REPORT
on the outstanding base-level industrial emissions requirements (BLIERs)

Environment and Climate Change Canada
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Executive Summary

Environment and Climate Change Canada's Audit and Evaluation Branch recently undertook an evaluation of the Addressing Air Pollution Horizontal Initiative (AAPHI) – the cornerstone of the federal government's approach to addressing air pollution. The AAPHI, led by Environment and Climate Change Canada (ECCC) in collaboration with Health Canada (HC) and the National Research Council (NRC), aims to improve air quality, reduce impacts of air pollution on health and the environment, and provide Canadians with the tools to make informed decisions to reduce their exposure to indoor and outdoor air pollutants.

The Air Quality Management System (AQMS) is a central element of the AAPHI. In 2012 ministers of the environment, agreed to implement the AQMS as a comprehensive approach for improving air quality in Canada.

Base-level industrial emissions requirements (BLIERs) are a key element of AQMS. BLIERs are emission requirements that are intended to apply to major industrial sectors or equipment types to ensure that significant industrial sources achieve a good base-level of performance across the country. Since 2012, several federal regulatory and non-regulatory instruments have been put in place to establish BLIERs for many sectors, pollutants and classes of equipment targeted under AQMS.

The AAPHI Evaluation noted that despite this progress, some planned mitigation measures had not moved forward to the extent originally envisioned and that less progress than planned had been made in developing and establishing some of the BLIERs, including regulations to reduce emissions from the petroleum refining sector. These BLIERs are considered to be "outstanding".

The AAPHI Evaluation recommended that the federal government:

> **Advance commitments to develop and establish outstanding Base-level Industrial Emissions Requirements (BLIERs), including in regulations to address emissions from petroleum refineries.**

In particular, this report fulfills the first of three deliverables outlined in the management response to the evaluation, as follows:

> **2.1 An initial report that examines the need for outstanding BLIERs, including for refineries, in light of measures adopted since the commitment was first made, is developed and submitted for approval.**

This report summarizes results of a review of potential impacts of federal, provincial and territorial measures that have been put in place since the BLIERs discussions were completed in 2012. This information along with a review of sector emission data from ECCC's 2020 Reference Case and reported facility emissions from ECCC's National Pollutant Release Inventory (NPRI) were used to draw conclusions on whether the BLIERs have been addressed. Conclusions are summarized in **Table EX.1**.

Table EX.1: Summary of Conclusions on Outstanding BLIERs

Outstanding BLIERs	Pollutants	Outstanding BLIERs Have Been Addressed	
		Yes	No
Electricity Sector	NO_x SO_2 $PM_{2.5}$ Mercury	√	
Hydrocarbon Production and Processing Sector	VOCs	√*	
Oil Sands Sector	NO_x SO_2 $PM_{2.5}$		X
Petroleum Refining Sector	NO_x SO_2 $PM_{2.5}$		X
Upstream Oil and Gas – Sour Gas Processing Sector	SO_2		X
Chemical Sector - Butyl Rubber Production	VOCs	√**	
Chemical Sector - Polyethylene (Polymer Production which includes Ethylene-based Polymer production)	VOCs		X
Chemical Sector - Carbon Black Production	NO_x	√	
Chemicals Sector - Ethanol Production, Fermentation and Grain Drying	VOCs		X
Chemical Sector - Ethylene Manufacturing from Steam Cracking	NO_x		X
Chemical and Nitrogen-based Fertilizer Sectors - Steam Methane Reformers	NO_x		X
Nitrogen-based Fertilizer Sector	NH_3		X
Iron Ore Pellets Sector	NO_x		X
Cement Plants (Grey Cement/White)	TPM	√	
Cement Plants (White Cement)	SO_2 NO_x		X

* Once proposed measures have been finalized ** Further analysis required

For any of the sources, sectors and pollutants where this initial assessment identifies that BLIERs have not been addressed, further detailed analysis would be needed to determine whether it is necessary or appropriate to recommend any potential further risk management actions.

In particular, the management response indicates that following this work, ECCC will conduct a more detailed analysis of gaps in coverage for the petroleum sector (petroleum refining, oil sands and upstream oil and gas – sour gas processing), and if warranted, develop a proposed approach to address emissions of sulphur dioxide and other air pollutants from refineries and other facilities in the petroleum sector.

Additionally, this initial report finds that further analysis should be undertaken in the chemicals and Nitrogen-based fertilizer (N-fertilizer) sector, with priority given to emissions from steam methane reformers and N-fertilizer production, as well as in the iron ore pelletizing and cement sectors. It also finds that further analysis should be undertaken for pollutants that were included in the Comprehensive Air Management System (CAMS), but not prioritized during BLIERs deliberations for AQMS, such as NO_x and VOC emissions from the pulp and paper sector. ECCC will prioritize some of this follow-up work outlined in the “Identified Future Work” section, in consideration of other governmental priorities.

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1. Introduction

Environment and Climate Change Canada's Audit and Evaluation Branch recently undertook an evaluation of the Addressing Air Pollution Horizontal Initiative (AAPHI) (ECCC 2021 a.). The AAPHI is the cornerstone of the federal government's approach to addressing air pollution. The AAPHI is led by Environment and Climate Change Canada (ECCC) in collaboration with Health Canada (HC) and the National Research Council (NRC). It aims to improve air quality, reduce impacts of air pollution on health and the environment, and provide Canadians with the tools to make informed decisions to reduce their exposure to indoor and outdoor air pollutants.

The evaluation focused on the period from FY 2016 to 2017 to the middle of FY 2019 to 2020 and included all AAPHI activities except HC's work under the National Radon Program, which will be assessed as part of separate evaluation activities. The evaluation examined questions related to relevance, efficiency and effectiveness (as per the 2016 Treasury Board Policy on Results). Lines of evidence included document and data review, key informant interviews and focus groups.

This report is in response to "Recommendation 2":

> **Advance commitments to develop and establish outstanding Base-level Industrial Emissions Requirements (BLIERs), including in regulations to address emissions from petroleum refineries.**

This report fulfills the first of three deliverables that were outlined in the management response to the evaluation, as follows:

> **2.1 An initial report that examines the need for outstanding BLIERs, including for refineries, in light of measures adopted since the commitment was first made, is developed and submitted for approval.**

The other two deliverables that are intended to fulfill *Recommendation 2* are as follows:

> **2.2 Detailed analysis of air pollution gaps and outstanding concerns related to the petroleum sector—informing recommendations on potential further risk management actions for the petroleum sector- is conducted** (December 2022)
>
> **2.3 If warranted, a proposed approach to address emissions of sulphur dioxide and other air pollutants from petroleum refineries and upgraders is developed and submitted for approval.** (December 2023)

2. Background

Air pollution is the leading environmental risk to health in Canada. By reducing air pollution, we can reduce the burden of disease from stroke, heart disease, lung cancer, and both chronic and acute respiratory diseases, including asthma, particularly to vulnerable populations. The lower the levels of air pollution, the better the cardiovascular and respiratory health of the population will be, both long- and short-term.[1] In particular, reductions of ozone and fine particulate matter

[1] WHO Press release September 22, 2021

($PM_{2.5}$) and their key precursors, sulphur dioxide (SO_2), nitrogen oxides (NO_x) and volatile organic compounds (VOCs) would lead to significant benefits to the health of Canadians and the environment. In support of this, in 2012 ministers of the environment, with the exception of Québec[2], agreed to implement the Air Quality Management System (AQMS) (CCME 2012). AQMS provides a comprehensive approach for improving air quality in Canada and identifies the roles and responsibilities of federal, provincial and territorial governments in the implementation of the system. Key elements of AQMS include:

1. Air zones – geographical areas that are used to manage local air quality within the provinces and territories in which they are located.

2. Airsheds – broad geographic areas that encompass a number of air zones and may cross provincial, territorial, and international boundaries. They provide a framework for inter-jurisdictional collaboration to address transboundary air quality issues.

3. Canadian Ambient Air Quality Standards (CAAQS) – health and environmental-based air quality objectives to further protect human health and the environment and to provide the drivers for air quality improvement across the country.

4. Air Zone Management Framework – a framework to manage air quality in air zones.

5. Base-level industrial emissions requirements (BLIERs) – emission requirements that are intended to apply to major industrial sectors or equipment types to ensure that significant industrial sources achieve a good base-level of performance.

6. Mobile Sources – work that builds on the existing range of federal, provincial and territorial initiatives aimed at reducing emissions from the transportation sector.

AQMS was informed by work that was previously done to develop the Comprehensive Air Management System (CAMS). CAMS was coordinated by an *ad hoc* Steering Committee co-chaired by Environment Canada and Alberta Environment beginning in 2009. Under CAMS, air management efforts were to be directed at all significant sources of pollution, in order to ensure an effective and equitable approach to pollution reduction.[3] During that time, the federal government led a time-limited federal, provincial and territorial (FPT) consensus-based process, with stakeholder involvement to develop BLIERs. A number of BLIERs expert groups that included industry and health- and environmental non-governmental organizations were created to carry out this work.

Under AQMS, the federal government subsequently championed the BLIERs finalization/development process working in collaboration with their provincial and territorial colleagues. The deadline for expert groups to complete the work was December 31, 2011[4], but additional work was completed without stakeholder involvement until March 2012, in an effort to

[2] Although Québec supports the general objectives of the AQMS, the province will not implement the system since the system calls for federal industrial emission requirements that duplicate Québec regulations. However, Québec is collaborating with jurisdictions on developing other elements of the system, notably air zones and airsheds.
[3] Comprehensive Air Management System A Proposed Framework to Improve Air Quality Management
[4] Rules of Engagement for the Base Level Industrial Emissions Standards (BLIERs) Sector and Equipment Expert Groups

gain FPT consensus on BLIERs. Where FPT discussions could not resolve the non-consensus, Environment Canada (EC) was to propose a recommended BLIER.

In the interest of time and resource availability to implement AQMS, priorities were identified for the industry sectors, equipment types and pollutants that would be initial focus of the work as outlined below. The pollutants covered for each of the BLIERs was determined by the Expert Groups and therefore varied from one group to another to address specific needs.

Sectors

- aluminium and alumina
- base metal smelting
- cement
- chemicals
- electricity
- fertilizers
- iron ore pellets
- iron, steel and ilmenite
- oil sands
- petroleum refining
- pipelines
- potash
- pulp and paper
- upstream oil and gas
- hydrocarbon production and processing

Classes of Equipment

- gaseous-fuel-fired boilers and heaters
- stationary spark-ignition gaseous-fuel-fired engines
- natural gas-fuelled stationary combustion turbines

Pollutants Considered

- Fine particulate matter ($PM_{2.5}$)
- Nitrogen oxides (NO_x)
- Sulphur dioxide (SO_2)
- Volatile Organic Compounds (VOCs)
- Mercury
- Total Particulate Matter (TPM)
- Ammonia (NH_3)

Since 2012, federal regulatory and non-regulatory instruments have been put in place for many of the sectors, pollutants and classes of equipment that were identified as initial priorities in the BLIERs development process. Some of these instruments are the culmination of the BLIERs work and other instruments are the result of ECCC's implementation of the Chemicals Management Plan, climate agenda and under other programs. In some cases, regulatory instruments were introduced prior to 2012 to help reduce air pollutants from off-road vehicles and engines, such as those used in agriculture, construction, forestry, and mining applications. One example is the *Off-Road Compression-Ignition Engine Emission Regulations* (ORCIEER), published in 2005, to help reduce emissions from off-road diesel engines. A full list of the federal instruments that have been put in place since 2012 that are relevant to the industrial sectors is included in **Annex 1**: Base-level Industrial Emission Requirements.

Several BLIERs expert groups did not achieve full consensus for some sources, sectors or pollutants. In other cases, consensus was achieved with all stakeholders or with federal, provincial and territorial governments, but no federal instrument was developed. As a result, instruments for a few sectors and pollutants were not developed at the conclusion of the BLIERs process. These outstanding BLIERs are the focus of this initial report.

It was also recognized that additional work would be needed in the future to determine subsequent priorities. For example, the pulp and paper sector originally considered developing BLIERs for four pollutants (SO_2, TPM, NO_x and VOCs) at the outset of CAMS, but in the interest of time focused only on SO_2 and TPM in the implementation of BLIERs under AQMS[5]. Air emissions profiles of various sectors have changed and implementation of air pollution control measure were done at different rates. In order to make informed decisions to improve air quality, reduce the impacts of air pollution on health and the environment, data collection and analysis work is needed.

In addition to BLIERs, CAAQS have been put in place for $PM_{2.5}$, ozone, SO_2, and NO_x. CAAQS are now in place for 2020 for all four pollutants, while more stringent standards for ozone, SO_2, and NO_x come into force in 2025. The CAAQS for $PM_{2.5}$ is currently under review with the objective of establishing a more stringent 2025 standard.

2.1. Definition of BLIERs

Expert Groups consisting of representatives from federal, provincial and territorial governments, industry, health and environmental non-governmental organizations began working together in 2009, first under CAMS and subsequently under AQMS to reach consensus on BLIERs for key sectors, sources and equipment types. The following definition of a BLIER was provided to all working groups:

> The BLIERs are intended to be quantifiable requirements that could be reflected in regulations or permits applicable to new or existing facilities/units/equipment and may include equipment standards, process standards, facility standards, fuel-based standards or a combination. Qualitative requirements would be applied where it is not feasible to implement a numerical emission limit.
>
> The stringency of BLIERs should match what leading jurisdictions – inside or outside Canada – require for comparable industrial sources in attainment areas (areas where air quality standards are being met without the highly stringent requirements designed to address severe air quality issues), adjusted where necessary for Canadian circumstances. A BLIER should ensure that all significant industrial sources in Canada, regardless of the air quality where facilities are located, meet a good base-level of environmental performance.
>
> BLIERs within a sector may be different for existing and new facilities/units/equipment with requirements for new being particularly important in sectors which anticipate significant growth. In addition, some sources within a sector may already meet BLIER performance levels, particularly where BLIERs are based on an existing provincial permit or regulation that is currently the best standard in an attainment area for the sector.

[5] Code of practice for the management of air emissions from pulp and paper facilities

2.2. Summary of Outstanding BLIERs

Following is the list of the outstanding BLIERs showing the pollutants that were the focus of the discussions, the current number of active facilities and the coverage in terms of what aspects of the sources and sectors were being considered by the expert groups (**Table 2.1**: Outstanding BLIERs

).

Table 2.1: Outstanding BLIERs

Sector / Equipment	Pollutants	Current Number of Active Facilities in Each Province/Territory in 2021	Proposed Coverage
Electricity Sector	NO_x SO_2 $PM_{2.5}$ Mercury	Canada (>150 units)	Units combusting coal and/or petcoke; Units combusting oil or employing gasification or Carbon Capture & Storage technologies; and Units combusting natural gas, biomass or landfill gas in boilers.
Hydrocarbon Production and Processing Sector	VOCs	Canada (>45,000)	New and existing: Similar sources such as equipment leaks, storage and loading at production and processing plants, including upstream oil and gas, oil sands, petroleum refining and some chemical sectors
Oil Sands Sector	NO_x SO_2 $PM_{2.5}$	AB (37) SK (1)	New and existing sulphur recovery: Upgraders and in-situ New and existing boilers and heaters: non-gaseous and alternative gaseous fuel In-use mine fleet
Petroleum Refining Sector	NO_x SO_2 $PM_{2.5}$	BC (2) AB (5) SK (2) ON (5) QC (2) NB (1)	New and existing facilities including all relevant sources.
Upstream Oil and Gas – Sour Gas Processing Sector	SO_2	BC (8) AB (62) SK (10)	New and existing sour gas processing Includes sulphur recovery

Sector / Equipment	Pollutants	Current Number of Active Facilities in Each Province/Territory in 2021	Proposed Coverage
Chemical Sector - Butyl Rubber Production	VOCs	ON (1)	New and existing slurry tanks used in synthetic rubber production
Chemical Sector - Polyethylene (Polymer Production which includes Ethylene-based Polymer production)	VOCs	AB (4) ON (3)	New and existing facilities
Chemical Sector - Carbon Black Production	NO_x	ON (2) Furnace AB (1) Thermal	Existing furnace and thermal carbon black manufacturing facilities
Chemicals Sector - Ethanol Production, Fermentation and Grain Drying	VOCs	SK (3) MB (2) ON (6) QC (1) AB (1)	New and existing facilities
Chemical Sector - Ethylene Manufacturing from Steam Cracking	NO_x	AB (2) ON (2)	New, major modified and existing facilities
Chemical and Nitrogen-based Fertilizer Sectors - Steam Methane Reformers	NO_x	AB (8) ON (2) SK (1) MB (1) QC (1)	New, major modified and existing: Nitrogen-based fertilizer, other captive hydrogen production (except refineries), or stand-alone hydrogen production facilities
Nitrogen-based Fertilizer Sector	NH_3	AB (7) ON (1) SK (1) MB (1)	New, major modified and existing: Ammonium nitrate and urea production facilities
Iron Ore Pellets Sector	NO_x	QC (1) NL (1)	New, major modification and existing facilities
Cement Plants (Grey Cement)	TPM	BC (2) AB (2) ON (5) QC (4) NS (1)	New and Existing plants
Cement Plant (White Cement)	SO_x NO_x TPM	ON (1)	New and existing plants

3. Methodology

Since 2012, a number of factors may have influenced whether there is still a need to develop a BLIERs instrument for a sector, source or pollutant. These factors may include:

- new federal, provincial or territorial measures that have been put in place to address:

    - greenhouse gases such as methane and carbon dioxide
    - air pollutants, such as NO_x, VOCs and benzene
    - the Chemicals Management Plan (CMP)
- actions by companies that have resulted in significant changes in the emissions profile of facilities/sectors, such as the installation of emission controls, process changes or facility closures
- the introduction of new measures by jurisdictions outside of Canada that may define a new "leading jurisdiction" for a given sector or source
- availability of new monitoring data
- new science or developments that improve the understanding of the effects and sources of air pollution

As outlined in the figure below, the methodology consists of two main steps. Not all of the factors noted above have been assessed as part of this report.

Step 1: Analysis of Federal, Provincial and Territorial Measures

- Federal, provincial or territorial measures that have been put in place since 2012 were reviewed to determine whether they are addressing the original objectives of the BLIERs for the sector, source and pollutant for each of the outstanding BLIERs.

Step 2: Emissions Analysis

- Where relevant, ECCC's 2020 Reference Case (Ref20) (ECCC 2021 b) was reviewed for each sector to understand the historical emissions trend and the emissions projections to 2035. Ref20 helps to see how historical emissions may have changed since 2012 or how they are expected to change in the future as a result of many of the measures identified in Step 1.

- Facility specific emissions data from 2012 and 2019 were also assessed to determine whether any substantial changes in facility emissions had occurred during that period.

Results of the two-step analysis described above were used to make a preliminary conclusion on the current need for each BLIER. Where no new federal, provincial or territorial measures were identified and the emissions trends showed no significant decline in emissions since the original need for the BLIER was identified, it was concluded that the BLIER has not yet been addressed. For any sectors or equipment types where it was determined that a need for a BLIER may still exist, further detailed analysis will be conducted by ECCC to inform any recommendations on potential further risk management actions.

Following are a number of the key considerations used in the methodology for the development of this report:

- Only readily available information was used.
- Comparisons of stringency for BLIERs was based on the original analysis that was completed in 2011/2012. However, it is acknowledged that any future analysis would need to consider updated information.
- ECCC's 2020 Reference Case (Ref20) (ECCC 2021 b.) was developed during the 2020 annual update of Canada's GHG and AP emissions projections. Ref20 was undertaken

using the Energy, Emissions, and Economy Model for Canada (E3MC) using 2018 as the last historical year. Included in the Ref20 are all policies and measures funded, legislated, and implemented by federal, provincial, and territorial governments as of September 2020. It also accounts for the expected impact of the COVID-19 pandemic and economic recession in 2020 and a gradual recovery in the following years. Ref20 includes a number of climate policies such as carbon pricing at a rate of $50/tonne from 2022 onwards (in nominal dollars), but does not include a number of the climate policies and federal investments that have been announced recently (e.g. ZEV to represent 100% of sales of new passenger vehicles from 2035 onwards). Further analysis in the future would be needed to determine how these additional measures could affect the air pollutant emissions for the outstanding BLIERs.

- The reported facility emissions data for 2012 to 2019 comes from ECCC's National Pollutant Release Inventory (NPRI) (ECCC 2021 c.) and is included in **Annex 3**: Reported Facility Emissions for Active Facilities – NPRI data from 2012 to 2019 for each sector.
- Identification of additional sources, sectors or pollutants needing further action is not within the scope of this report.

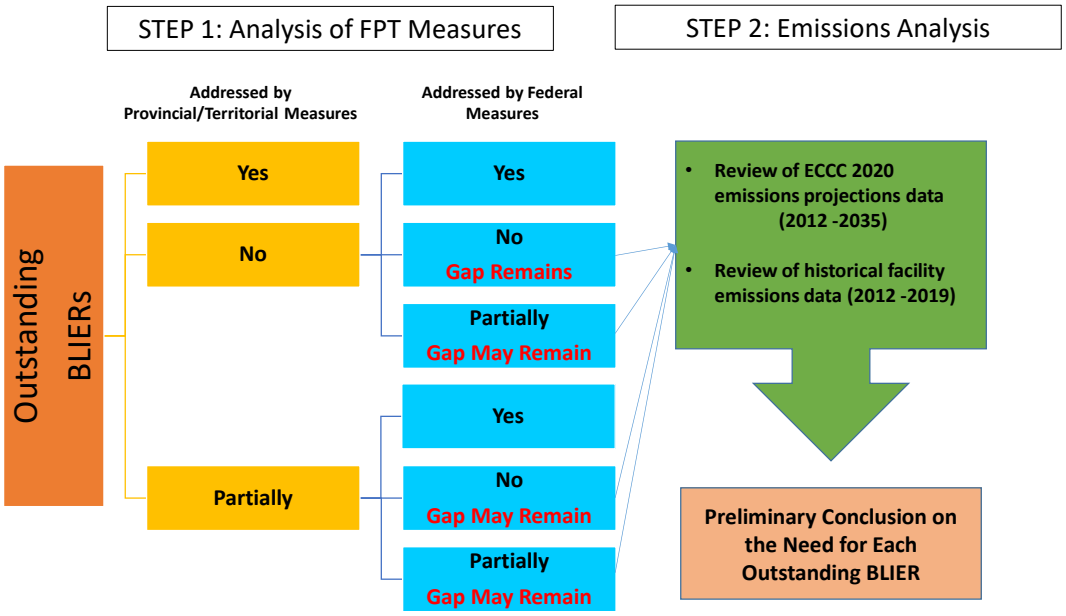

Figure 3.1: Outstanding BLIERs Methodology

4. Analysis of Each Outstanding BLIER

4.1. Electricity Sector (SO_2, NO_x, $PM_{2.5}$, Mercury)

Canada is one of the largest and most geographically diverse countries in the world and has an electricity sector that has embraced regional differences to build an efficient system. The Canadian electricity sector operates with varying geographic and air issues, existing infrastructure and generation mix, natural endowments (e.g. coal supplies, hydro potential, etc.), and regulatory, market and ownership frameworks. (BLIERs 2012 b.)

The objective of the BLIERs was to establish measures to address SO_2, NO_x, $PM_{2.5}$ and mercury emissions from the electricity sector. The Electricity Sector Expert Group prioritized BLIERs discussions into three categories:

1. Units combusting coal and/or petcoke;
2. Units combusting oil or employing gasification or Carbon Capture & Storage technologies; and
3. Units combusting natural gas, biomass or landfill gas in boilers.

Coal-fired electricity was the main area of focus for the expert group. Although no consensus was reached among governments and stakeholders during the BLIERs process for the electricity sector, a significant portion of emissions from the electricity sector is already being addressed by federal and provincial measures, including the accelerated coal phase-out. The measures to phase-out coal-fired electricity go well beyond the original objective of BLIERs, where NO_x and SO_2 emissions standards were under consideration informed by requirements in the leading jurisdictions. In addition, recent announcements to achieve net-zero for electricity generation by 2035 will go even further to reduce air pollutants from most types of electricity generation (**Table 4.1**: Federal and Provincial Instruments Addressing Electricity since 2012**)**.

Table 4.1: Federal and Provincial Instruments Addressing Electricity since 2012

Electricity Sector	Pollutants NO_x SO_2 $PM_{2.5}$ Mercury	Current Number of Active Facilities in Each Province Canada (>150 units)
Federal Instruments *Regulations Amending the Reduction of Carbon Dioxide Emissions from Coal-fired Generation of Electricity Regulations* (SOR/2012-167; SOR/2018-263). *Regulations Limiting Carbon Dioxide Emissions from Natural Gas-fired Generation of Electricity* (SOR/2018-261). *Guidelines for the Reduction of Nitrogen Oxide Emissions from Natural Gas–fuelled Stationary Combustion Turbines.* *Greenhouse Gas Pollution Pricing Act* (S.C. 2018) is an Act to mitigate climate change through the pan-Canadian application of pricing mechanisms to a broad set of greenhouse gas emission sources. *Output-Based Pricing Systems Regulations* (SOR/2019-266) a regulatory trading system under the authority of the *Greenhouse Gas Pollution Pricing Act* for industrial facilities that is administered by the Department of the Environment (the Department) and the Canada Revenue Agency. In addition, planned measures include updating ECCC's *New source emission guidelines for thermal electricity generation* which was first published in 1993. ***Provincial Instruments***		

Electricity Sector	Pollutants NO_x SO_2 $PM_{2.5}$ Mercury	Current Number of Active Facilities in Each Province Canada (>150 units)
Ontario: Subsequent to the completion of the phase-out of coal in Ontario in 2014, the *Ending Coal for Cleaner Air Act, 2015* (S.O. 2015, c. 25 - Bill 9) was enacted which stipulates that coal cannot be used in the future to generate electricity in Ontario. **Alberta:** *Alberta's Technology Innovation and Emissions Reduction System* (TIER) addresses GHG and likely achieves co-benefit air pollutant reductions. Individual power plants also have operating approvals that generally include limits for air pollutants. **Saskatchewan:** The *Management and Reduction of Greenhouse Gases (General and Electricity Producer) Regulations* (M-2.01 Reg 1) address GHGs and likely achieve co-benefit AP reductions. Individual power plants have operating permits that may include limits for air pollutants. **Nova Scotia:** *Air Quality Regulations* (O.I.C. 2020-016) address the emission of NO_x and SO_2 and would be applicable for Coal-Fired Electricity. GHG emissions from Coal units are capped under provincial *Greenhouse Gas Emissions Regulations* (O.I.C. 2013-332), which have been deemed equivalent to federal coal regulations under the current equivalency agreement. **New Brunswick:** A proposed provincial regulation, *Phasing Out of Coal-fired Electricity Generation Regulation* (21-083E), would cap GHG emissions and likely achieve co-benefit air pollutant reductions. Individual power plants have permits that generally include limits for air pollutants.		

Figures 4.1 to 4.4 show the historical emissions and projections based on the ECCC 2020 reference case. The data shown for the Utility Electric Generation sector includes all electricity generation. For SO_x and mercury, the emissions reductions by 2035 can be directly attributed to the reduction in coal-fired electricity. Reductions in emissions of NO_x and $PM_{2.5}$ are also significant with the anticipated reduction in coal-fired electricity generation. However the reduction is not as pronounced as for SO_x and mercury due to the replacement of the coal-fired electricity, in part, by electricity produced by natural gas. **Annex 3**: Reported Facility Emissions for Active Facilities – NPRI data from 2012 to 2019 includes facility specific emissions data from 2012 to 2019 for the coal-fired electricity sector. Emission reductions can be seen for some facilities for some pollutants during this period.

