GHG Emissions

CANADA'S OIL & NATURAL GAS PRODUCERS

Note to Reader – Disclaimer Statement

- This presentation includes data compiled from multiple third-party sources. Sources are indicated at the bottom of the applicable slide. Although we believe this data to be reliable, we do not guarantee the accuracy of data from third parties. The data in this presentation may be updated from time to time following the release of updated data.
- Readers are cautioned that different methodologies may be used to gather and present certain data in this presentation. Results may differ depending on the specific sources and methodologies used.
- This presentation may contain forecasts or future estimates. Such forecasts and estimates are based on information available at the time and are not guarantees of future results.
- The information in this presentation is intended for general informational purposes only. Readers should not rely on this presentation to make business or investment decisions.

Oil and Gas Production and Emissions Definitions

Oil Sands

The extra heavy crude from the oil sands region is called bitumen. It can be extracted by surface mining or produced in situ (from wells, using steam to mobilize the bitumen to flow to the surface). In-situ methods include steam-assisted gravity drainage (SAGD) and cyclic steam stimulation (CSS). To prepare the bitumen for pipeline transport, it's either upgraded into a lighter crude oil called synthetic crude oil (SCO) or diluted with light liquids (often condensates) into a blended product called diluted bitumen (dilbit).

Conventional Oil and Natural Gas

All other oil and natural gas production is categorized as conventional. Traditionally, oil and natural gas were produced from vertical wells, but today, horizontal wells and hydraulic fracturing are the dominant methods. Conventional oil production is categorized as light and heavy. It also includes NGLs, condensates, and pentanes plus, although these products are typically produced in association with natural gas production. In this chapter NGLs, condensates and pentanes plus are included in the natural gas production category.

Absolute Emissions

Absolute emissions measure the total amount of GHG emissions emitted into the atmosphere over a specified period of time.

Emission Intensity

Emission intensity is defined as the emissions rate of a given pollutant (i.e., CO_2) relative to the intensity of a specific activity of production process. It is another methodology for measuring GHG emissions, wherein absolute GHG emissions are divided by some unit of output, like crude oil and/or natural gas produced. Emission intensity normalizes absolute emissions to account for changes in activity, such as increasing or decreasing production levels.

Summary

Total Industry Emissions

- Emissions from oil and natural gas in Canada fell from 192 to 189 Mt CO_2e in the 10-year period between 2012 and 2021 (-2%) while production on a BOE basis grew (+37%). This divergence is the result of improving greenhouse gas (GHG) intensities.
- Total oil and natural gas emissions peaked in 2015. From the peak to 2021, emissions fell by 7%.

Sector Emissions

- Conventional production has been making substantial gains. For oil, absolute emissions were down 29% between 2012 and 2021, while emissions intensity decreased by 21% over the same period.
- Natural gas production also made significant strides as absolute emissions declined 22% between 2012 and 2021, while emissions intensity decreased by 42% over the same period.
- Oil sands have an advantage for future GHG reductions since the emissions are large-scale and in a relatively small geographic area. The Pathways Alliance, an industry group representing 95% of oil sands production, has pledged to reduce emissions to net zero by 2050 using carbon capture, electrification, energy efficiency, and other technologies.
- Conventional oil and natural gas will require a different approach given the significant number of small facilities over a large geographic region. However, considerable progress has already been achieved in reducing emissions through electrification, efficiency, fuel switching, and methane loss reduction. The industry has adopted a multi-pronged, collaborative approach through industry partnerships to develop new emissions reduction technologies, including smaller-scale carbon capture.

Canadian Oil and Natural Gas Emissions and Production Trends (2012-21)

-2%

Emissions decrease*

+37%

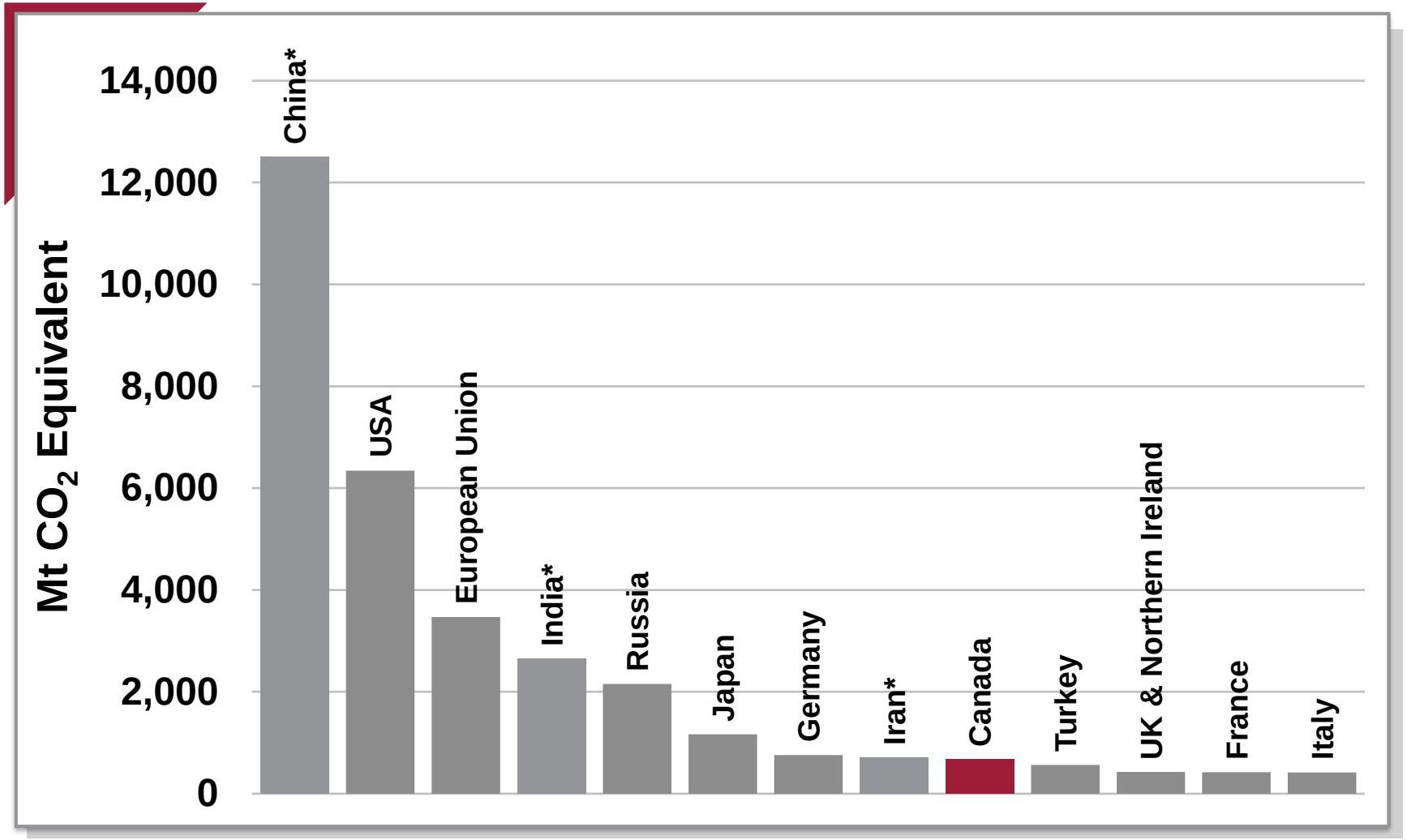
Oil and gas production growth on a BOE basis

*Natural gas emissions: -22%; Conventional oil emissions: -29%; Oil sands emissions: +36%

Context on Canadian and Global GHG Emissions

CANADA'S OIL & NATURAL GAS PRODUCERS

Comparison of Total GHG Emissions by Country and Regions | 2021

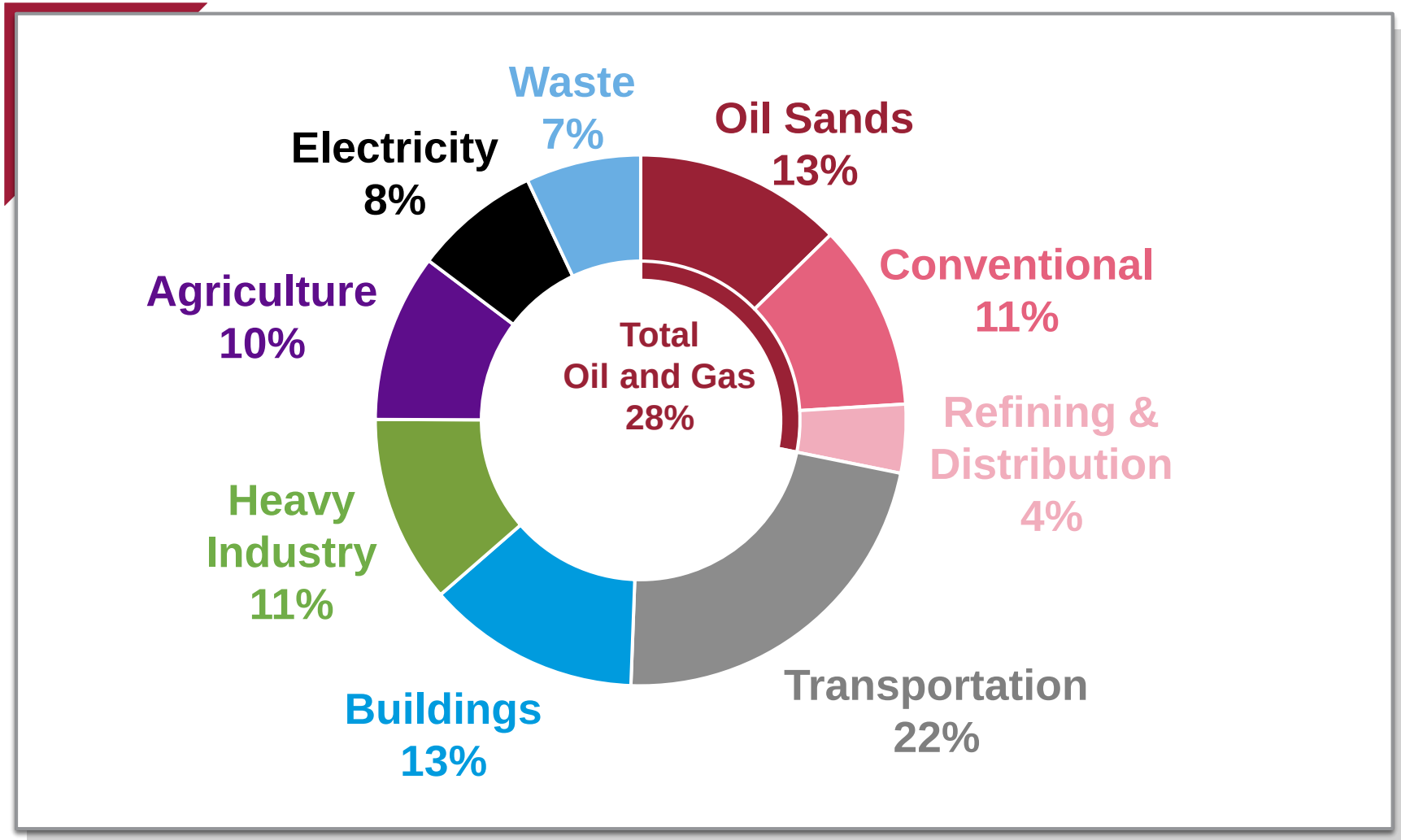


- On total emissions, Canada ranks closely with many other industrialized countries like those in the EU.
- One big difference is that Canada is a major producer of upstream oil and gas.
- In 2021, Canada exported 79% of its oil supply and 48% of its natural gas supply to the United States.

Source: UNFCCC GHG Data Interface, Emissions Database for Global Atmospheric Research

*China, India, and Iran do not report report emissions to United Nations

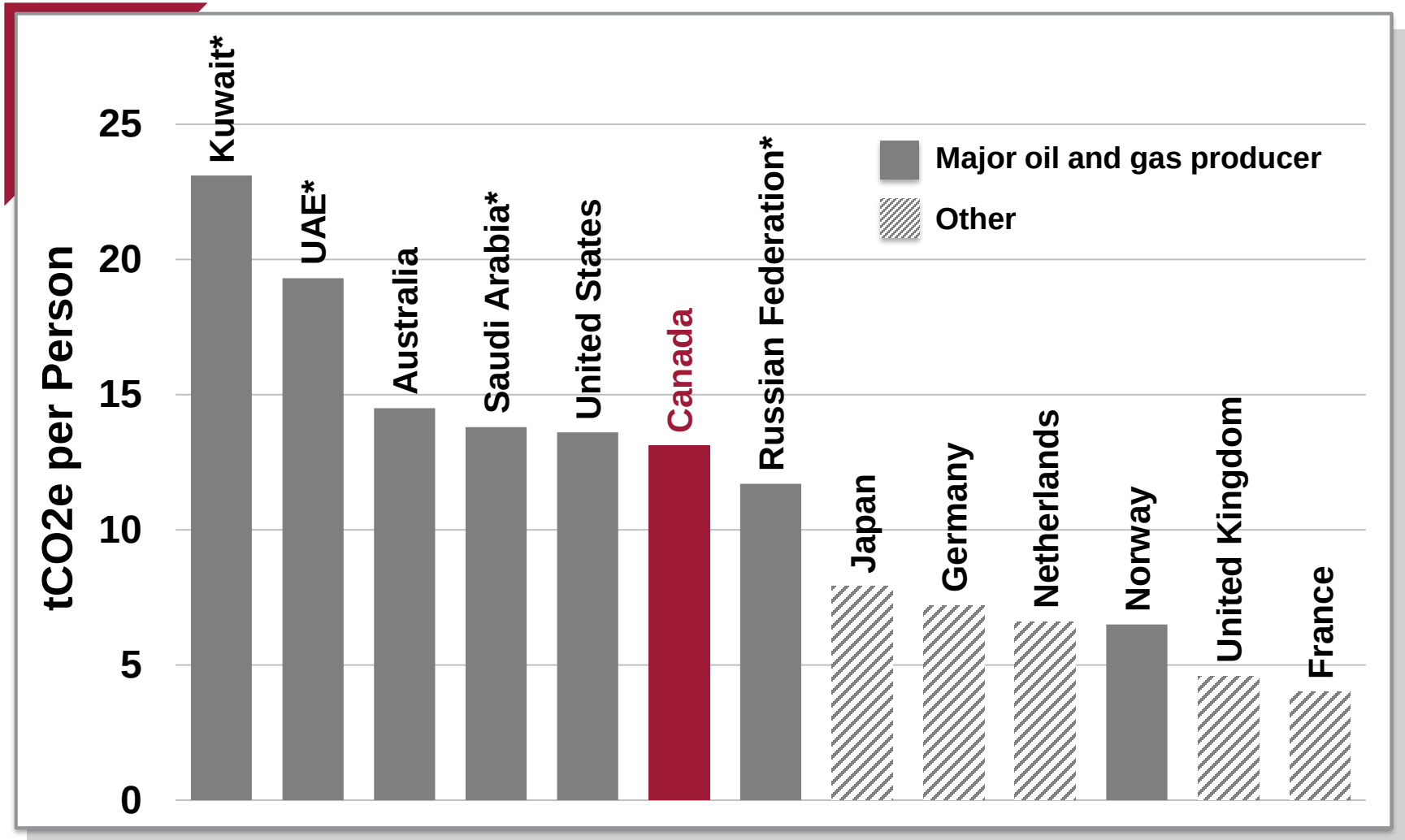
Canada's Greenhouse Gas Emissions by Economic Sector | 2021



- Canada's oil and gas industry accounts for 28% of the country's total GHG emissions.
- Conventional oil and natural gas upstream emissions are about 40% of the total oil and gas emissions and 11% of Canada's total.
- Oil sands are 45% of the total oil and gas emissions, and 13% of Canada's total.

