Canada Oil and Gas Industry Overview

CANADA'S OIL & NATURAL GAS PRODUCERS

Content Summary

Canada in a Global Context

- Canada is the fourth-largest global producer of crude oil and the fifth-largest producer of natural gas. It ranks as one of the least corrupt in the world, with low levels of corruption correlated to high levels of environmental performance. In an increasingly polarized world geopolitically, Canada accounts for one-sixth of the production from countries within the Western Alliance and about 6% of global oil production.

Evolution of the Industry

- Canada has been a trailblazer in the oil and gas industry since the inception of the modern petroleum industry in the 1800s. Over the more than 160 years of operating, Canadian producers have consistently innovated to adapt to new technology and a rapidly changing global environment.

Geology of the Western Canadian Sedimentary Basin

- The country's large land base is home to many oil and gas deposits and play types thanks to a long, varied geologic history and complex tectonics. The Western Canadian Sedimentary Basin, the largest producing basin in the country, stretches across four provinces and two territories.

Industry Structure

- Canada is unique in that, on top of a prolific conventional oil and gas industry, much of the country's production comes from the oil sands. Both the conventional and oil sands industries have seen significant innovations over the decades, both now routinely producing oil and gas from deposits that were once considered impossible to unlock hydrocarbons from.

Product Types and Location

- Hydrocarbons include a spectrum of product types, from low-density, gaseous molecules like natural gas to high-density, viscous bitumen. All forms can be found and are produced in Canada.

Canada in a Global Context

CANADA'S OIL & NATURAL GAS PRODUCERS

Canada is the Fourth-Largest Producer of Oil in the World

Rank		Oil Production (MMB/d)	Percent Contribution to World Demand
1	United States	17.8	18%
2	Saudi Arabia	12.1	13%
3	Russia	11.2	12%
4	**Canada**	**5.6**	**6%**
5	Iraq	4.5	5%
6	China	4.1	4%
7	United Arab Emirates	4.0	4%
8	Iran	3.8	4%
9	Brazil	3.1	3%
10	Kuwait	3.0	3%

Source: Energy Institute Statistical Review of World Energy (2023)
Note: Production definitions may not match the Canadian Energy Regulator.

- Canada is one of the world's largest producers of secure and reliable oil, supplying 6% of global production.
- North American oil production and energy security have been boosted by the growth in Canada, but also the United States. The surge of US tight oil over the past decade has made the United States the largest oil producer in the world.
- While not listed, Mexico produced 1.9 MMB/d of oil in 2022, making it the 11th largest producer behind Kuwait.

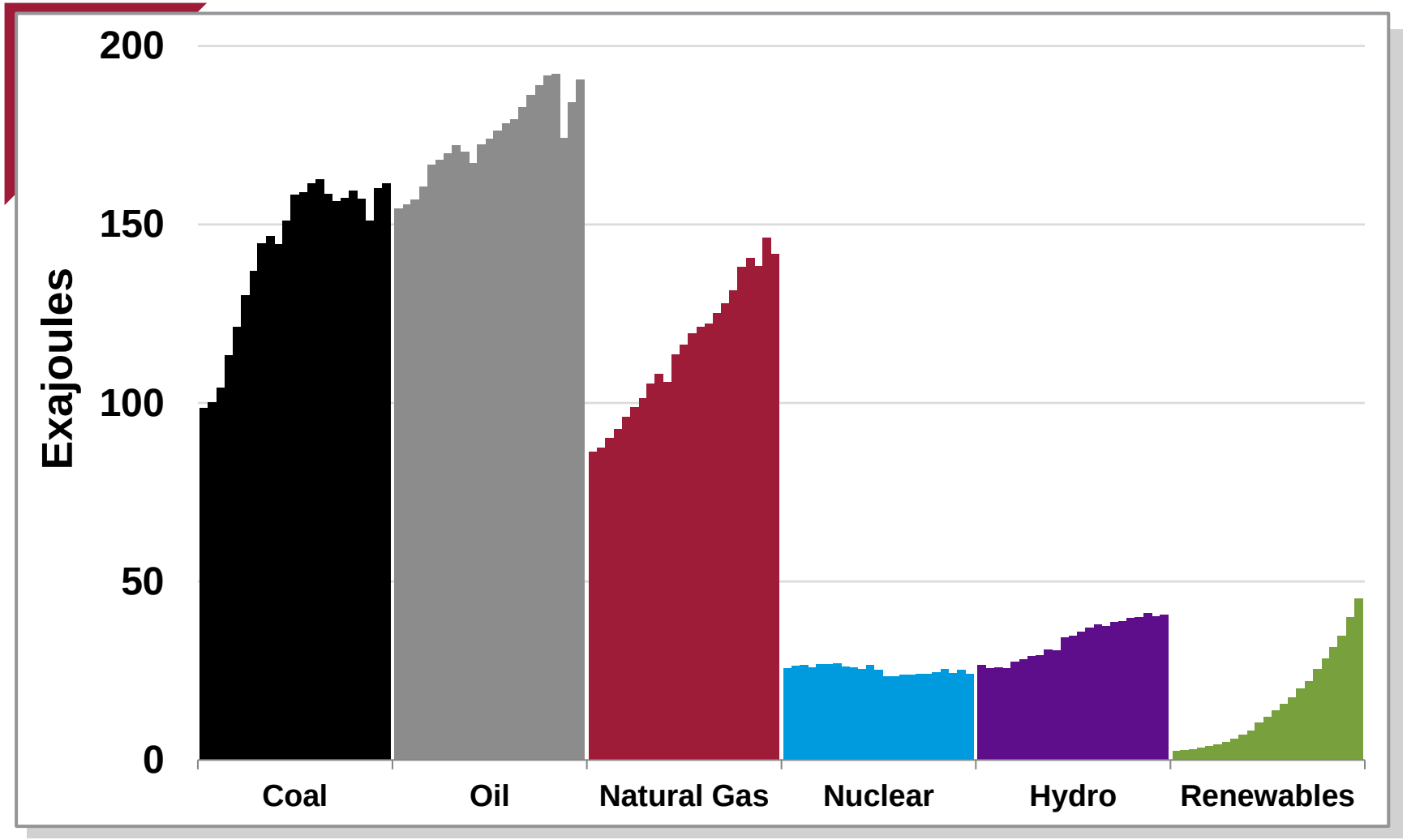
Canada is the Fifth-Largest Producer of Natural Gas

Rank		Gas Production (Bcf/d)	Percent Contribution to World Demand
1	United States	94.7	25%
2	Russia	59.8	16%
3	Iran	25.1	7%
4	China	21.5	6%
5	**Canada**	**17.9**	**5%**
6	Qatar	17.3	5%
7	Australia	14.8	4%
8	Norway	11.9	3%
9	Saudi Arabia	11.6	3%
10	Algeria	9.5	3%

Source: Energy Institute Statistical Review of World Energy (2023)
Note: Production definitions may not match the Canadian Energy Regulator.

- In 2022, Canada accounted for 5% of world natural gas production.
- The surge of US shale gas resulted in the United States surpassing Russia in 2011 to become the world's largest natural gas producer.
- Together, the United States and Russia make up 40% of world natural gas production.

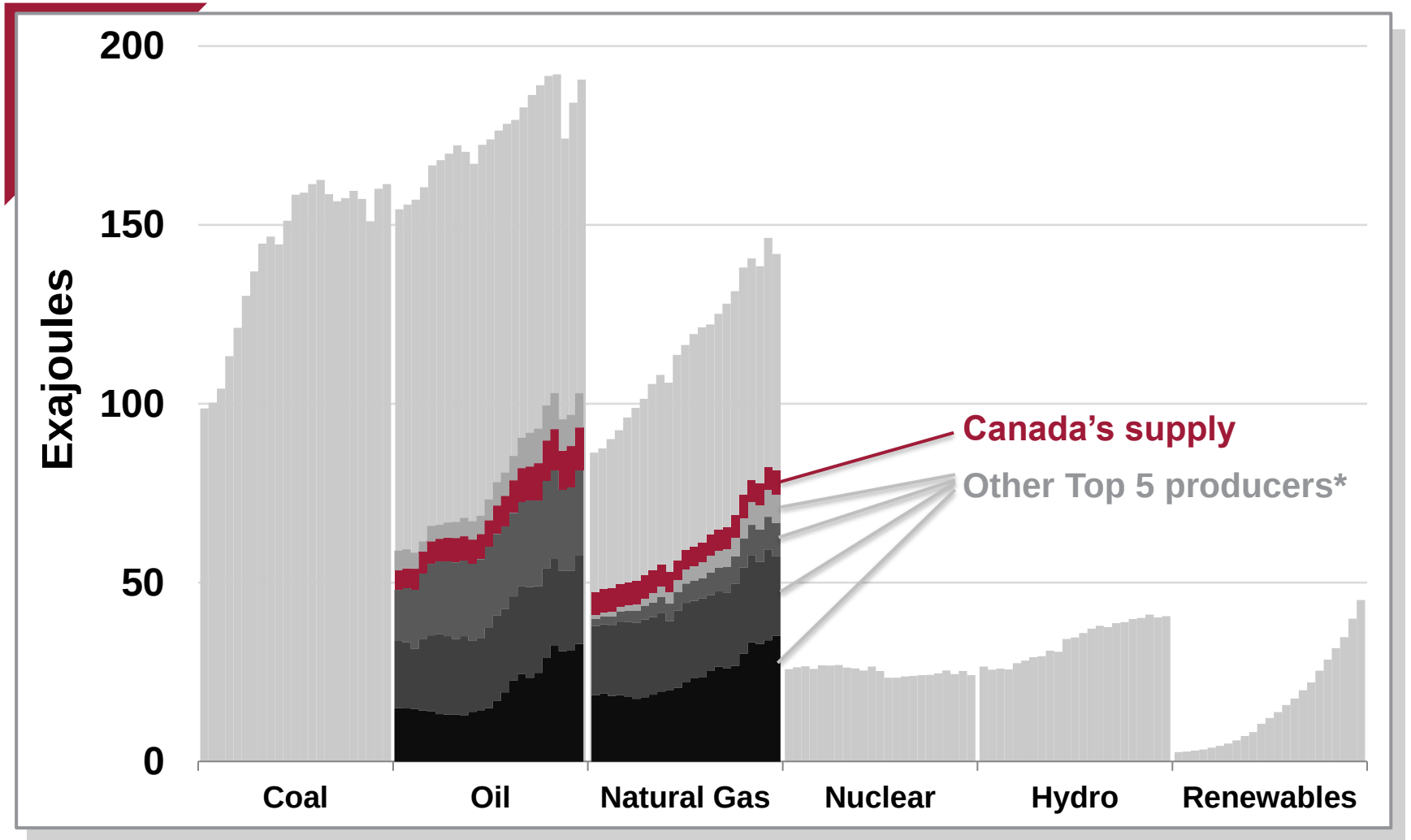
Global Primary Energy Consumption | By Source | 2000 to 2022



- Global energy demand has grown over the past two decades, largely driven by the economic growth of China. Consumption has increased for all sources except nuclear.
- Coal consumption began to level off in 2014 over preferences for renewables and natural gas.
- Low-cost wind and solar have accelerated the adoption of renewables across the world.
- Natural gas has been increasingly adopted, in part due to the growth of liquefied natural gas (LNG).

Source: Energy Institute Statistical Review of World Energy (2023)

