Canada's Path to Paris Targets

Forecasting Oil and Gas GHG Emissions in Canada for Period 2019 to 2030

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Oil and Gas Sector

Executive Summary Showing Results and Conclusions

Conclusions of Forecast for Emissions from Oil and Gas

- The model forecasts emissions from the various sub-sectors of oil and gas

- The Environment and Climate Change Canada (ECCC) released the Emissions Reduction Plan (ERP) in late March 2022
  - the ERP stated an emissions target in 2030 for oil and gas of 110 million tons (MT) of greenhouse gas (GHG) emissions

- The model forecasts emissions from oil and gas in 2030 as follows

	2019	ERP 2030 Target	Model 2030 Forecast
Oil Sands	85	45	61
Conventional Oil	25	15	25
Natural Gas	51	32	38
Refining and Pipelines	30	18	19
Total	191	110	143

- The conclusion from the model is that 2030 emissions from oil and gas will exceed the 2030 target in the Emissions Reduction Plan by 33 MT

Conclusions of Forecast for Emissions from Oil and Gas

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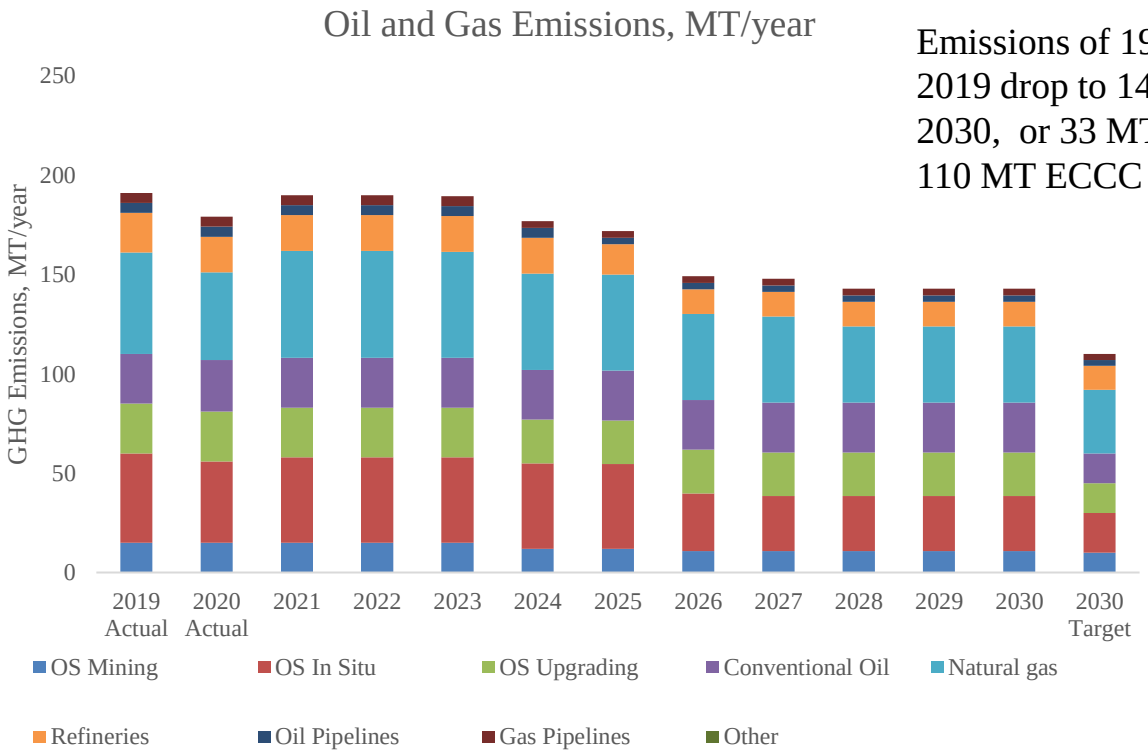
Reasons why Model Forecasts ERP 2030 Target for GHG Emissions Will Not be Met

- The major tools to lower emissions are cogeneration, carbon capture, utilization and storage (CCUS), Direct Air Capture (DAC), renewable fuels, renewable power, reducing methane leaks, replacing natural gas with another energy source such as small modular reactors (SMRs) to generate steam and the use of solvent as opposed to steam for in situ production.

- The model concludes that the major reductions will be CCUS for 16 MT and methane emission reductions for17 MT

- Shortfall in not reaching 2030 target is caused in part by no DAC or SMRs by 2030

Forecast of Oil and Gas Emissions for Period 2020 to 2030



Emissions of 191 MT in 2019 drop to 143 MT in 2030, or 33 MT above the 110 MT ECCC ERP target.

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Methodology of Model

Methodology of Model Used to Forecast Emissions of the Oil and Gas Sector

- Model starts with data from two Government of Canada documents
  - Emissions Reduction Plan (ERP) dated March 29 2022 from ECCC
  - National Inventory Report dated April 14 2022

- These two documents are used to set the 2019 emissions and the 2030 target for emissions for the eight subsectors that comprise the oil and gas sector
  - Oil Sands Production
    - Mining
    - in situ
    - upgrading
  - Conventional oil
  - Natural gas
  - Refineries
  - Oil pipelines
  - Gas pipelines

- Model allocates emissions to these eight subsectors

Methodology of Model Used to Forecast Emissions of the Oil and Gas Sector

- There are ten companies that emit 60% of emissions in the oil and gas sector
  - Suncor
  - Cenovus
  - Canadian Natural Resources Limited (CNRL)
  - Imperial Oil
  - ConocoPhillips
  - MEG Energy
  - Shell Canada
  - Irving Oil
  - Enbridge
  - TC Energy

- The first six companies comprise the Pathways Alliance group

- The remaining 40% of emissions come from many companies that produce mostly conventional oil and particularly natural gas
  - Tourmaline, Whitecap and Crescent Point are examples of these companies

Methodology of Model Used to Forecast Emissions of the Oil and Gas Sector

- The main tools to be used to reduce emissions are
  - Cogeneration
  - Carbon capture utilization and storage (CCUS)
  - Renewable fuels
  - Renewable energy
  - Reducing methane emissions
  - Other such as using solvents instead of steam

- The model looks at the emissions of the ten companies
  - current emissions in 2019
  - announced plans and targets for emissions reductions
  - makes assumptions for how the various emissions reducing tools could be used by each of the ten companies
  - uses these assumptions to forecast emissions of each company in each year from 2019 to 2030

- For the remaining companies comprising 40% of emissions, the assumption is that they will reduce emissions by 20% from 2019 to 2030, primarily by reducing methane emissions from their natural gas production

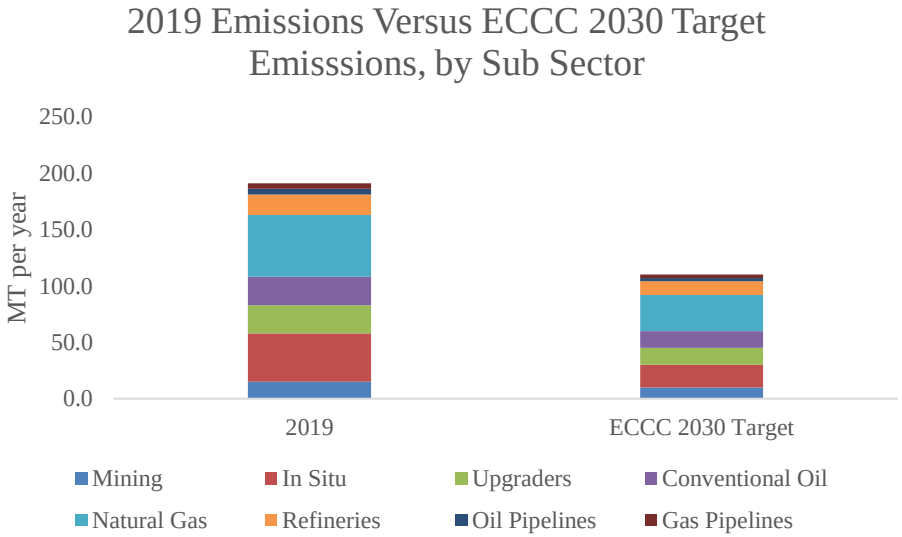
Methodology of Model Used to Forecast Emissions of the Oil and Gas Sector

- The final result is a forecast of the total emissions of the entire oil and gas sector for each year from 2019 to 2030, broken down either by
  - each of the eight sub sectors
  - each of the ten companies plus the remaining companies

Summary of 2019 Emissions and 2030 Targets for Oil and Gas Sector in Canada

Summary of ECCC 2030 Target Emission Reductions for All Sub Sectors

- ECCC 2030 Target of 110 MT assumes 81 MT reduction from the 2019 Emissions of 191 MT
- The numbers shown below are a reasonable allocation amongst these sub sectors of this 81 MT reduction
- Greatest reductions are for natural gas (methane reduction) and in situ (CCUS)



Factor analysis	
Mining	-5.0
In situ	-23.0
Upgrading	-10.0
Oil	-10.0
Natural gas	-23.0
Refining.	-6.0
Oil Pipelines	-2.0
Gas Pipelines	-2.0
Total	-81.0

