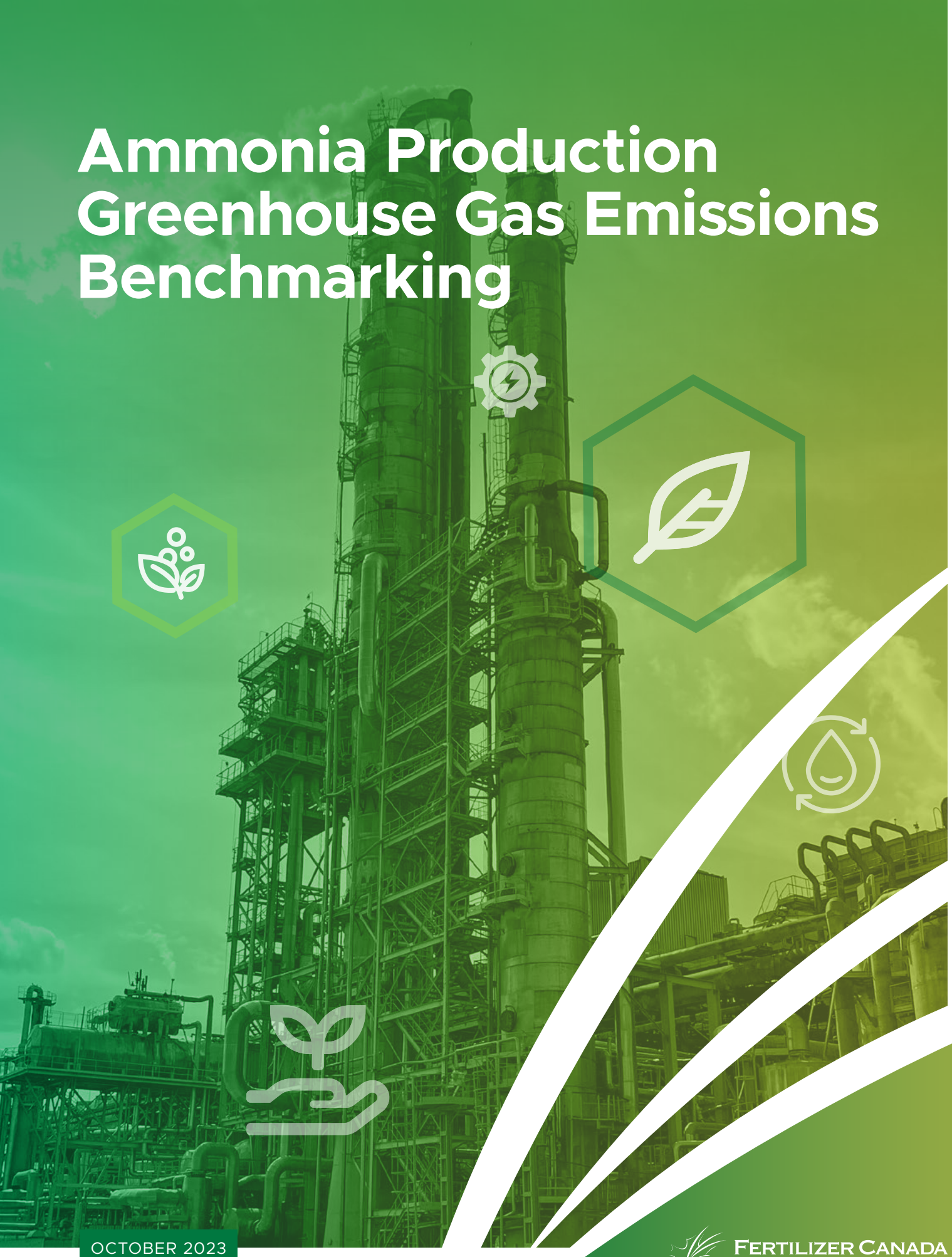
Ammonia Production Greenhouse Gas Emissions Benchmarking



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FERTILIZER CANADA

Introduction

The objectives of the ammonia production greenhouse gas benchmarking Study were:

Develop a Canadian sector greenhouse emissions intensity for ammonia production.

Compare emission intensities from Canadian facilities to available international emission intensities.