Global Primary Energy Consumption | By Source | 2000 to 2022

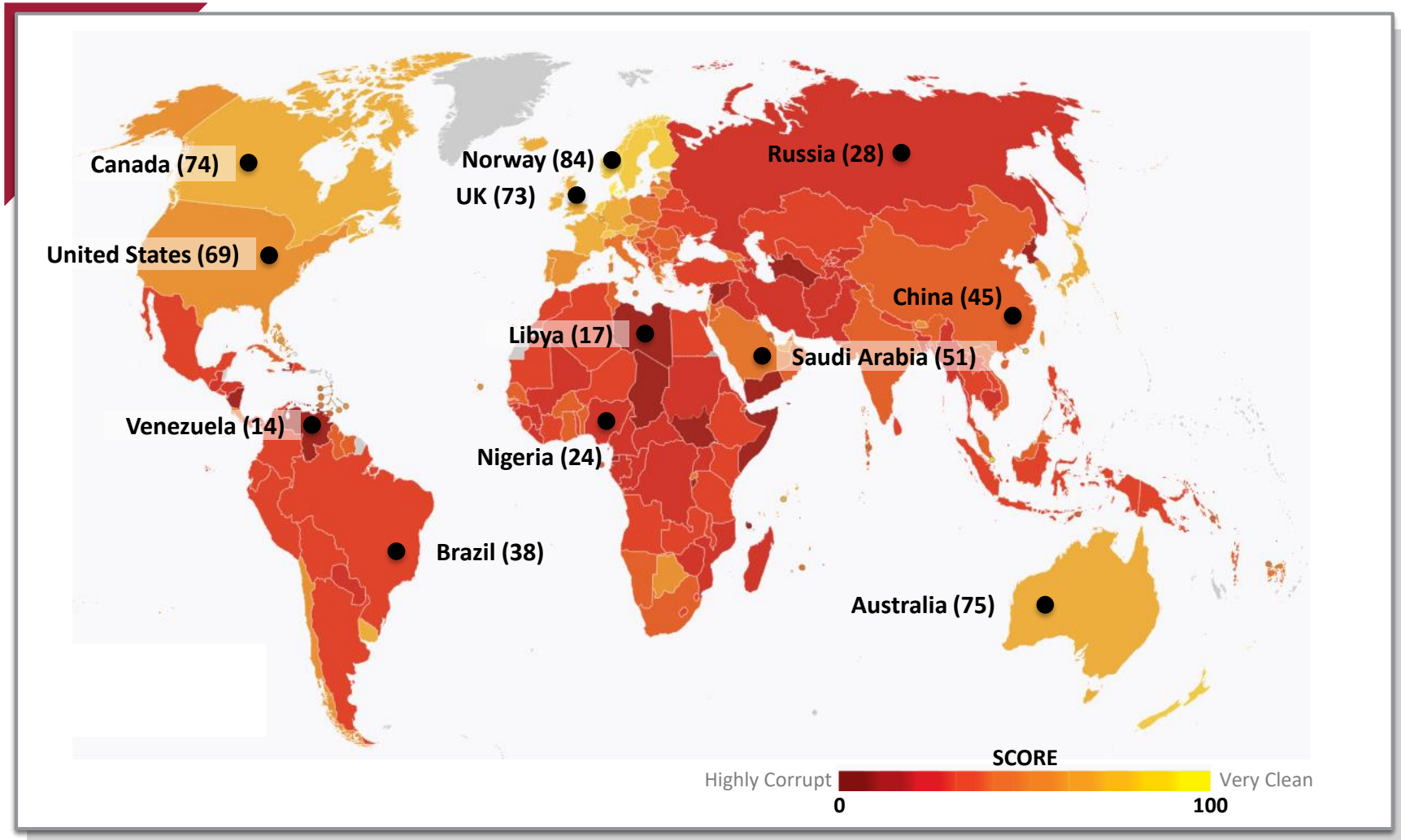


- Globally, Canada accounts for roughly 6% of oil production and 5% of gas production.
- Prices for both can be affected by just small changes in the global supply-demand balance. If Canada's production were to be taken out of the markets, it would meaningfully increase prices around the world.
- About 2.9 MMB/d of refineries (according to Enbridge and CER data) in Western Canada, the US Midwest, and Ontario completely depend on Western Canadian and US inland crude supplies. Therefore, a disruption or reduction in Canadian supply would create refined product shortages in these regions.

Source: Energy Institute Statistical Review of World Energy (2023)

*Top 5 oil producers: (1) United States, (2) Saudi Arabia, (3) Russia, (4) Canada, (5) Iraq
*Top 5 natural gas producers: (1) United States, (2) Russia, (3) Iran, (4) China, (5) Canada

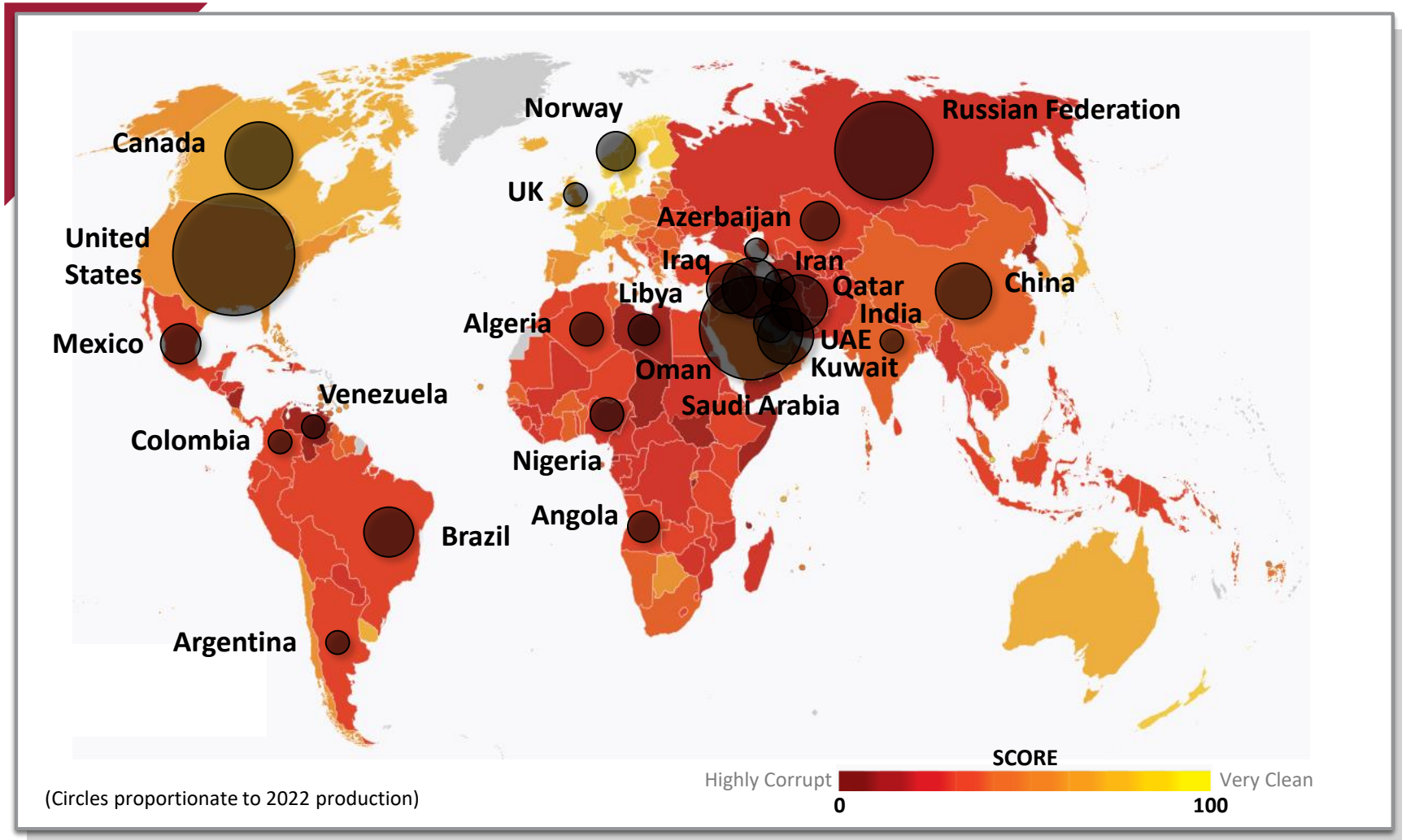
Global Map of Corruption Perceptions Index



- The Global Perceptions Index is created by Transparency International every year to rank 180 countries and territories worldwide by their perceived levels of public sector corruption.
- Canada is ranked 14th out of 180 countries with a score of 74.

Source: Transparency International (2022)

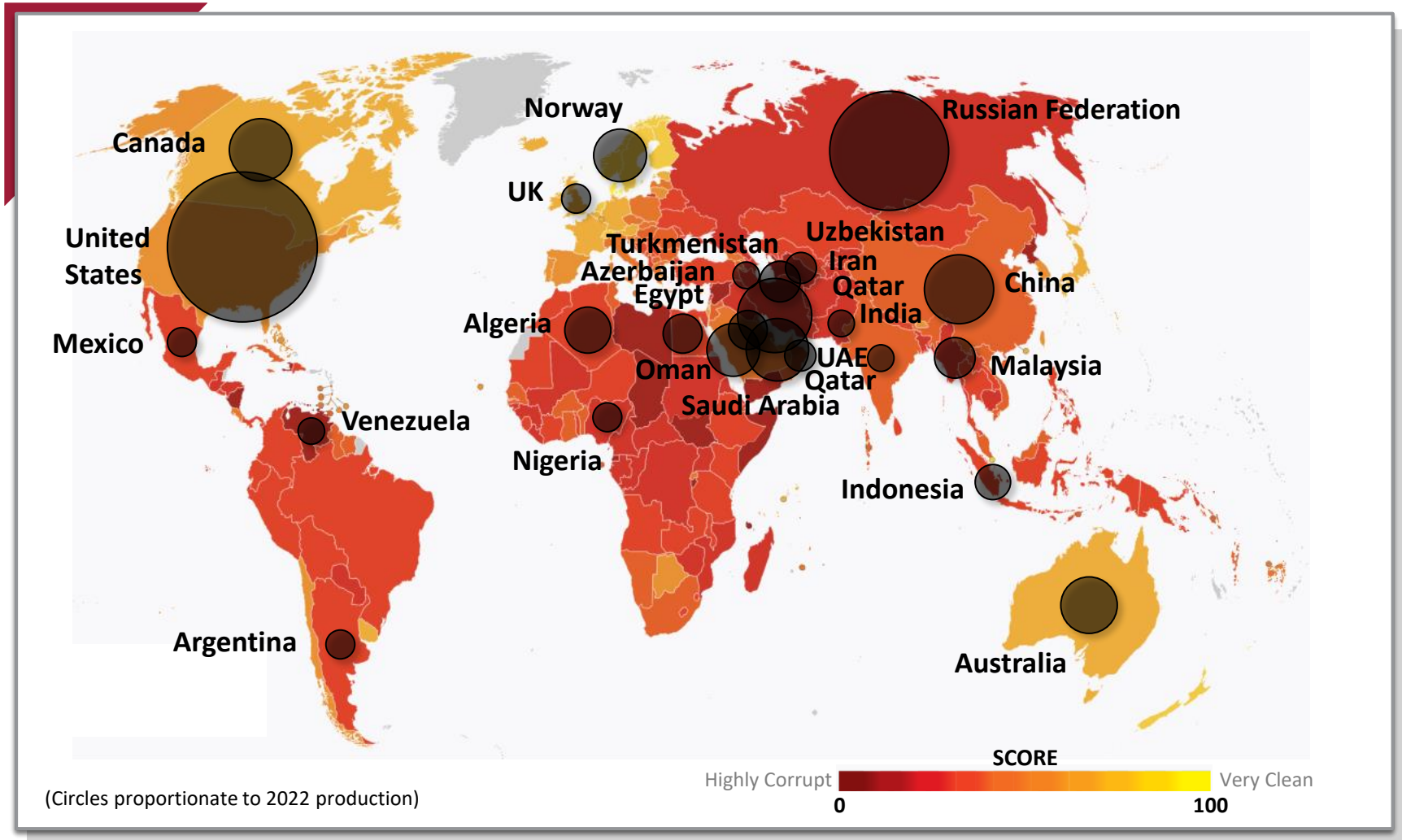
Top 25 World Oil Producers by Global Corruption Perceptions Index



- Oil producing countries with low corruption levels include just the United States, Canada, Norway, Australia, and the United Kingdom, which account for 28% of global production combined.
- The Organization of Petroleum Exporting Countries plus its allies including Russia (known as OPEC+) produce about half of the world's oil and rate lower than Canada.
- Included in the top 25 oil producers are Brazil, Russia, India, and China, who make up four of the five founding members of BRICS – a group of emerging market countries looking to counter-balance traditional Western influence.

Source: Transparency International (2022), Energy Institute Statistical Review of World Energy (2023)

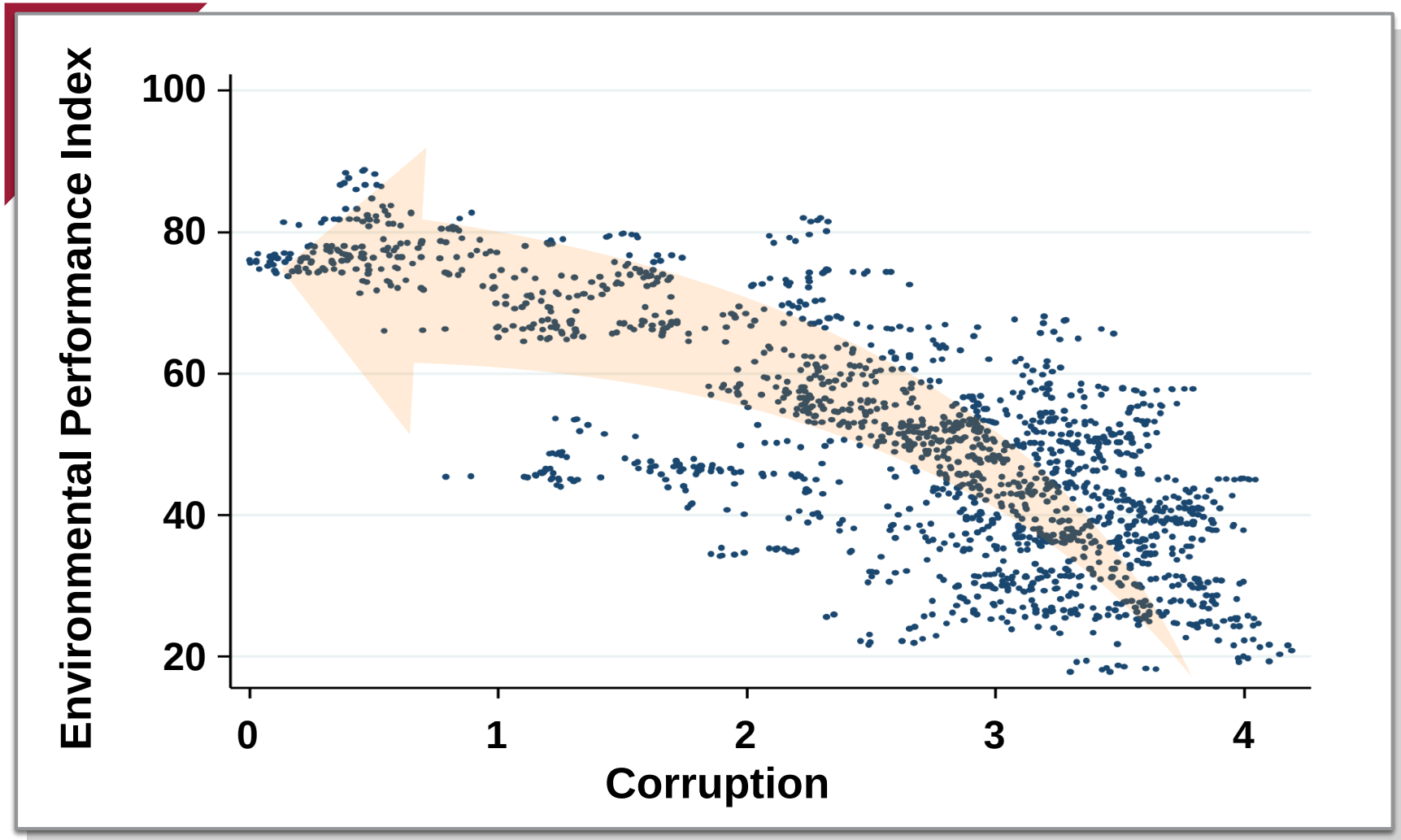
Top 25 World Natural Gas Producers by Global Corruption Perceptions Index



- The geopolitical structure of natural gas is similar to that of crude oil.
- Countries with low corruption levels account for 37% of the world's natural gas production.
- Following Russia's invasion of Ukraine, global energy trading was upended and restructured closer to global corruption rankings. While Russia diverted its gas supplies to ship east, notably to buyers in China and India, North America strengthened its economic ties to Europe by sending LNG to help offset the loss of Russian gas imports.