Specific Numbers for Emissions of Oil and Gas Sector in Canada

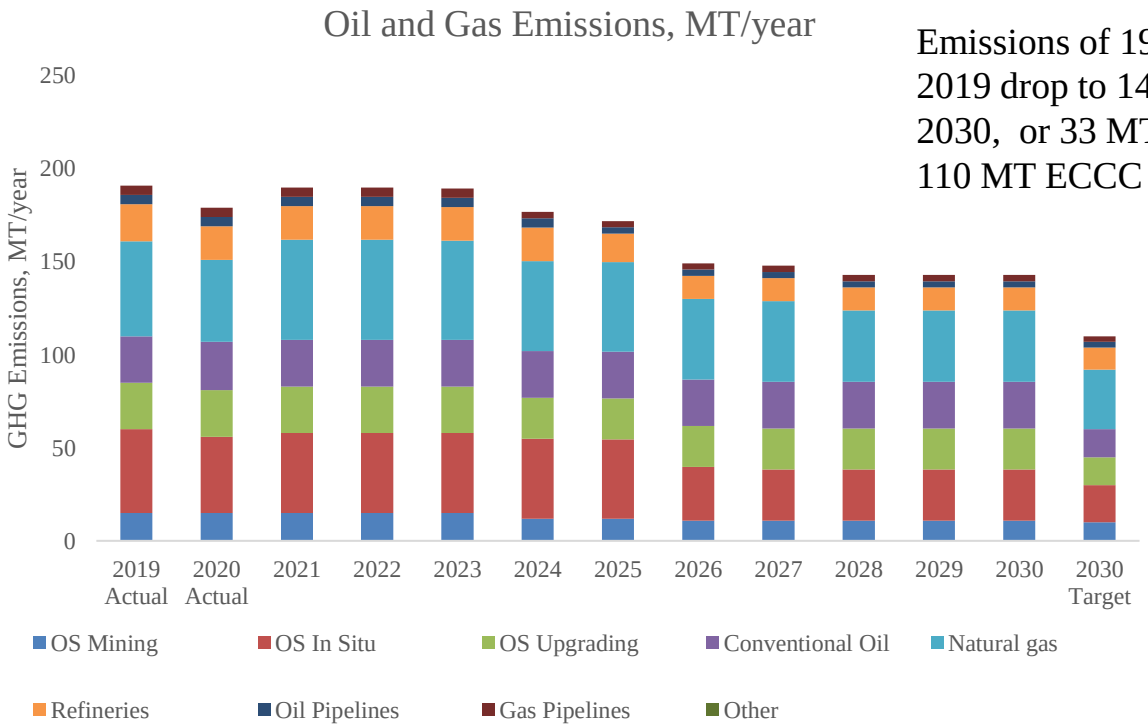
Sub Sector	2019 Emissions	2030 Emissions Target
Upstream Production		
• Mining Oil Sands	15	10
• In situ Oil Sands	43	20
• Upgraders	25	15
• Conventional Oil	25	15
• Natural Gas	55	32
Downstream		
• Refineries	18	12
• Oil Pipelines	5	3
• Gas Pipelines	5	3
Total	191	110

- Allocation of 2019 emissions in MT/year are from NIR Report and ERA Report
- Allocation of 2030 targets to each subsector is an educated guess as to the necessary reductions to meet the overall target of 110 MT
- Biggest challenge will be reducing emissions in natural gas production by reducing releases of methane

Source: ECCC National Inventory Report 1990 – 2020 dated April 14 2022

Summary of Emissions Reductions Forecasted by Model

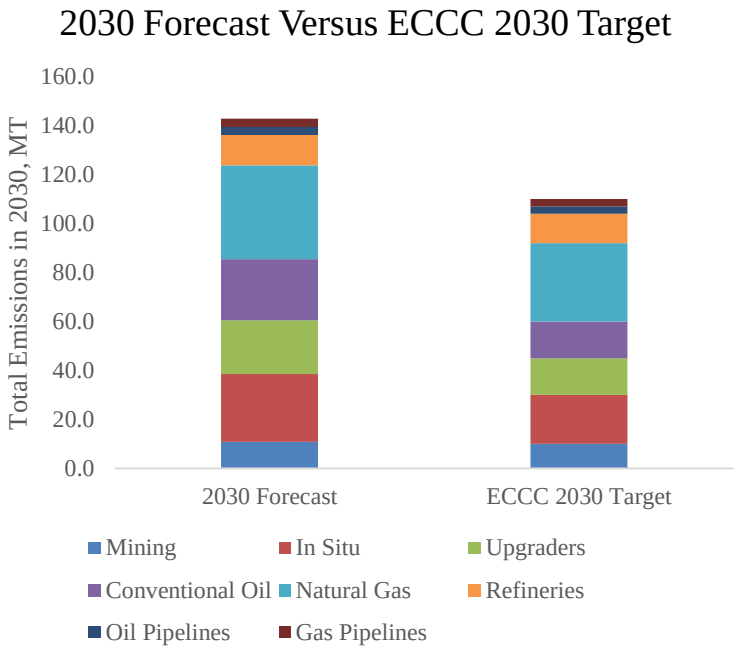
Forecast of Oil and Gas Emissions for Period 2020 to 2030



Emissions of 191 MT in 2019 drop to 143 MT in 2030, or 33 MT above the 110 MT ECCC ERP target.

Summary of Total Emission Reductions by 2030 for All Sub Sectors

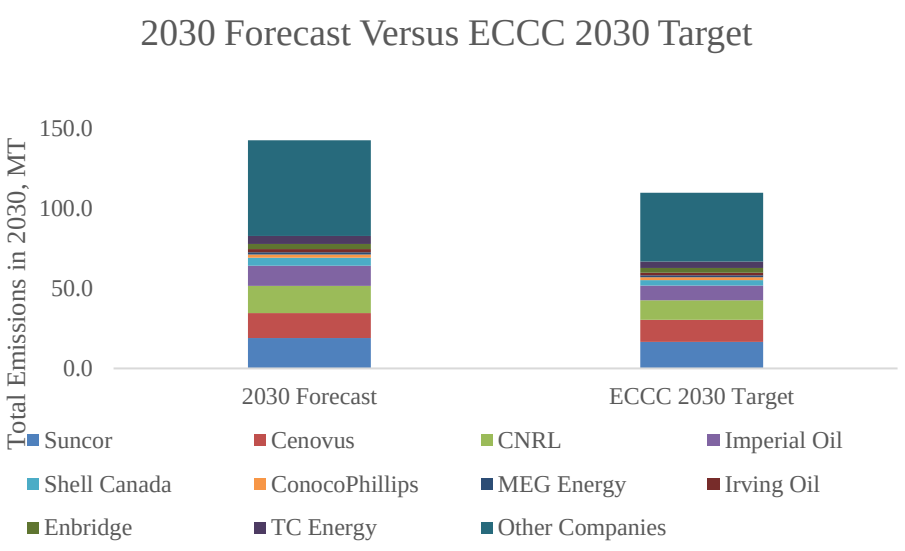
- Forecast from model shows total emissions in 2030 of 143 MT versus ECCC 2030 target of 110 MT, a shortfall of 33 MT
- Main shortfall occurs in conventional oil, natural gas and oil sands



Factor analysis	
Mining	-0.9
In situ	-7.6
Upgrading	-7.0
Oil	-10.1
Natural gas.	-6.3
Refining.	-0.4
Oil Pipelines	-0.3
Gas Pipelines	-0.4
Total	-33.0

Summary of Total Emission Reductions by 2030 for All Companies

- Forecast from model shows same total emissions in 2030 of 143 MT versus ECCC 2030 target of 110 MT, a shortfall of 33 MT
- Main shortfall occurs in other companies whose production is oil and natural gas, not oil sands



Factor analysis	
Suncor	-2.3
Cenovus	-1.8
CNRL	-4.9
Imperial Oil	-3.4
Shell Canada	-1.5
ConocoPhillips	-0.3
MEG Energy	-0.2
Irving Oil	-0.4
Enbridge	-0.4
TC Energy	-0.9
Other Companies	-16.9
Total	-33.0

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Summary of Various Methods of Reducing Emissions Used by Model

Key Variables for Oil and Gas sector

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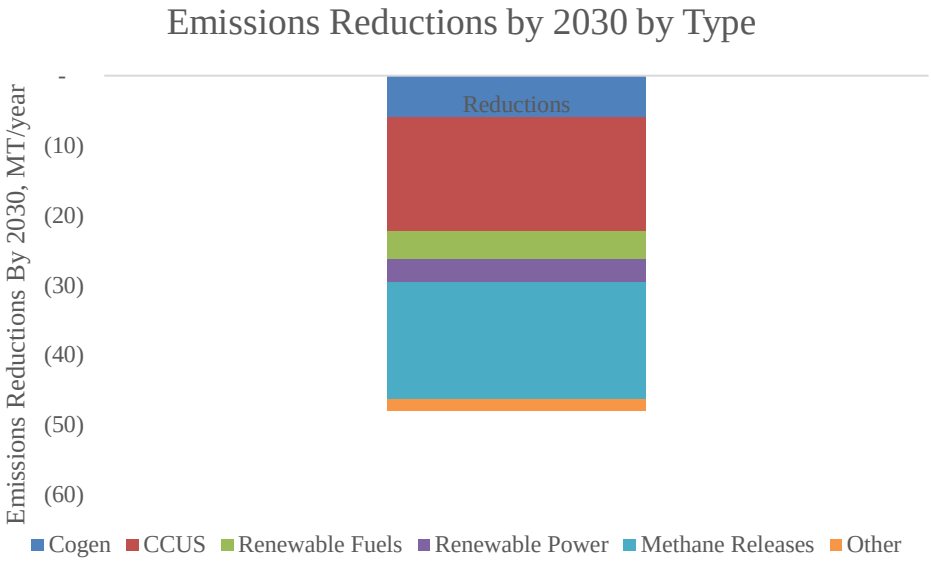
Key Variables

- Emissions intensity of oil sands producing facilities
- Rate of construction of carbon capture facilities for point of combustion
- Rate of construction of direct air capture (DAC) facilities
- Rate of adoption of small modular reactors as a source of heat
- Rate of electrification of refineries, oil pipelines and gas pipelines

Summary of Reductions from Various Types of Activity

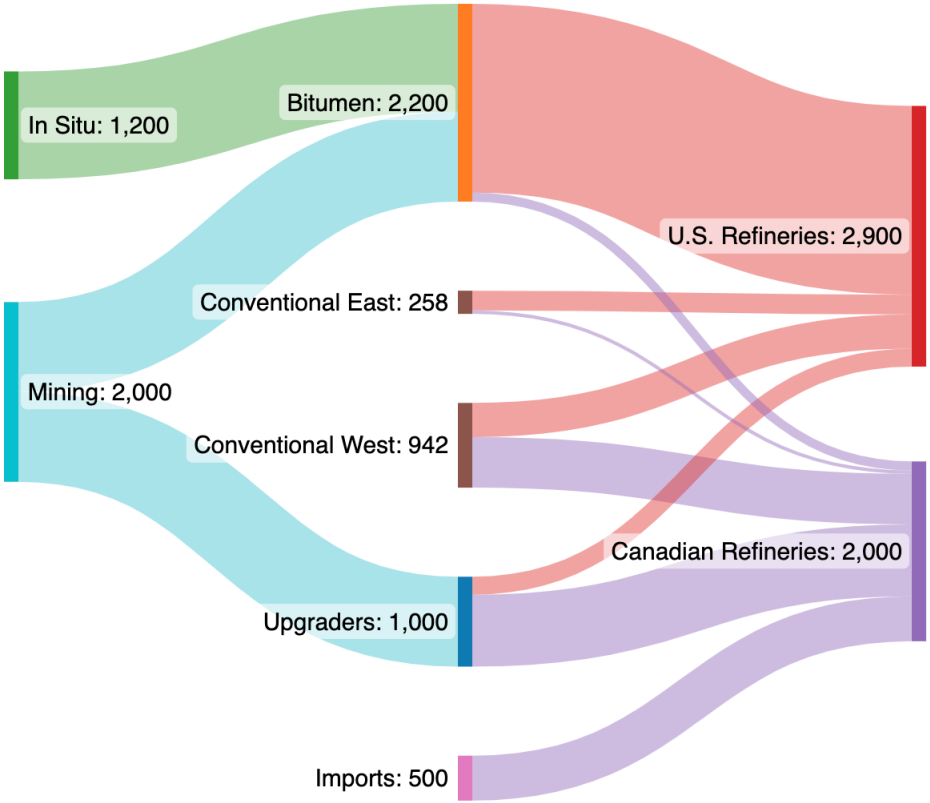
- Model forecasts emissions reduction in oil and gas sector of 48 MT by 2030 (191 MT in 2019 decreasing to 143 MT in 2030)
- Model assumes largest reductions come from reducing methane releases (17 MT) and CCUS (16 MT)
- No Direct Air Capture (DAC) or Small Modular Reactors (SMRs) are planned