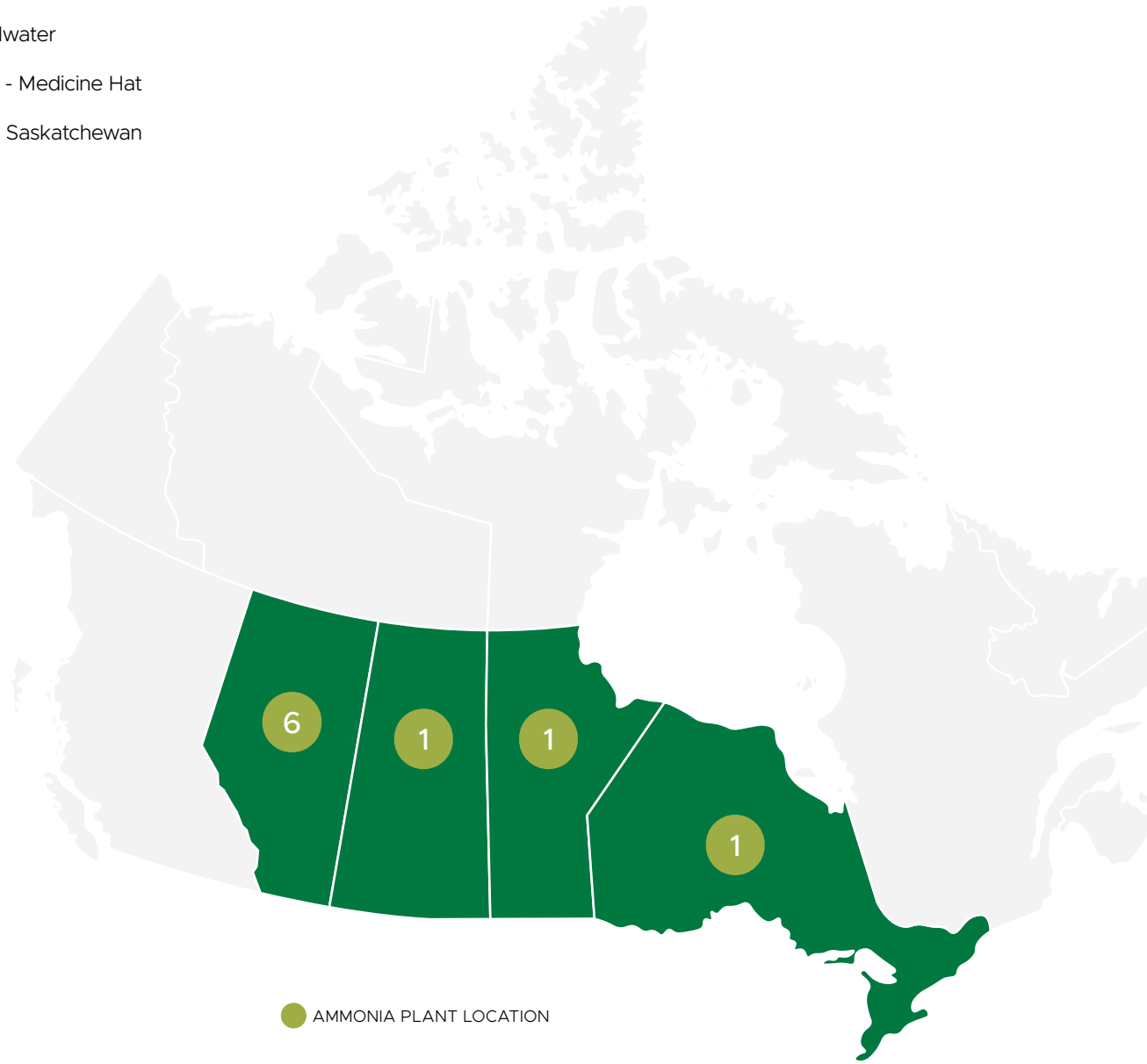
Compare, to the extent possible, emission intensities from Canadian facilities to previous benchmark data developed based on data from 2000 – 2002 presented within the Canadian Industry Program for Energy Conservation (CIPEC) Ammonia Benchmarking Report.

Ammonia Production in Canada

9 Facilities produce Ammonia (and other nitrogen fertilizer products) in Canada for a total production of 4.9 million tonnes NH3 in 2020:

- 6 facilities are in Alberta, one uses Hydrogen as the feedstock and does not use steam methane reforming (SMR).
  - Nutrien - Carseland
  - Nutrien - Fort Saskatchewan
  - Nutrien - Joffre
  - Nutrien - Redwater
  - CF Industries - Medicine Hat
  - Sheritt - Fort Saskatchewan
- 1 facility is in Saskatchewan: Yara - Belle Plaine.
- 1 facility is in Manitoba: Koch – Brandon.
- 1 facility is in Ontario: CF industries – Courtright.

Facilities are aged between 30 and 67 years.



Typical GHG Emission Sources in Ammonia Production

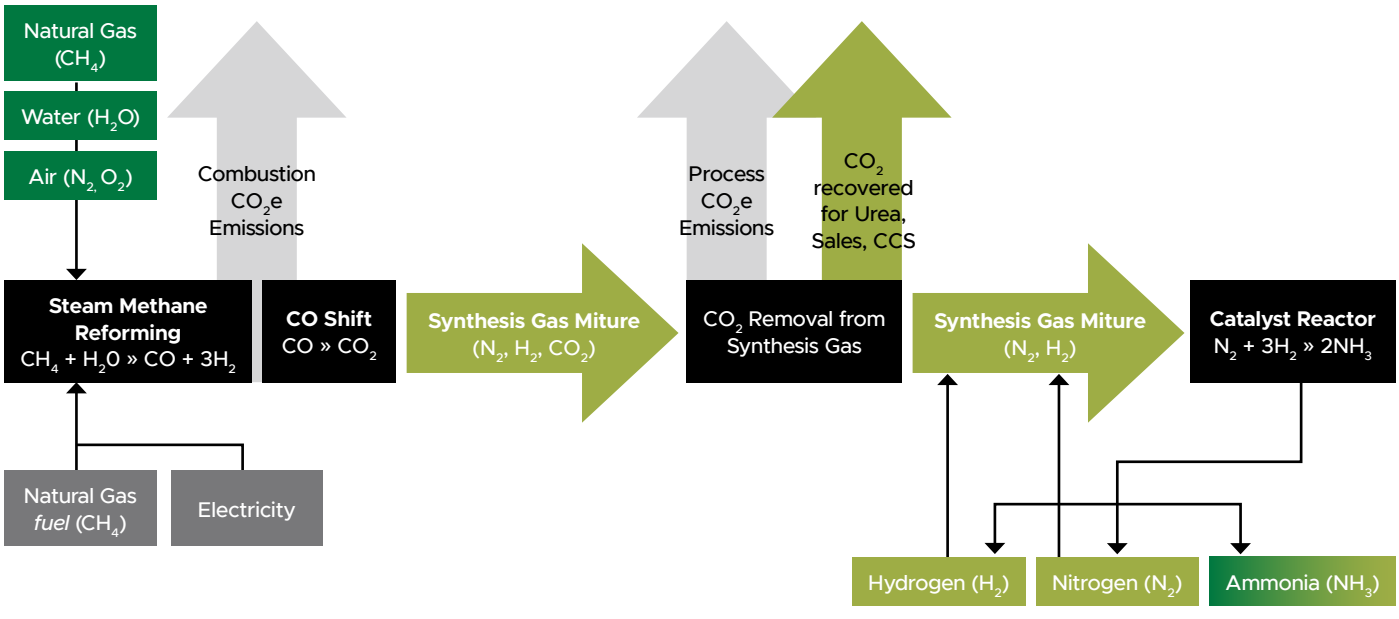
Sources of GHG emissions in Ammonia production include:

Direct emissions

- Steam methane reforming to produce the hydrogen inputs from natural gas.
- Combustion of natural gas to provide heat for the steam methane reformer and auxiliary boilers to generate the conditions needed for the synthesis reaction.
- Flaring and venting of process gas and associated flare pilots.

Indirect emissions

- Electricity used in operating the facility for pumps, compressors, etc.
- Process heat obtained from steam generated in a neighbouring facility or in non-ammonia focused area of the same facility.



