Canadian Environmental Sustainability Indicators 2005

Greenhouse Gas Emissions Indicator: Data Sources and Methods

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Environment Canada
Statistics Canada
Health Canada

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1. Introduction

Canadians' health and their social and economic well-being are fundamentally linked to the quality of their environment. Recognizing this, in 2004, the Government of Canada committed to establishing national indicators of freshwater quality, air quality, and greenhouse gas emissions. The goal of these new indicators is to provide Canadians with more regular and reliable information on the state of their environment and how it is linked with human activities. Environment Canada, Statistics Canada, and Health Canada are working together to develop and communicate these indicators. Reflecting the joint responsibility for environmental management in Canada, this effort has benefited from the cooperation and input of the provinces and territories.

This report is part of a suite of documents released under the Canadian Environmental Sustainability Indicators (CESI) initiative.[1] Each indicator reported in a given year under CESI has an associated "data sources and methods" report to provide technical detail and other background that will facilitate interpretation of the indicator or allow others to build further analysis using the CESI data and methods as a starting point.

This report deals with the underlying methods and data for the *greenhouse gas emissions indicator* as it was reported in 2005.

2. Description of the indicator

The greenhouse gas (GHG) emissions indicator reports the trend in human made greenhouse gas emissions at a national, provincial/territorial, and sectoral level for six greenhouse gases in Canada: carbon dioxide, methane, nitrous oxide, sulphur hexafluoride, perfluorocarbons, and hydrofluorocarbons.

The indicator is based on GHG emissions data taken directly from the 2005 National Inventory Report (NIR) prepared by Environment Canada titled *Canada's Greenhouse Gas Inventory: 1990–2003*. As an Annex I Party (Developed Countries) to the United Nations Framework Convention on Climate Change (UNFCCC) Canada is required to prepare and submit a national inventory of anthropogenic sources and sinks of greenhouse gases on an annual basis.

Since direct measurement of emissions from all sources is not practical, the UNFCCC requires that all countries develop, update, publish, and maintain national inventories using comparable emissions estimation methods.

Descriptions of the six greenhouse gases estimated and their main Canadian sources are outlined in Table 1. Emissions from natural sources (material decay, plant and animal respiration, volcanic and thermal venting, etc.) and absorption of emissions by natural sinks (forests, oceans) are not measured by this indicator.

1 http://www.environmentandresources.ca and www.statcan.ca

Table 1 Greenhouse gas descriptions and main sources

Greenhouse gas	Description
Carbon dioxide (CO_2)	A naturally occurring gas produced by living organisms and fermentation, CO_2 is also produced by the burning (combustion) of hydrocarbon based fuels. CO_2 is also generated from deforestation, biomass burning, and industrial processes such as aluminium smelting and lime production.
Methane (CH_4)	A naturally occurring, flammable gas emitted by geological coal formations and by the decomposition of organic matter. Main sources of CH_4 emissions include: enteric fermentation[2], manure management, biomass burning, natural gas delivery systems, landfills, and coal mining.
Nitrous oxide (N_2O)	Naturally occurring from microbial action in soil N_2O is also emitted by the application of nitrogen fertilizers, soil cultivation, production of nitric acid and adipic acid and the combustion of fossil fuels and wood.
Sulphur hexafluoride (SF_6)	A colorless gas soluble in alcohol and slightly soluble in water. It is mainly applied as cover gas in the production of magnesium. It can also be used as insulating material for high-voltage transformers and circuit breakers.
Perfluorocarbons (PFCs)	Synthetic chemicals composed of carbon and fluorine with high global warming potentials and atmospheric lifetimes of up to 50 000 years. PFCs are principally emitted as by-products during aluminium smelting..
Hydrofluorocarbons (HFCs)	Synthetic chemicals containing carbon, hydrogen, and fluorine. HFCs are used in various applications, such as air conditioning systems, refrigeration systems, firefighting agents, aerosols, and foam-blowing agents.