Detailed Material on Data Generated by Model

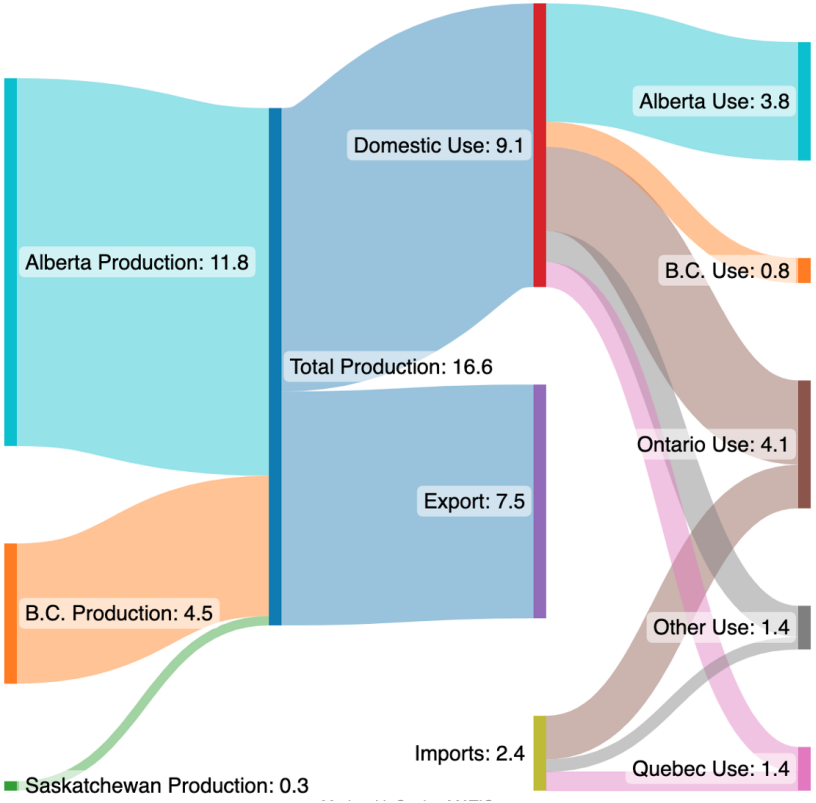
Upstream Production of Hydrocarbons in Canada

Sankey Diagram Showing Sources and Uses of Crude Oil in Canada



This chart (called a Sankey chart) shows the sources and uses of crude oil production in Canada. The numbers are in units of thousands of barrels (bbl) per day. Adding up the various numbers shows that Canada produces about 4.4 million bbl/day, of which 2.9 million bbl/day is exported to U.S. Refineries and the balance of 1.5 million bbl/day goes to Canadian Refineries. Canadian refineries in Eastern Canada also import 0.5 million bbl/day of crude oil from the United States, the Middle East and other producers.

Sankey Diagram Showing Sources and Uses of Natural Gas in Canada



About 45% of Canada's natural gas production is exported to the United States. The value of Canadian net exports (exports minus imports) was $4.9 billion in 2019. The remaining 55% is consumed in Canada, mostly for heating of buildings, generation of electricity or for industrial use. In eastern Canada, imports from the United States supply about 21% of Canada's natural gas needs.

Emissions Intensity of Crude Oil and Natural Gas Production

Type of Production	Volume, Million bbl/year	Emissions, MT/year	Emissions Intensity kg/bbl
Mining	365	15	41
Upgrading	365	25	69
In situ	438	43	98
Conventional Oil	438	25	57
Natural Gas (OEB)	973	55	57
Total	2,579	163	63

- In situ has the highest emissions intensity due to large amount of natural gas needed to heat steam for underground injection
- Upgrading requires large amount of natural gas to produce steam needed to separate bitumen from earth and then upgrade it to synthetic crude
- Mining is simple process with small steam requirements
- Natural gas emissions include methane leaks

Refineries and Pipelines in Canada

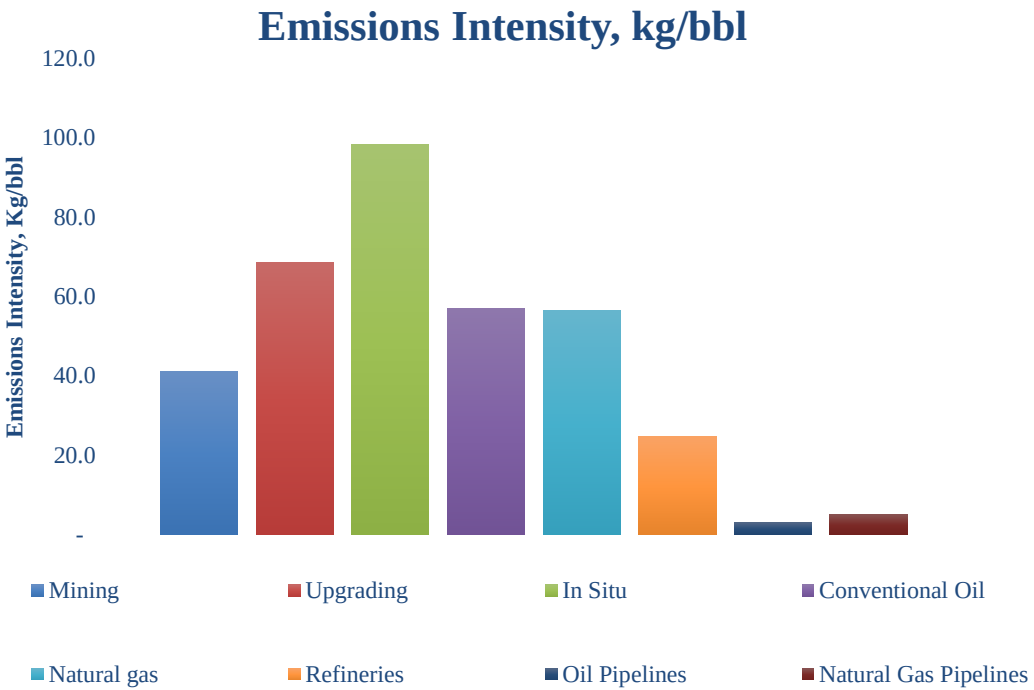
Emissions Intensity of Refineries and Pipelines Production

Type of Operation	Volume, Million bbl/year	Emissions, MT/year	Emissions Intensity kg/bbl
Refineries	730	18	25
Oil Pipelines	1,606	5	3
Natural Gas Pipelines	973	5	5
Total	3,309	28	9

- Refineries use a large amount of natural gas needed to heat steam to enable the refinery to heat crude oil and make the various refined products such as gasoline, diesel and aviation fuel

- For pipelines, a simple assumption was made that oil pipelines move all the oil produced, and natural gas pipelines move all the natural gas produced. Emissions come from natural gas and electricity used to pump the oil and compress the natural gas

Emissions Intensities of Subsectors in Oil and Gas Industry



In situ oil sands and upgrader production have the highest emissions intensity, and therefore are the best candidates for installing CCUS

Specific Steps to Reduce Emissions

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Specific Steps to Reduce Emissions in Oil and Gas Sector

- Carbon Capture, Utilization and Storage (CCUS)
  - Upgrading Production
  - In situ production
  - Mining production
  - Refinery operation
- Small modular reactors (SMRs)
  - In situ production
- Process Improvements
  - Use of solvent in in situ projects
  - New cogeneration facilities
  - Renewable Fuels
  - Renewable Energy
- Direct Air Capture

Specific Companies in the Oil and Gas Sector

Current Emissions of Specific Companies in the Oil and Gas Sector

- Determining the current emissions of specific companies can be a challenge
- Some companies publish Sustainability Reports that contain this information
- Other private or wholly-owned companies may not disclose detailed information for emissions
    - This requires making some educated assumptions and guesses based on the asset mix operated by such companies

Current Emissions of Specific Companies in the Oil and Gas Sector

- The following 10 companies comprise almost 61% of the total emissions of the Oil and Gas sector
- The model focuses on the emissions reduction plans of these 10 companies

Company	Emissions in 2019, MT	Percentage
Suncor	29	15.2%
Cenovus	24	12.6%
CNRL	21	11.0%
Imperial Oil	16	8.4%
Shell Canada	6	3.1%
ConocoPhillips	3	1.6%
MEG Energy	2	1.0%
Irving Oil	3	1.6%
Enbridge	5	2.6%
TC Energy	7	3.7%
Subtotal	116	60.7%
Other Companies	75	39.3%
Total	191	100%

Current Emissions of Companies by Sub Sector

- These 5 companies are fully integrated, with oil sands and conventional production, as well as refining operations
- Units are in MT of emissions in 2019

Subsector	Suncor	Cenovus	CNRL	Imperial Oil	Shell Canada
Oil Sands					
- Mining	5.8	0.0	4.4	3.1	1.0
- In situ	6.5	17.6	2.0	5.2	0.0
- Upgrading	11.5	0.0	2.8	3.0	2.0
Conventional Oil	0.5	4.4	9.0	0.0	0.0
Natural Gas	0.0	0.5	2.0	0.1	0.0
Refineries	4.7	1.5	0.8	4.6	3.0
Oil Pipelines	0.0	0.0	0.0	0.0	0.0
Gas Pipelines	0.0	0.0	0.0	0.0	0.0
Total	29.0	24.0	21.0	16.0	6.0

Current Emissions of Companies by Sub Sector

- These 5 companies are not fully integrated, with operations in various sub sectors
- Units are in MT of emissions in 2019