Methods for Estimating Emissions

Data covering process and combustion fuel and electricity as well as energy exchanged via steam were obtained from Canadian facilities for the 2018 – 2020 period.

The facility using hydrogen as their feedstock (no SMR) is excluded from the results presented in this slide deck (except for where results are compared to a previous report in which that facility was included).

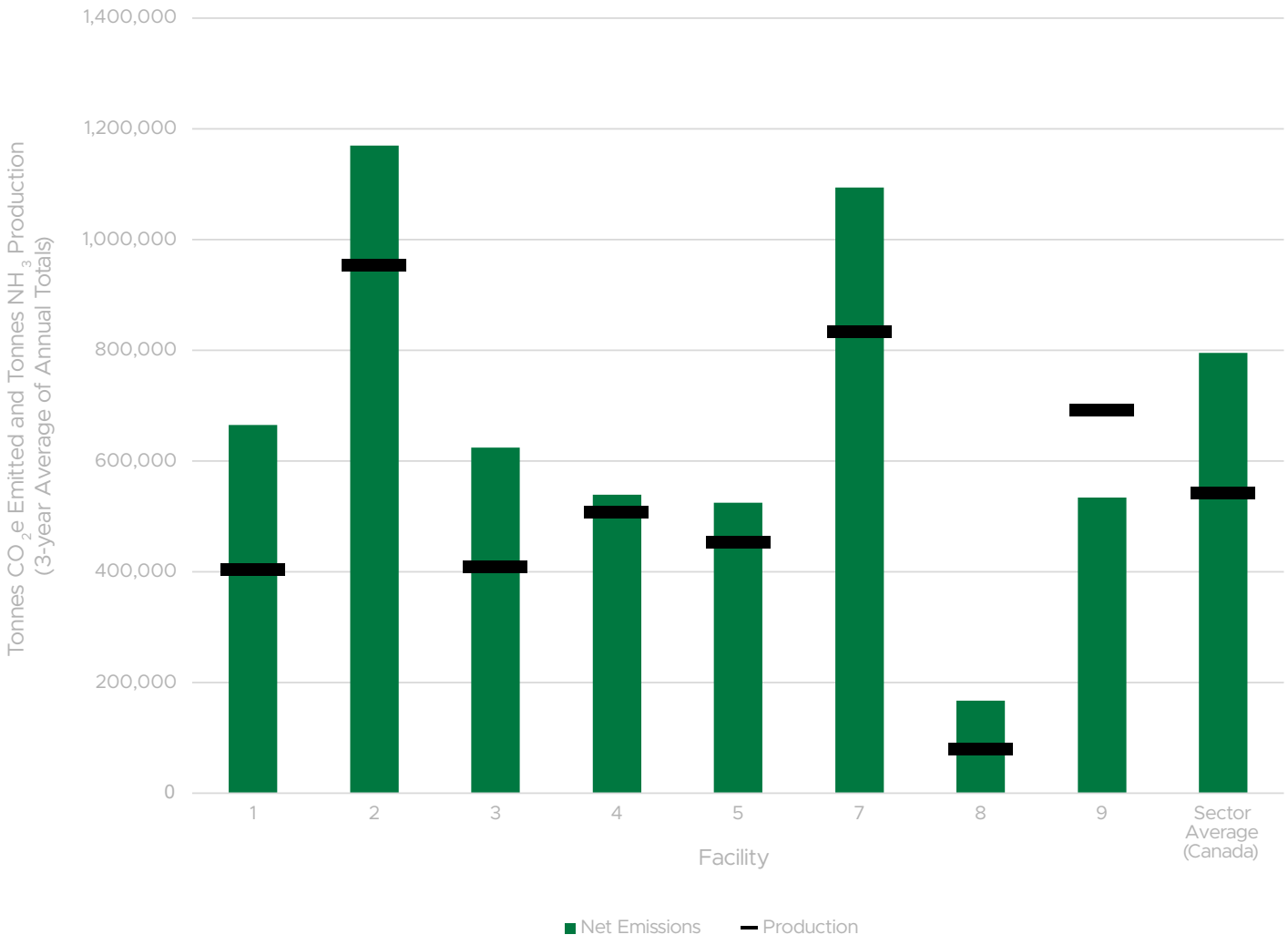
Emissions calculation method:

- Methods and references are described in greater detail in the accompanying methodology annex.
- Generally followed the Environment and Climate Change Canada (ECCC) Greenhouse Gas Reporting Program (GHGRP) quantification methods.
- Where there were gaps in the GHGRP, calculations were based on the Western Climate Initiative methods (WCI).
- The same calculation methods were applied to all facilities regardless of location (regional differences in electricity grid intensities were accounted for by using the provincial emission factors).
- GHG emissions associated with on site transportation was excluded (for facilities where data was provided, this was a small portion of facility emissions).
- Considered direct and indirect (electricity and steam import) emissions.
- Used actual production data reported by the facilities, not the production capacity of the facilities.

Comparable international emission intensity data were found via a literature review of available data.
Emission intensities from major ammonia producing regions were available from the International Fertilizer Association and other public documents such as reports from producers.