Source: Environment and Climate Change Canada (scope 1)

Carbon Emissions Intensity per Capita by Select Country | 2022

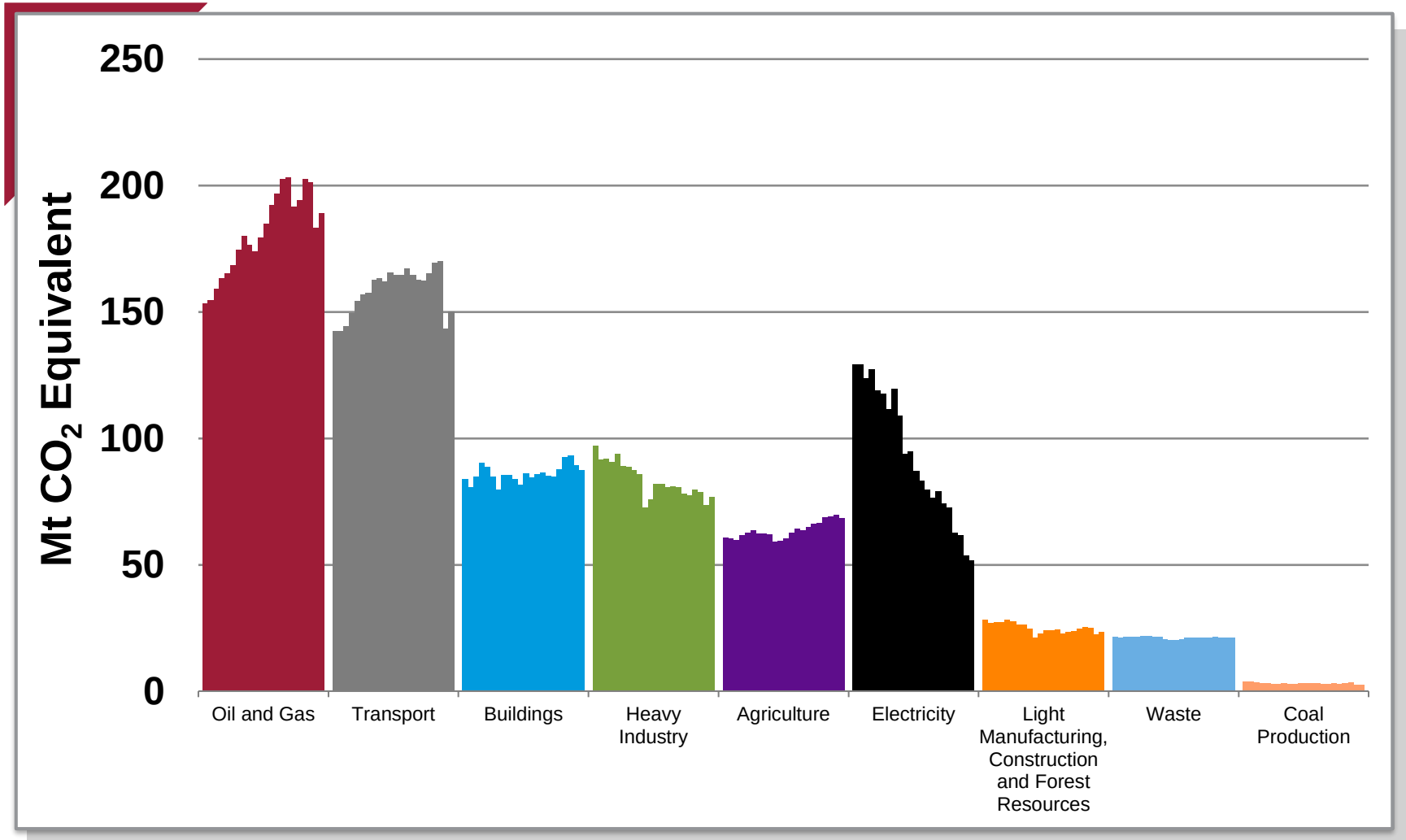


- The highest per capita emitting countries are typically those that are major oil and gas exporters.
- Among the largest exporting nations of oil and gas, Canada ranks favorably on a per capita basis.
- Only Norway has convincingly better performance.
- In addition to having a resource-based economy, Canada is also hindered by a cold climate and a geographically dispersed population, which necessitate higher energy requirements for both heating and transportation.

Source: International Energy Agency (scope 1)

*Countries that only had 2021 data

Canada's Greenhouse Gas Emissions by Economic Sector | 2000 to 2021



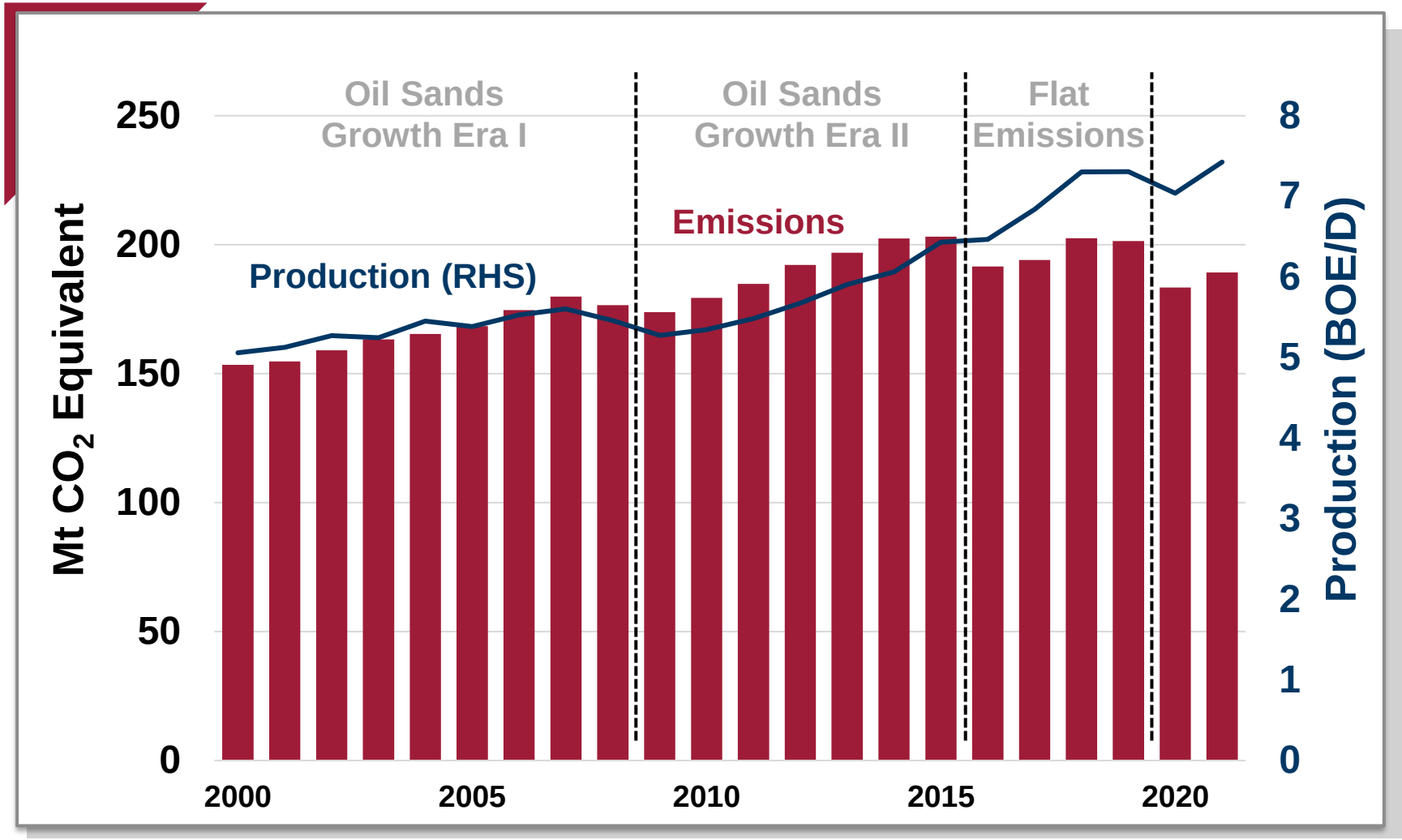
- As the world's 4th largest producer of oil and the 5th largest for natural gas, Canada's upstream industry is the largest emitter in the country.
- Although most of the oil and gas produced in Canada is exported, the emissions from production remain in Canada's emissions inventory.
- Oil and gas emissions flattened after 2015 and post-COVID numbers show a down trend, currently down 7% from peak.
- Electricity emissions show the steepest decline: down 60% since 2000, due to more renewables and coal-to-natural gas switching.

Source: National Inventory Report 1990-2021 (scope 1)

Oil and Gas Sector

CANADA'S OIL & NATURAL GAS PRODUCERS

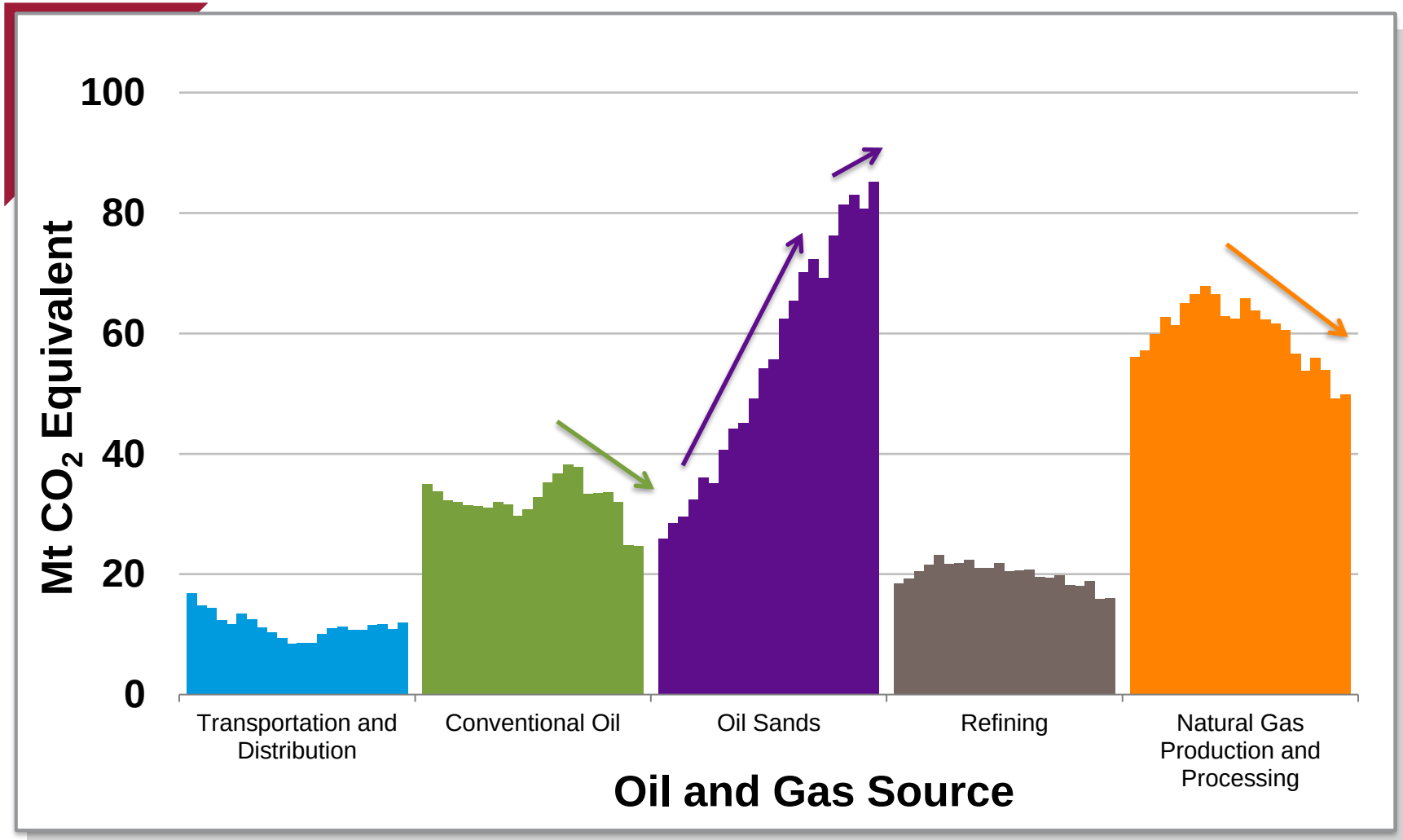
Canada's Greenhouse Gas Emissions and Production| Oil and Gas | 2000 to 2021



- Oil sands production began in the 1960s but kickstarted significant growth circa 2000. Early plants were emissions intense.
- A high rate of oil sands growth between 2008 and 2017 was paired with greater efficiency and progressively lower emissions intensity.
- Between 2015 and 2019 emissions were about flat, despite growing oil sands supply. Conventional emissions reductions contributed.
- Total emissions fell during the pandemic. In 2021, emissions were still below the 2015 peak despite the production recovery.