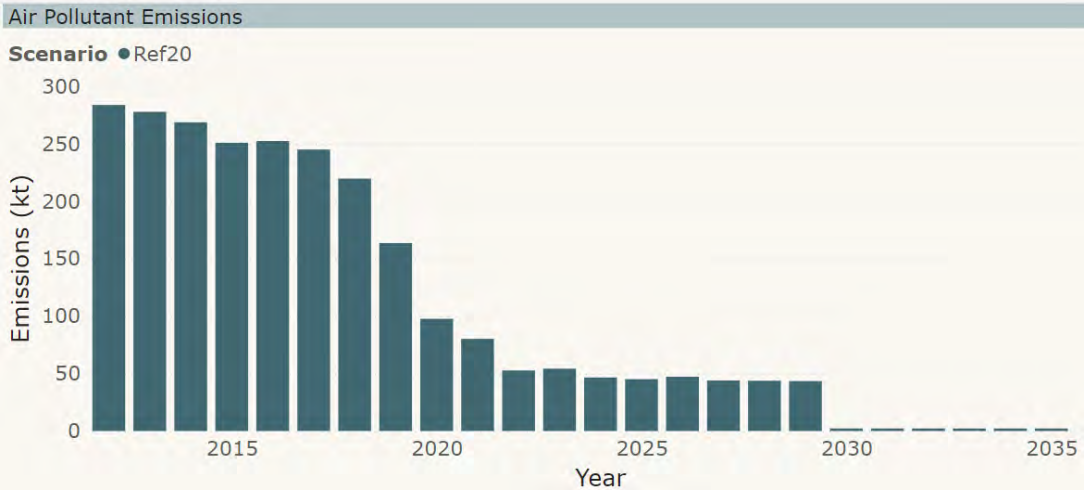

Figure 4.1: SO_x Emissions under 2020 Reference Case: Utility Electricity Generation

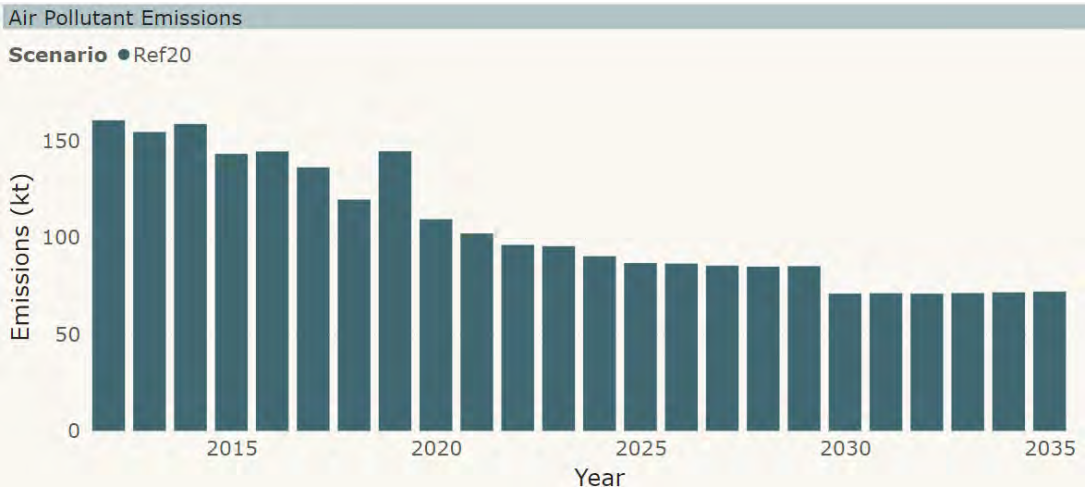

Figure 4.2: NO_x Emissions under 2020 Reference Case: Utility Electricity Generation

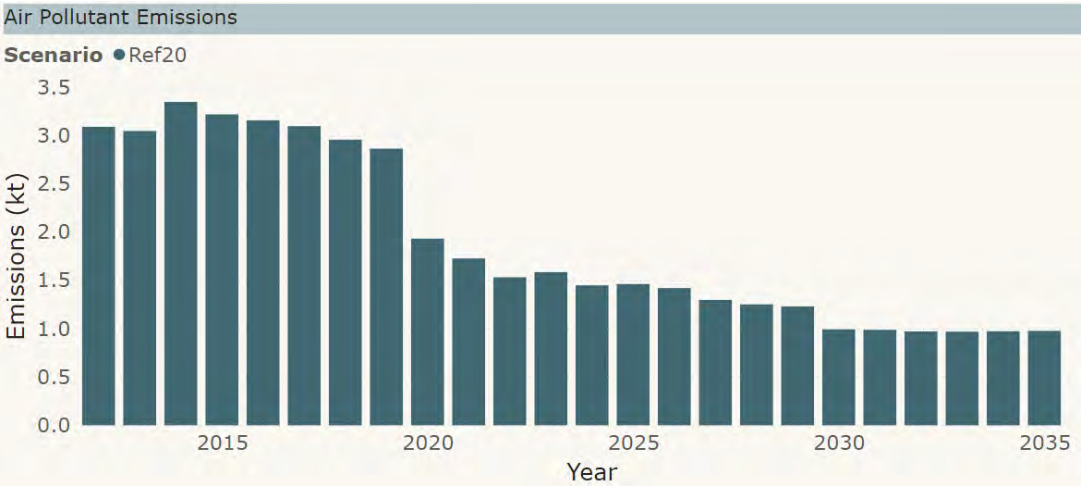

Figure 4.3: $PM_{2.5}$ Emissions under 2020 Reference Case: Utility Electricity Generation

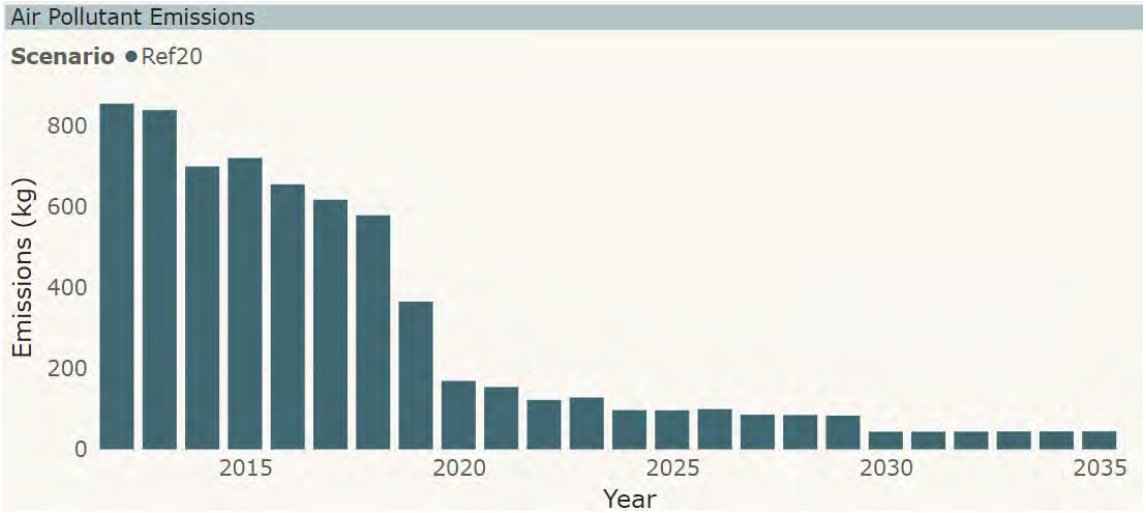

Figure 4.4: Mercury Emissions under 2020 Reference Case: Utility Electricity Generation

Conclusion

As a result of recent federal and provincial measures to address electricity generation, the original objectives for BLIERs will be achieved once all of the current and proposed measures have been fully implemented.

> **C1 -** Initial analysis indicates that BLIERs for the electricity sector are being addressed by current and proposed measures.

4.2. Hydrocarbon Production and Processing Sector – (VOCs)

Volatile organic compounds (VOCs) are carbon-containing compounds such as gasoline fumes and solvents. Many individual VOCs are known or suspected of having direct toxic effects on humans, ranging from carcinogenesis to neurotoxicity. A number of individual VOCs (e.g. benzene, dichloromethane) have been assessed to be toxic under the Canadian Environmental Protection Act, 1999, as have VOCs as a group. Reactive VOCs combine with nitrogen oxides (NOx) in photochemical reactions in the atmosphere to form ground-level ozone, a major component of smog. VOCs are also precursor pollutants to the secondary formation of fine particulate matter (PM2.5). Both ozone and PM2.5 are known to have harmful effects on human health and the environment. (BLIERs 2012 c.)

Recognizing that the VOC emissions result from similar sources (that is, emissions from equipment leaks, storage tanks and loading and unloading operations) in several sectors which produce and process hydrocarbons, a cross-sectoral approach was adopted for this BLIER. The scope included upstream and downstream petroleum, pipelines and associated storage at terminals, oil sands and chemicals sectors. Methane, which is not included in the definition of VOCs based on Schedule 1 of CEPA, is also a significant source of emissions for many of the same sources in the upstream oil and gas sector.

The working group discussions focused on reducing fugitive and venting emissions from storage, loading operations and process sources through good engineering, operating and maintenance practices.

Although no consensus was reached among governments and stakeholders during the BLIERs process, a number of actions have recently been taken by federal and provincial governments that cover a significant portion of the hydrocarbon and processing sector, including the upstream oil and gas sector and sources within the petroleum refining sector. Additionally, proposed federal instruments are expected to address additional VOC sources within the petroleum refining sector, the petroleum product and distribution sector and to a lesser degree the chemical sector. These new measures meet or exceed the original objectives of the BLIERs, which were based on CCME codes and select provincial requirements (AB, BC or SK depending on the emission source and facility type) (**Table 4.2**: Federal and Provincial Instruments Addressing Hydrocarbon Production and Processing since 2012).

Table 4.2: Federal and Provincial Instruments Addressing Hydrocarbon Production and Processing since 2012

Hydrocarbon Production and Processing	Pollutants VOCs	Current Number of Active Facilities in Each Province Canada (>45,000)
Federal Instruments *Regulations Respecting Reduction in the Release of Methane and Certain VOCs (Upstream Oil and Gas Sector)* (SOR/2018-66); *Reduction in the Release of VOCs Regulations (Petroleum Sector)* (SOR/2020-231); In addition, planned measures for storage and loading of petroleum liquids will address additional sources (facilities covered would include refineries, upgraders, terminals, bulk plants and petrochemical plants). ***Provincial Instruments*** Individual facilities may also have operating permits or approvals that are updated periodically and generally include requirements for VOCs. **British Columbia:** *Drilling and Production Regulation* (282/2010) has been amended to regulate methane emissions from the oil and gas sector in a manner equivalent to the federal methane regulations. *Air Quality Objectives for Formaldehyde* establishes a two-tiered objective comprises an "action level" and an "episode level." The action level is the target used when managing the level of formaldehyde in an airshed. **Alberta:** *Methane Emission Reduction Regulation* (244/2018) applies to all upstream oil and gas facilities except processing plants approved under section 11 of the *Oil Sands Conservation Act* (RSA 2000). **Saskatchewan:** The *Oil and Gas Emissions Management Regulations* (O-2 Reg 7) came into effect January 1, 2019, and was deemed equivalent to federal methane regulations. **Ontario:** Ontario's industry standards as defined in section 1 of *O. Reg. 419/05* address emissions of benzene (petroleum refining and petrochemical manufacturing) and 1,3-butadiene (petrochemical manufacturing). https://www.ontario.ca/document/technical-standards-manage-air-pollution/petroleum-refining-industry-standard		

Hydrocarbon Production and Processing	Pollutants VOCs	Current Number of Active Facilities in Each Province Canada (>45,000)
https://www.ontario.ca/document/technical-standards-manage-air-pollution/petrochemical-industry-standard		

Figure 4.5: Fugitive and Venting VOC Emissions under 2020 Reference Case: Upstream Oil and Gas shows the historical emissions and projections for VOCs from fugitive and venting from the upstream oil and gas sector based on the ECCC 2020 reference case. The federal *Regulations Respecting Reduction in the Release of Methane and Certain VOCs (Upstream Oil and Gas Sector)* are included in the reference case and are contributing to significant emission reductions.

Figure 4.6: VOC Emissions Under 2020 Reference Case: Petroleum Product and **Figure** 4.7: VOC Emissions Under 2020 Reference Case: Chemicals and Fertilizers show the historical emissions and projections for VOCs for the petroleum products sector and the chemicals sector. The federal *Reduction in the Release of VOCs Regulations (Petroleum Sector)* and the planned federal measures for storage and loading of petroleum liquids are not included in the projection data. Due to the number of facilities under this BLIER, no facility specific emissions data has been included in **Annex 3**: Reported Facility Emissions for Active Facilities – NPRI data from 2012 to 2019.

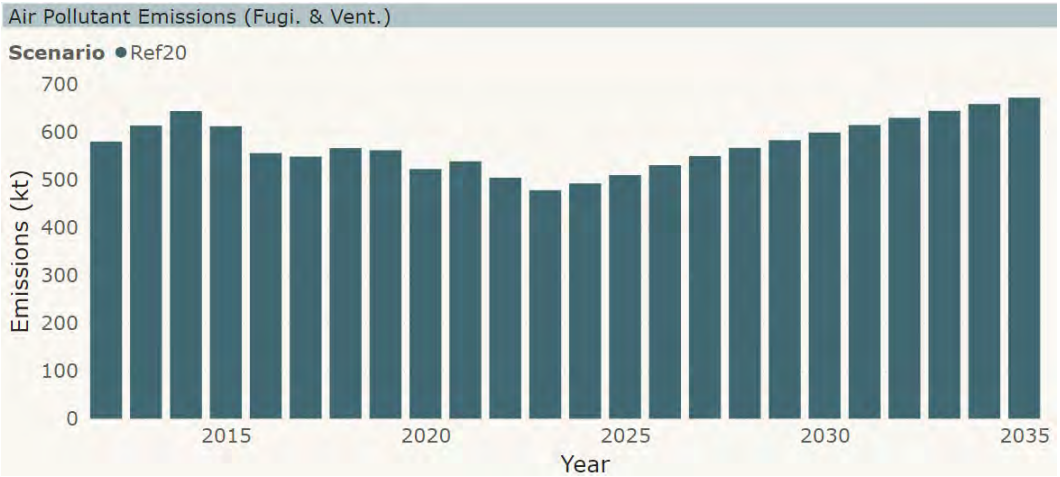

Figure 4.5: Fugitive and Venting VOC Emissions under 2020 Reference Case: Upstream Oil and Gas

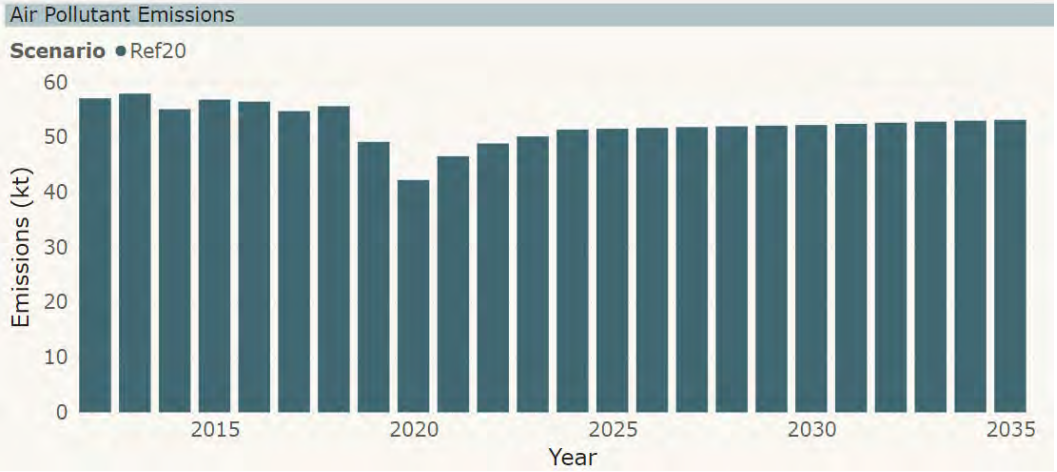

Figure 4.6: VOC Emissions Under 2020 Reference Case: Petroleum Product

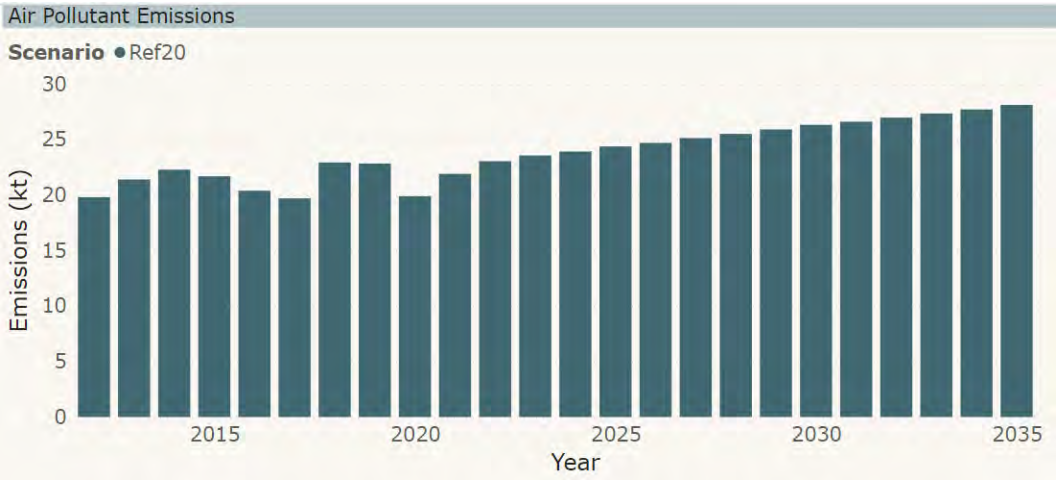

Figure 4.7: VOC Emissions Under 2020 Reference Case: Chemicals and Fertilizers

Conclusion

In summary, since the BLIERs discussions were completed in 2012, a number of federal and provincial measures have been put in place that cover VOC sources across the hydrocarbon production and processing sector. Additional federal measures are currently under development that will contribute to addressing additional sources, including tanks and loading emissions in the downstream petroleum sector as well as some facilities within the chemical sector. Further analysis by ECCC will be needed in order to assess if additional risk management action for any additional VOC sources may be warranted.

> **C2 –** Initial analysis indicates BLIERs for the hydrocarbon production and processing sector are being addressed by current and proposed measures. Once the proposed federal instrument for storage and loading of petroleum liquids has been finalized, further analysis will be required to determine if additional risk management action is needed to address VOCs from some specific sources.

4.3. Oil Sands Sector (SO_2, NO_x, $PM_{2.5}$)

The oil sands sector consists of in-situ and mining methods to extract bitumen from the oil sand deposits in Alberta and Saskatchewan. Upgrading is an intermediate refining step which generally reduces sulphur content and converts bitumen to a synthetic crude oil product that can then be refined further to make a range of petroleum products. (BLIERs 2011 f.)

The oil sands sector is generally covered by provincial measures in Alberta and Saskatchewan including regulations, directives, permits and operating approvals. Some equipment emitting NO_x emissions is subject to part 1 of the *Multi-Sector Air Pollutants Regulations* (SOR/2016-151) (MSAPR) to address NO_x emissions from some boilers and heaters using gaseous fuels with a certain percentage of methane and by part 2 of MSAPR for any stationary spark-ignition engines and by the CEPA Guidelines for the Reduction of Nitrogen Oxide Emissions from Natural Gas–fuelled Stationary Combustion Turbines.

The Oil Sands working group BLIERs discussions were focused on three key sources of air pollution namely: sulphur recovery equipment (SO_2); mine fleet ($PM_{2.5}$ and NO_x); and boilers and heaters (SO_2, NO_x, $PM_{2.5}$). The status for each of the key sources is outlined in the following sections.

Note that VOC emissions from some oil sands facilities, such as upgraders, were considered as part of the Hydrocarbon Production and Processing sector. See section **4.2** for discussion of that work, including the federal *Reduction in the Release of Volatile Organic Compounds Regulations (Petroleum Sector)* which were finalized in 2020.

Information on relevant new federal and provincial measures are outlined within each section, where available.

4.3.1. Sulphur Recovery

Sulphur recovery refers to the conversion of hydrogen sulphide (H_2S) to elemental sulphur which is a by-product of processing bitumen and crude oil. The inlet rate and concentration of H_2S determine the technology options to be able to recover the sulphur and limit the emissions of SO_2.

At the conclusion of the BLIERs discussions in 2012, consensus was achieved among federal and provincial governments for limited aspects of sulphur recovery. There was no consensus on the largest source of sulphur recovery emissions from existing upgraders and insufficient time to address other large sources of sulphur emissions from the sector. No measures were put in place by the federal or provincial governments beyond those already in place by the provincial governments.

4.3.2. Mine Fleet

The oil sands sector, in particular the off-road mobile diesel equipment involved in the oil sands mining operations, is a significant source of emissions in Canada. Non-road diesel engines can also contribute significantly to the levels of $PM_{2.5}$ and NO_x. The level of emissions can be influenced by the age/technology of the engines, as well as how they are operated.

Although no consensus was reached among governments and stakeholders during the BLIERs process for the oil sands sector mine fleet, actions have recently been taken by the federal government that will address a portion of those emissions (**Table 4.3**: Federal and Provincial Instruments Addressing the Oil Sands Mine Fleet since 2012).

Federal regulations were introduced in 2005 for off-road mobile diesel engines under the *Off-Road Compression-Ignition Engine Emission Regulations*. New regulations, the *Off-road Compression-Ignition (Mobile and Stationary) and Large Spark-Ignition Engine Emission Regulations*, introduced emission standards and requirements for off-road large spark-ignition engines and off-road stationary diesel engines and apply to those types of engines manufactured on or after June 4, 2021. Note that these new regulations repealed and replaced the previously mentioned regulations, combining the mobile diesel engine standards together with the new large spark-ignition engine and stationary diesel engine standards into one consistent framework. Emission standards for mobile diesel engines are unchanged, although some new administrative and compliance flexibility are introduced for certain applications. Mobile diesel engines of the 2006 and later model years must meet the applicable emissions standards in place at their time of manufacture. However, during the original BLIERs discussions, the pre-2005 engines made up the majority of the mine fleet as oil sands mining operations would commonly rebuild engines as long as they are still serviceable. Idling emissions from the mine fleet, which was an element being discussed under the BLIERs process may also remain as a gap. The guidance document developed by the CCME Mobile Sources Working Group may assist jurisdictions with addressing in-use diesel emissions.

Table 4.3: Federal and Provincial Instruments Addressing the Oil Sands Mine Fleet since 2012

Oil Sands Sector Mine Fleet	Pollutants NO_x $PM_{2.5}$	Current Number of Active Facilities in Each Province AB (7)
Federal Instruments		

Oil Sands Sector Mine Fleet	Pollutants	Current Number of Active Facilities in Each Province
	NO_x $PM_{2.5}$	AB (7)
Mine Fleet: *Off-Road Compression-Ignition Engine Emission Regulations* (SOR/2005-32) are applicable to 2006 model year and later off-road mobile diesel engines. These engines may be used at oil sands facilities. **Mine Fleet:** *Off-road Compression-Ignition (Mobile and Stationary) and Large Spark-Ignition Engine Emission Regulations* (SOR 202-258), covers large spark-ignition engines and stationary diesel engines manufactured on or after June 4, 2021. These types of engines may be used in oil sands facilities. ***Canadian Council of Ministers of the Environment (CCME) Instruments*** *Options To Address Air Pollutant And Greenhouse Gas Emissions From In-Use Heavy Duty On-Road And Off-Road Diesel Vehicles And Engines* (Available upon request from CCME)		

4.3.3. Boilers and Heaters for Fuels not Covered by the *Multi-Sector Air Pollutants Regulations*

Boilers and heaters play a key role in mining and thermal in-situ extraction and recovery methods, as well as in upgrader processing of bitumen by providing process heat, steam or hot water. In addition boilers are also used in oil sands cogeneration facilities to produce electricity.

Boilers and heaters can use a variety of fuels including bitumen, petroleum coke, asphaltenes, fuel oil, natural gas as well as produced and other process-generated gases. Each of these fuels has different combustion characteristics and produces a distinct emissions profile. Natural gas has the lowest NO_x, SO_x, and PM emissions, whereas non-gaseous fuels such as bitumen, petroleum coke and asphaltenes are high producers of NO_x, SO_x, and PM as well as CO_2. Most boilers and heaters in the oil sands sector are fired on gaseous fuels. Gaseous fuels include natural gas and various mixtures of natural gas, produced gas, refinery gas and synthetic gas. NO_x emissions from boilers and heaters from natural gas are being addressed under MSAPR.

At the conclusion of the BLIERs discussions in 2012, consensus was achieved among federal and provincial governments for boilers and heaters combusting non-gaseous fuel (liquid/solid fuels), while consensus was not achieved for boilers and heaters combusting alternative gaseous fuels. In many cases, fuels with higher sulphur content will also generate more CO_2 per unit of energy so a number of the GHG measures that have been put in place or are under development by the federal and provincial governments, may have a co-benefit of addressing a portion of the SO_2, NO_x, and $PM_{2.5}$ emissions that were envisioned by this BLIER (**Table 4.4**). Further analysis is needed to identify any gaps or concerns regarding emissions from boilers and heaters using alternative gaseous fuels.

Table 4.4: Federal and Provincial Instruments Addressing Boilers and Heaters for Fuels Not Covered by the *Multi-Sector Air Pollutants Regulations* since 2012

Sector / Equipment	Pollutants	Current Number of Active Facilities in Each Province
	SO_2 NO_x $PM_{2.5}$	AB (37) SK (1)
Federal Instruments *Greenhouse Gas Pollution Pricing Act* (S.C. 2018) is an Act to mitigate climate change through the pan-Canadian application of pricing mechanisms to a broad set of greenhouse gas emission sources. *Output-Based Pricing Systems Regulations* (SOR/2019-266) a regulatory trading system under the authority of the *Greenhouse Gas Pollution Pricing Act* for industrial facilities that is administered by the Department of the Environment (the Department) and the Canada Revenue Agency. Proposed *Clean Fuel Regulations* (2020) would require liquid fossil fuel primary suppliers (i.e. producers and importers) to reduce the carbon intensity (CI) of the liquid fossil fuels they produce in and import into Canada. ***Provincial Instruments*** **Alberta:** *Alberta's Technology Innovation and Emissions Reduction System* (TIER) addresses GHG and likely achieves co-benefit air pollutant reductions. Individual facilities also have approvals that generally include limits for air pollutants. **Saskatchewan:** The *Management and Reduction of Greenhouse Gases (General and Electricity Producer) Regulations* (M-2.01 Reg 1) address GHGs and likely achieve co-benefit AP reductions. Individual facilities have operating permits that may include limits for air pollutants.		

Figure 4.8 Figure 4.10 show the historical emissions and projections based on the ECCC 2020 reference case for the oil sands sector. Some emission reductions for SO_X can be seen in the beginning of the period, while both NOx and $PM_{2.5}$ are trending up which indicates that the need for BLIERs still exists. This data is not available based on each equipment type, so the data is shown for the sector as a whole for SO_X, NO_x and $PM_{2.5}$. Any relevant federal or provincial measures have been included in the reference case, where possible.

Annex 3: Reported Facility Emissions for Active Facilities – NPRI data from 2012 to 2019 includes facility specific emissions data for the oil sands sector. This data shows that a small number of facilities are responsible for the majority of the emissions within the sector.