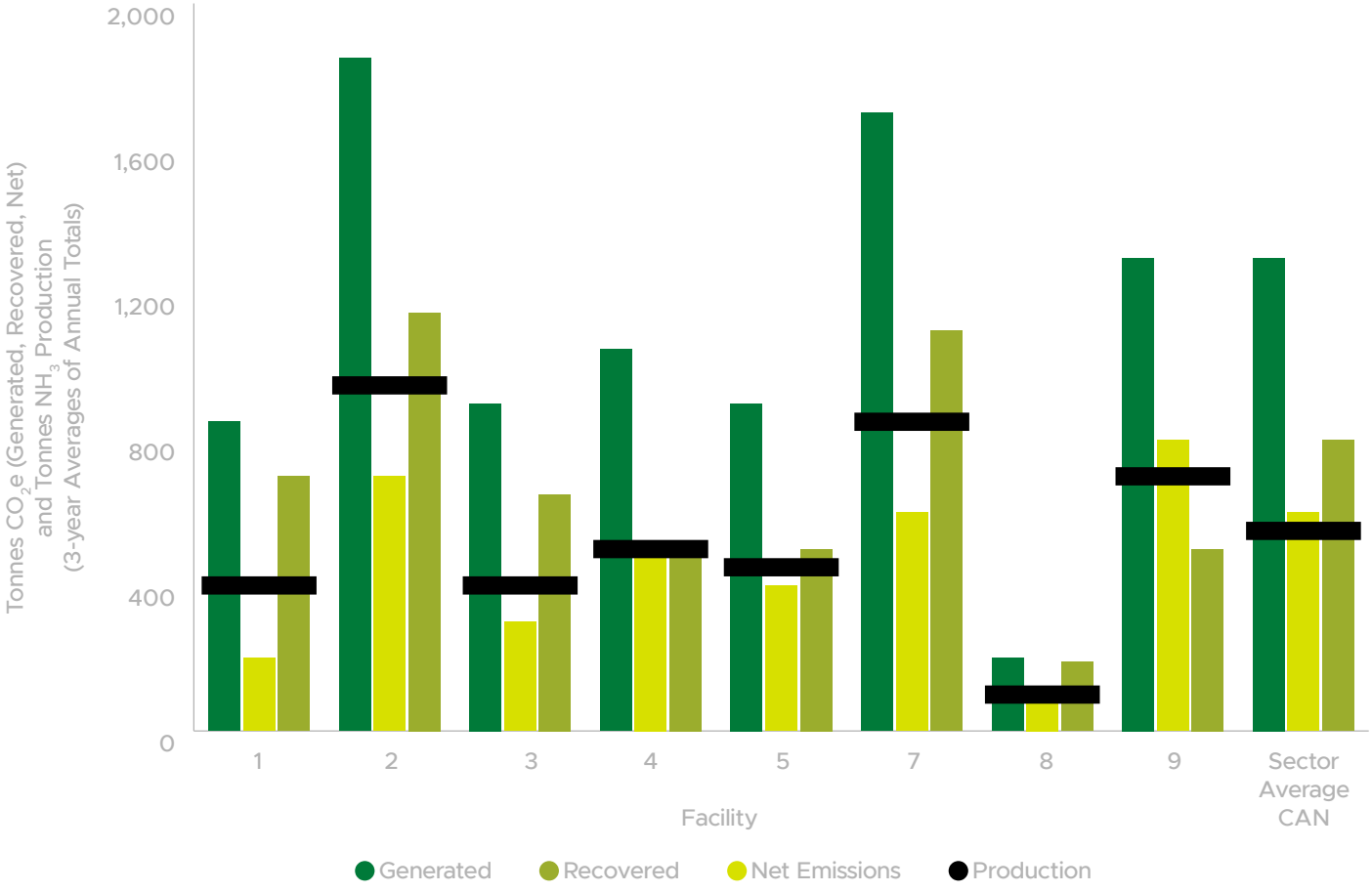
Total Net Emissions by Facility

- Net Emissions = Generated Emissions – Recovered Emissions.
- Net Emissions = (Process + Combustion + Venting + Flaring + Electricity + Steam energy import) Emissions – (CO_2 + Steam energy export) Recovery.
- Values presented are the 3-year average of annual total emissions and production by facility.
- As expected, facilities reporting higher production of NH_3 were found to have higher net GHG emissions and vice-versa.



Net Emissions Breakdown by Facility

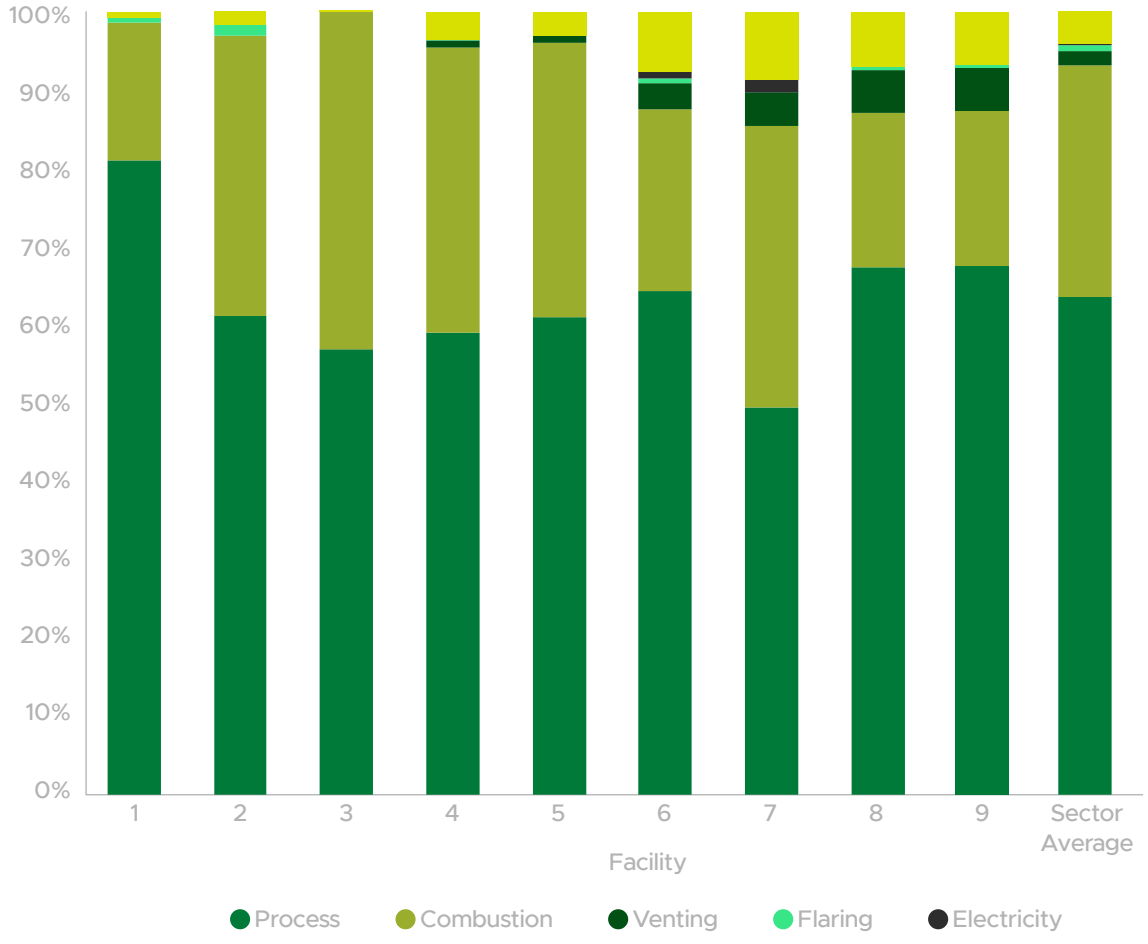
- This figure shows the relationship between Generated Emissions, Recovered Emissions and the Net Emissions at each facility to highlight variability and find differences and common aspects between facilities.
- Values are 3-year averages of annual totals.
- Generated Emissions are the sum of (Process + Combustion + Venting + Flaring + Electricity + Steam energy import) emissions.
- Recovered Emissions are the sum of recovered process CO_2 and emissions associated with energy exported via steam.
- At all facilities, there is an aspect of recovery of CO_2 which lowers Net Emissions.