Source: National Inventory Report 1990-2021 (scope 1), Canada Energy Regulator

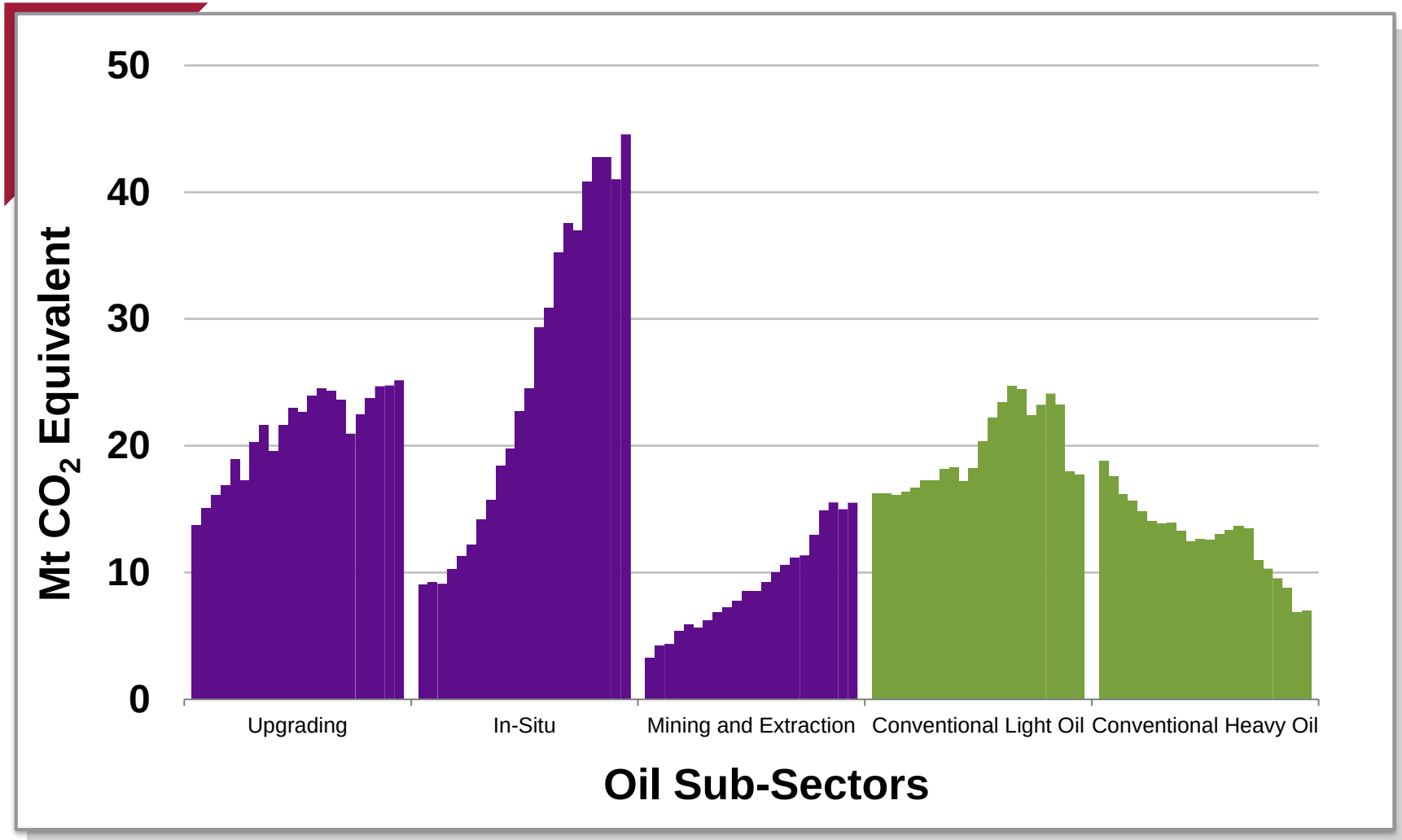
Canada's Greenhouse Gas Emissions | Oil and Gas | 2000 to 2021



- Between 2012 and 2021, conventional oil output was down 9%, while emissions declined 29%.
- Oil sands production growth has been the dominant source of rising industry emissions, but it began decelerating in 2018.
- Although absolute emissions have increased, the emissions intensity of oil sands production has continued to decrease. From 2012 to 2021, oil sands output increased by 70%, while emissions increased only 36%.
- In the same time period (2012 to 2021), natural gas emissions fell 22%, while production grew 35%.

Source: National Inventory Report 1990-2021 (scope 1)

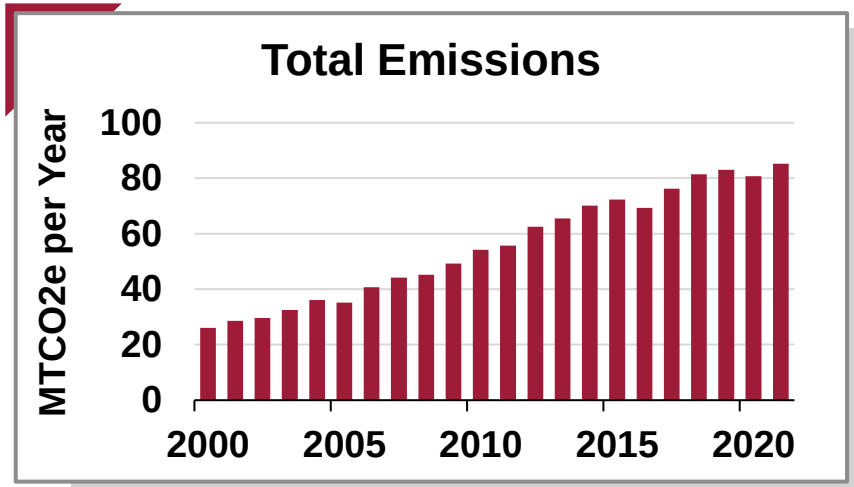
Canada's Greenhouse Gas Emissions | Oil Sub-Sectors | 2000 to 2021

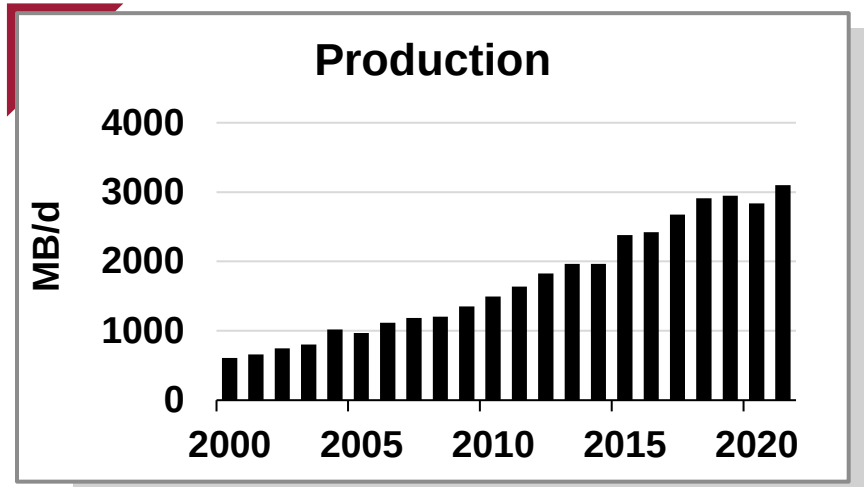


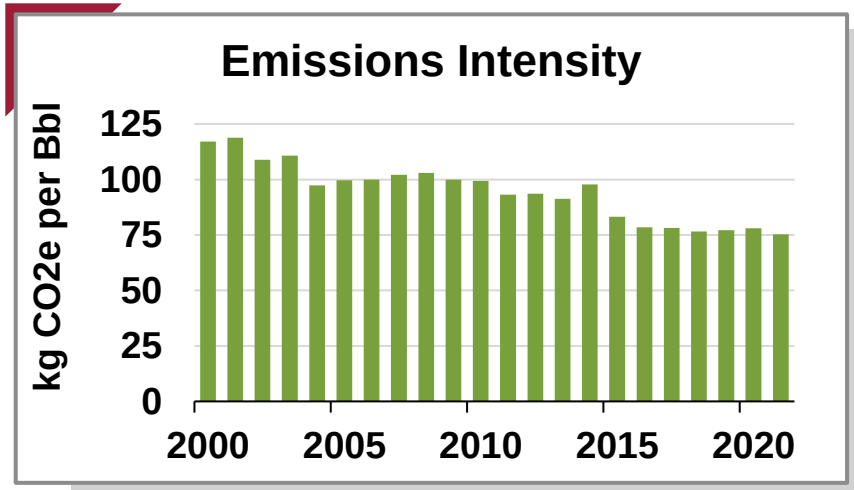
- In-situ oil sands production is the most carbon intense. This is due to the requirement to steam the reservoirs.
- Steam for in-situ oil sands production is generated by boilers fueled by natural gas.
- Conventional light oil emissions are declining due to recent falls in production levels and improved emissions intensity.
- Conventional heavy oil emissions have taken a big step down primarily due to the reduction of methane emissions.

Source: National Inventory Report 1990-2021 (scope 1)

Oil Sands | Production and Greenhouse Gas Emissions | 2000 to 2021







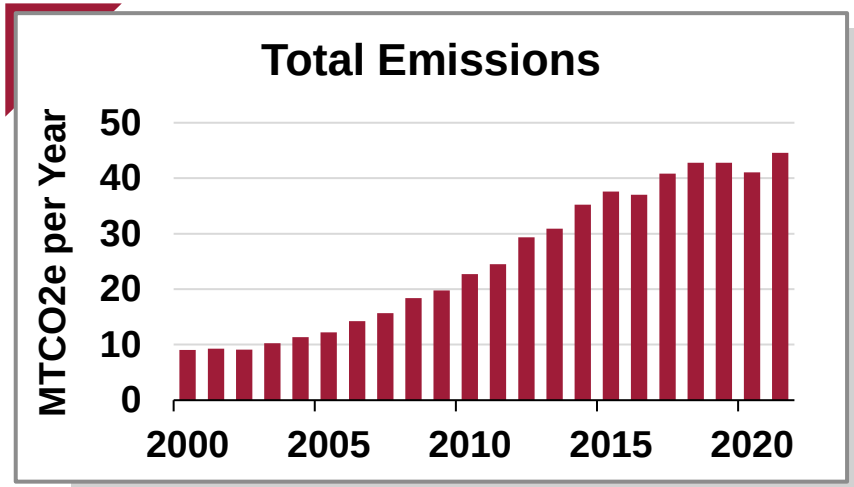
10-Year Change (2012 to 2021)

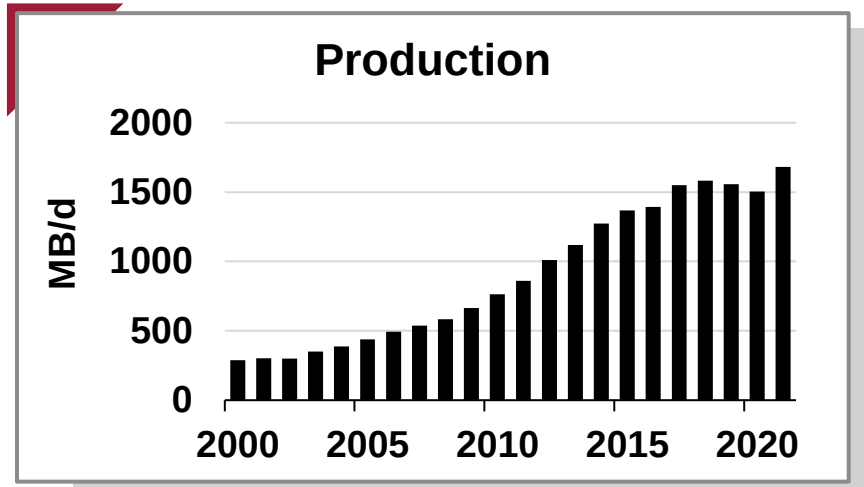
Emissions Change:	+ 36%
Production Change:	+ 70%
Intensity Change:	- 20%

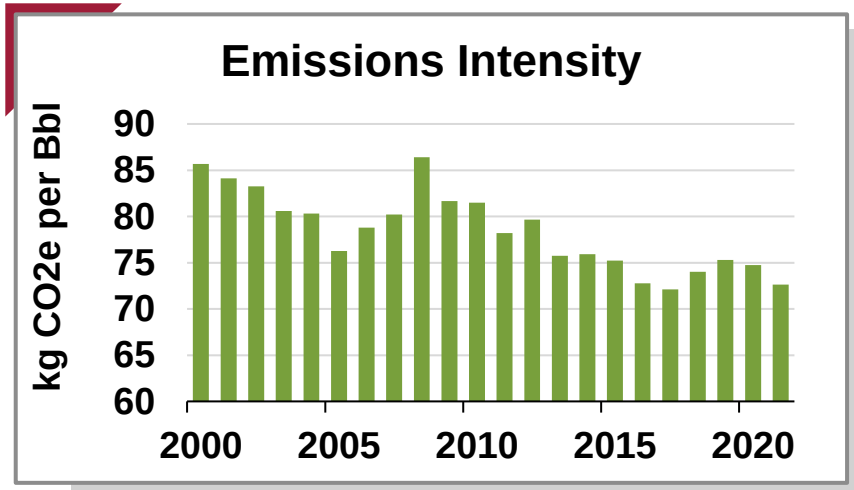
- Emissions from the oil sands have risen since 2000 as the industry has quintupled in size.
- Emissions have grown slower than overall production, however, as the emissions intensity of production has continually decreased.
- If the emissions intensity of oil sands production was the same today as it was in 2000, emissions would be 56% higher.
- Emissions intensity of production has decreased due to a mix of efficiency gains, improved practices, and a smaller share of barrels being upgraded to synthetic crude oil (SCO).