Source: Transparency International (2022), Energy Institute Statistical Review of World Energy (2023)

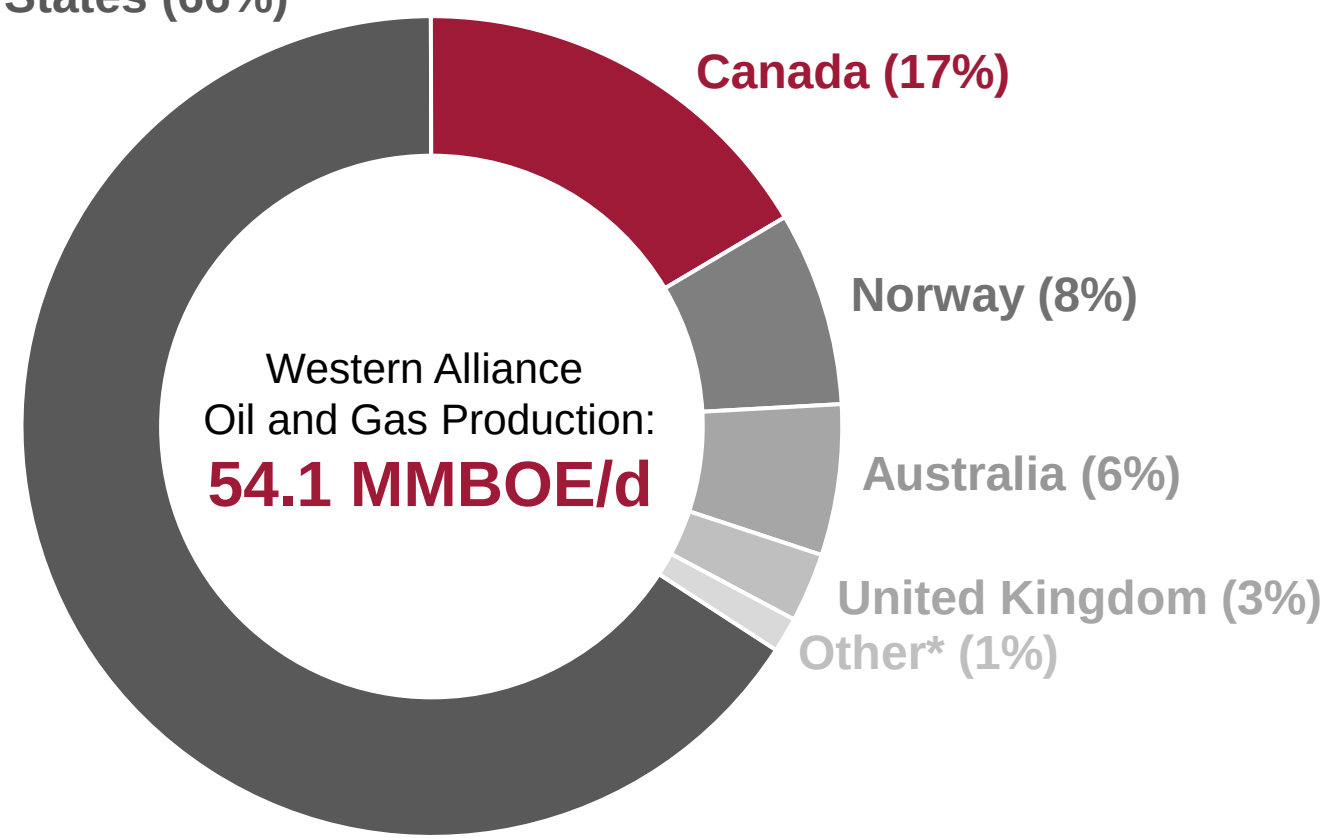
Global Correlation Between Corruption and Environmental Performance



- Several studies have found strong correlations between a country's corruption and its environmental performance. Countries with low levels of corruption generally have high levels of environmental performance.
- Canada is one of the only large global producers of oil and gas with low corruption levels. Should Canada reduce its supply of oil and gas, production may shift to a jurisdiction with higher corruption levels and a weaker corresponding environmental performance.

Source: Lisciandra, M., Migliardo, C. An Empirical Study of the Impact of Corruption on Environmental Performance: Evidence from Panel Data. *Environ Resource Econ* 68, 297–318 (2017)

Western Alliance Oil and Gas Supply by Country | 2022



Note: The Western Alliance consists of NATO countries plus Japan, South Korea, Australia, and New Zealand
*Other producers: Romania, Denmark, Italy, and the Netherlands

- Canada is the second largest oil and gas supplier of Western Alliance countries, accounting for 17% of production.
- Energy security re-emerged as a top concern for both the voting public and governments following Russia's invasion of Ukraine in February 2022.
- With rising east-west global tensions, countries are increasingly looking at their supply chains to mitigate any geopolitical risks.
- Safe and reliable oil and gas supplies will be a priority for governments for years, and Canada is a major contributor to Western energy security.

Source: Energy Institute Statistical Review of World Energy (2023)

Evolution of the Industry

CANADA'S OIL & NATURAL GAS PRODUCERS

Major Oil and Gas Producing Regions Across Canada

- There are two main producing areas in Canada, with the most prolific being Western Canada in an area that spans 4 provinces and 2 territories.
- Since the 1840s, Canadian companies have adopted and developed new technologies and processes to both extract oil and gas from the country's varied and complex deposits and to adapt to rapidly changing global environments.
- The industry now routinely develops oil and gas from deposits that were previously considered impossible to produce.

A Canadian Regarded as “Father of the Modern Petroleum Industry”

- Abraham Gesner was born and worked professionally in Nova Scotia in the 1800s where he invented kerosene oil and laid the foundations for refining and the modern oil and gas industry.
- In the 1840s, he first demonstrated how “coal oil” could be distilled from solid hydrocarbons into something he later named “kerosene”.
- Kerosene went on to become the standard lighting fuel in homes in North America.
- The processes he outlined helped launch the modern petrochemical industry and its wide array of products known and used today.

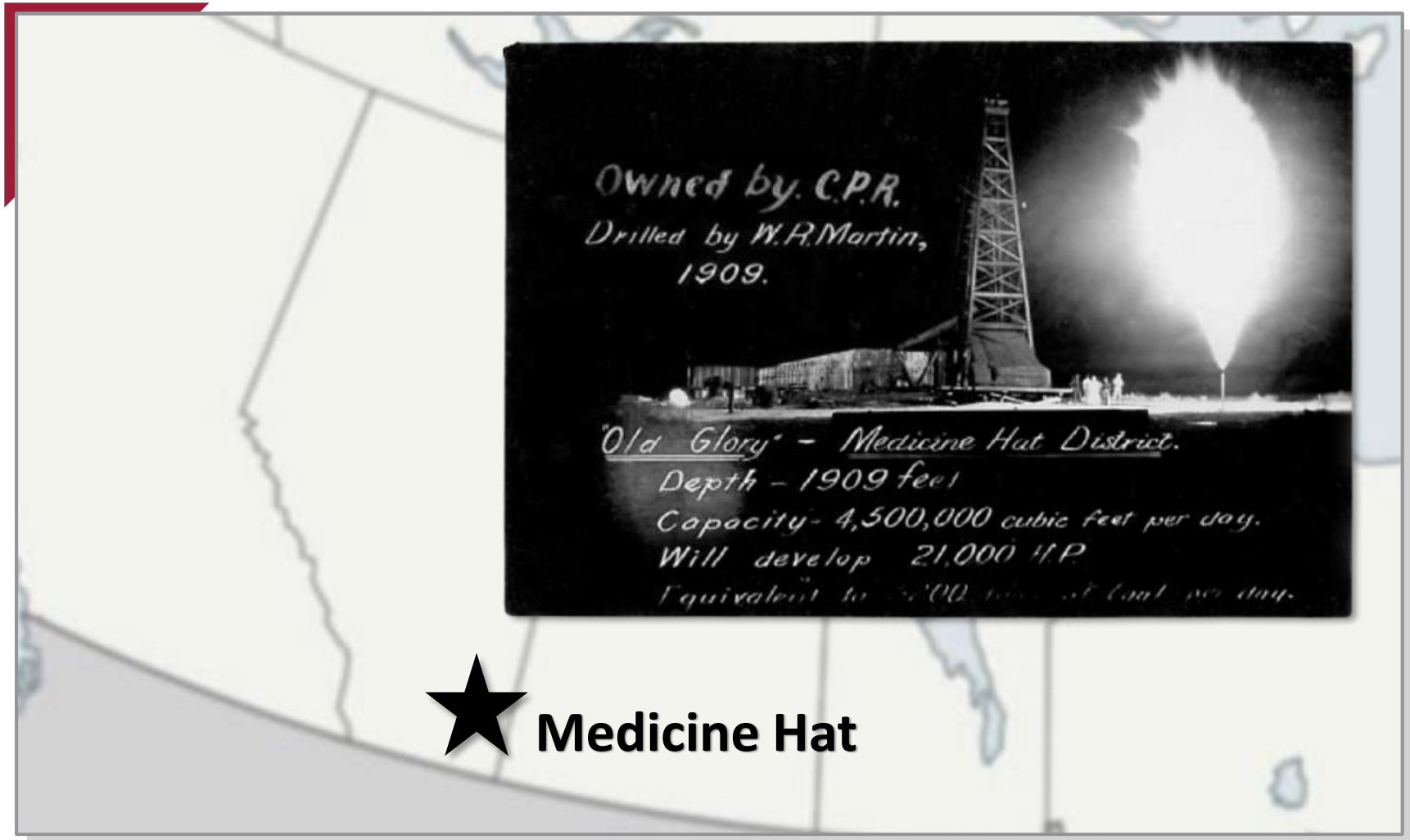
Source: From the collection of Peter Tertzakian

Oil Springs and Petrolia | The First North American Oil Boom

- In the 1860s and early 1870s, oil was discovered in several towns in Ontario, notably Oil Springs and Petrolia.
- The discoveries were the first in North America, leading to the first oil boom on the continent.
- The two towns are located near the US-Canada border, prompting a similar oil boom in the United States.
- For a brief time, Ontario was the epicenter of the Canadian oil and gas industry, a title it would relinquish following impressive discoveries out west.

