Assessment of the Comparability of Greenhouse Gas and Black Carbon Emissions Inventories in North America

Commission for Environmental Cooperation

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Executive Summary

Parties to the North American Agreement on Environmental Cooperation (NAAEC) have a strategic objective to improve the comparability of emissions data, methodologies, and inventories in North America. Improved comparability of greenhouse gas (GHG) and black carbon inventories will enable the Parties to share results and strengthen capacities, while working towards advancing domestic mitigation objectives, standards, regulations, and policies over the next five years.

In order to fulfill this goal, the Commission for Environmental Cooperation (CEC) has commissioned ICF to assess the comparability of GHG (both national and subnational) and black carbon (BC) inventories across North America.

National GHG Inventory Comparability

There are three ways in which comparability between national GHG emissions inventories were evaluated for the study: source coverage, GHG coverage, and the methods of emissions estimation used by each country. The latter would include methods taken from the standards and guidelines that might in some cases attribute emissions to sources differently. Overall, the national GHG emissions inventories between Canada, the United States, and Mexico are largely comparable. A large difference identified between the three inventories is in the tier of methods used to estimate emissions. Using a lower tier methodology to estimate GHG emissions has the effect of creating a greater range of uncertainty, but does not render those emissions less comparable.

Energy represents the largest source category of GHG emissions for each country. Canada and the United States use higher tier[1] (more detailed) methodologies and country-specific emission factors to estimate emissions from energy, whereas Mexico uses lower tier methodologies to estimate its GHG emissions from energy. The same major sources for Energy were covered by all three countries.

GHG emissions in the industrial processes sector necessarily vary depending on the type of industry and manufacturing processes used in each country. For example, under mineral products, Mexico includes glass production in the “other” category, while Canada includes magnesite production; similarly, asphalt roofing (2A5) and road paving with asphalt (2A6) are only estimated in Mexico (not estimated in Canada, and included elsewhere in the US). Source coverage and GHG coverage for the chemical industry are generally consistent across the three countries, but the tier of methods used varies for each country. In addition, the United States uses the Intergovernmental Panel on Climate Change (IPCC) 2006 Guidelines, while Canada applies the IPCC 1996 Guidelines, which introduces some differences among the emission streams included in specific subcategories of the industrial processes sector, as well as the number of secondary sources included.

Similar to the industrial processes sector, source coverage of agriculture and land use change and forestry emissions depends upon the national circumstances of each country, including ecosystems and climate. While source coverage varies by country, so do methods used to estimate emissions from these sources.

One comparability consideration in the waste sector is that the United States estimates emissions from waste incineration in the Energy Sector, whereas these emissions are included in the waste sector for both Canada and Mexico.

Subnational GHG Inventory Comparability

In addition to the national GHG inventories that are submitted to the United Nations Framework Convention on Climate Change (UNFCCC), subnational inventories have been completed for many of the individual states and provinces, as well as regional initiatives such as the Regional Greenhouse Gas Initiative (RGGI) and the Western Climate Initiative (WCI). The purpose and drivers for these local and regional inventories

[1] Simple methods (Tier 1) estimate emissions based on activity data and average or default emission factors. Detailed methods (Tiers 2 and 3) estimate emissions based on detailed information on fuels and technology, and use country-specific, regional, or industry-specific emission factors, or incorporate direct measuring or modeling. The specific Tier 1, 2, and 3 methodologies vary by sector and source category. (Source: Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual, http://www.ipcc-nggip.iges.or.jp/public/gl/guidelin/ch1ref1.pdf).

differ from their national counterpart initiatives, and some of these inventories are largely compiled from national inventory data.

At least five Canadian provinces or territories, thirty-one states in the United States, and ten states in Mexico have completed GHG inventories or compiled reported emissions independent of their respective national GHG inventories as of this publication. In Canada, provinces such as British Columbia and Manitoba present finished results from the National Inventory Report (NIR) as their own provincial GHG inventories, while other provinces such as the Northwest Territories developed a separate GHG inventory that differs from the NIR. Subnational inventories were found to follow IPCC Guidelines (either 1996 or 2006), and use methodologies similar to those used by the national GHG inventories in each country. National inventories were found to include more emission sources than subnational inventories because states and provinces do not have all source categories within their geographic boundaries. The type and granularity of data available at the state level was found to result in lower tiers used in subnational inventories. In addition, most subnational inventories did not estimate uncertainty.

Black Carbon Inventory Comparability

Though there is no standardized methodology for producing a BC inventory, the US EPA has developed a framework for estimating BC emissions by source category that has been largely adopted by the Canadian and Mexican governments. For many source categories, BC emissions are estimated from $PM_{2.5}$ inventory data. Each country has a national inventory database that includes $PM_{2.5}$, a regulated pollutant known to impair human health. The Canadian and US governments estimate BC emissions by applying the speciation profile database (SPECIATE4.2), which matches source profiles of $PM_{2.5}$ to BC to estimate the BC emissions. This is the intended methodology for Mexico's BC inventory (expected to be released during the summer of 2012). The Canadian and US inventories are relatively transparent in their methodologies and data collection methods, and, as they draw from similar approaches in calculating BC emissions, these two countries are somewhat comparable and consistent. An initial challenge in comparing these two countries was the varying definitions of top-level source categories, requiring some manipulation for a consistent comparison. Though the Mexican $PM_{2.5}$ inventory appears similar in design to the other countries, the BC inventory is still under development and was not available for comparison purposes in this study. Given the similarities in the inventory approach across countries, it is likely many of the differences in the inventory comparison are due to differences in activity data and treatment of uncertainty.

1 Introduction

1.1 Objectives and Rationale

The CEC has a stated strategic objective to improve the comparability of greenhouse gas (GHG) and black carbon (BC) emissions inventories among the North American Parties (Canada, Mexico, and the United States). Improved comparability of GHG and black carbon inventories will enable the Parties to share results and strengthen capacities, while working towards advancing domestic mitigation objectives, standards, regulations, and policies over the next five years. While the inventories are generally consistent in the methodologies used and reporting requirements followed (based on IPCC and UNFCCC guidelines), key differences do exist regarding activity data collection, methodologies, emission factors, and other aspects (e.g., what time series they report).

The objectives of this report are to provide the Parties with an understanding of the gaps, inconsistencies, and similarities among the national inventories, taking into consideration respective circumstances, priorities and capacities of each country, and to identify opportunities to improve the comparability. To achieve this objective, CEC engaged ICF International to assess the national and subnational GHG inventories, as well as the black carbon inventories of each country and compare the key characteristics of each.

Only the UNFCCC Expert Review Team can ensure that national inventories are comparable and consistent with reporting requirements. This report is therefore intended as an assessment of potential comparability issues, not a certification of comparability.

2 Approach

In order to evaluate the comparability of North American inventories, ICF worked with the Commission for Environmental Cooperation (CEC) and representatives of the Parties to develop a structured approach. This approach targeted the elements of each inventory that are commonly associated with comparability, as defined by the IPCC:

> *"Comparability means that estimates of emissions and removals reported by Annex I Parties in inventories should be comparable among Annex I Parties. For this purpose, Annex I Parties should use the methodologies and formats agreed by the COP for estimating and reporting inventories. The allocation of different source/sink categories should follow the split of the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, and the IPCC Good Practice Guidance for Land Use, Land-Use Change and Forestry, at the level of its summary and sectoral tables."* [2]

Each inventory was evaluated against a common suite of metrics organized by source category, and areas that may yield an "apples to oranges" comparison when regarding a ton of carbon reported by different Parties were identified.

Specifically, GHG and BC emissions inventories that have been completed in Canada, Mexico, and the United States, were identified and obtained. To facilitate the cross-comparison of North American GHG and BC inventories, a comparability matrix to document various characteristics of the national and subnational inventories was developed. Because of the large quantity of information contained in each inventory, specific points of comparability, or metrics, were defined and used to assess each inventory. The development of the matrix and description of metrics are described in more detail in sections 2.1.1 and 2.2.1 for the GHG and BC assessments, respectively.

Next, data were collected from each emissions inventory for each metric specified in the GHG and BC matrices. Each matrix was completed using published inventories, and in certain cases, interviews with national subject matter experts. The specific sources of information used and the data collection process are described in sections 2.1.2 and 2.2.2 for the GHG and BC assessments, respectively.

After the matrices were completed for the GHG and BC inventories of the three countries, the comparability and key differences were evaluated against each other in the following ways:

- For the national-level GHG assessment, national GHG inventories were compared to one another, and key differences were identified for the national-level metrics;
- Subnational GHG emissions inventories (e.g., inventories by states or provinces) were compared to their respective national inventory, and key comparability issues were identified;
- For the national-level BC assessment, national BC inventories were compared to one another and key differences were identified between the US and Canada. Although Mexico has not yet completed a BC inventory, its plans for compiling a BC inventory were also considered in this assessment. The $PM_{2.5}$ emissions inventories for all three countries were also compared, because BC emissions were often developed as a component of $PM_{2.5}$ emissions for each country.

The outcome of the assessment is summarized in the following sections.

2.1 Greenhouse Gases

Over the past approximately 200 years, the burning of fossil fuels such as coal and oil, deforestation, and other sources have caused the concentrations of heat-trapping greenhouse gases to increase significantly in our atmosphere. These gases absorb some of the energy being radiated from the surface of the earth and trap it in the atmosphere, essentially acting like a blanket that makes the earth's surface warmer than it would be otherwise. Most of the warming in recent decades is very likely the result of human activities. Other aspects of the climate are also changing such as rainfall patterns, snow and ice cover, and sea level. Although the direct GHGs, carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O), occur naturally in the atmosphere, human activities have changed their atmospheric concentrations (IPCC 1996, IPCC 2001, IPCC 2007).

[2] Updated UNFCCC Reporting Guidelines on Annual Inventories Following Incorporation of the Provisions of Decision 14/CP.11, November 2006. <http://unfccc.int/resource/docs/2006/sbsta/eng/09.pdf>.

GHGs are emitted from a wide variety of human (anthropogenic) activities. Developing a GHG emissions inventory that accurately identifies and quantifies a country's anthropogenic sources and sinks (e.g., absorption of CO_2 by forests) of GHGs is an essential first step in assessing opportunities for GHG mitigation and ultimately reducing GHG emissions in an efficient manner.

The United States and Canada are both Annex I Parties to the UNFCCC, under which each Party has committed to "develop, periodically update, publish and make available… national inventories of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol, using comparable methodologies…"[3] Mexico is a non-Annex I Party to the UNFCCC, and is required to "…communicate to the Conference of the Parties a national inventory of anthropogenic emissions by sources and removals by sinks of all greenhouse gases (GHGs) not controlled by the Montreal Protocol, to the extent its capacities permit, following the provisions in these guidelines."[4]

This section describes the approach used to evaluate the North American GHG emissions inventories for comparability in terms of coverage, data, methods, and objectives.

2.1.1 Matrix Development

The GHG comparability matrix documents characteristics of the national and subnational North American GHG emissions inventories, including source coverage, methodologies, and other considerations, as described below. The matrix was used to perform an overall assessment of the comparability of the inventory reports. The results of the comparability matrix were used to prepare this assessment report, and are intended to assist the CEC and the Parties' common goals of sharing results and strengthening capacities, and advancing domestic mitigation objectives, standards, regulations, and policies over the next five years. This comparability study looked at a number of metrics that are not limited to UNFCCC reporting requirements at the request of the CEC panel in order to provide a broader picture of comparability.

Definition of Metrics – National Assessment

The national GHG inventory comparability matrix is composed of five parts, each of which is described further within this section:

1. **National GHG Metrics.** Contains comparability metrics that apply to national GHG inventories as a whole for Canada, the United States, and Mexico, and identifies key differences between the three national inventories.
2. **GHG Metrics by Source Category.** Contains comparability metrics that apply to individual emissions sources within each country's national GHG emissions inventory.
3. **Sector-Specific Questions.** Contains specific sector/source questions for Canada, the United States, and Mexico national GHG emissions inventories.
4. **Source Coverage.** Lists all IPCC sources covered by Canada, the United States, and Mexico national GHG inventories.
5. **Key Categories**. Lists key categories for each national inventory – level and trend Tier 1 assessments, including the Land Use, Land Use Change and Forestry (LULUCF) sources.

The subnational GHG comparability matrix contains similar metrics as the national GHG inventory comparability matrix that apply to subnational GHG inventories in Canada, the United States, and Mexico. The subnational matrix also identifies key differences between each country's subnational inventory and its national GHG emissions inventory.

The main components of the national GHG inventory comparability matrix are defined below. For a complete list of metrics used and their definitions, as well as the completed matrices, refer to *APPENDIX C: National GHG Metrics* and *APPENDIX D: Sector-Level Matrix Tables.*

[3] Article 4(1)(a) of the United Nations Framework Convention on Climate Change (also identified in Article 12). Subsequent decisions by the Conference of the Parties elaborated the role of Annex I Parties in preparing national inventories. See <http://unfccc.int>
[4] Guidelines for NAI National Communications and User Manual, August 3, 2004. <http://unfccc.int/national_reports/non-annex_i_natcom/guidelines_and_user_manual/items/2607.php>

National GHG Metrics

For the national GHG metrics assessment, metrics were organized into four categories:

- **Coverage and Scope** metrics identify basic characteristics of the national GHG inventories, including guidance followed, geospatial coverage, and global warming potentials (GWPs) used.

- **Methodologies and Data Sources** metrics identify the methods and data used to compile each nation's GHG emissions inventory, such as standards and guidelines used, vintage of data, years covered, and the handling of uncertainty.

- **Inventory Processes and Systems** metrics describe the overall process for compiling and reporting GHG emissions inventories in each nation, including institutional arrangements, legal arrangements, and data management systems.

- **Main Drivers and Objectives** metrics identify the purposes and considerations for each country in preparing a national GHG emissions inventory, such as international agreements and legal requirements or partnerships within each country.

GHG Metrics by Source Category

In addition to the national-level overview metrics, there are a number of points of comparability that vary by source category. Source categories within each national inventory were evaluated for metrics such as GHGs covered in the inventory, IPCC methodology tier levels and emission factors, and models used.

Sector-Specific Questions

A number of additional questions, relevant to specific sectors, were also identified and evaluated for each country. These include each country's handling of biogenic CO_2 emissions and where specific emission sources that could fit in multiple sectors are reported.

Source Coverage

The source coverage section of the matrix identifies which source categories are covered by each national GHG inventory. Specific exclusions, as identified in the Common Reporting Format (CRF) tables for the United States and Canada, and in the supporting inventory documents for Mexico, are also reported in this section.

Key Categories

While this matrix identified comparability issues among the national GHG emissions inventories as a whole, issues that affect key categories for each country will have the largest impact on the comparability of the national inventories because they represent the largest share of each country's emissions. This section of the matrix identifies the key categories for the most recent US, Canadian, and Mexican GHG emissions inventories, based on both trend and level assessments without accounting for uncertainty (Tier 1),[5] and including the LULUCF sector.

Definition of Metrics – Subnational Assessment

The structure of the subnational GHG inventory comparability matrix is similar to that of the National GHG Metrics worksheet within the national GHG inventory comparability matrix, but scaled down to apply to subnational inventories. The subnational metrics fall into four categories:

[5] When using the Tier 1 approach for key category analysis, key source categories are identified using a predetermined cumulative emissions threshold. The predetermined threshold has been determined based on an evaluation of several inventories, and is aimed at establishing a general level where 90% of inventory uncertainty will be covered by key source categories. (Source: IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories, Chapter 7: Methodological Choice and Recalculation, <http://www.ipcc-nggip.iges.or.jp/public/gp/english/7_Methodological.pdf>).

- **Coverage and Scope** metrics identify basic characteristics of the subnational GHG inventories as a whole, including GHG coverage, sector coverage, and geographical coverage (how many states or provinces completed inventories within each country).

- **Emissions Estimation Methods and Data** metrics identify the methods and data used to compile subnational GHG emissions inventories, such as methodologies used, IPCC tier of methods, and handling of uncertainty.

- **Inventory Processes and Systems** metrics describe the overall process for compiling and reporting GHG emissions inventories, including institutional arrangements and reporting.

- **Main Drivers and Objectives** metrics identify the purposes and considerations for subnational inventories, such as legal requirements or partnerships within each country.

2.1.2 Data Collection

Each country's literature (provided by CEC or national GHG experts) was collected and reviewed. In addition, a brief literature review was conducted for additional inventory information. Table 1 and Table 2 summarize the literature used in the national and subnational GHG assessment. The most recent Mexico GHG inventory and its supporting documents (Semarnat 2009) were translated into English for this evaluation.

Table 1. Sources of Information for the GHG National Assessment

Country	Sources
Canada	• National Inventory Report (NIR) 1990–2009: Greenhouse Gas Sources and Sinks in Canada, http://www.ec.gc.ca/ges-ghg/default.asp?lang=En&n=83A34A7A-1 • CRF Submission to the UNFCCC
United States	• Inventory of US Greenhouse Gas Emissions and Sinks, 1990–2009, http://epa.gov/climatechange/emissions/usinventoryreport.html • CRF Submission to the UNFCCC
Mexico	• Mexico's Fourth National Communication to the United Nations Framework Convention on Climate Change, <http://www.ine.gob.mx/descargas/cuarta_com_alta.pdf> • Mexico: Greenhouse Gas Emissions and Sinks: 1990–2006 Individual Report, <http://www.ine.gob.mx/cpcc-lineas/929-inem-1990–2006>

Table 2. Sources of Information for the GHG Subnational Assessment

Country	Sources
Canada	• Manitoba Regional Inventory, <http://www.climatechangeconnection.org/emissions/Manitoba_emissions.htm> • Quebec Regional Inventory, <http://www.mddep.gouv.qc.ca/changements/ges/index.htm> • British Columbia Regional Inventory, <http://www.env.gov.bc.ca/cas/mitigation/ghg_inventory/pdf/pir-2008-full-report.pdf> • Northwest Territories Regional Inventory, <http://www.enr.gov.nt.ca/_live/documents/content/Greenhouse_Gas_Strategy_FINAL.pdf> • Reported Alberta GHG Emissions, <http://environment.gov.ab.ca/info/library/8267.pdf>

United States	• US State and Regional Inventories, <http://www.epa.gov/statelocalclimate/state/state-examples/ghg-inventory.html>
Mexico	• <http://www2.ine.gob.mx/sistemas/peacc/> • Chiapas State Inventory • Sonora State Inventory • Baja State Inventory • Coahuila State Inventory • Nuevo León State Inventory • Veracruz State Inventory

2.1.3 Expert Interviews

GHG inventory experts were identified from each country based on input from the CEC and designated country leads. For the United States, ICF supports EPA in developing the national *Inventory of US Greenhouse Gas Emissions and Sinks* and coordinates the *State Inventory Tool* used for most state-level inventories. As such, ICF's inventory experts were able to provide sufficient information on the inventory development process for the national and subnational US inventories. For Canadian inventories, in-country experts were consulted for aspects of the subnational assessment, including specifics of provincial inventories. For Mexico, the national lead for the GHG inventory was consulted about data management, key categories, and handling of uncertainty. A full list of experts interviewed is provided in the references section of this report.

2.2 Black Carbon

Black carbon (BC) is a carbonaceous component of particulate matter (i.e., $PM_{2.5}$) emitted by incomplete combustion processes.[6] BC has been recognized as an air pollutant detrimental to human health, but recently has become of interest to climate change experts due to its climatic impacts. BC creates regional warming by absorbing incoming and reflected solar radiation (IPCC 2007). It is a strong climate forcer, absorbing more than a million times more energy than the same unit mass of carbon dioxide (Arctic Council 2011; EPA 2011b). BC further warms the climate when the particle deposits on snow and ice surfaces, decreasing the reflection of solar radiation and accelerating melting (IPCC 2007, Ramanathan and Carmichael 2008). In addition, over its short atmospheric lifetime, it can interact with cloud processes impacting local precipitation and cloud reflectivity (Ramanathan and Carmichael 2008). This can cause a localized cooling effect (Kopp and Mauzerall 2010). The complex interaction of BC with cloud formation and properties is an area of active research.

A recently released international study suggests that reducing BC emissions will reduce near-term climate change, as well as protect public health (UNEP/WMO 2011). As BC has a short lifetime in the Earth's atmosphere of approximately days to weeks (CCSP 2009), the benefits of mitigating this particle include the immediate slowdown of the rate of climate change in the near term (EPA 2011b; UNEP/WMO 2011). However, this will not replace the need for mitigating accumulating GHGs to reduce climate change impacts in the long term. In addition, reducing BC will have additional societal benefits, as this particle is associated with harming respiratory and cardiovascular health.

In an effort to inform decision making regarding BC mitigation and categorize major sources of BC, countries are beginning to develop inventories of their BC emissions. The governments of Canada, Mexico, and the United States consider $PM_{2.5}$ a regulated air pollutant; therefore, national inventories are in place to collect $PM_{2.5}$ emissions data. Methodologies have been developed to estimate how much of this fine particulate matter can be considered BC. Both the United States and Canadian governments have BC inventories available, while the Mexican government is in the process of developing a BC inventory. An inter-country comparison is embedded in the methodology discussions below, followed by a comparison of inventory findings. The process developed within the United States is currently the basis for the Canadian and Mexican BC inventory estimates; as such, the methodology for the United States is presented first.

[6] $PM_{2.5}$ is particulate matter with a diameter of 2.5 micrometers (10^{-6} meters) or smaller. $PM_{2.5}$ represents a number of chemical species, including black carbon.

2.2.1 Matrix Development

A comparability matrix was developed to inform an inter-country comparison amongst BC national inventories for Canada, Mexico, and the United States. The analysis presented here draws from the findings of the comparability matrix, which facilitates comparison of source coverage, methodologies, and other considerations across black carbon inventories. This matrix comparison was informed by available literature and national expert communication. The matrix is organized into five main parts, described below, (see Appendices F and G):

1. **National Inventory by Inventory Category.**[7] Contains comparability metrics that apply to national BC inventories for Canada, the United States, and Mexico.
2. **National Inventory by Source Category.**[8] Contains comparability metrics for the source categories of the Canadian, Mexican, and US BC emissions inventories.
3. **Flowchart Development BC Emissions.** Flowcharts show the development of black carbon estimates for different source categories for the United States national BC emissions inventories. Discussions are provided describing the similarities and differences between the US flowcharts and the inventory development for Mexico and Canada.
4. **Emissions by Country.** Lists the black carbon emissions by source category for Canada, Mexico, and the United States.
5. **SPECIATE 4.2 Profiles.** Contains sources of information by category for BC/$PM_{2.5}$ ratios.

Within the BC comparability matrix, the following key metrics were evaluated for comparison purposes:

- Inventory process and inventory structure, including such issues as comparability and baseline years;
- Methodologies for estimating BC emissions across source categories, including category definition, source emissions, and key uncertainties;
- A series of flowcharts describing the methodology for developing BC emissions by source category;
- National BC emissions across various source categories;
- A collection of speciation profiles used in SPECIATE 4.2 by source category to translate $PM_{2.5}$ emissions to BC emissions.