Source: Canada Energy Regulator, National Inventory Report 1990-2021 (scope 1)

Oil Sands | In Situ*| Production and Greenhouse Gas Emissions | 2000 to 2021







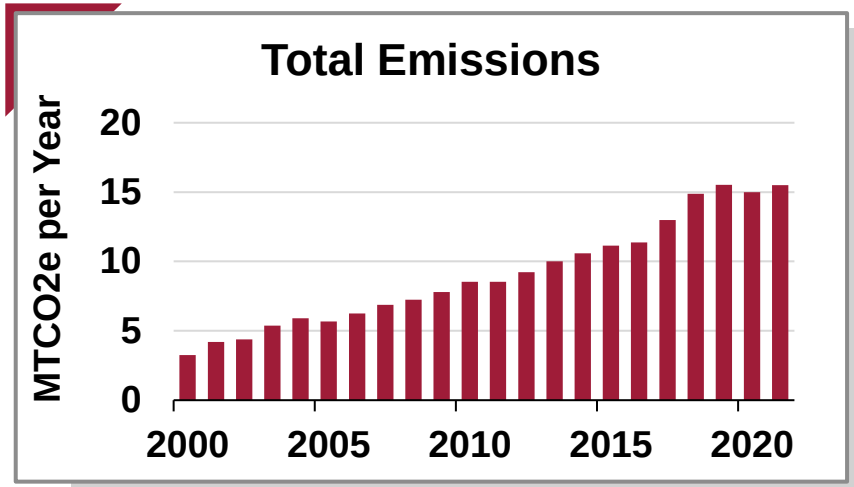
10-Year Change (2012 to 2021)

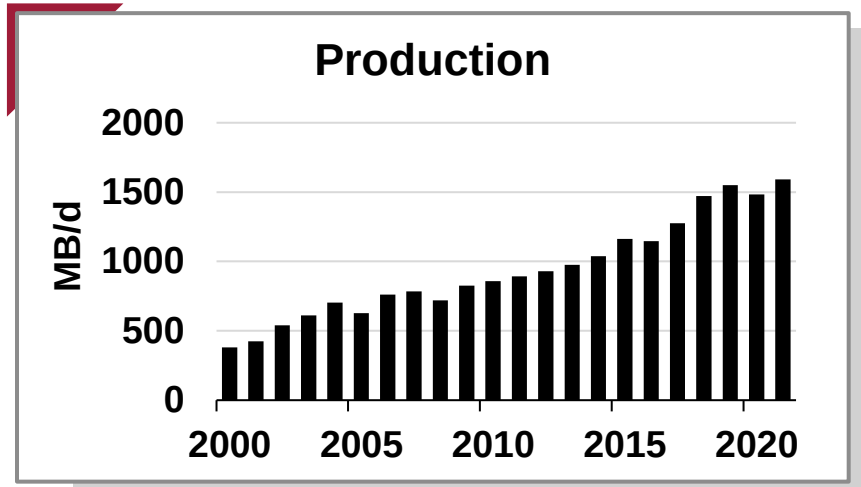
Emissions Change:	+ 52%
Production Change:	+ 67%
Intensity Change:	- 9%

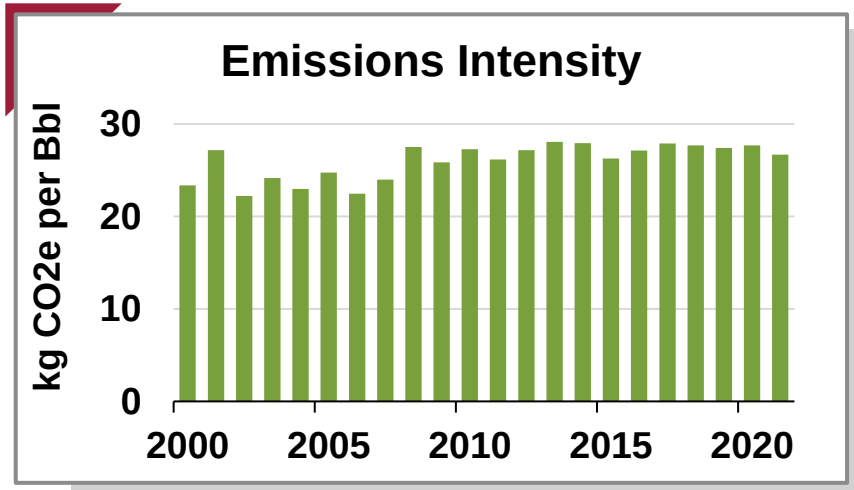
- In-situ oil sands production rose to a record high in 2021, growing to nearly 6X the 2000 levels.
- Emissions also grew significantly over that time (4.9X), but slower than production as operators improved their practices and drove down emissions intensity by 15%.
- Improving steam oil ratios and implementation of cogeneration contributed significantly to the intensity reductions, among other actions.
- Carbon capture utilization and storage (CCUS) and solvents are expected to play a major role in future reductions.

Source: Canada Energy Regulator, National Inventory Report 1990-2021 (scope 1), *Based on production of raw bitumen

Oil Sands | Mining*| Production and Greenhouse Gas Emissions | 2000 to 2021







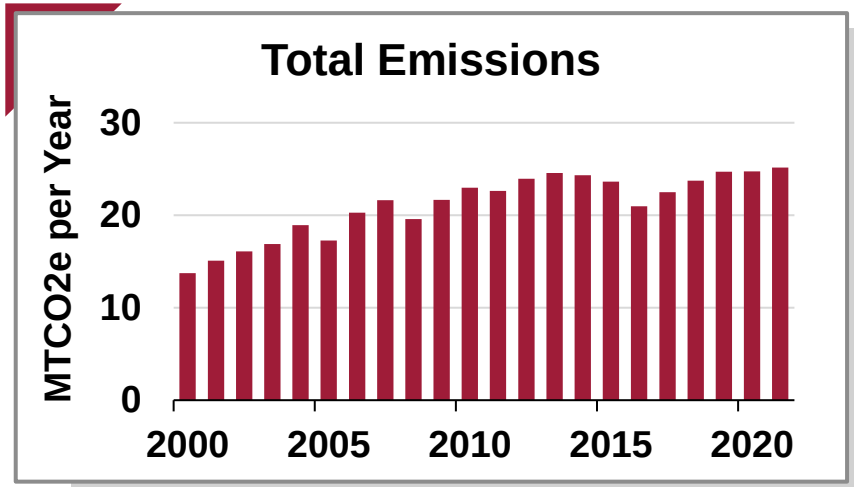
10-Year Change (2012 to 2021)

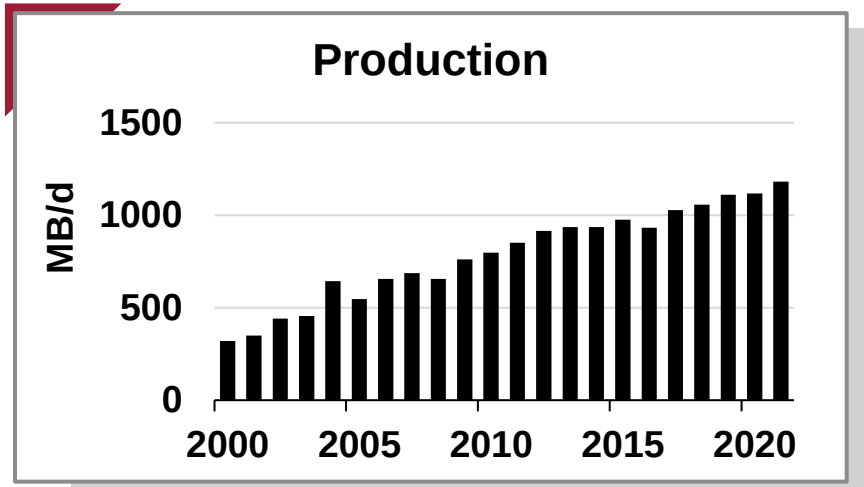
Emissions Change:	+ 68%
Production Change:	+ 71%
Intensity Change:	- 2%

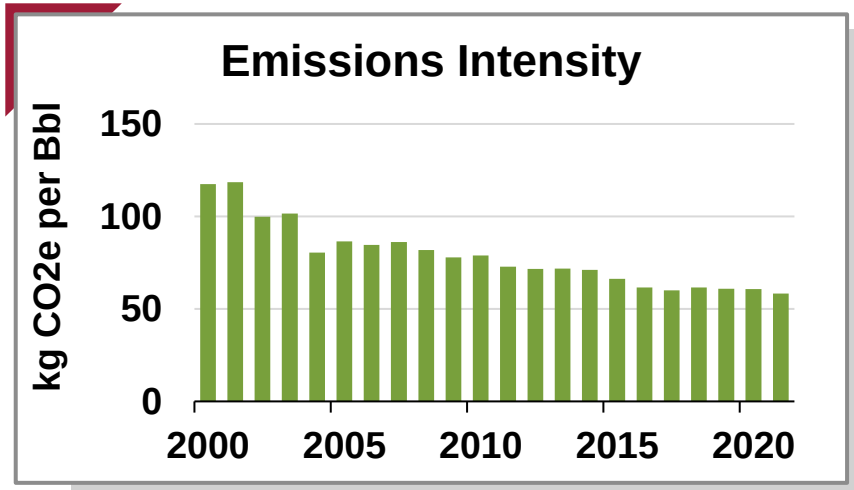
- Oil sands mining produced a similar amount of raw bitumen to in-situ production in 2021, with about 35% of the direct emissions.
- Oil sands mining is less energy intensive as it does not require the production of steam to mobilize resource underground.
- Oil sands mining has the lowest emissions intensity of onshore Canadian oil and gas sub sectors.
- Despite having a lower emissions intensity, a large share of mined bitumen is subsequently upgraded, which adds emissions.

Source: Canada Energy Regulator, National Inventory Report 1990-2021 (scope 1), *Based on production of raw bitumen

Oil Sands | Upgrading | Production and Greenhouse Gas Emissions | 2000 to 2021







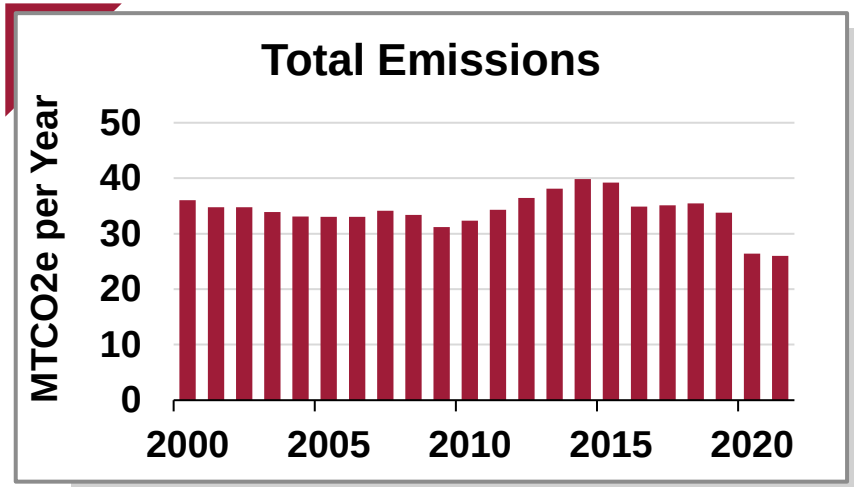
10-Year Change (2012 to 2021)

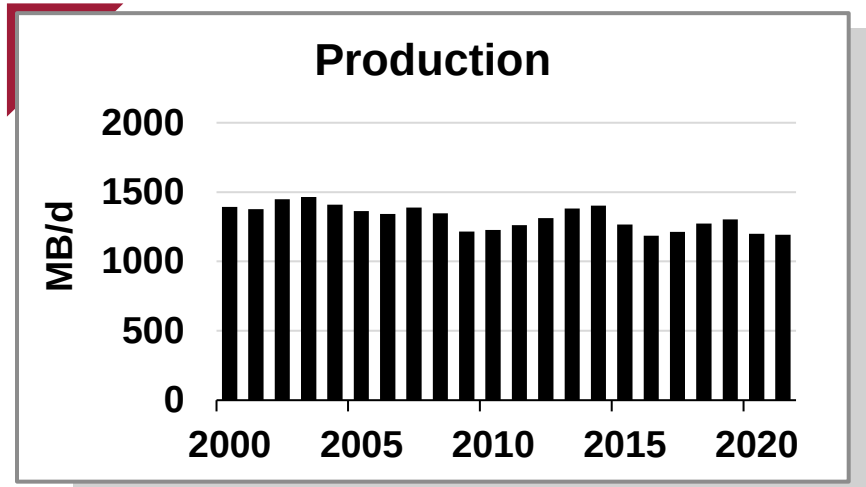
Emissions Change:	+ 5%
Production Change:	+ 29%
Intensity Change:	- 19%

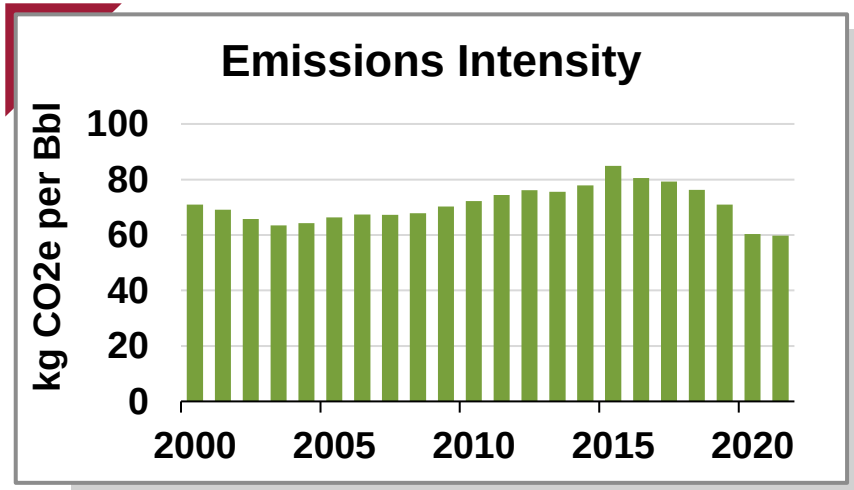
- Oil sands upgrading generates just over 25 $MTCO_2e$ per year. This has increased by 83% since 2000, while upgrader production has grown by 269%.Upgrading emissions intensity has decreased substantially since 2000, falling more than 50%.
- Conversion from high emitting coke boilers to efficient natural gas drove some of the decrease. The implementation of cogeneration has also helped to reduce the emissions intensity of upgrading.
- Upgrading production has increased overall, but a smaller share of oil sands volumes are being upgraded than in the past due to cost considerations associated with upgraders, and increased market demand for heavier crude oils.