Source: From the collection of Peter Tertzakian

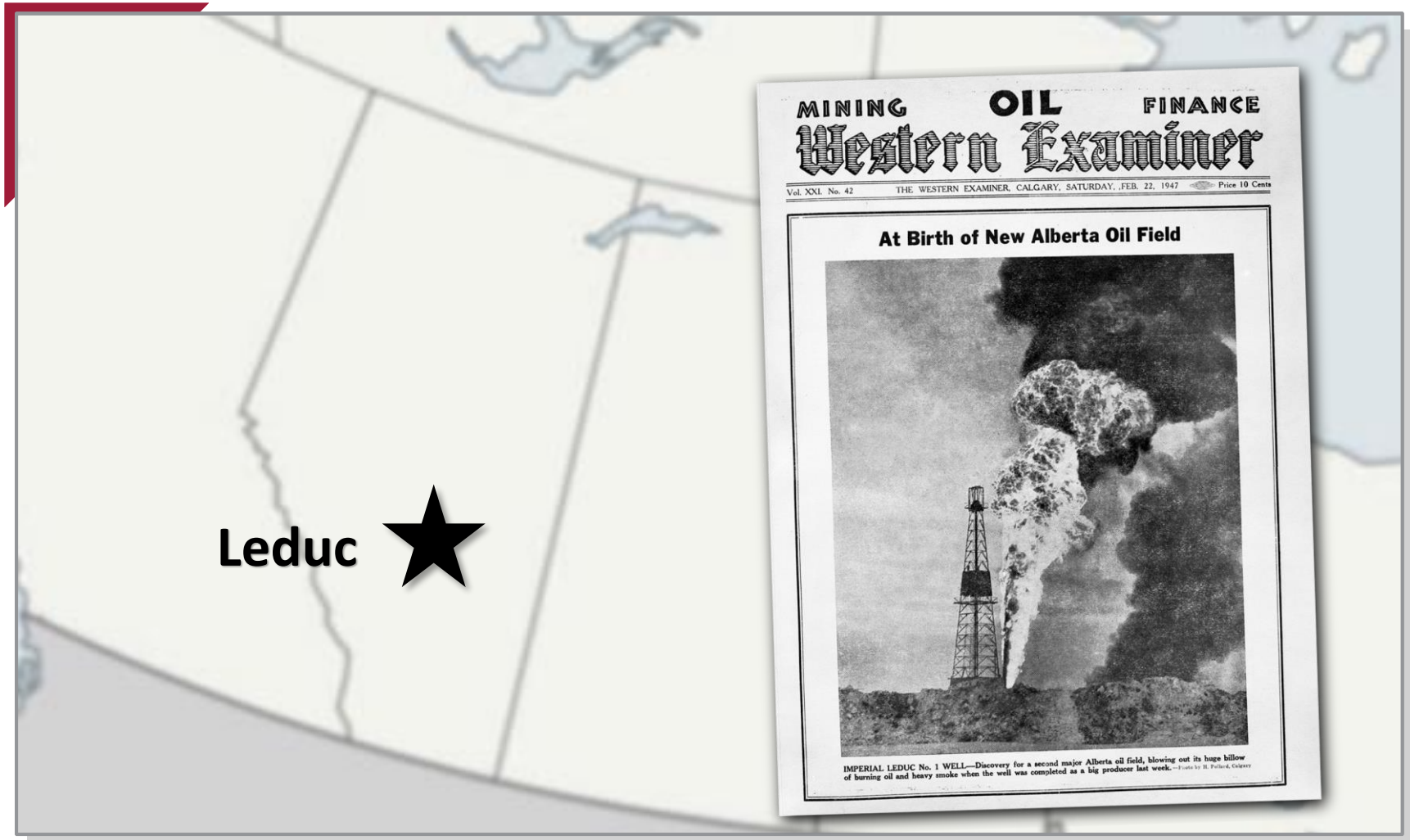
Old Glory | The First Major Discovery in Western Canada



- Following accidental natural gas discoveries by railroad workers near Medicine Hat looking for water, prospectors began drilling.
- In 1909, W. R. Martin drilled a well 1909 feet deep discovering the Bow Island gas field.
- The well was dubbed “Old Glory” and produced natural gas at a daily rate of 4.5 million cubic feet of gas, the largest at the time in Canada and similar to volumes from modern gas wells.
- The discovery also led to the first major pipeline, that carried gas from Medicine Hat to Calgary.

Source: From the collection of Peter Tertzakian

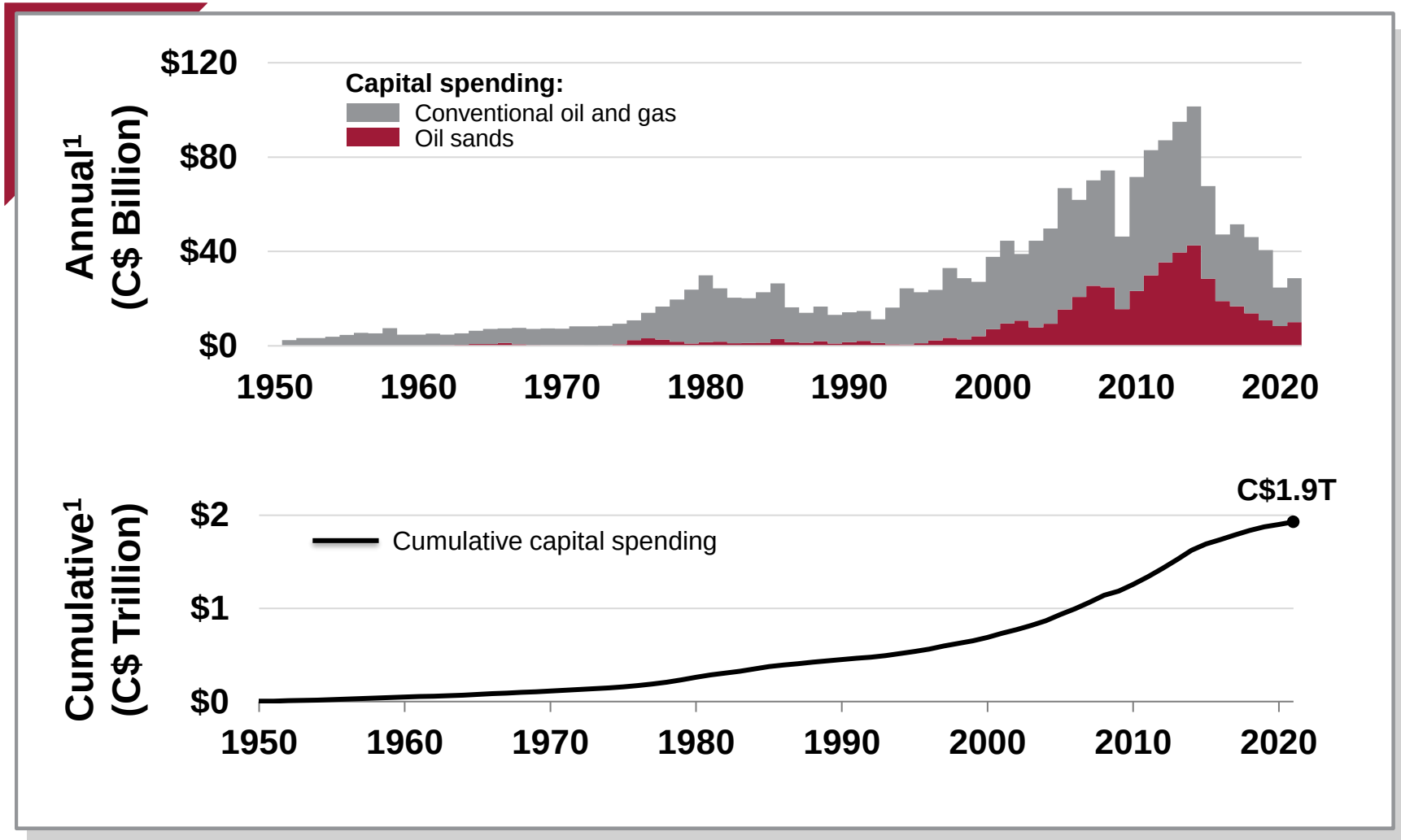
Leduc #1 | The Well That Changed the Course of Alberta's History



- The Leduc #1 well drilled in 1947 struck a huge pool of oil, sending a geyser past the height of the derrick, signaling a significant discovery.
- The find came after more than 100 exploration wells had been drilled by the company, initially finding only small traces of oil and gas.
- The Leduc discovery led to a boom in Alberta. At the time of the discovery, Canada as a whole produced just 21,000 barrels per day of oil. Less than a decade later, that had jumped to 400,000 barrels per day.
- Leduc #1 produced actively for nearly three decades.

Source: Western Examiner

Capital Spending in the Canadian Oil and Gas Industry Reflects Long History

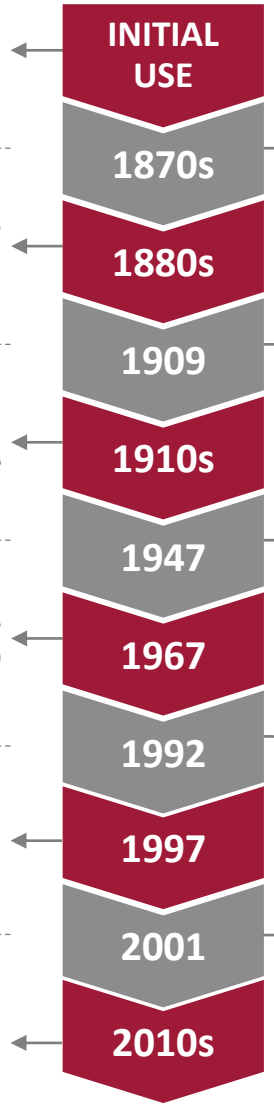


- The Canadian oil and gas industry has grown significantly since the Leduc #1 discovery in the late 1940s.
- Since 1950, nearly $2 trillion of capital has been invested (inflation-adjusted, 2023$) in the upstream industry.
- Conventional oil and gas accounts for approximately $1.5 trillion of that total spending, with the oil sands amounting to another ~$475 billion.
- Seven decades of significant capital spending has built extensive energy infrastructure across Western Canada that supports the industry.

Source: CAPP, Bank of Canada

(1) Capital spending and cumulative spending values are in 2023$; in Chapter 4, figures are not adjusted for inflation

Timeline of Major Events in Canada's Oil and Gas Industry



Indigenous Peoples have known about Alberta's large oil deposits since well before the arrival of Europeans, using the bitumen near the Athabasca River to caulk canoes and for other uses.

FIRST WESTERN GAS DISCOVERY
Canadian Pacific Railway accidentally discovered natural gas near Medicine Hat, Alberta drilling for water. Subsequent wells were then drilled specifically to produce natural gas to use as a fuel.

TURNER VALLEY
The discovery of wet gas in the Turney Valley region with the Dingman #1 well led to the field playing an important role in both world wars. At one point, the Turner Valley field was Canada's largest oil-producing region.

THE GREAT CANADIAN OIL SANDS
The first large-scale oil sands surface mine and upgrader begins operations using bucket wheel excavators. The project was initially designed for 15,000 barrels per day but took five years to operate at capacity.

HIBERNIA
The first offshore oil platform in Newfoundland and Labrador came online, marking a major milestone for Canada's oil and gas industry.

HORIZONTAL DRILLING AND HYDRAULIC FRACTURING
New methods that stimulate conventional reservoirs to enhance production in formations that were previously uneconomic.

OIL SPRINGS / PETROLIA
A carriage maker named James Miller Williams dug North America's first commercial oil well in Ontario near the US-Canada border leading to the continent's first oil boom.

OLD GLORY
The first major discovery in Alberta's oil and gas industry was the Bow Island gas field to the southwest of Medicine Hat and its first well was dubbed Old Glory.

LEDUC #1
Imperial Oil strikes oil in the Leduc Formation, producing more than 1,000 barrels per day and kickstarting an oil boom in Western Canada.

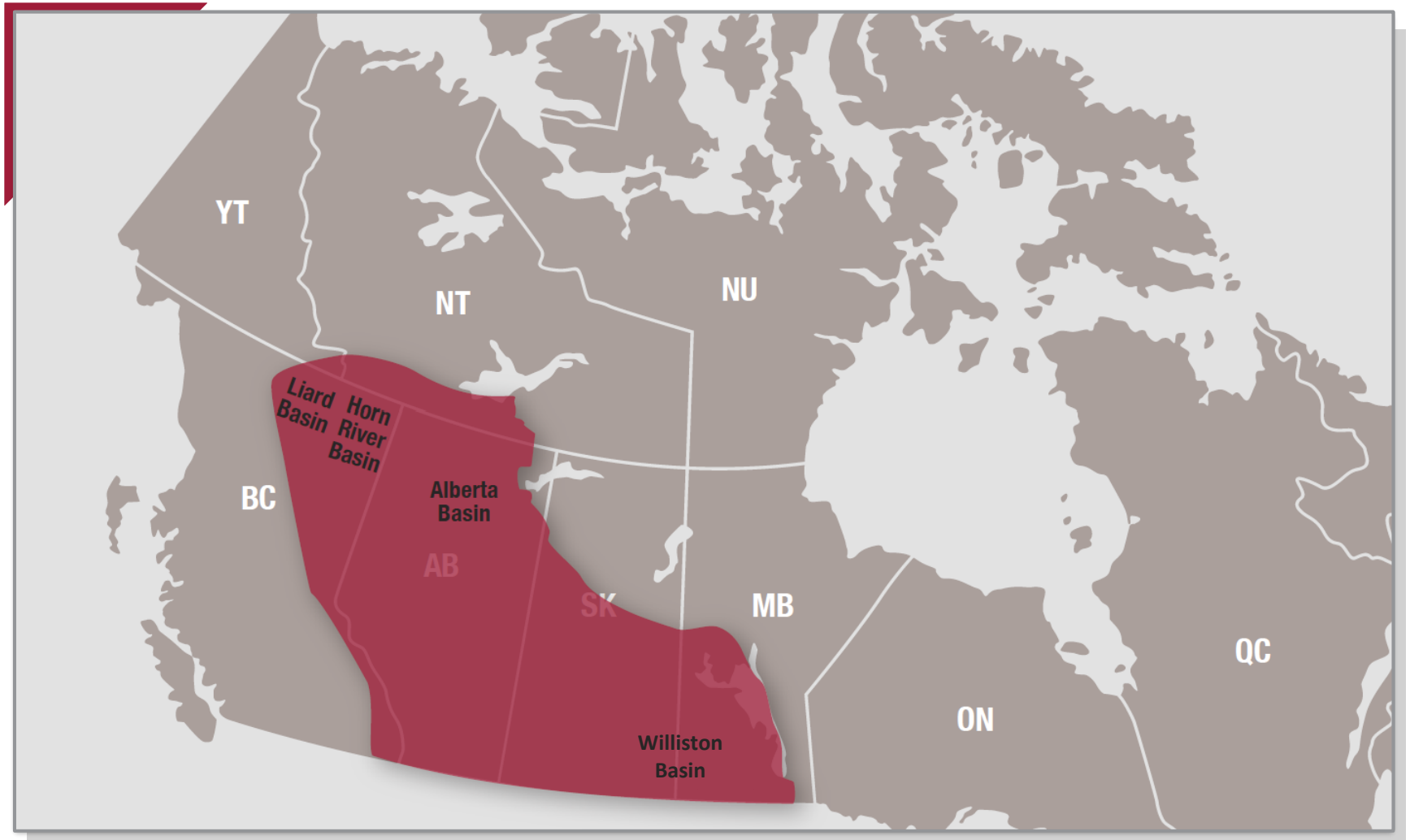
COHASSET-PANUKE
Canada's first offshore oil platform in Nova Scotia. The project produced 44.5 MMB from 1992 to 1997.