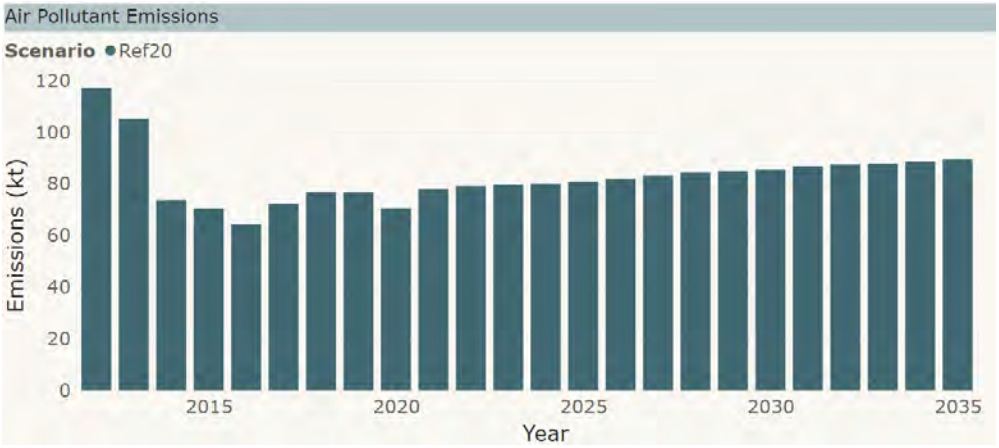

Figure 4.8: SO_x Emissions under 2020 Reference Case: Oil Sands

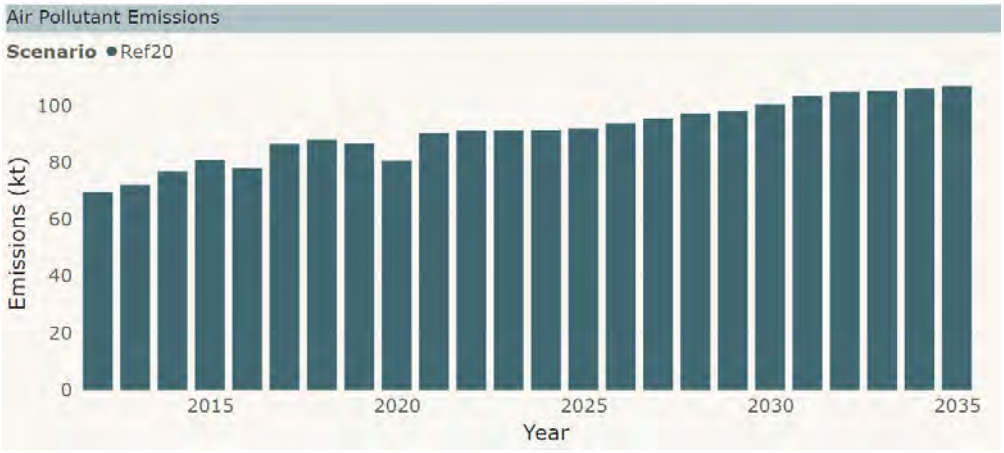

Figure 4.9: NO_x Emissions under 2020 Reference Case: Oil Sands

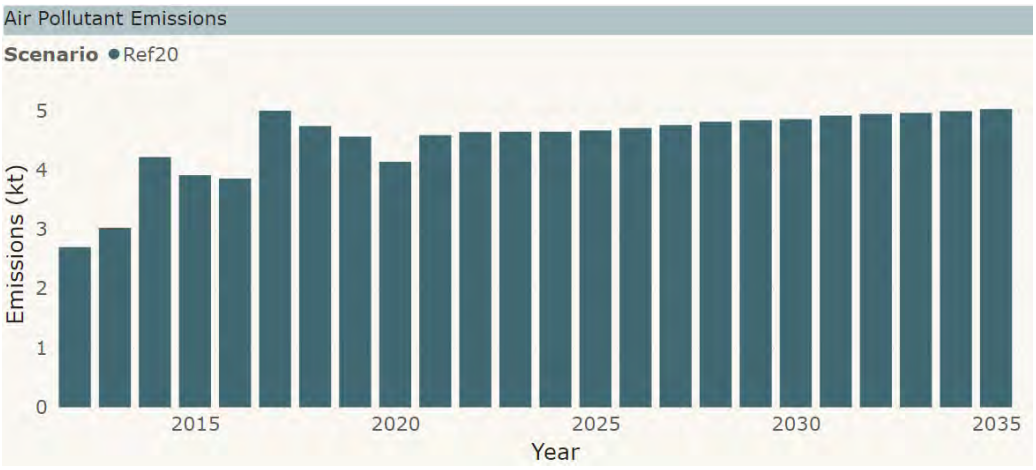

Figure 4.10: $PM_{2.5}$ Emissions under 2020 Reference Case: Oil Sands

Conclusion

For the oil sands sector, the summary for each source category is as follows:

a) No measures in addition to existing provincial measures were put in place to address sulphur recovery. Analysis is needed to determine any gaps or concerns regarding emissions from sulphur recovery and other large sources of SO_2 emissions, including flaring, scrubbing, flue gas desulphurization and use of process fuel gas.
b) A portion of the mine fleet emissions are being addressed by new federal instruments, although some aspects of the existing mine fleet have not yet been addressed.
c) Additional analysis is needed to determine whether the original intent of BLIERs for boilers and heaters have been addressed.

C3 – Initial analysis indicates that BLIERs for the oil sands sector have not been addressed. ECCC is currently conducting analysis to identify outstanding gaps and concerns regarding air pollution from the sector. These efforts will address the additional deliverables identified in the management response to the AAPHI evaluation which are to be finalized in 2022 and 2023.

4.4. Petroleum Refining (SO_2, NO_x and $PM_{2.5}$)

Petroleum refineries process crude oil or other feedstocks to produce gasoline, diesel and other petroleum products. Active petroleum refineries are located in six provinces across Canada, including British Columbia, Alberta, Saskatchewan, Ontario, Quebec and New Brunswick. The discussions on BLIERs focused on three pollutants, namely SO_2, NO_x and $PM_{2.5}$ and were intended to address all sources within facilities. VOCs from refining were to be addressed through the VOC emissions qualitative cross-sectoral BLIERs development work and are currently being addressed separately by federal and provincial measures. (BLIERs 2012 e.) See section **4.2** for discussion of that work, including the federal *Reduction in the Release of Volatile Organic Compounds Regulations (Petroleum Sector)* which were finalized in 2020.

A number of approaches to address BLIERs for SO_2, NO_x and $PM_{2.5}$ were discussed with the stakeholder group and subsequently within a federal, provincial and territorial (FPT) forum. No consensus was achieved and no additional measures specifically targeting SO_2, NO_x and $PM_{2.5}$ from the refining sector were put in place by the federal government since the BLIERs process concluded. ECCC is currently conducting analysis to identify outstanding gaps and concerns regarding air pollution from the sector.

The refining sector is included in MSAPR and is subject to the requirements for Part 2 (Stationary Spark-Ignition Engines), but is not subject to Part 1 (Boilers and Heaters). As a result MSAPR is not expected to have much of an impact on refinery emissions. Refining is also covered by the CEPA Guidelines for the Reduction of Nitrogen Oxide Emissions from Natural Gas–fuelled Stationary Combustion Turbines. A number of actions have recently been taken by federal and provincial governments to address GHG emissions and may also have co-benefit air pollutant emissions as a co-benefit from the sector (**Table 4.5**: Federal and Provincial Instruments Addressing Petroleum Refineries since 2012).

Table 4.5: Federal and Provincial Instruments Addressing Petroleum Refineries since 2012

Petroleum Refineries	Pollutants SO_2 NO_x $PM_{2.5}$	Current Number of Active Facilities in Each Province BC (2) AB (5) SK (2) ON (5) QC (2) NB (1)

Federal Instruments

Greenhouse Gas Pollution Pricing Act (S.C. 2018) is an Act to mitigate climate change through the pan-Canadian application of pricing mechanisms to a broad set of greenhouse gas emission sources.

Output-Based Pricing Systems Regulations (SOR/2019-266) a regulatory trading system under the authority of the *Greenhouse Gas Pollution Pricing Act* for industrial facilities that is administered by the Department of the Environment (the Department) and the Canada Revenue Agency.

Proposed *Clean Fuel Regulations* (2020) would require liquid fossil fuel primary suppliers (i.e. producers and importers) to reduce the carbon intensity (CI) of the liquid fossil fuels they produce in and import into Canada.

Provincial/Municipal Instruments

Individual refineries may also have operating permits or approvals that are updated periodically and generally include limits for air pollutants.

BC: *GHG Industrial Reporting and Control Act* (SBC 2014) addresses GHG and may achieve co-benefit air pollutant reductions. Individual refineries also have operating permits that are updated periodically and generally include limits for air pollutants.

Metro Vancouver: The operating permit for the Parkland Burnaby refinery is renewed periodically. The emission limits for SOx and NOx have been reduced since 2012.

Alberta: *Alberta's Technology Innovation and Emissions Reduction System* (TIER) addresses GHG and may achieve co-benefit air pollutant reductions. Individual refineries also have operating approvals that are updated periodically and generally include limits for air pollutants.

Saskatchewan: The *Management and Reduction of Greenhouse Gases (General and Electricity Producer) Regulations* (M-2.01 Reg 1) address GHGs and may achieve co-benefit air pollutant reductions. Individual facilities have operating permits that may include limits for air pollutants.

Ontario: *GHG Emissions Standards Regulation* (O. Reg2 41/19) addresses GHGs and may achieve co-benefit air pollutant reductions.

Air Pollution – Local Air Quality (419/05) (2019) has updated Air Standards for SO_2. Work is underway to provide a compliance mechanism so that existing refineries can comply by 2023 when the new air standard comes into force.

Petroleum Refineries	Pollutants	Current Number of Active Facilities in Each Province
	SO_2 NO_x $PM_{2.5}$	BC (2) AB (5) SK (2) ON (5) QC (2) NB (1)
On February 22nd, 2022, Ontario MECP finalized a regulation to reduce sulphur dioxide air emissions from petroleum facilities in Ontario. (ERO 019-3443) **Quebec:** *Regulation respecting a cap-and-trade system for greenhouse gas emission allowances* (Q-2, r. 46.1) address GHGs and may achieve co-benefit air pollutant reductions. Individual refineries also have operating permits that are updated periodically and generally include limits for air pollutants. **New Brunswick:** *Climate Change Act* (Bill 39) address GHGs and may achieve co-benefit air pollutant reductions. Individual refineries also have operating permits that are updated periodically and generally include limits for air pollutants.		

Figure 4.11: SO_X Emissions under 2020 Reference Case: Petroleum Products Sector **to Figure** 4.13: $PM_{2.5}$ Emissions under 2020 Reference Case: Petroleum Products Sector show the historical emissions and projections based on the ECCC 2020 reference case for petroleum refining. Any relevant federal or provincial measures have been included in the reference case, where possible. In Ref20, some of the historical SO_x emission reductions can be attributed to facility closures and changes in energy demand. Ref20 projections also show that emissions are expected to increase (SO_x) or remain unchanged (NO_x, $PM_{2.5}$) out to 2035. **Annex 3**: Reported Facility Emissions for Active Facilities – NPRI data from 2012 to 2019 provides the facility specific emissions for the sector and shows that facility emissions for the three key pollutants have generally not changed since the need for the BLIER was first identified.

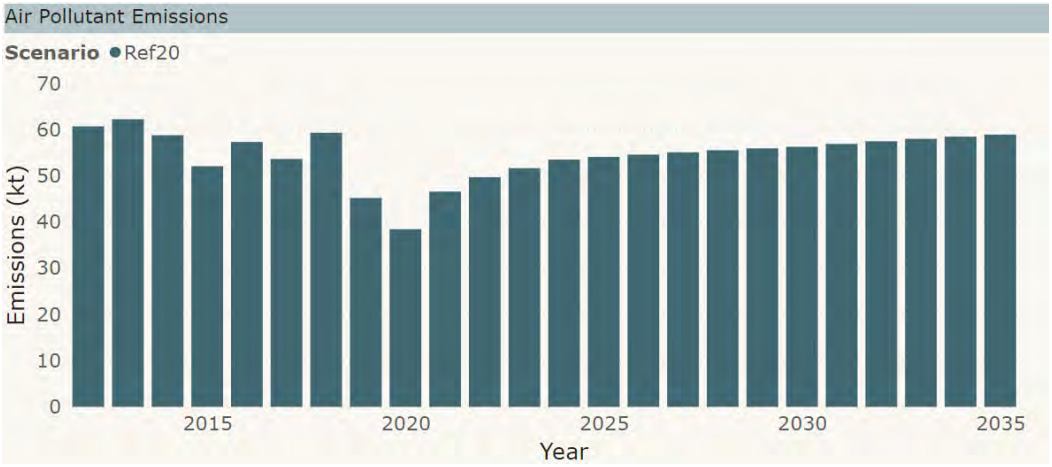

Figure 4.11: SO_X Emissions under 2020 Reference Case: Petroleum Products Sector

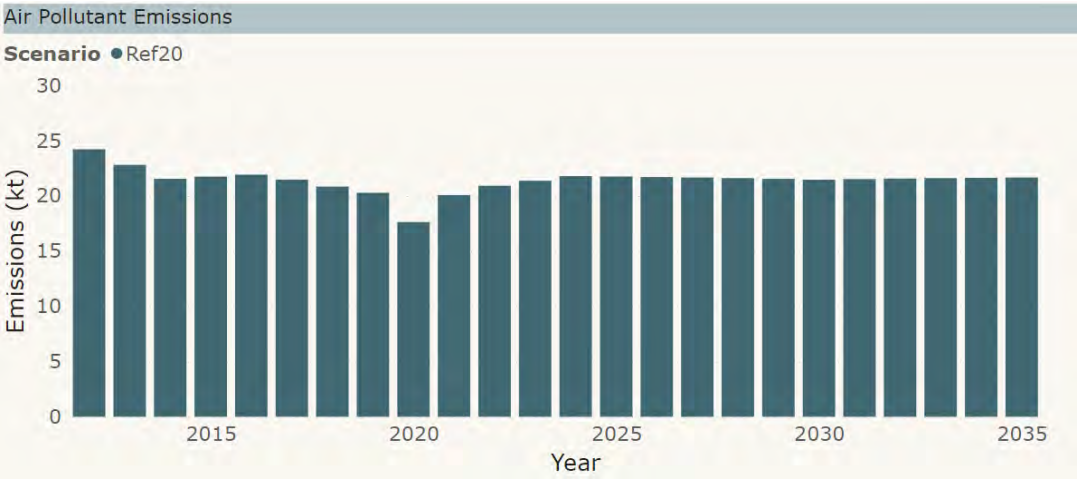

Figure 4.12: NO_X Emissions under 2020 Reference Case: Petroleum Products Sector

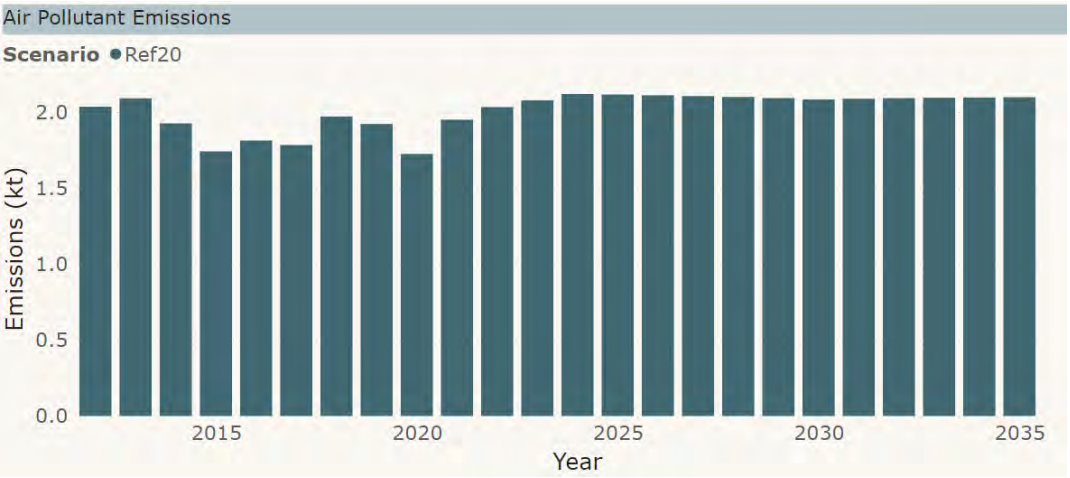

Figure 4.13: $PM_{2.5}$ Emissions under 2020 Reference Case: Petroleum Products Sector

Conclusion

A portion of the petroleum refining SO_2, NO_x and $PM_{2.5}$ emissions may be addressed as a co-benefit of new federal and provincial GHG instruments; however, based on historical facility emissions and projected emissions, emissions are not expected to change from where they were when the need for the BLIER was first identified, with the exception of emissions of SO_2 from petroleum refineries in Ontario now that Ontario has finalized new regulations.

> **C4 –** Initial analysis indicates that BLIERs for the petroleum refining sector have not been addressed. Further detailed analysis by ECCC is needed to inform any recommendations on potential further risk management actions for the petroleum refining sector. Those efforts will address the additional deliverables identified in the management response to the AAPHI evaluation which are to be finalized in 2022 and 2023.

4.5. Upstream Oil and Gas – Sour Gas Processing Plants (SO_2)

The upstream oil and gas (UOG) sector includes the exploration, production and basic processing of crude oil and natural gas. There are many air emissions associated with activities from the UOG sector. Note that VOC emissions from some upstream oil and gas facilities, such as gas processing plants, were considered as part of the Hydrocarbon Production and Processing sector. See section **4.2** for discussion of that work, including the federal *Regulations Respecting Reduction in the Release of Methane and Certain Volatile Organic Compounds Regulations (Upstream Oil and Gas Sector)* which were finalized in 2018.

SO_2 from upstream oil and gas production results primarily from the combustion of gas containing sulphur and sulphur compounds at sour gas processing plants. SO_2 emissions from sour gas processing comprised 82% of the sector's total SO_2 emissions.[6] (BLIERs 2012 f.)

Sour gas processing converts the produced raw gas into a commercial sales gas product (methane). Sour gas processing involves the removal of hydrogen sulphide (H_2S), carbon dioxide (CO_2), water and some natural gas liquids in order to produce sales gas. The H_2S and CO_2 are removed in an amine plant and typically sent to a sulphur recovery unit (SRU). The residue gas is further treated to remove sufficient water and natural gas liquids in order to meet the gas transmission pipeline specifications. The sulphur recovery efficiency of a plant depends on the technology used in the sulphur recovery process and the concentration of H_2S in the acid gas feed to the sulphur recovery unit.

The BLIER discussions focused on addressing emissions of SO_2 through requirements to establish consistent sulphur recovery standards similar to Alberta's requirements that would apply in Alberta, Saskatchewan and British Columbia where gas plants operate. However, no working group consensus was obtained for sulphur recovery requirements.

UOG is included in MSAPR and is subject to the requirements for Part 1 (Boilers and Heaters) and Part 2 (Stationary Spark-Ignition Engines). However, MSAPR does not address SO_2 emissions associated with this sector. UOG is also subject to the CEPA Guidelines for the Reduction of Nitrogen Oxide Emissions from Natural Gas–fuelled Stationary Combustion Turbines. No additional measures have been put in place by the federal or provincial governments since 2012 that further address SO_2 emissions from sour gas plants.

Figure 4.14 shows the historical emissions and projections based on the ECCC 2020 reference case for UOG – Sour Gas Processing. Any relevant federal or provincial measures have been included in the reference case, where possible. Although a decline is shown in the historical years, SO_2 emissions are projected to increase to 2035. **Annex 3**: Reported Facility Emissions for Active Facilities – NPRI data from 2012 to 2019 includes facility specific emissions for the sector and shows that some facilities have reduced emissions since 2012. However, additional analysis is required since one company with 3 facilities has reported data for 2019 that is very low relative to previous years.

[6] CAPP (2004) A National Inventory of Greenhouse Gas (GHG), Criteria Air Contaminant (CAC) and Hydrogen Sulphide (H2) Emissions by the Upstream Oil and Gas Industry, Volume 2.

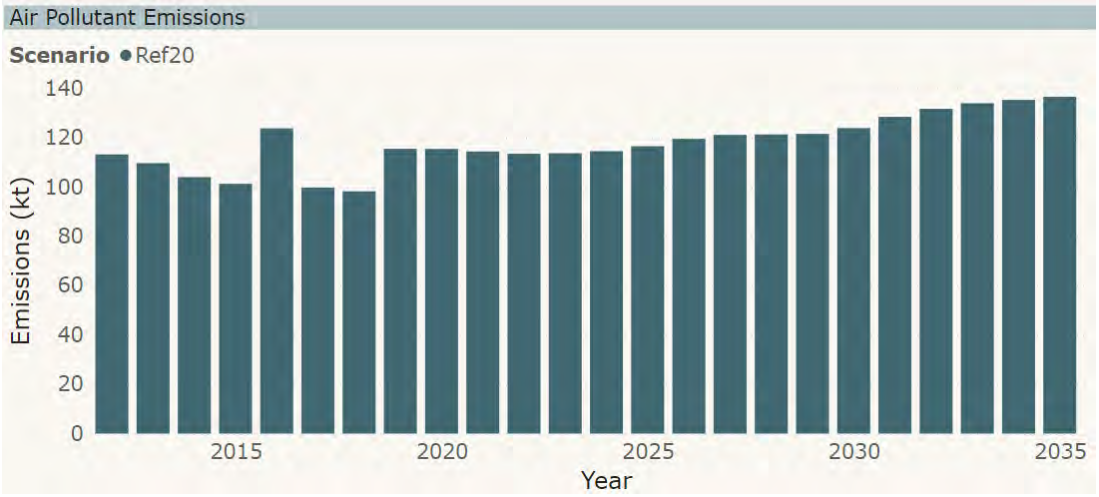

Figure 4.14: SO_X Emissions under 2020 Reference Case: Oil and Gas – Natural Gas - Sour Gas Processing

Conclusion

No additional measures have been put in place by the federal or provincial governments since 2012 that further address SO_2 emissions from sour gas plants. Emissions projections indicate that emissions for the sector will increase to 2035. NPRI reported data need further analysis in order to be able to make conclusions from the data.

> **C5 –** Initial analysis indicates that BLIERs for natural gas sour gas processing have not been addressed. ECCC is currently conducting analysis to identify outstanding gaps and concerns regarding air pollution from the sector. These efforts will address the additional deliverables identified in the management response to the AAPHI evaluation which are to be finalized in 2022 and 2023.

4.6. Chemical and Nitrogen-based Fertilizer Sectors (NO_x, VOCs and NH_3)

The chemical sector consists of a diverse set of facilities that transform raw materials into inputs that are needed to manufacture products. The N-fertilizer sector consists of facilities that produce ammonia in order to produce several products including ammonium nitrate and urea which are used directly as N-fertilizers or as feedstocks in the production of urea-ammonium nitrate (UAN) liquid fertilizers. The work on BLIERs focused on a number of the key subsectors located in Ontario, Alberta, Quebec and Saskatchewan. In many cases these facilities are grouped together in industrial regions and may also be partially integrated with other facilities such as refineries or oil sands upgraders. The pollutants of interest included NO_x, VOCs and NH_3.

A working group was established for the chemical and N-fertilizer sectors with seven technical groups focused on:

- butyl rubber manufacturing;
- ethylene based polymers;

- carbon black (thermal/furnace);
- ethanol production for industrial and fuel applications;
- ethylene manufacturing from steam cracking;
- steam methane reformers; and
- nitrogen-based fertilizer production

Figure 4.15 Figure **4.16** show the historical emissions and projections based on the ECCC 2020 reference case for the petrochemical sector. Both VOC and NO_x emissions for the sector are projected to increase to 2035, however, more detailed emissions projections for each of the chemical sub-sectors have not been published for the 2020 reference case. Any relevant federal or provincial measures have been included in the reference case, where possible.

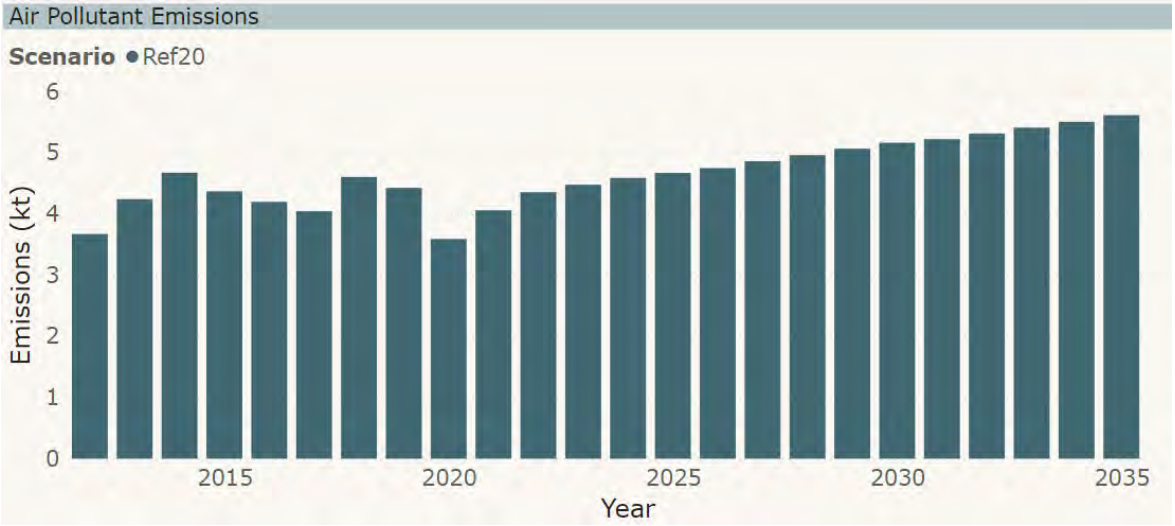

Figure 4.15: VOC Emissions under 2020 Reference Case: Petrochemical Sector

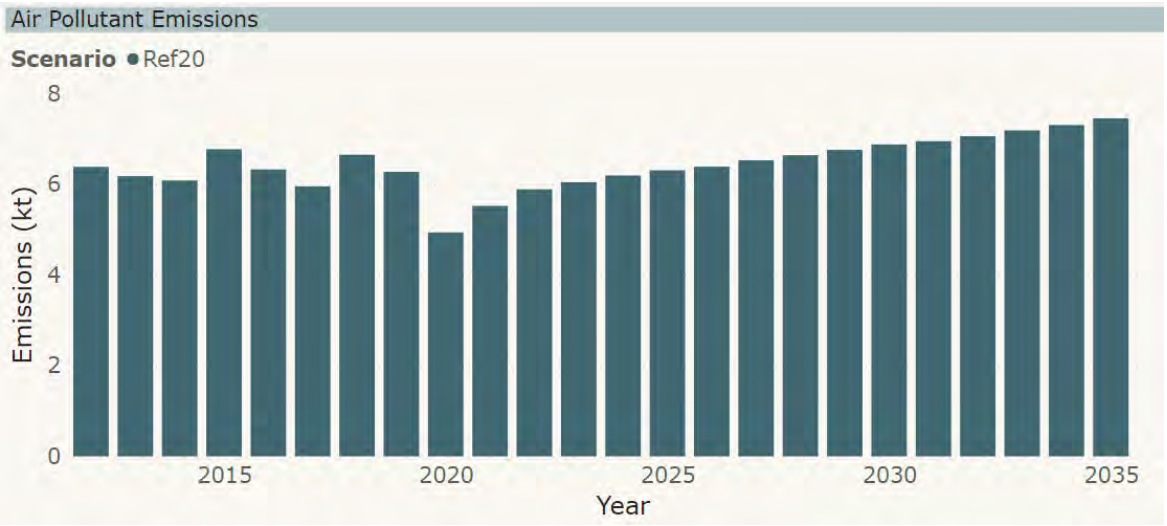

Figure 4.16: NO_x Emissions under 2020 Reference Case: Petrochemical Sector

More detail on each of the seven chemicals sector BLIERs is outlined below.