Source: Canada Energy Regulator, National Inventory Report 1990-2021 (scope 1), Based on volume of upgraded bitumen produced

Conventional Oil | Production and Greenhouse Gas Emissions | 2000 to 2021







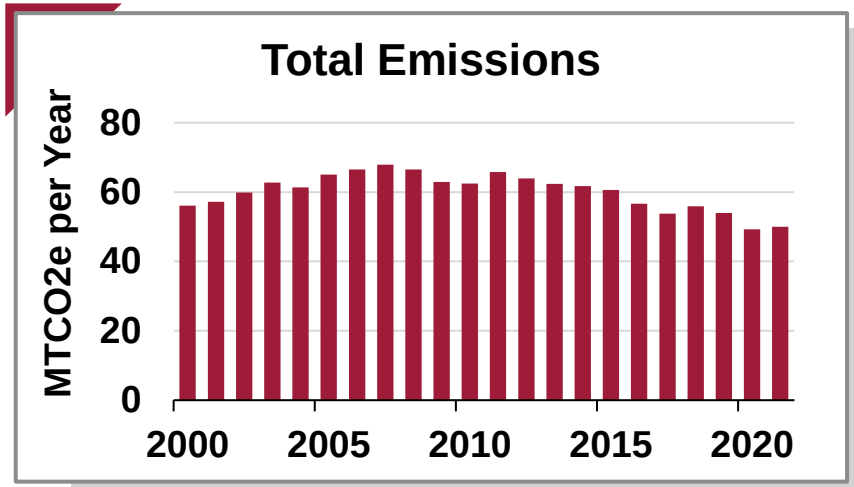
10-Year Change (2012 to 2021)

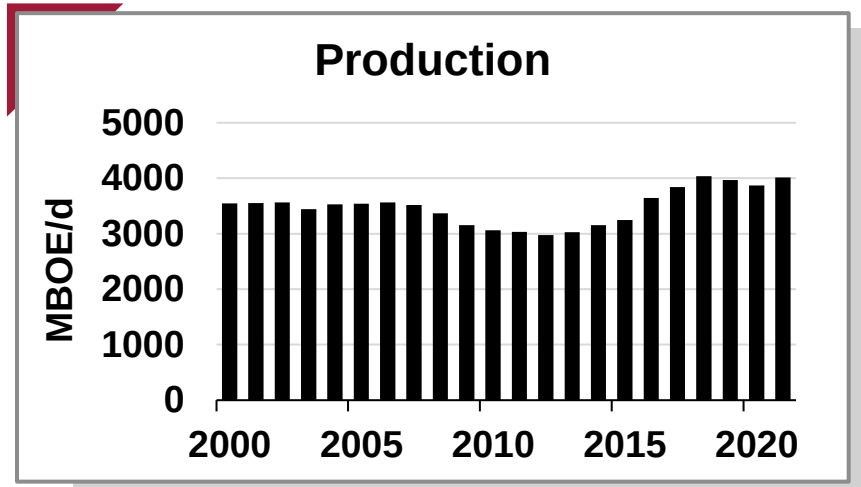
Emissions Change:	- 29%
Production Change:	- 9%
Intensity Change:	- 21%

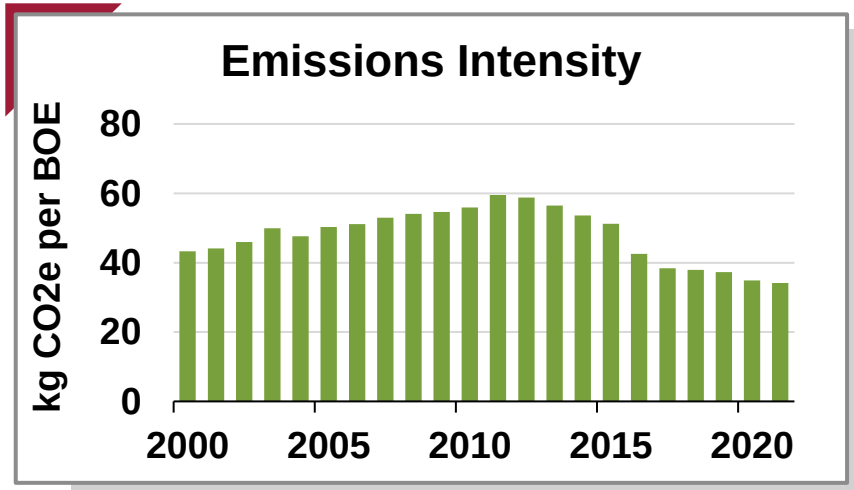
- Emissions from conventional oil production have been trending down since 2012, falling faster than conventional production.
- Since 2012 emissions are down 29%, while production is down just 9%. The emissions intensity of conventional oil production has fallen by 21% in that time.
- This decrease in intensity was mostly driven by methane reductions, accounting for about two-thirds of the drop. A variety of other projects also contributed, including electrification, fuel switching, and energy efficiency.

Source: Canada Energy Regulator, National Inventory Report 1990-2021 (scope 1)

Natural Gas* | Production and Greenhouse Gas Emissions | 2000 to 2021







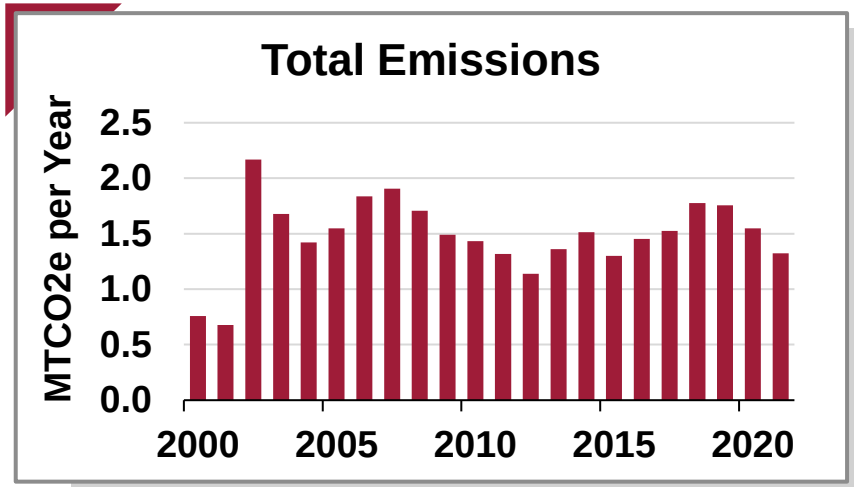
10-Year Change (2012 to 2021)

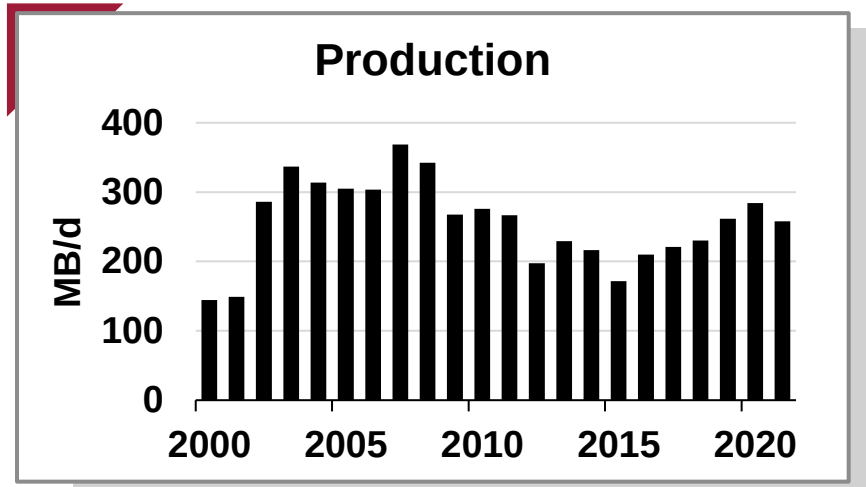
Emissions Change:	- 22%
Production Change:	+ 35%
Intensity Change:	- 42%

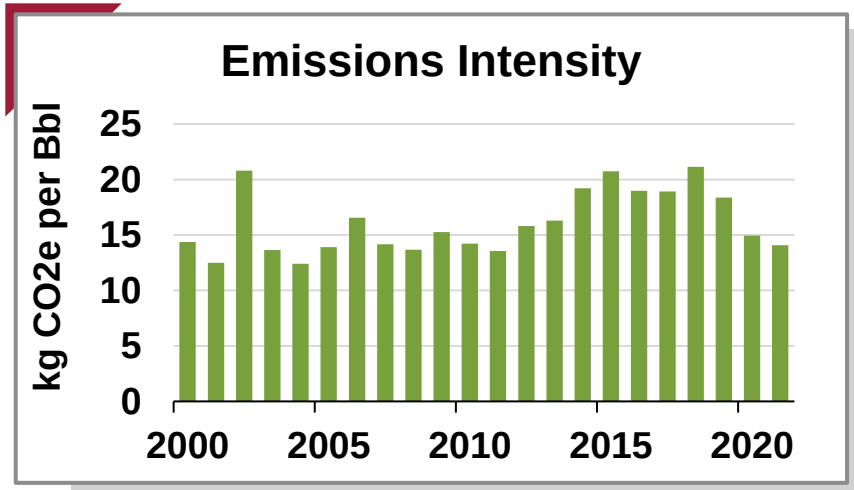
- From 2012 to 2021, production of natural gas, condensate, and NGLs rose by 35%. Over the same period, emissions fell by 22%.
- The emissions intensity of production over that time decreased by 42%, to less than 40 kg CO2e per BOE.
- Reductions in methane emissions were a large driver of the decrease, accounting for around half of the drop in intensity. A variety of other projects also contributed, including electrification, fuel switching (from diesel to natural gas), and energy efficiency.

Source: Canada Energy Regulator, Statistics Canada, National Inventory Report 1990-2021 (scope 1), *Includes condensate and NGLs
Production data prior to 2012 is sourced from the CER, from 2012 to 2021 a combination of CER and Statistics Canada data is used

East Coast Offshore | Production and Greenhouse Gas Emissions | 2000 to 2021







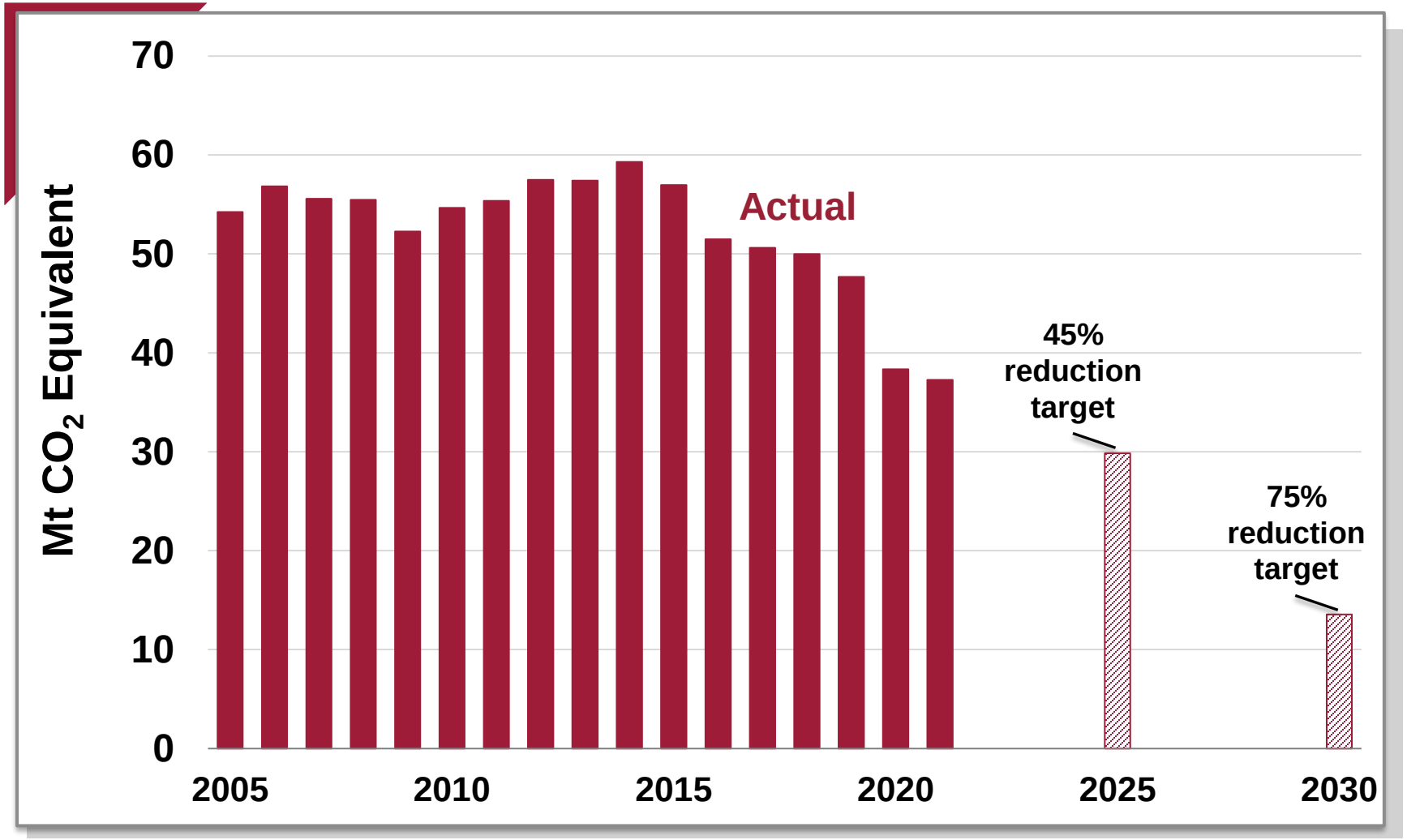
10-Year Change (2012 to 2021)

Emissions Change:	**+ 16%**
Production Change:	**+ 31%**
Intensity Change:	**- 11%**

- East Coast offshore emissions have been relatively consistent between 1 and 2 $MTCO_2e$ per year since 2004.
- On an intensity basis, offshore oil is the lowest emitting category of oil production in Canada.
- Offshore operators have implemented a variety of initiatives, including the use of fuel management and monitoring systems on supply vessels, fugitive emissions monitoring, and the use of low-carbon fuels in the marine transportation industry.