FOSTER CREEK
Cenovus Energy began operations at the province's first large-scale commercial SAGD facility at Foster Creek which is still in operation today.

Geology of the Western Canadian Sedimentary Basin

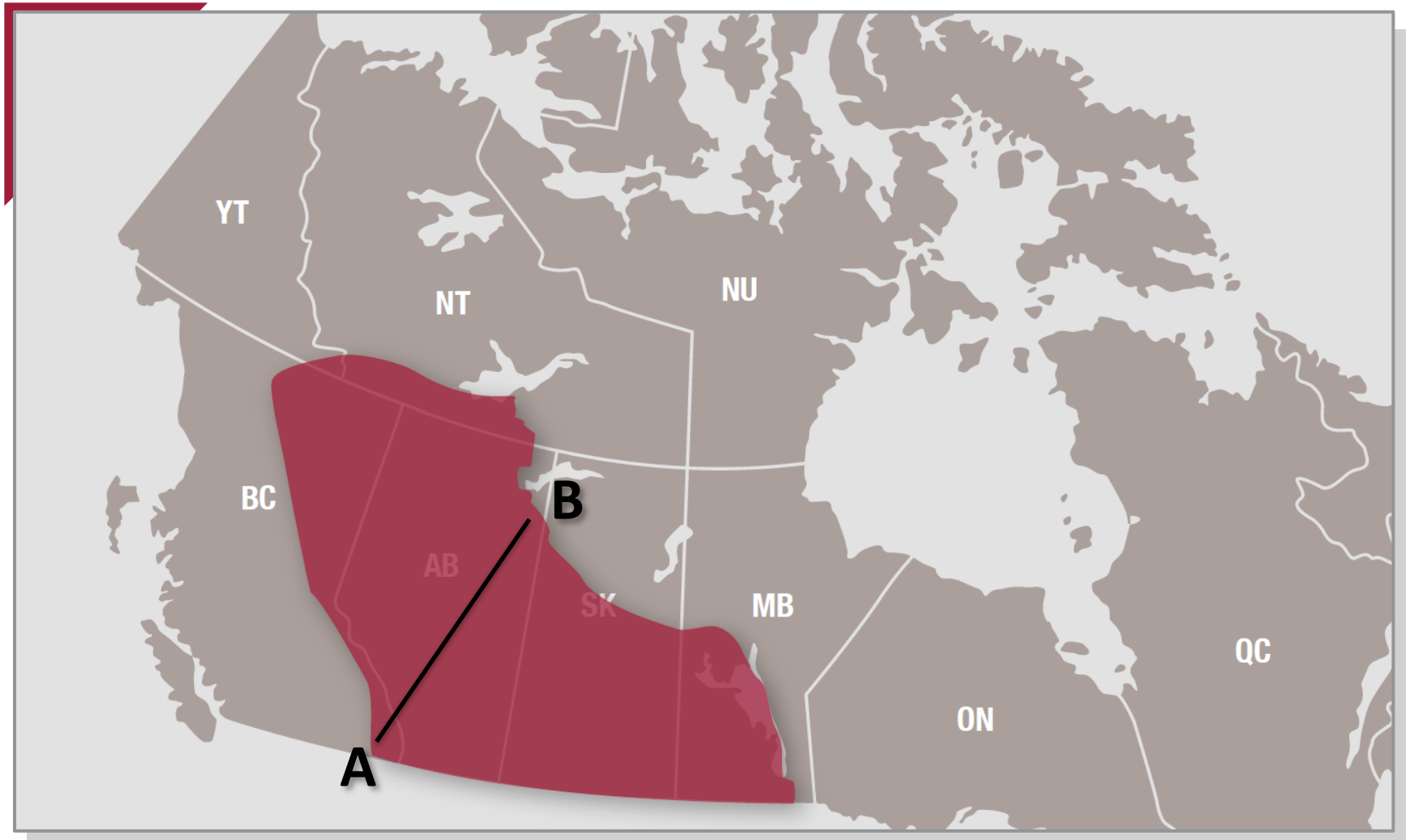
CANADA'S OIL & NATURAL GAS PRODUCERS

Key Elements Within the Western Canadian Sedimentary Basin



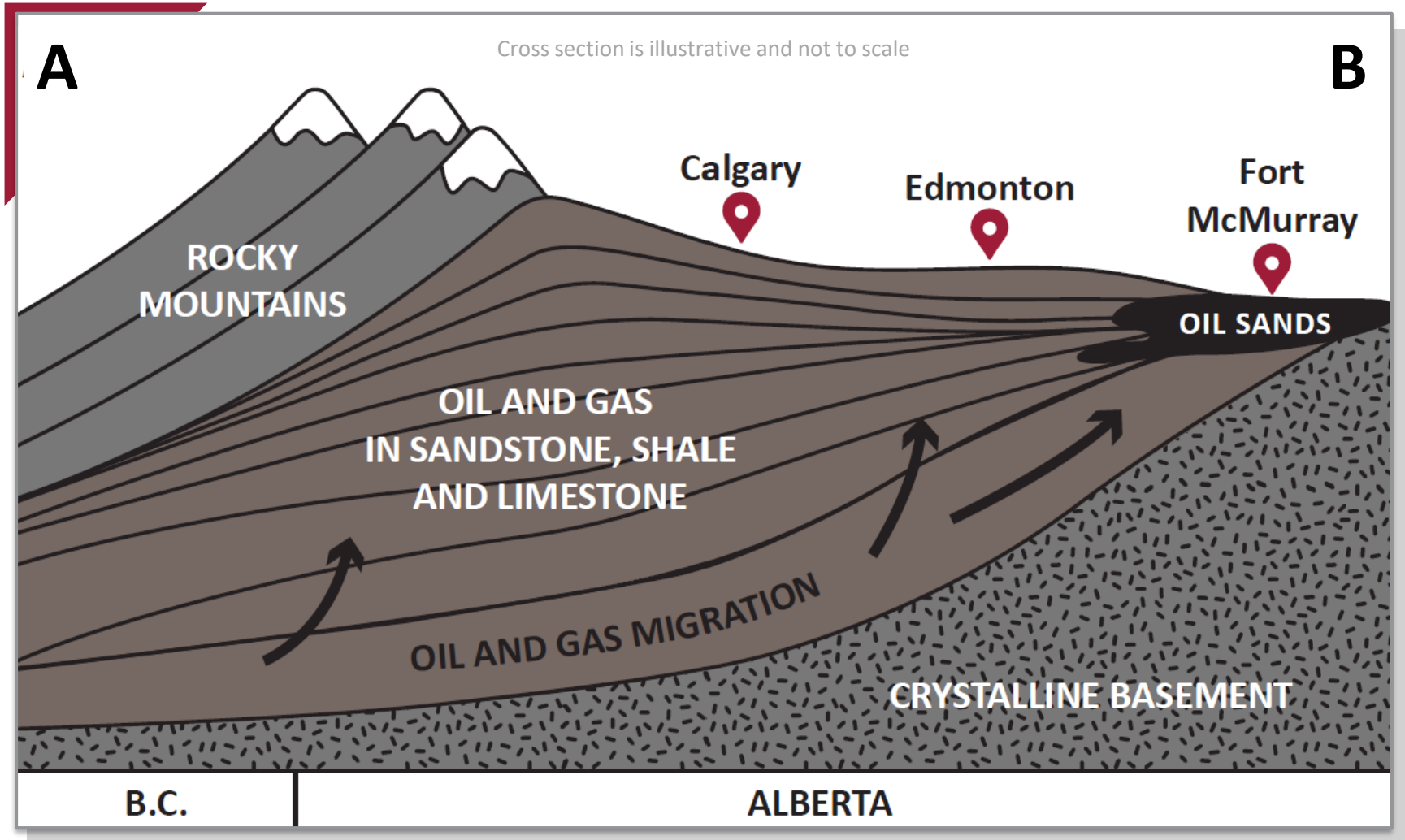
- The Western Canadian Sedimentary Basin (WCSB) is a wedge of sedimentary layers stretching from southern Manitoba and stretching up to the southeastern tip of Yukon.
- The wedge of the WCSB gets thicker towards the southwest while thinning to the northeast and eventually pinching out in the east.
- The two most productive basins within the WCSB for oil and gas are the Alberta Basin and Williston Basin.
- The varied geologic history and complex tectonics of the WCSB have led to a wide range of oil and gas deposits and play types.

Outline of Cross Section Across the Western Canadian Sedimentary Basin



- A cross section across the WCSB (following page) will highlight the wedge of sediments that make up the basin.
- The cross section runs from southeastern British Columbia to just north of Fort McMurray where the oil sands are located.

Illustrative Cross Section Across Western Canadian Sedimentary Basin

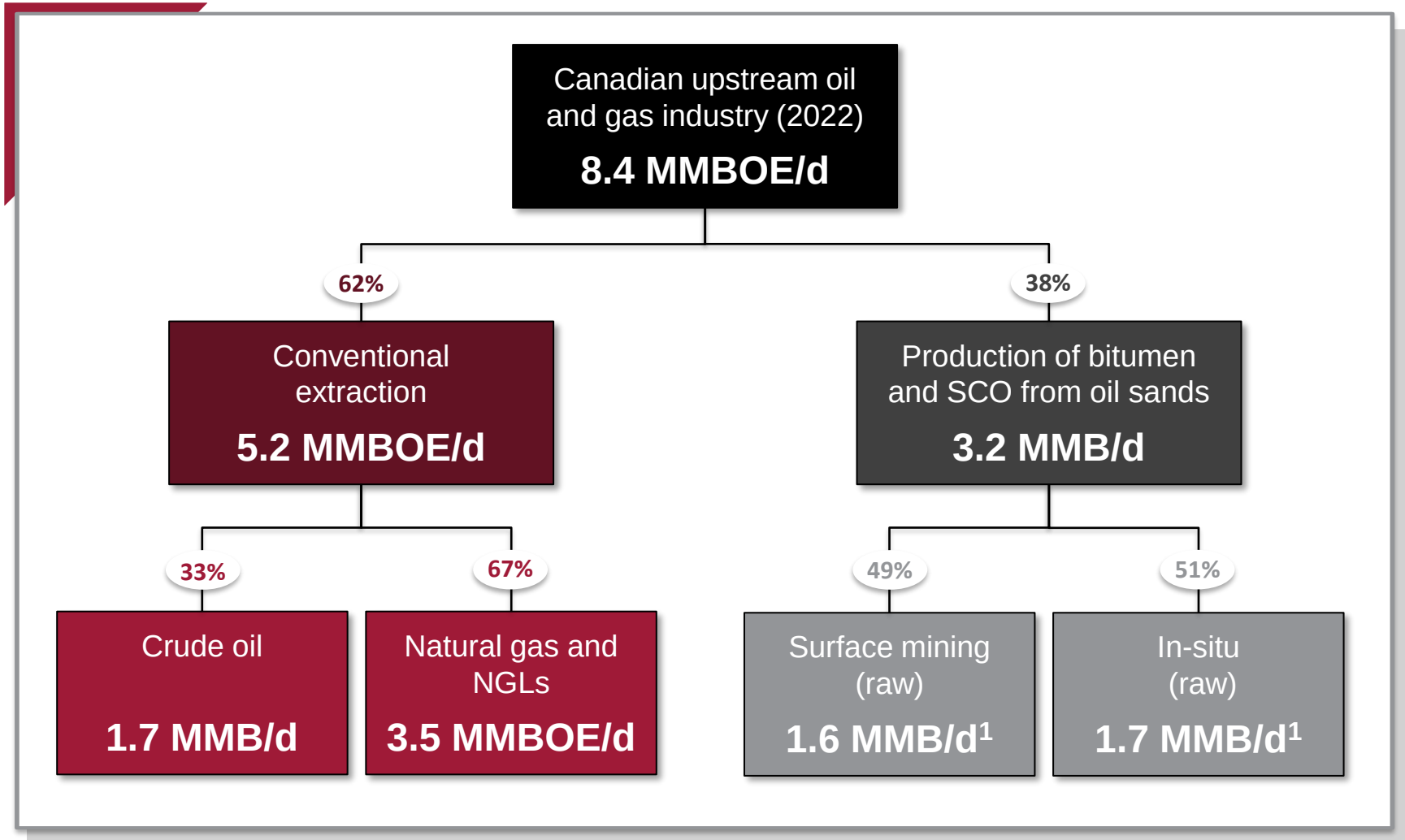


- Laying on top of a crystalline basement are individual layers of sedimentary rocks deposited over hundreds of millions of years known collectively as the Western Canadian Sedimentary Basin (WCSB).
- The tectonic forces that shaped the Rocky Mountains played a hand in burying the organic materials that were transformed into oil and gas that migrated across the basin to charge reservoirs.
- There are oil and gas reservoirs found across the basin. These include the bitumen deposits of the oil sands near Fort McMurray, light-to-heavy oils, condensates, and natural gas.