The findings in the comparability matrix provide the foundation for this written analysis.

Various challenges existed at the onset of the BC analysis. The literature that discusses the methodology and emissions for source categories specific to each country did not readily allow for a simple comparison across countries. Considerable effort was required to identify and disaggregate inventory source categories accordingly to provide a common comparison point. The published literature on Mexico was particularly limited, although the Mexican government intends to publish a significantly updated BC inventory in summer 2012. ICF relied on Mexican experts to provide the most up-to-date information.

As mentioned, emissions of BC and $PM_{2.5}$ were reported for different source categories in the Canadian, Mexican, and US emissions inventories. For the purposes of the inventory comparison, the emissions sectors were redistributed into eleven source categories to streamline the comparison process. Table 3 outlines the eleven source categories and the definitions for each country. Overall, the first nine source categories are relevant across the North American countries, while the last two source categories are specific to Mexico (ideally, these source categories would be disaggregated to fold into the first nine source categories).

[7] "Inventory category" refers to the inventory structure and process properties used to compare these national inventories.
[8] "Source category" refers to the emission sources such as power generation, biomass combustion, etc. (see Table 3 for a complete set of source categories).

Table 3. Black Carbon Source Categories and Definitions

Source Category	Canada	United States	Mexico
1. Power Generation / Fossil Fuel Combustion	Electricity and heat generation	Includes natural gas combustion, bituminous combustion, sub-bituminous combustion, distillate oil combustion, wood-fired boiler, process gas combustion	Utilities - electricity generation
2. Biomass Combustion: 2.A Wildfires	Forest fires	Wildfires	
2. Biomass Combustion: 2.B Agricultural Burning/Prescribed	Agriculture (prescribed burning)	Agricultural burning, prescribed burning	
3. Mobile On-Road	Road transport gasoline, road transport diesel	On-road diesel, on-road gasoline, tire and brake wear. Includes passenger cars, motorcycles, minivans, sport-utility vehicles, light-duty trucks, heavy-duty trucks, and buses.	Gasoline- and diesel-powered on-road motor vehicles including light-duty vehicles and trucks, heavy-duty trucks, buses, and motorcycles.
4. Mobile Non-Road	Aviation, marine, rail, off-road gasoline/LP/CNG, off-road diesel	Includes recreational marine and land-based vehicles, commercial marine (C1 & C2), commercial marine (C3), aircraft, farm and construction machinery, industrial, commercial, logging, and lawn and garden equipment.	Diesel-powered equipment used in construction and agricultural activity, locomotives, aircrafts, and commercial marine vessels*
5. Industry	Petroleum refining, other energy industries (including pipelines), mining, and manufacturing industries & construction	Stationary diesel, cement production, chemical manufacturing, aluminum production, pulp and paper, industrial manufacturing, etc.	Manufacturing and other industrial processes
6. Non-Industry	Commercial and Institutional		Merchant wholesalers, nondurable goods, other services
7. Residential	Residential includes residential coal and wood burning, other	Residential heating and cooking includes: residential wood oil, coal, and natural gas consumption	Includes only wood burning; coal was not considered
8. Dust	Road dust	Paved road dust, unpaved road dust	Fugitive dust
9. Other	Forestry and waste	Charbroiling, wood products-drying, paved road dust, dairy soil, wood products-sawing, unpaved road dust, wood products-sanding, fly ash, asphalt manufacturing, etc.	

Source Category	Canada	United States	Mexico
10. Fixed/Point**	*Comparable to Industry, Non-Industry, Electricity Generation*		Stationary industrial facilities including chemical manufacturing, food manufacturing, pulp and paper manufacturing, electrical energy generation, hazardous waste treatment, federal airports/train/bus stations, etc.
11. Area**	*Comparable to Residential, Biomass combustion*		Includes residential wood fuel combustion, agricultural tilling, open burning waste/wildfires, agricultural burning, charbroiling/street vendors, remaining area sources.

*To maintain comparability with United States and Canada, the emissions from locomotive, aircraft, and commercial marine vehicles were moved to the Mobile Non-road source category
**Data are not available to disaggregate this source category into comparable United States and Canadian source categories.

2.2.2 Data Collection

Each country's literature (provided by CEC or national GHG experts) was collected and reviewed. In addition, a brief literature review was conducted for additional inventory information. Table 4 summarizes the literature used in this analysis.

Table 4. Sources of Information for Black Carbon Assessment (sources marked with an asterisk (*) indicate additional information sources that were not used to inform this study)

Country	Sources
Canada	• An Assessment of Emissions and Mitigation Options for Black Carbon for the Arctic Council, Technical Report of the Arctic Council Task Force on Short-Lived Climate Forcers, 2011 • 1993–2009 Canada Air Pollutant Emission Summaries and Trends, 2011
United States	• US EPA Report to Congress on Black Carbon, 2011 • Emissions Inventory for the National Particulate Matter Study, 1994 • US 2008 National Emissions Inventory, 2011 • Black Carbon as a Short-Lived Climate Forcer: A Profile of Emission Sources and Co-Emitted Pollutants, 2010 • US Black Carbon Inventory: Current and Future Activities (Presentation), 2010 • Documentation for the 2005 Mobile National Emissions Inventory, Version 2, 2008 • $PM_{2.5}$ Source Profiles for Black and Organic Carbon Emissions Inventories, 2011
Mexico	• Inventario nacional de emisiones de México (INEM) 2005 (Presentation), 2010 • Mexico's 1999 National Emissions Inventory for Air Quality, 2006 • Technical Workshop on Science and Policy of Short-lived Climate Forcers (<http://www.ine.gob.mx/cpcc-estudios-cclimatico/1005-slcf2011>)* • Emerging issues in climate change: methane and black carbon, their possible co-benefits and the development of research plans (<http://www.ine.gob.mx/descargas/cclimatico/2010_cca_mce2_temas_emergentes.pdf>)*

2.2.3 Expert Interviews

Black carbon experts were identified from each country based on input from the CEC. These discussions with Canadian, United States, and Mexican BC experts during and after the matrix development provided additional information and clarification of each country's inventory. The following aspects of the BC inventory comparison were discussed:

- Definition of source categories,
- Methodologies for calculating BC emissions (i.e., SPECIATE profiles used) for each source category,
- Identification of any additional useful sources of information, and
- Key uncertainties in the inventories.

Additional information provided by each set of experts was incorporated into the matrix.

3 Results

This section describes the results of the comparability assessment of the national GHG and BC emissions inventory efforts. These results are organized into the following sections:

1. National GHG Inventories – provides an overview of the Canadian, Mexican, and US national GHG emissions, and identifies key differences for comparing inventory efforts across North America.
2. Subnational GHG Inventories – provides an overview of state and provincial GHG inventory efforts in Canada, Mexico, and the United States and identifies key differences between each nation's subnational and national inventories.
3. Black Carbon Inventories – provides an overview of the Canadian, Mexican, and US BC inventory efforts, and identifies key differences for comparing inventory efforts across North America.

3.1 National GHG Inventories

This section describes the organization of each country's GHG inventory, followed by a discussion of their comparability.

3.1.1 National Inventory Basis and Drivers

The guiding principles and coverage of each country's GHG inventory are described below.

United States

The *Inventory of US Greenhouse Gas Emissions and Sinks: 1990-2009* covers GHG emissions in the United States for the years 1990-2009 on an annual basis (EPA 2011a). The US Inventory covers all six UNFCCC GHGs (CO_2, CH_4, N_2O, hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6)) for the six categories delineated by the IPCC: energy, industrial processes, solvents and other product use, agriculture, LULUCF, and waste.

The inventory utilizes *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories* (hereafter referred to as the 1996 IPCC Guidelines), the Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (hereafter referred to as the Good Practice Guidance), the *Good Practice Guidance for Land Use, Land-Use Change and Forestry* (hereafter referred to as the LULUCF Good Practice Guidance), and the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (hereafter referred to as the 2006 IPCC Guidelines). To maximize comparability with inventories submitted to UNFCCC by other Parties, the US Inventory predominately relies on the 1996 IPCC Guidelines and Good Practice Guidance and LULUCF Good Practice Guidance. However, the 2006 IPCC Guidelines are increasingly being used for source categories when doing so improves the accuracy of emission estimates.

As an Annex I Party to the UNFCCC, the United States is required to submit a national GHG inventory to UNFCCC on an annual basis that must be developed using IPCC guidelines. This reporting commitment is considered the key driver for development of the inventory. Beyond meeting these international commitments, there are no other domestic requirements for completing a national GHG emissions inventory in the United States.

Consistent with UNFCCC reporting guidelines that the NIR be a policy-neutral document, the US inventory does not address strategies to reduce future GHG emissions; its focus is exclusively on estimating emissions accurately for 1990-present and documenting historical emission trends.

Canada

The *National Inventory Report 1990–2009: Greenhouse Gas Sources and Sinks in Canada* estimates Canada's national GHG emissions from 1990 through 2009 on an annual basis (Environment Canada 2011c). The Canadian Inventory covers all six Kyoto Protocol GHGs (CO_2, CH_4, N_2O, HFCs, PFCs, and SF_6) for the six categories delineated by the IPCC: energy, industrial processes, solvents and other product use, agriculture, LULUCF, and waste.

Similar to the United States, the Canadian inventory utilizes 1996 IPCC Guidelines, Good Practice Guidance, 2003 IPCC Good Practice Guidance for LULUCF, and 2006 IPCC Guidelines. As an Annex I party to the UNFCCC, Canada is required to develop and submit a national GHG inventory to UNFCCC on an annual basis.

Consistent with UNFCCC reporting guidelines that the NIR be a policy-neutral document, the Canadian GHG inventory does not address mitigation strategies or potential to reduce future GHG emissions, and instead focuses on estimating emissions accurately and documenting past and present trends in emission levels.

Mexico

The *National Inventory of Emissions of Greenhouse Gases 1990–2006* (*Inventario Nacional de Emisiones de Gases de Efecto Invernadero*—INEGEI) was prepared as part of Mexico's Fourth National Communication to the UNFCCC. As a non-Annex I Party, Mexico is not required to submit an annual GHG emissions inventory to the UNFCCC, but is required to periodically submit national communications that include a GHG inventory overview.

Mexico's GHG inventory estimates anthropogenic emissions by sources and sinks for the period 1990–2006 for all six Kyoto Protocol greenhouse gases (CO_2, CH_4, N_2O, HFCs, PFCs, and SF_6) for the six categories defined by the IPCC: energy, industrial processes, solvents and other product use, agriculture, LULUCF, and waste. The most recent inventory is Mexico's fourth, and expands upon the previous inventory that covered the years 1990-2002, presented to the UNFCCC in Mexico's third national communication in 2006.

The Mexico inventory is prepared using the 1996 IPCC Guidelines, the Good Practice Guidance, the LULUCF Good Practice Guidance, 2006 IPCC Guidelines, and the IPCC Emissions Factor Database (EFDB) (hereafter referred to as the Emissions Factor Database). The INEGEI was developed using data from multiple sources, including government agencies, industrial associations), and industry sectors, through Mexico's voluntary GHG Reporting Program established in 2006. As of 2009, 98 companies were participating in Mexico's GHG Reporting Program, which represented 21% of Mexico's total estimated emissions (150 million tonnes of CO_2e). Mexico is currently exploring the possibility of including GHG data from this voluntary reporting into the national GHG inventory.

In addition, Mexico's National Development Program 2007–2012 and Special Program on Climate Change have directed the National Institute of Ecology (INE) to prepare two national GHG emissions inventories under the current federal administration. The Interministerial Climate Change Commission was established in 2005 to coordinate GHG inventory efforts for Mexico, and the second GHG inventory will be presented to the UNFCCC at COP 18 in 2012.

3.1.2 National GHG Inventory Comparability

The national-level GHG inventory assessment compared national GHG emissions inventories in Canada, Mexico, and the United States. This section describes the main findings of this assessment and highlights key differences between the national inventories that have implications for comparing inventory results across these countries.

National Metrics

Canada, Mexico, and the United States all utilize UNFCCC reporting guidelines and guidance documents, including the 1996 and 2006 IPCC Guidelines, Good Practice Guidance, and LULUCF Good Practice Guidance.[9] Despite the use of consistent guidance, there are differences between the three national GHG inventories. Five crosscutting areas where the three inventories differ in their approach include IPCC Guidelines, Common Reporting Format (CRF), uncertainty, QA/QC, and Key Category Analysis (KCA).

- IPCC Guidelines: The United States has incorporated IPCC (2006) Guidelines into the estimates of many source categories. This leads to some differences in source categories included in the inventory, and the placement of sources within sectors.

[9] Mexico's GHG inventory evaluated for this report is a portion of their national communication report, which not does necessarily follow UNFCCC's national GHG inventory reporting guidelines.

- CRF: Canada and the United States account for certain data sources differently in their respective CRF table submission. Mexico does not complete a CRF table, as this is not a requirement for non-Annex I countries.

- Uncertainty: Canada and the United States use a combination of Tier 1[10] and Tier 2 methods for estimating individual source category uncertainty, while Mexico uses the default Tier 1 approach for estimating uncertainty for all source categories. The United States uses Tier 2 method to estimate overall uncertainty, while Canada and Mexico apply a Tier 1 method for overall uncertainty.

- QA/QC: The United States conducts formal expert and public reviews prior to inventory submission to the UNFCCC; Canada conducts a formal expert review prior to inventory submission; Mexico does not currently have a formal review process in place.

- KCA: Differences between industrial processes are readily apparent when comparing the emissions categories that constitute the KCA for each country. Beyond differences that exist within each country's major industries, some industries do not exist in all three countries.

Table 5 lists some additional differences between the three national GHG inventories.[11] For a full comparison of differences among national inventories, *see APPENDIX C: National GHG Metrics*.

Table 5. National Inventory Comparability Highlights

	Canada	United States	Mexico
Inventory Requirements	Canada is an Annex I country and must submit annual GHG inventories to UNFCCC, developed using IPCC guidelines	The United States is an Annex I country and must submit annual GHG inventories to UNFCCC, developed using IPCC guidelines	Mexico is a Non-Annex I country, required to prepare periodic National Communications and submit them to UNFCCC
Inventory Year Coverage	1990–2009	1990–2009	1990–2006
Legal Requirements	Canada has no domestic legal requirement to complete a GHG inventory but is subject to UNFCCC requirements. The Canadian Environmental Protection Act provides the legislative authority for Environment Canada to implement a UNFCCC- and Kyoto Protocol-compliant national inventory system and the responsibility to prepare and submit the national inventory to the	The United States has no domestic legal requirement to complete a GHG inventory but is subject to UNFCCC requirements	The National Development Program 2007–2012 includes GHG inventory reporting requirements, and Mexico is subject to UNFCCC requirements for creating periodic national communications

[10] The *2000 IPCC Good Practice Guidance* describes two tiers for uncertainty analyses. Tier 1 is "Estimation of uncertainties by source category using the error propagation equation via Rules A and B, and simple combination of uncertainties by source category to estimate overall uncertainty for one year and the uncertainty in the trend." Tier 2 is described as "Estimation of uncertainties by source category using Monte Carlo analysis, followed by the use of Monte Carlo techniques to estimate overall uncertainty for one year and the uncertainty in the trend." (Source: <http://www.ipcc-nggip.iges.or.jp/public/gp/english/6_Uncertainty.pdf>).

[11] Mexico's GHG inventory evaluated for this report is a portion of their national communication report, which not does necessarily follow UNFCCC's national GHG inventory reporting guidelines.

	UNFCCC.		
Vintage of Data	Activity data are collected on an annual basis	Activity data are collected on an annual basis	Activity data are not currently collected on an annual basis but are fully available through 2006. For the next update, data for all sources will be collected on an annual basis

Sector-Level Metrics

A number of differences were identified for specific emission sectors and sources among the US, Canadian, and Mexican GHG inventories. One main difference is in the treatment of emissions from waste incineration. In the US inventory, all emissions from waste incineration are reported under the Energy sector, as source category 1A1a. In the Mexican and Canadian inventories, waste incineration is included under the Waste sector. The explanation for this difference is provided in the US inventory: "In the United States, almost all incineration of municipal solid waste (MSW) occurs at waste-to-energy facilities or industrial facilities where useful energy is recovered, and thus emissions from waste incineration are accounted for in the Energy chapter" (EPA 2011a). This is consistent with 2006 IPCC Guidelines, which state: "When energy is recovered from waste combustion, the associated greenhouse gas emissions are accounted for in the Energy sector under stationary combustion. Waste incineration with no associated energy purposes should be reported in the Waste source category" (2006 IPCC Guidelines). IPCC (1996) also allows for CO_2 emissions from combustion of industrial and municipal wastes to be calculated and reported under the Energy sector.

In terms of source coverage, the following sources listed in Table 6 are omitted by at least one country.

Table 6. Sources Not Listed by All North American National GHG Inventories

	Canada	United States	Mexico
Rice Cultivation	Not Applicable/Not Occurring		
Grasslands		Included Elsewhere /Not Estimated	
Unmanaged Waste Disposal Sites	Not Estimated/Not Occurring	Not Estimated	
Solvents		Confidential/Not Occurring	
By-product emissions from the production of halocarbons and sulfur hexafluoride	Not Available/Not Occurring		
Ferroalloys production	Included Elsewhere/Not Estimated		
SF_6 used in aluminum and magnesium foundries			Not Estimated

In addition to the sector-specific metrics, the Parties requested that the comparability analysis specifically present information on the treatment of cogeneration facilities, non-energy use of fuels, application of wastewater treatment biosolids, forest GHG emissions and sinks, and biomass (biogenic) CO_2 across the three inventories. The results of this analysis are in *APPENDIX D: Sector-Level Matrix Tables.* In sum, the findings of this sector-specific assessment were:

- **Cogeneration**: allocated to industrial subsector in Canada, captured under public electricity generation subsector in the United States, and could not be ascertained from the Mexico inventory.

- **Non-energy use of fuels**: Included in the industrial process (IP) sector in Canada, and included under the Energy sector for the United States and Mexico.
- **Application of wastewater treatment biosolids**: included in the Agricultural sectors for the United States, could not be ascertained for the Canadian and Mexican inventories.
- **Forests**: All forests are treated as managed forest in the United States and Mexico, while the Canadian inventory also includes non-managed forests.
- **Biomass (biogenic) CO_2:** Presented as a line item for informational purposes in the Energy sector in all three inventories.

One of the most basic metrics used to assess comparability relates to which GHGs are covered under specific sources in each country's inventory. Table 7 presents the source categories for which the GHGs covered varied among the three countries. The full list of GHG coverage for each national inventory is in *APPENDIX D: Sector-Level Matrix Tables.* Notations of the Common Reporting Format (CRF) are used to describe coverage of certain source categories, including:

- **"NO" (not occurring)** for activities or processes in a particular source or sink category that do not occur within a country.
- **"NE" (not estimated)** for existing emissions by sources and removals by sinks of greenhouse gases that have not been estimated. Where "NE" is used in an inventory for emissions or removals of CO_2, N_2O, CH_4, HFCs, PFCs or SF_6, the Annex I Party should indicate, in both the NIR and the CRF completeness table, why emissions or removals have not been estimated.
- **"NA" (not applicable)** for activities in a given source/sink category that do not result in emissions or removals of a specific gas. If categories in the CRF for which "NA" is applicable are shaded, they do not need to be filled in.
- **"IE" (included elsewhere)** for emissions by sources and removals by sinks of greenhouse gases estimated but included elsewhere in the inventory instead of the expected source/sink category. Where "IE" is used in an inventory, the Annex I Party should indicate, using the CRF completeness table, where in the inventory the emissions or removals from the displaced source/sink category have been included; and the Annex I Party should explain such a deviation from the expected category.
- **"C" (confidential)** for emissions by sources and removals by sinks of greenhouse gases which could lead to the disclosure of confidential information.

Table 7. Key Differences Identified in GHG Coverage (sources presented include only those for which differences in coverage exist)

	Sector/Source	Canada	United States	Mexico
1	**Energy**			
1A5	**Fuel Combustion Other** (Fuel Combustion) (includes Non-Energy Use)	CO_2, CH_4, N_2O	CO_2, CH_4, N_2O	NE
1B2	**Fugitive Emissions from Fuels** (Oil and Natural Gas)	CO_2, CH_4, N_2O	CO_2, CH_4	CH_4
2	**Industrial Processes**			
2C	Metal Production	CO_2, PFCs, SF_6	CO_2, CH_4, PFCs, SF_6	CO_2, CH_4, PFCs
2E	Production of Halocarbons and Sulphur Hexafluoride	NA, NO	HFCs	HFCs
2F	Consumption of Halocarbons and Sulphur Hexafluoride	HFCs, PFCs, SF_6	HFCs, PFCs, SF_6	HFCs, SF_6
2G	Other (Industrial Processes)	CO_2	NA/NO	NA
3	**Solvent and Other Product Use**			
3D	Other (Solvent and Other Product Use)	N_2O	N_2O	NA

4	**Agriculture**			
4C	Rice Cultivation	NA	CH_4	CH_4
5	**Land Use Change & Forestry**			
5A	Forest Land	CO_2, CH_4, N_2O	CO_2, CH_4, N_2O	CO_2, CH_4, N_2O, CO, NO_x
5B	Cropland	CO_2, CH_4, N_2O, CH_4	CO_2	CO_2
5C	Grassland	CO_2, N_2O	CO_2	CO_2
5D	Wetlands	CO_2	CO_2, N_2O	NE
5E	Settlements	CO_2	CO_2, N_2O	NE
5F	Other lands	NE	CO_2	NE
6	**Waste**			
6C	Waste Incineration	CO_2 (non-biogenic), N_2O, CH_4	CO_2 (non-biogenic), N_2O, CH_4 ** NOTE: *Reported under 1A1a in the US Inventory*	CO_2 (non-biogenic), N_2O
6D	Other (Waste)	NA	CH_4 and N_2O from composting	NA
	Waste Sources of Indirect GHG Emissions	CO, NO_x, NMVOC, SO_x	NO_x, CO, NMVOCs	NA

After GHG coverage was assessed for each country's inventory, each sector was evaluated for IPCC methods used. Inventory methods include simple methods (Tier 1), which estimate emissions based on activity data and average or default emission factors, as well as detailed methods (Tiers 2 and 3) which estimate emissions based on detailed information on fuels and technology, and use country-specific, regional, or industry-specific emission factors, or incorporate direct measuring or modeling. The specific Tier 1, 2, and 3 methodologies vary by sector and source category.[12] The degree of accuracy in estimating emission factors increases with increasing tiers. Specifically, for Tier 1, emission factors are calculated using global defaults; for Tier 2, emission factors are calculated using local defaults; and for Tier 3, emission factors are estimated by direct measurement or modeling. Table 8 shows the results of this comparison for the emission sources for which different methods were used by each country. The full list of methodologies used by each country is presented in APPENDIX D: Sector-Level Matrix Tables.