Source: Canada Energy Regulator, National Inventory Report 1990-2021 (scope 1), Based on production and emissions in Newfoundland and Labrador

Canadian Methane Emissions Trends | Oil and Gas Industry | 2005 to 2030e

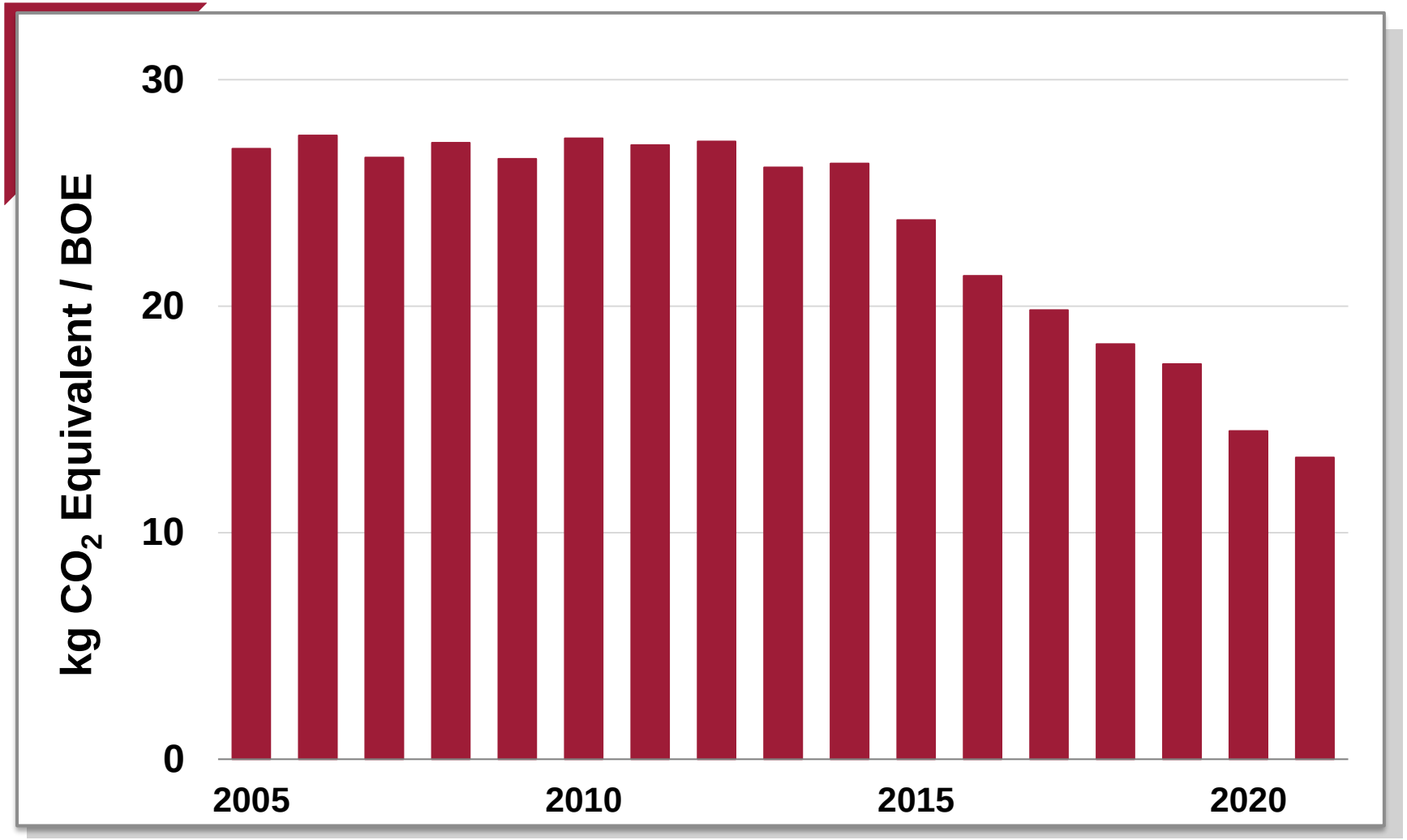


- Methane is a greenhouse gas many times more potent than carbon dioxide.
- Its global warming potential is 80X carbon dioxide over 20 years and 25X over 100 years[1].
- The Federal government, along with provincial Governments, have a target to reduce methane emissions from oil and gas by 45% by 2025 (versus 2012). Canada as a whole, and BC, AB and SK are all on track to meet this goal.
- At COP28, the Federal government announced draft regulations for a further goal of reducing methane emissions by 75% by 2030, relative to 2012.

Source: National Inventory Report

(1) Government of Canada as informed by the Fifth Assessment Report from the IPCC

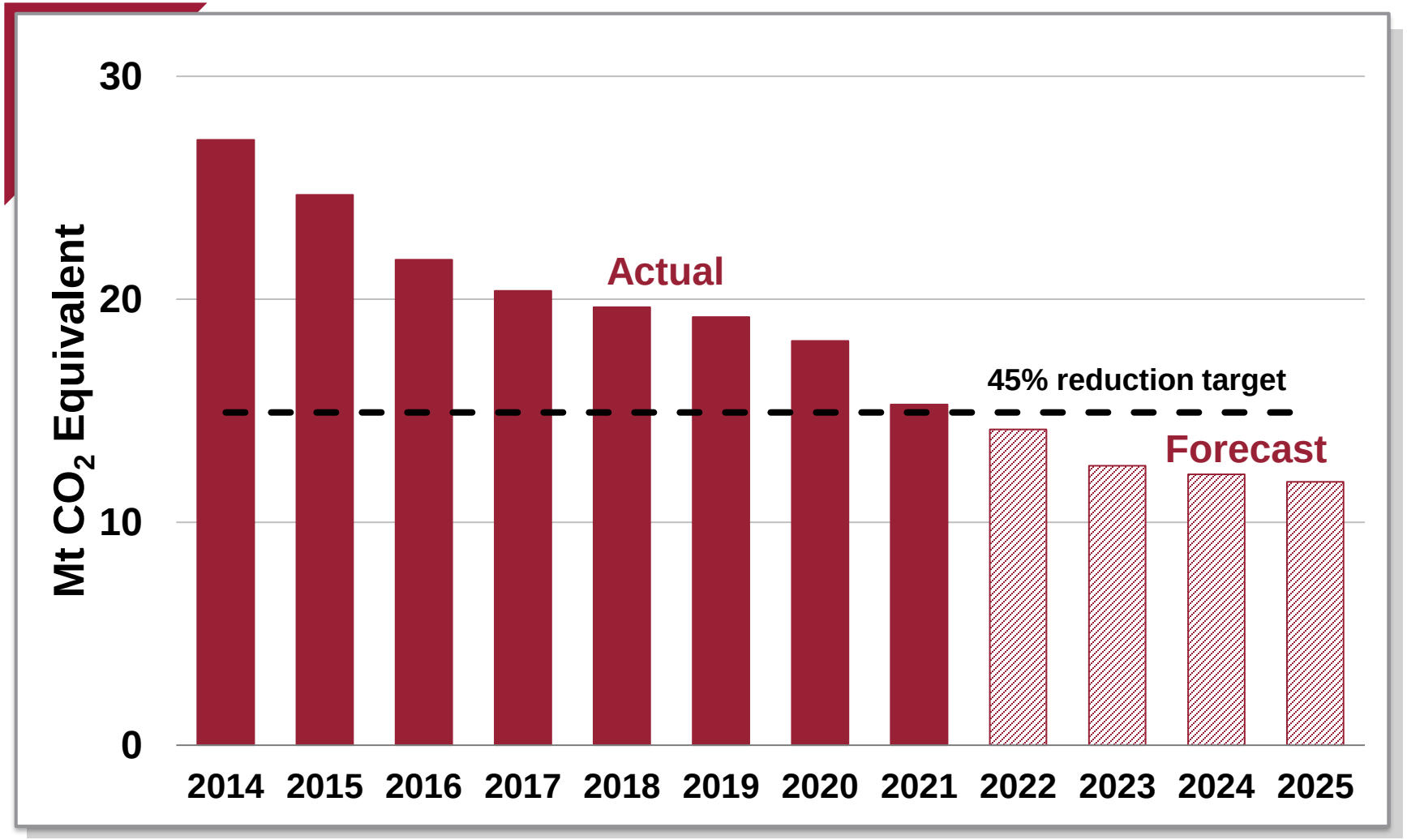
Canadian Methane Emissions Intensity Trends | Oil and Gas Industry | 2005 to 2021



- Methane emissions have fallen steadily since 2012, despite increasing production over the same period. As a result, the methane intensity of oil and gas production in Canada has fallen even more sharply.
- From 2012 to 2021 the amount of methane released for every BOE produced fell by over 50%.
- Operators have driven methane reductions in a variety of ways, such as:
  - Limiting routine venting and flaring
  - Replacing high bleed pneumatic devices
  - Increased measurement and monitoring.

Source: National Inventory Report, Canada Energy Regulator, CAPP, Note: Based off of total industry production including oil sands

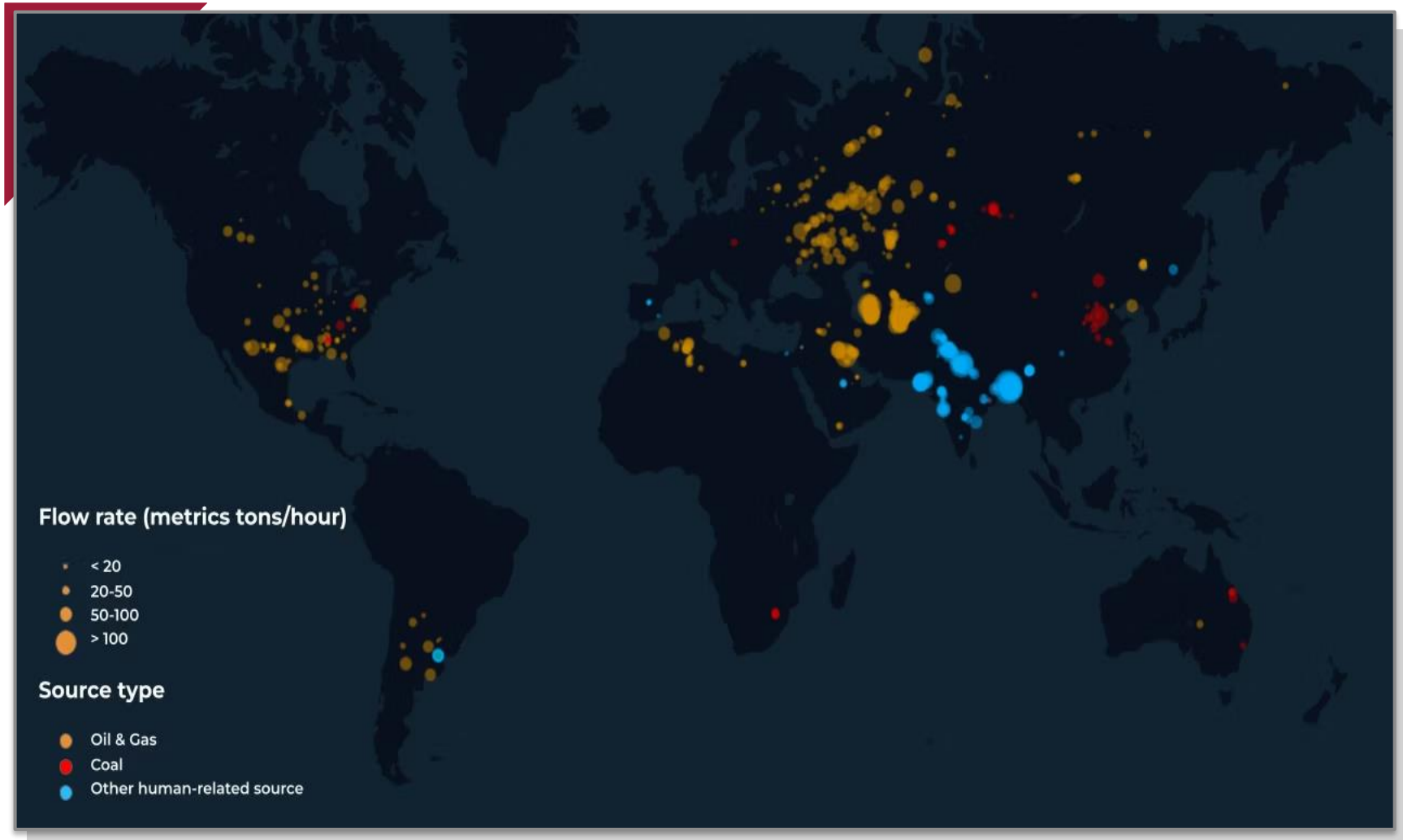
Alberta Methane Emissions Trends | Oil and Gas | 2014 to 2025f



- As a major oil and gas producer, Alberta has historically emitted a significant share of Canada's methane emissions, but these emissions are falling quickly.
- By the end of 2021, Alberta reduced methane emissions from oil and gas by 44% relative to 2014.
- Alberta is ahead of its commitment to reduce methane from oil and gas by 45% by 2025 (relative to 2014).