4.6.1. Butyl Rubber Manufacturing (VOCs)

Butyl rubber is produced by polymerization of isobutylene with about 2% isoprene. It's a synthetic rubber and used in many applications including tire inner tubes, sports equipment, adhesives and chewing gum. Butyl rubber has a good resistance against ozone, weathering and hot gases. It is also resistant to basic and acidic chemicals, and has very low permeability to liquids and gases, as well as good rheological properties. There is only one butyl rubber producer in Canada, which is located in Ontario. (BLIERs 2011 g.)

A BLIER was developed that focused on VOC emissions from the slurry tanks used in the manufacturing process. As part of the original technical discussions it was expected that the sole facility was considering installing technology to address this source in order to comply with a CEPA Pollution Prevention Planning Notice (P2) for isoprene. This technology would meet the original objectives of the BLIERs, which were based on European standards as the leading jurisdiction. The declaration of implementation report in 2018 indicates that the facility met the objectives for isoprene in 2018. In addition, 2019 NPRI reporting data shows a significant reduction in VOC emissions from the facility.

Butyl rubber manufacturing is included in MSAPR and is subject to the requirements for Part 1 (Boilers and Heaters) and Part 2 (Stationary Spark-Ignition Engines). However, these instruments do not address VOC emissions from this sector. A number of federal actions have already addressed or may address VOC emissions from the sector in the future (**Table 4.6**).

Annex 3: Reported Facility Emissions for Active Facilities – NPRI data from 2012 to 2019 includes facility specific emissions for the sector and shows that the single facility reduced VOC emissions significantly beginning in 2019.

Table 4.6: Federal Instruments Addressing Butyl Rubber Manufacturing since 2012

Butyl Rubber Manufacturing	Pollutants VOCs	Current Number of Active Facilities in Each Province ON (1)
Federal Instruments *Pollution Prevention Planning Notice for Isoprene* (2012) is a CEPA instrument that targeted isoprene emissions at the sole butyl rubber facility. In addition, planned measures for storage and loading of petroleum liquids may address additional VOC sources at this facility.		

Conclusion

The sole facility has addressed the requirements of the isoprene P2 plan and significant reductions in VOC emissions were reported to NPRI in 2019.

> **C6 -** Initial analysis indicates that BLIERs for the butyl rubber manufacturing sector have been addressed. Further assessment by ECCC may be needed to confirm this

emissions trend in 2020 and determine whether the actions taken under the isoprene P2 have addressed the intent of the original BLIER for this sector (VOC emissions from slurry tanks).

4.6.2. *Ethylene-based Polymer Production (VOCs)*

Ethylene-based polymers are long hydrocarbon chains built from ethylene monomers using catalytic or radical polymerization reactions. Polymers are classified based on the molecular weight and the branching characteristics of the hydrocarbon chain. The polymers are used for a variety of commercial products, including packaging, bags, containers, coatings, and some types of tubing.[7]

The BLIERs technical group focused on the development of a BLIER for VOCs from new and existing manufacturing facilities producing varieties of low- and high-density polyethylene, as well as ethylene copolymers with ethylene-vinyl acetate. The majority of the VOC emissions in polymer production are emitted through stacks from the polymerization reaction section, the material recovery section, and the product finishing section of manufacturing facilities. (BLIERs 2011 h.)

The European Commission's approach was chosen for the basis of the BLIER, as the performance standard was based upon the VOC emission benchmarks presented in the Best Available Techniques Reference Document (BREF) document which provides limits for both new and existing facilities. Although no consensus was achieved on the proposed BLIER, seven of the eight facilities met the BREF limits in 2011. The single facility which did not meet the limit was expected to take action to install a thermal oxidizer, or comparable technology which would have resulted in compliance with proposed standard.

Ethylene-based polymer production is included in MSAPR and is subject to the requirements for Part 1 (Boilers and Heaters) and Part 2 (Stationary Spark-Ignition Engines). However, these instruments do not address VOC emissions from this sector. No new federal or provincial instruments have been identified that specifically target VOC emissions from these facilities.

Annex 3: Reported Facility Emissions for Active Facilities – NPRI data from 2012 to 2019 includes facility specific emissions for the sector and shows that total reported NPRI VOC emissions for the sector have remained relatively stable since 2012, however, for some of the facilities the reported VOC emissions have increased since 2012. This may warrant a review relative to the initial limits (or more recent limits) to see how the facilities perform currently. These facilities produce a range of products, so emissions relative to the benchmarks cannot be ascertained simply from reported emissions.

Conclusion

No new federal or provincial instruments have been identified that specifically target VOC emissions from these facilities, although most of the facilities met the limits being discussed during BLIERs discussions. 2019 facility emissions are similar to where they were when the need for the BLIER was first identified.

[7] Kirk-Othmer Concise Encyclopedia of Chemical Technology, Fourth Edition (2001). Executive editor, J. Korshwitz. Wiley- Interscience.

C7 - Initial analysis indicates that BLIERs for the ethylene-based polymer production sector have not been addressed. Further analysis by ECCC of the VOC emissions from this sector and from individual facilities may be needed to inform any potential recommendations for further risk management actions.

4.6.3. Carbon Black Production (NO_x)

Carbon black is predominantly used as a pigment and reinforcement in rubber and plastic products. In Canada, there are currently two facilities employing the furnace process, which is globally the most common production process, and one facility using the thermal process to manufacture carbon black. A furnace process uses a closed reactor to atomize the feedstock oil (petroleum products, including oil, heavy oil, natural gas) under carefully controlled conditions (primarily temperature and pressure). The primary feedstock is introduced into a hot gas stream (achieved by burning a secondary feedstock, e.g. natural gas or oil), where it vaporizes and then pyrolyzes in the vapour phase to form microscopic carbon particles.[8] There are currently two furnace process facilities in Canada, both located in Ontario. (BLIERs 2011 c.)

Carbon black is also produced in a thermal process through the incomplete combustion or thermal decomposition of petroleum products, including oil, heavy oil, natural gas or tars. There is currently one thermal process in Canada, which is located in Alberta. (BLIERs 2011 d.)

Separate BLIERs were developed for NO_x from furnace and thermal carbon black production processes based on Alberta (thermal) and Europe (furnace) as the leading jurisdictions. No consensus was achieved on the proposed BLIER. However, it was determined in 2012 that all facilities in Canada met the BLIER, so no additional action was taken for this sector.

Carbon black production is included in MSAPR and is subject to the requirements for Part 1 (Boilers and Heaters) and Part 2 (Stationary Spark-Ignition Engines) for NO_x. No additional federal or provincial instruments have been identified that specifically target NO_x emissions from these facilities. A number of actions have recently been taken by federal and provincial governments that will address GHG emissions and may address NO_x emissions from the sector (**Table 4.7**).

Annex 3: Reported Facility Emissions for Active Facilities – NPRI data from 2012 to 2019 includes facility specific emissions for the sector and shows that total reported NPRI NO_x emissions for the sector have remained relatively stable since 2012.

Table 4.7: Federal and Provincial Instruments Addressing Carbon Black Production since 2012

Carbon Black Production	Pollutants NO_x	Current Number of Active Facilities in Each Province ON (2) AB (1)
Federal Instruments *Greenhouse Gas Pollution Pricing Act* (S.C. 2018) is an Act to mitigate climate change through the pan-Canadian application of pricing mechanisms to a broad set of greenhouse gas emission sources.		

[8] Carbon Black Users Guide published by the International Carbon Black Association (ICBA)

Carbon Black Production	Pollutants NO_x	Current Number of Active Facilities in Each Province ON (2) AB (1)
Output-Based Pricing Systems Regulations (SOR/2019-266) a regulatory trading system under the authority of the *Greenhouse Gas Pollution Pricing Act* for industrial facilities that is administered by the Department of the Environment (the Department) and the Canada Revenue Agency. *Multi-Sector Air Pollutants Regulations* (SOR/2016-151) NOx emissions from boilers and heaters in carbon black facilities are covered under these regulations. ***Provincial Instruments*** **Alberta:** *Alberta's Technology Innovation and Emissions Reduction System* (TIER) addresses GHG and may achieve co-benefit air pollutant reductions. Individual refineries also have operating approvals that are updated periodically and generally include limits for air pollutants. **Ontario:** *GHG Emissions Standards Regulation* (O. Reg2 41/19) addresses GHGs and may achieve co-benefit air pollutant reductions. *Ontario Air Pollution – Local Air Quality* (O. Reg 419/05) Nitrogen oxides emissions are limited in schedule 2 to a Half Hour Standard of 500 µg/m³, and from Schedule 3: One Hour Standard of 400 µg/m³ and a 24-Hour Standard of 200 µg/m³.		

Conclusion

In 2011 it was determined that both thermal and furnace carbon black production facilities were already meeting the BLIERs that were proposed at that time. Emissions for the sector have remained at the same level as in 2012. A number of actions have recently been taken by federal and provincial governments that will address GHG emissions and may address NO_x emissions from the sector.

> **C8 -** Initial analysis indicates that NO_X BLIERs for carbon black production have been addressed.

4.6.4. Ethanol production for industrial and fuel applications (VOCs)

Ethanol is produced in Canada to meet the renewable fuel content mandates across the country. Ethanol can be produced from grains (corn, sugarcane, wheat, barley, etc.), cellulosic feedstock and can also be derived from syngas. In Canada, the majority of the ethanol producers in the east use corn as feedstock and a dry-milling process, while wheat is used as a feedstock mostly in western Canada. There are a few ethanol production facilities using cellulosic feedstock or syngas to produce ethanol, but the quantity of ethanol produced is much smaller than the ethanol produced from grains.

The mandate of the ethanol manufacturing technical group was to develop VOC BLIERs for new and existing ethanol manufacturing facilities for industrial and fuel applications. The discussions for the BLIERs focused on controlling major emission sources: fermentation, distillation and

grain drying; and followed requirements put in place by the U.S. EPA and several U.S. states. (BLIERs 2012 g.)

No consensus was achieved on the proposed BLIER. At the conclusion of the BLIERs discussions, many of the 17 facilities producing ethanol at the time met the BLIERs requirements that were being discussed. Currently there are 15 facilities located in Ontario, Saskatchewan, Quebec, Alberta and Manitoba. The current performance relative to the BLIER proposed in 2014 has not been reassessed.

Ethanol production is included in MSAPR and is subject to the requirements for Part 1 (Boilers and Heaters) and Part 2 (Stationary Spark-Ignition Engines). However, these instruments do not address VOC emissions from this sector. No new federal or provincial instruments have been identified that specifically target VOC emissions from these facilities.

Annex 3: Reported Facility Emissions for Active Facilities – NPRI data from 2012 to 2019 includes facility specific emissions for the sector and shows that total reported NPRI VOC emissions are much lower than in 2012, mainly from reductions from one facility.

Conclusion

Although many of the 17 facilities met the BLIER that was being discussed in 2011, it may be necessary to conduct a review using current information. No new federal or provincial instruments have been identified that specifically target VOC emissions from these facilities. NPRI reported emissions are lower than in 2012 as a result of reductions from one facility.

> **C9 –** Initial analysis indicates that BLIERs for ethanol production have not been addressed. Further analysis by ECCC may be needed to compare current emissions with the original BLIER and any more recent, relevant limits in order to inform any potential recommendations for further risk management actions.

4.6.5. Ethylene Manufacturing from Steam Cracking (NO_x)

Ethylene is a gaseous compound which is formed by cracking lower olefins such as ethane. The majority of ethylene manufactured is used to produce polymers which are used in the production of hard and flexible plastics for a number of consumer and commercial applications. (BLIERs 2012 d.)

The proposed BLIER was intended to address NO_x emissions through the setting of equipment performance standards for new, major modified and existing ethylene manufacturing equipment in Canada. The base-level requirements were identified through a review of existing requirements in the U.S. and EU. EU standards were applied as the majority of U.S. existing equipment standards address local air quality issues.

No consensus was achieved on the proposed BLIER. During the original BLIERs discussions it was anticipated that only a small number of the existing steam cracking furnaces would require performance upgrades in order to meet the proposed BLIER. Currently there are 4 facilities with steam cracking furnaces located in Ontario and Alberta. The current performance relative to the proposed BLIER has not been reassessed.

Ethylene manufacturing is included in MSAPR and is subject to the requirements for Part 1 (Boilers and Heaters) and Part 2 (Stationary Spark-Ignition Engines) for NO_x. No additional federal or provincial instruments have been identified that specifically target NO_x emissions from ethylene production via steam cracking processes. A number of actions have recently been taken by federal and provincial governments that will address GHG emissions which may have a benefit of reducing NO_x emissions from this equipment (**Table 4.8**).

Table 4.8: Federal and Provincial Instruments Addressing Ethylene Manufacturing from Steam Cracking since 2012

Ethylene Manufacturing from Steam Cracking	Pollutants NO_x	Current Number of Active Facilities in Each Province ON (2) AB (2)
Federal Instruments *Greenhouse Gas Pollution Pricing Act* (S.C. 2018) is an Act to mitigate climate change through the pan-Canadian application of pricing mechanisms to a broad set of greenhouse gas emission sources. *Output-Based Pricing Systems Regulations* (SOR/2019-266) a regulatory trading system under the authority of the *Greenhouse Gas Pollution Pricing Act* for industrial facilities that is administered by the Department of the Environment (the Department) and the Canada Revenue Agency. *Multi-Sector Air Pollutants Regulations* (SOR/2016-151) NOx emissions from ethylene manufacturing from steam cracking facilities are covered under these regulations. ***Provincial Instruments*** **Alberta:** *Alberta's Technology Innovation and Emissions Reduction System* (TIER) addresses GHG and may achieve co-benefit air pollutant reductions. Individual refineries also have operating approvals that are updated periodically and generally include limits for air pollutants. **Ontario:** *GHG Emissions Standards Regulation* (O. Reg2 41/19) addresses GHGs and may achieve co-benefit air pollutant reductions.		

Annex 3: Reported Facility Emissions for Active Facilities – NPRI data from 2012 to 2019 includes facility specific emissions for the sector and shows that total reported NPRI emissions of NO_x have remained relatively stable since 2012.

Conclusion

In 2011, it was believed that only a small number of the existing steam cracking furnaces would require performance upgrades in order to meet the proposed BLIER. No new federal or provincial instruments have been identified that specifically target NO_x emissions from these facilities, but proposed GHG measures may address some of the emissions. Facility emissions have not changed since 2012.

> **C10 –** Initial analysis indicates that BLIERs for ethylene manufacturing from steam cracking have not been addressed. Further analysis by ECCC may be needed to

compare current emissions with the original BLIER and any more recent, relevant limits in order to inform any potential recommendations for further risk management actions. Sector projections that account for co-benefits from GHG actions could also be reviewed.

Nitrogen-based Fertilizer Sector

The pollutants of interest that were targeted in the BLIERs for the N-fertilizer sector included NO_x and NH_3.

A working group was established for the N-fertilizer sector with two technical groups that focused on:

- steam methane reformers;
- nitrogen-based fertilizer production

An internal ECCC prioritization exercise conducted in 2016 suggested that of the two BLIERs originally identified in the nitrogen fertilizer sector, only one should move forward as a BLIER (steam methane reformers, targeting NOx emissions). The other (ammonia emissions from nitrogen fertilizer facilities) would be better addressed through a code of practice. At the time, NO_x emissions from steam methane reformers were considered to be the highest priority for further analysis within the chemicals and nitrogen fertilizer sectors.

4.6.6. Steam Methane Reformers (NO_x)

A key input to ammonia production is hydrogen, which is produced using steam methane reformers (SMR) at N-fertilizer and other chemical facilities.

Steam methane reformers are used in several industries to produce hydrogen from natural gas (with methane as the predominant constituent). The Canadian N-fertilizer producers then use the hydrogen in ammonia production. Methane from natural gas is heated, with steam, usually with a catalyst, to temperatures around 750 C and 1000 C to produce a mixture of carbon monoxide and hydrogen. (BLIERs 2011 e.)

The work on BLIERs focused on N-fertilizer production facilities located in Ontario, Alberta, Saskatchewan and Manitoba, as well as facilities that are standalone hydrogen producers located in Ontario, Alberta and Quebec. Standalone SMRs are also used to support other industrial sectors, including chemical production, oil sands upgrading and petroleum refining, although only standalone SMRs supporting the chemical production sector are in scope for this BLIER.

The European Commission's approach was chosen for the basis of the BLIER, as the performance standards were based upon the NOx emission benchmarks presented in the Best Available Techniques Reference Document (BREF) document for Large Volume Organic Chemical Industry.

No consensus was achieved on the proposed BLIERs. During the original BLIERs discussions, it was anticipated that more than half of the facilities would require performance upgrades which could result in sectoral reductions of greater than 1,000 tonnes/year of NOx. Currently there are 13 facilities located in Alberta, Ontario, Quebec, Saskatchewan and Manitoba.

In 2014, a proposed BLIER discussion document was shared with the industry members, associations, and some provinces. Concerns with quantification and testing requirements were raised by stakeholders. Subsequently, no further work was completed on a federal instrument for SMRs as a result of the focus on climate measures. The current performance relative to the proposed BLIER has not been reassessed.

SMRs are excluded from MSAPR. No additional federal or provincial instruments have been identified that specifically target NO_x emissions from SMRs. However, a number of actions have recently been taken by federal and provincial governments that will address GHG emissions and may address NO_x emissions from SMRs (**Table 4.9**). A more detailed analysis may be necessary to assess how these measures may address NO_x emissions from SMRs. In particular, new or expanded SMRs built with carbon capture and storage systems will address CO_2 emissions, but will not address NO_x. This may lead to an overall increase in NO_x emissions as more facilities are built or expanded.

Considerations supporting a need to assess the status and the future outlook of NO_x emissions from SMRs, include the following:

- Alberta's Natural Gas Vision and Strategy outlines the plan for Alberta to become a global supplier of clean natural gas and related products, including hydrogen, petrochemicals and recycled plastics.
- The federal government's Hydrogen Strategy For Canada seeks to modernize Canada's energy through building new hydrogen supply and distribution infrastructure and fostering uptake in various end-uses, that will underpin a low-carbon energy ecosystem in the near- and long-term.

Table 4.9: Federal and Provincial Instruments Addressing Steam Methane Reformers since 2012

Steam Methane Reformers	Pollutants NO_x	Current Number of Active Facilities in Each Province AB (8) ON (2) SK (1) MB (1) QC (1)
Federal Instruments *Greenhouse Gas Pollution Pricing Act* (S.C. 2018) is an Act to mitigate climate change through the pan-Canadian application of pricing mechanisms to a broad set of greenhouse gas emission sources. *Output-Based Pricing Systems Regulations* (SOR/2019-266) a regulatory trading system under the authority of the *Greenhouse Gas Pollution Pricing Act* for industrial facilities that is administered by the Department of the Environment (the Department) and the Canada Revenue Agency. ***Provincial Instruments*** **Alberta:** *Alberta's Technology Innovation and Emissions Reduction System* (TIER) addresses GHG and may achieve co-benefit air pollutant reductions. Individual facilities also have operating approvals that are updated periodically and generally include limits for air pollutants. **Ontario:** *GHG Emissions Standards Regulation* (O. Reg2 41/19) addresses GHGs and may achieve co-benefit air pollutant reductions.		

Steam Methane Reformers	Pollutants NO_x	Current Number of Active Facilities in Each Province AB (8) ON (2) SK (1) MB (1) QC (1)
Saskatchewan: The *Management and Reduction of Greenhouse Gases (General and Electricity Producer) Regulations* (M-2.01 Reg 1) address GHGs and may achieve co-benefit air pollutant reductions. Individual facilities have operating permits that may include limits for air pollutants. **Quebec**: *Regulation respecting a cap-and-trade system for greenhouse gas emission allowances* (Q-2, r. 46.1) address GHGs and may achieve co-benefit air pollutant reductions. Individual facilities also have operating permits that are updated periodically and generally include limits for air pollutants. **Manitoba:** *The Climate and Green Plan Act* (C134) establish an economy-wide carbon savings account.		

Figure 4.17 shows the historical emissions and projections based on the ECCC 2020 reference case for the industrial gas sector. Any relevant federal or provincial measures have been included in the reference case, where possible. Sector emissions were projected to increase and then stabilize at 2015 levels until 2035. These projections do not account for possible increases in NO_x emissions from increased hydrogen production in the future as outlined above.

Annex 3: Reported Facility Emissions for Active Facilities – NPRI data from 2012 to 2019 includes facility specific emissions for the sector and shows that total reported NPRI emissions of NO_x have remained relatively stable since 2012.

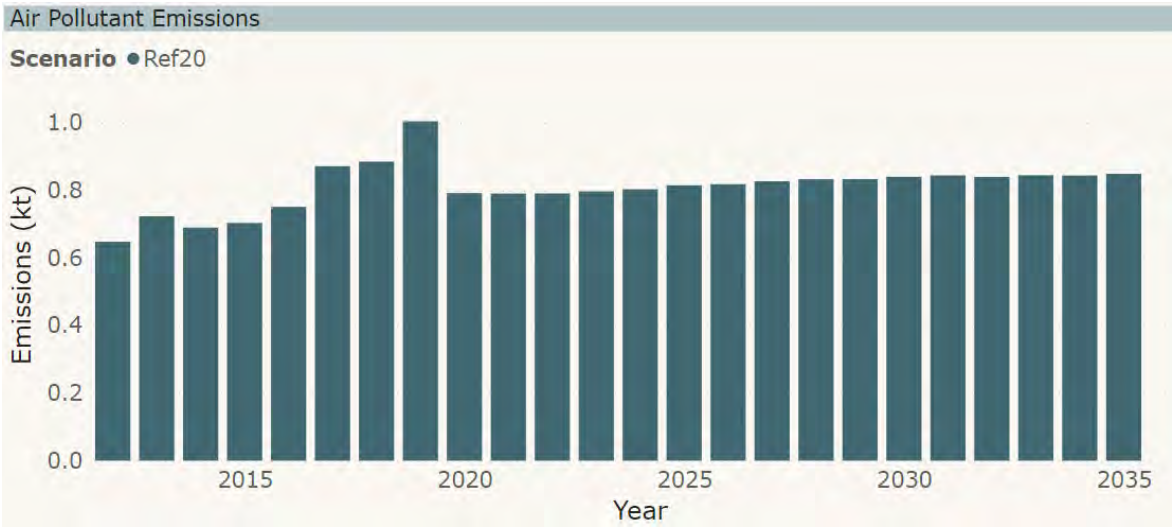

Figure 4.17: NO_x Emissions under 2020 Reference Case: Chemical and Fertilizer Sectors - Industrial Gas

Conclusion

No additional federal or provincial instruments have been identified that specifically target NO_x emissions from SMRs. Even with carbon capture and storage equipment to curb CO_2 emissions, NO_x emissions will remain the same or could increase if these facilities are expanded or

additional facilities are built. NO_x emissions from the current facilities have remained stable since 2012 based on NPRI reported emissions.

> **C11 –** Initial analysis indicates that BLIERs from steam methane reformers have not been addressed. Further analysis by ECCC may be needed to inform any potential recommendations for further risk management actions. This analysis should also consider the potential impact on NO_x emissions from SMRs resulting from recent actions to address GHG emissions as well as new initiatives to develop a hydrogen economy in Canada.

4.6.7. Nitrogen-based Fertilizer Production (Ammonia: NH_3)

In Canadian N-fertilizer production, steam methane reformers (SMR) are used to produce hydrogen which is combined with available nitrogen in the air to produce ammonia. Many Canadian facilities then use the ammonia to produce several products including ammonium nitrate and urea which are used directly as N-fertilizers or as feedstocks in the production of urea-ammonium nitrate (UAN) liquid fertilizers.

The European Commission's approach was chosen for the basis of the BLIER, as the performance standards were based upon the requirements presented in the Best Available Techniques Reference Document (BREF) for Large Volume Organic Chemical Industry and the *Best Available Techniques for Pollution Prevention and Control* in the European Fertilizer Industry from the European Fertilizer Manufacturers Association. The proposed BLIER required the installation and use of ammonia control technologies in the production of ammonia and urea. (BLIERs 2012 a.)

No consensus was achieved on the proposed BLIERs. During the original BLIERs discussions, further work was needed to identify a requirement that would be equivalent to base-level in Canada taking into account technical feasibility for ammonia production plants. For urea production plants, all Canadian facilities reported having a water scrubber or slightly acidic scrubber installed to treat ammonia emissions from urea finishing operations (CFI, 2011), therefore it was expected that all urea plants met the proposed emission intensity requirements under normal operating conditions. Currently there are 10 N-fertilizer production facilities that produce ammonia and/or urea located in Alberta, Ontario, Saskatchewan and Manitoba. The current performance relative to the proposed BLIER has not been reassessed.

Previously in 2012, ECCC senior management had directed that alternative instruments can be explored for ammonia. In the course of the N-fertilizer BLIERs discussions, industry suggested the development of a code of practice for NH_3 release from N-fertilizer producing facilities.

N-fertilizer production facilities are included in MSAPR and are subject to the requirements for Part 1 (Boilers and Heaters) and Part 2 (Stationary Spark-Ignition Engines) for NO_x. No additional federal or provincial instruments have been identified that specifically target NH_3 emissions from these facilities.

Figure 4.18 shows the historical emissions and projections based on the ECCC 2020 reference case for the fertilizer sector, which includes more than N-fertilizer production. Any relevant federal or provincial measures have been included in the reference case, where possible. Ammonia emissions are projected to increase to 2035.

Annex 3: Reported Facility Emissions for Active Facilities – NPRI data from 2012 to 2019 includes facility specific emissions for the sector and shows that total reported NPRI emissions of NO_x have remained relatively stable since 2012.

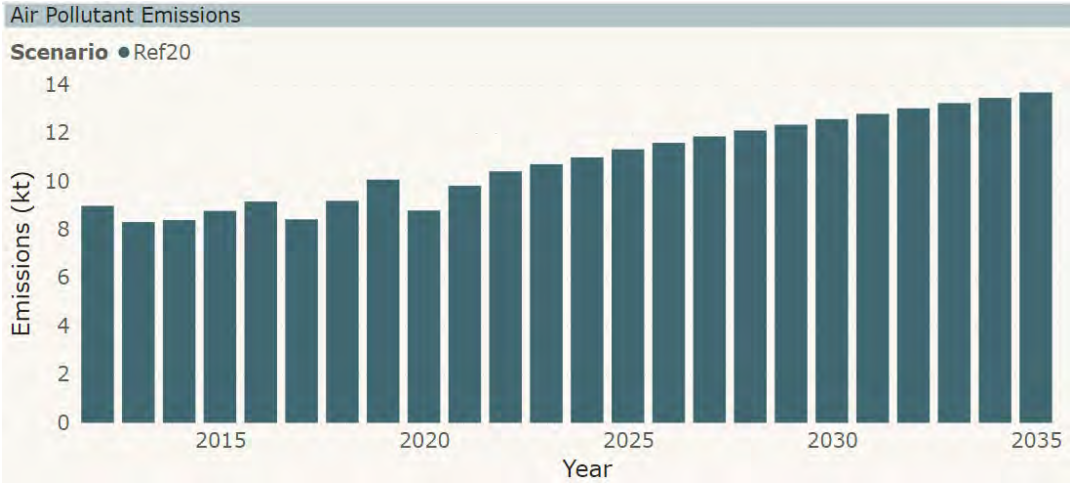

Figure 4.18: NH_3 Emissions under 2020 Reference Case: Fertilizer Sector

Conclusion

No additional federal or provincial instruments have been identified that specifically target NH_3 emissions from these facilities. No requirements were identified that were appropriate for BLIERs during the BLIERs discussions. Reported facility emissions have remained stable since 2012.

> **C12 –** Initial analysis indicates that BLIERs for N-fertilizer production have not been addressed. Further analysis by ECCC may be needed to inform any potential recommendations for further risk management actions for N-fertilizer production plants, including assessing the earlier proposal for the development of a Code of Practice.