Table 8. Key Differences Identified with IPCC Tier Methods (sources presented include only those for which differences in methodology exist)

	Sector/Source	Canada	United States	Mexico
1	**Energy**			
1A1	**Fuel Combustion** Energy Industries	Tier 2 (all gases)	Tier 2 (CO_2), Tier 1 (CH_4 and N_2O)	Tier 1 & 2
1A2	**Fuel Combustion** Manufacturing Industries and Construction	Tier 2 (all gases)	Tier 2 (CO_2), Tier 1 (CH_4 and N_2O)	Tier 1 & 2[1]

[12] Source: *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual,* <http://www.ipcc-nggip.iges.or.jp/public/gl/guidelin/ch1ref1.pdf>

1A3	**Fuel Combustion** Transport	Tier 1 for 1A3c Rail, 1A3d Maritime, and 1A3e Biomass & Off-Road; Tier 3 for 1A3b Ground or Motor Transportation; and Tiers 1 & 3 for 1A3a Domestic Aviation (Tier 1 for gasoline & Tier 3 for turbo fuel)	Tier 2 (CO_2); Modeled, Tier 1, Tier 2 (CH_4 and N_2O)	Tier 1 were used for 1A3c Rail and 1A3d Maritime; Tier 1 and 2 were used for 1A3b Ground or Motor Transportation; Tier 2 was used for 1A3a Civil Aviation. Tier 1 methods were used for 1A4a Commercial and 1A4c Agricultural; Tier 1 and 2 were used for 1A4b Residential.
1A4	**Fuel Combustion** Other Sectors	Tier 2 (all gases)	Tier 2 (CO_2), Tier 1 (CH_4 and N_2O)	NA
1A5	**Fuel Combustion** Other (Fuel Combustion) (includes Non-Energy Use)	Tier 3 (all gases)	Tier 2 (CO_2), Tier 1 (CH_4 and N_2O)	NE
1B1	**Fugitive Emissions from Fuels** Solid Fuels	Tier 2 (country-specific method applied for CH_4)	Tier 2, Tier 3	Tier 1
1B2	**Fugitive Emissions from Fuels** Oil and Natural Gas	Tier 2 (country-specific method applied for all gases)	Tier 2 (Modelled)	Tier 1
	Memo Items International Bunker Fuels	Tier 1 & Tier 2	Tier 2	Tier 1
	Memo Items CO_2 Emissions from Biomass	Tier 2	Tier 2	Tier 1
2	**Industrial Processes**			
2A	Mineral Products	Tier 1, Tier 2	Tier 1, Tier 2	Tier 1
2B	Chemical Industry	Tier 1, Tier 2, and Tier 3	Tier 1 and Tier 3	Tier 1
2C	Metal Production	Tier 1, Tier 2, and Tier 3	Tier 1, Tier 2, Tier 3	Tier 1
2E	Production of Halocarbons and Sulphur Hexafluoride	NA	Tier 1 and Tier 3	Tier 1
2F	Consumption of Halocarbons and Sulphur Hexafluoride	Tier 1, Tier 2, and Tier 3	Tier 1, Tier 2, and Tier 3	Tier 1 and Tier 2
2G	Other (Industrial Processes)	Tier 1		NA
3	**Solvent and Other Product Use**			
3D	Other (Solvent and Other Product Use)	IPCC method for this source does not have tiers	IPCC method for this source does not have tiers	NA
4	**Agriculture**			
4A	Enteric Fermentation	Tier 1: Other Livestock; Tier 2: Cattle	Tier 1: Most Cattle, Tier 2: Bulls, Other Livestock	Tier 2
4B	Manure	Tier 1: N_2O, Tier 2:	Tier 2	Tier 2

	Management	CH_4		
4C	Rice Cultivation	NA	Tier 2	Tier 1 (see notes)
4D	Agricultural Soils	Tier 1: Organic Soils; Tier 2: Synthetic N Fertilizer, Manure Fertilizer, Crop Residues, Manure on PRP, Indirect Emissions, (additional categories: N_2O from conservation tillage, summer fallow, & irrigation)	Tier 3: Major crops, some grasslands; Tier 1: Non-major crops, organic soils, some grasslands	Tier 1
4F	Field Burning of Agricultural Residues	Tier 1	Tier 2	Tier 1
5	**Land Use Change & Forestry**			
5A	Forest Land	Tier 3	Tier 3 (biomass C values) Forest Fires (Tier 2), Forest Soils (Tier 1)	Tier 1 or Tier 2
5B	Cropland	Tier 2	Tier 3, Tier 2, Tier 1	Tier 1
5C	Grassland	Tier 2	Tier 3 & Tier 2	Tier 1
5D	Wetlands	Tier 2	Tier 1	NE
5E	Settlements	Tier 2	Tier 2 & Tier 1	NE
5F	Other lands	NE	Tier 2	NE
6	**Waste**			
6A	Solid Waste Disposal	Tier 2	Tier 3 for most parameters; Tier 2 for certain parameters for industrial wastes	Uses the 1996 IPCC Guidelines) default method; does not correspond to a specific tier in 2006 IPCC Guidelines (Volume 5)
6B	Wastewater Handling	Tier 2 for CH_4 emissions from domestic wastewater Tier 3 for CH_4 emissions from industrial wastewater (Environment Canada 2011c, Part 2, p. 155) IPCC does not provide tiers for N_2O emissions from wastewater (2006 IPCC Guidelines, Volume 5, p. 6.24)	Tier 1 for CH_4 emissions from domestic wastewater treatment (based on 2006 IPCC Guidelines, Volume 5, p. 6.10) Tier 2 for CH_4 emissions from industrial wastewater treatment (based on 2006 IPCC Guidelines, Volume 5, p. 6.19) IPCC does not provide tiers for N_2O emissions from wastewater (2006	Tier 1 for CH_4 emissions from domestic and industrial wastewater

			IPCC Guidelines, Volume 5, p. 6.24)	
6C	Waste Incineration	Tier 2 for non-biogenic CO_2 emissions (2006 IPCC Guidelines, Volume 5, p. 5.10) Tier 1 for N_2O and CH_4 emissions (2006 IPCC Guidelines, Volume 5, p. 5.12)	Tier 2b for CO_2 emissions from incineration Tier 1 for CH_4 and N_2O emissions from incineration ** NOTE: *Reported under 1A1a in the US Inventory*	Tier 1
6D	Other (Waste)	NA	Tier 1	NA

[1] Tier 2 methods are applicable for cement production. Mexico's National Energy Balance is calculated within the Energy chapter, and as such, total fuel consumption for all sectors is calculated within the Energy chapter.

In addition to GHG coverage and methods used, the sector-specific assessment included a description of higher-tiered methods (if used), whether country-specific or default emission factors were used, consistency with Annex I Country source definitions, and models used to estimate emissions in each sector. The full results of this assessment are in APPENDIX D: Sector-Level Matrix Tables.

3.2 Subnational GHG Inventories

In addition to the national GHG inventories that are submitted to the UNFCCC, subnational inventories have been completed for many of the individual states and provinces, as well as regional initiatives such as the Regional Greenhouse Gas Initiative (RGGI) and the Western Climate Initiative (WCI). The purpose and drivers for these local and regional inventories differ from their national counterparts, and some of these inventories are largely compiled from national inventory data.

At least five Canadian provinces and territories, thirty-one states in the United States, and ten states in Mexico have completed GHG inventories or compiled reported emissions reports independent of their respective national GHG inventories, as of this publication. The states and provinces with these reports are shown below in Figure 1 and listed in Table 9.

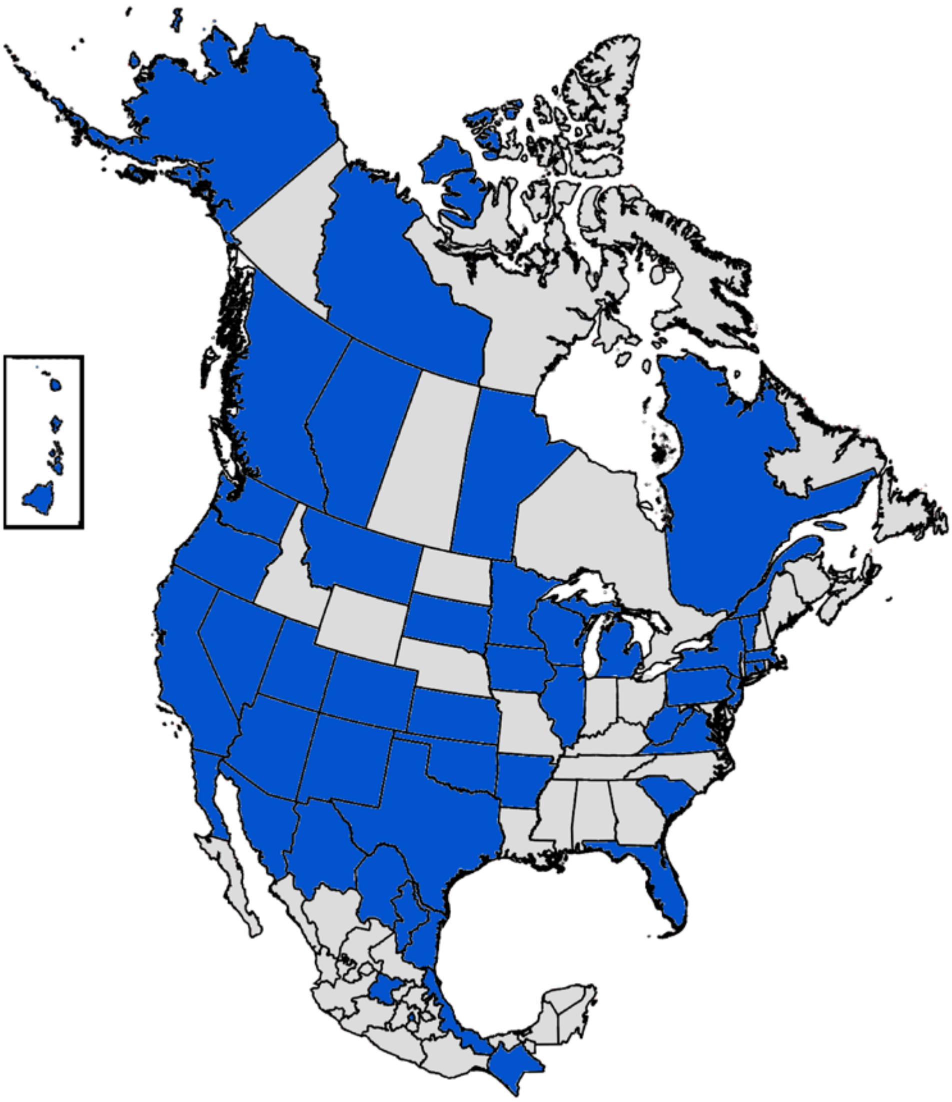

Figure 1. Map of State and Provincial Greenhouse Gas Inventories Evaluated

Table 9. List of States and Provinces with Completed GHG Inventories

	Canada	United States	Mexico
States and Provinces	• Alberta • British Columbia • Manitoba • Northwest Territories • Quebec	• Alaska • Arizona • Arkansas • California • Colorado • Connecticut • Delaware • Florida • Hawaii • Illinois • Iowa • Kansas • Massachusetts • Michigan • Minnesota • Montana • Nevada • New Jersey	• Baja California • Chiapas • Chihuahua • Coahuila • Nuevo León • Sonora • Tamaulipas • Veracruz • Distrito Federal • Guanajuato

	Canada	United States	Mexico
		• New Mexico • New York • Oklahoma • Oregon • Pennsylvania • South Carolina • South Dakota • Texas • Utah • Vermont • Virginia • Washington • West Virginia	

3.2.1 United States

GHG inventories at the state level are often an initial (and necessary) step in the climate action planning process. States and localities first estimate emissions to evaluate the number of sources and magnitude of emissions, and then use this information to inform a variety of mitigation actions and state climate action plan recommendations. Since there are over 30 state GHG inventories completed to date, this section presents a high-level analysis including a discussion of information sources, an overview of state inventories, and a comparison of state and national inventories.

Sources of Information

The Center for Climate Strategies (CCS) is the primary organization that has worked with US states to develop GHG inventories. Approximately 30 state GHG inventories have been prepared by CCS in coordination with the environmental department of each state (CCS 2010f). Each report contains historic GHG estimates from 1990 through 2005, and reference case projected estimates from 2006 through 2020. Some states engage in a coordinated effort to develop GHG inventories, such as within the Western Regional Air Partnership. Once developed, states have either updated the CCS-developed inventory as methodological or updated data are available (for example, Alaska updated the original CCS inventory and refined industrial and aviation emissions) or, as required through state regulations, updated the GHG inventory at consistent intervals (for example, Nevada requires an updated inventory at least every four years).

To develop state GHG inventories, US states primarily rely on EPA's State Inventory Tools (SIT) to calculate GHG emissions from residential/commercial/industrial fuel combustion, transportation, industrial processes, agriculture and forestry, and waste sources (EPA 2011c). The SIT provides an option of applying state-specific data or using default data pre-loaded for each state where state-specific data are unavailable. Default data are aggregated by federal agencies and other sources covering fossil fuel consumption, agriculture, forestry, waste management, and industry. EPA's SITs contain default energy consumption data from the Energy Information Administration's State Energy Data System, default industrial processes data from the United States Geological Survey, default agricultural statistics from the United States Department of Agriculture's National Agricultural Statistics Service, default waste data (primarily) from the EPA's Office of Solid Waste, and default forestry data from the United States Forest Service.

Overview of US Subnational Inventories

Some state-level GHG inventories are developed as a result of regulatory action. For example, in California, Assembly Bill 32 (AB32) signed into law in 2006 aimed to reduce GHG emissions to 1990 levels by 2010 and to reduce emissions 80 percent below 1990 levels by 2050. To track GHG emissions and progress towards the 2020 and 2050 goals, California first developed a GHG inventory. The regulation designated the Air Resources Board as responsible for maintaining and updating the state GHG inventory every five years, and tracking progress toward meeting the state GHG reduction goals.

Other state inventories are developed as the first step of the climate action planning process and used to develop GHG reduction targets and goals. For example, Colorado's GHG inventory served as the basis for its GHG reduction goal setting process. Colorado considered an 80 percent reduction in emissions by 2050; however after comparing the state GHG inventory with this goal, the state determined that reductions at this level might not be possible. As a result, Colorado initiated an intermediate goal of 20 percent GHG reductions from 2005 levels by 2020. Regulations and mitigation actions were then developed based on the greatest sources of emissions in the GHG inventory.

In general, state inventories follow IPCC Guidelines and the methodologies contained in the *Inventory of US Greenhouse Gas Emissions and Sinks*. The IPCC tier used to estimate emissions for each source at the state level is highly dependent on data availability. For example, for the Energy sector, Tier 1 estimates are primarily utilized for fossil fuel combustion in stationary sources since fuel consumption data are available; however, data on the specific combustion technology type necessary for a Tier 2 estimate are usually not readily available and, as a result, Tier 2 methodologies are rarely performed. Tier 2 estimates are usually performed for transportation given that state-level activity data and emission factors are available. Within each source category calculation, default activity data and default emission factors are primarily used, since most states do not have the resources to develop state- or process-specific emission factors.

Comparability to National GHG Inventory

US state inventories primarily present emission estimates for the six greenhouse gases included in the *Inventory of US Greenhouse Gas Emissions and Sinks*: CO_2, CH_4, N_2O, HFCs, PFCs, and SF_6. While all six GHGs are covered at the state level, the US national inventory includes emissions from more source categories, while states do not have all source categories within their geographic boundaries. In addition, the US national inventory uses higher Tiers to estimate emissions than is possible at the state level due to data availability. Proprietary data are typically not included in a state-level inventory, whereas the US national-level inventory contains some proprietary data as a result of national-level voluntary reporting programs for some sources.

Similar to the US national inventory, state-level inventories primarily follow methodologies outlined in the IPCC Guidelines; where appropriate, state-level inventories also use the more country-specific methodologies from the US national inventory. The documentation of methodologies in the state-level inventories is generally less detailed than in the US national inventory since the methodologies from the US national inventory are reviewed by the UNFCCC.

Uncertainty is another area where state and national-level inventories differ. While the US national inventory conducts a detailed uncertainty analysis at the source category and overall levels, state-level inventories rarely include an uncertainty analysis due to lack of available data and limited resources.

3.2.2 Canada

Five out of Canada's ten provinces and three territories have compiled at least one independent GHG inventory for informational and educational purposes. Manitoba encourages community involvement through its Emissions Reduction Program that follows the ICLEI 5 Milestone framework, which provides a simple, standardized means of calculating greenhouse gas emissions, of establishing targets to lower emissions, of reducing greenhouse gas emissions and of monitoring, measuring and reporting performance. The Northwest Territories publishes a GHG strategy that is used, among other things, to provide community resources for consumers to lower their environmental impacts. This section is an overview of the provincial and territorial GHG inventories and includes the main sources of information, notable differences, and a comparison between these inventories and the Canadian national inventory.

Sources of Information

Canada's provincial and territorial inventories range from scaled versions of Canada's national inventory (for example, British Columbia uses relevant data from the Canadian national inventory and then adds net deforestation to its report) (BC Ministry of Environment 2011); to entirely independent GHG inventories. Data sources include Federal departments such as Statistics Canada, National Resources Canada, and Environment Canada; provincial/territorial Ministries; Census data; the National Inventory Report and other reports from industry associations, institutes, and research centres, private sector consulting firms, academic institutions, and peer-reviewed journals and literature. British Columbia and Manitoba both rely on the NIR for the majority of their activity data and results, though each province does provide additional data.

Overview of Canadian Subnational Inventories

Although GHG emissions data are reported by province/territory in the Canadian Inventory report, Environment Canada works with many provinces, territories and regions in Canada to develop their own GHG emissions inventories. These jurisdictions use their GHG emissions data to establish reduction goals and policies. Quebec has prepared an independent GHG inventory since 1990.[13] Emissions inventories have also been prepared by Alberta, British Columbia, Manitoba, and the Northwest Territories. The inventories calculate emissions for all six major GHGs and include the energy, industrial processes, solvents, agriculture, and waste sectors. Three inventories (British Columbia, Manitoba, and Northwest Territories) also include the LULUCF sector.

In addition to the subnational inventories mentioned above, Quebec, Ontario, Alberta, and British Columbia have facility GHG reporting regulations that require facilities to declare their GHG emissions in tonnes of CO_2e (tCO_2e) if they exceed a threshold or are in certain sectors. In Quebec and British Columbia, facilities that emit over 10,000 tCO_2e must report their emissions. In Ontario, all emitters in certain sectors are required to report, and facilities that emit more than 25,000 tCO_2e must have their emissions estimates verified by a third party. In Alberta, industrial facilities that emit more than 50,000 tCO_2e are required to submit annual reports on their greenhouse gas emissions. The Quebec inventory does not include emissions from fossil fuels used for international air and marine transport or hydroelectric reservoirs.

Comparability to National GHG Inventory

A major component of provincial/territorial inventories that is not comparable to the Canadian national inventory stems from the lack of an uncertainty analysis at the subnational level. As British Columbia and Manitoba develop their own inventories directly from the NIR, these reports are very comparable to their national counterpart. An additional major difference stems from the years of reported data, with the most recent provincial/territorial data (as of this publishing) ranging from 2006–2009.

3.2.3 Mexico

GHG inventories at the state level in Mexico are an important step for state climate action planning processes. States use information on the magnitude of their emissions to inform mitigation actions and state climate action plan recommendations. While more than 20 of 31 Mexican states have some sort of climate action planning under development or completed, ten in-depth GHG emissions inventories have been identified during this assessment. This section presents information on seven of these state-level GHG emissions inventories, and identifies similarities and differences between state inventories and the Mexican inventory (INEGEI).

Sources of Information

The Center for Climate Strategies (CCS 2010a, b, c, d, e; CCS 2011) has collaborated with six Mexican states to develop GHG inventories. Approximately six state GHG inventories were prepared by CCS in coordination with the environmental department for each state. Each report contains historic GHG estimates from 1990 through 2005, and reference case projected estimates from 2006 through 2020. These reports are intended to assist Mexican states in gaining an initial understanding of GHG sources within their geographic boundaries, and to inform analysis impacting potential mitigation strategies and Climate Action Plans (Maldonado, Roe, and Quiroz 2009).

An additional source of information for Mexican state inventories is the State Climate Change Action Programs (PEACC) Web site, provided by the National Institute of Ecology (INE). This program tracks the climate change action programs of Mexican states and indicates that 19 states have climate action programs in development, while eight have completed climate action programs.

Overview of Mexico Subnational Inventories

Ten state-level GHG emissions inventories were identified in Mexico, including Chiapas, Sonora, Baja California, Coahuila, Nuevo León, Chihuahua, Tamaulipas, Veracruz, Distrito Federal, and Guanajuato. The

[13] <http://www.mddep.gouv.qc.ca/changements/ges/index.htm>

CCS collaborated with Mexican state agencies to prepare GHG emissions inventories for states on the US-Mexico border (CCS 2010a, b, c, d, e; 2011). All of these inventories prepared by CCS—including Baja California, Sonora, Chihuahua, Nuevo León, Coahuila, and Tamaulipas—use consistent methods and assumptions. These inventories document GHG emission trends and forecasts from 1990 to 2025.

For the most part, the state inventories cover emissions from the six major GHGs in the energy, LULUCF, industrial processes, waste, and agriculture sectors. The Special Program on Climate Change (*Programa Especial de Cambio Climático*—PECC) helps coordinate federal actions to set quantitative mitigation and adaptation goals. State Climate Change Action Programs help states identify and reduce local GHG emissions, in order to develop public policies on climate change at the state level.

Comparability to National GHG Inventory

The subnational Mexican inventories prepared by the CCS include a comparison of the methods used in the state inventories to those used in Mexico's national GHG inventory (Table 10).