Contribution to Generated Emissions by Source—by Facility

The largest contributor at all facilities is process emissions (>60% total emissions at 5/8 facilities and >50% at all but one facility).

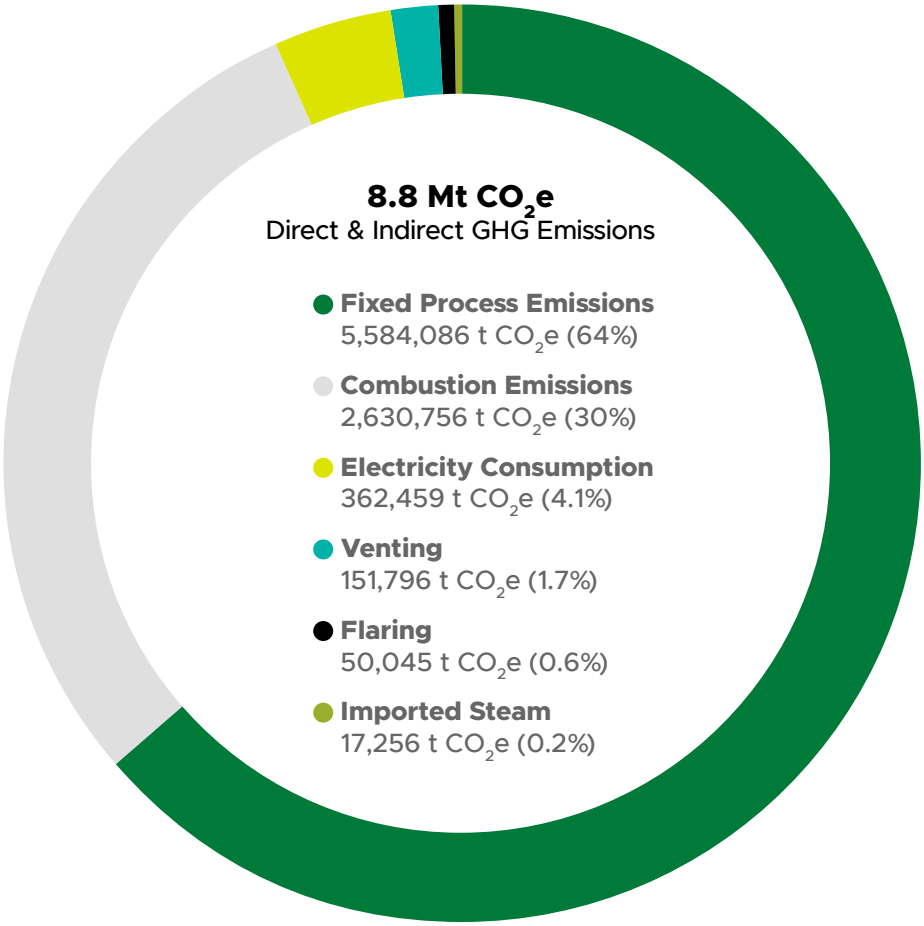
- There is variability in contribution from combustion emissions (18% to 43%), expected to be due to different facility configurations.
- Emissions associated with electricity consumption depend heavily on provincial grid intensity.
- Two facilities reported a net import of steam as a heat source to their ammonia plant(s).



Contribution of Sources to Generated Emissions—Sector Total

Process emissions are the largest contributor to GHG emissions. These emissions are fixed by chemistry and can't be reduced.

- Process heat obtained through the combustion of natural gas accounts for 30% of emissions, sector-wide.
- Indirect emissions (electricity and steam imported from other product lines) account for a small portion (4.3%) of overall annual GHG emissions.
- Venting and flaring during upset conditions account for 2.3% of overall annual GHG emissions.
- Data is based on the annual sum of facility emissions from each source, averaged over 3 years .