Subsector	Conoco	MEG	Irving	Enbridge	TC Energy
Oil Sands					
- Mining	0.0	0.0	0.0	0.0	0.0
- In situ	3.0	2.0	0.0	0.0	0.0
- Upgrading	0.0	0.0	0.0	0.0	0.0
Conventional Oil	0.0	0.0	0.0	0.0	0.0
Natural Gas	0.0	0.0	0.0	0.0	0.0
Refineries	0.0	0.0	3.0	0.0	0.0
Oil Pipelines	0.0	0.0	0.0	5.0	0.0
Gas Pipelines	0.0	0.0	0.0	0.0	7.0
Total	3.0	2.0	3.0	5.0	7.0

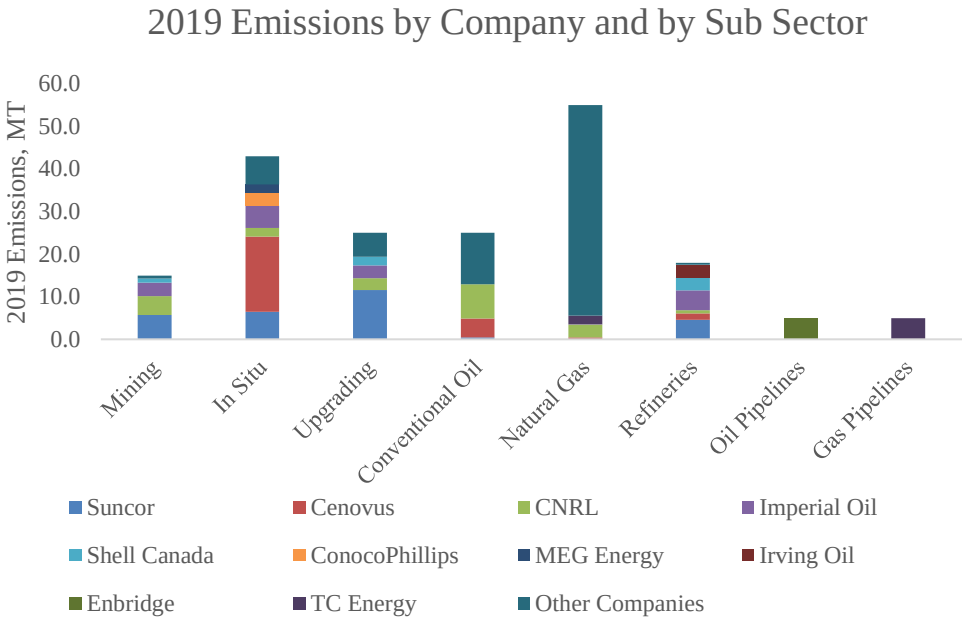
Current Emissions of Companies by Sub Sector

- These other companies comprise many mid cap companies such as Tourmaline, Whitecap, Crescent Point etc.
- Units are in MT of emissions in 2019

Subsector	Other Companies
Oil Sands	
- Mining	0.7
- In situ	6.7
- Upgrading	5.6
Conventional Oil	12.1
Natural Gas	49.4
Refineries	0.5
Oil Pipelines	0.0
Gas Pipelines	0.0
Total	75.0

- As can be seen, most of emissions from these other companies are concentrated in production of natural gas and conventional oil

Current Total Emissions by Sub Sector And Companies



- Top ten companies have most of emissions in each sub sector except for natural gas
- Natural gas production is spread amongst many mid cap companies such as Tourmaline, Whitecap, Crescent Point etc.

Specific Steps of Specific Companies to Reduce Emissions

Emissions of Suncor

Suncor Total Emissions in 2017 to 2021 Period

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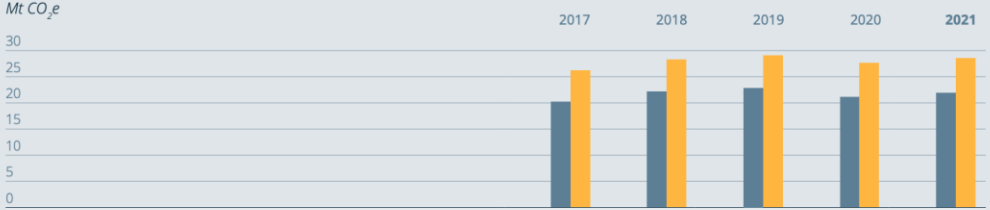
Absolute scope 1 and 2 GHG emissions

Mt CO_2e



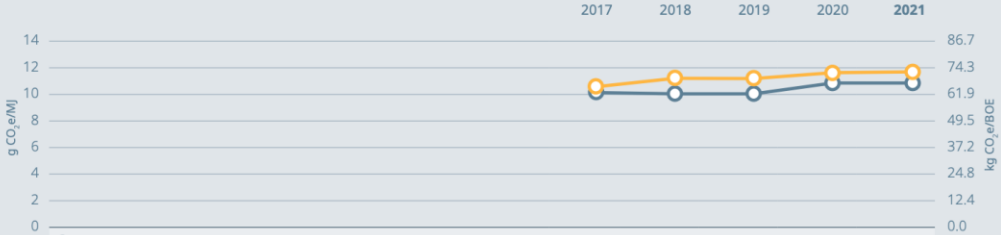
	2017	2018	2019	2020	2021
Operated total scope 1 and 2 emissions	19.88	21.99	22.72	20.86	**21.56**
Equity total scope 1 and 2 emissions	25.94	28.00	29.00	27.70	**28.45**
Operated total upstream and downstream net production *(million BOE)*	305.24	339.33	351.28	299.02	**309.92**
Equity total upstream and downstream net production *(million BOE)*	381.89	393.23	410.09	372.16	**383.40**

		Equity (%)	2017	2018	2019	2020	2021
Oil Sands Base Plant – Mining, Extraction	operated	100.00	3.82	3.30	3.95	3.80	**3.74**
Oil Sands Base Plant – Upgrading	operated	100.00	4.64	4.57	4.69	4.27	**4.29**
Oil Sands Fort Hills	operated	54.11	NA*	2.15	2.26	1.95	**1.88**
Oil Sands In Situ	operated	100.00	5.42	6.28	5.98	5.73	**6.54**
Syncrude – Mining, Extraction, Upgrading	non-operated***	58.74	6.10	6.91	7.18	7.26	**7.34**
Exploration and Production Canada	operated	48.00	0.65	0.62	0.52	0.00	**0.00**
Exploration and Production	non-operated	25.68	0.39	0.47	0.45	0.49	**0.42****
Refining and Logistics	operated	100.00	5.19	4.92	5.15	4.97	**4.96**
Renewable Fuels	operated	100.00	0.16	0.16	0.17	0.14	**0.14**
Renewable Power	operated	75.00	0.00	0.00	0.00	0.00	**0.00**

https://sustainability-prd-cdn.suncor.com/-/media/project/ros/shared/documents/climate-reports/2022-climate-report-en.pdf?modified=20220912201304&_ga=2.216044702.905057178.1663561720-7610438.1663561720&_gac=1.83094116.1663561726.CjwKCAjwg5uZBhATEiwAhhRLHhzwudQWs5U2X-EtXt7pW27XAO1h6hUpvdjoLfwdGMfzTDrRk3cenhoCWqgQAvD_BwE

Suncor Emissions Intensity in 2017 to 2021 Period

Scope 1 and 2 GHG emissions intensity



	2017	2018	2019	2020	2021
Operated total scope 1 and 2 emissions intensity (g/MJ)	10.31	10.04	10.07	10.89	**10.86**
Equity total scope 1 and 2 emissions intensity (g/MJ)	10.72	11.19	11.16	11.72	**11.84**

Suncor uses a conversion of 1 g CO_2e/MJ = 6.193 kg CO_2e/BOE

		Equity (%)	2017	2018	2019	2020	2021
Oil Sands Base Plant – Mining, Extraction	operated	100.00	5.96	6.13	6.47	6.80	**6.45**
Oil Sands Base Plant – Upgrading	operated	100.00	5.37	5.93	5.45	5.05	**5.11**
Oil Sands Fort Hills	operated	54.11	NA*	6.10	5.31	6.36	**7.00**
Oil Sands In Situ	operated	100.00	9.20	9.40	9.90	10.30	**9.88**
Syncrude – Mining, Extraction, Upgrading	non-operated***	58.74	20.32	21.11	18.61	19.87	**19.67**
Exploration and Production Canada	operated	48.00	8.90	8.80	7.50	0.00	**0.00**
Exploration and Production	non-operated	25.68	1.70	2.40	2.20	2.16	**2.51****
Refining and Logistics	operated	100.00	5.10	5.00	5.00	5.39	**5.44**
Renewable Fuels[12]	operated	100.00	28.10	27.90	29.50	29.50	**28.44**
Renewable Power	operated	75.00	0.00	0.00	0.00	0.00	**0.00**

https://sustainability-prd-cdn.suncor.com/-/media/project/ros/shared/documents/climate-reports/2022-climate-report-en.pdf?modified=20220912201304&_ga=2.216044702.905057178.1663561720-7610438.1663561720&_gac=1.83094116.1663561726.CjwKCAjwg5uZBhATEiwAhhRLHhzwudQWs5U2X-EtXt7pW27XAO1h6hUpvdjoLfwdGMfzTDrRk3cenhoCWqgQAvD_BwE

Suncor Emissions

- Suncor emissions have been essentially flat from 2017 to 2021 at about 21 MT for operated facilities and 29MT for equity facilities (includes Syncrude and non-operated conventional facilities)
- Suncor has stated that it has a target of reducing total emissions by 10 MT by 2030
- Contribution to 10 MT reduction is
    - 60% cogen
    - 15% renewable fuels
    - 15% renewable power
    - 5% solvents
    - 3% CCUS
    - 2% other

Assumed Reduction Plans of Suncor Between 2019 and 2030

- Units are in MT of emissions per year

Subsector	2019	Cogen[1]	CCUS[2]	Renewables[3]	Other	2030
Oil Sands						
- Mining	5.8	-3.0				2.8
- In situ	6.5		-2.0			4.5
- Upgrading	11.5	-3.0				8.5
Conventional Oil	0.5					0.5
Natural Gas	0.0					0.0
Refineries	4.7			-2.0		2.7
Oil Pipelines	0.0					0.0
Gas Pipelines	0.0	0.0	0.0	0.0	0.0	0.0
Total	29.0	-6.0	-2.0	-2.0	0.0	19.0