Table 10. Comparison of Mexican State Inventory Methods with Mexico National Inventory Methods

Sector	Mexico National Inventory Methods	Baja California, Sonora, Tamaulipas, Chihuahua, Nuevo León, Coahuila Methods
Electricity Consumption and Supply	1996 IPCC Guidelines, Tier 1 method; national electricity production data from SENER.	2006 IPCC Guidelines, Tier 1 method, where fuel consumption is multiplied by default emission factors.
Residential, Commercial, and Industrial (RCI) Fuel Combustion	1996 IPCC Guidelines, Tier 1 method; national-level fuel consumption from SENER.	2006 IPCC Guidelines, Tier 1 method, where fuel consumption is multiplied by default emission factors.
Transportation Energy Use	1996 IPCC Guidelines, Tier 1 method; SENER provided fuel consumption data for all sources except aircraft. 1996 IPCC Guidelines, Tier 2 method for aviation based on landing & takeoff statistics.	2006 IPCC Guidelines, Tier 1 method, where fuel consumption is multiplied by default emission factors.
Industrial Processes and Product Use	Cement Production: 1996 IPCC Guidelines, Tier 1 method; national cement production data from Canacem Mineral Production: 1996 IPCC Guidelines, Tier 1 method, where mineral production from *Servicio Geológico Mexicano* production is multiplied by a default emission factor. Consumption is obtained through mass balance using national production, and import/export data. Mobile HFC Emissions: 1996 IPCC Guidelines, Tier 1 method, where fugitive HFC emissions are calculated through mass balance using national	Cement Production: 2006 IPCC Guidelines, Tier 1 method, where clinker production is multiplied by a default emission factor. Cement, Lime, and Limestone Production (Sonora): EPA SIT Tool. Mineral Production: 2006 IPCC Guidelines, Tier 1 method, where consumption is multiplied by a default emission factor. Consumption is obtained through mass balance using state production. Mobile HFC emissions: The number of mobile air conditioning (AC) units is multiplied by an IPCC default emission factor. Steel production (Coahuila, Nuevo León): 2006 IPCC Guidelines, Tier 1 method where steel production is multiplied by a default emission factor as a function of technology used.

	production, import and export data. Steel production: 1996 IPCC Guidelines, Tier 2 method where emissions are a function of steel production and the chemical composition of reducing agents.	
Fossil Fuel Industry	1996 IPCC Guidelines, Tier 1 method, where national production from PEMEX is multiplied by default emission factors.	EPA SIT method, where fossil fuel industry infrastructure is multiplied by United States industry average emission factors.
Agriculture	1996 and 2003 IPCC Guidelines, SAGARPA-SIACON national data. Emission factors were updated based on field studies conducted in Mexico.	2006 IPCC Guidelines, Tier 1 method and emission factors.
Waste Management	1996 IPCC Guidelines, Tier 1 method with Sedesol national data for solid waste generation.	2006 IPCC Guidelines, Tier 1 method and emission factors.
Forestry and Land Use	2003 IPCC Guidelines. Carbon flux assessed based on national digital maps. Covers carbon flux in selected land use categories due to land use practices, and changes in land use.	2006 IPCC Guidelines, Tier 1 method. CCS relied on forest coverage statistics from FAO and woody crop coverage from SIACON. Covers carbon flux in selected land use categories due to land use practices.

Sources: (CCS 2010 a, b, c, d, e; CCS 2011)

While both the Mexican national inventory and the Mexican state GHG inventories used methods from the IPCC, four of the state inventories identified use 2006 IPCC Guidelines methodologies, whereas the national-level inventory uses IPCC 1996 methods for most sources. In addition, state-level inventories typically use Tier 1 IPCC methods, whereas the national inventory uses Tier 2 methods for certain emission sources. This means that the national inventory may have more accurate estimates for emissions from certain source categories. Finally, uncertainty is not estimated for subnational inventories in Mexico.

3.3 Black Carbon Inventories

As there is no common or accepted methodology currently in place for directly calculating BC emissions across all source categories, BC is generally estimated from available $PM_{2.5}$ inventory data. Each country has a national inventory database that includes $PM_{2.5}$, a regulated pollutant known to impair human health. The US EPA developed the SPECIATE database that estimates the portion of $PM_{2.5}$ that is black carbon, using source-specific speciation profiles (EPA 2010a). The Canadian and Mexican governments have also adopted the use of EPA's SPECIATE database to translate $PM_{2.5}$ inventory data to BC emissions, which promotes comparability and consistency of accounting methods across the inventories. This section provides an overview of each country's BC inventory process, the general methodologies applied to obtain BC emissions, areas of uncertainty, and available ambient monitoring data. The United States inventory is discussed first as it acted as a primary source for Mexican and Canadian BC inventory development.

3.3.1 United States

The United States BC inventory was compiled in 2010 for the year 2005. The inventory was developed for all source categories listed in the adjacent textbox, except mobile sources, by applying speciation profiles to estimate $PM_{2.5}$ emissions data from the 2005 US National Emissions Inventory (NEI) (EPA 2011b). [14]

US BC Source Categories

- Power generation/fossil fuel combustion
- Biomass combustion (wildfires and agricultural burning/prescribed)
- Mobile On-road
- Mobile Non-road
- Industry
- Non-Industry
- Residential
- Dust

General Methodology

The US Draft Report to Congress on Black Carbon reports BC emissions within six major source categories: open biomass burning; residential; energy/power; industrial; mobile sources; and other (EPA 2011b). For the purposes of the comparability matrix, the US BC emissions were disaggregated and redistributed into the source categories listed in
Table 3 and provided in the textbox. The methodologies for developing BC emissions for each source category are described below.

Category 1: Stationary Sources. Stationary sources include both point and nonpoint sources from energy/power, open biomass burning, residential, and industry. A two-step process is used to estimate BC emissions (see Figure 2). The first step involves estimating $PM_{2.5}$ emissions, and the second step translates the $PM_{2.5}$ emissions to BC emissions. $PM_{2.5}$ emissions are available from the NEI and are determined as the product of the activity data (i.e., reported information from facilities, input from Regional Planning Organizations (RPOs), surveys), an emission factor from EPA's AP-42 Compilation of Air Pollutant Emission Factors (EFs), and any emission reduction associated with PM control technologies, such as tbaghouse filters.[15] The $PM_{2.5}$ emissions are then converted to BC by applying a speciation factor (i.e., the ratio of BC to $PM_{2.5}$) from EPA's SPECIATE4.2 database (see APPENDIX F: $PM_{2.5}$ and Black Carbon SPECIATE4.2 Source Profiles).

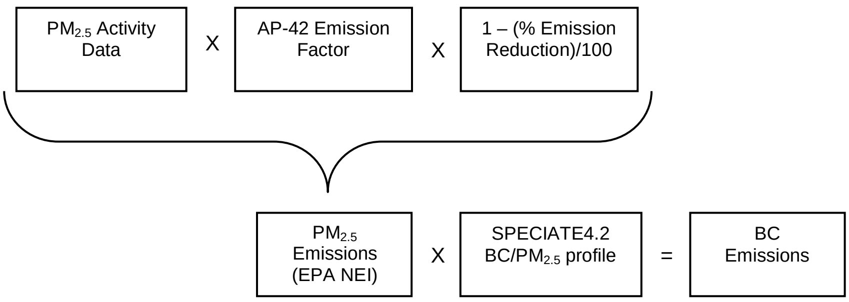

Figure 2. Methodology for Estimating BC Emissions

$PM_{2.5}$ activity data for point and non-point stationary sources are estimated using a variety of processes (EPA 2011b). Activity data for most point sources can be determined directly using local permits, continuous emission monitoring systems (CEMs), and other reporting mechanisms. However, it is more challenging to estimate activity data for nonpoint sources such as wildfires, as these sources tend to be small, diverse, and sometimes intermittent. These sources may be estimated by applying a top-down methodology that relies on state- or national-level data such as population, land use, and economic activity.

Category 2: Mobile Sources. This category is an important contributor to US emissions of black carbon and as such, has benefited from continuing inventory-related research (EPA 2011b). This category is divided into two source categories: mobile on-road and mobile non-road. For mobile on-road sources, US EPA uses the Motor Vehicle Emission Simulator (MOVES2010) model to directly calculate BC emissions for on-road gasoline and diesel vehicles using vehicle activity data, such as vehicle population, vehicle type, and driving mode (see Figure 3). MOVES2010 improves upon the previously applied MOBILE6.2 model by directly calculating BC emissions, taking into account the reduction of BC emissions from on-road diesels due to the

[14] http://www.epa.gov/ttnchie1/trends/. The US NEI is a bottom-up database of air pollutants, including $PM_{2.5}$, emitted annually by source category.
[15] Recently, AP-42 has transitioned into the FIRE 6.25 Data System (EPA Black Carbon; available at <http://cfpub.epa.gov/webfire>).

application of diesel particulate filters and accounting for BC emissions as a function of lower ambient temperatures (EPA 2011b). One exception is the BC emissions from tire and brake wear, which is calculated in MOVES by applying speciation factors to $PM_{2.5}$. The national emissions for this source category are aggregated from country scale estimates.

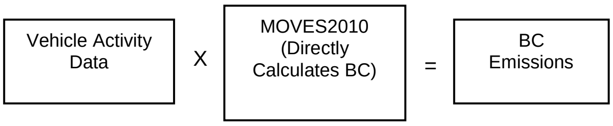

Figure 3. Mobile On-Road Methodology for Estimating BC Emissions

The mobile non-road source category is further disaggregated into the following categories: non-road diesel and gasoline, commercial marine, locomotives, and aircraft. For non-road engines in the United States, BC emissions are calculated using a two-step methodology similar to stationary sources (see Figure 4). $PM_{2.5}$ emissions are directly calculated from non-road vehicle activity data using EPA's NONROAD2008 model. This model uses emission factors, engine output, and usage data. Speciation factors are then applied to the $PM_{2.5}$ emissions to determine BC emissions.

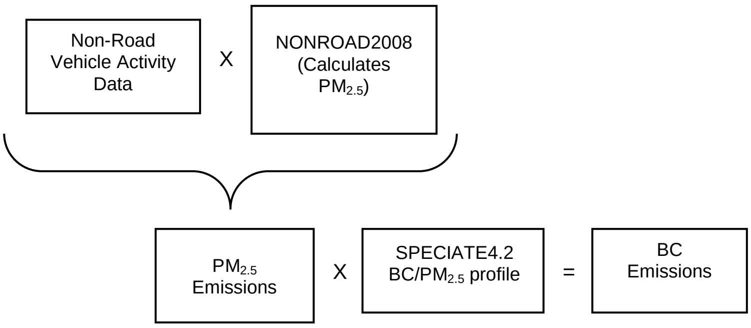

Figure 4. Mobile Non-Road Methodology

Commercial marine, locomotive, and aircraft emissions do not use the NONROAD2008 model, but rather spreadsheet models equipped with separate BC speciation factors.

US Inventory

Figure 5 shows the BC emissions for the United States by source category.[16] The transportation sector, which includes the mobile on-road and mobile off-road source categories, is the largest source of BC emissions, followed by wildfires and agricultural/prescribed burning.[17]

[16] The term "elemental carbon" is used in the US inventory synonymously with BC. Organic carbon is not addressed in this discussion.
[17] These emission estimates are based on best available data and are continually being updated and revised.

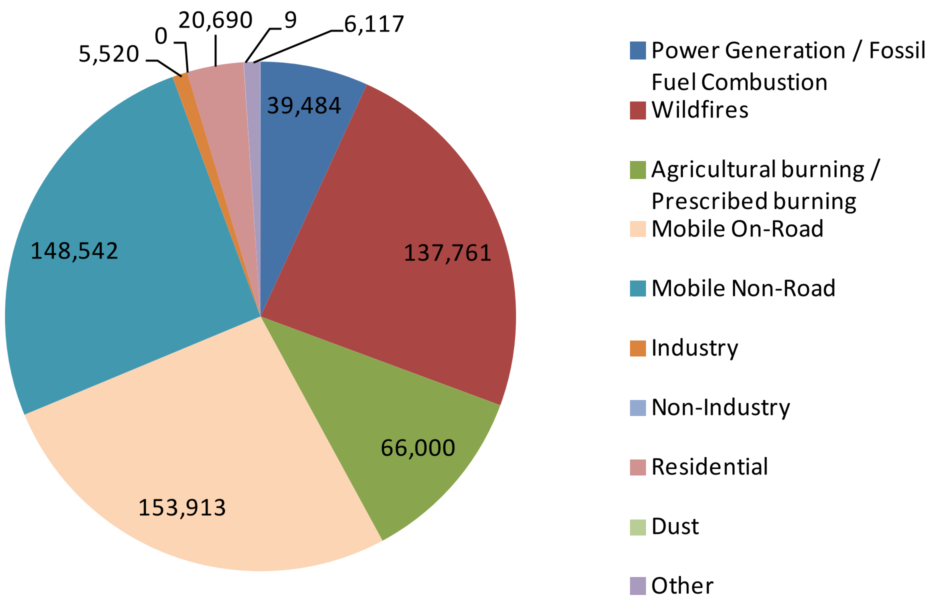

Figure 5. United States 2005 Black Carbon Emissions (metric tons)

Areas of uncertainty

Across the entire BC national inventory, there are a number of sources of uncertainty:

- *AP-42 Emission Factors.* The emission factors provided in the AP-42 have varying levels of reliability and accuracy, and generally only represent the condensable fraction of total $PM_{2.5}$ emissions. That is, $PM_{2.5}$ emissions from a given source comprise two parts: the filterable fraction that is a solid particle at the point of emission, and the condensable gaseous fraction that forms into liquid droplets (i.e., particles) shortly after emission (NARSTO 2002, as cited by EPA 2011b).

- *Emission Controls.* As the effectiveness of PM emission controls may vary with the design, maintenance, and nature of the process being controlled, the accuracy of the emission-reduction factor for a given emission control may vary over time and by process.

- *Activity Levels.* Though stationary point sources tend to have well documented estimates of activity, the activity levels associated with stationary non-point sources are significantly more difficult to estimate. Non-point sources tend to be small, diverse, and intermittent. Some of the methods in estimating activity levels are not measured at source but rely on proxies, such as state- or national-level population patterns, land use, and economic activity.

- *Speciation Factors*. Some sources require additional data than are currently available to accurately estimate the amount of $PM_{2.5}$ that is BC (e.g., non-road gasoline two-stroke engine). In addition, the choice of speciation profile to use for a particular source category is not always clear. Chow et al. (2011) found that the speciation profiles available in US EPA's SPECIATE database had ranges of BC from 6 to 13% for agricultural burning, 4 to 33% for residential wood combustion, 6 to 38% for on-road gasoline vehicles, and 33 to 74% for on-road heavy-duty diesel vehicles. The choice of profile can have a significant impact on the translation of $PM_{2.5}$ to BC.

Observations of BC Concentrations

Within the United States, ambient BC data are available through $PM_{2.5}$ urban and rural speciation monitoring networks and tend to be measured using thermal measurement techniques. The two major monitoring networks include: (1) the Interagency Monitoring of Protected Visual Environments (IMPROVE), and (2) the Chemical Speciation Network (CSN). The IMPROVE network of 160 monitors began in the late 1980s and includes rural locations covering national parks and wilderness areas. The CSN network started in the early

2000s consists of approximately 200 monitors in major urban areas. These datasets are enhanced by the use of remote sensing of BC via satellites and ground-based networks.

Overall, the average urban concentration of BC is relatively constant across the United States, with pockets of higher concentrations found along the eastern United States and California (EPA 2011b).

3.3.2 Canada

The national BC inventory for Canada was compiled by Environment Canada (EC) in 2011 for the year 2006 at the request of the Arctic Council. The inventory is published as part of the Arctic Council's "Assessment of Emissions and Mitigation Options for Black Carbon for the Arctic Council" report, also published in 2011. The BC inventory was developed using $PM_{2.5}$ emissions data from Environment Canada's 2006 National Pollutant Release Inventory (NPRI).

Canadian BC Source Categories

- Power generation/fossil fuel combustion
- Biomass combustion (wildfires and agricultural burning/prescribed)
- Mobile On-road
- Mobile Non-road
- Industry
- Residential
- Dust
- Other

General Methodology

Literature summarized Canada's BC inventory for seven sectors: transportation, residential, industry, open sources, commercial and institutional, electricity & heat generation, and other (includes forestry and waste) (Arctic Council 2011; EC 2006). In addition, the inventory contains BC emissions data for natural sources; however, due to the high uncertainty in the emission calculations, these emissions are not included in Canada's BC emission totals. For the purposes of the comparability matrix, the Canadian BC emissions were disaggregated and redistributed into the source categories listed in
Table **3** and provided in the textbox. EC bases its BC emissions inventory on the methodology used for the US BC inventory. The methodologies for estimating BC emissions for each Canadian source category are described below.

Category 1: Stationary Sources. For the stationary source categories including electricity and heat generation, residential, industry, open, commercial and institutional, and other, the methodology for estimating BC emissions is similar to that used in the United States (see Figure 2). $PM_{2.5}$ emissions data are available through the National Pollutant Release Inventory (NPRI), which is informed by activity data (i.e., reported information from facilities, published statistics, and surveys), emission factors based on EPA's AP-42 Compilation of Air Pollutant Emission Factors, and control information (see section 2.2.2 for listing of reports providing additional detail). For some end-uses, AP-42 emission factors are revised to better reflect conditions in Canada. $PM_{2.5}$ emissions are then converted to BC by applying a matching speciation factor from EPA's SPECIATE4.2 database.

An exception is the treatment of source categories within biomass combustion. The speciation profile has been adjusted to represent Canadian data and the forest fire emissions are calculated using a constant $PM_{2.5}$ emission factor (mass basis) regardless of year, location, burning conditions, or completeness of burn.

Category 2: Mobile Sources. EC employs a modified version of US EPA's MOBILE6.2 model (revised to reflect transportation conditions in Canada) to calculate $PM_{2.5}$ emissions from vehicle activity data such as vehicle population and type, allowing for variability in driving mode and specific model mix. In addition, MOBILE6.2 is capable of estimating black carbon emissions from diesel exhaust. The SPECIATE4.2 database then converts the $PM_{2.5}$ emissions to estimated BC emissions.

Similar to the United States methodology, EC uses the NONROAD2008 model to calculate $PM_{2.5}$ emissions for the mobile non-road source category and then estimates the portion of $PM_{2.5}$ that is BC using the SPECIATE4.2 database. Commercial marine, locomotive, and aircraft emissions do not use the NONROAD2008 model, but spreadsheet models equipped with separate BC speciation factors.

Canadian Inventory

Figure 6 shows the BC emissions for Canada in 2006 by source category. The transportation sector (mobile on-road and mobile off-road) is the largest source of black carbon emissions, followed by wildfires and residential burning.[18]

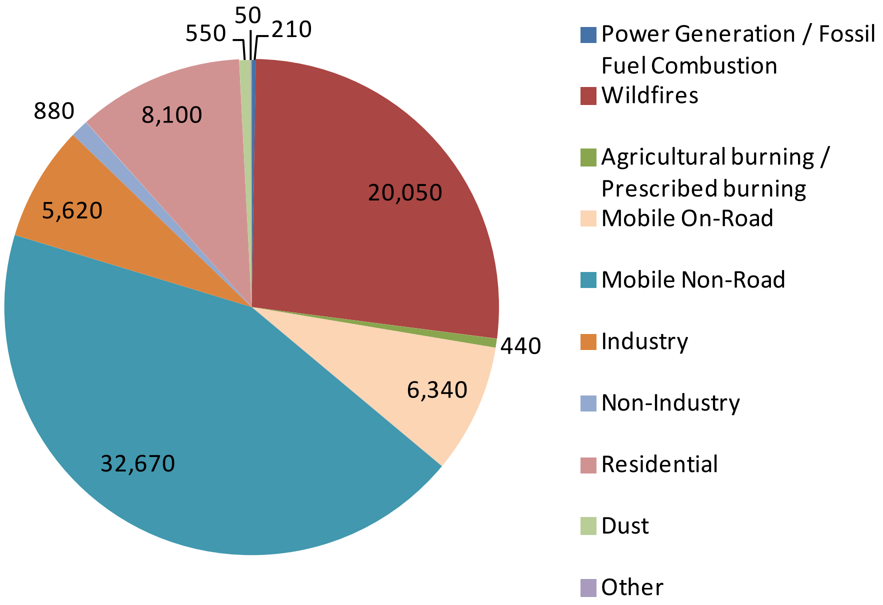

Figure 6. Canada 2006 BC Emissions (metric tons)

Areas of uncertainty
Across the entire BC national inventory, there are a number of sources of uncertainty:

- *AP-42 Emission Factors.* The emission factors provided in the AP-42 have varying levels of reliability and accuracy, and generally only represent the condensable fraction of total $PM_{2.5}$ emissions. That is, $PM_{2.5}$ emissions from a given source comprise two parts: the filterable fraction that is a solid particle at the point of emission, and the condensable gaseous fraction that forms into liquid droplets (i.e., particles) shortly after emission (NARSTO 2002, as cited by EPA 2011b).

- *Emission Controls.* As the effectiveness of PM emission controls may vary with the design, maintenance, and nature of the process being controlled, the accuracy of the emission-reduction factor for a given emission control may vary over time and by process.

- *Activity Levels.* Though stationary point sources tend to have well documented estimates of activity, the activity levels associated with stationary non-point sources are significantly more difficult to estimate. Non-point sources tend to be small, diverse, and intermittent. Some of the methods in estimating activity levels are not measured at source but rely on proxies, such as state- or national-level population patterns, land use, and economic activity.

- *Speciation Factors*. Some sources require additional data than are currently available to accurately estimate the amount of $PM_{2.5}$ that is BC (e.g., non-road gasoline two-stroke engine). In addition, the choice of speciation profile to use for a particular source category is not always clear and significant ranges of BC can exist (Chow et al. 2011). Hence, the choice of profile can have a significant impact on the translation of $PM_{2.5}$ to BC.

[18] These emission estimates are based on best available data and are continually being updated and revised.

Observations of BC Concentrations
In Canada, there are three initiatives underway for monitoring BC: the National Air Pollution Surveillance Network (NAPS), the Canadian Air and Precipitation Monitoring Network (CAPMoN), and the Canadian Aerosol Baseline Measurement Program (CABM). The NAPS network consists of 288 sites monitoring air quality in urban and rural areas. The CAPMoN network was established to study regional spatial and temporal patterns of air pollution and has one site that measures the ratio of organic carbon to BC from $PM_{2.5}$. The CABM network has four sites that monitor changes in particles to investigate source attribution and assist in climate model research.

3.3.3 Mexico

The Mexican government is planning to release a BC inventory in the summer of 2012 as part of its 2008 National Emissions Inventory (INEM).[19] Though the BC inventory data is not yet available, the $PM_{2.5}$ inventory is available and was used to inform the comparability matrix. The most recent emissions inventory containing $PM_{2.5}$ emissions data is Mexico's National Emissions Inventory (Mexico INEM), which was published in 2006 for 1999 emissions.

Mexican BC Source Categories
- Power generation/fossil fuel combustion
- Mobile On-road
- Mobile Non-road
- Industry
- Non-Industry
- Residential
- Dust
- Fixed/Point
- Area

General Methodology

Literature summarized $PM_{2.5}$ emissions within six major source categories used in this analysis: mobile on-road, mobile non-road, point, and area (see section 2.2.2 for listing of reports). For the purposes of the comparability matrix, the $PM_{2.5}$ emissions were disaggregated and redistributed into the source categories listed in Table 3. Additional disaggregation of fixed/point and area source categories would be beneficial for this comparison. The methodologies for each source category are described below.

<u>*Category 1: Point, Area Sources*</u>. The Mexican government follows a similar methodology as that described for the United States and Canada. $PM_{2.5}$ emissions are housed in the National Emissions Inventories Program (INEM) of Mexico. These emissions are informed by activity data (i.e., reported information from facilities, vehicle activity data, surveys), emission factors from EPA's AP-42 Compilation of Air Pollutant Emission Factors (EFs), and control technologies, such as baghouse filters. The BC emissions will be estimated from $PM_{2.5}$ emissions by applying a matching speciation factor from EPA's SPECIATE4.2 database (this is currently under development). See Figure 7.