4.7. Iron Ore Pellets Sector (NO_x)

The production of iron ore pellets involves the mining of iron ore from open pits, crushing and concentrating the ore into a concentrate, and finally pelletizing. In the pelletizing process, iron ore concentrate is rolled into balls (pellets) and hardened through thermal treatment in an induration furnace. The induration furnace is the primary source of emissions from this sector of sulfur dioxide (SO_2), inhalable particles with a diameter of 2.5 microns or less ($PM_{2.5}$), and oxides of nitrogen (NO_x). (BLIERs 2011 b.)

During the BLIERs process, some consensus was reached among governments and stakeholders for some pollutants. Subsequently the Performance Agreement Concerning Air Pollutants from the Iron Ore Pellet Sector was put in place with the two companies in Canada producing iron ore pellets. The agreement focused on addressing emissions of SO_2 and $PM_{2.5}$ from these facilities. Work to investigate requirements to address NO_x emissions from the sector is ongoing. The industry members of the Iron Ore Pellets Sector Working Group led the completion of a consultant's study in 2020 to look at the current NO_x reduction technology

options for the sector. The working group plans to meet to discuss the applicable options and possible quantitative NO_x targets in fall 2021.

The iron ore pellets sector is included in MSAPR and is subject to the requirements for Part 1 (Boilers and Heaters) and Part 2 (Stationary Spark-Ignition Engines) for NO_x. No new federal or provincial instruments have been identified that are currently addressing NO_x emissions from the iron ore pellets sector, however, a number of the GHG measures that have been put in place or are under development by the federal and provincial governments, may address a portion of the NO_x emissions (**Table 4.10**).

Table 4.10: Federal and Provincial Instruments Addressing Iron Ore Pellets since 2012

Iron Ore Pellets Sector	Pollutants NO_x	Current Number of Active Facilities in Each Province QC (1) NL (1)
Federal Instruments *Multi-Sector Air Pollutants Regulations* (SOR/2016-151) NOx emissions from iron ore pelletizing facilities are covered under these regulations. *Greenhouse Gas Pollution Pricing Act* (S.C. 2018) is an Act to mitigate climate change through the pan-Canadian application of pricing mechanisms to a broad set of greenhouse gas emission sources. *Output-Based Pricing Systems Regulations* (SOR/2019-266) a regulatory trading system under the authority of the *Greenhouse Gas Pollution Pricing Act* for industrial facilities that is administered by the Department of the Environment (the Department) and the Canada Revenue Agency. ***Provincial Instruments*** **Quebec**: *Regulation respecting a cap-and-trade system for greenhouse gas emission allowances* (Q-2, r. 46.1) address GHGs and may achieve co-benefit air pollutant reductions. Individual facilities also have operating permits that are updated periodically and generally include limits for air pollutants. **Newfoundland and Labrador:** Environmental Protection Regulatory Permits and Licences issued under the *Environmental Protection Act*, SNL 2002 c E-14.2 Section 83 – Industrial Compliance		

ECCC's Ref20 does not have data that is specific for the iron ore pellets sector so no emissions projections are included here. NPRI data is included in **Annex 3**: Reported Facility Emissions for Active Facilities – NPRI data from 2012 to 2019 and shows a slight decline from 2012 for the two facilities in the sector, however, it does not represent a significant change in emissions that would be expected from the addition of pollution controls or a technology shift in the production technology.

Conclusion

No new federal or provincial instruments have been identified that are currently addressing NO_x emissions from the iron ore pellets sector, however, it is possible that GHG measures may

address a portion of the NO_x emissions. Reported emissions for the two facilities in the sector have declined slightly since 2012.

> **C13 –** Initial analysis indicates that NO_x BLIERs for the iron ore pellets sector have not been addressed. Efforts on NO_x with the Iron Ore Pellets Working Group should continue. Further detailed analysis by ECCC is needed to inform any recommendations on potential further risk management actions.

4.8. Cement Sector (TPM, SO_2, NO_x)

Portland cement, which can be grey or white, contains appropriate proportions of lime, silica alumina and iron components. The raw materials are pulverized and mixed in the desired proportions. After blending, the prepared mix is fed into the upper end of a rotary kiln, where it is burned or fired at temperatures of 1400-1650°C and changed into portland cement clinker. The clinker is then cooled and pulverized. During this operation, a small amount of gypsum is added to regulate the initial chemical reaction of the cement. This pulverized product is finished portland cement, ready for use in making concrete.[9]

Currently there are 14 grey cement plants in Canada, located in British Columbia, Alberta, Ontario, Quebec and Nova Scotia. One white cement plant is located in Ontario. White cement is used in ornamental and architectural applications. Following the original BLIERs discussion, the grey cement sector was regulated through the *Multi-Sector Air Pollutants Regulations* (MSAPR) Part 3 for NO_x and SO_2.

During the BLIERs discussions, it was acknowledged that additional data would be needed on emissions and potential reductions for white cement in order to be able to determine appropriate standards. (BLIERs 2011 a.) As a result, the one white cement facility located in Ontario was not included in MSAPR. No new federal or provincial instruments have been identified that are currently addressing NO_x and SO_2 from white cement. Work on BLIERs for the white cement facility can be considered once facility data is reassessed. Additionally, a number of the GHG measures that have been put in place or are under development by the federal and provincial governments, may address a portion of the NO_x emissions from the sector (**Table 4.11**).

For total particulate matter (TPM), no consensus was reached among governments and stakeholders during the BLIERs process for both the grey and white cement plants. No new federal instruments have been implemented that are currently addressing TPM emissions from this sector, however provincial governments address particulate emissions via operating permits. The provincial measures for TPM meet the original objectives of the BLIERs, which were based on European standards as the leading jurisdiction. Alberta, Ontario and Quebec have PM emissions standards and fugitive dust control regulations. These 3 provinces account for 85% of the total TPM sector emissions. BC and NS also have PM emissions standards. All cement facilities operate abatement control devices (ESP and/or fabric filter) and provinces have requirements in place for fugitive emissions via permits. Emissions of TPM from the cement sector (2kt/y) are <1% of total industrial releases.

[9] The Canadian Encyclopedia https://www.thecanadianencyclopedia.ca/en/article/cement-industry

Table 4.11: Federal and Provincial Instruments Addressing Cement since 2012

Cement Plants	Pollutants	Current Number of Active Facilities in Each Province
	SO_2 NO_x TPM	Grey Cement: BC (2) AB (2) ON (5) QC (4) NS (1) White Cement: ON (1)
Federal Instruments *Multi-Sector Air Pollutants Regulations* (SOR/2016-151) NO_x and SO_2 emissions from grey cement manufacturing facilities are covered under these regulations. *Greenhouse Gas Pollution Pricing Act* (S.C. 2018) is an Act to mitigate climate change through the pan-Canadian application of pricing mechanisms to a broad set of greenhouse gas emission sources. *Output-Based Pricing Systems Regulations* (SOR/2019-266) a regulatory trading system under the authority of the *Greenhouse Gas Pollution Pricing Act* for industrial facilities that is administered by the Department of the Environment (the Department) and the Canada Revenue Agency. ***Provincial Instruments*** Individual cement plants have operating permits or approvals that are updated periodically and generally include limits for TPM. **BC:** *GHG Industrial Reporting and Control Act* (SBC 2014) addresses GHG and may achieve co-benefit air pollutant reductions. Individual refineries also have operating permits that are updated periodically and generally include limits for air pollutants. **Alberta:** *Alberta's Technology Innovation and Emissions Reduction System* (TIER) addresses GHG and may achieve co-benefit air pollutant reductions. Individual refineries also have operating approvals that are updated periodically and generally include limits for air pollutants. **Ontario:** *GHG Emissions Standards Regulation* (O. Reg2 41/19) addresses GHGs and may achieve co-benefit air pollutant reductions. *Air Pollution – Local Air Quality* (419/05) (2019) have updated Air Standards for SO_2. **Quebec:** *Regulation respecting a cap-and-trade system for greenhouse gas emission allowances* (Q-2, r. 46.1) address GHGs and may achieve co-benefit air pollutant reductions. Individual refineries also have operating permits that are updated periodically and generally include limits for air pollutants. **Nova Scotia:** *Cap-and-Trade Program Regulations* (N.S. Reg. 48/2020) include greenhouse gas emission caps, rules for distributing, buying and selling greenhouse gas allowances, and other details and include provisions for cement production.		

Figure 4.19 to **Figure** 4.21 show the historical emissions and projections based on the ECCC 2020 reference case for the cement sector. TPM emissions have declined and are projected to

stay at 2017 levels until 2035. Although emissions of NO_x and SO_2 are rising slightly in the projections, MSAPR is off-setting the significant growth in emissions that would have been anticipated as a result of the growth in production.

NPRI emissions data in **Annex 3**: Reported Facility Emissions for Active Facilities – NPRI data from 2012 to 2019 show that TPM emissions have decreased slightly overall due to some reductions at a few facilities. Emissions for the only white cement plant in Canada indicate that NO_x and SO_2 emissions have not changed since 2012, when the original need for the BLIER was identified.

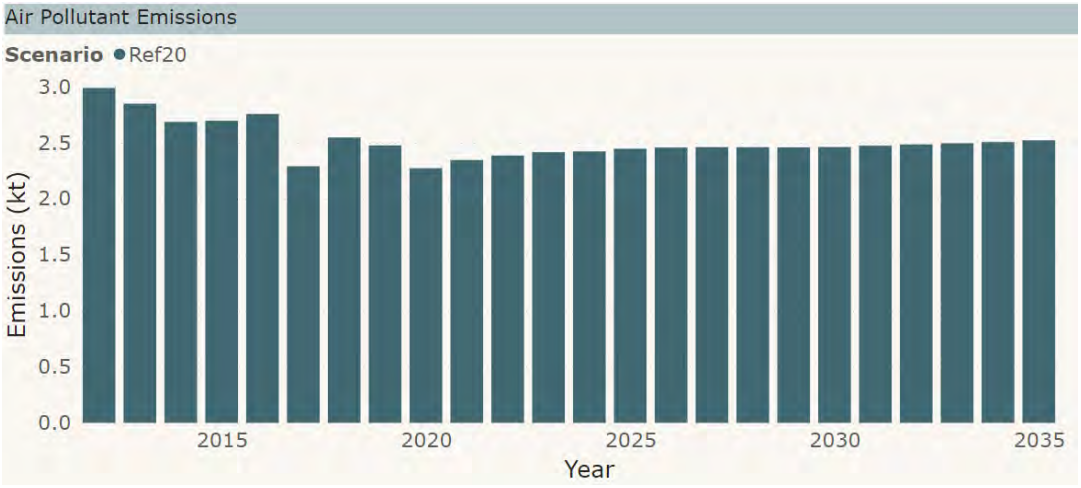

Figure 4.19: TPM Emissions under 2020 Reference Case: Cement Sector

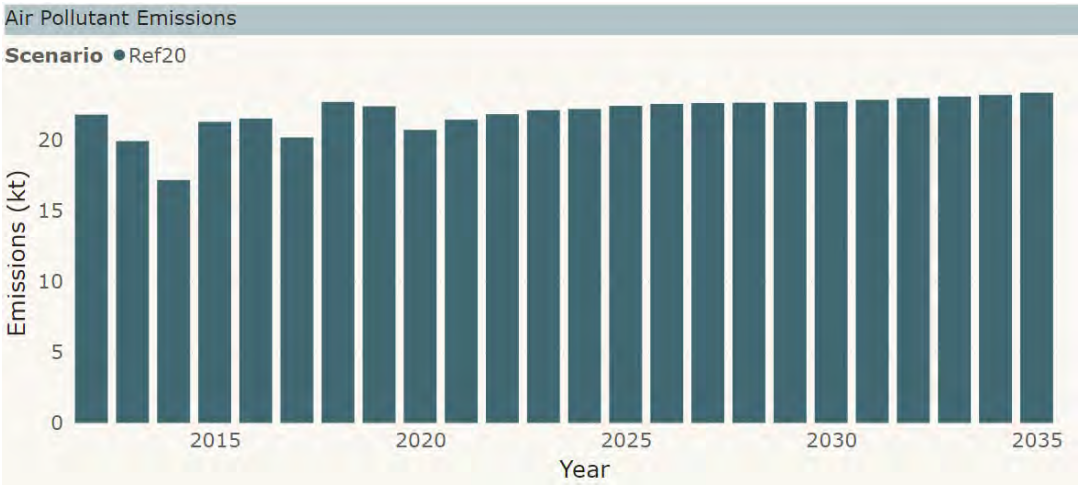

Figure 4.20: SO_x Emissions under 2020 Reference Case: Cement Sector

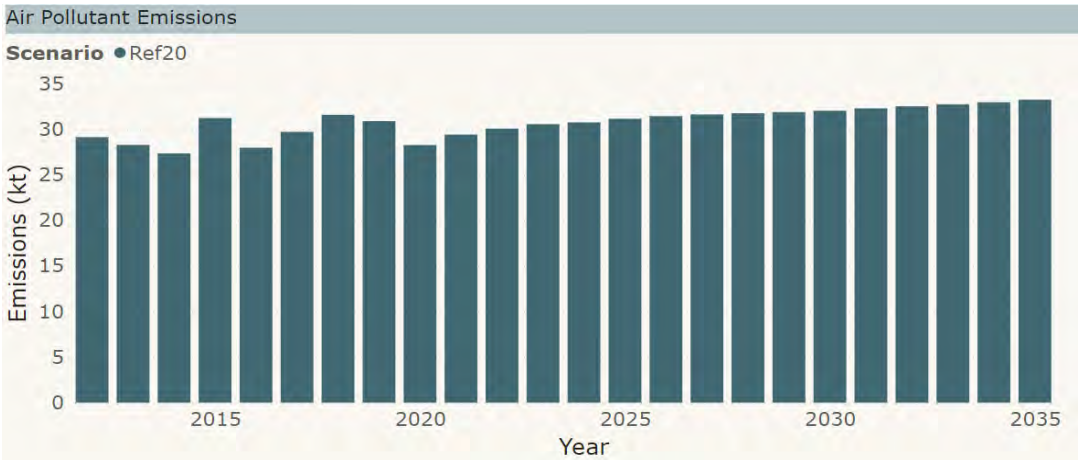

Figure 4.21: NO_x Emissions under 2020 Reference Case: Cement Sector

Conclusion

Provincial governments address particulate emissions through operating permits. Reported facility emissions of TPM have decreased slightly since 2012 and projected emissions are expected to remain stable to 2035. Emissions for the only white cement plant in Canada indicate that NO_x and SO_2 emissions have not changed since 2012, when the original need for the BLIER was identified.

> **C14 –** Initial analysis indicates that BLIERs for TPM from the cement sector are being addressed, while BLIERs for NO_x and SO_2 from white cement plants are not being addressed. Further detailed analysis by ECCC may be needed to inform any recommendations on potential risk management actions for this facility.

5. Identified Future Work

This report is an initial report that examines the need for outstanding BLIERs, in light of measures adopted since the BLIERs commitments were first made. Following are some potential next steps for the outstanding BLIERs that have not been addressed to date.

Additionally, under AQMS, the working groups were directed to focus on key priorities. As a result, a broader suite of pollutants that were included in CAMS were not prioritized during BLIERs deliberations for AQMS, such as NOx and VOCs emission from pulp and paper sector. Additional work is needed in the future to determine if measures are needed for additional pollutants, sectors and sources to fully address the “Industrial Emission Requirements” element of AQMS.

Petroleum Sector

The management response and action plan also identified two additional activities that may be completed. The first is a detailed analysis of air pollution gaps and outstanding concerns related to the petroleum sector—informing recommendations on potential further risk management actions for the petroleum sector (December 2022). If warranted, a second follow-

up activity is the development of a proposed approach to address emissions of sulphur dioxide and other air pollutants from petroleum refineries and upgraders (December 2023).

The detailed analysis should cover all subsectors of the petroleum sector, including refineries, oil sands, and upstream oil and gas, informed by conclusions of this report, and consideration should be given to proposing an approach to addressing emissions from these subsectors if warranted.

Chemicals and N-Fertilizer Sectors

Further analysis is suggested for six of the seven outstanding chemical BLIERs – butyl rubber, ethylene manufacturing from steam cracking, ethylene based polymers, ethanol production, Steam Methane Reformers (SMR), and ammonia from N-fertilizer production.

Of these, it is recommended that NO_x emissions from SMRs and ammonia emissions from N-fertilizer production be prioritized for further analysis. NO_x emissions from SMRs make up a large portion of NO_x emissions from the chemical sector and ammonia emissions from N-fertilizer production make up a significant portion of ammonia emissions from all the industrial sectors.

Iron Ore Pellets Sector

For the iron ore pellets sector, work is underway within the Iron Ore Pellets Working Group to review and assess the potential NO_x reduction opportunities for the sector.

Cement Sector

Further detailed analysis by ECCC may be needed to inform any recommendations on potential risk management actions to address NO_x and SO_2 emissions from white cement plants.

Pulp and Paper

In order to make informed decisions to improve air quality, reduce the impacts of air pollution on health and the environment, data collection and analysis work is needed by ECCC to inform any recommendations on potential risk management actions to address NOx and VOC emissions from pulp and paper, the largest producer of energy from biomass (a significant source of air pollutants such as NOx and VOCs) in Canada.

6. Next Steps

This report addresses the first of three deliverables to address outstanding BLIERs identified in the Management Response and Action Plan for the Evaluation of the AAPHI. ECCC plans to undertake additional work before taking any decisions about addressing the outstanding BLIERs. This work will include the more detailed analysis on the petroleum sector (MRAP deliverable 2.2), as well as prioritizing some of the other items included in the “Identified Future Work” section, in consideration of other governmental priorities.

References

BLIERs Reports

2012 a. “Ammonia Emissions From Nitrogen-Based Fertilizer Production BLIERs Expert Group, BLIERs Working Document Final Report.” (2012)

2012 b. “BLIERs Sector Expert Group, Electricity BLIERs Sector Expert Group Final Report.” (2012)

2011 a. “Cement BLIERs Expert Group, BLIERs Final Report.” (2011)

2012 c. “Hydrocarbon Production and Processing Sectors BLIERs Expert Group, Final Report Hydrocarbon Production and Processing Sectors BLIERs (VOCs).” (2012)

2011 b. “Iron Ore Pellet Sector BLIERs Expert Group, BLIERs Final Report.” (2011)

2011 c. “NO_X From Carbon Black Production - Furnace Process BLIERs Expert Group, BLIERs Final Document.” (2011)

2011 d. “NO_X From Carbon Black Production - Thermal Process BLIERs Expert Group, BLIERs Final Document.” (2011)

2012 d. “NO_X From Ethylene Cracking BLIERs Expert Group, BLIERs Working Document Final Report.” (2012)

2011 e. “NO_X From Steam Methane Reformers (SMR) - Nitrogen-Based Fertilizers And Stand-Alone Hydrogen Production BLIERs Expert Group, BLIERs Final Document.” (2011)

2011 f. “Oil Sands BLIERs Expert Group, BLIERs Final Report.” (2011)

2012 e. “Petroleum Refining BLIERS Expert Group, BLIERs Final Report.” (2012)

2012 f. “Upstream Oil and Gas (Conventional) Base Level Industrial Emission Requirements SO_2.” (2012)

2011 g. “VOC Emissions From Butyl Rubber Manufacturing BLIERs Expert Group, BLIERs Final Document.” (2011)

2011 h. “VOC From Ethylene Based Polymers BLIERs Expert Group, BLIERs Final Document.” (2011)

2012 g. “VOC From Grain Ethanol Production For Industrial And Fuel Applications BLIERs Expert Group, BLIERs Final Report.” (2012)

Canadian Council of Ministers of the Environment. “The Air Quality Management System: Federal, Provincial and Territorial Roles and Responsibilities.” (2012) PN 1475

Environment and Climate Change Canada. 2021 a. “Evaluation of the Addressing Air Pollution Horizontal Initiative.” (2021).

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Environment and Climate Change Canada. 2021 c. National Pollutant Release Inventory Data. (2021). Accessed October 2021.

ANNEX

Annex 1: Base-level Industrial Emission Requirements

Excerpt from the AQMS roles and responsibilities document:

> **Base-Level Industrial Emission Requirements**
>
> These industrial emission requirements are to achieve a consistent base-level of performance for major emitters across the country.
>
> Roles and Responsibilities:
>
> • Governments will work collaboratively within the Canadian Council of Ministers of the Environment through mutually agreed processes to develop, review and amend the base-level industrial emissions requirements (BLIERs) as necessary, with the appropriate involvement of stakeholders.
>
> • Under the Canadian Environmental Protection Act, 1999, the federal government will regulate where feasible, or use alternative instruments, to establish the BLIERs across Canada, which will function as a backstop to provincial and territorial instruments implementing the BLIERs.
>
> • The provinces and territories may regulate or otherwise implement the BLIERs. Where provinces or territories opt not to implement a BLIER, the federal regulation or instrument could apply and the federal government would ensure compliance with the BLIER(s).

Annex 2: List of Federal Instruments

Table A.1: List of Published Federal Instruments Relevant to Industrial Sectors

Instrument name	Registration/ Publication date
Multi-Sector Air Pollutants Regulations	17 June 2016
Code of Practice to reduce fugitive emissions of total particulate matter (TPM) and VOCs from iron, steel, and ilmenite sector	28 May 2016
Code of Practice to reduce emissions of fine particulate matter ($PM_{2.5}$) from the primary aluminium sector	28 May 2016
Iron, Steel and Ilmenite Sector Pollution Prevention Planning Notice for NO_x, SO_2, and VOCs	6 May 2017
Code of Practice for managing particulate matter emissions in the potash sector	Sep 2017
Guidelines for the Reduction of Nitrogen Oxide Emissions from Natural Gas-fuelled Stationary Combustion Turbines	Nov 2017
Performance Agreement Concerning Air Pollutants from the Aluminum and Alumina Sector	13 Nov 2017
Base Metals Smelter Sector Performance Agreements for SO_2 and TPM	5 Jan 2018
Performance Agreement Concerning Air Pollutants from the Iron Ore Pellet Sector	5 Jan 2018
Code of Practice for the management of air emissions from pulp and paper facilities	Jul 2018
Regulations Respecting Reduction in the Release of Methane and Certain Volatile Organic Compounds (Upstream Oil and Gas Sector)	26 April 2018
Reduction in the Release of Volatile Organic Compounds Regulations (Petroleum Sector)	11 Nov 2020

Annex 3: Reported Facility Emissions for Active Facilities – NPRI data from 2012 to 2019