Industry Structure

CANADA'S OIL & NATURAL GAS PRODUCERS

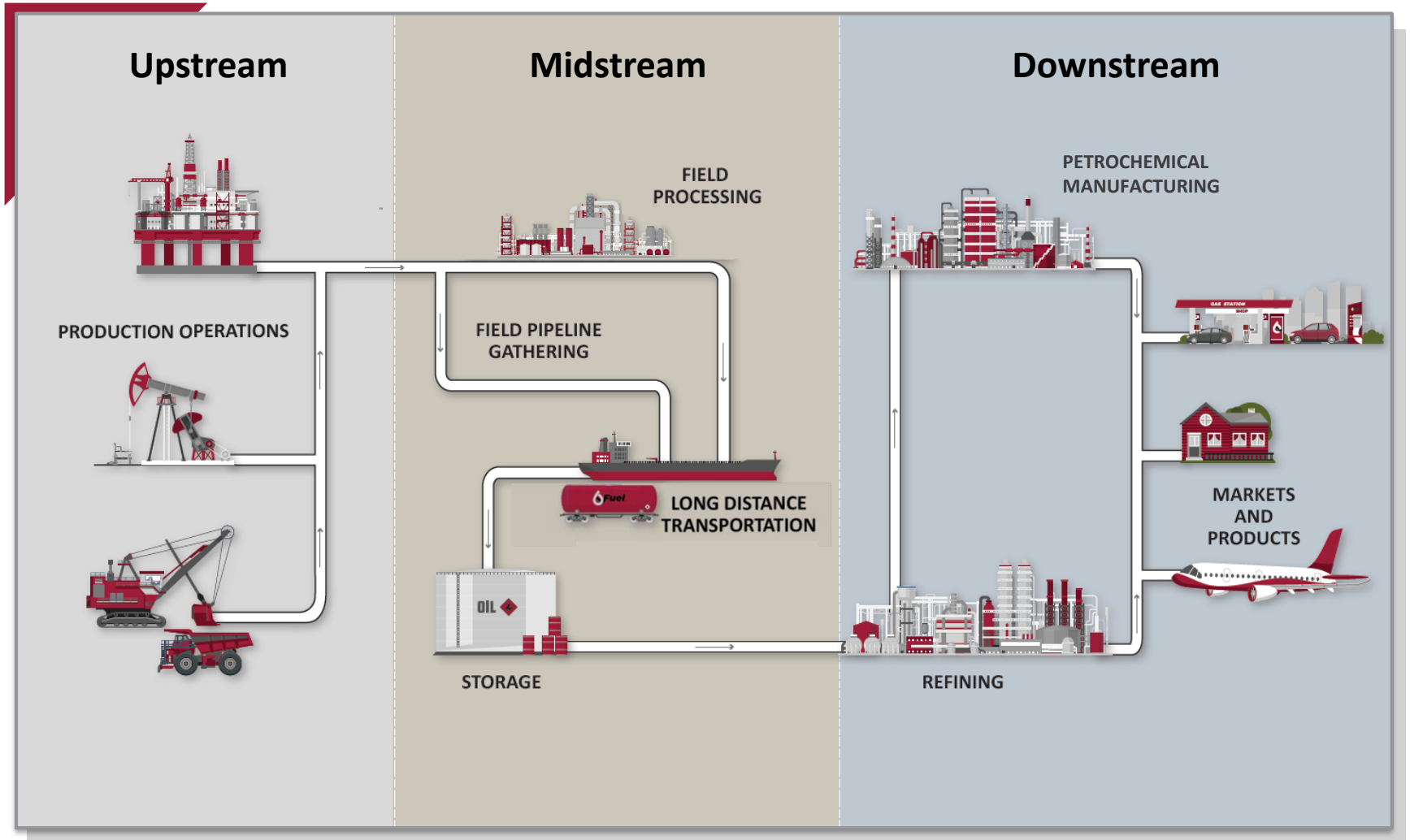
Taxonomy of Canadian Oil and Gas | 2022



- The Canadian oil and gas industry is unique in that, on top of conventional oil and gas, much of the country's production comes from the oil sands.
- The oil sands account for roughly one-third of the country's production on a BOE basis, with almost equal production coming from surface mining and in-situ processes.
- Conventional has changed significantly over the years, adopting new technologies and production methods to compete globally. Today, it accounts for almost two-thirds of the country's production.

Source: Canada Energy Regulator (CER), Alberta Energy Regulator (AER) (1) These are raw volumes and don't add to up to the upgraded volumes above

What is Upstream, Midstream and Downstream?



- The oil and gas industry can be divided into upstream, midstream, and downstream industries.
- **Upstream:** Bringing oil and gas to the surface through exploration, drilling, and production.
- **Midstream:** Transporting, processing and storing of raw hydrocarbons from production facilities to refineries and distribution points.
- **Downstream:** Refining hydrocarbons into their final products like gasoline, diesel, and petrochemicals, then distributing to final customers.

Timeline of Major Innovations in Conventional Oil and Gas

1860s – **Cable drilling tools** – The first modern oil well used a cable-tool drilling rig that repeatedly dropped to break the downhole rock apart

1880s – **Oil tankers** – Introduced by Ludvig Nobel, tankers enabled the transportation of oil across great bodies of water

1880s – **Rotary drilling rig** – A system to rotate drill bits while drilling using hollow pipe allowed fluid to flush out broken rock, making drilling much more efficient

1900s – **Roller-cone drill bit** – A drill bit designed to crush rock efficiently while minimizing the wear and tear on the surface of the tool

1920s – **Electrical logging** – Physical properties of rocks are measured electronically downhole helping subsurface experts to both make discoveries and better estimate reservoir potential

1930s – **Directional drilling** – Drillers developed tools to control the physical reach of a well, allowing companies to tap difficult-to-access reservoirs

Early drilling rig from Waterton, Alberta. (1914)

Modern drilling rig (2020s)

1950s – **Seismic exploration** – Geophysicists started regularly interpreting acoustic waves reflected off subsurface geologic layers to better estimate the shape and properties of reservoirs

1990s – **3D seismic models** – Computers allowed companies to build digital simulations of the subsurface to improve reservoir characterization, production management, and drilling

1990s – **Liquefied natural gas** – The first large-scale liquefied natural gas (LNG) facility opened in Qatar in 1997 enabling the economic transportation of natural gas across water

2000s – **Hydraulic fracturing** – By pumping water, sand, and treatment chemicals into a target reservoir, rocks could be fractured open to improve well performance and recovery efficiencies

2000s – **Pad drilling** – Modern onshore pad drilling allowed multiple wells to be drilled, completed, and produced from the same location or "pad", improving operating efficiencies and minimizing land use

2000s – **Shale Era** – The ability to complete a hydraulic fracture at multiple points along a horizontal wellbore led to the shale gas boom and access to new oil and gas reservoirs

Source: From the Collection of Peter Tertzakian, Wikimedia Commons

Conventional Oil and Gas Era|Pre-2010s, Vertical Wells

Photo credit: From the collection of Peter Tertzakian

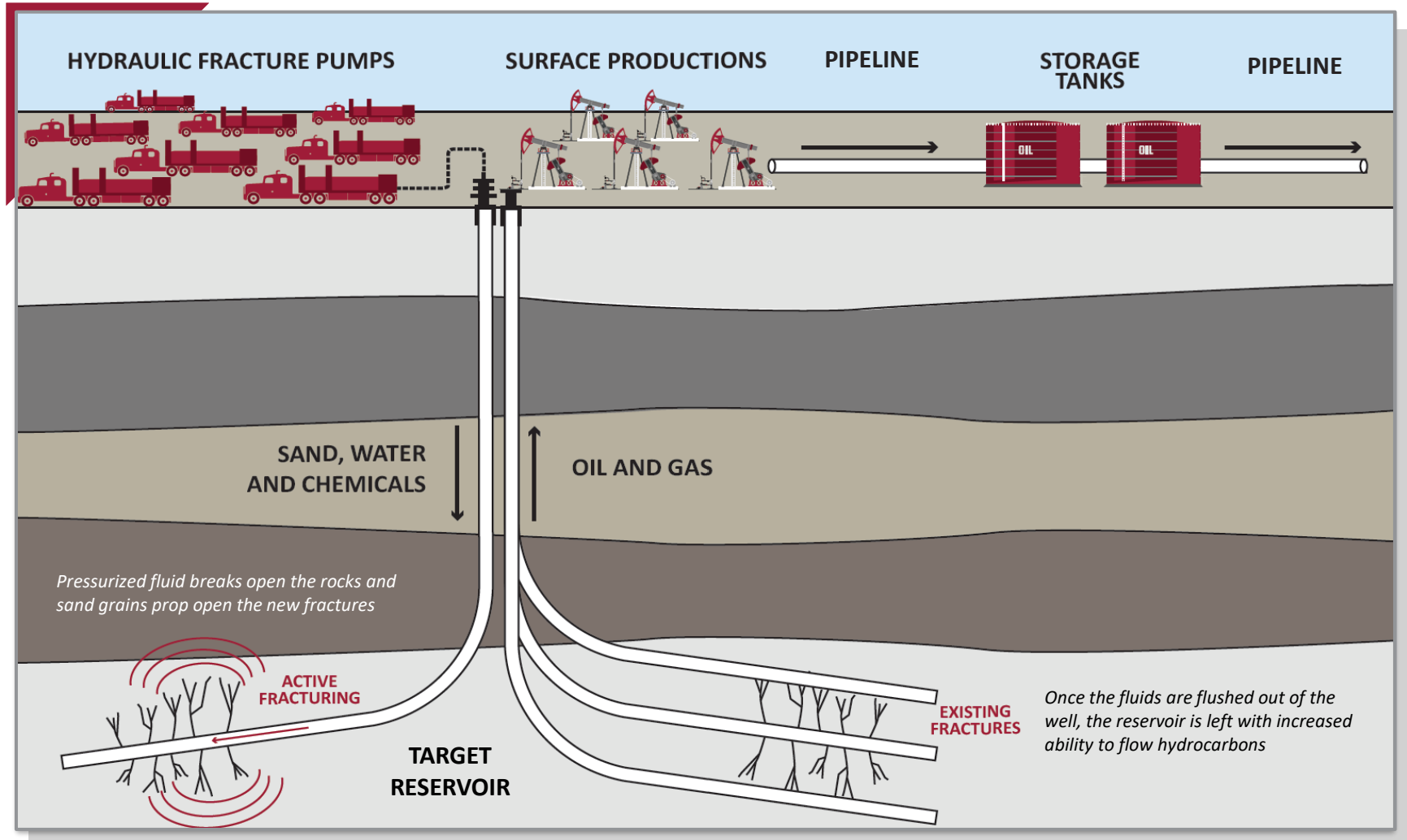
- For much of the modern history of oil and gas, reservoirs were developed using single vertical wells with individual production units.
- Geologists, geophysicists, and engineers would identify “sweet spots” in reservoirs and hope to drill through them with a vertically penetrating well.
- Wells that produced economic volumes of oil would be placed on production, often using technology, such as pump jacks, to help pull the hydrocarbons to the surface.
- Vertical wells were limited to accessing just a few meters of reservoir surrounding the well.

Shale Era: Post-2010 | Horizontal Drilling and Hydraulic Fracturing

Photo credit: From the collection of Peter Tertzakian

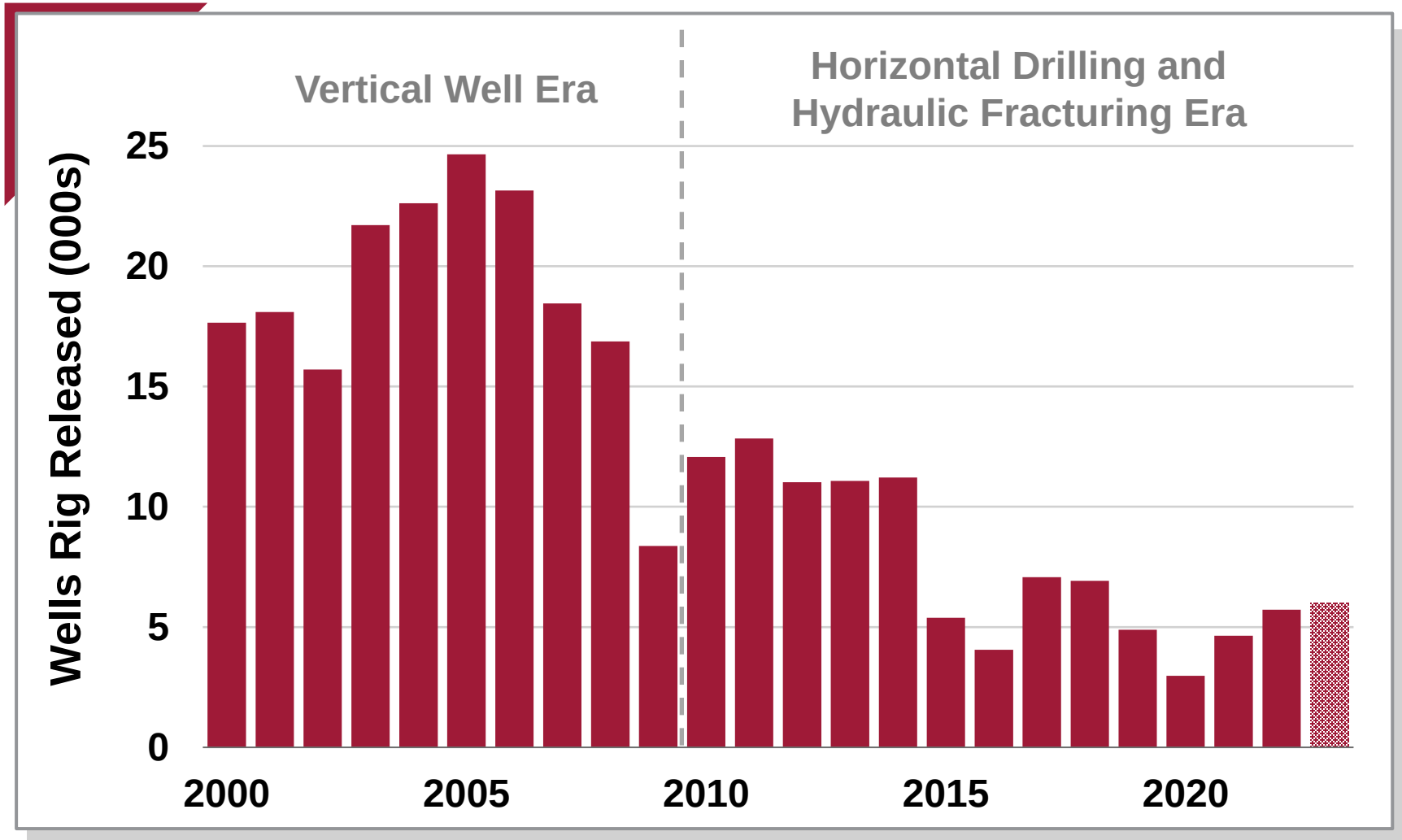
- Starting about 2010, innovators recognized that if wells could be directionally drilled inside a reservoir horizontally, they could access many times more reserves than vertical wells for incremental additional capital costs.
- Engineers also learned how to stimulate the rocks along the horizontal wellbore, known as multistage hydraulic fracturing, resulting in more productive wells and opening up new plays across North America.
- Horizontal drilling and hydraulic fracturing used at scale by employing pad drilling led to the shale boom and kickstarted a new era in oil and gas.