1. Cogen plant starts in 2024, reduces emissions by 6 MT per year, 50% each to mining and upgrading
2. CCUS starts in 2026, reduces in situ emissions by 2 MT per year
3. Renewable fuels and renewable energy start in 2025, I MT reduction each, reduce refinery emissions by 2 MT per year


cenovus
ENERGY

Cenovus Total Emissions in 2017 to 2021 Period

https://mc-ced23ebb-4707-4c95-9c94-3171-cdn-endpoint.azureedge.net/-/media/Project/WWW/docs/sustainability/2021/2021-esg-report.pdf?rev=45bf1a4e20464dd0bd82154411fff1db&sc_lang=en&hash=B2241BE6D75EB7F4CD0A30297BD58690

Cenovus Emissions

- Cenovus total emissions in 2019 were 24 MT on an equity basis
    - About 86% comes from combustion, most of which is natural gas to make stream for injection into in situ producing facilities
- Cenovus has set a target of reducing total emissions to 15.6 MT in 2035
- Contribution to 8.4 MT reduction is
    - 85% CCUS
    - 10% Methane reduction
    - 5% other

Assumed Reduction Plans of Cenovus Between 2019 and 2030

- Units are in MT of emissions per year

Subsector	2019	Cogen	CCUS[1]	Renewables	Other[2,3]	2030
Oil Sands						
- Mining	0.0					0.0
- In situ	17.6		-7.0		-1.3	9.3
- Upgrading	0.0					0.0
Conventional Oil	4.4					4.4
Natural Gas	0.5				-0.1	0.4
Refineries	1.5					1.5
Oil Pipelines	0.0					0.0
Gas Pipelines	0.0	0.0	0.0	0.0	0.0	0.0
Total	24.0	0.0	-7.0	0.0	-1.4	15.6

1. CCUS starts in 2026, reduces in situ emissions by 7 MT per year
2. Other reduction methods starting in 2027could include use of solvents giving a I.3 MT per year reduction
3. Reduction in methane leaks starting in 2025 reduces emissions by 0.1 MT/year


Canadian Natural

CNRL Emissions

- CNRL total emissions in 2019 were 21 MT on an equity basis
- Main steps to reduce emissions are
    - 2.2 MT per year by CCUS starting in 2026 for its mining and in situ oil sands facilities
    - 1.1 MT per year by methane emissions reductions starting in 2020 for its large natural gas production
    - 0.7 MT per year by renewable power starting in 2025 for its refining facilities

Assumed Reduction Plans of CNRL Between 2019 and 2030

- Units are in MT of emissions per year

Subsector	2019	Cogen	CCUS[1]	Renewables[2]	Other[3]	2030
Oil Sands						
- Mining	4.5		-1.1			3.4
- In situ	2.0		-1.1			0.9
- Upgrading	2.8					2.8
Conventional Oil	7.9					7.9
Natural Gas	3.0				-1.1	1.9
Refineries	0.8			-0.7		0.1
Oil Pipelines	0.0					0.0
Gas Pipelines	0.0	0.0	0.0	0.0	0.0	0.0
Total	21.0	0.0	-2.2	-0.7	-1.1	17.0

1. CCUS starts in 2026, reduces mining and in situ emissions each by 1.1 MT/yr
2. Renewable power at refineries starting in 2025 reduces emissions by 0.7 MT/yr
3. Reduction in methane leaks starting in 2020 reduces emissions by 1.1 MT/yr

Emissions of Imperial Oil

Imperial Oil Plans to Reduce Emissions

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Technology solutions

SHORT TERM

Ongoing

- Boiler flue gas
- Liquid addition to steam for enhanced recovery (LASER)
- Supporting renewable power
- Advanced fuels and lubricants
- Biofuel blending

Underway

- Renewable fuel production with low-carbon intensity hydrogen
- Solvent Assisted Steam Assisted Gravity Drainage (SA-SAGD)
- Coprocessing
- Oil Sands Pathways to Net Zero
- Autonomous haul trucks

MEDIUM TERM

Developing

- Carbon capture and storage
- Sustainable aviation fuel
- Next-generation in situ technologies
  - Cyclic solvent process (CSP) [4]
  - Enhanced bitumen recovery technology (EBRT) [5]
  - Non-condensable gas (NCG) [6]
  - Enhanced late life process (ELP) [7]

LONG TERM

Evaluating

- Low-carbon intensity hydrogen
- Advanced biofuels
- Carbon fibre from bitumen
- Carbonate fuel cell technology
- Small modular reactors (SMR)
- Direct air capture

https://www.imperialoil.ca/-/media/Imperial/Files/Publications-and-reports/Advancing-Climate-Solutions-report.pdf

Imperial Oil Emissions

- Imperial Oil total emissions in 2021 were about 16 MT on an equity basis
    - Most emissions come from combustion, most of which is natural gas to make stream for injection into in situ producing facilities such as Cold Lake and to operate its' three refineries

- Imperial Oil has set a 2030 target of reducing emissions intensity from crude oil production by 30% from 2016 levels
    - Assuming production levels remain constant, this also means a 30% reduction in total emissions by 2030
    - This implies a 3.4 MT reduction in emissions by 2030

- Contribution to 3.4 MT reduction is
    - 65% CCUS
    - 10% solvents in Cold Lake
    - 20% renewable biodiesel fuel
    - 5% other perhaps low carbon hydrogen

Assumed Reduction Plans of Imperial Oil Between 2019 and 2030

- Units are in MT of emissions per year

Subsector	2019	Cogen	CCUS[1]	Renewables[2]	Other[3,]	2030
Oil Sands						
- Mining	3.1					3.1
- In situ	5.2		-2.0		-0.4	2.8
- Upgrading	3.0					3.0
Conventional Oil	0.0					0.0
Natural Gas	0.1					0.1
Refineries	4.6			-1.0		3.6
Oil Pipelines	0.0					0.0
Gas Pipelines	0.0	0.0	0.0	0.0	0.0	0.0
Total	16.0	0.0	-2.0	-1.0	-0.4	12.6

1. CCUS starting 2026 at Cold Lake, reduces in situ emissions by 2.0 MT per year
2. Biodiesel at Strathcona refinery could reduce emissions by 1.0 MT per year
3. Other reduction methods starting in 2027 could include use of solvents giving a 0.4 MT per year reduction


Shell

Shell Canada Emissions

- Shell Canada has 2 refineries in Canada plus a portion of the Albian mining oil sands facility and upgrader
- The estimate is that Shell Canada has emissions of 6 MT per year, or about 10% of Shell's worldwide emissions of 60 MT per year
- Shell Canada has announced a CCUS facility for its' Scotford refinery

Assumed Reduction Plans of Shell Canada Between 2019 and 2030

- Units are in MT of emissions per year

Subsector	2019	Cogen	CCUS[1]	Renewables	Other	2030
Oil Sands						
- Mining	1.0					1.0
- In situ	0.0					0.0
- Upgrading	2.0					2.0
Conventional Oil	0.0					0.0
Natural gas	0.0					0.0
Refineries	3.0		-1.0			2.0
Oil Pipelines	0.0					0.0
Gas Pipelines	0.0	0.0	0.0	0.0	0.0	0.0
Total	6.0	0.0	-1.0	0.0	0.0	5.0

1. CCUS starts in 2026, likely at Scotford Refinery, reduces refinery emissions by 1.0 MT per year


ConocoPhillips
Canada

ConocoPhillips Emissions

- ConocoPhillips main operations are in situ facilities
- The estimate is that they emit 3 MT per year
- ConocoPhillips is a member of the Pathways Alliance
- The main tool for emissions reductions for ConocoPhillips would be a CCUS facility, similar to ones being proposed by the other members of the Pathway Alliance

Assumed Reduction Plans of ConocoPhillips Between 2019 and 2030

- Units are in MT of emissions per year

Subsector	2019	Cogen	CCUS[1]	Renewables	Other	2030
Oil Sands						
- Mining	0.0					0.0
- In situ	3.0		-1.0			2.0
- Upgrading	0.0					0.0
Conventional Oil	0.0					0.0
Natural gas	0.0					0.0
Refineries	0.0					0.0
Oil Pipelines	0.0					0.0
Gas Pipelines	0.0	0.0	0.0	0.0	0.0	0.0
Total	3.0	0.0	-1.0	0.0	0.0	2.0

1. CCUS starts in 2026 at an in situ facility that would reduce emissions by 1.0 MT per year

Emissions of MEG Energy

MEG Energy Emissions

- MEG Energy's main operations are in situ facilities that emit 2 MT per year
- MEG Energy is a member of the Pathways Alliance
    - MEG Energy has announced a target of 30% emissions intensity reduction by 2030
- The main tool for emissions reductions for MEG Energy would be a CCUS facility, similar to ones being proposed by the other members of the Pathway Alliance

Assumed Reduction Plans of MEG Energy Between 2019 and 2030

- Units are in MT of emissions per year

Subsector	2019	Cogen	CCUS[1]	Renewables	Other	2030
Oil Sands						
- Mining	0.0					0.0
- In situ	2.0		-0.6			1.4
- Upgrading	0.0					0.0
Conventional Oil	0.0					0.0
Natural gas	0.0					0.0
Refineries	0.0					0.0
Oil Pipelines	0.0					0.0
Gas Pipelines	0.0	0.0	0.0	0.0	0.0	0.0
Total	2.0	0.0	-0.6	0.0	0.0	1.4

1. CCUS starts in 2026, likely at an in situ facility, reduces in situ emissions by 0.6 MT per year

Emissions of Irving Oil

Irving Oil Emissions

- Irving Oil's main operation is its' refinery in Saint John, New Brunswick that emit 3 MT per year
- Irving Oil has announced a target of 30% emissions intensity reduction by 2030
- The main tools for emissions reductions for Irving Oil would be a CCUS facility as well as renewable fuels

Assumed Reduction Plans of Irving Oil Between 2019 and 2030

- Units are in MT of emissions per year

Subsector	2019	Cogen	CCUS[1]	Renewables[2]	Other	2030
Oil Sands						
- Mining	0.0					0.0
- In situ	0.0					0.0
- Upgrading	0.0					0.0
Conventional Oil	0.0					0.0
Natural gas	0.0					0.0
Refineries	3.0		-0.5	-0.4		2.1
Oil Pipelines	0.0					0.0
Gas Pipelines	0.0	0.0	0.0	0.0	0.0	0.0
Total	3.0	0.0	-0.5	-0.4	0.0	2.1