Emission Intensity by Facility

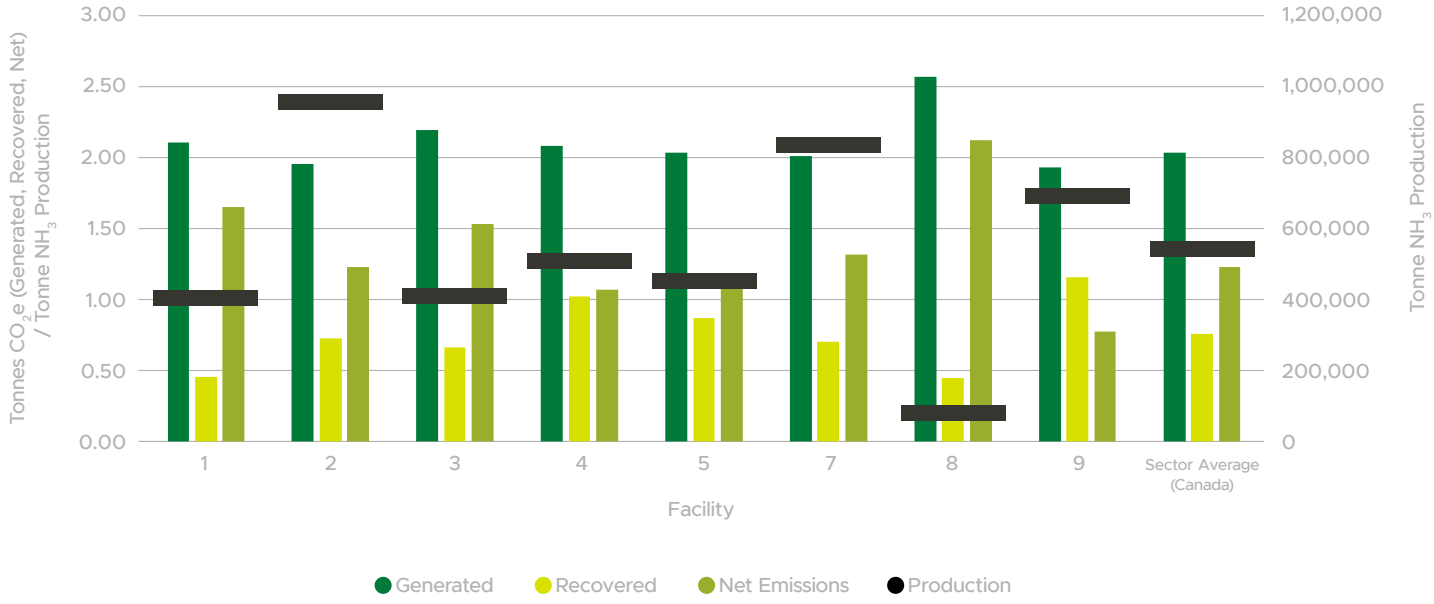
The average Generated, Recovered and Net Emissions intensities for the sector are 2.0, 0.76 and 1.2 tonnes CO_2e/tonnes NH_3, respectively (average of Canadian facilities excluding the facility using H_2 as feedstock).

Facility 8 had the highest Generated and Net Emissions intensities in the sector of 2.6 and 2.1 t CO_2e/t NH_3, respectively but this may be related to their lower ammonia production rate than any other facility examined in this study as it also had the lowest total emissions.

All other facilities :

- Had similar Generated Emissions intensities (between 1.9 and 2.2 t CO_2e/t NH_3).
- Variations in Net Emissions intensities are influenced by the recovery of CO_2 from process emissions.

Facility 9 was the only one to report a Net Emissions intensity of less than 1 t CO_2e/t NH_3, partially attributable to its relatively high proportion of recovered process CO_2. Facility 9 is also the largest producer of urea among the studied facilities by more than 200,000 tonnes. As a result, it needs more of its process CO_2 for production of subsequent fertilizer products.

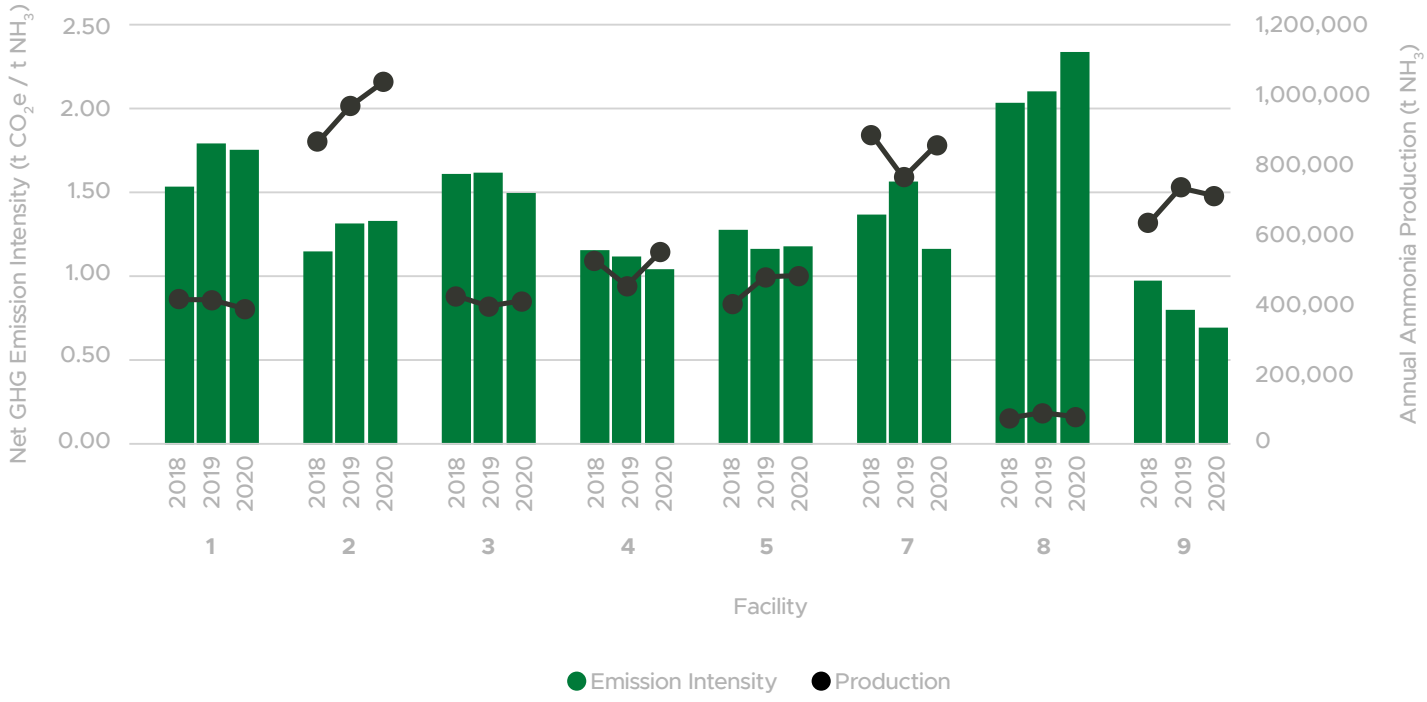


Facility Net Emission Intensities—Relationship to Production

Considering all facilities, there is no clear overall relationship between year-over-year changes in production and the Net Emission intensity.

If emission intensities are not tied to production, reductions will require:

- Equipment changes/upgrades to decrease combustion emissions
- Increases to CO_2 recovery (increased urea capacity or increased CO_2 export or sales).