Sources: Derived from the Global Development Research Centre: Urban Environmental Management-Urban Waste Management GHG definitions (http://www.gdrc.org/uem/waste/waste-gases.html) and the United Nations Framework Convention on Climate Change (UNFCCC) glossary, (http://unfccc.int/resource/cd_roms/na1/ghg_inventories/english/8_glossary/Glossary.htm)

Estimates are provided at the national level, the provincial/territorial level, and the sectoral level for five economic sectors: energy, industrial processes, solvent and other product use, agriculture, and waste. Provincial and territorial emission totals do not include emissions from consumption of halocarbons, and from limestone and soda ash use, since the activity data associated with these sources are only available at national level. Ammonia production-related process emissions are included under Undifferentiated Production at the provincial level. (Environment Canada, 2005).

.Data from the land use, land-use change and forestry sector are excluded from the national totals in the NIR and therefore are not included in the CESI report. The NRTEE's "*Environment and Sustainable Development Indicators for Canada"* report recommended that the GHG indicator excludes sources and sinks from land-use change and forestry (National Round Table on the Environment and the Economy, 2003).

Table 2 provides a description of the main sources of the greenhouse gas emissions included in the indicator, broken down by economic sector.

Although the greenhouse gas emissions indicator is quite comprehensive, some emission sources have not been included as a result of exclusions within the NIR. Owing to their relatively small contributions to the total emissions, these exclusions do not significantly affect the overall completeness of the inventory. A detailed discussion of the emission sources not included can be found in Annex 5 of the NIR (Environment Canada, 2005).

2 The digestion of carbohydrates by organisms in livestock.

Table 2 Sources of greenhouse gas emissions by sector

Energy

Stationary Fuel Combustion	
Electricity and Heat Generation	Emissions from fuel consumed by:
Electricity Generation	Utility and industry electricity generation
Heat Generation	Steam generation (for sale)
Fossil Fuel Industries	Emissions from fuel consumed by:
Petroleum Refining & Upgrading	Petroleum refining industries (including upstream facilities)
Fossil Fuel Production	Conventional and non-conventional oil and gas production industries (some refining is included)
Mining	Emissions from commercial fuel sold to:
	Metal and non-metal mines, stone quarries, and gravel pits
	Oil and gas extraction industries
	Mineral exploration and contract drilling operations
Manufacturing Industries	Emissions from fuel consumed by the following industries:
	Iron and steel (steel foundries, casting and rolling mills)
	Non-ferrous metals (aluminium, magnesium, and other production)
	Chemical (fertilizer manufacturing, organic and inorganic chemical manufacturing)
	Pulp and paper (primarily pulp, paper, and paper product manufacturers)
	Cement production
	Other manufacturing industries not listed (such as automobile manufacturing, textiles, food and beverage industries)
Construction	Emissions from fuels consumed by the construction industry - buildings, highways, etc.
Commercial & Institutional	Emissions from fuel consumed by:
	Service industries related to mining, communication, wholesale and retail trade, finance and insurance, real estate, education, etc.
	Federal, provincial, and municipal establishments
	National Defence and Canadian Coast Guard
	Train stations, airports, and warehouses
Residential	Emissions from fuel consumed for personal residences (homes, apartment hotels, condominiums, and farm houses)
Agriculture & Forestry	Emissions from fuel consumed by:
	Forestry and logging service industry
	Agricultural, hunting and trapping industry (excluding food processing, farm machinery manufacturing and repair)
Transportation	Emissions resulting from combustion and/or the fugitive releases due to moving passengers, freight, and commodities throughout Canada
Domestic Aviation	Emissions resulting from the consumption of fossil fuels by Canadian-registered airlines flying domestically
Road Transportation	Emissions resulting from the consumption of fossil fuels