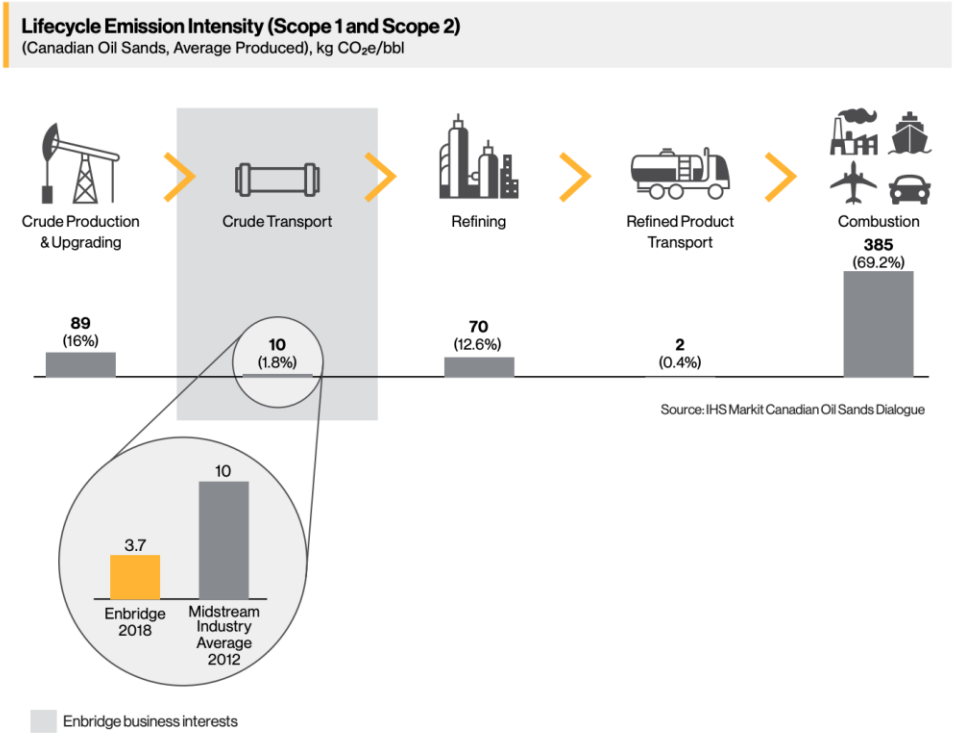
1. CCUS starts in 2026 at its' Saint John refinery to reduce emissions by 0.5 MT per year.
2. Renewable fuel facility starts in 2026 to reduce emissions by 0.4 MT per year


ENBRIDGE

Enbridge Emissions

- Enbridge's main operation is the operation of its' crude oil pipelines in Canada (Line 3, Line 9 are the main ones)
- Enbridge's emissions in 2019 in Canada were about 5 MT per year
- Enbridge has announced a target of 30% emissions intensity reduction by 2030
- The main tool for emissions reductions for Enbridge would be to increase its' use of renewable energy

Emissions For Life Cycle of Crude Oil and Liquid Hydrocarbon Products



This chart shows the average emissions intensity for the various stages of crude oil production, transportation, refining, distribution and combustion.

https://www.enbridge.com/-/media/Enb/Documents/Reports/Resilient_Energy_Infrastructure_report_FINAL.pdf?rev=cda58b294a1a4585b42b9c4649b2168f

Total Emissions For Enbridge

Environmental[1]	2017	2018
Greenhouse Gases (operational control basis)		
Business Unit Direct GHG emissions (Scope 1) *(tCO_2e)*		
LP	21,000	18,000
GTM	9,392,000	9,789,000
GDS	797,000	869,000
Power Operations	200	200
Corporate Services	4,400	4,200
Business Unit Indirect GHG emissions (Scope 2) *(tCO_2e)*		
LP	5,395,000	5,813,000
GTM	1,032,000	972,000
GDS	2,600	2,300
Power Operations	600	400
Corporate Services	6,100	7,300

https://www.enbridge.com/-/media/Enb/Documents/Reports/Resilient_Energy_Infrastructure_report_FINAL.pdf?rev=cda58b294a1a4585b42b9c4649b2168f

Emissions Intensity For Enbridge

GREENHOUSE GAS EMISSIONS INTENSITY[1,2]		
LP (Canada and U.S.)		
Greenhouse gas emissions intensity by scope tCO_2e/kbbl		
Scope 1: Direct	0.0	0.0
Scope 2: Indirect	3.6	3.7
GTM (Canada)[3,4]		
Greenhouse gas emissions intensity by scope tCO_2e/Bcf		
Scope 1: Direct	1,505	1,445
Scope 2: Indirect	0.2	19.7

This chart shows the emissions intensity or Enbridge's oil pipelines (LP) and gas pipelines (GTM).

https://www.enbridge.com/sustainability-reports/resilient-energy-infrastructure/metrics-and-targets

Assumed Reduction Plans of Enbridge Between 2019 and 2030

- Units are in MT of emissions per year

Subsector	2019	Cogen	CCUS	Renewables[1]	Other	2030
Oil Sands						
- Mining	0.0					0.0
- In situ	0.0					0.0
- Upgrading	0.0					0.0
Conventional Oil	0.0					0.0
Natural gas	0.0					0.0
Refineries	0.0					0.0
Oil Pipelines	5.0			-1.7		3.3
Gas Pipelines	0.0	0.0	0.0	0.0	0.0	0.0
Total	5.0	0.0	0.0	-1.7	0.0	3.3

1. Use of renewable energy starts in 2025 at pumping facilities and reduce emissions by 1.7 MT per year


TC Energy

TC Energy Emissions

- TC Energy has stated that it intends to reduce its' emissions intensity by 30% by 2030
- Most (71%) of emissions come from combustion to operate compressors for pipelines
- Reduction would come from electrification of power for compressors
- Emission reductions could also be achieved by reducing methane emissions

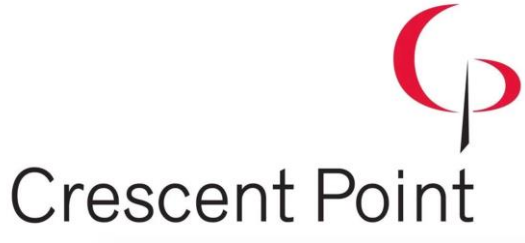
Assumed Reduction Plans of TC Energy Between 2019 and 2030

- Units are in MT of emissions per year

Subsector	2019	Cogen	CCUS	Renewables[1]	Other[2]	2030
Oil Sands						
- Mining	0.0					0.0
- In situ	0.0					0.0
- Upgrading	0.0					0.0
Conventional Oil	0.0					0.0
Natural gas	2.0				-0.5	1.5
Refineries	0.0					0.0
Oil Pipelines	0.0					0.0
Gas Pipelines	5.0	0.0	0.0	-1.6	0.0	3.4
Total	7.0	0.0	0.0	-1.6	-0.5	4.9

1. Obtain compressor power from electricity rather than natural gas starting in 2024, reduces in situ emissions by 1.6 MT per year
2. Methane release reductions of 0.5 MT per year starting in 2023

Emissions of Other Companies



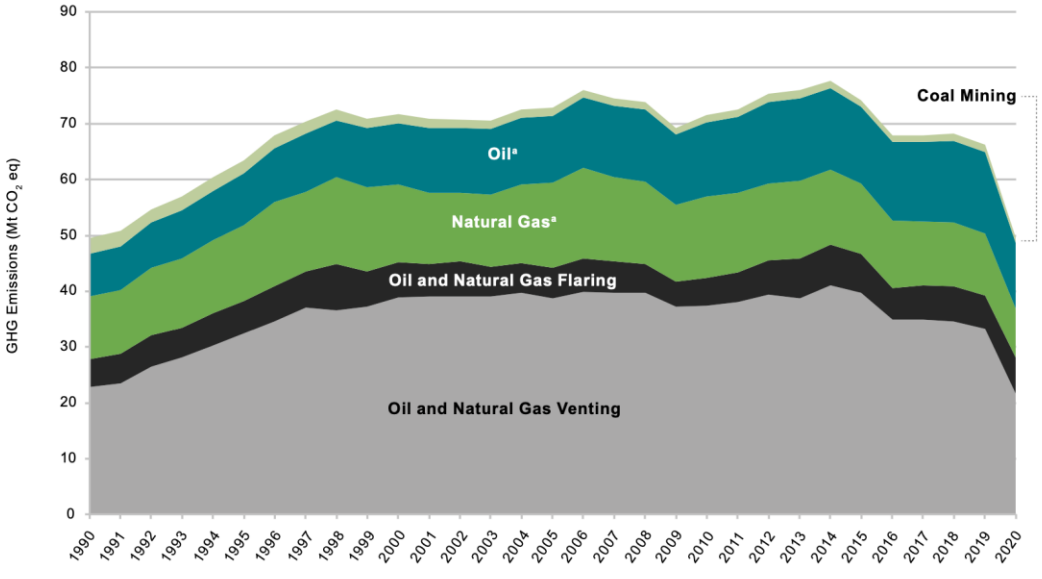
Other Company Emissions

- Other companies emissions in 2019 were 75 MT in 2019
  - 49.4 MT from natural gas, 12.4 from conventional oil
- Biggest method of reductions is reducing methane emissions
- ECCC publication indicates that reduction of methane emissions by 2030 of 15 MT is a realistic number

Methane Emissions from Various Sources

- Extract from April 14 2022 NIR shows methane emissions

Figure 2–18 **Trends in Canadian GHG Emissions from Fugitive Sources (1990–2020)**



Note:
a. These categories represent fugitive releases due to leakage from oil and natural gas systems.