Electricity Sector

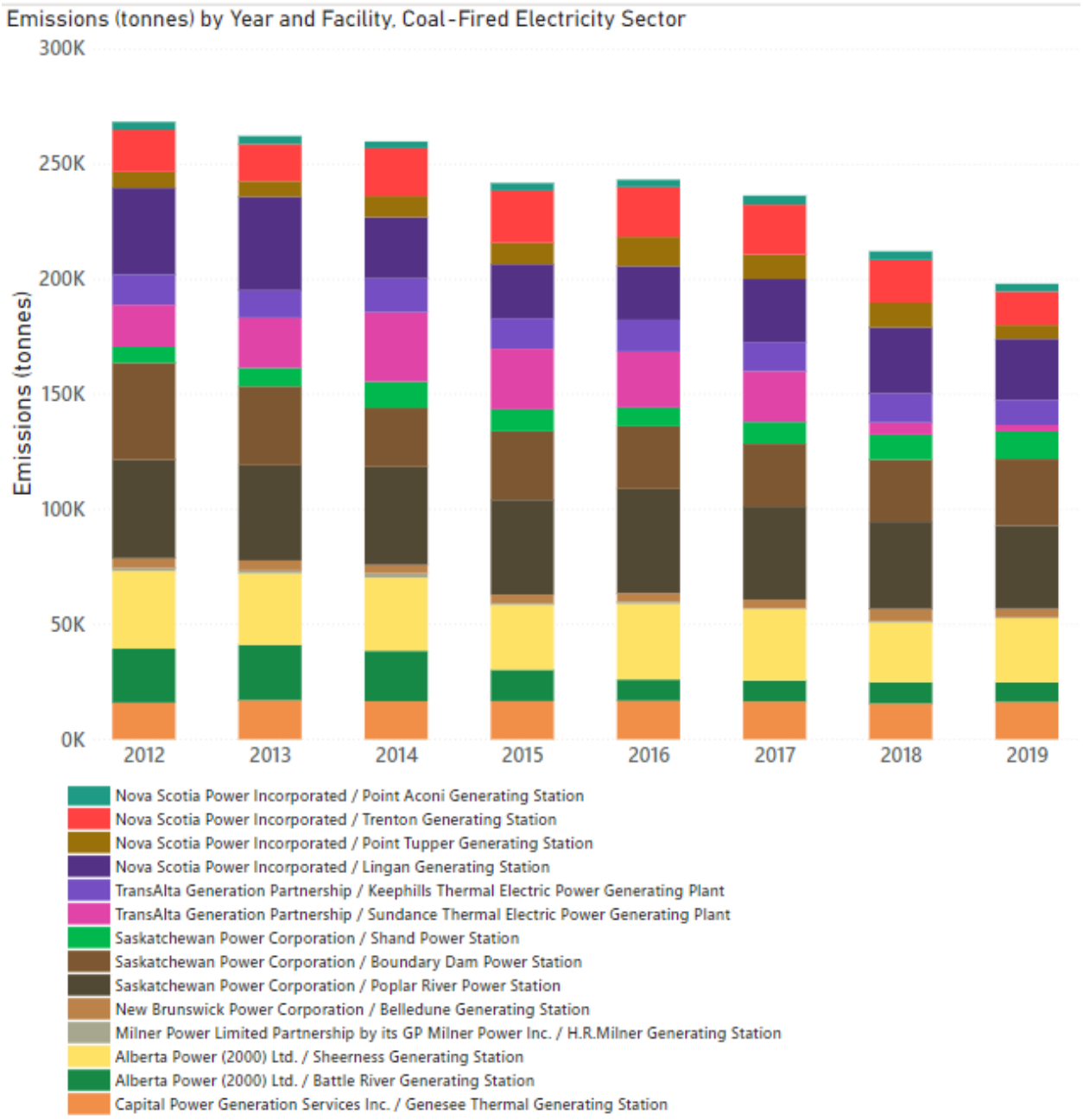

Figure A.1: Coal-fired Electricity Sector – SO_2 Emissions

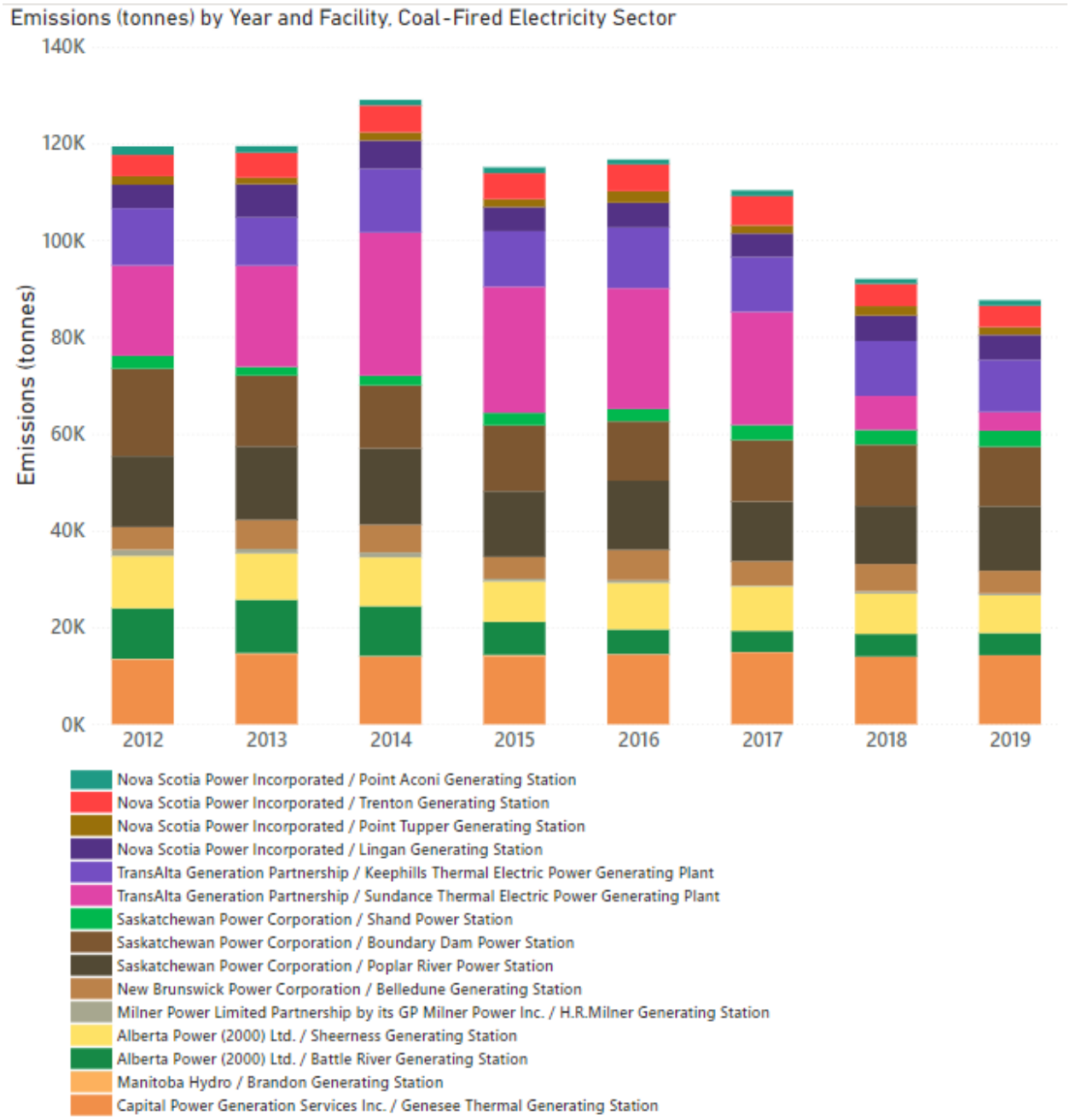

Figure A.2: Coal-fired Electricity Sector – NO_X Emissions

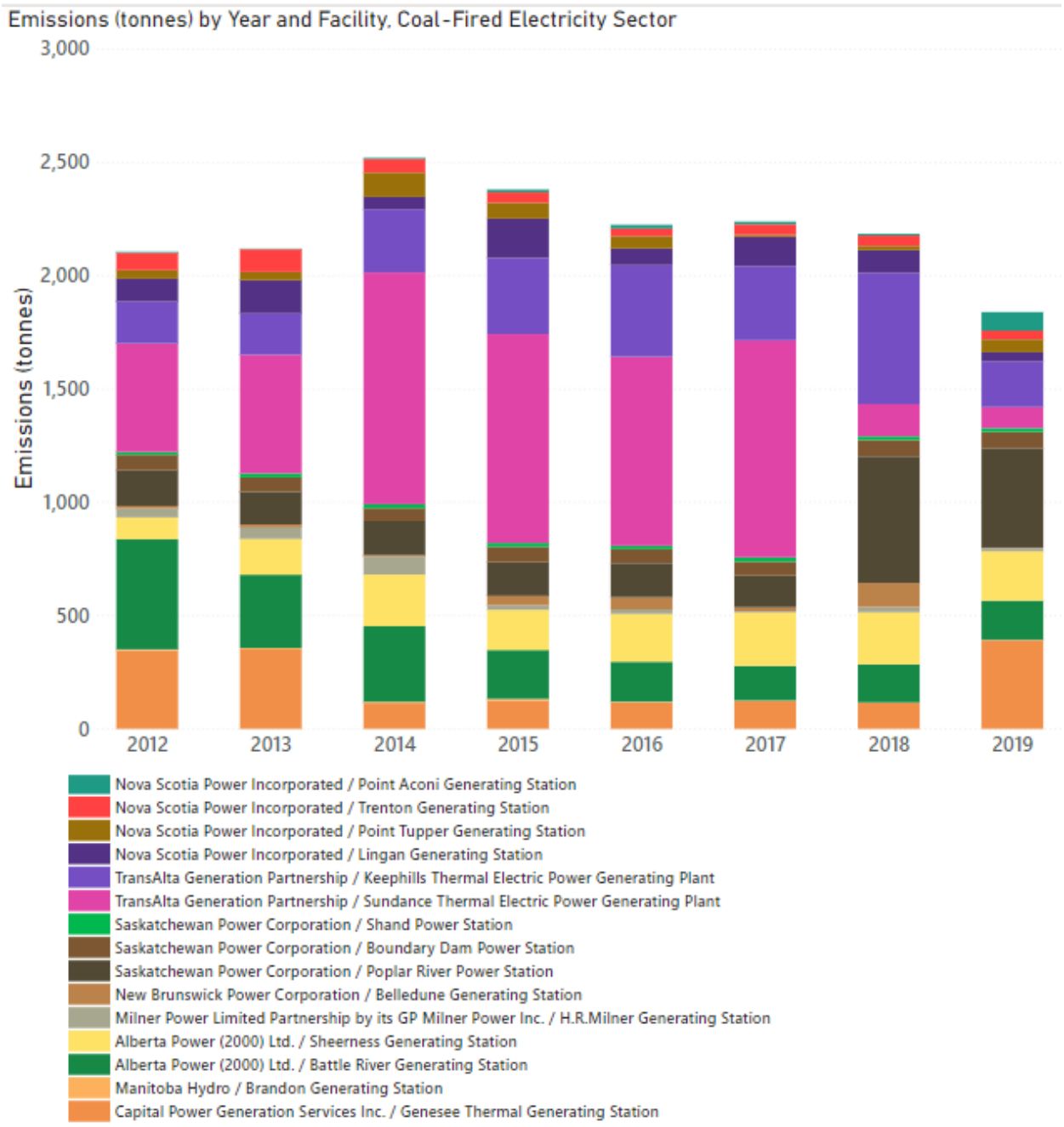

Figure A.3: Coal-fired Electricity Sector – $PM_{2.5}$ Emissions

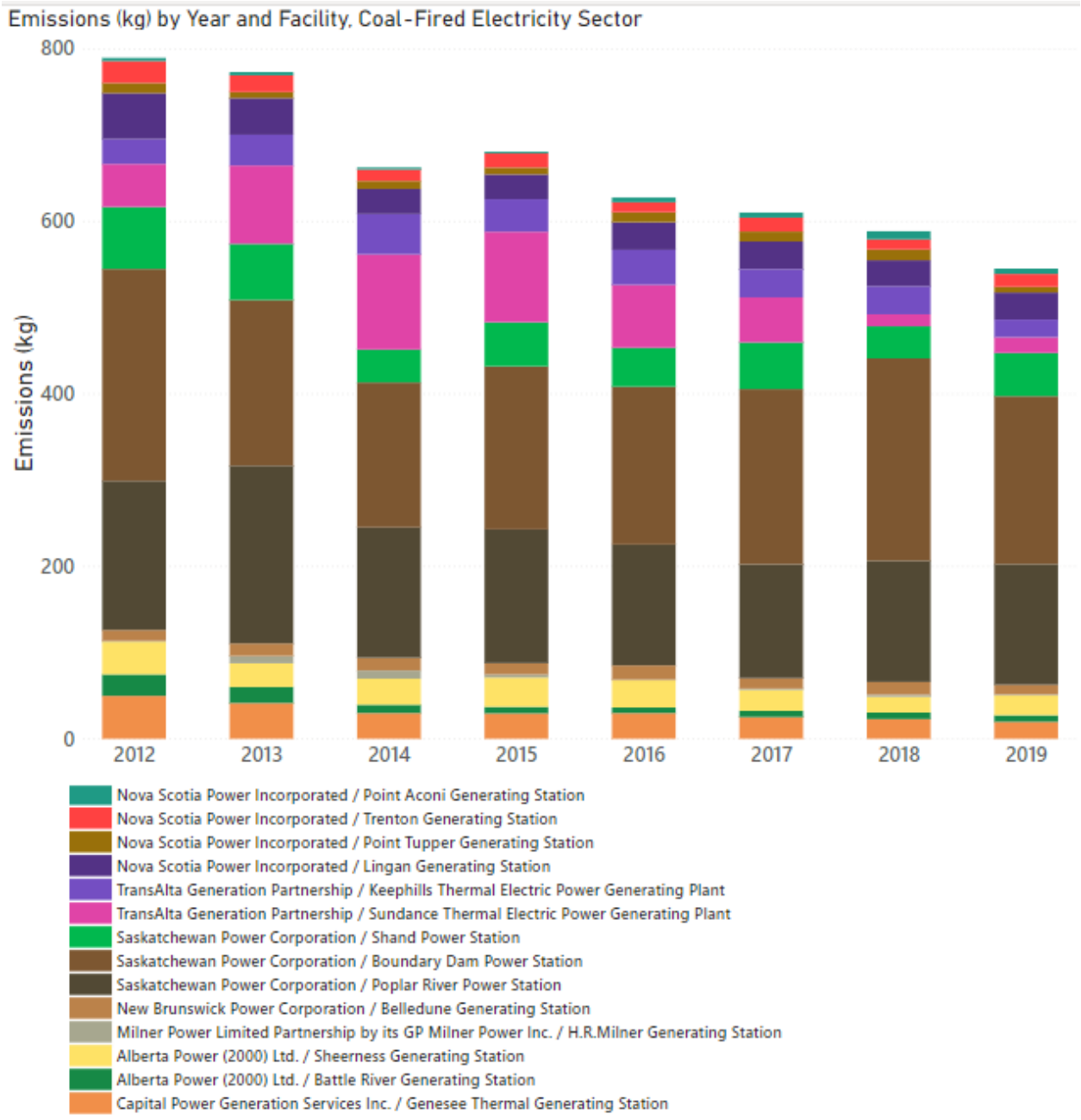

Figure A.4: Coal-fired Electricity Sector – Mercury Emissions

Oil Sands

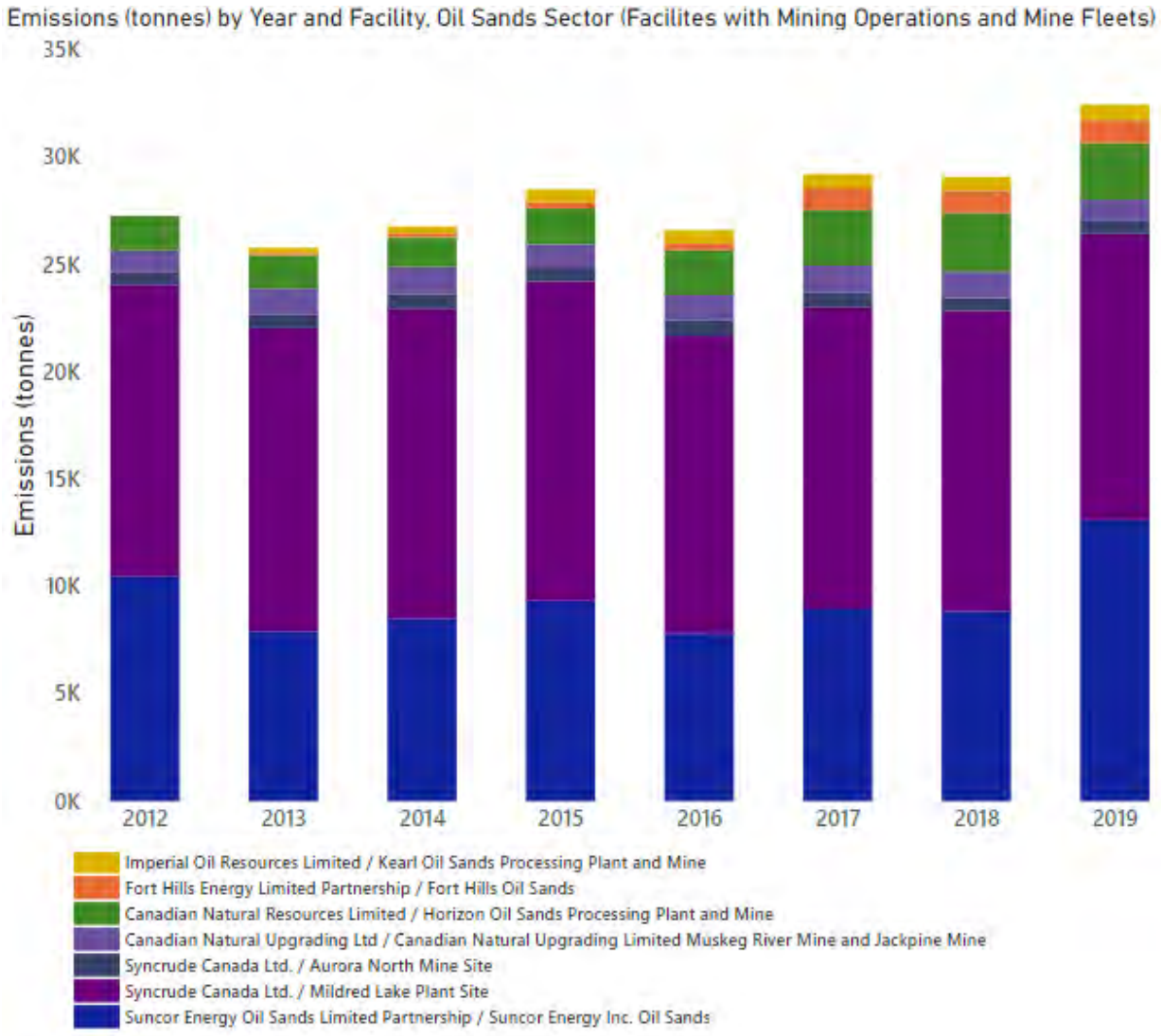

Figure A.5: Oil Sands Sector (Facilities with Mining Operations and Mine Fleets) – NO_X Emissions