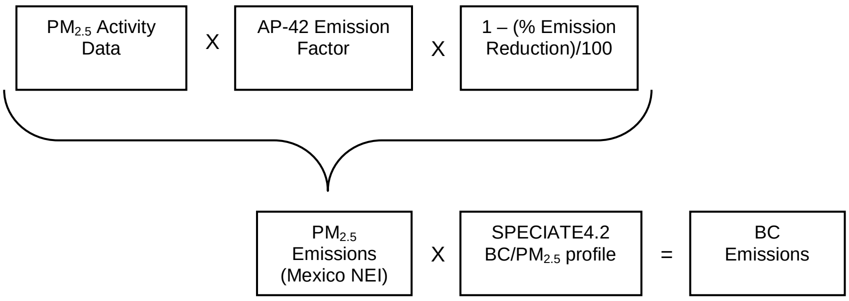

Figure 7. Stationary Sources Methodology

For wildfires, the Factor Information REtrieval (FIRE) 6.22 and 6.23 Data Systems are used to store emission factors, which incorporates EFs from AP-42, along with emission factors from AIR Clearinghouse for Inventories and Emission Factors (CHIEF 12) and the California Air Resource Board (CARB 2002).

<u>*Category 2: Mobile Sources.*</u> The Mexican government uses a similar approach as that used in Canada for estimating mobile on-road emissions, utilizing the MOBILE6.2 Mexico model to estimate $PM_{2.5}$ emissions and then translating these to BC emissions.

[19] Personal communication with Mexican experts (see References and Interviews).

Mexican Inventory

The latest version of the Mexican INEM provides $PM_{2.5}$ estimates but does not provide BC emission estimates. For an inter-country comparison, the BC emissions estimates provided by EPA (2011b) for 2000 are provided here (it is unclear how representative these estimates are of the BC emissions data to be released in the summer of 2012).[20] The source categories provided in EPA (2011b) were aggregated to provide similar source categories as presented in this analysis, where the "Other" category presented in Figure 8, represents "waste." Wildfires and mobile sources clearly represent the greatest BC sources, followed by power generation/fossil fuel combustion and residential sources.

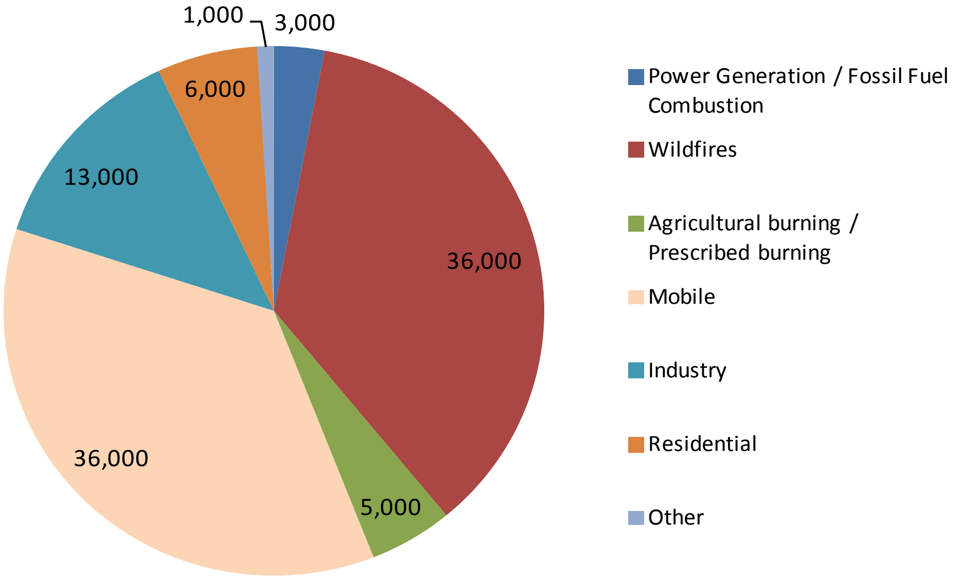

Figure 8. Mexican 2000 BC Emissions

Areas of uncertainty

Across the entire BC national inventory, there are a number of sources of uncertainty:

- *AP-42 Emission Factors.* The emission factors provided in the AP-42 have varying levels of reliability and accuracy, and generally only represent the condensable fraction of total $PM_{2.5}$ emissions. That is, $PM_{2.5}$ emissions from a given source comprise two parts: the filterable fraction that is a solid particle at the point of emission, and the condensable gaseous fraction that forms into liquid droplets (i.e., particles) shortly after emission (NARSTO 2002, as cited by EPA 2011b).

- *Emission Controls.* As the effectiveness of PM emission controls may vary with the design, maintenance, and nature of the process being controlled, the accuracy of the emission-reduction factor for a given emission control may vary over time and by process.

- *Activity Levels.* Though stationary point sources tend to have well documented estimates of activity, the activity levels associated with stationary non-point sources are significantly more difficult to estimate. Non-point sources tend to be small, diverse, and intermittent. Some of the methods in estimating activity levels are not measured at source but rely on proxies, such as state- or national-level population patterns, land use, and economic activity.

- *Speciation Factors*. Some sources require additional data than are currently available to accurately estimate the amount of $PM_{2.5}$ that is BC (e.g., non-road gasoline two-stroke engine). In addition, the choice of speciation profile to use for a particular source category is not always clear and significant

[20] New emission estimates may be available in the summer of 2012 based on a significantly updated BC inventory.

ranges of BC can exist (Chow et al. 2011). Hence, the choice of profile can have a significant impact on the translation of $PM_{2.5}$ to BC.

Observations of BC
Though there are a regional monitoring networks of $PM_{2.5}$ concentrations in Mexico (e.g., BRAVO, National Air Quality Information System), there is no network monitoring BC. Observations of BC atmospheric concentrations must rely on available remote sensing data.

3.3.4 Inter-Country Comparison of BC Emissions

Currently, the United States BC inventory methodology provides the basis for the development of the Canadian and Mexican inventory with adjustments to emission factors, activity levels, and speciation profiles. The methodology section provides descriptions of how these countries' BC inventory initiatives vary. Presented in Table 11 are the BC emissions for the United States and Canada. Mexico is currently developing a BC emissions inventory that will be available in the summer of 2012.

Table 11. Emissions of Black Carbon by Source Category

	Canada		United States	
Source Category	**2006 BC Emissions (metric tonnes)**	**% of Total BC**	**2005 BC Emissions (metric tonnes)**	**% of Total BC**
Power Generation / Fossil Fuel Combustion	210	0.3	39,484	6.8
Wildfires	20,050	26.7	137,761	23.8
Agricultural burning / Prescribed burning	440	0.6	66,000	11.4
Mobile On-Road	6,340	8.4	153,913	26.6
Mobile Non-Road	32,670	43.5	148,542	25.7
Industry	5,620	7.5	5,520	1.0
Non-Industry	880	1.2	N/A	N/A
Residential	8,100	10.8	20,690	3.6
Dust	550	0.7	9	0.0
Other	50	0.1	6,117	1.1
Total	**75,150**	**100**	**578,032**	**100**

3.3.5 Mitigation Approaches

In the future, areas of increasing and decreasing BC emissions will vary by region and sector. While developed countries have experienced reductions in BC emissions that will likely continue under the implementation of existing regulations, some developing countries may experience increases (EPA 2011b). Reductions in BC emissions can occur through the application of control technologies and/or improving efficiency. For example, the United States diesel retrofit program is projected to substantially reduce mobile source emissions by 84% between 2005 and 2030 (EPA 2011b). Control measures that reduce PM from sources that are larger emitters of BC will not only benefit human health but also reduce regional warming. Table 12 provides a description of mitigation strategies by source category where replacing, retrofitting, regulating, and training are all key strategies to reduce BC. Examples include (EPA 2011b):

- *Replacing.* Globally, using improved stove technologies to replace the current practice of cooking food or heating homes by burning biomass or coal in a simple stove or open fires would significantly reduce global BC emissions.
- *Retrofitting.* Retrofitting existing engines and requiring new engine standards is instrumental in reducing mobile BC emissions.
- *Regulating.* Some countries have begun transitioning emission standards and altering vehicle fuel to allow for BC-reducing technology.
- *Training.* Training in proper burning techniques and tools will assist in effective and appropriate use of prescribed fires.

Mobile and wildfire sources represent the largest contributor of BC to national totals for the United States and Canada. The United States government has implemented two primary measures to regulate mobile sources: (1) emission standards for new engines, and (2) retrofit programs for in-use mobile diesel engines. BC emissions from stationary sources in the United States have seen a dramatic decline over the past century as control technologies reducing PM, a criteria air pollutant regulated under the Clean Air Act, have been implemented.

The Canadian government has federal, provincial, and territorial measures that affect BC emissions (Arctic Council). The federal measures include on-road/off-road vehicle and engine emission regulations and federal standards of particulates. These measures include industrial limits of air emissions, vehicle emission standards and testing, and open burning policies.

Table 12. Mitigation Strategies by Source Category

Source Category	Mitigation Strategy
Power Generation / Fossil Fuel Combustion	Fabric Filters (i.e., baghouses); electrostatic precipitators; diesel particulate filters (DPFs); oxidation catalysts; reducing the frequency of mass transfer operations; improving operational efficiency; using proper use of dust collection devices at the point of generation; fuel substitution
Industry	
Non-Industry	
Wildfires	Restore and maintain fire-dependent ecosystems; control weeds, pests, and disease; reduce fuel loading to reduce catastrophic wildfire risk; control invasive species; the use of fire suppression or other appropriate management response
Agricultural burning / Prescribed burning	Training in proper burning techniques and tools; conservation tillage; collecting and hauling crop residue to central processing site; apply alternative year burning; increase combustion efficiency reduce fuel loading; convert to a crop that does not require burning; educate farmers; minimize burning when moisture content is low
Mobile On-Road	Retrofitting, replacing, or upgrading existing engines; requiring new engine standards; adopting emission standards; improve fleet maintenance practices; use of cleaner fuels such as ultra low-sulfur diesel, compressed natural gas, liquefied natural gas, ethanol, hydrogen, and electrification; fuel economy improvements (e.g., low-rolling resistance tires); idle reduction of trucks and locomotive engines; shifting transport of goods to a lower BC emitter
Mobile Non-Road	

Residential	Use of new residential wood heaters, including hydronic heaters, furnaces, fireplaces, and stoves; providing alternatives to wood; replacing inefficient units; retrofitting existing units; use of alternative fuels such as natural gas;

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APPENDIX A: Key Categories

These tables provide the key categories reported by Canada, Mexico, and the United States, listed by sector. These key categories are Tier 1 specific (no uncertainty), with LULUCF, and include both level (L) and trend (T) key categories.

Table 13. Key Category Analysis Results for the United States National GHG Inventory, 2009

Source Table	IPCC Source Category	Gas	Assessment
1A1	Electrical Transmission and Distribution	SF_6	T
1A1b	Petroleum Systems	CH_4	L, T
1A3	Mobile Combustion: Marine	CO_2	T
1A3a	Mobile Combustion: Aviation	CO_2	L, T
1A3b	Mobile Combustion: Road	CO_2	L, T
1A3b	Mobile Combustion: Road	N_2O	T
1A5b	Mobile Combustion: Other	CO_2	L, T
1A5d	Non-Energy Use of Fuels	CO_2	L, T
1A6	Stationary Combustion: Gas	CO_2	L, T
1A6	Stationary Combustion: Coal	CO_2	L, T
1A7	Stationary Combustion: Oil	CO_2	L, T
1B1a	Coal Mining	CH_4	L, T
1B2b	Natural Gas Systems	CH_4	L, T
1B2b	Natural Gas Systems	CO_2	L, T
2A1	Cement Production	CO_2	T
2B	Aluminum Production	PFCs	T
2B1	Ammonia Production and Urea Consumption	CO_2	T
2B2	Nitric Acid Production	N_2O	T
2B3	Adipic Acid Production	N_2O	T
2C1	Iron and Steel Production & Metallurgical Coke Production	CO_2	L, T
2C4	Magnesium Production and Processing	SF_6	T
2E1a	HCFC-22 Production	HFCs	T
2F	Substitutes for Ozone-Depleting Substances	Several	L, T
4D	Indirect N_2O Emissions from Applied Nitrogen	N_2O	L
4A	Enteric Fermentation	CH_4	L
4B	Manure Management	CH_4	L, T
5G	Landfilled Yard Trimmings and Food Scraps	CO_2	T
5E	Urban Trees	CO_2	L, T
5	Changes in Forest Carbon Stocks	CO_2	L, T
5	Agricultural Soil Management	N_2O	L, T
5B1	Cropland Remaining Cropland	CO_2	T
5C1	Grassland Remaining Grassland	CO_2	T
6A	Landfills	CH_4	L, T

Table 14. Key Category Analysis Results for Canada National GHG Inventory, 2009

Source Table	IPCC Source Category	Gas	Assessment
1A	Gaseous Fuels	CO_2	L, T
1A	Solid Fuels	CO_2	L, T
1A	Liquid Fuels	CO_2	L, T
1A3a	Civil Aviation (Domestic Aviation)	CO_2	L, T
1A3b	Road Transportation	CO_2	L, T
1A3c	Railways	CO_2	L, T
1A3d	Navigation (Domestic Marine)	CO_2	L
1A3e	Other Transport (Off Road)	CO_2	L, T
1A3e	Pipeline Transport	CO_2	L, T
1A3e	Other Transport (Off Road)	N_2O	T
1B1a	Coal Mining	CH_4	T
1B2(a+c)	Stationary Combustion: Oil	CH_4	L, T
1B2(a+c)	Stationary Combustion: Oil	CO_2	L, T
1B2(b+c)	Natural Gas	CH_4	L, T
1B2(b+c)	Stationary Combustion: Natural Gas	CO_2	L
2A1	Cement Production	CO_2	L, T
2A2	Lime Production	CO_2	T
2B1	Ammonia Production	CO_2	L
2B3	Adipic Acid Production	N_2O	T
2C1	Iron and Steel Production	CO_2	L, T
2C3	Aluminum Production	CO_2	L, T
2C3	Aluminum Production	PFCs	T
2F	Consumption of Halocarbons	HFCs	L, T
2G	Other (Undifferentiated Processes)	CO_2	L
4A	Enteric Fermentation	CH_4	L, T
4B	Manure Management	N_2O	L
4D1	Direct Agricultural Soils	N_2O	L, T
4D3	Indirect Agricultural Soils	N_2O	L, T
5A.1	Forest Land remaining Forest Land	CO_2	L, T
5A.1	Forest Land remaining Forest Land	CH_4	L, T
5A.1	Forest Land remaining Forest Land	N_2O	T
5B.1	Cropland remaining Cropland	CO_2	L, T
5B.2	Land converted to Cropland	CO_2	L, T
5D.2	Land converted to Wetlands	CO_2	T
5E.2	Land converted to Settlements	CO_2	L
6A	Solid Waste Disposal on Land	CH_4	L, T

Table 15. Key Category Analysis Results for Mexico's National GHG Inventory, 2006

Source Table	IPCC Source Category	Gas	Assessment
1A1	Energy Industries	CO_2	L, T
1A2	Manufacturing and Construction Industry	CO_2	L, T
1A3	Transport	CO_2	L, T
1A3	Transport	N_2O	L, T
1A4	Other Sectors	CO_2	L, T
1B2	Natural Gas and Petroleum	CH_4	L
2A	Mineral Products	CO_2	L, T
2B	Chemical Industry	CO_2	T
2C	Metal Production	CO_2	L
2E	Production of Halocarbons and SF_6	HFCs	T
2F	Consumption of Halocarbons and SF_6	HFCs	T
4A	Enteric Fermentation	CH_4	L, T
4D	Agricultural Soils	N_2O	T
5A	Agricultural Lands	CO_2	L
5B	Forest Lands	CO_2	T
5C	Grasslands	CO_2	L, T
6A	Solid Waste Disposal on Land	CH_4	L, T
6B	Management and Treatment of Wastewater	CH_4	L, T

APPENDIX B: Source Coverage List

This table indicates which emission sources are included in each country's national GHG inventory. Covered sources are identified with an "X."

Table 16. GHG Inventory Source Coverage for the United States, Canada, and Mexico

IPCC ID	Sector/Source	Source Coverage by Country		
		United States*	Canada*	Mexico*
1	**Energy**	**X**	**X**	**X**
1A	**Fuel Combustion**	X	X	X
1A1	Energy Industries	X	X	X
1A2	Manufacturing Industries and Construction	X	X	X
1A3	Transport	X	X	X
1A4	Other Sectors	X	X	X
1A5	Other (Fuel Combustion)	X	X	NE
1A5d	Non-Energy Use (indicate if under Energy or IP sector)	X	X	X
1B	**Fugitive Emissions from Fuels**	X	X	X
1B1	Solid Fuels	X	X	X
1B2	Oil and Natural Gas	X	X	X
	Memo Items	X		X
	International Bunker Fuels	X	X	X
	Aviation	X	X	X
	Marine	X	X	X
	Multilateral Operations	NE	IE	NE
	CO_2 Emissions from Biomass (biogenic CO_2)	X	X	X
2	**Industrial Processes**	**X**	**X**	**X**
2A	**Mineral Products**	X	X	X
2A1	Cement Production	X	X	X
2A2	Lime Production	X	X	X
2A3	Limestone and Dolomite Use	X	X	X
2A4	Soda Ash Production and Use	X	X	X
2A5	Asphalt Roofing	IE	NE	X
2A6	Road Paving with Asphalt	IE	NE	X
2A7	Other (Mineral Products)	IE	X (Magnesite)	X (Glass 2006GL)
2B	**Chemical Industry**	X	X	X
2B1	Ammonia Production	X	X	X
2B2	Nitric Acid Production	X	X	X
2B3	Adipic Acid Production	X	X	X
2B4	Carbide Production	X	NO	X
2B5	Other (Chemical Industry)	X	X[21]	X
2C	**Metal Production**	X	X	X
2C1	Iron and Steel Production	X	X	X
2C2	Ferroalloys Production	X	IE, NE	X
2C3	Aluminum Production	X	X	X

[21] Carbon black, ethylene, EDC, methanol, and styrene.

2C4	SF_6 Used in Aluminum and Magnesium Foundries	X	X	NE
2C5	Other (Metal Production)	X	IE	NE
2D	**Other Production**		IE	X
2D1	Pulp and Paper	NE	IE	X
2D2	Food and Drink	NE	IE	X
2E	**Production of Halocarbons and Sulphur Hexafluoride**	X	NA, NO	X**
2E1	By-product Emissions	X	NA, NO	X
2E2	Fugitive Emissions	IE, NA, NE	NA, NO	NE
2E3	Other (Production of Halocarbons and Sulphur Hexafluoride)	NA	NA	NE
2F	**Consumption of Halocarbons and Sulphur Hexafluoride**	X	X	X
2F1	Refrigeration and Air Conditioning Equipment	X	X	IE
2F2	Foam Blowing	X	X	IE
2F3	Fire Extinguishers	X	X	IE
2F4	Aerosols/Metered Dose Inhalers	X	X	IE
2F5	Solvents	C, NO	X	NA
2F6	Semiconductor Manufacture	X	X	NA
2F7	Electrical Equipment	X	X	NA
2F8	Other (Consumption of Halocarbons and Sulphur Hexafluoride)	X	X	X
2G	Other (Industrial Processes)	NA	X	X
3	**Solvent and Other Product Use**			
3A	Paint Application	NE	NA	NE
3B	Degreasing and Dry Cleaning	NE	NA	NE
3C	Chemical Products, Manufacture and Processing	NE	NA, NE	NE
3D	Other (Solvent and Other Product Use)	X	X	NE[1]
4	**Agriculture**	**X**	**X**	
4A	Enteric Fermentation	X	X	X
4B	Manure Management	X	X	X
4C	Rice Cultivation	X	NA, NO	X
4D	Agricultural Soils	X	X	X
4E	Prescribed Burning of Savannas	NA	NA	NA, NO
4F	Field Burning of Agricultural Residues	X	X	X
4G	Other (Agriculture)	NA	NA	NA
5	**Land Use Change & Forestry**	**X**	**X**	
5A	Forest Land	X	X	X
5B	Cropland	X	X	X
5C	Grassland	X	IE, NE	X
5D	Wetlands	X	X	NA, NO
5E	Settlements	X	X	NA, NO
5F	Other Land	NE	NE, NO	NA
5G	Other (please specify)	X	IE, NE	NA
6	**Waste**	**X**	**X**	
6A	**Solid Waste Disposal on Land**	X	X	X

6A1	Managed Waste Disposal on Land	X	X	X
6A2	Unmanaged Waste Disposal Sites	NA	NE, IE	X
6A3	Other (Solid Waste Disposal)	NA	X	NA
6B	**Wastewater Handling**	X	X	X
6B1	Industrial Wastewater	X	X	X
6B2	Domestic and Commercial Wastewater	X	X	X
6B3	Other (Wastewater Handling)	NA	NO	NA
6C	**Waste Incineration**	IE	X	X
6D	**Other (Waste)**	X	NA	NA

[*]Notes: NE=not estimated, NO=not occurring, NA=not available, IE=included elsewhere, C=confidential
[**]Industry reported no domestic production of HFCs or PFCs
[1] No methodology is available for GHG emissions from Solvent and Other Product Use in the IPCC 1996 guidelines, only NMVOC emissions are included.

APPENDIX C: National GHG Metrics

This table contains the national-level GHG metrics used to compare national GHG emissions inventories in the US, Canada, and Mexico. Each national inventory has been evaluated for each metric, and key differences were identified across the national inventories.