		by vehicles licensed to operate on roads
	Railways	Emissions resulting from the consumption of fossil fuels by Canadian railways
	Domestic Marine	Emissions resulting from the consumption of fossil fuels by Canadian-registered marine vessels fuelled domestically
	Others - Off-Road	Emissions resulting from the consumption of fossil fuels by combustion devices not licensed to operate on roads
	Others - Pipelines	Emissions resulting from the transportation and distribution of crude oil, natural gas, and other products
	Fugitives	Intentional and unintentional releases of greenhouse gases from the following activities:
	Coal Mining	Underground and surface mining
	Oil and Natural Gas	Conventional and unconventional oil and gas exploration, production, transportation, and distribution
Industrial Processes		Emissions resulting from the following process activities:
	Mineral Production	Production of cement and lime; use of soda ash and limestone
	Chemical Industry	Production of ammonia, nitric acid, and adipic acid
	Metal Production	Production of aluminium, iron and steel; magnesium production and casting
	Consumption of Halocarbons and SF_6	Use of HFCs and/or PFCs in air conditioning units, refrigeration units, fire extinguishers, aerosol cans, solvents, foam blowing, semi-conductor manufacturing and electronics industry; use of SF_6 in electrical equipment
	Other & Undifferentiated Production	Non-energy use of fossil fuels
Solvent & Other Product Use		Emissions resulting from the use of N_2O as anaesthetic and propellant
Agriculture		Emissions resulting from:
	Enteric Fermentation	Livestock
	Manure Management	Livestock waste management
	Agricultural Soils	,
	Direct N_2O Emissions	Emissions resulting from synthetic fertilizer, manure nitrogen on pasture and cropland, biological nitrogen fixation, crop residue, and cultivation of organic soils
	Indirect N_2O Emissions	Emissions from volatilization, leaching and runoff of animal manure nitrogen and synthetic fertilizer nitrogen
Waste		Emissions resulting from:
	Solid Waste Disposal on Land	Municipal waste management sites (landfills) and wood waste landfills
	Wastewater Handling	Domestic wastewater treatment
	Waste Incineration	Municipal solid waste and municipal wastewater treatment sludge incineration

Source: Environment Canada 2005

3. How the indicator is used

The greenhouse gas emissions indicator is used to track progress in Canada's efforts to lower emissions and reach our environmental performance objectives. Measuring the greenhouse gas emissions indicator in conjunction with economic performance indicators such as the Gross Domestic Product (GDP) will help to support national-level decision-making on sustainable development. Sectoral and geographic breakdowns have been used to inform policy development and plans to reduce emissions.

4. How the indicator is calculated

Data used to produce the greenhouse gas emissions indicator come directly from the NIR and do not undergo any further manipulation. The inventory follows the internationally approved methods developed by the Intergovernmental Panel on Climate Change (IPCC) to estimate emissions for the six greenhouse gases outlined in Table 1. The IPCC guidelines are approved and developed through an international process that includes comments from national experts, testing of methods through preliminary inventory development, country studies, technical and regional workshops, and informal expert groups (IPCC, 1997).

4.1 Methods

In general, the same approach to estimating emissions is applied across the various gases and human activities. Emissions are estimated by multiplying activity data[3] by specific emission factors[4]. At a simple level, the calculation is:

Activity data × emission factor = emissions

The IPCC guidelines provide various methods for calculating a given emission. The same general structure is used, but the level of detail at which the calculations are carried out can vary. The methods for estimating the gases are divided into "tiers," encompassing different levels of activity and technological detail. "Tier 1" methods are generally very simple, requiring less detail and expertise than the most complicated "Tier 3" methods. For example, electricity and heat generation could be measured using three different methods. A Tier 1 method would entail mass-balance calculations based on aggregated country-wide (or regional) statistics on consumption of basic fuels. A Tier 2 method would involve emission calculation by source types, based on fuel use for each industry and sector of the economy. A Tier 3 method would utilize source-specific data and could be used for only a small number of principal emission sources.

The intention of this tiered structure is to encourage countries to work at the most detailed level possible, while ensuring that for those countries that do not have detailed data, estimates can be made. The Tier 2 and Tier 3 methods are expected to produce more accurate emission estimates, but are more resource-intensive, as they usually

3 Activity data refers to the quantitative amount of human activity resulting in emissions taking place during a given period of time. The annual activity data for fuel combustion sources, for example, are the total amounts of fuel burned. In the agriculture sector, annual activity data for methane emissions from enteric fermentation, are the total number of animals, by species.