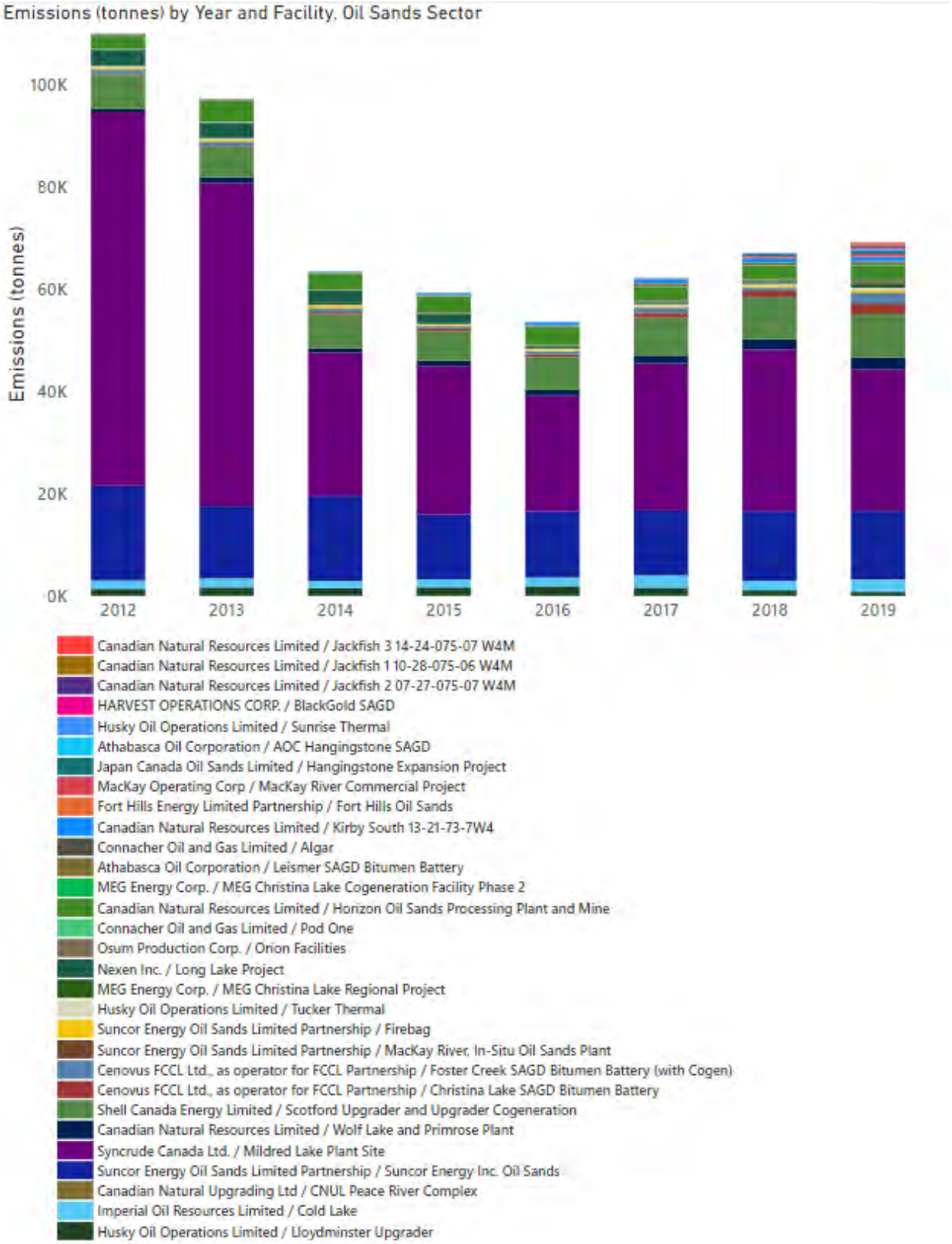

Figure A.6: Oil Sands Sector – SO_2 Emissions

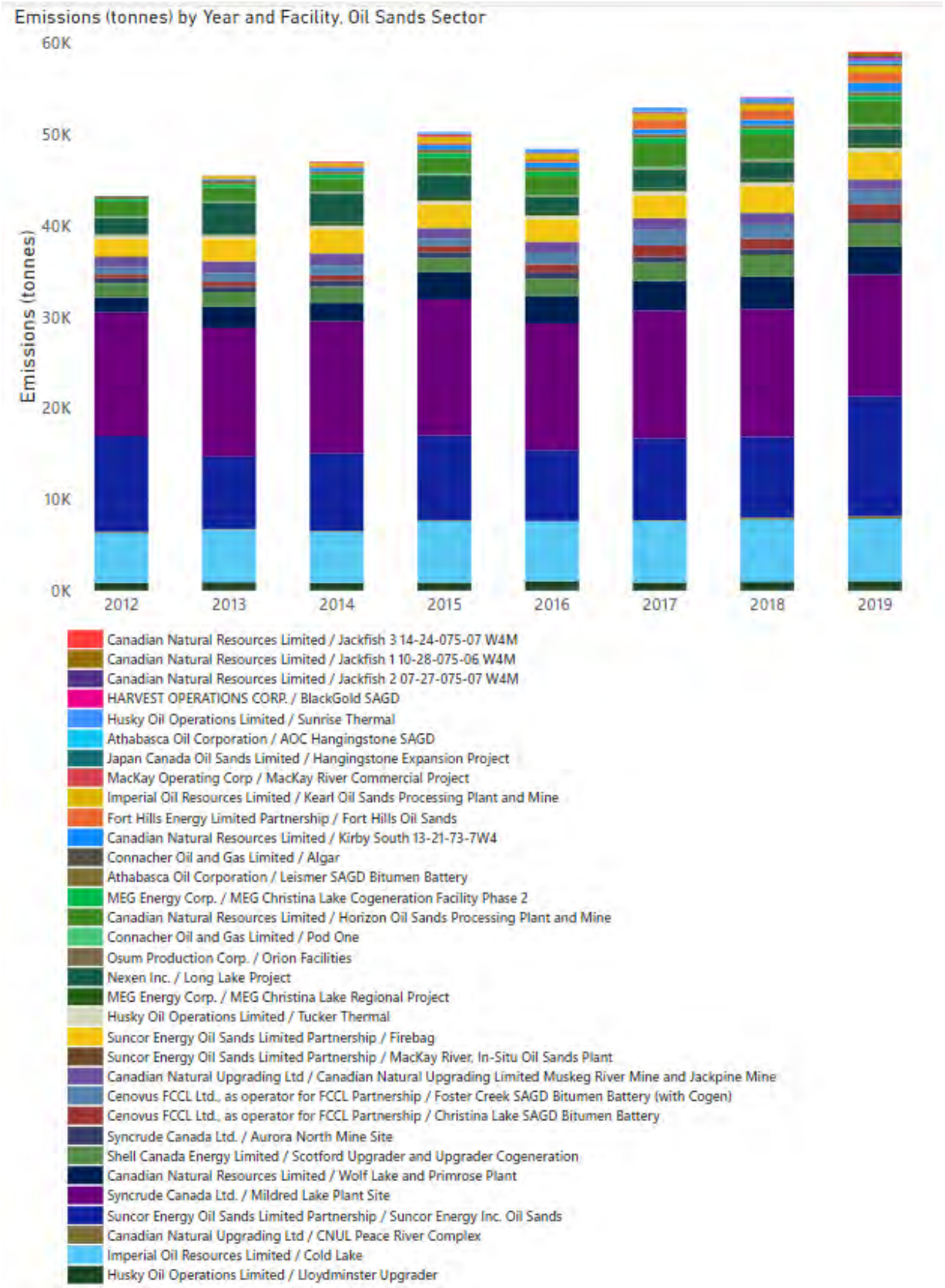

Figure A.7: Oil Sands Sector – NO_X Emissions

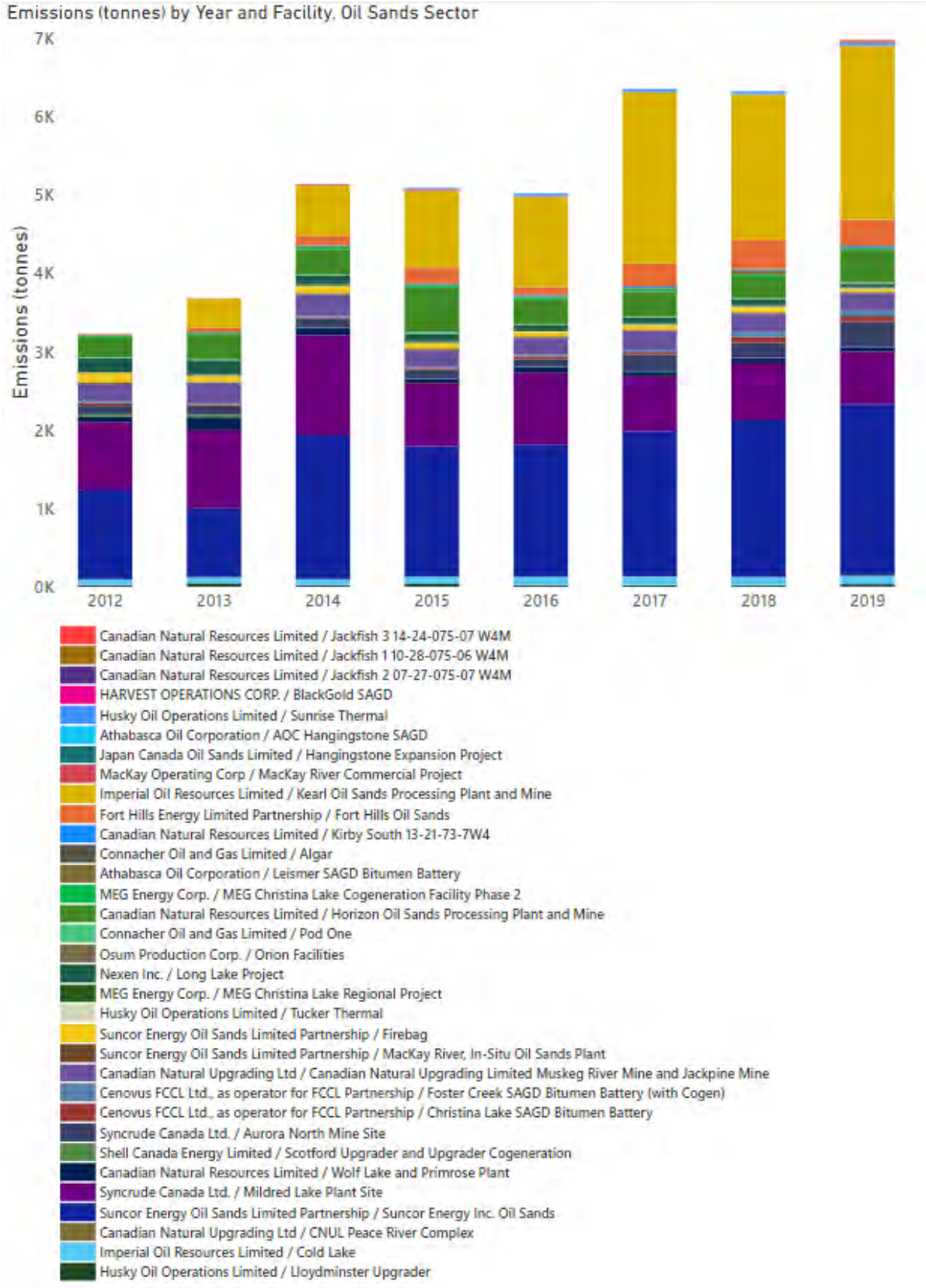

Figure A.8: Oil Sands Sector – $PM_{2.5}$ Emissions

Petroleum Refining

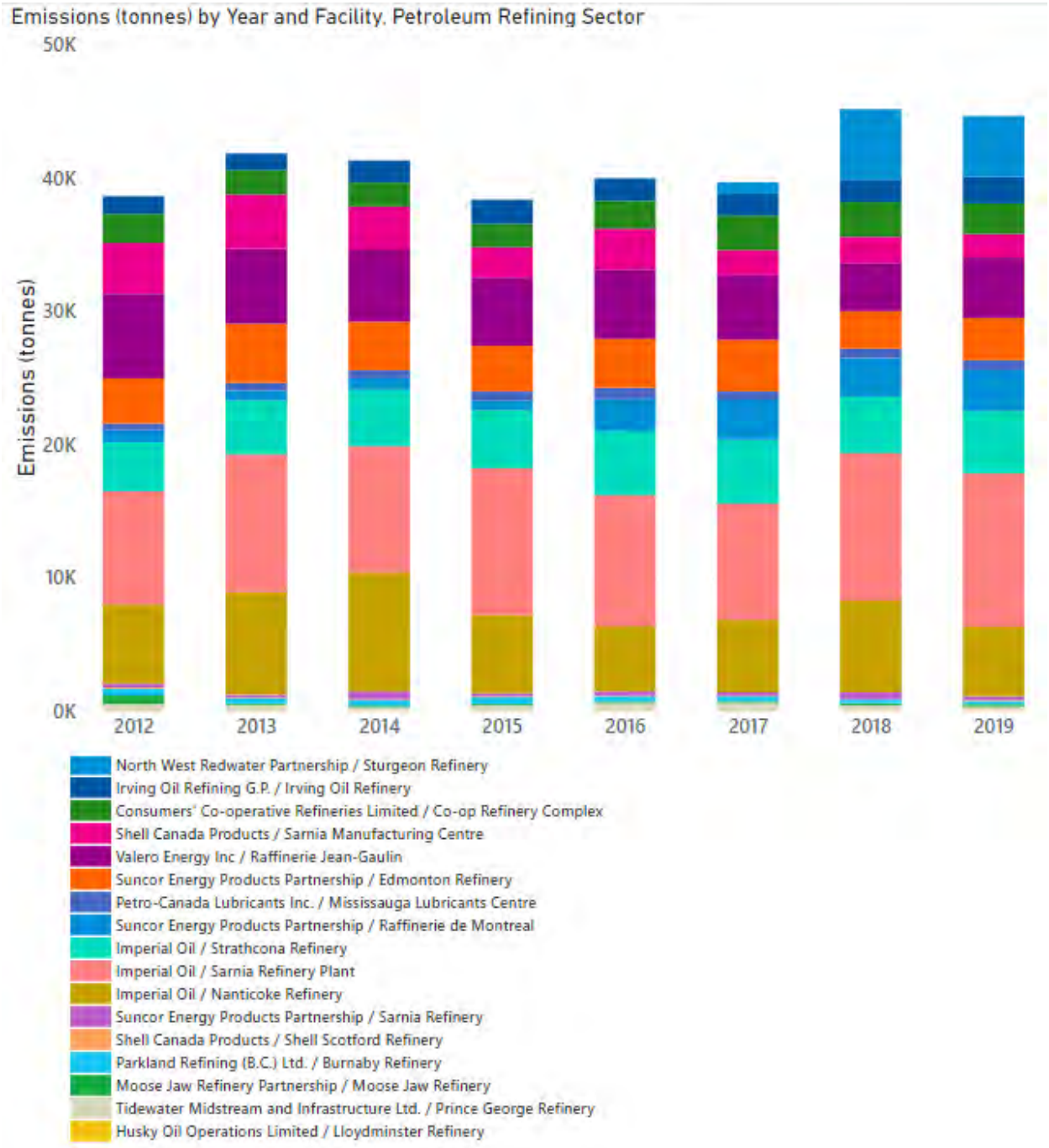

Figure A.9: Petroleum Refining Sector – SO_2 Emissions

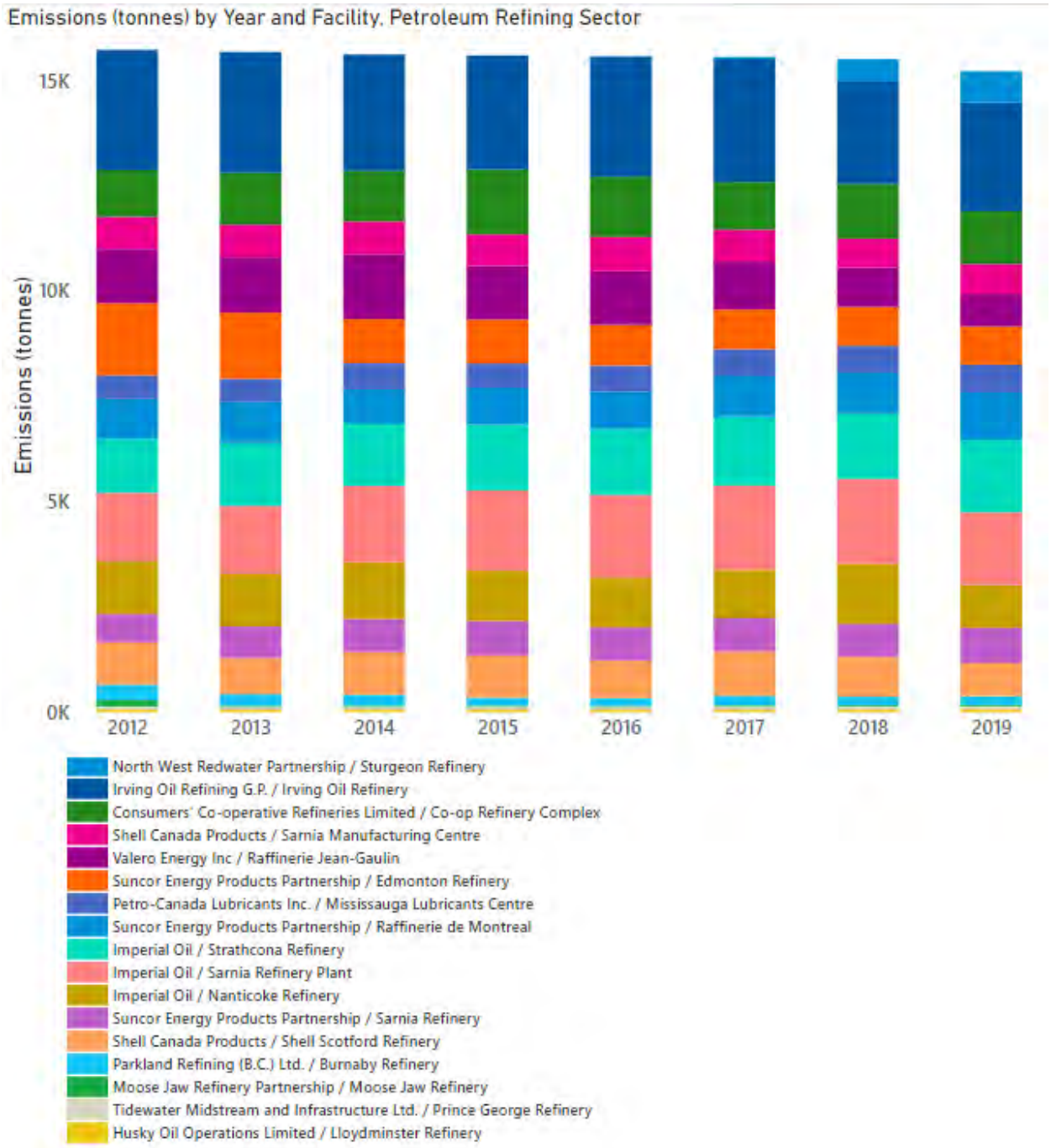

Figure A.10: Petroleum Refining Sector – NO_X Emissions

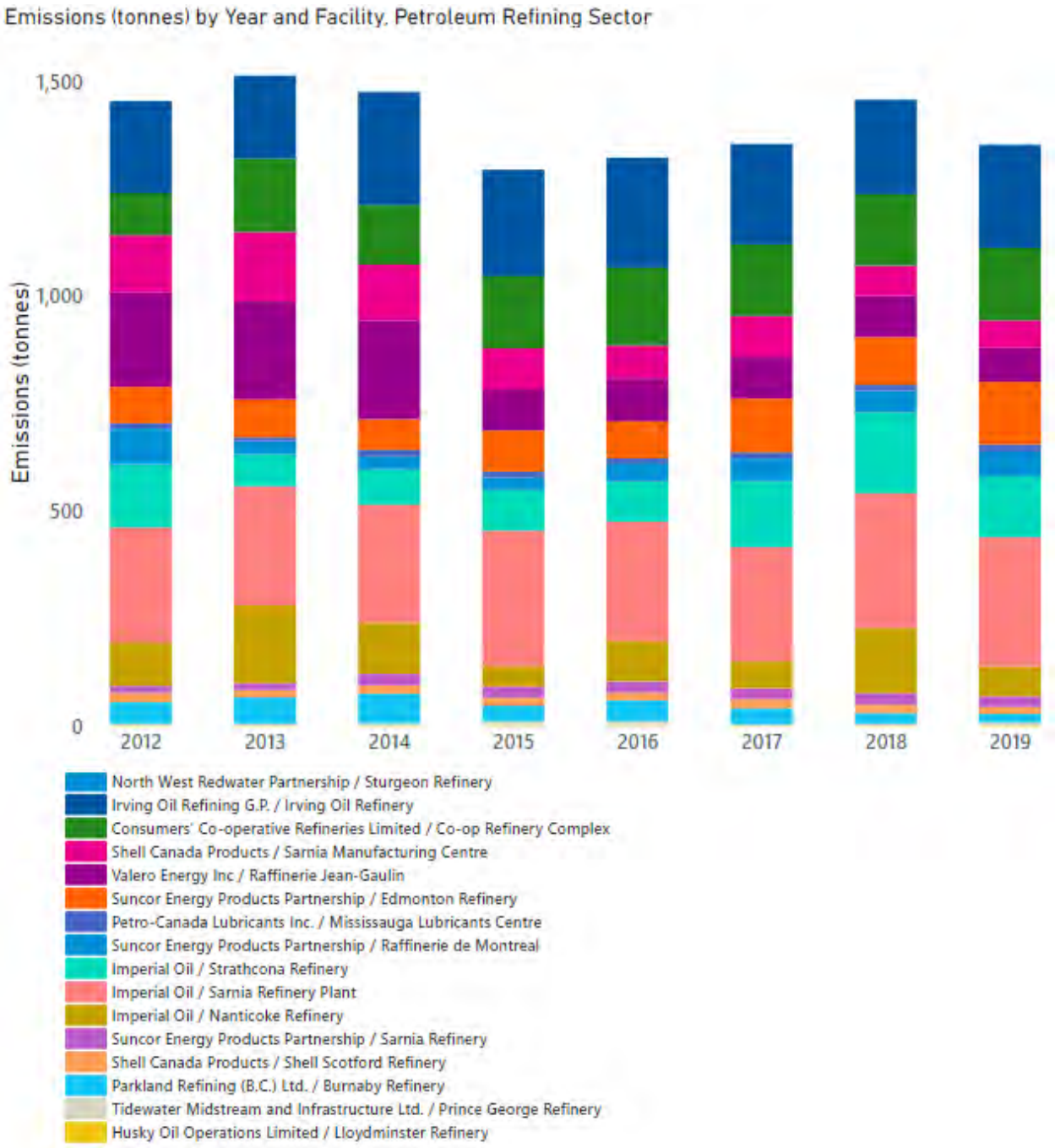

Figure A.11: Petroleum Refining Sector – $PM_{2.5}$ Emissions

Upstream Oil and Gas – Sour Gas Processing

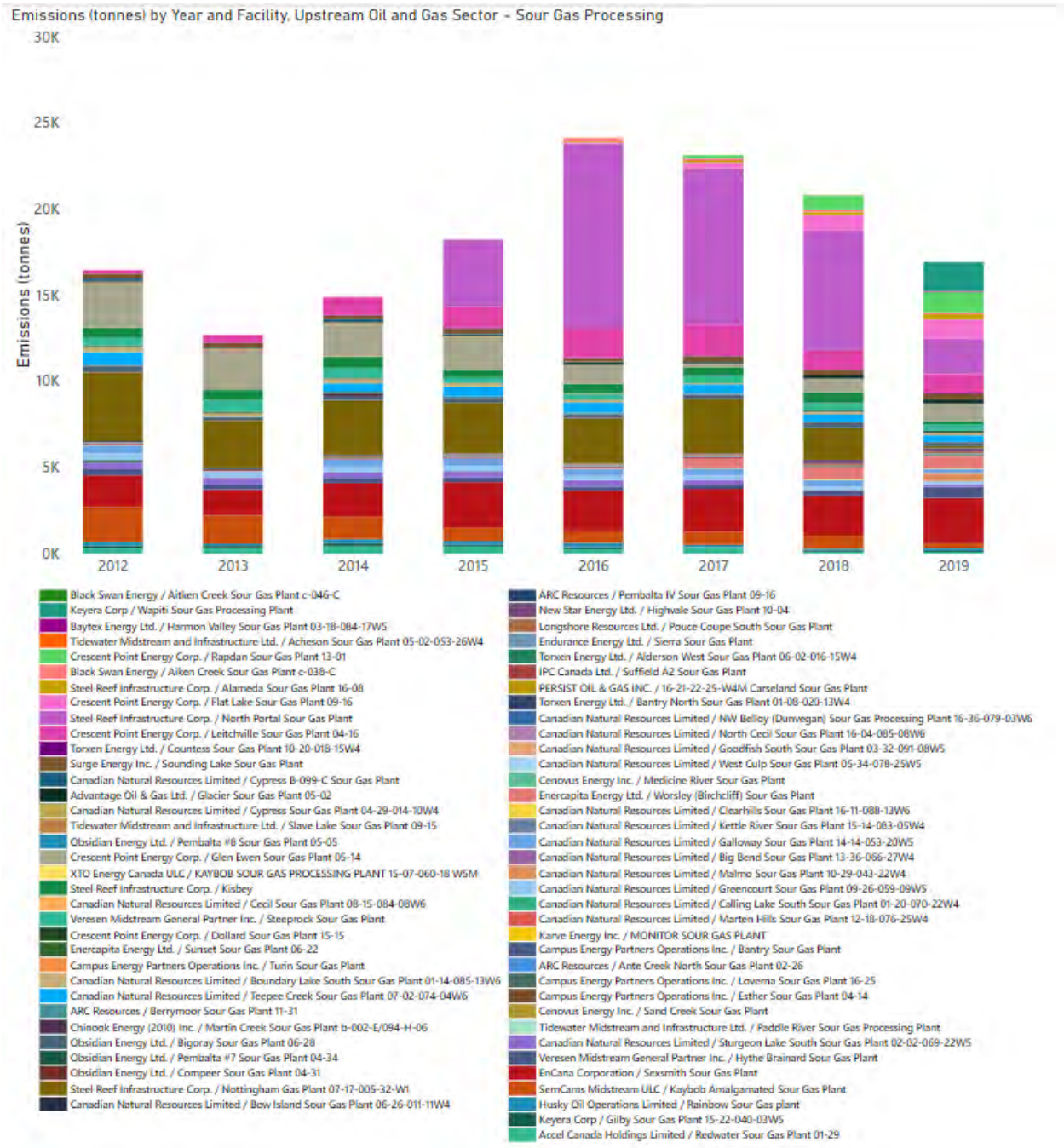

Figure A.12: Sour Gas Processing – SO_2 Emissions

Notes:

Steel Reef facilities indicated a change in reporting methodology for 2019. Preliminary 2020 data indicates that emissions are on par with pre-2019 data and warrants further analysis before finalizing conclusions.

Chemical Sector

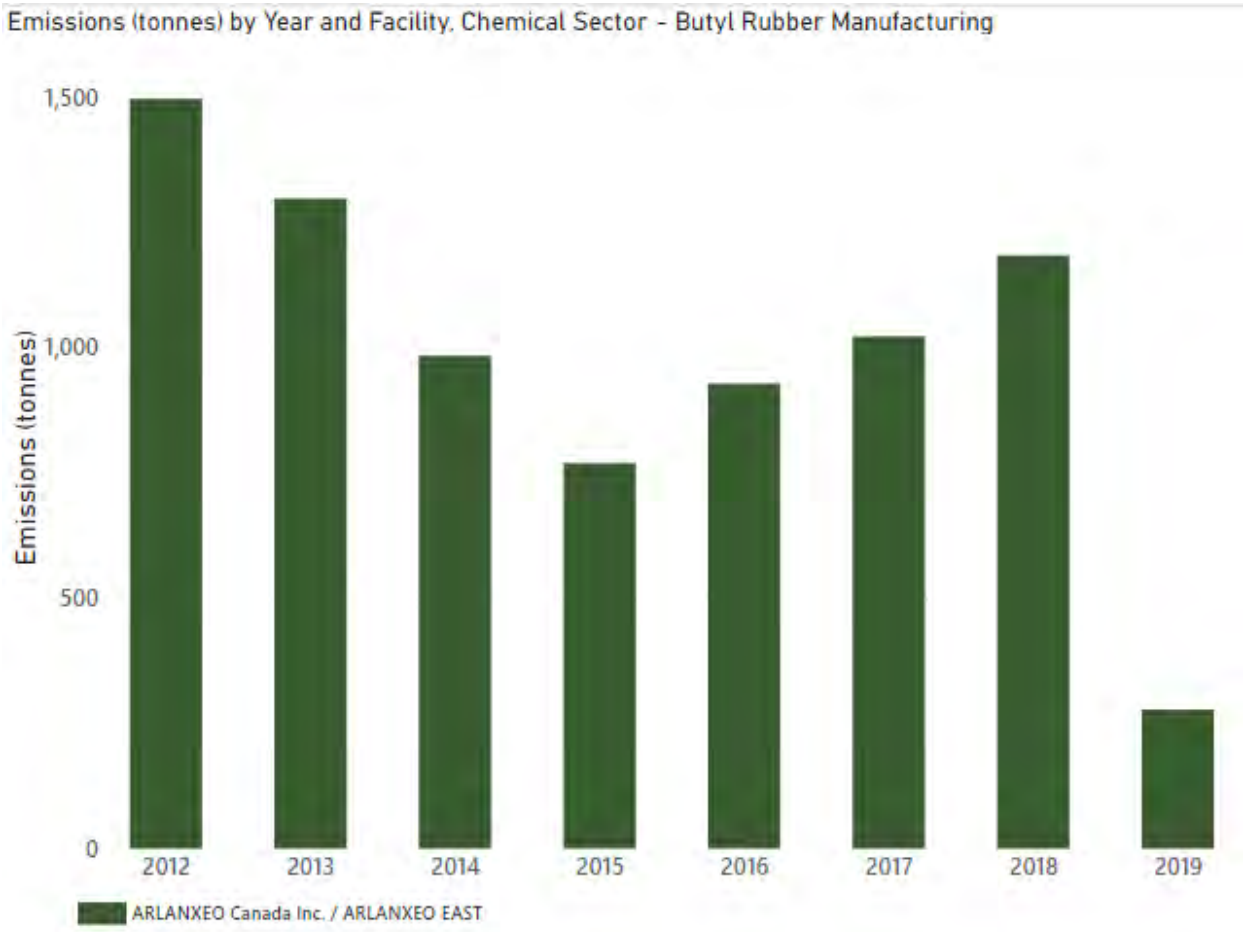

Figure A.13: Chemical Sector – Butyl Rubber Manufacturing – VOC Emissions

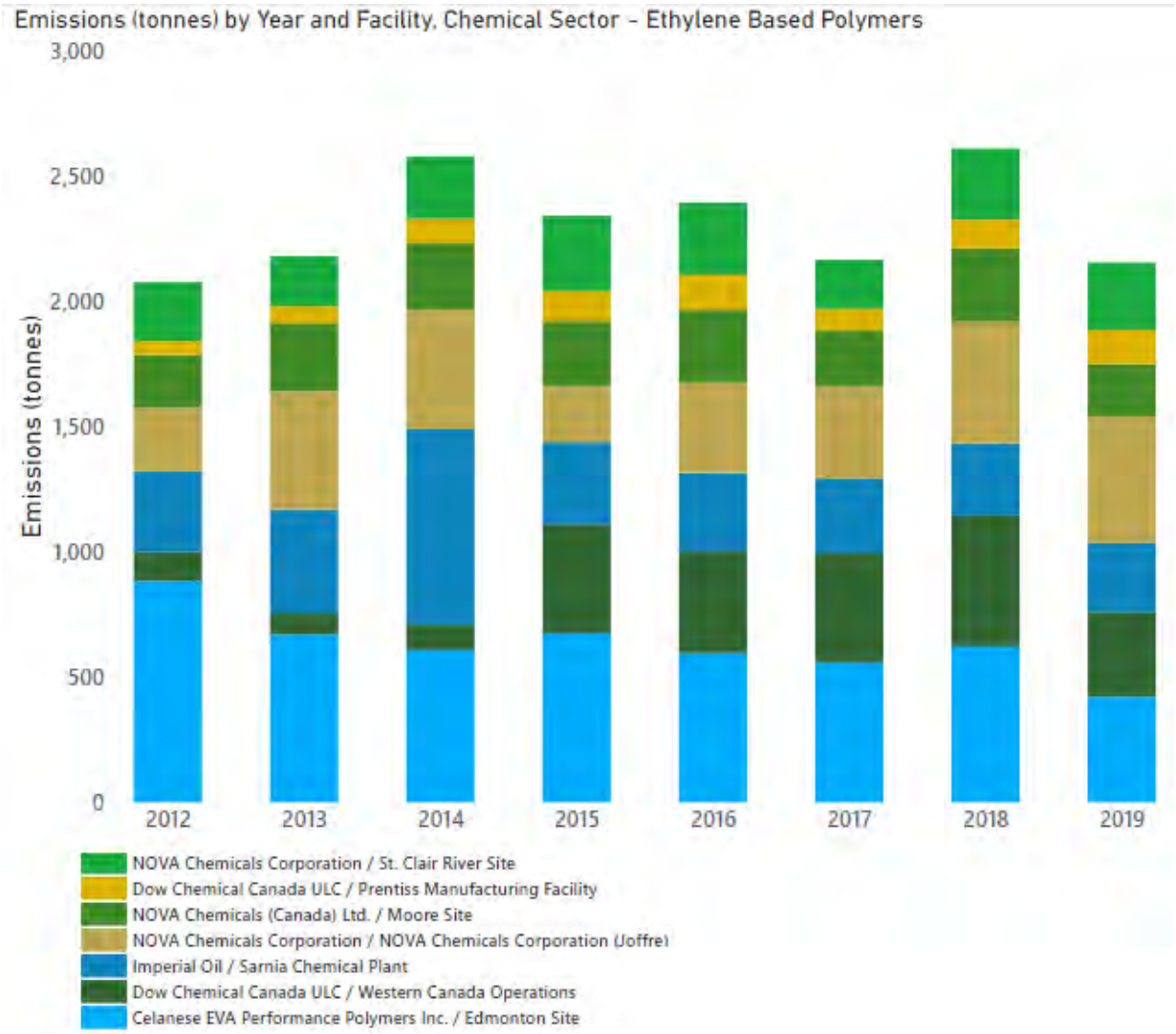

Figure A.14: Chemical Sector – Ethylene Based Polymers – VOC Emissions

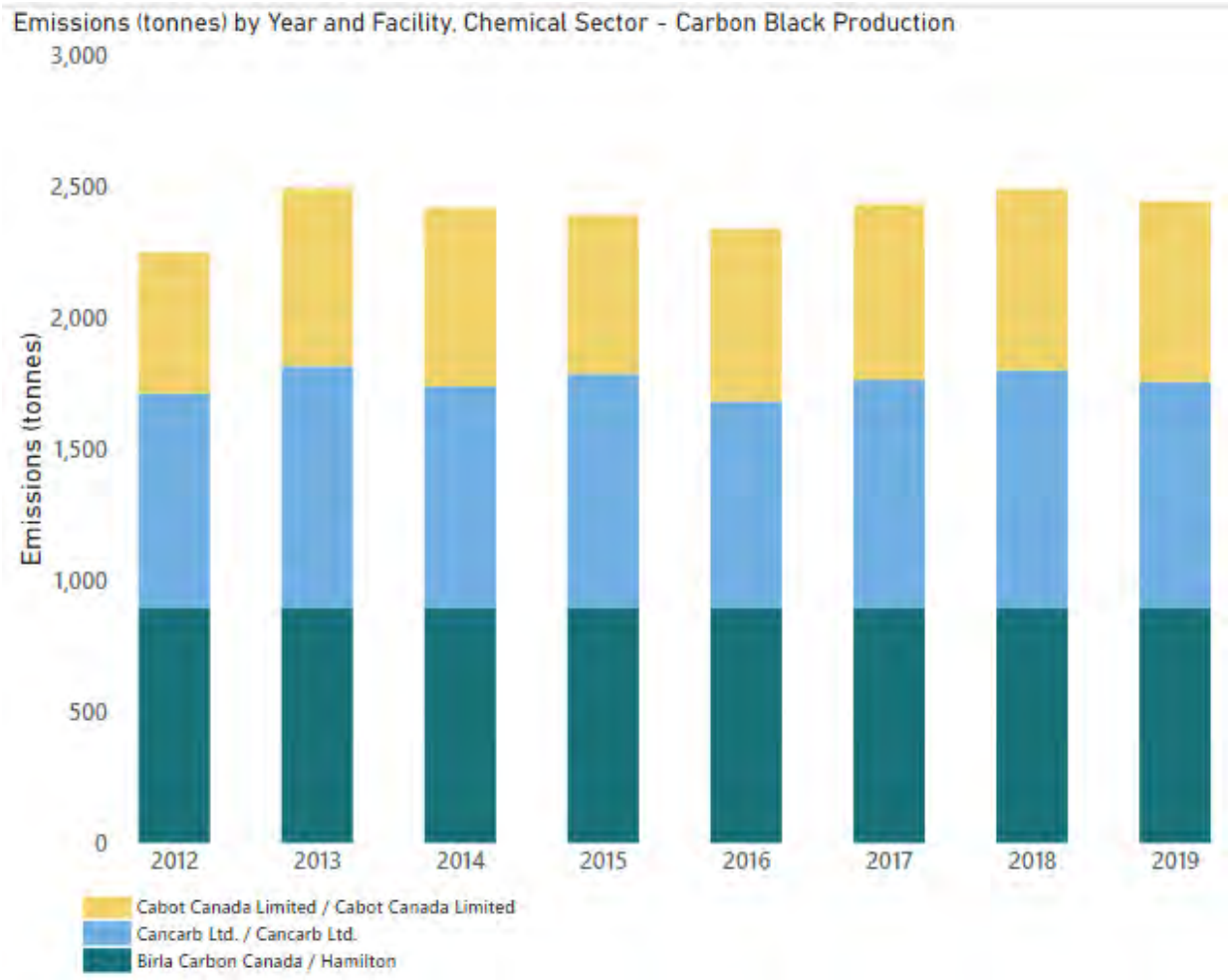

Figure A.15: Chemical Sector – Carbon Black Production - NO_X Emissions

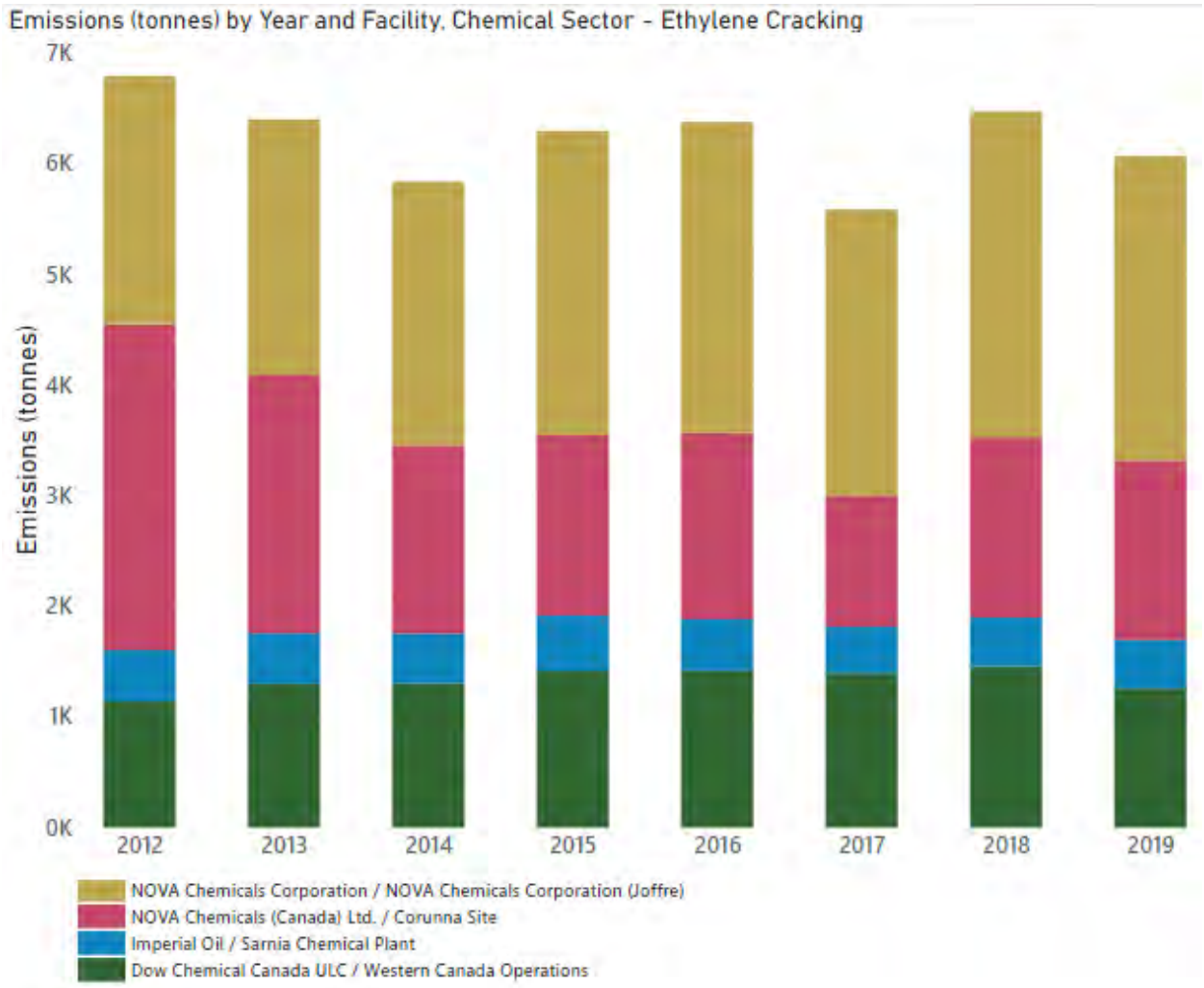

Figure A.16: Chemical sector – Ethylene Manufacturing from Steam Cracking - NO_X Emissions