Table 17: Comparability of National-Level GHG Inventories of the United States, Canada, and Mexico

Category	Country			Key Differences Identified
	United States	Canada	Mexico	
Coverage / Scope				
Guidance Followed	1996 IPCC Guidelines, Good Practice Guidance, LULUCF Good Practice Guidance, and 2006 IPCC Guidelines.	1996 IPCC Guidelines, Good Practice Guidance, 2003 IPCC Good Practice Guidance for LULUCF, and 2006 IPCC Guidelines.	1996 IPCC Guidelines, Good Practice Guidance, LULUCF Good Practice Guidance, 2006 IPCC Guidelines and Emissions Factor Database.	Mexico refers to the IPCC Emission Factor Database, but the United States and Canada do not. This does not necessarily mean that it is not used, but it is not listed as a reference in their national inventory reports.[1]
Indirect CO_2 from NMVOC and Anthropogenic CH_4[2]	No	No	No	
Indirect Greenhouse Gases	Indirect Greenhouse Gases (CO, NO_x, NMVOCs, and SO_2) from Energy, IP, Solvent and Other Product Use, and Waste sources	SO_x, NO_x, CO and NMVOCs (criteria air contaminants) are reported in the NIR under Annex 10: Ozone and Aerosol Precursors for all sectors except LULUCF.	Indirect GHGs (CO, NO_x, NMVOCs, and SO_2) from IP, Solvents and Energy	Indirect GHGs are not reported from the Waste sector in Mexico.
New greenhouse gases	No	No	No	
Global Warming Potentials (SAR vs. 4AR)	SAR	SAR	SAR	

Geospatial Coverage/Level of Detail	National and regional	National and Provincial, reporting zones	National and regional	
Methodologies & Data Sources				
Proprietary Data?	Numerous source categories rely on confidential business information provided to EPA by industry	Numerous source categories rely on confidential business information and business sensitive data provided to Environment Canada by industry	No. Mexico uses public data that can be obtained through the Internet or by request to the National Institutes. Maps for the National Institute of Statistics restrict license of use, but anyone can request this license.	Mexico's GHG inventory does not rely on proprietary data.
Vintage of most recent activity data	New data is obtained annually for most sources	New data is obtained annually for most sources	Estimates have been recalculated for 1990-2006; national inventories are not annual, however. Most sources have data for full time-series (1990-2006). (QAQC Chapter 1 Report).	Activity data is not obtained on an annual basis by Mexico.
Uncertainty	Uncertainty estimation is based on Tier 1 and 2 methods from Good Practice Guidance. Tier 2 uncertainty analysis is implemented for all source categories with the exception of Composting and parts of Agricultural Soil Management (but goal is to apply Tier 2 for those categories as well) in the US National GHG Inventory. Overall uncertainty estimates for the national inventory are estimated using Tier 2. However, uncertainty models for all emission source categories could not be directly integrated to develop overall uncertainty estimates, so an alternative approach is used. Trend uncertainty (between the base year of 1990 and current year) is measured using both Tier 1	More complex (Tier 2) methods are in some cases applied to develop uncertainty estimates at the sectoral or category level, for the inventory as a whole these uncertainties were combined with the simple (Tier 1) error propagation method. Separate analyses were conducted for the inventory as a whole with and without LULUCF. The calculation of trend uncertainties was performed without the LULUCF Sector. Annex I inventory reporting guidelines are specific about what to include in an annual inventory, and Annex I Parties are subject to annual reviews to assess the reporting of such information.	Uncertainty is estimated using Tier 1 methods from the Good Practice Guidance. Uncertainty is estimated for default IPCC emission factors (using uncertainty values from the Good Practice Guidance), as well as for activity data. Estimated uncertainty of emissions for each source is a combination of the uncertainties of emission factors and the corresponding activity data. An overall uncertainty estimate of 5.23% is given for 2006.	Canada and US use a combination of Tier 1 and Tier 2 methods for individual source categories. Mexico uses a Tier 1 approach for all source categories. The US used Tier 2 to estimate overall uncertainty, Canada and Mexico used Tier 1 for overall uncertainty.

	and Tier 2 approaches. Annex I inventory reporting guidelines are specific about what to include in an annual inventory, and Annex I Parties are subject to annual reviews to assess the reporting of such information.			
Transparency: Documentation of Methods	Methods are documented for each source category within the National Inventory Report, and additional methodology information is provided in the Annexes. Annex I inventory reporting guidelines are specific about what to include in an annual inventory, and Annex I Parties are subject to annual reviews to assess the reporting of such information.	Methods are documented for each source category within the National Inventory Report and Annexes. Annex I inventory reporting guidelines are specific about what to include in an annual inventory, and Annex I Parties are subject to annual reviews to assess the reporting of such information.	Methods are documented for each source category in the national inventory reports.	
Transparency: Storage of Original Reference Materials	Yes. EPA's Climate Change Division keeps an archive of original reference materials	Yes, GHG Division does keep an archive of original reference materials.	Yes. Most inventory data sources are integrated into each individual report, however, not all of the activity data is documented. Some official activity data are requested that are not publicly available by Internet or published. Most of the data gathered by the researchers are obtained by Internet or official books with public access. All this information is stored in a CD as an original copy.	
Data Sources	Wide variety, including industry, national agencies, state/local agencies, academia, private-sector consulting	Wide variety, including industry, national agencies, state/local agencies, academia, private-sector consulting	Wide variety, including industry, national ministries, and experts in the field	
Common Base Year /Years Covered?	1990-2009 (annual estimates)	1990-2009 (annual estimates)	1990-2006	1990-2009 inventory is not provided by Mexico (the Mexico inventory extends through 2006). There is a common base year among all three countries.

How does reference approach (RA) compare to sectoral approach (SA)?	For 2009 estimates, RA resulted in a 1.2% lower estimate of energy consumption than SA, and a 0.8% lower GHG emission estimate than SA.	For the most recent inventory year (2009), when the RA energy amounts include adjustments for non-energy use of fossil fuels, the difference between the SA and adjusted RA varies from 0.9% to 4.1%, while the emissions difference varies between -1.52% and 0.9%.	For 2006, RA resulted in 0.5% lower estimate of energy consumption than SA and 0.1% lower estimate of GHG emissions than SA.	
Inventory Processes/Systems				
Institutional Arrangements/Capacity	US Environmental Protection Agency (EPA)	Environment Canada	National Institute of Ecology (INE) within Ministry of Environment and Natural Resources (Semarnat).	
Procedural Arrangements (data sharing and integration with other agencies, other issues)	Data used in the inventory is obtained from the following agencies: US Department of Energy (DOE), including Energy Information Administration (EIA); US Department of Transportation, including Federal Aviation Administration (FAA) and Federal Highway Administration; US Department of Interior, including US Geological Survey; United States Department of Agriculture (USDA), including National Agricultural Statistics Service (NASS), US Forest Service, and US Department of Agriculture Economic Research Service; and the US Department of Commerce, including the US Census Bureau. Most of the data utilized from these other agencies is released to the public annually. However, it can be	The following agencies also contribute to the data collection process: Statistics Canada, Natural Resources Canada, Agriculture Canada, Agri-food Canada, Transport Canada, Canadian Space Agency, & the Canadian Forest Service of Natural Resources Canada (NRCan/CFS). Data is collected from provincial governments, and industry and associations (such as the Canadian Electricity Association and the Aluminum Association of Canada) directly and processed by consultants and universities.	Semarnat, through the Program Coordination INE Climate Change, established a working structure and institutional arrangements to the interior and other ministries of state and public research institutions and private development INEGEI 1990-2006. Based on experience from previous inventory, the INE convened a series of experts, both independent from renowned institutions in the area of climate change and development of emissions inventories, to participate in the preparation INEGEI of 1990-2006. The Interministrial Climate Change Commission was created in April 2005 to coordinate GHG inventory efforts. Institutional collaboration: Energy - Ministry of Energy (Sener); IP & Solvents - Federal Electricity Commission (CFE), Mexican Geologic Service, Dupont Mexico, National Institute of Statistics and Geography (Inegi), Ministry of Economy (SE), Quimobásicos S.A. de C.V.; Agriculture and LULUCF - National Forest Commission	Provincial data is used to inform the national inventory in Canada.

	challenging to obtain recent data from other agencies for use in the current inventory year since each agency typically delays the publishing of data for 1-2 years. This challenge can be partially ameliorated by working with agencies directly to obtain data directly before it is released to the public, but this level of cooperation is not always achieved.		(Conafor), National Commission for the Knowledge and Use of Biodiversity (Conabio), National Institute of Statistics and Geography (Inegi), Semarnat, Ministry of Agrarian Reform (SRA); Waste - National Water Commission (Conagua), Ministry of Social Development (Sedesol), Semarnat.	
Legal Arrangements (contracts, MOUs)	MOU agreements are used in various EPA voluntary emission reduction partnerships with industry. For example, EPA has MOU-based Partnerships focused on high-GWP GHG emissions in the Aluminum, Electric Power, Magnesium, and Semiconductor industries. Through these Partnerships, companies generally report emissions data to EPA as confidential business information. The data is compiled to track industry's progress in reducing emissions, and also contributes to the development of emission estimates for the sectors (enabling partial Tier 3 estimates). US EPA and the US DOE EIA have a MOU for energy data sharing.	Memorandums of Understanding (MOU) agreements are used with multiple industries to obtain data (such as for coal mining). MOUs are not limited to industries, and include agreements with AAFC and NRCan (among others).	None identified.	
Description of Data Management System: Available Tools and Capacity	Source categories use one or more source-specific spreadsheets, but each source has a summary tab and CRF reporter tab that feed into different	Source categories use one or more source-specific spreadsheets, but each source has a summary tab and CRF reporter tab that feed into different	Activity data is stored. Active inventory files are kept on a central computer, and INE is working to formalize their data management structure by 2012. For emissions data, Mexico builds an Excel file that	Data management practices are similar in Canada and the US; Mexico's data management system is evolving.

	spreadsheets that organize inventory-wide data.	spreadsheets that organize inventory-wide data.	contains all estimated emissions and the summary reports used in the National Communications.	
Recordkeeping and Archiving Procedures	An electronic docket, containing all data sources is prepared and stored after each Inventory is developed. In addition, all files (spreadsheets, text files, annexes) are archived in binders and electronically. Annex I inventory reporting guidelines are specific about what to include in an annual inventory, and Annex I Parties are subject to annual reviews to assess the reporting of such information.	The inventory archives consist of both electronic and hardcopy archives. The hard-copy archives are in the form of a reference library that contains hard-copy references cited within the NIR. The reference library is populated on an annual basis with updated references from the most recent submission. The electronic archives consist of a shared networked drive with a standard folder system designed specifically to contain all relevant information required to rebuild the inventory, including information on QA/QC procedures and their results. The electronic archives are also updated on an annual basis and contain information and records from the most recent inventory. Annex I inventory reporting guidelines are specific about what to include in an annual inventory, and Annex I Parties are subject to annual reviews to assess the reporting of such information.	Most of the data gathered by the researchers are obtained via the Internet or in official books with public access. An original copy of all of this information is stored on a CD.	

QAQC Process/Quality Management	Each source category is put through a standardized QAQC process, customized for that source, to verify the accuracy and consistency of the source spreadsheets. In addition, the inventory team verifies that spreadsheet estimates have been input into the text correctly.	Every submission year, all key categories (and categories where a significant methodological change has occurred) are to be subject to Tier 1 QC. Over a three-year cycle, all categories will undergo a Tier 1 QC. Some Tier 2 QC, QA and verification activities will be performed every year over a seven-year timeframe.	QAQC is conducted internally before the Interministerial Commission on Climate Change approves the inventory. Estimates are compared to IEA's inventory estimate and emission estimates of other countries. As with the previous inventory, for the 1990-2006 inventory controls have been quality of reporting category, which were completed during 2008 and an external consultation estimated emissions to date. Quality control is performed on the estimates for each category of greenhouse gas emissions within the National Inventory of Greenhouse Gas Emissions 1990-2006. Quality control checks the transparency, consistency, consistency, accuracy and completeness of National Inventory of Greenhouse Gas Emissions 1990-2006, including reports for each category of emissions. QAQC chapter of inventory is available.	Mexico uses a Tier 1 QC process. All source categories are reviewed in a formal QC process in the US. Canada's key categories receive QC annually, while all other source categories are rotated so that each source is covered within a 7 year period.
Participation and Review	Expert and public reviews are conducted on an annual basis. Comments from these reviews are reviewed and incorporated (where applicable) the final inventory submission. As an Annex I Party, the United States inventory is subject to annual Annex I inventory review per UNFCCC review decisions.	A third-party review comment period is conducted. As an Annex I Party, Canada's inventory is subject to annual Annex I inventory review per UNFCCC review decisions.	Limited external reviews.	The US and Canada have formal expert review periods. The US also has a formal public review period. Mexico does not have a formal review process in place.
Verification	None	Some verification does take place on a sector-by-sector basis. The Aviation Greenhouse Gas Emission Model (AGEM) model is specifically cited for finding	None identified.	

		discrepancies in aviation fuel emissions.		
Public Communication, Education & Outreach	Executive summaries, annexes, and for recent years, complete reports are available on EPA's Web site for all inventories that have been developed (since 1997). Full NIRs are made available at UNFCCC's website. All Inventory text and annexes, as well as historical inventories are available. EPA has historically shared Inventory data with the Energy Information Administration to support their GHG Inventory.	Executive summaries of the NIRs, national communications, guidance manuals, emission summaries and trends, and some reported facility data are available on Environment Canada's website for all inventories that have been developed (since 1999). Full NIRs and CRFs are made available at UNFCCC's website.	The inventory and associated final reports are posted on INE's climate change website. Documents are available for the most recent inventory (1990–2006), and previous national communications and reports are available in English and Spanish.	Canada provides an Executive Summary but not the full report. Mexico provides the full report but not the source data.
Lessons Learned During Reporting	Lessons learned are continuously integrated into the inventory process-- this occurs through the QAQC procedures, as well as annual updates to data and methodology changes where necessary.	Lessons are continuously learned through each inventory cycle. Examples are continuous coordination between Environment Canada, Statistics Canada and Natural Resources Canada; and reviewing QA/QC procedures over a 7-year cycle.	Mexico has identified problems encountered during the inventory experience. Problems include a lack of human resources, availability of information (especially in LULUCF, waste sectors), a lack of local GHG emission factors, no experience with the 2006 IPCC Guidelines (availability of information), and top-down vs. bottom-up inventories. Mexico identified the following lessons learned: (1) Continuity of working groups is a successful way to build capacity (establishment of processes), (2) collaboration within the Interministerial Commission on Climate Change is essential, and (3) collaboration with academia, research institutions, private sector, etc. is essential.	
Main Drivers/Objectives				
Promote Reductions / Mitigation	The United States does not systematically indicate how the inventory is used to drive mitigation.	Canada does not systematically indicate how the inventory is used to drive mitigation.	Mexico does not systematically indicate how the inventory is used to drive mitigation.	

International, Bi-lateral Agreements, Markets	The United States is an Annex I party to the UNFCCC COP, therefore, each year it is required to submit a national GHG inventory to UNFCCC that must be developed using IPCC guidelines.	Canada is an Annex I party to the UNFCCC COP, therefore, each year it is required to submit a national GHG inventory to UNFCCC that must be developed using IPCC guidelines.	Mexico is a non-Annex I party to the UNFCCC COP, and therefore has to prepare periodic national communications with GHG inventory overview and not annual GHG emissions inventories. Must be developed using IPCC guidelines, following non-Annex I reporting requirements.	
Cross-border Drivers	None	None	None	
Legal Requirements within each country to prepare and submit a GHG inventory	None.	There is no legal requirement within Canada to prepare the inventory, however, Canada is required to prepare and submit an inventory based on international obligations. The Canadian Environmental Protection Act provides the legislative authority for Environment Canada to implement a UNFCCC and Kyoto compliant national inventory system and created the responsibility to prepare and submit the national inventory to the UNFCCC.	Mexico's National Development Program 2007-2012 and Special Program of Climate Change request two GHG inventories for the current administration. These two federal documents define our functions as government employees in the National Institute of Ecology that are in charge of developing the GHG Inventory. Not for national inventory. There is a voluntary program that uses the GHG Protocol of the World Resources Institute and World Summit on Sustainable Development. For this administration, it is mandatory for federal institutions to deliver two National Communications with their GHG inventory. The last one must be done before COP this November 2012. In Cancun accords we are studying the possibility that GHG inventories be bi-annual.	The United States and Canada do not have a domestic legal requirement for compiling a national GHG inventory. Mexico has a federal directive requiring federal agencies to compile GHG emissions Inventories for two national communications to the UNFCCC.
Linkages/ level of integration with air quality inventory data / priorities	Indirect GHG emissions of CO, NO_x, NMVOCs, and SO_2 are reported in inventory, but data is not integrated with methodologies for estimating direct GHGs.	Indirect GHG emissions of CO, NO_x, NMVOCs, and SO_x are reported in inventory, but data is reported separately in Annex 10 and not integrated with methodologies for estimating direct GHGs.	Indirect emissions of CO, NO_x, NMVOCs, and SO_2 are reported in the inventory, separate from direct GHGs.	

Government-Industry Relationships (e.g., nationalized/utilities)	There are Partnerships between EPA and industry in which individual companies voluntarily report emissions data directly to EPA. These data provide a key resource for estimating emissions from these sectors. In addition, some industry groups (e.g., American Iron and Steel Association) provide industry-level activity data directly to EPA that contribute to emission estimates. In 2012, relatively large emission sources will be required by law to begin reporting GHG emissions through EPA's Greenhouse Gas Reporting Program (GHGRP). Emissions collected through GHGRP will likely contribute to national inventory emission estimates in future years.	There are Partnerships between Environment Canada and industry in which individual companies voluntarily report emissions data directly to Environment Canada. These data provide a key resource for estimating emissions from these sectors. In addition, some industry groups (such as the Canadian Electricity Association and the Aluminum Association of Canada) provide Environment Canada directly with industry-level activity data that contribute to emission estimates. Facility data collected through Environment Canada's GHG Reporting Program is also used to validate emission estimates in sectors where there is adequate coverage.	Mexico's GHG Program was initiated in 2004, whereby companies report GHG emissions voluntarily under the World Resources Institute/World Business Council for Sustainable Development Protocol.	

[1] The IPCC EFDB is only used if Parties lack country-specific information. In these cases the Party must demonstrate that those parameters are appropriate in the specific national circumstances and are more accurate than the default data provided in the IPCC Guidelines.

[2] Inclusion of this information is not required under the current reporting guidelines, but the methodologies are included in the 2006 IPCC Guidelines.

APPENDIX D: Sector-Level Matrix Tables

These figures contain the comparability metrics that apply to individual emission sources within each country's national GHG emissions inventory. Table 18 refers to the United States, Table 19 refers to Canada, and Table 20 refers to Mexico. In addition, sector-specific questions are addressed in Table 21 for each country's inventory.

Table 18. Assessment of Emissions Estimation Methods and Data Sources for the United States Inventory[22]

IPCC ID	Sector/Source	GHG Coverage	IPCC Tier Levels	Description of Higher-Tiered Method	Country-specific (CS) or Default (D) Emission Factors?	Consistency with Annex I Country Source Definitions (list differences)	Models Used
1	**Energy**						
1A	**Fuel Combustion**						
1A1	Energy Industries	CO_2, CH_4, N_2O	Tier 2 (CO_2), Tier 1 (CH_4 and N_2O)	For CO_2 estimates, country-specific activity data (with adjustments) are multiplied by country-specific carbon content coefficients. For CH_4 and N_2O, country-specific activity data are multiplied by default CH_4 and N_2O emission factors.	CS (CO_2), D (CH_4 and N_2O)	No differences noted	NA
1A1a	Waste Incineration	CO_2 (non-biogenic), N_2O, CH_4	Tier 2b for CO_2 emissions from incineration Tier 1 for CH_4 and N_2O emissions from incineration	CO_2 emissions are calculated by multiplying the amount of each material incinerated by the fossil carbon content of the material and the fraction oxidized (consistent with method in 2006 IPCC Guidelines, Volume 5, pp. 5.6 - 5.10). Country-specific factors are used for waste amount, carbon contents, and oxidation factor (EPA 2011a, p. 3-35). "CH_4 and N_2O emissions are calculated by multiplying total mass of waste incinerated by CH_4 and N_2O emission factors. IPCC default factors were used for CH_4 and N_2O emissions (EPA 2011a, p. 3-35)."	CS for CO_2 emissions from incineration D for CH_4 and N_2O emissions from incineration	Waste Incineration is reported under Energy in the US GHG Inventory. "In the United States, almost all incineration of MSW occurs at waste-to-energy facilities or industrial facilities where useful energy is recovered, and thus emissions from waste incineration are accounted for in the Energy chapter." This is consistent with 2006 IPCC Guidelines, which state "When energy is recovered from waste combustion, the associated greenhouse gas emissions are accounted for in the Energy sector under	None; calculations are consistent with IPCC guidelines

[22] NE—not estimated, NO—not occurring, NA—not available/not applicable, IE—included elsewhere, C—confidential

						stationary combustion. Waste incineration with no associated energy purposes should be reported in the Waste source category."	
1A2	Manufacturing Industries and Construction	CO_2, CH_4, N_2O	Tier 2 (CO_2), Tier 1 (CH_4 and N_2O)	For CO_2 estimates, country-specific activity data (with adjustments) are multiplied by country-specific carbon content coefficients. For CH_4 and N_2O, country-specific activity data are multiplied by default CH_4 and N_2O emission factors.	CS (CO_2), CS, D	No differences noted	NA
1A3	Transport	CO_2, CH_4, N_2O	Tier 2 (CO_2), M, Tier 1, Tier 2 (CH_4 and N_2O)	For CO_2 estimates, country-specific activity data are multiplied by country-specific carbon content coefficients. CH_4 and N_2O emissions are modeled estimates that are dependent on vehicle type, model year, and technology type.	CS (CO_2), CS, D, M (modeled) (CH_4 and N_2O)	No differences noted	US-specific spreadsheets were developed and are considered the model to estimate CH_4 and N_2O emissions.
1A4	Other Sectors	CO_2, CH_4, N_2O	Tier 2 (CO_2), Tier 1 (CH_4 and N_2O)	For CO_2 estimates, country-specific activity data (with adjustments) are multiplied by country-specific carbon content coefficients. For CH_4 and N_2O, country-specific activity data are multiplied by default CH_4 and N_2O emission factors.	CS (CO_2), D (CH_4 and N_2O)	No differences noted	NA
1A5	Other (Fuel Combustion) (includes Non-Energy Use)	CO_2, CH_4, N_2O	Tier 2 (CO_2), Tier 1 (CH_4 and N_2O)	"For non-energy uses, the quantity of fuel is determined, and adjusted to account for net exports. Consumption of industrial coking coal, pet. Coke, other oils and natural gas were adjusted to subtract for non-energy uses accounted for in the IP sector. The quantity of C stored was estimated by estimating the potential emissions by an emission factor. US Territorial emissions are included in 1A5 and are estimated by multiplying consumption by a US-specific emission factor. 1AA5b includes emissions military fuel combustion."	CS (CO_2), CS, D (CH_4 and N_2O)	No differences noted	NA
1B	**Fugitive Emissions from Fuels**						

1B1	Solid Fuels	CH_4	Tier 2, Tier 3	"The methodology for estimating CH_4 emissions from coal mining consists of two parts. The first part involves estimating CH_4 emissions from underground mines. Because of the availability of ventilation system measurements, underground mine emissions can be estimated on a mine-by-mine basis and then summed to determine total emissions. The second step involves estimating emissions from surface mines and post-mining activities by multiplying basin-specific coal production by basin-specific emission factors. Estimating CH_4 emissions from abandoned coal mines requires predicting the emissions of a mine from the time of abandonment through the inventory year of interest (applying a decline function)."	CS	No differences noted	NA
1B2	Oil and Natural Gas	CO_2, CH_4	Tier 2 (Modeled)	"The primary basis for estimates of CH_4 and non-combustion-related CO_2 emissions from the US natural gas industry is a detailed study by the Gas Research Institute and EPA (EPA/GRI 1996). The EPA/GRI study developed over 80 CH_4 emission and activity factors to characterize emissions from the various components within the operating stages of the US natural gas system. The methodology for estimating CH_4 emissions from petroleum systems is a bottom-up approach, based on comprehensive studies of CH_4 emissions from US petroleum systems (EPA 1996, EPA 1999). These studies combined emission estimates from 64 activities occurring in petroleum systems from the oil wellhead through crude oil refining, including 33 activities for crude oil production field operations, 11 for crude oil transportation activities, and 20 for refining operations."	M	No differences noted	US-specific spreadsheets were developed and are considered the model to estimate CO_2 and CH_4 emissions.
	Memo Items (source and sink categories reported but not in national totals)						

	International Bunker Fuels	CO_2, CH_4, N_2O	Tier 2	Emissions of CO_2 were estimated by applying C content to fuel consumption activity data. Emission estimates for CH_4 and N_2O were calculated by multiplying emission factors by measures of fuel consumption by fuel type and mode.			
	Multilateral Operations	NE	NE	NE	NE	NE	NE
	CO_2 Emissions from Biomass	CO_2	Tier 2	Woody biomass emissions were estimated by applying two EIA gross heat contents to US consumption data, provided in energy units for the industrial, residential, commercial, and electric generation sectors.	CS	No differences noted	NA
2	**Industrial Processes**						
2A	Mineral Products	CO_2	Tier 1, Tier 2	IPCC Tier 2 emission factors were applied to national activity data	D, CS	No differences noted	NA
2B	Chemical Industry	CO_2, CH_4, N_2O	Tier 1 and Tier 3	Emissions data measured using continuous emissions monitoring data was obtained directly from a plant engineer, when available	D	yes	NA
2C	Metal Production[23]	CO_2, CH_4, PFCs, SF_6	Tier 1, Tier 2, Tier 3	Plant-specific input consumption data and production data is reported voluntarily to EPA, which allows for the use of the Tier 3 method to estimate emissions	CS, D	yes	
2D	Other Production	NE	NE	NE	NE	NE	NE
2E	Production of Halocarbons and Sulphur Hexafluoride	HFCs	Tier 1 and Tier 3	An industry association aggregates and reports country-level emissions to EPA	D	yes	NA

[23] Use of published non-IPCC factors that are assumed to be more representative of US industry or more conducive to methodologies developed specifically for US inventory.