CO_2 Recovery

All facilities recovered CO_2 from their process emission streams that would otherwise be emitted to atmosphere.

Facility 8 does not produce Urea, so all CO^2 is sold for re- use offsite.

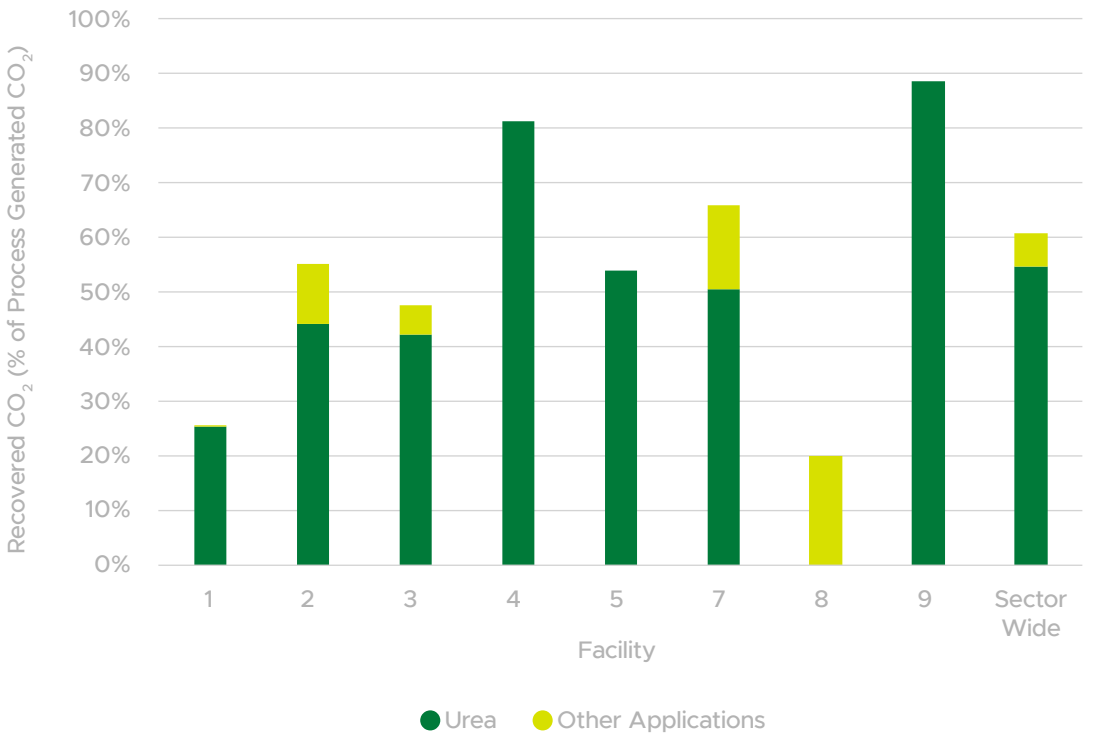
Other applications for CO_2 recovery that were listed are:

- Injection into the Alberta carbon trunk line.
- Sale to specialty gas distributors.
- Use in greenhouses.

61% of all process emissions from the production of ammonia (CO_2) are recovered (sector-wide).

Facility 9 reported the greatest proportion of CO_2 recovery, at 89%.

PROPORTION OF PROCESS GENERATED CO2 RECOVERED FOR BENEFICIAL PROCESSES AT EACH FACILITY IN 2020



Comparison to the 2000–2002 Benchmarking Data (CIPEC Report)

This study calculated greater Generated, Recovered and Net Emissions intensities than those reported in the 2000–2002 CIPEC report[1].

A direct comparison to the study could not be made because the methodology used in the 2000–2002 report was not transparent and therefore could not be replicated exactly.

The increase can likely be attributed to differences in methodology between the two studies and not an actual increase in emission intensity at the facilities.

Both studies relied on production, energy consumption and CO_2 recovery data provided by the facilities.

This study (2018–2020 data):

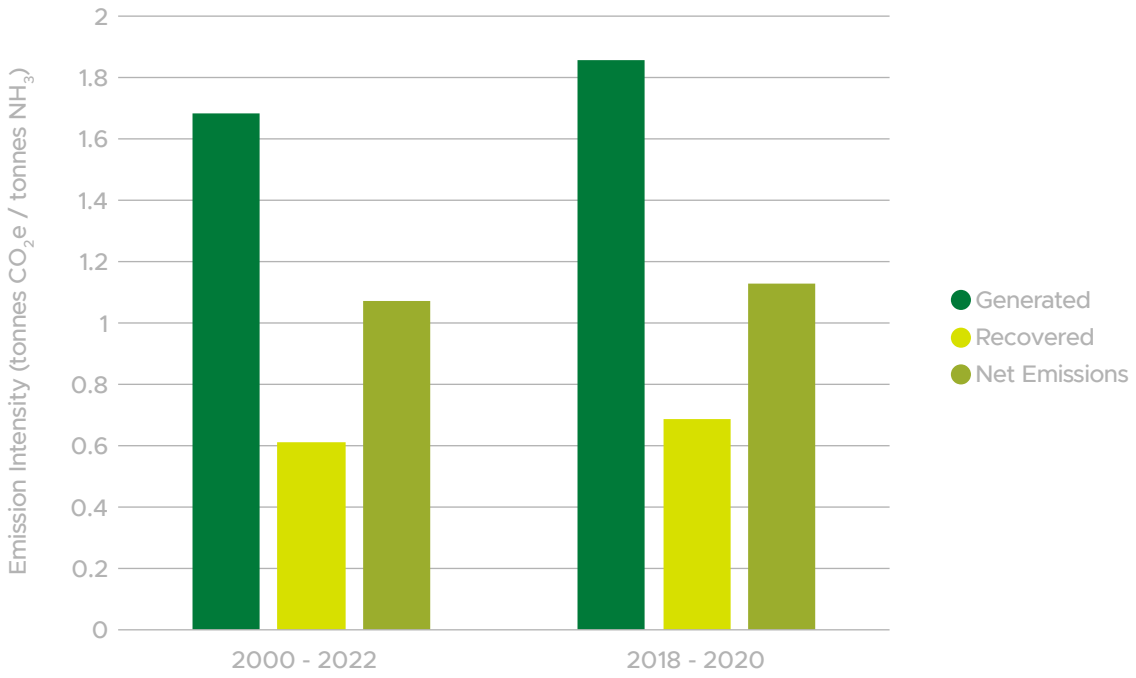
- Considered both direct and indirect emissions.
- Calculated GHG emissions for each source based on standard methods published by the government of Canada for the purpose of GHG reporting.
- Where possible, calculated emissions were aligned with values reported annually to the ECCC GHG reporting program.
- Includes the hydrogen-as-feedstock facility in this figure to optimize comparability to the historical report.