4 Based on samples of measurement data, emission factors are representative rates of emissions for a given activity level under a given set of operating conditions. They are the estimated average emission rate of a given pollutant for a given source, relative to units of activity.

require collection of more detailed data and a more thorough understanding of technologies.

Table 3 describes the methods used to estimate some of Canada's greenhouse gas emissions. This table illustrates that the selection of IPCC method type is highly dependent on the availability of data for emission factor development.

Table 3 Types of methods employed in estimating selected sources for Canada's GHG emissions

Category	IPCC method type	Notes
Energy – fuel combustion	Tier 2	Emission estimations are based on detailed fuel/technology information covering stationary and mobile sources.
Energy – fugitive emissions	Tier 2/Tier 3 hybrid	Hybrid approach is appropriate in situations when specific measurement data are available for only a subset of the data (i.e. mine-specific emissions).
Industrial processes – ammonia production	Tier 1	Based on the use of national production data and an average national emission factor.
Industrial processes – nitric acid production	Tier 2	Uses Canada-specific emission factors based on the type of abatement technology employed at individual plants.
Industrial processes – adipic acid production	Tier 3	Based on direct observation reports of facility-specific emissions data.
Agriculture – enteric fermentation	Tier 1/Tier 2	Uses domestic animal population data and average emission factors for all animal categories except cattle, where country-specific factors are applied.
Agriculture – manure management	Tier 1/Tier 2	Uses domestic animal population data and average emission factors for manure N_2O (Tier 1), and country-specific emission factors for manure CH_4 (Tier 2) for all animal categories.
Agriculture – soil emissions of nitrous oxide	Tier 1	All emissions in this category are calculated using default emission factors.
Waste – solid waste disposal on land	Tier 2	Uses a model to produce an emission profile that reflects the pattern of the degradation of waste over time.

Source: Derived from Environment Canada 2005 and IPCC 1997.

To better understand the variation and complexities that arise in estimation methods, the following two sections provide examples of the methods used to calculate greenhouse gas emissions. The first example provides an overview of the methods used to estimate emissions from fuel combustion, while the second illustrates how methane gas is estimated for Canadian dairy and beef cattle.

4.1.1 Example of estimating emissions: fuel combustion

The energy sector includes emissions of all greenhouse gases from the production and use of fuels for the primary purpose of delivering energy. Emissions in this sector are classified as either fuel combustion or fugitive releases[5].

Emissions from fuel combustion for all energy sub-sectors are estimated using the following equation:

5 These are intentional or unintentional releases of gases from industrial activities. In particular, they may arise from the production, processing, transmission, storage and use of fuels and include emissions from combustion only when it does not support a primary activity (e.g. flaring of natural gases at oil and gas production facilities) (Environment Canada)

Emissions = quantity of fuel combusted × emission factor per physical unit of fuel

The fuel energy-use data used to estimate the combustion emissions are taken from Statistics Canada's annual energy supply and demand report (Statistics Canada, 2004a). The fuel- and technology-specific emission factors used to estimate the emissions can be found in Annex 13 of the NIR (Environment Canada. 2005). These factors are based upon the physical quantity of fuel combusted and are subdivided by the type of fuel used.

The equation above applies to all source sectors; however, more detailed methods are often used. Fuel combustion emissions attributed to the transport sector, for example, are calculated using Canada's Mobile Greenhouse Gas Emission Model (MGEM05). This model is used to disaggregate fuel statistics into 23 categories that represent the estimated amount of fuel consumed by vehicles of similar emission characteristics determined as a function of their model year, fuel, and vehicle type. A detailed discussion of this specific method can be found in Section 3.1.3 of the NIR (Environment Canada. 2005).