Conventional Oil Development | Horizontal Drilling and Hydraulic Fracturing



- With the discovery of multistage horizontal drilling paired with hydraulic fracturing, the technology is now considered conventional for oil and gas.
- The process starts with a drilling rig, typically drilling several horizontal wells into a target reservoir from a single pad.
- Pumping trucks then move onto the pad, pumping sand, water, and chemicals into the target reservoir, creating small fractures to enhance the reservoir's productivity.
- Once completed, the wells are produced, allowing oil and gas to flow to the surface where it's collected and transported.

WCSB Oil and Gas Industry Activity | Wells Drilled | 2000 to 2023e



- The transition from vertical wells (pre-2010s) to horizontal drilling and fracturing drastically reduced the total number of wells, but now each well is longer, more complex, takes longer to drill, and costs more.
- In 2005, shallow gas drilling and high natural gas prices led to a record ~25,000 wells and ~30 million meters drilled.
- In 2022, 5,723 wells were drilled with 18 million meters drilled. That equates to wells being about 2.6X longer today than in 2005.

Source: Daily Oil Bulletin, CAPP. Note: Western Canadian Sedimentary Basin (WCSB) includes BC, Alberta, Saskatchewan and Manitoba.

Timeline of Major Innovations in Oil Sands

Early mining process using bucketwheel to scoop & move oil sands ore **(Est. 1960s)**

Truck-and-shovel mining adopted later **(Est. 1990s)**

1920s

Oil-water separation

Dr. Karl Clark first used hot water and mixing to help separate the bitumen from the oil sands

1967

First commercial oil sands mine

The first large-scale oil sands mine and upgrader begins operations, known initially as the Great Canadian Oil Sands

1970s

Cyclic steam simulation (CSS)

Imperial Oil started a production pilot in the Cold Lake region in 1975 at Cold Lake Leming which was later commercialized

1980s

Cold Heavy Oil Production with Sand (CHOPS)

Wells drilled into unconsolidated oil sand reservoirs produce both sand and heavy oil. By maintaining the sand influx into a well, oil can be produced economically

1987

Underground Test Facility

The Alberta government opened a test facility where SAGD technologies were tested and optimized for commercialization

2000s

Hydrotransport

To reduce hot water usage for separating the bitumen from sand in mining operations, long pipelines were used instead

2010s

Paraffinic Froth Treatment

This innovation allowed oil sands mines to avoid upgrading the bitumen and instead produce dilbit that could be transported

2001

First commercial SAGD project

Cenovus Energy's Foster Creek project began operations using steam assisted gravity drainage at commercial scale for the first time

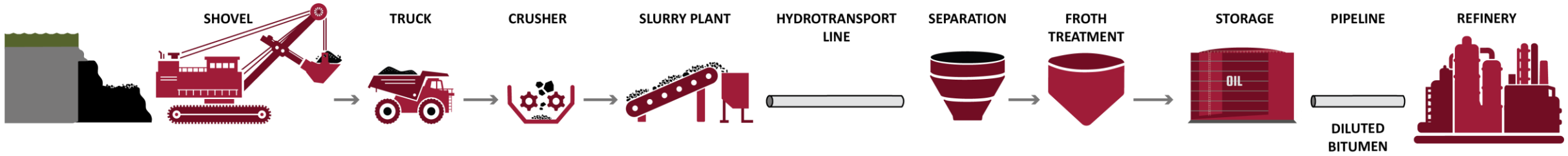
2020s

Solvents

Modern solvents are looking to significantly reduce the use of heat from natural gas for in-situ bitumen development

Source: Oil Sands Magazine with modifications

Oil Sands Development and Production | Mining to Dilbit



Mining

- First, large shovels scoop the oil sands ore into the beds of large haul trucks.
- The trucks then move the mined material from the mine face to the crusher.

Ore Preparation

- Mined oil sands ore is sent through a processing plant which first loosely crushes the material, and then mixes in warm water to create a slurry.
- The slurry is then sent down a hydrotransport line which provides the ore additional residence time to help separate the bitumen from the sand.

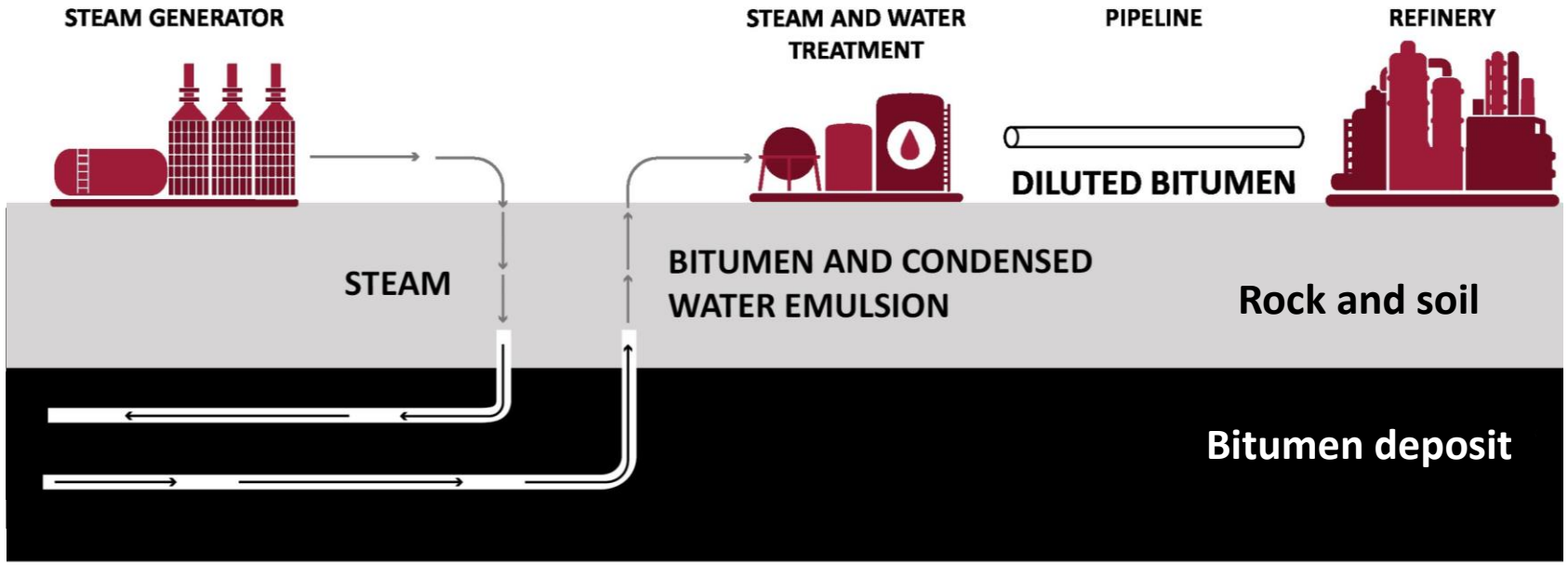
Bitumen Extraction

- A water-based gravity method is then used to separate the bitumen from the sand. Bitumen attaches to air bubbles that rise to the top of the vessel, creating a froth.
- An additional froth treatment step helps remove remaining water and impurities.

Upgrading / Refining

- Depending on the process of extracting bitumen, an additional upgrading step may be required to transform bitumen into a product that can be transported to downstream refineries.
- With the innovation of paraffinic froth treatment, new mining projects can now produce diluted bitumen and do not upgrade.

Oil Sands Development and Production | In-situ to Dilbit



Steaming

- Bitumen underground is too thick to flow to the surface. To produce it and reduce the viscosity, the bitumen is heated by injecting steam into the reservoir through an injection well.

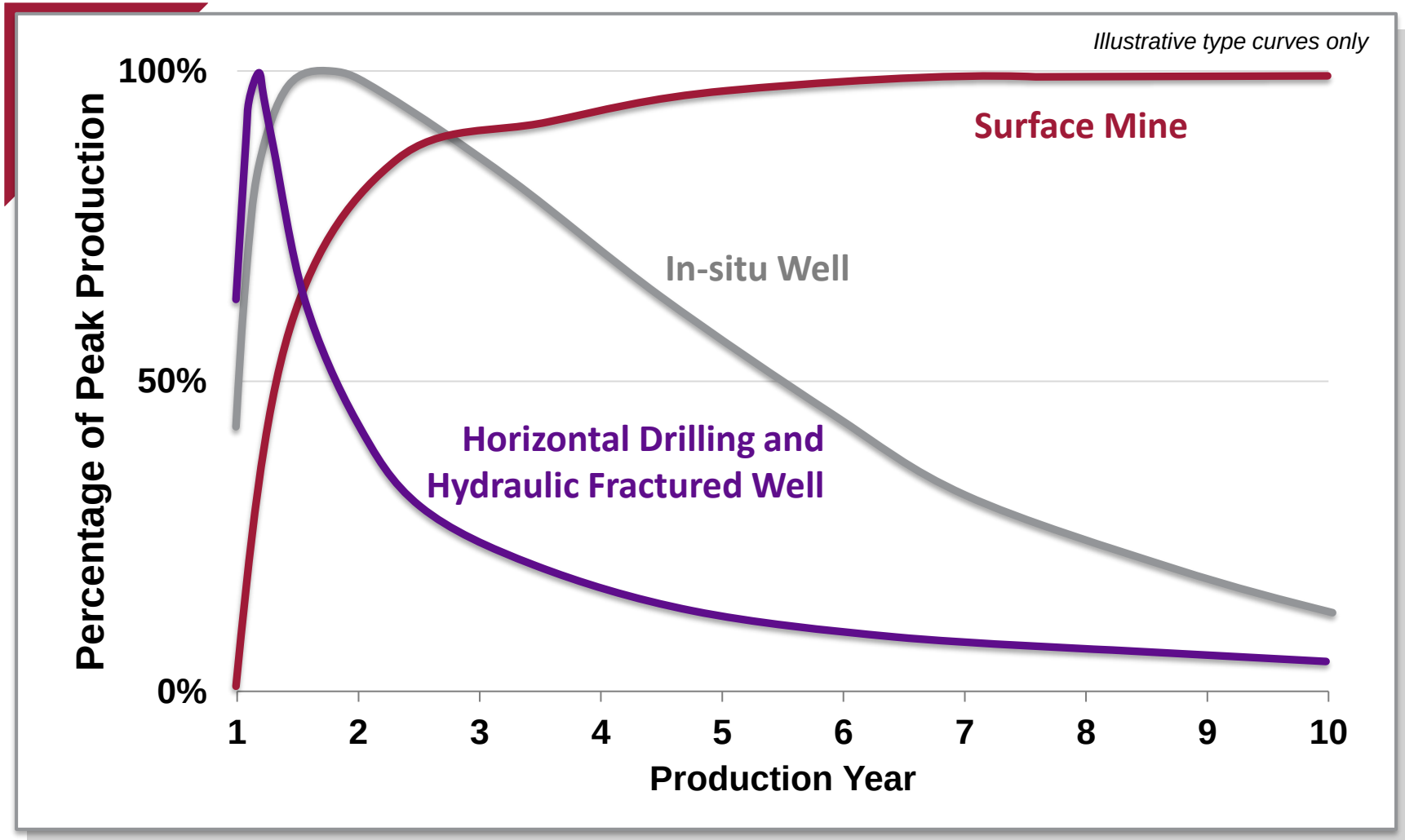
Production

- Once the bitumen has been liquefied, the bitumen-water emulsion is pumped to the surface through a second well sitting below the steam injector.