2F	Consumption of Halocarbons and Sulphur Hexafluoride	HFCs, PFCs, SF_6	Tier 1, Tier 2, and Tier 3	Companies monitor emissions using a Tier 3 mass-balance approach and report emissions data voluntarily to EPA	D	yes	EPA's "Vintaging Model" for ODS substitutes used for refrigeration, air conditioning, aerosols, foams, and solvents. EPA's PFC Emissions Vintage Model (PEVM) used for semiconductor manufacturing source
2G	Other (Industrial Processes)	NA/NO					
3	**Solvent and Other Product Use**						
3A	Paint Application	NE	NE	NE	NE	NE	NE
3B	Degreasing and Dry Cleaning	NE	NE	NE	NE	NE	NE
3C	Chemical Product, Manufacture and Processing	NE	NE	NE	NE	NE	NE
3D	Other (Solvent and Other Product Use)	N_2O	IPCC method for this source does not have tiers	National-level production quantities are attributed to different end uses and then multiplied by associated default emission factors	D	yes	NA
4	**Agriculture**						
4A	Enteric Fermentation	CH_4	Tier 1: Most Cattle Tier 2: Bulls, Other Livestock	Used the Cattle Enteric Fermentation Model divide cattle into state, age, sub-type, and production (i.e., pregnant, lactating) groupings to capture differences in CH_4 emissions. It also simulates age & weight of each sub-type by month. US-specific diet characteristics used with Tier 2 equations from 2006 IPCC Guidelines to produce CH_4 emission factors.	CS, D	No differences noted	US EPA's Cattle Enteric Fermentation Model
4B	Manure Management	CH_4, N_2O	Tier 2	Many country-specific parameters were used, although EFs were IPCC defaults.	D	No differences noted	US EPA's Cattle Enteric Fermentation Model (population estimates)
4C	Rice Cultivation	CH_4	Tier 2	US specific emission factors, based	CS	No differences noted	None

				on in-country studies.			
4D	Agricultural Soils	N_2O	Tier 3: Major crops, some grasslands Tier 1: Non-major crops, organic soils, some grasslands	Process-based DAYCENT model used to estimate emissions based on crop history, weather data, N inputs, soil processes, etc., for major crops (corn, soybeans, wheat, alfalfa hay, other hay, sorghum, and cotton) on mineral soils and for non-federal grasslands.	CS	No differences noted	DAYCENT
4E	Prescribed Burning of Savannas	NE	NE	NE	NE	NE	NE
4F	Field Burning of Agricultural Residues	CH_4, N_2O	Tier 2	Uses crop- and country-specific emission factors and variables.	CS	No differences noted	None
4G	Other (Agriculture)	NE	NE	NE	NE	NE	NE
5	**Land Use Change & Forestry**						
5A	Forest Land	Forest land remaining forest land (CO_2); Forest Fires (CH_4), (N_2O); Forest Soils (N_2O)	Tier 3 (biomass C values) Forest Fires (Tier 2), Forest Soils (Tier 1)	"Forest ecosystem stock and flux estimates are based on the stock-difference method and calculations for all estimates are in units of C. The Tier 3 biomass C values are from forest inventory tree-level data. The Tier 2 dead organic and soil C pools are based on empirical or process models from the inventory data. All carbon conversion factors are specific to regions or individual states within the United States, which are further classified according to characteristic forest types within each region."--LULUCF 7-17	CS, D	Yes	FIADB-to-Carbon calculator; WOODCARB II model.
5B	Cropland	Cropland remaining cropland (CO_2); Land converted to cropland (CO_2)	Tier 3, Tier 2, Tier 1	An IPCC Tier 3 model-based approach was applied to estimate C stock changes for mineral soils used to produce a majority of annual crops in the United States. The remaining crops on mineral soils were estimated using an IPCC Tier 2 method. Tier 2 methodology was used for estimating emissions from agricultural liming. A tier 1 methodology was used to calculate CO emissions from urea fertilization. A Tier 3 approach was used to estimate CO from land converted to cropland.	CS, D	Yes	CENTURY Model.

5C	Grassland	Grassland remaining grassland (CO_2); Land converted to grassland (CO_2)	Tier 3 & Tier 2	Grassland remaining grassland is calculated using a Tier 3 approach to estimate carbon stock changes and a Tier 2 method for gravelly, cobbly, or shaley soils. A Tier 3 approach is used to calculate CO_2 from land converted to grassland. A Tier 2 approach is used to calculate carbon stock changes in the remaining soils.	CS, D	Yes	CENTURY Model.
5D	Wetlands	Wetlands remaining wetlands (CO_2); Peatlands remaining peatlands (CO_2) (N_2O)	Tier 1	Wetlands remaining wetlands and peatlands remaining peatlands calculations use a Tier 1 methodology.	D	Yes	NA
5E	Settlements	Settlements remaining settlements (CO_2), (N_2O)	Tier 2 & Tier 1	"Methods for quantifying urban tree biomass, C sequestration, and C emissions from tree mortality and decomposition were taken directly from Nowak and Crane (2002) and Nowak (1994). First, field data from 14 cities were used to generate algometric estimates of biomass from measured tree dimensions. Second, estimates of tree growth and biomass increment were generated from published literature and adjusted for tree condition and land-use class to generate estimates of gross C sequestration in urban trees. Third, estimates of C emissions due to mortality and decomposition were subtracted from gross C sequestration values to derive estimates of net C sequestration. For direct N_2O from settlements remaining settlements an IPCC Tier 1 approach was used for synthetic N fertilizer and sewage sludge applications."--LULUCF 7-49	CS, D	Yes	NA

5F	Other lands[24]	Other (Landfilled yard trimmings and food scraps)(CO_2)	Tier 2	C stock estimates were calculated by determining the mass of landfilled C resulting from yard trimmings or food scraps discarded in a given year; adding the accumulated landfilled C from previous years; and subtracting the mass of C landfilled in previous years that decomposed.	CS, D	Yes	NA
5G	Other (Land Use Change & Forestry)	NA	NA	NA	NA	NA	NA
6	**Waste**						
6A	Solid Waste Disposal[25]	CH_4	Tier 3 for most parameters Tier 2 for certain parameters for industrial wastes	Uses first-order decay (FOD) model with country-specific estimates of current and historical waste disposal and solid waste disposal sites. Country-specific factors for degradable organic content (DOC), methane generation potential (Lo), and decay rate constant (k) are used in most cases, although IPCC default values are used for certain industrial waste parameters. More details follow: 1) Waste sent to municipal solid waste (MSW) landfills is taken from a survey of state agencies compiled from various sources cited in in EPA 2011a, pp. A-304, A-305). 2) Waste sent to industrial landfills is calculated from food processing and pulp and paper production data from 1990 through 2009, and extrapolated between 1940 and 1989 based on US population. (EPA 2011a, pp. A-306, A-307) 3) For MSW, DOC, Lo, and k values are derived from a set of 52 representative landfills across the United States. in different precipitation ranges (EPA 2011a, p. A-305) 4) For industrial waste, estimates of	CS (most parameters) D (industrial waste decay rate constants, i.e. k values).	No differences noted	First-order decay (FOD) model; IPCC Waste Model

[24] "For each of the four materials (grass, leaves, branches, food scraps), the stock of C in landfills for any given year is calculated according to the following formula: LFCi,t = Σ Wi,n × (1 − MCi) × ICCi × {[CSi × ICCi] + [(1 − (CSi × ICCi)) × e−k(t − n)]} where, t = Year for which C stocks are being estimated (year), i = Waste type for which C stocks are being estimated (grass, leaves, branches, food scraps), LFCi,t = Stock of C in landfills in year t, for waste i (metric tons), Wi,n = Mass of waste i disposed in landfills in year n (metric tons, wet weight), n = Year in which the waste was disposed (year, where 1960 < n < t), MCi = Moisture content of waste i (percent of water), CSi = Proportion of initial C that is stored for waste i (percent), ICCi = Initial C content of waste i (percent), e = Natural logarithm, and k = First-order decay rate for waste i, (year−1)."-LULUCF 7-57

[25] First-order decay (FOD) model incorporates a time delay of six months before generation of CH_4 begins (EPA 2011a, p. A-305)

				DOC and Lo are derived from relevant data; IPCC defaults are used for k. (EPA 2011a, p. A-307)			
6B	Wastewater Handling	CH_4, N_2O	Tier 1 for CH_4 emissions from domestic wastewater treatment (based on 2006 IPCC Guidelines, Volume 5, p. 6.10) Tier 2 for CH_4 emissions from industrial wastewater treatment (based on 2006 IPCC Guidelines, Volume 5, p. 6.19) IPCC does not provide tiers for N_2O emissions from wastewater (2006 IPCC Guidelines, Volume 5, p. 6.24)	CH_4 emissions from domestic wastewater are estimated using default emission factors of B_o and MCF from 2006 IPCC Guidelines) (EPA 2011a, pp. 8-8 to 8-9) CH_4 emissions from industrial wastewater are estimated based on industry-specific wastewater outflow, COD loadings, and IPCC default values for B_o and MCF, based on industry-specific data on wastewater treatment practices (EPA 2011a, pp. 8-10 to 8-14) N_2O emissions from wastewater are estimated using approach described in 2006 IPCC Guidelines), using default emission factors (EPA 2011a, pp. 8-14, 8-15).	D (B_o and MCF factors) CS (wastewater treatment practices)	No differences noted	NA
6C	Waste Incineration	NA	NA	NA	NA	Waste Incineration is reported under Energy in the US GHG Inventory	NA
6D	Other (Waste)	CH_4 and N_2O from composting	Tier 1 (p. 8-18)	CH_4 and N_2O emissions from composted are calculated using IPCC default methodology and factors (EPA 2011a, p. 8-18)	D	No differences noted	NA
	Waste Sources of Indirect GHG Emissions	NO_x, CO, NMVOCs	NA	See US GHG Inventory (EPA 2011a, p. 8-20)	CS	No differences noted	NA

Table 19. Assessment of Emissions Estimation Methods & Data Sources for Canada Inventory[26]

IPCC ID	Sector/Source	GHG Coverage	IPCC Tier Levels	Description of Higher-Tiered Method	Country-specific (CS) or Default (D) Emission Factors?	Consistency with Annex I Country Source Definitions (list differences)	Models Used
1	**Energy**						
1A	**Fuel Combustion**						
1A1	Energy Industries	CO_2, CH_4, N_2O	Tier 2 (all gases)	Country-specific activity data are multiplied by country- and region-specific emission factors. For fossil fuel industries, emissions are estimated on a national basis and emissions associated with flaring are subtracted from the total GHG emissions for each category.	CS	No differences noted	NA
1A2	Manufacturing Industries and Construction	CO_2, CH_4, N_2O	Tier 2 (all gases)	"Country-specific activity data and national emission factors used where available. In order to reallocate the fuel reported in the summary lines for electricity and steam in the national statistics, a fractional allocation method was developed based on the quantities reported by category in the ICE survey. For each fuel and each province, the fuel use data reported by industry in the Industrial Consumption of Energy (ICE) survey for electricity generation are used to develop each industry's fraction of the total fuel use." See Part 2, p. 40 of Canada's NIR (Environment Canada 2011c).	CS	No differences noted	NA
1A3	Transport	CO_2, CH_4, N_2O	Tier 1, Tier 2, Tier 3 (all gases)	"Emission estimates are developed at the provincial/territorial level and aggregated to the national level. Methodologies vary for civil aviation, road transportation, railways, navigation, and other transportation (off-road and pipelines)." See Part 2, p.43 of Canada's NIR for detailed methodology descriptions.	CS (CO_2), CS and D (CH_4 and N_2O)	Military air transportation emissions attributed to the consumption of aviation turbo fuel are reported in the Other subsector (CRF Category 1.A.5). However, military emissions generated by the consumption of aviation gasoline remain in this category (1.A.3.a) since the current data source for this type of fuel consolidates military and civil fuel use to facilitate confidentiality.	Canada's Mobile Greenhouse Gas Emission Model (MGEM) and the Aviation Greenhouse Gas Emission Model (AGEM) are used to calculate the emissions from Road Transportation, Railways, Navigation, Off-road and Aviation.

[26] NE—not estimated, NO—not occurring, NA—not available/not applicable, IE—included elsewhere, C—confidential

1A4	Other Sectors[27]	CO_2, CH_4, N_2O	Tier 2 (all gases)	"Country-specific activity data are multiplied by country-specific emission factors, with the exception of firewood. The activity data used in the calculation of GHG emissions from the combustion of residential firewood are based on estimated fuel use. GHG emissions were calculated by multiplying the amount of wood burned in each appliance by the emission factors." See Part 2, p. 42 of Canada's NIR.	CS	No differences noted	NA
1A5	Other (Fuel Combustion) (includes Non-Energy Use)	CO_2, CH_4, N_2O	Tier 3 (all gases)	Includes military air transportation emissions attributed to the consumption of aviation turbo fuel.	CS (CO_2 and CH_4), D (N_2O)	See 1.A.3 differences	NA
1B	**Fugitive Emissions from Fuel**						
1B1	Solid Fuels[28]	CH_4	Tier 2 (CS method applied for CH_4)	"Methodology consists of a hybrid of IPCC Tier 3- and Tier 2-type methodologies, depending on the availability of mine-specific data. Emissions for underground mines are determined on a mine-specific basis by summing emissions from the ventilation system, degasification systems and post-mining activities. For surface mines, it was assumed that 60% of the CH_4 content is released in the atmosphere before combustion." See Part 2, p. 50 of Canada's NIR.	CS	No differences noted	NA
1B2	Oil and Natural[29] Gas	CO_2, CH_4, N_2O	Tier 2 (CS method applied for all gases)	"A Tier 3 analysis was performed to estimate all GHG emissions from the upstream oil and gas (UOG) sector for the year 2000, with the exclusion of oil sands mining, extraction and upgrading. The emissions were then backcast to the years 1990 through to 1999 to develop emission estimates for the industry. The UOG fugitive emissions for 1990–2000 were taken directly from the UOG study (CAPP 2005a). UOG fugitive emissions for 2001 and onwards are projected using the UOG estimation model." Methodology for the 2000 emission estimates are provided in detail in Part 2, p. 52 of Canada's NIR.	CS	No differences noted	Upstream oil and gas (UOG) model, Oil Sands/Bitumen Model, Fugitive Refinery Model and Natural Gas Transmission and Distribution models
	Memo Items (source and sink categories reported but not in national totals)						

[27] Other Sectors subsector consists of three categories: Commercial/Institutional, Residential and Agriculture/Forestry/ Fisheries.
[28] Fugitive emission estimates are based on the study Management of Methane Emissions from Coal Mines: Environmental, Engineering, Economic and Institutional Implications of Options prepared by B. King in 1994 for Neill and Gunter Ltd (King 1994)
[29] Fugitive emission estimates are based on the study, *A National Inventory of Greenhouse Gas (GHG), Criteria Air Contaminant (CAC) and Hydrogen Sulphide (H_2S) Emissions by the Upstream Oil and Gas Industry.*

	International Bunker Fuels	CO_2, CH_4, N_2O	Tier 1 & Tier 2	"Emissions resulting from fuel sold to foreign marine vessels are assumed to be used only for international travel and are reported under international bunkers. Some Canadian vessels are engaged in international marine travel. Comprehensive data that would allow an accurate disaggregation of domestic and international shipping activities by Canadian vessels are currently unavailable." See Part 2, p. 48 of Canada's NIR.	NA	NA	NA
	Multilateral Operations	Canada notes in CRF tables it was unable to disaggregate multilateral operations from civil aviation and navigation.	NA	NA	NA	NA	NA
	CO_2 Emissions from Biomass[30]	CO_2	Tier 2	Residential emissions are calculated based on technology type, industrial combustion of biomass is dependent primarily on the characteristics of the fuel being combusted.	CS	No differences noted	
2	**Industrial Processes**						
2A	Mineral Products	CO_2	Tier 1, Tier 2	IPCC Tier 2 emission factors were applied to national activity data	D, CS	No differences noted	NA
2B	Chemical Industry[31]	CO_2, CH_4, N_2O	Tier 1, Tier 2, and Tier 3	Plant-specific production data are applied to plant-specific emission factors (when data permits)	D, CS	No differences noted	NA
2C	Metal Production[32]	CO_2, PFCs, SF_6	Tier 1, Tier 2, and Tier 3	Plant-specific production data are applied to plant-specific emission factors (when data permits)	D, CS	No differences noted	NA
2D	Other Production	NA	NA	NA	NA	NA	NA
2E	Production of Halocarbons and Sulphur Hexafluoride	NA, NO	NA	NA	NA	NA	NA
2F	Consumption of Halocarbons and Sulphur Hexafluoride	HFCs, PFCs, SF_6	Tier 1, Tier 2, and Tier 3	For SF_6 use at electrical utilities, the amount of gas used to replace the gas assumed to have escaped to the atmosphere is measured using either flow meters or by weighing/tracking the cylinders from which new gas is extracted.	D	No differences noted	NA

[30] Emissions of CO_2 from the combustion of biomass (whether for energy use, from prescribed burning or from wildfires) are not included in National Inventory totals. These emissions are estimated and recorded as a loss of biomass stock in the Land Use, Land-use Change and Forestry (LULUCF) Sector.
[31] Use of published non-IPCC factors that are assumed to be more representative of US industry or more conducive to methodologies developed specifically for US inventory.
[32] Same as above.

2G	Other (Industrial Processes)[33]	CO_2	Tier 1		CS	No differences noted	NA
3	**Solvent and Other Product Use**						
3A	Paint Application	NA	NA	NA	NA	NA	NA
3B	Degreasing and Dry Cleaning	NA	NA	NA	NA	NA	NA
3C	Chemical Product, Manufacture and Processing	NA/NE	NA/NE	NA/NE	NA/NE	NA/NE	NA/NE
3D	Other (Solvent and Other Product Use)	N_2O	IPCC method for this source does not have tiers	NA	NA	NA	NA
4	**Agriculture**						
4A	Enteric Fermentation	CH_4	Tier 1: Other Livestock Tier 2: Cattle	For cattle, annual national emission factors for several cattle subcategories, based on a domestic study/model (Boadi et al. 2004).	CS: Cattle D: Other Livestock	No differences noted	The Boadi et al. (2004) cattle production model calculates an emission factor in kg/head/yr, based on daily gross energy intake according to equation 4.14 of the *IPCC GPG* (2000).
4B	Manure Management	CH_4, N_2O	Tier 1: N_2O Tier 2: CH_4	For cattle CH_4, the Boadi et al. (2004) Tier 2 animal production model was used to derive gross energy of consumption from which volatile solids were estimated. Manure ash content and manure management systems were taken from domestic studies. Annual EFs reflect changes in gross energy intake for cattle. For other livestock CH_4 different parameters were used for subcategories based on size class.	CS: Cattle CH_4 D: Other Livestock CH_4, and all N_2O	No differences noted	Boadi et al. 2004
4C	Rice Cultivation	NA	NA	NA	NA	NA	NA
4D	Agricultural Soils	N_2O	Tier 1: Organic Soils Tier 2: Synthetic N Fertilizer, Manure Fertilizer, Crop	Country-specific emission factors were used for Tier 2 sources.	CS for Tier 2 D for Tier 1	No differences noted	None

[33] Includes non-energy use of fossil fuels.

			Residues, Manure on PRP, Indirect Emissions, (additional categories: N_2O from conservation tillage, summer fallow, & irrigation)				
4E	Prescribed Burning of Savannas	NA	NA	NA	NA	NA	NA
4F	Field Burning of Agricultural Residues	CH_4, N_2O	Tier 1	NA	D	No differences noted	None
4G	Other (Agriculture)	NA	NA	NA	NA	NA	NA
5	**Land Use Change & Forestry**						
5A	Forest Land[34]	CO_2, CH_4, N_2O The assessment includes emissions and removals of CO_2, additional emissions of CH_4, N_2O and CO due to wildfires and controlled burning, and N_2O released following land conversion to cropland.	Tier 3	Canada applies a Tier 3 methodology for estimating GHG emissions and removals in managed forests.	CS	Yes	Carbon Budget Model

[34] Canada's National Forest Carbon Monitoring, Accounting and Reporting System (NFCMARS – Kurz and Apps 2006) includes a model-based approach (Carbon Budget Model of the Canadian Forest Sector, CBM-CFS3 – Kull et al. 2006; Kurz et al. 2009).

5B	Cropland	CO_2. Cropland remaining cropland includes CO_2 emissions /removals in mineral soils, CO_2 emissions from agricultural lime application and cultivation of organic soils, and CO_2 emissions /removals resulting from changes in woody biomass from specialty crops. CO_2, N_2O, CO and CH_4 emission and removals are calculated for land "converted to cropland".	Tier 2	An enhanced Tier 2 approach is used for cropland remaining cropland using a combination of activity data and the CENTURY model. Direct N_2O emissions from agricultural soils emissions of N_2O from forest conversion to cropland were estimated "by multiplying the amount of carbon loss by the fraction of nitrogen loss per unit of carbon and by an emission factor (EFBASE). EFBASE was determined for each ecodistrict, based on topographic and climate conditions (see Annex 3.3)." "Tier 2 methodology, multiplying the amount of carbon loss by the fraction of nitrogen loss per unit of carbon by a base emission factor (EFBASE). EFBASE is determined for each ecodistrict, based on climate and topographic characteristics (see Annex 3.3.6)."	CS	Yes	CENTURY model
5C	Grassland[35]	NA	NA	NA	NA	NA	NA
5D	Wetlands	CO_2 for managed peatlands and Flooded land and reservoirs	Tier 2	"Estimates were developed using a Tier 2 methodology, based on domestic emission factors. They include emissions and removals during all five phases of peat extraction. A domestic approach was developed and used to estimate emissions from reservoirs based on measured CO_2 fluxes above reservoir surfaces, consistent with the descriptions of IPCC Tier 2 methodology (LULUCF Good Practice Guidance, 2006 IPCC Guidelines) and following the guidance in Appendix 3a.3 of LULUCF Good Practice Guidance)."	CS	Yes	NA

[35] Canada reports this Grassland remaining grassland category as not estimated.