Methane Emissions from Various Sources

- Extract from April 14 2022 NIR shows methane emissions

Table 2–7 **GHG Emissions from Fugitive Sources, Selected Years**

GHG Source Category	GHG Emissions (Mt CO_2 eq)								Change (%)	
	1990	2005	2015	2016	2017	2018	2019	2020	1990–2020	2005–2020
Fugitive Sources[a]	**50**	**73**	**74**	**68**	**68**	**68**	**66**	**50**	**0%**	**-32%**
Coal Mining	**2.8**	**1.4**	**1.1**	**1.3**	**1.2**	**1.3**	**1.4**	**1.1**	**-62%**	**-23%**
Oil and Natural Gas	**47**	**71**	**73**	**67**	**67**	**67**	**65**	**49**	**4%**	**-32%**
Oil[b]	7.7	12	14	14	14	15	15	12	52%	-2%
Natural Gas[b]	11	15	13	12	11	11	11	8.7	-22%	-43%
Venting	23	39	40	35	35	35	33	22	-5%	-44%
Flaring	5.1	5.5	6.9	5.7	6.0	6.3	6.1	6.4	27%	17%

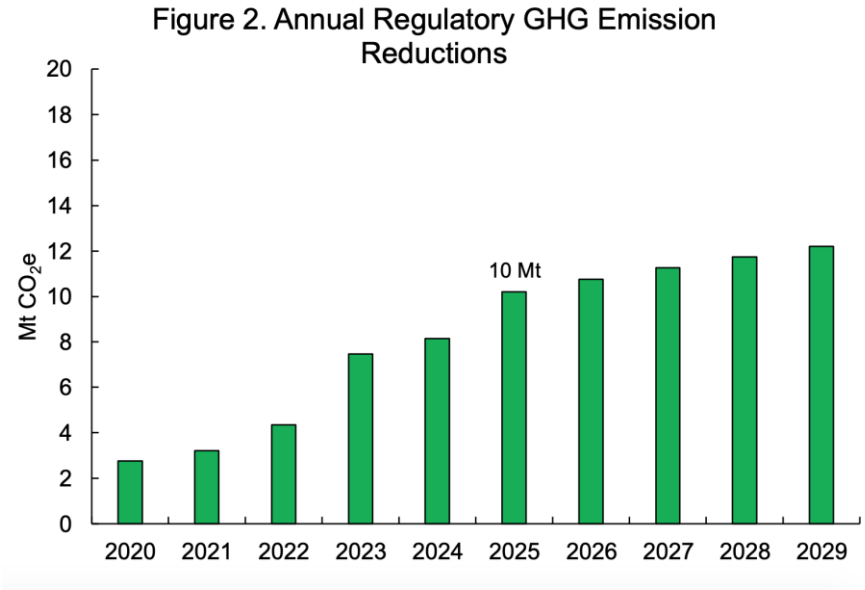
Notes:

a. Totals may not add up due to rounding.

b. These categories represent fugitive releases due to leakage from oil and natural gas systems.

- Methane emissions from
  - oil and gas producers was about 37 MT/year
  - Oil and gas pipelines was about 12 MT/year
- Total methane emissions dropped by 16 MT from 2019 to 2020

Emissions of Other Companies



- Extract from 2021 report of ECCC showing anticipated reduction in methane emissions

https://www.canada.ca/en/environment-climate-change/services/canadian-environmental-protection-act-registry/review-methane-regulations-upstream-oil-gas-sector.html

Assumed Reduction Plans of Other Companies Between 2019 and 2030

- Units are in MT of emissions per year

Subsector	2019	Cogen	CCUS	Renewables	Methane[1,]	2030
Oil Sands						
- Mining	0.7					0.7
- In situ	6.7					6.7
- Upgrading	5.6					5.6
Conventional Oil	12.1					12.1
Natural Gas	49.4				-15.0	34.4
Refineries	0.5					0.5
Oil Pipelines	0.0					0.0
Gas Pipelines	0.0	0.0	0.0	0.0	0.0	0.0
Total	75.0	0.0	0.0	0.0	-15.0	60.0

1. Assumes that these other companies will reduce methane releases by 15 MT per year by 2030, in line with federal announced targets

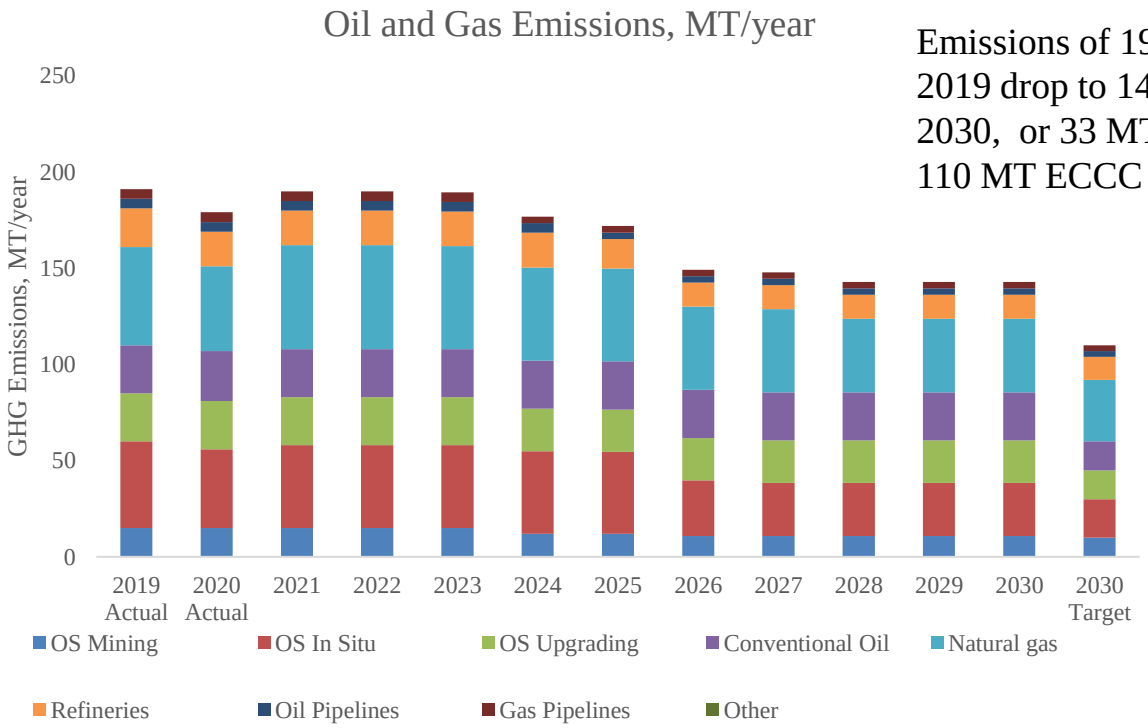
Summary of Total Emission Reductions by 2030 for All Sub Sectors and All Companies

Emissions for 2019, ECCC Target for 2030 and 2030 Forecast of Model, by Sub Sector

- ECCC 2030 Target of 110 MT assumes 81 MT reduction from the 2019 Emissions of 191 MT
- The numbers shown below are a reasonable allocation amongst these sub sectors of this 81 MT reduction

Subsector	2019	2030 ECCC Target	2030 Model Forecast
Oil Sands			
- Mining	15.0	10.0	11.0
- In situ	43.0	20.0	28.0
- Upgrading	25.0	15.0	22.0
Conventional Oil	25.0	15.0	25.0
Natural Gas	55.0	32.0	38.0
Refineries	18.0	12.0	12.0
Oil Pipelines	5.0	3.0	3.0
Gas Pipelines	5.0	3.0	3.0
Total	191.0	110.0	143.0

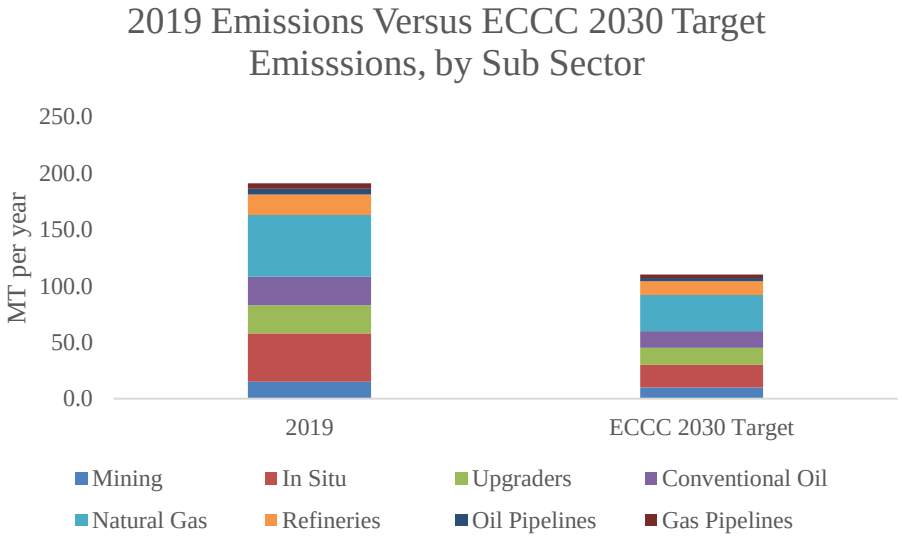
Forecast of Oil and Gas Emissions for Period 2019 to 2030



Emissions of 191 MT in 2019 drop to 143 MT in 2030, or 33 MT above the 110 MT ECCC ERP target.

Summary of ECCC 2030 Target Emission Reductions for All Sub Sectors

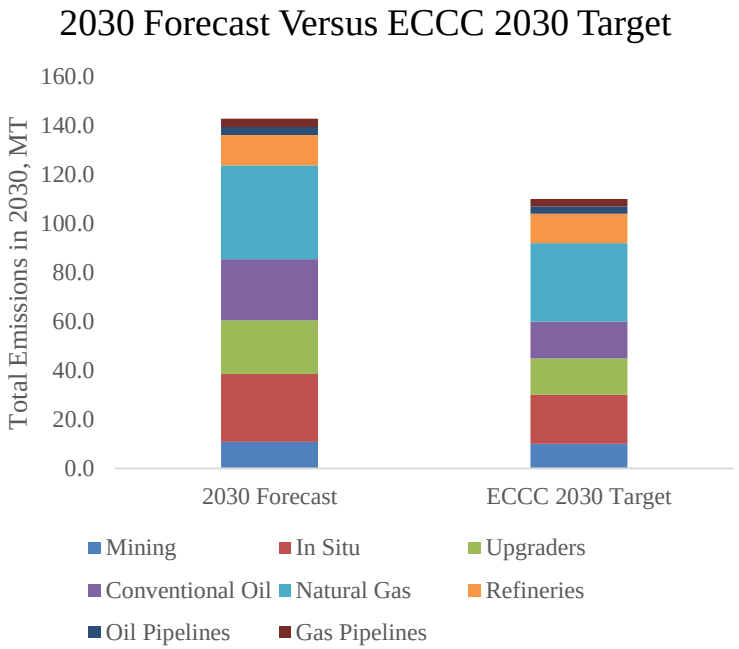
- ECCC 2030 Target of 110 MT assumes 81 MT reduction from the 2019 Emissions of 191 MT
- The numbers shown below are a reasonable allocation amongst these sub sectors of this 81 MT reduction
- Greatest reductions are for natural gas (methane reduction) and in situ (CCUS)



Factor analysis	
Mining	-5.0
In situ	-23.0
Upgrading	-10.0
Oil	-10.0
Natural gas	-23.0
Refining	-6.0
Oil Pipelines	-2.0
Gas Pipelines	-2.0
Total	-81.0