Water Separation

- Bitumen and water are separated at a processing plant. The recovered water is recycled back into the process.
- The bitumen is diluted with condensate and transported to market by pipeline as diluted bitumen.

Lifetime Production Profiles of Different Oil Extraction Methods

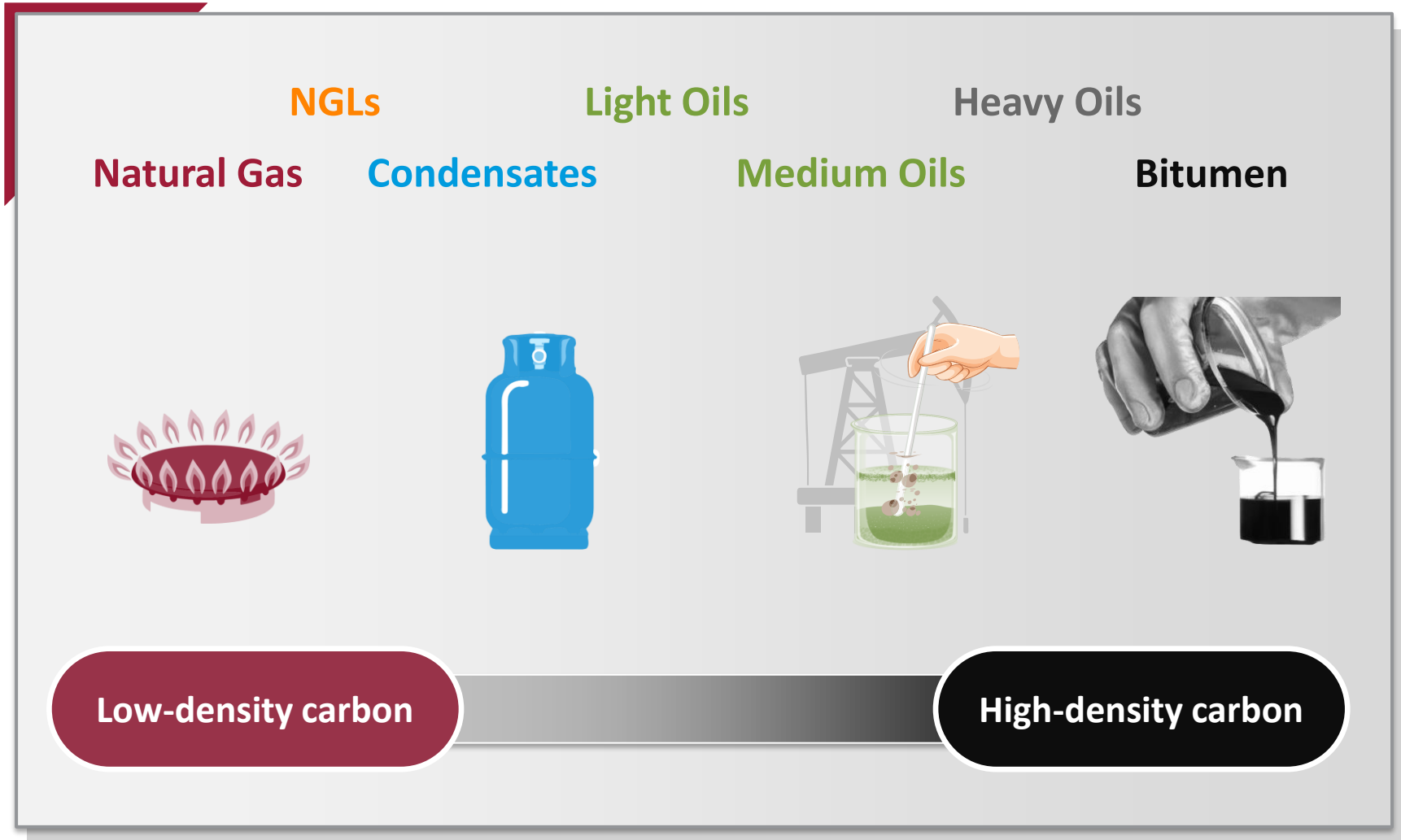


- The production profiles of each extraction method vary significantly, affecting capital outlay requirements for each type of development.
- Horizontally drilled, hydraulically fractured oil wells yield significant volumes initially before declining quickly. These developments require constant reinvestment in new wells to offset declines from the existing wells.
- Conversely, oil sand projects require a large capital investment upfront, but they maintain the initial production levels longer, requiring less ongoing capital investment.

Product Types and Location

CANADA'S OIL & NATURAL GAS PRODUCERS

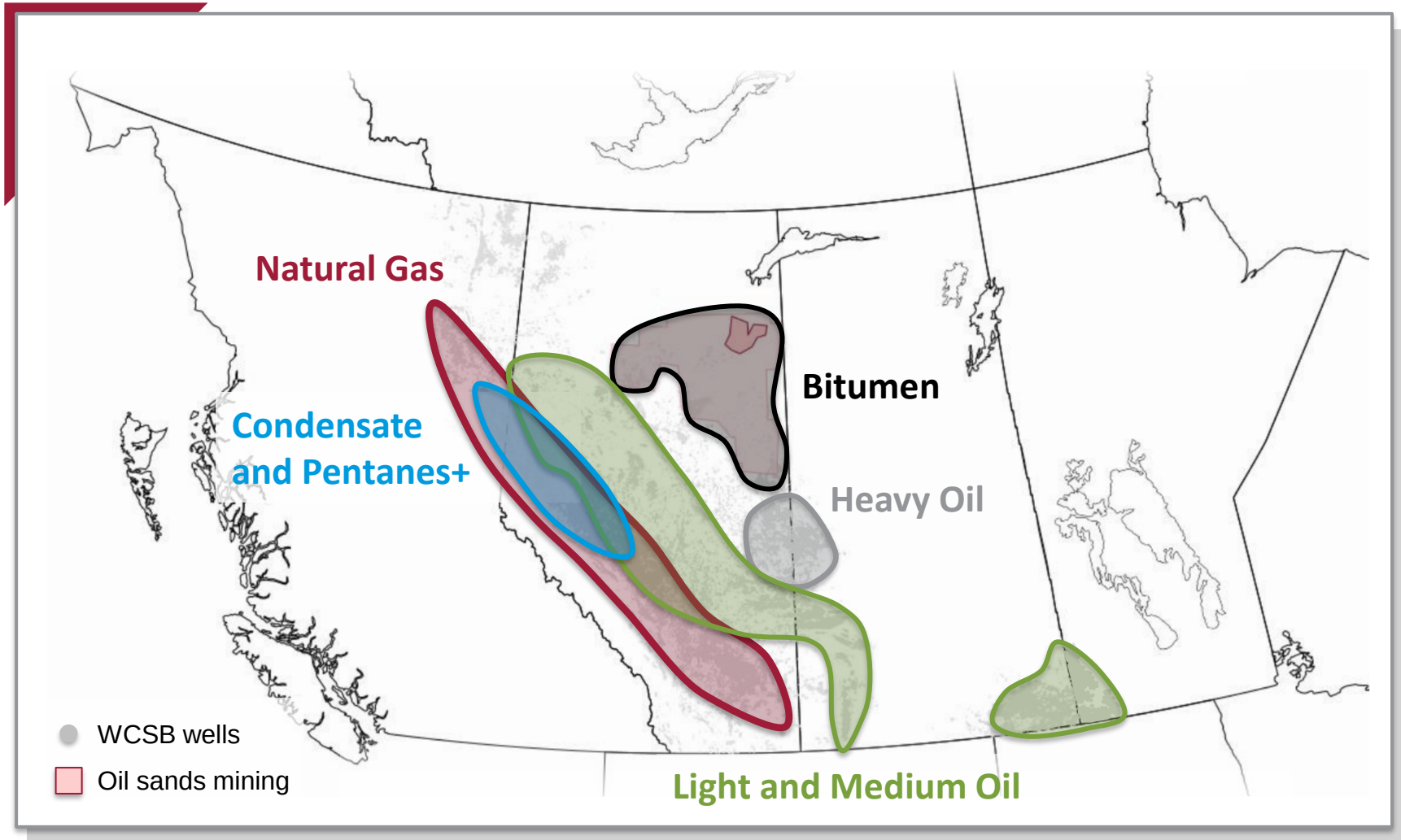
Canada Produces a Diverse Range of Hydrocarbon Types



- Oil and gas can be considered a spectrum, from low-density, gaseous natural gas to high-density, viscous bitumen.
- Low-density carbon fuels like natural gas have short chemical chains – methane contains just one carbon and four hydrogen atoms. By contrast, bitumen often has 70 or more carbons in a single molecule.
- Given their wide range of products, engineers and chemists have found ways to distill, transport, refine, and transform hydrocarbons into a wide array of energy and non-energy everyday products.

Source: Pixabay, iStock, Eagle petrochem, Arab oil and gas, MEC

WCSB Production Locations by Hydrocarbon Type

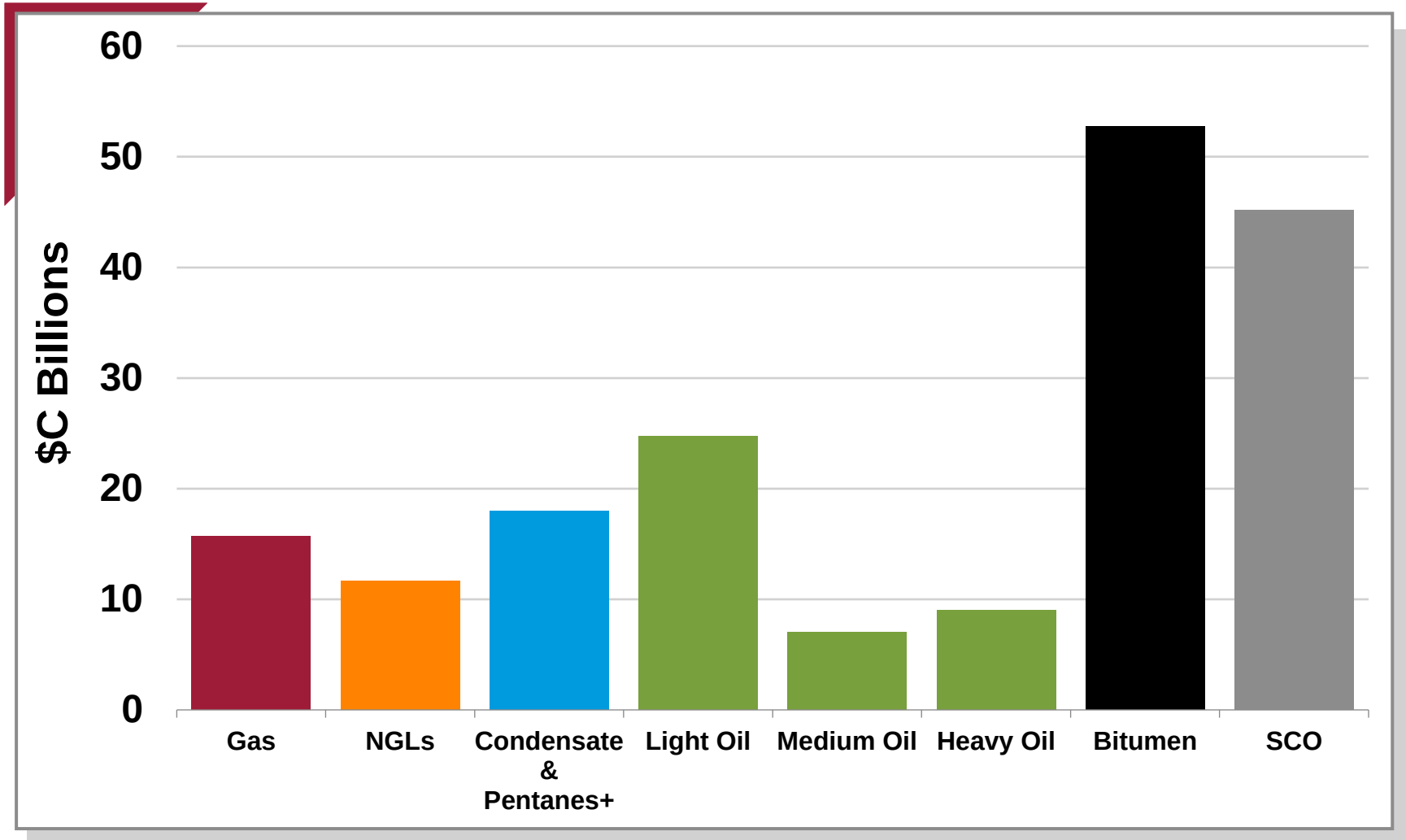


- The WCSB is host to a range of hydrocarbons ranging from natural gas to bitumen.
- Generally, natural gas is found in the deeper reservoirs to the southwest of the basin, while crude oils are found in shallower formations.
- The bitumen making up the oil sands is effectively an oil seep, breaching in the northeastern portion of the basin.

Source: geoSCOUT; Natural Resources Canada for oil sands areas

(1) Includes all non-cancelled wells in BC, AB, SK, and MB (~850,000 wells)

Breakdown of Canadian Upstream Oil and Gas Revenues by Type | 2023e



- Revenues are generated across the hydrocarbon spectrum by companies producing hydrocarbons in Canada.
- Despite making up only about 40% of production on a BOE basis, bitumen and synthetic crude oil (SCO) account for more than half of the total oil and gas revenues.

Source: ARC Energy Research Institute