4.1.2 Detailed example of applying the method: methane gas from enteric fermentation

National methane gas emission estimations for dairy and beef cattle are derived using methodologies provided by the IPCC and use the following calculation:

Methane Emission Estimates for Canadian Dairy and Beef Cattle

$$CH_4 = \sum_{l=1}^{n} (P_l \times EF_l)$$

where:

CH_4	=	Enteric fermentation methane emissions for all animal categories
P_l	=	Animal population (*P*) for each specific livestock category or sub-category (*l*)
EF_l	=	Methane emissions factor for each specific livestock category (*l*)

Methane emission estimates for Canadian cattle are calculated using the following steps:

Step 1: Emission factors are calculated for various cattle sub-categories based on the IPCC Tier-2 methodology, along with specific information on animal sub-category, physiological status, age, gender, weight, rate of gain, level of activity, and production environment.

Step 2: Emission factors are calculated for each cattle sub-category (dairy cows, dairy heifers, beef cows, bulls, calves <1 year, heifer replacement, heifers >1 year, and steers >1 year) by province and then combined to produce a weighted national average emission factor.

Step 3: National enteric emissions are calculated by multiplying the emission factor with its cattle sub-category population, and by summing up estimates for all cattle sub-categories.

For more detailed information on the methods used to estimate emissions in each source category, refer to Chapters 3 through 8 and Annexes 2 and 3 in the NIR (Environment Canada, 2005).

4.2 Reporting units

The greenhouse gas emissions indicator uses the same source categories as are used in the NIR, following the same sub-sector breakdown. This reporting format is agreed upon internationally and groups emissions into the following six sectors: energy, industrial processes, solvent and other product use, agriculture, land use, land-use change and forestry, and waste. Each of these categories is further subdivided and follows UNFCCC sector and sub-sector divisions closely, with some minor differences. The indicator does not include data from the land use, land-use change and forestry category. Refer to Table 2 for a list of all source categories for which greenhouse gas emissions are estimated by the indicator.

Greenhouse gases differ in their ability to absorb heat in the atmosphere based on their chemical properties and lifetime in the atmosphere. For example, over a period of 100 years, methane is 21 times as powerful as carbon dioxide in terms of its potential to trap heat in the atmosphere, so it is considered to have a “global warming potential” of 21. Therefore, greenhouse gas emissions are reported in terms of “carbon dioxide equivalents,” determined by multiplying the amount of emissions of a particular gas by the global warming potential of that gas. The IPCC publishes the global warming potentials for each greenhouse gas (Table 4).

Table 4 Global warming potentials and atmospheric lifetimes

Greenhouse gas	Formula	100-year global warming potential	Atmospheric lifetime
Carbon dioxide	CO_2	1	variable
Methane	CH_4	21	12 ± 3
Nitrous oxide	N_2O	310	120
Sulphur hexafluoride	SF_6	23 900	3 200
Hydrofluorocarbons (HFCs)			
HFC-23	CHF_3	11 700	264
HFC-32	CH_2F_2	650	5.6
HFC-41	CH_3F	150	3.7
HFC-43-10mee	$C_5H_2F_{10}$	1 300	17.1
HFC-125	C_2HF_5	2 800	32.6
HFC-134	$C_2H_2F_4$ (CHF_2CHF_2)	1 000	10.6
HFC-134a	$C_2H_2F_4$ (CH_2FCF_3)	1 300	14.6
HFC-143	$C_2H_3F_3$ (CHF_2CH_2F)	300	1.5
HFC-143a	$C_2H_3F_3$ (CF_3CH_3)	3 800	3.8
HFC-152a	$C_2H_4F_2$ (CH_3CHF_2)	140	48.3
HFC-227ea	C_3HF_7	2 900	36.5
HFC-236fa	$C_3H_2F_6$	6 300	209
HFC-245ca	$C_3H_3F_5$	560	6.6
Perfluorocarbons (PFCs)			
Perfluoromethane	CF_4	6 500	50 000
Perfluoroethane	C_2F_6	9 200	10 000
Perfluoropropane	C_3F_8	7 000	2 600
Perfluorobutane	C_4F_{10}	7 000	2 600
Perfluorocyclobutane	c-C_4F_8	8 700	3 200
Perfluoropentane	C_5F_{12}	7 500	4 100
Perfluorohexane	C_6F_{14}	7 400	3 200

Source: Environment Canada, 2005

5. Data sources

The greenhouse gas emissions indicator comes directly from the NIR and has not undergone any further manipulation. Data used to develop the NIR come from published as well as non-published sources from various government departments, scientific papers, and internationally accepted IPCC reference documents.