Source: Alberta Energy Regulator, Note: AER methane data may not line up with National Inventory Report estimates of oil and gas methane emissions

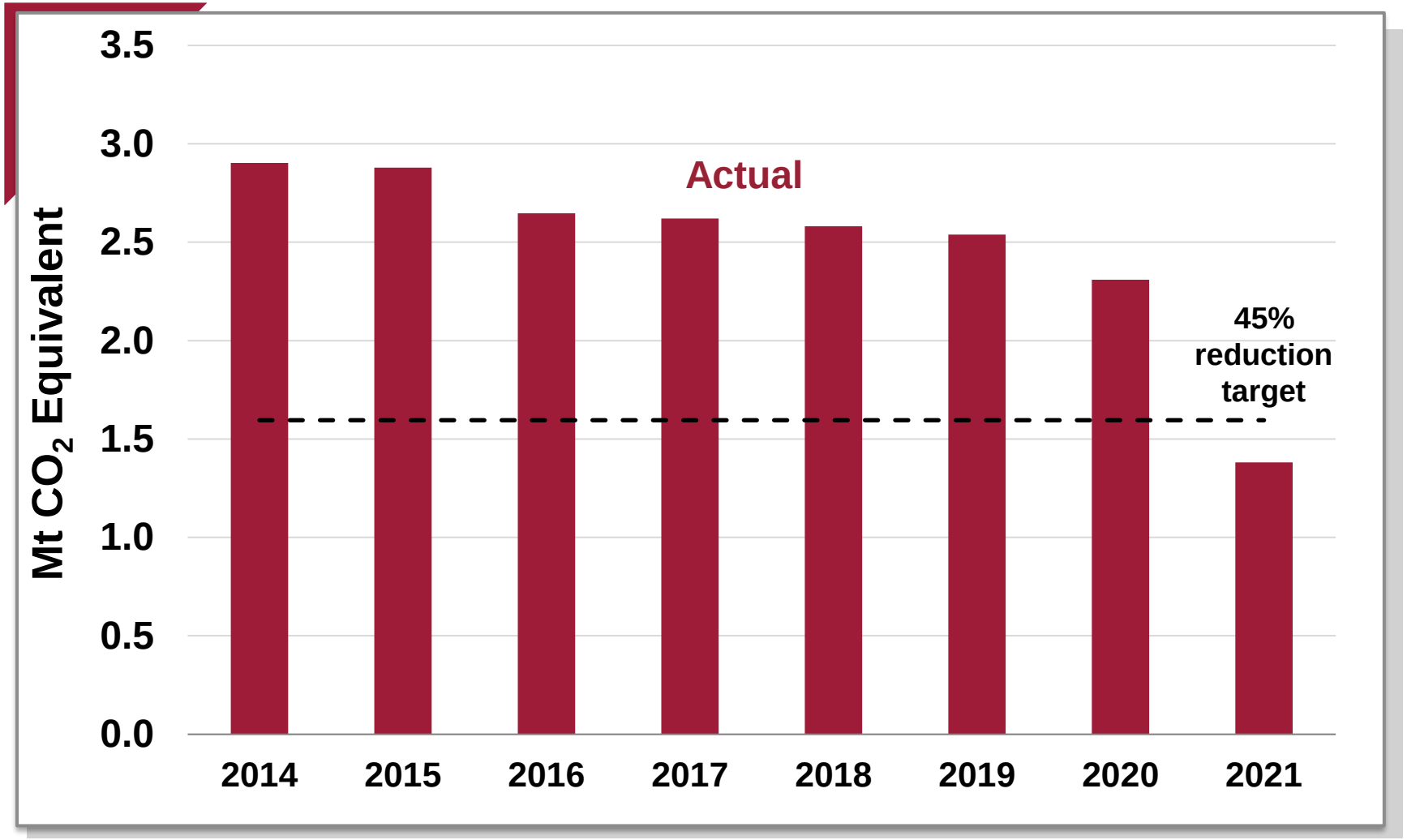
Satellite-Detected Methane Leaks From Human Activity | 2022



- Satellite imagery is becoming a useful technology for measuring global methane emissions, particularly for detecting large leaks. Importantly, satellite imagery provides transparency.
- However, global satellite coverage is not currently all-encompassing. There is currently no coverage in equatorial regions, some northern areas (Russia), and offshore operations.
- From a satellite imagery perspective, Canada's oil and gas methane emissions are visibly lower compared to other oil and gas-producing regions such as the Middle East, the United States, and Central Asia, which is a testament to the industry's progress in reducing its methane emissions.

Source: International Energy Agency - Global Methane Tracker 2023

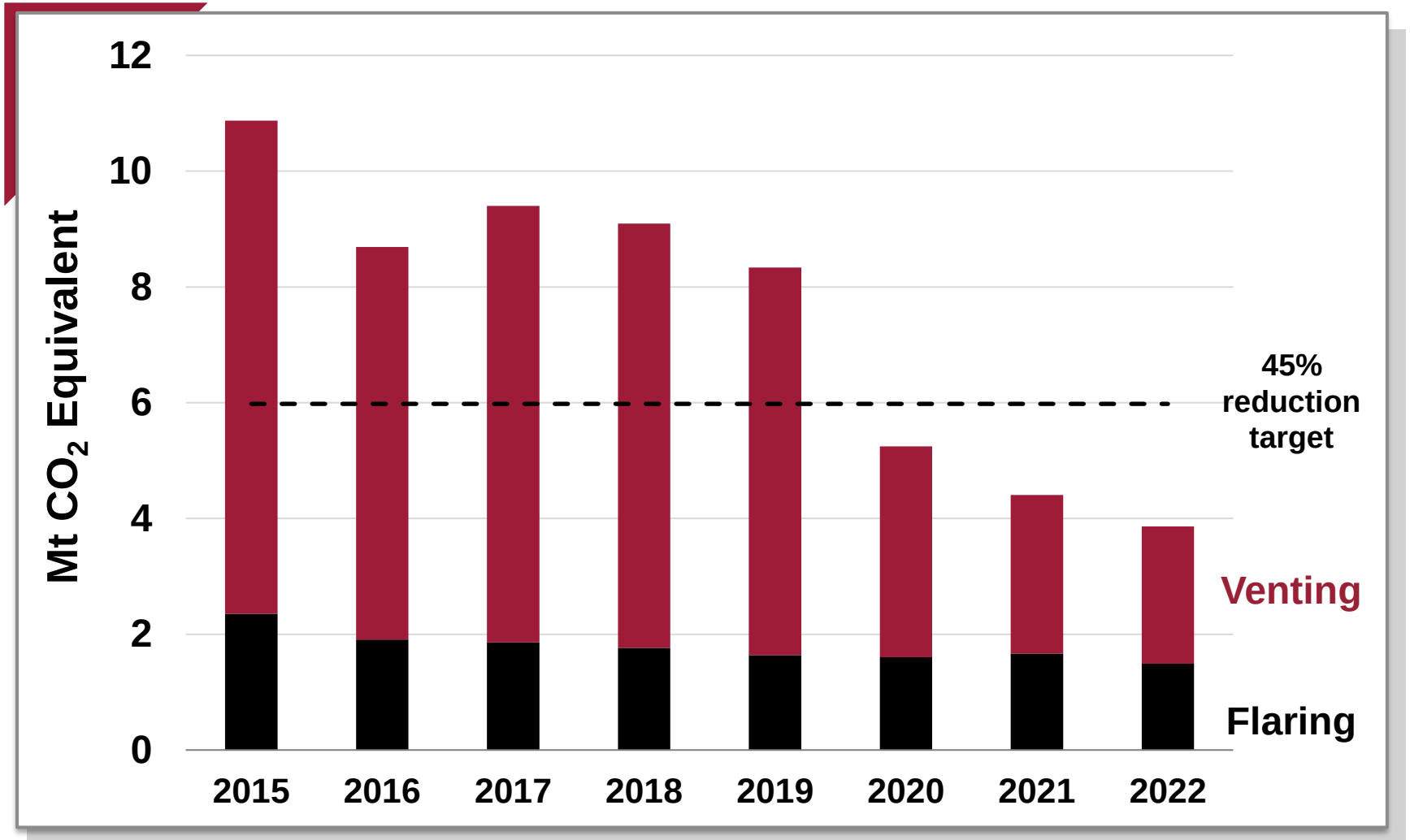
British Columbia Methane Emissions Trends | Oil and Gas | 2014 to 2021



- BC has a goal to reduce methane emissions under its CleanBC initiative.
- As of 2021, methane emissions had been reduced by 50% (relative to 2014 levels), exceeding the 45% reduction target early.
- Under the CleanBC roadmap, BC aims to reduce methane emissions from oil and gas by 75% by 2030 and make progress towards near-elimination by 2035.

Source: Government of BC, National Inventory Report

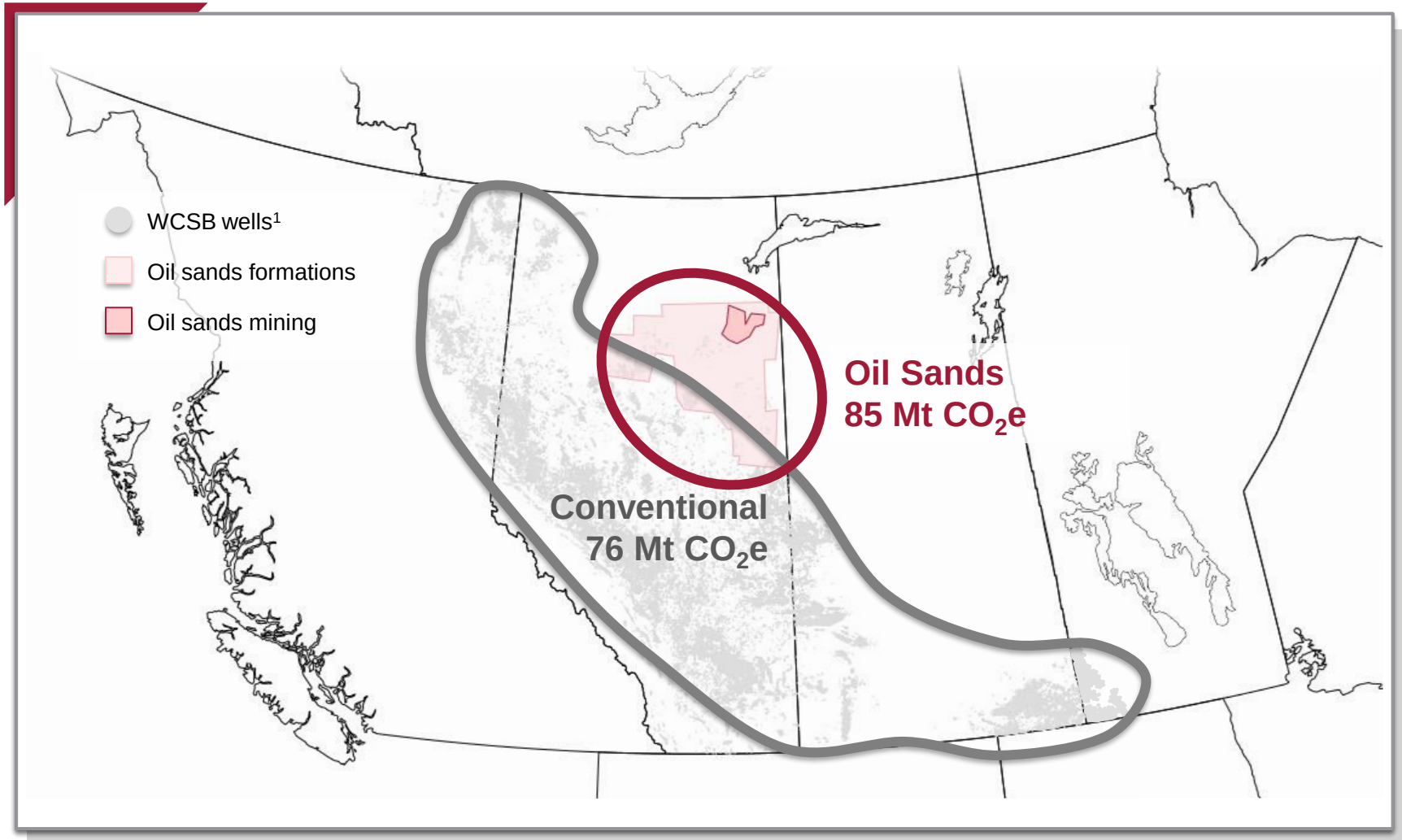
Saskatchewan Flaring and Venting Emissions Trends | Oil and Gas | 2015 to 2022



- Saskatchewan has a goal of reducing the emissions from venting and flaring in the upstream oil and gas industry by 40 to 45% under 2015 levels by 2025.
- The total emissions reduction target under this goal was 4.5 Mt of CO_2e. As of 2022, the total reductions have exceeded this goal, falling by 7 Mt CO_2e from 2015 levels.
- Reductions primarily occurred from activities such as installing combustion equipment on previously venting wells and facilities, utilizing previously vented gas on site, and improving gas gathering infrastructure.

Source: Saskatchewan Ministry of Energy and Resources

Location of Canada's Upstream Oil and Gas Emissions | Annual | 2021

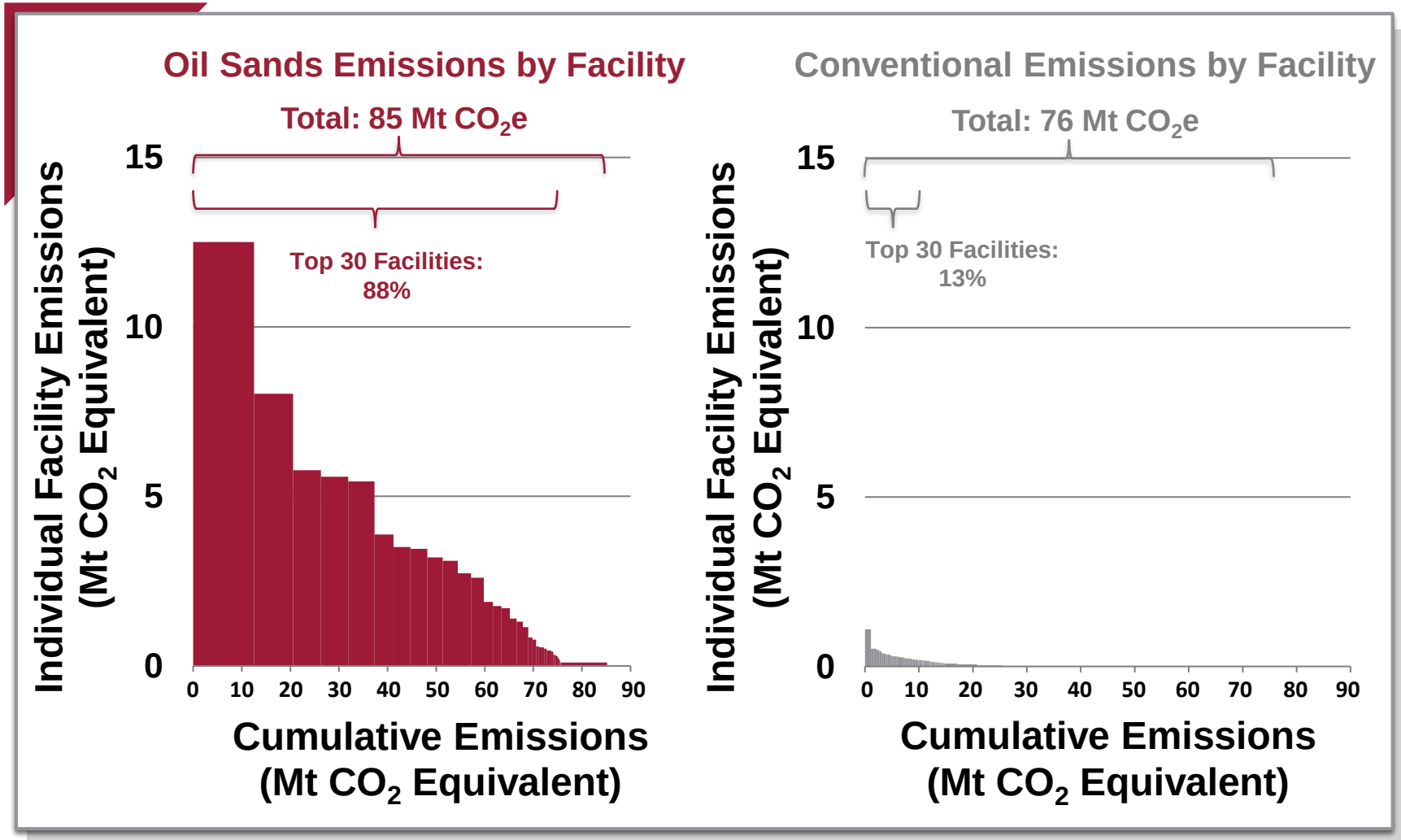


- Onshore conventional oil and natural gas production spans four provinces, from British Columbia to Manitoba. In contrast, oil sands production is relatively concentrated in northeast Alberta.
- The geographic concentration of the oil sands is a strategic advantage for carbon capture and other decarbonization efforts.
- Offshore oil is also considered conventional production. Currently all offshore production takes place in Newfoundland and Labrador (not pictured), and accounts for just over 1 Mt CO_2e.