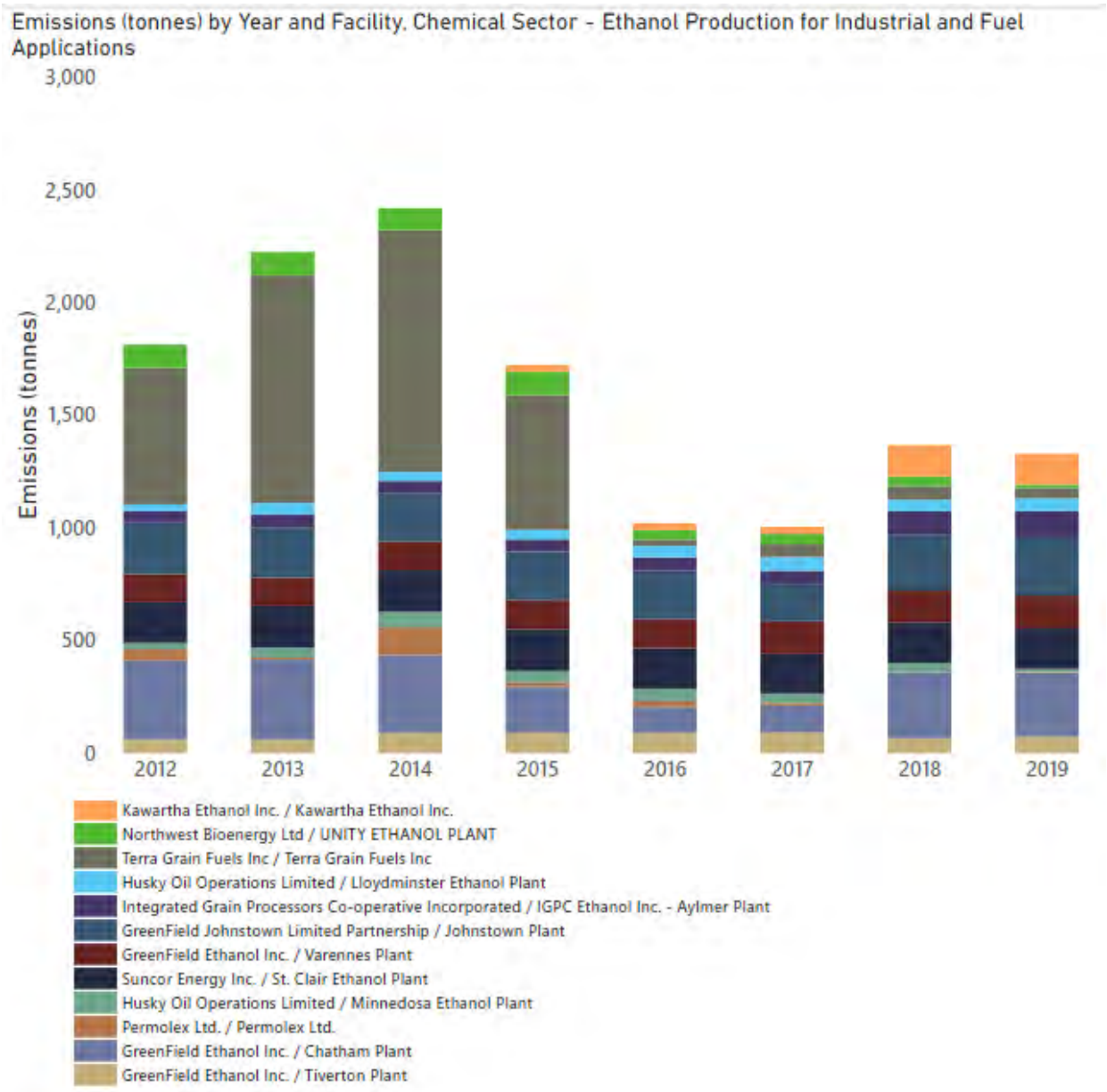

Figure A.17: Chemical sector – Ethanol Production for Industrial and Fuel Applications – VOC Emissions

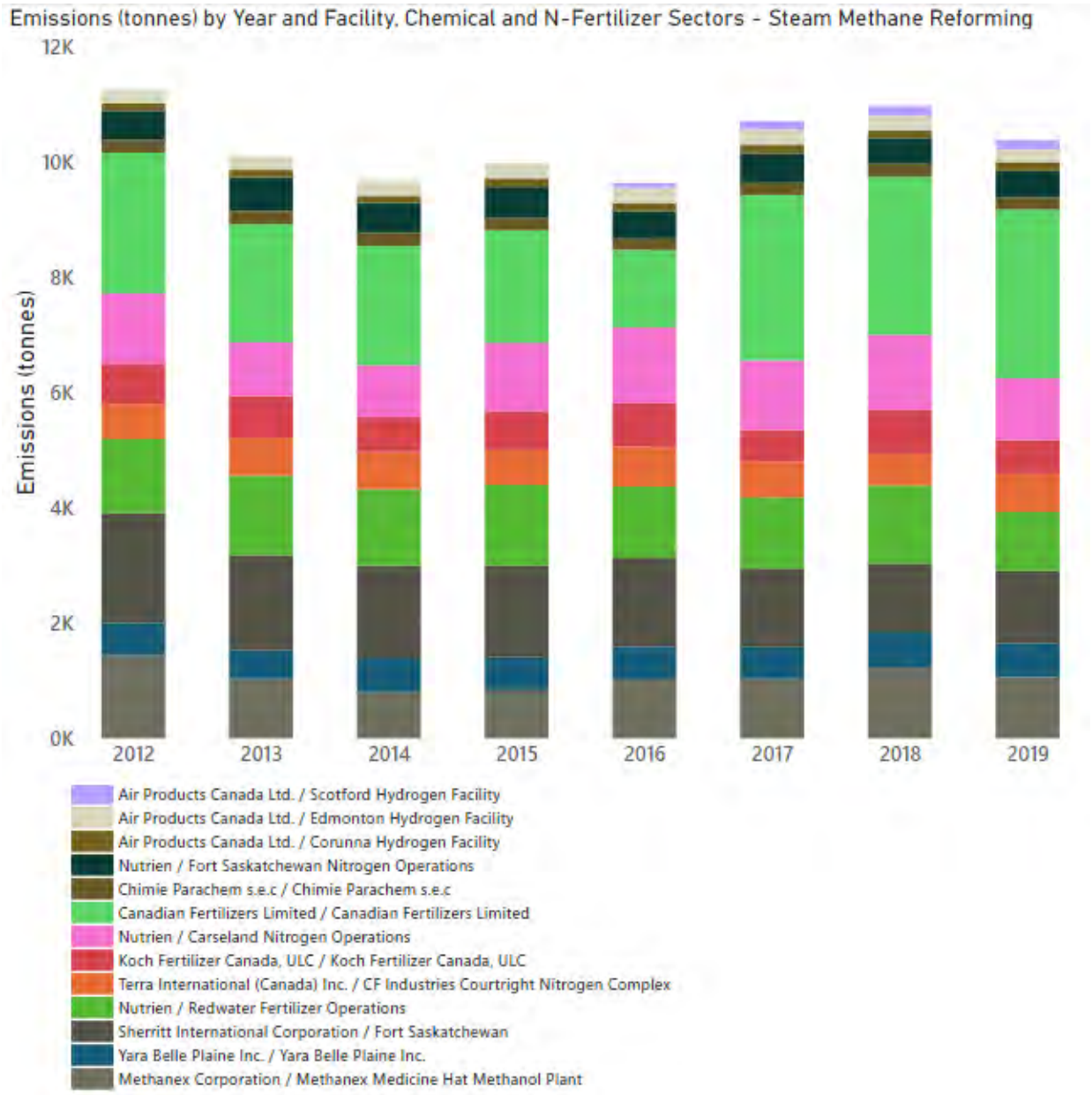

Figure A.18: Chemical and N-Fertilizer sectors (Steam Methane Reforming) – NO_X Emissions

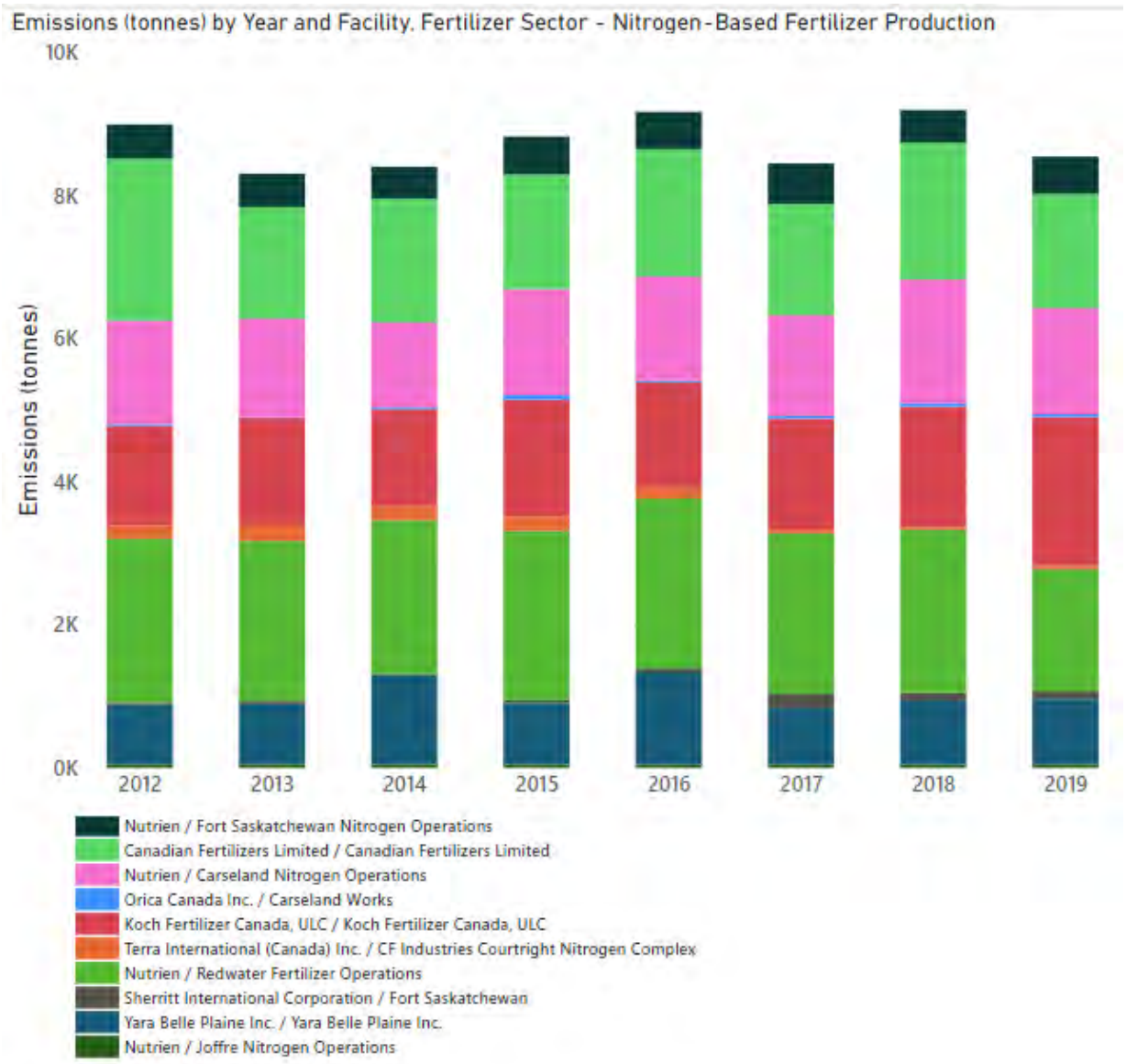

Figure A.19: N-Fertilizer sector – N-fertilizer Production – NH_3 Emissions

Iron Ore Pellets Sector

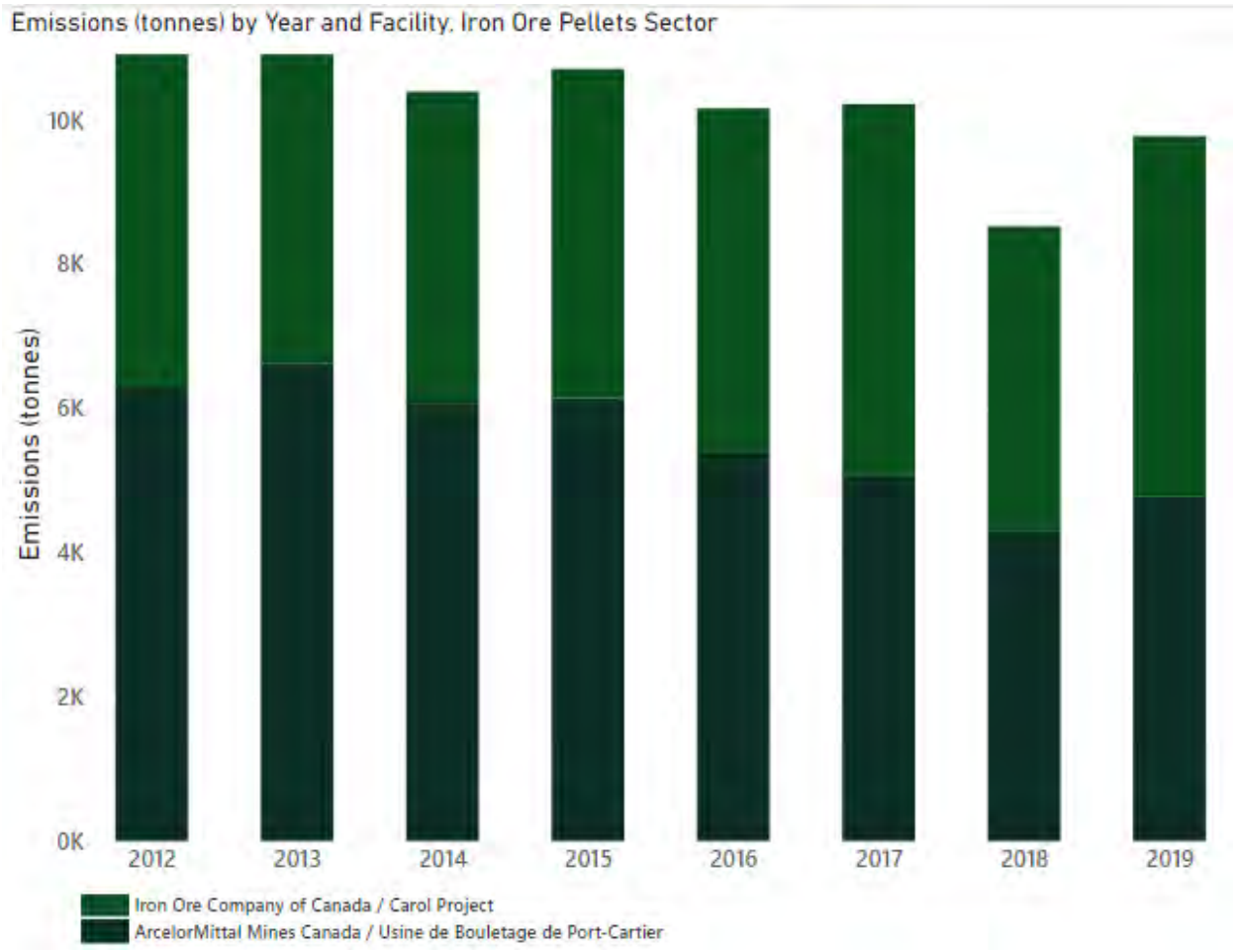

Figure A.20: Iron Ore Pellets – NO_X Emissions

Cement Sector

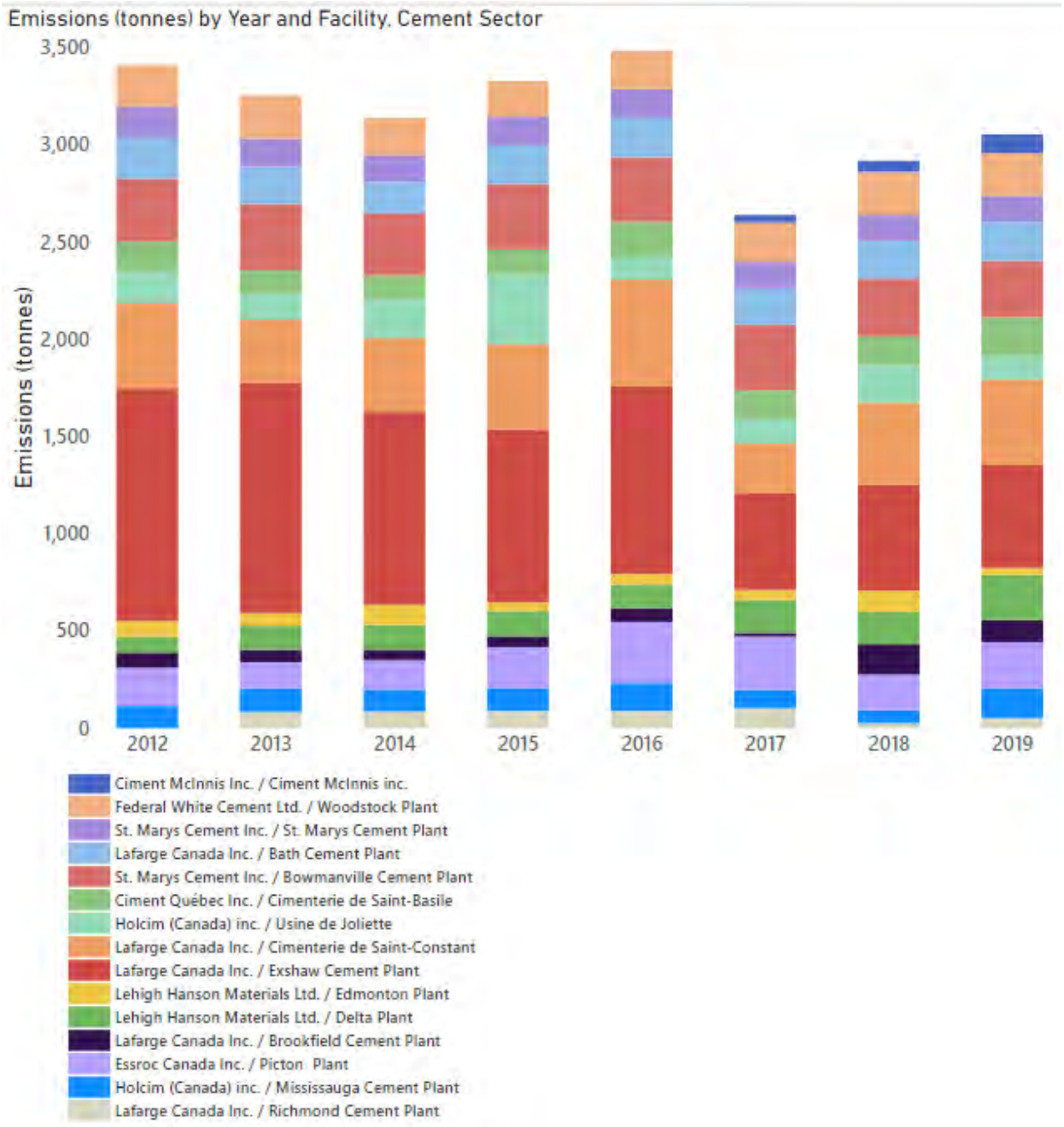

Figure A.21: Cement Sector – TPM Emissions

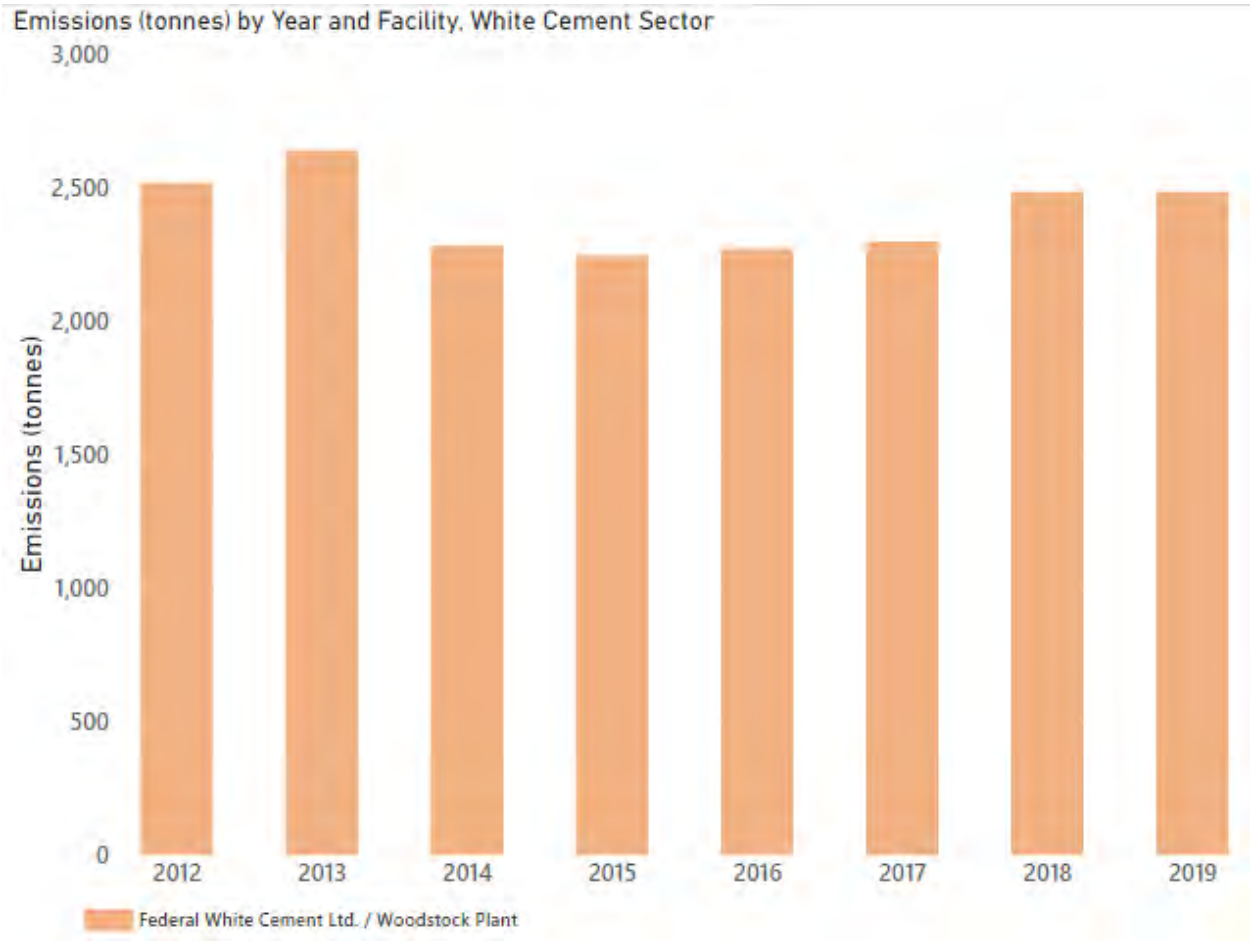

Figure A.22: White Cement Sector – SO_2 Emissions

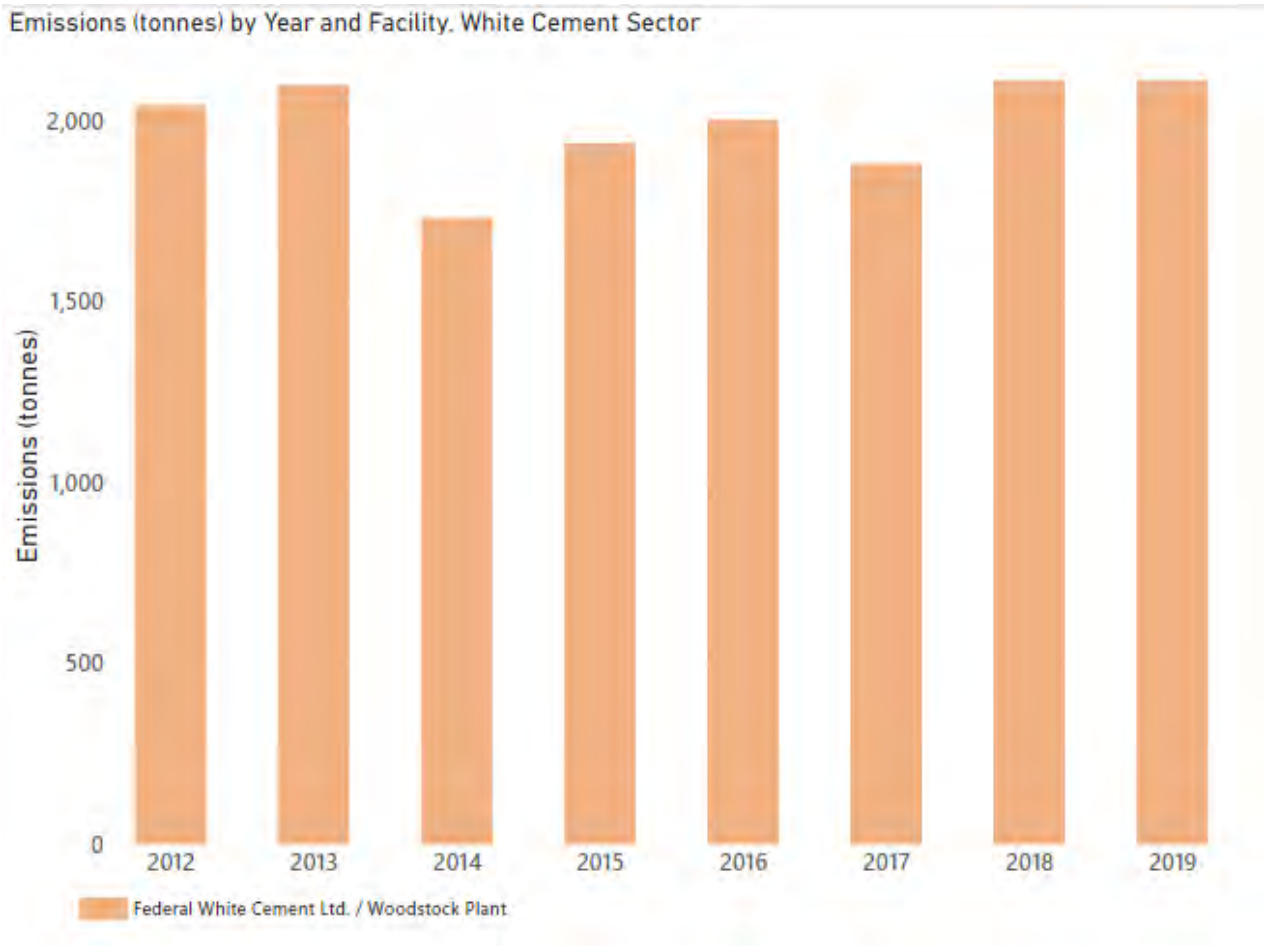

Figure A.23: White Cement Sector – NO_X Emissions