The sections below provide a brief outline of the data sources that were used to calculate emissions for each source category. A comprehensive detailing of all data sources used can be found in Chapters 3 through 8 of the NIR (Environment Canada, 2005), disaggregated by sector and sub-sector.

5.1 Energy

Many of the data used to estimate stationary and mobile fuel combustion emissions are acquired from Statistics Canada.

Certain sub-sectors require data from additional sources to assess emissions more completely. Some of the data sets used to estimate emissions from road transport activities, for example, are found in Table 5.

Table 5 Data sets and sources: Road transport activities

Data set	Source
Vehicle population data	Desrosiers Automotive Consultants; Environment Canada; R.L. Polk and Co.; Statistics Canada
Fuel consumption ratios	Transport Canada; U.S. Environmental Protection Agency
Vehicle kilometres travelled	Environment Canada; Statistics Canada
Road taxed fuel	Statistics Canada

An inventory of fugitive emissions from Canadian coal mining operations is used as the basis for estimating emission factors for releases associated with the mining of solid fuels (King, 1994). These emission factors are multiplied by coal production data from Statistics Canada. Fugitive emission estimates from the oil and natural gas industry are based on two studies (Radian International, 1997; Canadian Association of Petroleum Producers, 1999), using data collected from various sources, such as the Alberta Energy and Utilities Board, Natural Resources Canada, and provincial energy ministries.

5.2 Industrial processes

Activity data used to develop estimates of greenhouse gas emissions from some of Canada's industrial processes, using either default IPCC or industry-specific emission factors, are outlined in Table 6.

Table 6 Data sets and sources: Industrial processes

Data set	Source
Cement production; Lime production; Limestone and dolomite use	Natural Resources Canada, *Canadian Minerals Yearbook*, Annual.
Cement production	Statistics Canada, *Cement*, 1990–2003, Monthly, 44-001-XIB.
Ammonia production; Nitric acid production	Statistics Canada, *Industrial Chemicals and Synthetic Resins*, Monthly, 46-002-XIE.
Soda ash production and use	Statistics Canada, *Non-Metallic Mineral Products Industries*, Annual, 44-250-XIE
Iron and steel production	Statistics Canada, *Primary Iron and Steel*, 1990–2003, Monthly, 41-001-XIB.
Iron and steel production; Non-energy use of fossil fuels	Statistics Canada, *Report on Energy Supply and Demand*, Annual, 57-003-XIB.

HFC emissions from consumption of halocarbons are estimated from data gathered from surveys conducted by the Chemical Controls Division of Environment Canada in 1996, 1998, 1999, and 2001. Process CO_2 and PFC emission estimates for aluminium production were obtained directly from the Aluminium Association of Canada.

5.3 Solvent and other product use

Emission factors for this sector were developed based on 1990 population statistics and the nitrous oxide consumption patterns. Population data from Statistics Canada's *Annual Demographic Statistics* (Statistics Canada, 2004b) were multiplied by each of the emission factors to estimate emissions for this sector.

5.4 Agriculture

Statistics Canada livestock population data were used in conjunction with IPCC Tier-1 or Tier-2 emission factors to produce estimates of emissions from enteric fermentation and manure management. Livestock categories for which population data are available include cattle (dairy and non-dairy), buffalo, sheep and lambs, goats, horses, swine and poultry. These data are obtained from Statistics Canada's Census of Agriculture and other annual reports.

Emissions of nitrous oxide from synthetic fertilizers are calculated using annual fertilizer sales data from regional fertilizer associations, combined with the IPCC default emission factor. To produce emission estimates from animal manure applied to soils and manure on pasture, range and paddock, the same data sources are used as for manure management emissions. Crop production data from Statistics Canada are applied to the default IPCC emission factor to produce estimates of emissions from nitrogen-fixing crops and crop residue decomposition. The area of cultivated organic soils obtained through consultations with national and regional soil and crop specialists is applied to the IPCC default emission factor to generate emission estimate for histosols.