The CIPEC report (2000–2002):

- Excludes electrical consumption.
- Applied normalization calculations to the facility energy inputs.

The choice to diverge from the methodology of the CIPEC report (2000 – 2002) was motivated by transparency and adherence to current reporting methodologies.

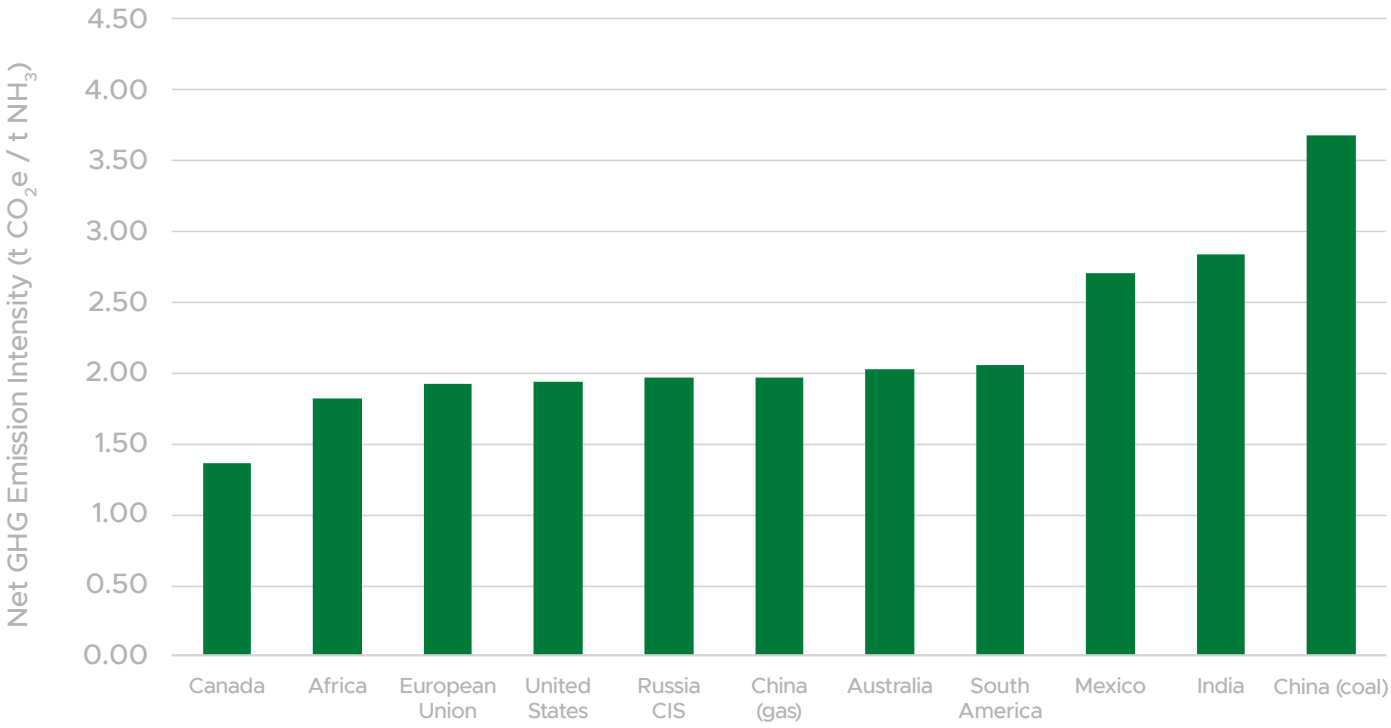
1. Natural Resources Canada. 2008. Canadian Ammonia Producers, Benchmarking Energy Efficiency and Carbon Dioxide Emissions.



International Benchmarking

Net Emission intensities at Canadian ammonia fertilizer facilities are the lowest of any of the countries/regions considered in this study.

- 30% lower than ammonia produced in the United States
- 31% lower than ammonia produced in the Russian commonwealth of independent states.
- 52% lower than ammonia produced in China from gas
- 63% lower than ammonia produced in China from coal



Sources: Canadian emission intensities calculated from facility information. U.S., South America, Africa, EU, Russia CIS and China emission intensities from Fertilizers Europe. Mexico, Australia and India emission intensities from select corporate sustainability reports.

Summary

Canadian ammonia is produced with an overall Net Emissions intensity that is the lowest of all countries/regions examined (30 to 63% lower than other countries from which Canada imports nitrogen fertilizer).

- There are 9 facilities in Canada, producing 4.9 million tonnes of Ammonia annually.
- 61% of Ammonia is consumed in the production of other fertilizer products (Urea, Urea/Ammonium Nitrate, HNO_3, Ammonium Polyphosphate, Ammonium Thiosulfate, etc.). Meaning that any use of ammonia as an energy carrier will require additional production.
- Process emissions count for 64% of total generated emissions across the sector. These emissions are fixed by chemistry and cannot be reduced.
- 61% of those process emissions are recovered for use in the production of urea, for resale to specialty gas distributors, injection into the carbon trunk line, etc.
- 30% of total emissions are from stationary combustion.
- This study calculated Generated and Net Emissions that were greater than those reported by Natural Resource Canada for 2000–2002. However, a direct comparison was not possible because the original methodology was not transparent and is considered proprietary by the report authors. Differences in methodology are expected to have contributed to this increase.

Study Limitations

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FERTILIZER CANADA

INFO@FERTILIZERCANADA.CA

FERTILIZERCANADA.CA | FERTILISANTSCANADA.CA

907-350 SPARKS, OTTAWA ON K1R 758

T (613) 230-2600 | F (613) 230-5142