Summary of Total Emission Reductions by 2030 for All Sub Sectors

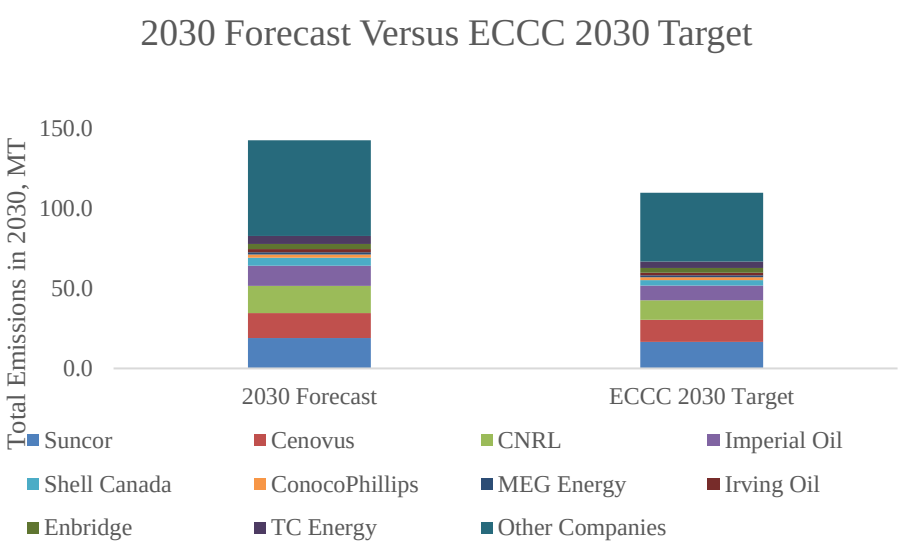
- Forecast from model shows total emissions in 2030 of 143 MT versus ECCC 2030 target of 110 MT, a shortfall of 33 MT
- Main shortfall occurs in conventional oil, natural gas and oil sands



Factor analysis	
Mining	-0.9
In situ	-7.6
Upgrading	-7.0
Oil	-10.1
Natural gas.	-6.3
Refining.	-0.4
Oil Pipelines	-0.3
Gas Pipelines	-0.4
Total	-33.0

Summary of Total Emission Reductions by 2030 for All Companies

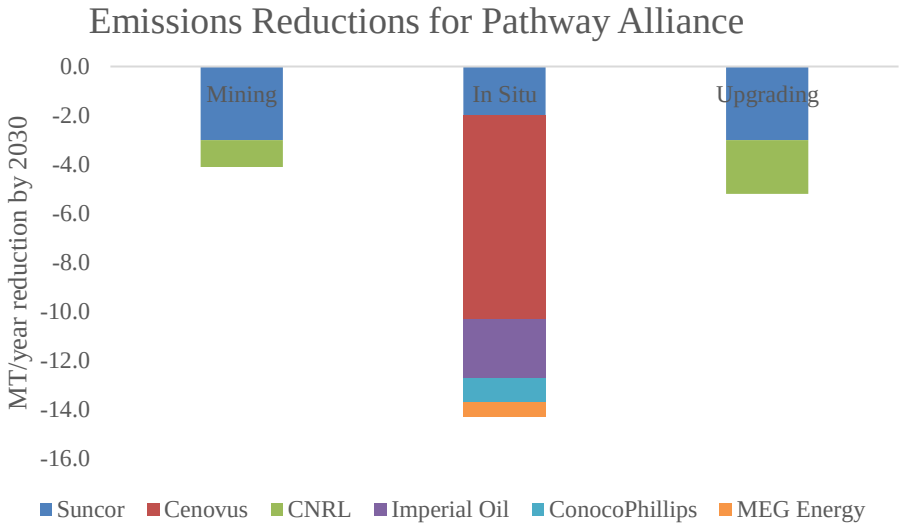
- Forecast from model shows same total emissions in 2030 of 143 MT versus ECCC 2030 target of 110 MT, a shortfall of 33 MT
- Main shortfall occurs in other companies whose production is oil and natural gas, not oil sands



Factor analysis	
Suncor	-2.3
Cenovus	-1.8
CNRL	-4.9
Imperial Oil	-3.4
Shell Canada	-1.5
ConocoPhillips	-0.3
MEG Energy	-0.2
Irving Oil	-0.4
Enbridge.	-0.4
TC Energy.	-0.9
Other Companies	-16.9
Total	-33.0

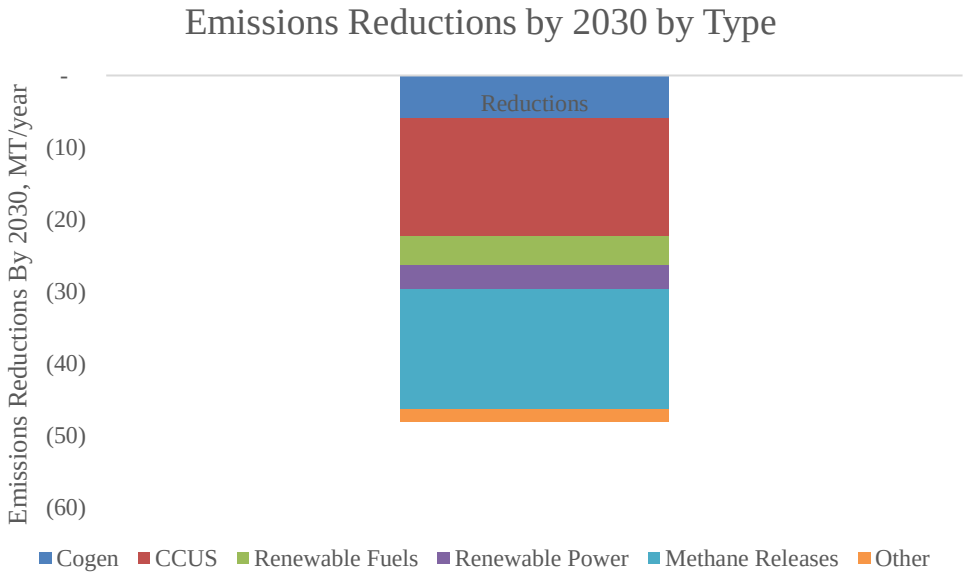
Summary of Reductions for Six Companies In Pathways Alliance

- Six companies in Pathways alliance (Suncor, Cenovus, CNRL, Imperial Oil, ConocoPhillips, MEG Energy) have publicly set a target of a 22 MT/year reduction from oil sands activities by 2030
- Model assumes that this 22 MT/year reduction will occur by 2030
- Largest reduction is in situ production, which has the largest emissions due to large amount of natural gas used for combustion to heat steam



Summary of Reductions from Various Types of Activity

- Model forecasts emissions reduction in oil and gas sector of 48 MT by 2030 (191 MT in 2019 decreasing to 143 MT in 2030)
- Model assumes largest reductions come from reducing methane releases (17 MT) and CCUS (16 MT)

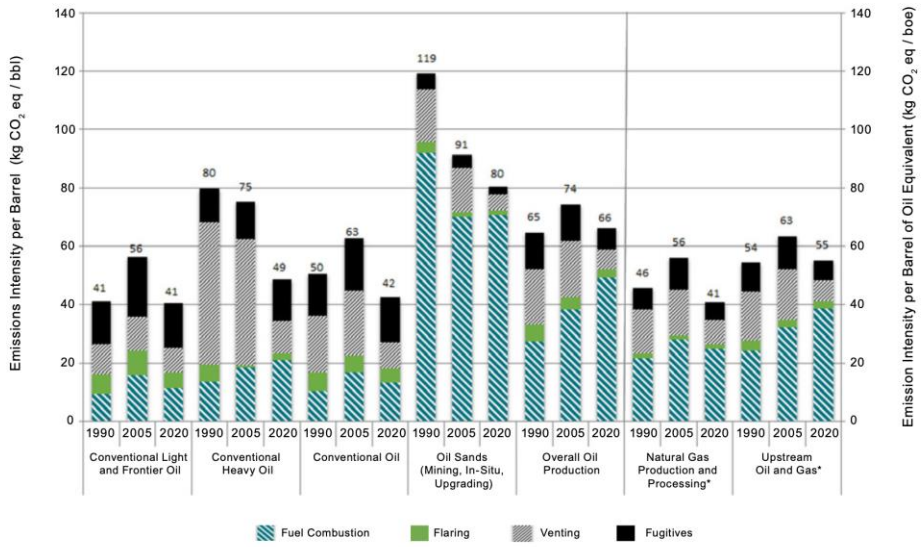


Backup Charts

Emissions Intensities of Subsectors in Oil and Gas Industry

- Extract from April 14 2022 NIR shows emissions intensity

Figure 2–27 **Emissions Intensity by Source Type for Oil and Gas (1990, 2005 and 2020)**



In situ oil sands and upgrader production have the highest emissions intensity, and therefore are the best candidates for installing CCUS

Emissions for Oil and Gas sector in National Inventory Reports April 14 2022

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Table 2–12 **Trends in GHG Emissions by Canadian Economic Sector**

	1990	2005	2015	2016	2017	2018	2019	2020
	Mt CO_2 eq							
Oil and Gas	**103**	**171**	**205**	**194**	**196**	**205**	**203**	**179**
Upstream Oil and Gas	83	148	184	173	177	186	183	160
Natural Gas Production and Processing	31	66	61	57	54	56	55	44
Conventional Oil Production	24	35	40	37	37	37	35	25
Conventional Light Oil Production	15	19	25	24	24	25	24	17
Conventional Heavy Oil Production	9.1	14	13	11	10	9.5	8.7	6.5
Frontier Oil Production	0.26	1.7	1.5	1.7	1.8	1.9	1.9	1.8
Oil Sands (Mining, In-situ, Upgrading)	15	35	73	70	77	82	83	81
Mining and Extraction	2.2	5.6	11	11	13	15	15	15
In-situ	4.5	12	38	38	42	44	43	41
Upgrading	8.4	17	24	21	22	24	25	25
Oil, Natural Gas and CO_2 Transmission	12	12	10	9.9	9.8	11	11	10
Downstream Oil and Gas	20	23	21	21	19	19	20	18
Petroleum Refining	18	22	20	20	18	18	19	17
Natural Gas Distribution	1.6	1.3	1.2	1.2	1.2	1.1	1.2	1.1

Note: Figures for conventional oil in 2019 are higher than ERA numbers for 2020. Numbers for conventional oil and refineries to be used are from 2020.

Source: ECCC National Inventory Report 1990 – 2020 dated April 14 2022