Source: geoSCOUT; Natural Resources Canada for oil sands areas

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

The Differing Nature of Oil Sands and Conventional GHG Emissions | 2021



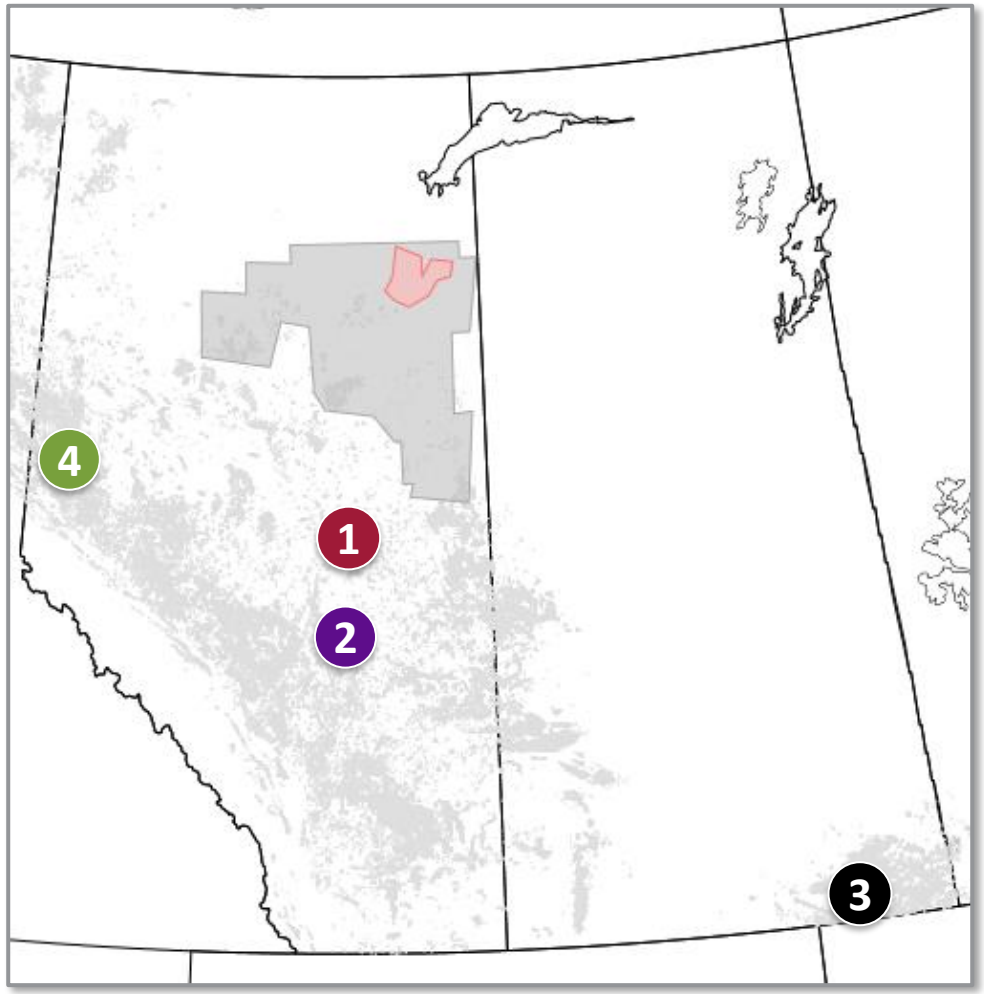
- Total emissions from each of oil sands and conventional production are similar at 85 and 76 Mt CO_2e, respectively. However, the concentration of the emissions differs greatly between the two.
- Oil sands has large facilities with high emission levels per facility. Large oil sands facilities produce more than 10X the emissions of large conventional facilities.
- In contrast, emissions from conventional are spread across a greater number of small facilities, especially after the 25 Mt CO_2e mark.

Source: Government of Canada, Environment and Climate Change Canada (scope 1)

Current Emissions Reduction Initiatives and Technologies (1/3)

- Canadian producers have successfully lowered the carbon intensity of oil and gas, spending $1.4 billion annually on clean investments[1].
- Producers are now looking to employ additional technologies to further reduce their emissions.
- A key technology to be harnessed will be **carbon capture, storage, and utilization (CCUS)**, with Canada already a leading operator from several operating projects in the country:

1. **Quest CCS** successfully captured and stored 6.8 megatonnes of CO_2e between 2015 and 2021.
2. **The Alberta Carbon Trunk Line**, one of the largest CO_2e pipelines in the world, can transport up to 14.6 megatonnes of CO_2e annually and is injecting underground near Clive, AB.
3. **The Boundary Dam** has operated for seven years and has sequestered 4 megatonnes of CO_2e to date.
4. **Entropy Glacier** Phase 1A has operated since July 2022, sequestering 0.047 megatonnes of CO_2e annually .



Source: Company Reports, [1]A 2019 study by Global Advantage Consulting Group for CRIN

Current Emissions Reduction Initiatives and Technologies (2/3)

- **Fuel switching** (from diesel to natural gas) and **improved efficiencies** on existing assets can reduce emissions. Current examples include:
  - **Waste heat recovery units (WHRU)** use a heat exchanger to transfer heat from high-temperature process outputs to other areas, thereby reducing the need to burn additional fuel for power generation.
  - **Displacing diesel** with natural gas across drilling and well completion operations as well as natural gas processing facilities.
  - **Flare recovery systems** recover natural gas that would have otherwise been flared to re-use it for compression, injection, enhanced oil recovery, etc.
- **Cogeneration** uses waste heat to generate electricity, thereby reducing the need to burn additional fuel for power generation. Cogeneration is well suited for oil sands operations, which generate waste heat via steam generation for bitumen extraction. Excess electricity can then be sold to the grid.
  - In Alberta, existing cogeneration facilities have a combined capacity of over 3,000 megawatts and supply over 30% of the province's electricity.
  - Oil and gas exploration & production (E&P) companies who use cogeneration include Imperial (Kearl, Cold Lake), Suncor (Syncrude, Fort Hills, Firebag, Mackay River), CNRL (Horizon, Primrose, Muskeg River, Scotford), Cenovus (Foster Creek, Christina Lake), CNOOC International (Long Lake), MEG (Christina Lake), and Strathcona (Lindberg).

Current Emissions Reduction Initiatives and Technologies (3/3)

- **Using low or non-emitting sources of electricity** such as hydroelectricity to power facilities, particularly in BC where hydroelectricity is readily available (where location permits). Other forms of renewable energy, like solar, are also used. Examples include:
  - Since 2011, **ARC Resources** has fully electrified four of its natural gas processing facilities in BC, avoiding 420,000 tonnes of CO_2e emissions annually as a result.
  - **LNG Canada** will use hydroelectricity to fuel part of its operations and is expected to have an emissions intensity of 0.15 tonnes of CO_2e per tonne of LNG, roughly 40% less than the global average emissions intensity for LNG of 0.35 tonnes of CO_2e per tonne of LNG, and in accordance with the BC government's legislated LNG emissions intensity benchmark.
  - Since 2009, **Ovintiv** has constructed over 1 Bcf/d of hydroelectric-powered natural gas processing and related infrastructure in BC, avoiding over 860,000 tonnes of CO2e emissions annually, with imminent plans to avoid further emissions through continued electrification efforts.
- **Paraffinic froth treatment (PFT)** has enabled mined bitumen to be shipped to market with diluent and without the need for upgrading, which greatly reduces the GHG emissions of the production. Current oil sands mining operations that use PFT include Fort Hills (Suncor), Kearl (Imperial), and the Athabasca Oil Sands Project (CNRL).
- Offshore operators have implemented a variety of initiatives, including the use of fuel management and monitoring systems on supply vessels, fugitive emissions monitoring, and the use of low-carbon fuels in the marine transportation industry.

Source: Oil Sands Magazine, Oxford Institute for Energy Studies, Company Reports

Research & Development (R&D)

- Canada's oil and gas industry has adopted a multi-pronged, collaborative approach to developing new emissions reduction technologies. Some of these collaborative organizations include:
  - Pathways Alliance
  - Petroleum Technology Alliance Canada (PTAC)
  - Clean Resource Innovation Network (CRIN)
  - Natural Gas Innovation Fund (NGIF)
  - Energy Research and Innovation Newfoundland and Labrador
  - The BC Oil and Gas Methane Emissions Research Collaborative (MERC)
  - Avatar Innovations
- In addition, organizations such as Evok Innovations (an investment fund that backs entrepreneurs with innovative solutions to reduce emissions) are leaders in industrial innovation and decarbonization, investing in innovative technologies related to carbon capture, electrification, and hydrogen.
- Alberta Innovates and Emissions Reduction Alberta are examples of government-based organizations facilitating investment in emissions reduction technologies.
- Lastly, post-secondary institutions and internal R&D at select companies are vital to progressing new technologies.

Emerging Emissions Reduction Initiatives and Technologies (1/2)

- **Solvent-assisted steam assisted gravity drainage (SA-SAGD)** is an emerging bitumen extraction technology that supplements steam injection in the traditional SAGD process with light oil (solvents) such as butane and propane to reduce steam use. The solvents are then recovered and re-used, reducing steam requirements by as much as 25% compared to traditional SAGD and allowing for lower steam-to-oil ratios (SOR). Current applications include:
  - By the end of 2023, **Imperial** will be the first to commercialize SA-SAGD at its 15 MB/d Grand Rapids Phase 1 project. Compared to cyclic steam stimulation (CSS), the GHG emissions intensity of SA-SAGD is 40% lower.
  - **CNRL, Cenovus, ConocoPhillips,** and **Suncor** have piloted solvent-enhanced technologies across their thermal operations.
- **Direct contact steam generation (DCSG)** combusts fuel with oxygen and water at high pressure to create a stream of CO_2 and steam[1]. DCSG can be applied in processes such as SAGD and bitumen mining with wastewater containing solids and hydrocarbon to generate steam. This technology minimizes freshwater requirements and produces a pure CO_2 stream that can be permanently stored and not released into the atmosphere.
- **Electrifying greenfield floating production storage and offloading (FPSO) vessels** using onshore power is being evaluated. FPSOs are not connected to onshore power grids and must therefore generate their electricity. However, Canada's limited offshore activity levels do not make this economically viable. The potential to electrify brownfield and greenfield offshore production facilities via offshore wind farms is also being evaluated.

Source: [1]Natural Resources Canada

Emerging Emissions Reduction Initiatives and Technologies (2/2)

- **Blue hydrogen** is derived from natural gas, and the CO_2 byproduct produced in making the blue hydrogen can be captured and permanently stored in underground geological formations. Hydrogen can be used in industrial applications, heating, and electricity generation. Importantly, when combusted, hydrogen produces no GHG emissions.
- **Direct air capture (DAC)** can capture CO_2 directly from the air, which can then be permanently stored in underground geological formations. In the US, Occidental Petroleum is building the world's largest DAC facility in Ector County, Texas, which is expected to be commercially operational by mid-2025.
- **Small modular reactors (SMRs)** are nuclear reactors that are smaller and have lower costs than traditional, large ones. This technology has the potential to be deployed in remote or rural areas, making it highly suitable for providing heat and power in oil sands operations. In September 2023, Cenovus announced they are undertaking a study with the help of provincial government funding to research how SMRs could be used in oil sands operations in the future.

Source: Canada's Oil Sands Innovation Alliance, IEA, Occidental Petroleum Corporation

Emissions Testing Center (ETC)

The ETC Program is a collaborative industry, government, and academia initiative headed by Canada's Natural Gas Innovation Fund (NGIF) Accelerator that provides startups with a dedicated space to develop, test and field-validate technologies to measure, monitor and reduce methane emissions. The program is unique by providing technology innovators free-to-test access to support rapid scale-up of technologies from concept to commercial-ready deployment.

The ETC Lab

The University of Calgary provides capabilities to test and de-risk technologies in a controlled environment.

West Wolf Lake Gas Plant

Live field trials at the West Wolf Lake Gas Plant (jointly owned by Tourmaline Oil Corp. and Perpetual Energy) along with other Tourmaline assets.

Natural Gas Innovation Fund Accelerator

NGIF Accelerator is the not-for-profit arm of NGIF Capital and operates all technology and innovation programs. The NGIF Accelerator mandate is to de-risk and accelerate technology development by supporting startups through their pilot projects, field trials, and industry validation. It will coordinate with federal and provincial governments to co-fund projects to advance market commercialization. NGIF Accelerator currently operates the Industry Grants program and the ETC program.

Source: Tourmaline Oil Corp.

Pathways Alliance

Formed in 2021, the Pathways Alliance is a joint industry group committed to net-zero emissions by 2050. The Pathways Alliance consists of CNRL, Cenovus, Imperial, MEG Energy, Suncor, and ConocoPhillips Canada, who collectively account for roughly 95% of Canada's oil sands production. To achieve its target, the organization will implement a suite of technologies through a phased approach:

- **Phase 1 (2021-2030)**
  - Invest $16.5 billion to build a proposed carbon capture and storage (CCS) network in northeastern Alberta. This and other phase 1 activities are anticipated to reduce GHG emissions by 22 million tonnes of CO_2 per year (scope 1 and 2).
  - Invest an additional $7.6 billion in new and existing technology, research, and energy-efficiency projects.
- **Phase 2 (2031-2040)**
  - Expand the existing CCS network to include more than 20 oil sands sites.
  - Invest in more R&D for alternative power sources, including hydrogen and small modular reactors (SMR).
- **Phase 3 (2041-2050)**
  - Explore and develop existing and emerging technologies, such as DAC.
  - Implement CCS for any remaining oil sands sites.
  - Potential deployment of hydrogen and SMRs at oil sands sites.

Source: Pathways Alliance