5.5 Waste

A variety of data sources were used to collect activity data to produce solid waste emission estimates. These sources include Environment Canada (1996), Canadian Council of Ministers of the Environment (1998), Statistics Canada (2004b), Natural Resources Canada (1997), and various other unpublished waste inventories.

Provincial-level data was required to determine methane emissions from landfills. Using inputs from the above-mentioned sources, the Scholl Canyon model was used to estimate emissions (Environment Canada, 2005:118). This model relates emission contributions to the waste that has been landfilled in previous years, as opposed to the static, default method, which relates emissions to the quantity of waste landfilled in that year only

Wastewater handling emission estimates were developed using specific emission rates based on the amount of organic matter generated per person in Canada. These emission rates were then multiplied by the amount of wastewater treated anaerobically in each province and then by the population of each province.

Waste incineration estimates were derived from an Environment Canada (1996) study and extrapolated using Statistics Canada population growth figures.

6. Statistical analysis

6.1 Quality assurance and quality control

The data used to compile the NIR are calculated by designated experts within the Greenhouse Gas Division at Environment Canada and are reviewed internally. A draft inventory is then distributed in a formal review process to the Emissions and Projections Working Group (EPWG). The EPWG includes representatives of provincial, territorial, and federal government departments working in the field of air pollution measurement and estimation.

Emission estimates for the various sectors are also reviewed by experts from which the source data were derived, such as Statistics Canada (energy data, livestock and crop production statistics), Natural Resources Canada (mineral production and forest statistics), Agriculture Canada and industrial associations. The inventory is then submitted to the UNFCCC in April of each year. Subsequently, the inventory is subject to a formal review by a UN Expert Review Team (ERT).

The review of inventories by the UNFCCC is a three-stage process and provides a thorough technical assessment of the inventory. Each stage of the review is finalized with a review report, which is published on the secretariat web site (http://www.unfccc.int). Annual review of individual inventories became mandatory in 2003, ensuring that adequate consideration is given to recalculations and emission trends over time. International teams of sectoral inventory experts examine the data, methods, and procedures used in preparing the inventory.

7. Future improvements

The data and methods used to develop the greenhouse gas emissions indicator described in this document are considered to be the best available at this time (Environment Canada, 2005). Annex I Parties are required to continuously improve the quality of their national greenhouse gas inventory. As new information and data become available, and more accurate methods developed, previous estimates are updated to provide a consistent and comparable trend in emissions. Although more accurate methods are sometimes available, the lack of necessary activity data often limits the use of these methods. Some of the initiatives planned to improve data availability are outlined below.

7.1 Mandatory greenhouse gas emissions reporting

Mandatory greenhouse gas emissions reporting was established in 2004, the result of an ongoing collaboration between federal, provincial, and territorial governments to develop a harmonized system of greenhouse gas emissions reporting. The reporting system is being implemented in phases, with the first phase requiring facilities emitting 100 kilotonnes or more of carbon dioxide equivalent emissions to report their 2004 emissions. This information may be used as an additional source of data for future emission estimations.

7.2 Statistics Canada greenhouse gas emissions account

In later CESI reports, the indicator analysis will be complemented with data and analysis from Statistics Canada's greenhouse gas emissions account. This account borrows heavily from the National Inventory Report, but is produced following the concepts of the System of National Accounts (SNA), as opposed to the methodology required by the IPCC. As such, the Statistics Canada emissions account can be linked directly to the detailed economic data of the SNA. In particular, this linkage permits use of Statistics Canada's national input–output accounts to analyze emission intensities of industrial sectors and to study the indirect emissions linked to intermediate use of goods. This account produces highly detailed sectoral emission estimates for 122 industries.

7.3 Household environment survey

Information to provide context for the greenhouse gas emissions indicator will be developed from a survey of Canadian households regarding their environmental practices, such as driving habits and use of wood-burning stoves. Preliminary results of this survey should be available in 2006.

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