force Survey, 2014

**Provincial/territorial gross domestic product:** StatCan CANSIM tables 379-0030 and 384-0037

**Provincial/territorial employment:** StatCan CANSIM Table 383-0029

**Capital expenditures:** StatCan CANSIM tables 029-0045, 029-0046, and 029-0051

**Exports/imports:** StatCan International Merchandise Trade Database (TRAGS Database)

**Government revenues:** StatCan CANSIM Table 180-0003, StatCan special tabulation (royalties), Canadian Association of Petroleum Producers, *Statistical Handbook*, Table 01-01C

**Energy and Cleantech:** BNEF & Frankfurt School FS-UNEP Collaborating Centre for Climate and Sustainable Energy Finance (2015) *Global Trends in Renewable Energy Investment; Tracking the Energy Revolution*; and, Analytica Advisors, *Canadian Clean Technology Industry Report*, 2016

**Expenditure on energy RD&D:** IEA RD&D Budget database; Statistics Canada, CANSIM Table 358-0142, *Federal Expenditures on Science and Technology and its Components in Current Dollars and 2007 Constant Dollars, Research and Development in Current Dollars for 2014-15*; Statistics Canada, *Energy R&D Expenditures by Area of Technology for industry expenditures*; and data compiled by NRCan

**Foreign control:** StatCan CANSIM tables 179-0004, 179-0005, and 180-0003 and StatCan document 61-220-X

**Investment:** StatCan CANSIM Table 376-0052

**Major recent deals:** S&P Capital IQ, Canoils, Bloomberg (based on closing dates when available)

**Canadian energy assets:** NRCan estimates based on company financial statements and annual reports

**Canadian production:** StatCan CANSIM tables 127-007, 128-0016, and 128-0007, and NRCan estimates

**Total primary energy supply:** IEA Annual Database, World Energy Balances and IEA SLT questionnaire

## 2. Crude oil

**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*, May 2016; Alberta Energy Regulator (AER), Alberta's Energy Reserves 2015 and Supply/Demand Outlook 2016–2025

**Wells completed and metres drilled in western Canada:** JuneWarren-Nickle's Energy Group, Canadian Association of Oilwell Drilling Contractors (CAODC)

**Canadian production:** StatCan CANSIM Table 126-0001 and NRCan analysis

**Canadian supply and demand:** StatCan CANSIM tables 126-0001, 134-0001, and 133-0003

**Trade:** StatCan CANSIM Table 126-0001 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*, Table 4-16B, Statistics Canada CANSIM tables 029-0046 and 126-0001, Alberta Energy Regulator (AER) Alberta's Energy Reserves 2015 and Supply/Demand Outlook 2016–2025, Table R3.2, and NRCan analysis

**Light tight Oil/Shale Oil:** U.S. EIA, Technically Recoverable Shale Oil Resources

**Environmental challenges:** compiled by NRCan

**Crude by rail:** CANSIM Table 404-0002, *CAPP Crude Oil Forecast, Markets & Transportation*, *NEB Canadian Crude Oil Exports by Rail – Quarterly Data*, *Oil Sands Magazine*, and company websites.

### 3. Petroleum products

**Canadian refineries:** compiled by NRCan from company information and Conference Board of Canada, Canada's Petroleum Refining Sector, and other published sources

**Canadian supply and demand:** StatCan CANSIM tables 134-0001 and 134-0004, NRCan analysis

**Trade:** StatCan CANSIM Table 134-0004

**Trade, Key Facts:** 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

**Canadian petroleum refineries:** Canadian Fuels Association, Canadian Association of Petroleum Producers

### 4. Hydrocarbon gas liquids

**Canadian supply:** StatCan CANSIM tables 134-004 and 131-0002

**Trade:** NEB for Exports; and StatCan International Merchandise Trade Database (TRAGS Database) for Imports

**Production by province:** *CAPP Statistical Handbook*, tables 3.5a, 3.6a, and 3.14a

## 5. 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*, Table 02-13B

**Canada resources:** NEB, *Canada's Energy Future 2013*

**U.S. reserves:** U.S. EIA, *Natural Gas Reserves Summary*, dry gas

**U.S. resources:** Potential Gas Committee, *Report of Potential Supply of Natural Gas in the United States, 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

**Shale gas:** U.S. EIA, *Technically Recoverable Shale Gas Resources*, June 2013, Table 6

**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

**Wells completed and metres drilled in western Canada:** JuneWarren-Nickle's Energy Group and CAODC

**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 and calculations by NRCan

**Canadian domestic demand:** StatCan CANSIM tables 128-0017 and 129-0002



**Prices:** GLJ Energy Publications, *Canadian National Gas Focus*, 2002–2014

**Pipelines:** compiled by NRCan

**LNG export applications:** compiled by NRCan

## 6. 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

## 7. Uranium and nuclear power

**World production and exports:** World Nuclear Association

**World known recoverable resources:** Organisation for Economic Co-operation and Development, Nuclear Energy Agency, International Atomic Energy Agency

**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 world generation:** U.S. EIA Table Nuclear Electricity Net Generation

**Nuclear power plants in Canada:** compiled by NRCan from StatCan and other public sources

## 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 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 and other public sources

**Biofuels – Canadian production of biofuels; World production of biofuels:** Bloomberg New Energy Finance, F.O. Licht, FAPRI

**Biofuels – supply and demand:** production:, Bloomberg New Energy Finance, FO Licht; imports/exports: StatCan

**Biofuels – ethanol prices:** Oil Price Information Service, Chicago Ethanol Market Price

**Biofuels – regulations:** compiled by NRCan

## 9. 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*

## 10. Energy demand

**Primary and secondary energy use:** Office of Energy Efficiency’s National Energy Use Database based on StatCan data

**Canada’s secondary energy use:** Office of Energy Efficiency’s National Energy Use Database based on StatCan data

**Natural gas energy use:** Office of Energy Efficiency’s National Energy Use Database based on StatCan data

**Electricity energy use:** Office of Energy Efficiency’s National Energy Use Database based on StatCan data

**Natural gas liquids 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

**Household expenditures:** StatCan CANSIM Table 203-0021

**Consumer prices:** StatCan CANSIM Table 326-0020

**Residential sector:** Office of Energy Efficiency's National Energy Use Database based on StatCan data

**Commercial and institutional sector:** Office of Energy Efficiency's National Energy Use Database based on StatCan data

**Industrial sector:** Office of Energy Efficiency's National Energy Use Database based on StatCan data

**Transportation sector:** Office of Energy Efficiency's National Energy Use Database based on StatCan data

## 11. Greenhouse gas emissions

**Greenhouse gas emissions:** Environment and Climate Change Canada's *National Inventory Report 1990–2014: Greenhouse Gas Sources and Sinks in Canada* and NRCan analysis