5E	Settlements[36]	NA	NA	NA	NA	NA	NA
5F	Other lands	NE	NE	NE	NE	NE	NE
5G	Other (Land Use Change & Forestry)[37]	CO_2 for land converted to settlements and non-forest land conversion to settlements in the Canadian north.	Tier 2	The approach adopted for estimating forest areas converted to other uses is based on three main information sources: systematic or representative sampling of remote sensing imagery, records, and expert judgment. The core method involves mapping of deforestation on samples from remotely sensed Lands at images dated circa 1975, 1990, 2000 and 2008. For implementation purposes, all permanent forest removal wider than 20 m from tree base to tree base and at least 1 ha in area was considered forest conversion. This convention was adopted as a guide to consistently label linear patterns in the landscape.	CS	Yes	NA
6	**Waste**						
6A	Solid Waste Disposal[38]	CH_4	Tier 2	Uses first-order decay model with country-specific estimates of current and historical waste disposal and solid waste disposal sites (See Part 2, p. 143-145 of Canada's NIR). IPCC default values are used for methane conversion factor (MCF), degradable organic content (DOC) by waste fraction, fraction of CH_4 in landfill gas, and the fraction of DOC that is dissimilated (See Part 2, p. 148 of Canada's NIR). Landfill gas capture quantities are based on country-level surveys and data sources (See Part 2, p. 153 of Canada's NIR).	CS (most parameters) D (MCF, fraction of CH_4 in landfill gas, and the fraction of DOC that is dissimilated) (Environment Canada 2011c, Part 2, p. 148).	No differences noted	Scholl Canyon model is used, based on first-order decay (FOD) equation (Environment Canada 2011c, Part 2, p. 142)

[36] "The other main information sources consist of databases or other documentation on forest roads, power lines, oil and gas infrastructure, and hydroelectric reservoirs. Expert opinion was called upon when the remote sensing sample was insufficient, to resolve differences among records and remote sensing information, and to resolve apparent discrepancies between the 1975–1990, 1990–2000 and 2000–2008 area estimates." --LULUCF, 192, (Canada)

[37] Other represents deforestation, which is a crosscutting LULUCF category with emissions being reported under cropland, wetlands and settlements in the inventory.

[38] Assumes initial lag time before anaerobic conditions are established in landfill is negligible (See Part 2, p. 143 of Canada's NIR)

6B	Wastewater Handling[39]	CH_4, N_2O	Tier 2 for CH_4 emissions from domestic wastewater Tier 3 for CH_4 emissions from industrial wastewater (Environment Canada 2011c, Part 2, p. 155) IPCC does not provide tiers for N_2O emissions from wastewater (2006 IPCC Guidelines, Volume 5, p. 6.24)	For domestic wastewater, uses a country-specific estimate of maximum methane-producing capacity (B_o) and an MCF factor based on the type of system (septic systems, facultative lagoons, and direct discharge) and estimates of the provincial populations served by anaerobic systems (See Part 2, p. 154 of Canada's NIR). For industrial wastewater, data on CH_4 production (for pulp and paper facilities) and process wastewater volumes and chemical oxygen demand (COD) loadings (for food processing facilities) was collected directly in order to calculate CH_4 and N_2O emissions (See Part 2, p. 155 of Canada's NIR).	CS (CH_4 emissions from domestic wastewater) CS (CH_4 and N_2O emissions from industrial wastewater) D (N_2O emissions from municipal wastewater)	No differences noted	None
6C	Waste Incineration	CO_2 (non-biogenic), N_2O, CH_4	Tier 2 for non-biogenic CO_2 emissions (2006 IPCC Guidelines, Volume 5, p. 5.10) Tier 1 for N_2O and CH_4 emissions (2006 IPCC Guidelines, Volume 5, p. 5.12)	Uses IPCC default method following Box 2 in Figure 5.5 of Good Practice Guidance (p. 5.26). Uses country-specific amounts of waste incinerated and default carbon-content factors; equivalent to a Tier 2 approach based on 2006 IPCC Guidelines). IPCC default N_2O emission factors are used to estimate N_2O emissions from MSW and sewage sludge incineration; equivalent to a Tier 1 approach based on 2006 IPCC Guidelines). CH_4 emissions are assumed to be zero for MSW incineration (See Part 2, p. 161 of Canada's NIR). CH_4 emissions from sewage sludge are calculated using a default CH_4 emission factor from US EPA and country-specific estimates of dried solids incinerated (See Part 2, p. 161 of Canada's NIR).	CS (amount of waste incinerated) D (carbon-content factors, N_2O and CH_4 emissions from incineration)	No differences noted	None
6D	Other (Waste)	NA	NA	NA	NA	NA	NA

[39] Although the method used to calculate CH_4 emissions from domestic wastewater is similar to the IPCC methodology, the IPCC default method was not used because data on the volumes of wastewater treated were not available (See Part 2, p. 154 of Canada's NIR)

	Waste Sources of Indirect GHG Emissions	CO, NO_x, NMVOC, SO_x	NA	Emissions data are taken from information reported to the United Nations Economic Commission for the Environment under the Convention on Long-range Transboundary Air Pollution (LRTAP) (See Part 2, p. 208 of Canada's NIR)	NA	No differences noted	NA

Table 20. Assessment of Emissions Estimation Methods & Data Sources for Mexico National Inventory[40]

IPCC ID	Sector/Source	GHG Coverage	IPCC Tier Levels	Description of Higher-Tiered Method	Country-specific (CS) or Default (D) Emission Factors?	Consistency with Annex I Country Source Definitions (list differences)	Models Used
1	**Energy**						
1A	**Fuel Combustion**						
1A1	Energy Industries	CO_2, CH_4, N_2O	Tier 1 & 2	NA	D	No differences noted	NA
1A2	Manufacturing Industries and Construction	CO_2, CH_4, N_2O	Tier 1 & 2 (Cement production called out as Tier 2)	NA	D	No differences noted	NA
1A3	Transport	CO_2, CH_4, N_2O	Tier 1 for 1A3c Rail, 1A3d Maritime, 1A4a Commercial, and 1A4c Agricultural; Tier 1 & 2 for 1A3b Ground or Motor Transportation, and 1A4b Residential; and Tier 2 for 1A3a Civil Aviation	NA	D, CS	No differences noted	NA
1A4	Other Sectors	CO_2, CH_4, N_2O	NA	NA	NA	NA	NA
1A5	Other (Fuel Combustion) (includes Non-Energy Use)	NE	NE	NE	NE	NE	NE
1B	**Fugitive Emissions from Fuels**						
1B1	Solid Fuels	CH_4	Tier 1	NA	D	No differences noted	NA
1B2	Oil and Natural Gas	CH_4	Tier 1	NA	D	No differences noted	NA
	Memo Items (source and sink categories reported but not in national totals)						
	International Bunker Fuels	CO_2, CH_4, N_2O	Tier 1	NA	D	No differences noted	NA
	Multilateral Operations	NE	NE	NE	NE	NE	NE
	CO_2 Emissions from Biomass	CO_2	Tier 1	NA	D	No differences noted	NA
2	**Industrial Processes**						

[40] NE—not estimated, NO—not occurring, NA—not available/not applicable, IE—included elsewhere, C—confidential

2A	Mineral Products[41]	CO_2	Tier 1	NA	D	yes	NA
2B	Chemical Industry	CO_2, CH_4, N_2O	Tier 1	NA	D	yes	NA
2C	Metal Production	CO_2, CH_4, PFCs	Tier 1	NA	D	yes	NA
2D	Other Production	NA	NA	NA	NA	NA	NA
2E	Production of Halocarbons and Sulphur Hexafluoride	HFCs	Tier 1	NA	D	yes	NA
2F	Consumption of Halocarbons and Sulphur Hexafluoride	HFCs, SF_6	Tier 1 and Tier 2	IPCC default emission stages for each life-cycle phase were multiplied by activity data for each phase.	D	yes	NA
2G	Other (Industrial Processes)	NA	NA	NA	NA	NA	NA
3	**Solvent and Other Product Use[42]**						
3A	Paint Application	NA	NA	NA	NA	NA	NA
3B	Degreasing and Dry Cleaning	NA	NA	NA	NA	NA	NA
3C	Chemical Product, Manufacture and Processing	NA	NA	NA	NA	NA	NA
3D	Other (Solvent and Other Product Use)	NA	NA	NA	NA	NA	NA
4	**Agriculture**						
4A	Enteric Fermentation	CH_4	Tier 2	Used country-specific EFs	CS	No differences noted	None
4B	Manure Management	CH_4, N_2O	Tier 2	Country-specific EFs for anaerobic fermentation	CS	No differences noted	None
4C	Rice Cultivation[43]	CH_4	Tier 1 (see notes)	NA	D	No differences noted	None
4D	Agricultural Soils	N_2O	Tier 1	NA	D	No differences noted	None
4E	Prescribed Burning of Savannas	NE	NE	NE	NE	NE	NE
4F	Field Burning of Agricultural Residues	CH_4, N_2O	Tier 1	NA	D	No differences noted	None
4G	Other (Agriculture)	NA	NE	NE	NE	NE	NE

[41] For cement production emissions, WBCSD emission factor for clinker was used rather than IPCC factor to be consistent with a voluntary reporting program currently underway in Mexico
[42] Mexico uses IPCC 1996 IPCC Guidelines. GHG estimates from this category are not required.
[43] Although Mexico designates this source in a summary table as having been calculated with Tier 2, (p. 4-64 of the Ag section of the NIR), it appears to in fact be Tier 1, and to use default EFs.

5	Land Use Change & Forestry*[44]						
5A	Forest Land[45]	Forest land remaining forest land CO_2 (carbon stock changes) and CO, NH, N_2O, and NO_x from forest fires. Also include Forest land converted to cropland (CO_2), Forest land converted to grassland (CO_2).	Tier 1 or Tier 2	Activity data is from forestry sampling data in 1992-1994 with approximately 16,000 sites distributed across all kinds of land uses in the country (SARH 1994) and data from samples taken between 2004 and 2007, with about 22,000 clusters distributed across all kinds of land uses in the country (Conafor 2008). Additionally, there is a base of approximately 25,000 soil profiles with data on carbon density collected over the past 40 years by the National Institute for Statistics and Geography (Inegi). To calculate the volume of wood, biomass and allometric equations published in the national literature were used. The carbon content calculation uses a default emission factor. The overall estimate of the GHG emissions from forest fires (spontaneous) used the general equation for the guidelines of the IPCC in the section Using Soil, Land Use Change and Forestry (LULUCF Good Practice Guidance)." *Source:* Semarnat-INE 2011, pp. 22.	D	Yes	The CONSUME 3 model was used to develop consumption factors for forest fire emission calculations.

[44] Although the levels of uncertainty in estimates of GHG emissions in the sector LULUCF are high, it is expected that short-term measures could substantially reduce this uncertainty. Currently, there is much national effort aimed at improving the quality and amount of information needed for national GHG inventories in the LULUCF sector. From 2009, Conafor has included the measurement of all reservoirs of C in the National Forest and Soils Inventory, established nationally for 25,000 soil agglomerations, between 2004 and 2008. This allows for the first time the reporting of flows of C in dead matter on soil and mulch and estimating more accurately the flow of C in the category “Forest Land Remaining as Forest Land.” It also allows for a direct relationship between C biomass and soil C. On the other hand, several states in Mexico are in the process of making state forest inventories, many under the coordination of Conafor, allowing information to be integrated on a national basis. Furthermore, Semarnat is in the process of capturing all data on approved forest management plans in a single format to be available on its website, which will allow it to substantially reduce the uncertainty in the category, “Forest Land Remaining Forest Land.” Sagarpa is establishing a nationwide monitoring system for grasslands and shrublands, with more than 500 permanent sites, to quantify the flows of C in the category “Grassland Remaining Grassland.” Additionally, systems are being established semi-automated analysis and classification satellite imagery to generate maps of land use changes. Source: Semarnat-INE 2011, 8, 9. (Translated)

[45] Drawn from national forest inventory biomass estimates for the types of forests and jungles in Mexico (SARH 1994, Conafor 2008); dasometric data were converted by allometric equations to yield estimated increases of biomass and volume. These estimates were in turn used to calculate expansion factors for species (22 species) types and stands (10 forest communities). The carbon content in biomass was calculated using a default value. To estimate the C fluxes in forests methodology developed by the LULCF Good Practice Guidance) was used. It should be mentioned that this section quantifies carbon fluxes derived from changes in aboveground biomass and roots of vegetation, and did not take into account possible changes in reservoirs of dead matter and litter, as no data are available nationwide on this." Extracted from: Semarnat-INE 2011, p. 21.

5B	Cropland	Cropland converted to forest land (CO_2), Cropland converted to grassland.	Tier 1	The inventory used the alternative regime emission factor [$f_{regime\ alt\ (i)}$] to estimate the dynamics of C changes in land use. This factor was calculated based on the average of the soil organic carbon (SOC) in the land use in the reporting year, divided by the SOC of reference for the vegetation types and successional stages of approx. 25,000 soil profiles collected by Inegi over 40 years and tabulated between 2004 and 2008 for the INFyS. The alt regime $f_{regime\ alt\ (i)}$ was estimated using the average of SOC in land use in the reporting year versus the SOC for the reference dimensionless native forest stand. *Source:* Semarnat-INE 2011, based upon pp.9, 25-26.	D	Yes	NA
5C	Grassland	Grassland converted to forest land, Grassland converted to cropland (CO_2)	Tier 1	There are data from national forest inventory increases in 1992-1994 (INF) and the national forest inventory and land 2004-2008 (INFyS 2004-2008). These data were used to estimate the change in biomass of each sampling site in INFyS 2004-2009. The growth rates were calculated by forest type and precipitation classes, as a close relationship was found between increments of change in biomass and precipitation (particularly less than 1200 mm rainfall / year). Calculated data increases were allocated to each polygon of land use change. The final report estimated the average increase weighted by the corresponding area for each forest type. In order to estimate the loss of C from soil, the disturbance regime emission factor $f_{regime\ alt\ (i)}$ was calculated. Expansion factors were calculated from allometric equations for biomass and volume. Biomass is considered to have grade level 2 to 3, with only the proportion of carbon present as a default value. The losses of Carbon that occurred during the stages of woody vegetation recovery, from the abandonment of cropland and pasture, were analyzed in two stages of time. This means that only areas that changed from non-forest use to forest were counted. *Source:* Semarnat-INE. 2009, pp. 24-25.	D	Yes	NA
5D	Wetlands	NE	NE	NE	NE	NA	NA
5E	Settlements	NE	NE	NE	NE	NA	NA

5F	Other lands	NE	NE	NE	NE	NA	NA
5G	Other (Land Use Change & Forestry)	NE	NE	NE	NE	NA	NA
6	**Waste**						
6A	Solid Waste Disposal	CH_4	Uses the IPCC (1996) default method; does not correspond to a specific tier in 2006 IPCC Guidelines(Volume 5)	Using country-specific waste disposal data, the inventory develops emissions estimates for three representative landfill types based on management practices, using IPCC defaults for methane conversion factors (MCFs), degradable organic content (DOC), fraction of DOC that dissimilates, portion of landfill gas that is CH_4 (Semarnat-INE 2011, p. 7-19). Does not estimate k values. Does not use a first-order decay model to estimate CH_4 emissions. See flow chart on p. 7-98 (Semarnat-INE 2011).	D	No differences noted.	None
6B	Wastewater Handling	CH_4, N_2O	Tier 1 for CH_4 emissions from domestic and industrial wastewater	For domestic and commercial wastewater, uses IPCC default factors of maximum methane-producing capacity (B_o) for wastewater and sludge handling systems, IPCC default MCF factors based on the type of system (septic systems, facultative lagoons, and direct discharge), and country-specific estimates of the type of systems used for wastewater treatment and disposal. See flow chart on p. 7-101 (Semarnat-INE 2011). Equivalent to a Tier 2 approach based on 2006 IPCC Guidelines (Volume 5, p. 6.10). For industrial wastewater, country-specific information on COD, wastewater outflow was used with IPCC default values for B_o and MCF based on country-specific information on wastewater treatment practices. See Flow chart on p. 7-105 (Mexico 2008). Equivalent to a Tier 2 approach based on 2006 IPCC Guidelines (Volume 5, p. 6.19).	D (Bo and MCF factors) CS (wastewater treatment practices)	No differences noted.	None

				IPCC default N_2O emission factors are used to estimate N_2O emissions from human sludge according to the method described in IPCC (1996, p. 6.28).			
6C	Waste Incineration[46]	CO_2 (non-biogenic), N_2O	Tier 1	CO_2 and N_2O emissions from incineration of hospital and hazardous waste are calculated from country-specific estimates of the amount of waste incinerated and IPCC default values. Closest to a Tier 1 approach based 2006 IPCC Guidelines (Volume 5, pp. 5.9, 5.12).	D	No differences noted.	None
6D	Other (Waste)	NA	NA	NA	NA	NA	NA
	Waste Sources of Indirect GHG Emissions[47]	NA	NA	NA	NA	NA	NA

Table 21. Sector-Specific Questions for National GHG Inventories

Sector	Question	Canada	United States	Mexico
Energy	Cogeneration (Electricity & Steam) Facilities: Are emissions from utility and industry generated combined heat and power plants captured under public electricity generation subsector or has there been an allocation to the appropriate industrial subsector?	Allocated to the appropriate industrial subsector.	Captured under public electricity generation subsector.	Could not be ascertained.
Energy	Non-energy use of fuels: have these been accounted for? And if so, do they reside under the energy or industrial processes sectors?	Yes, non-energy uses of fuels are accounted for; these estimates are included in the IP sector under "Other & Undifferentiated Production" (2G).	Yes, non-energy uses of fuels are accounted for, and included in the energy sector.	Yes, these have been calculated and included in the energy sector.

[46] CH4 emissions from waste incineration are not estimated.
[47] Estimates of indirect GHG emissions (e.g., CO, NOx, NMVOC, SOx) were not located in the waste sector.

Waste	Application of wastewater treatment biosolids: provided in the wastewater treatment or agricultural sectors?	Uncertain. Inclusion of biosolids or human sewage applications to land is not stated in waste section. Application of wastewater treatment biosolids is not discussed under direct N_2O emissions from agricultural soils (Environment Canada 2011c, Part 1, p. 157).	Biosolids application is included in agricultural sectors (EPA 2011a, p. 7-40). N_2O emission estimates for N disposal into aquatic environments are reduced to account for the removal of N for application on land (p. 8-14).	Could not be ascertained. Inclusion of biosolids or human sewage applications to land is not stated in waste section. Application of wastewater treatment biosolids is not discussed under direct N_2O emissions from agricultural soils (pp. 4-11, 4-12).
Waste	Biogenic CO_2: has this been accounted for and, if so, how has it been presented in the relevant sectors (i.e., as background information or in the reported emission estimates)?	Biogenic CO_2 emissions from waste are not included in the waste sector. CO_2 emissions from the incineration of fossil-carbon in waste are included in incineration emissions, although application of manure is included (Environment Canada 2011c, Part 2, p. 159). Biogenic CO_2 emissions from landfills and wastewater treatment are not included in the waste sector (Environment Canada 2011c, Part 1, p. 201).	Biogenic CO_2 emissions from waste are not included in the waste sector. Net carbon fluxes from changes in biogenic carbon reservoirs (i.e., carbon storage in landfills from biogenic wastes) are accounted for in the estimates for Land Use, Land-Use Change, and Forestry sector of the US GHG Inventory. (EPA 2011a, p. 3-34).	Biogenic CO_2 emissions from waste are not included in the waste sector. CO_2 emissions from the incineration of fossil-carbon in waste are included in incineration emissions. Biogenic CO_2 emissions from landfills and wastewater treatment are not included in the waste sector.
LULUCF	Forest GHG emissions/sinks: are all forests treated as managed forests?	No. Monitoring of forest conversion activity covers all forest areas of Canada, and is not limited to the managed forest. (Source: Environment Canada 2011c, Part 2 Annex 3.4.2)	Yes. For the purpose of the GHG inventory, managed forests are those managed for timber and non-timber resources (including parks) or subject to fire protection. Forest Land: A land-use category that includes areas at least 36.6 m wide and 0.4 ha in size with at least 10 percent cover (or equivalent stocking) by live trees of any size, including land that formerly had such tree cover and that will be naturally or artificially regenerated. Forest land includes transition zones, such as areas between forest and non-forest lands that have at least 10 percent cover (or equivalent	Yes. In the country there are no statistics collected for forests on a regular basis, or systematic use of methodologies consistent over time to maintain a time series. These challenges have led to significant gaps in forestry data that are required to develop the GHG inventory, specifically regarding the estimation of GHG dynamic flows. Note that the national forest and soil inventory began in 2004, and aims to establish a network of monitoring plots that contributes to ongoing provision of information changes over time in the reservoirs of C in forest ecosystems, so it is

			stocking) with live trees and forest areas adjacent to urban and built-up lands. Roadside, streamside, and shelterbelt strips of trees must have a crown width of at least 36.6 m and continuous length of at least 110.6 m to qualify as forest land. Unimproved roads and trails, streams, and clearings in forest areas are classified as forest if they are less than 36.6 m wide or 0.4 ha in size; otherwise they are excluded from Forest Land and classified as Settlements. Tree-covered areas in agricultural production settings, such as fruit orchards, or tree-covered areas in urban settings, such as city parks, are not considered forest land (Smith et al. 2009). NOTE: This definition applies to all US lands and territories. However, at this time, data availability is limited for remote or inaccessible areas such as interior Alaska. (Source: US-GHG-Inventory LULUCF (Ch.7) pg. 7 of 72.)	expected that the next national inventory of GHG will have a smaller uncertainty in this section.

All	Biogenic CO_2: has this been accounted for and, if so, how has it been presented in the relevant subsector (i.e., as background information or in the reported emission estimates)?	Yes, biogenic CO_2 is accounted for and presented for certain sectors for informational purposes. "For reporting under the UNFCCC, CO_2 emissions from biomass fuels (including landfill gas) are not included in the Energy Sector total. CO_2 emissions from biomass fuel combustion are accounted for in the Land Use, Land-Use Change and Forestry (LULUCF) Sector as a loss of biomass (forest) stocks. CO_2 from biomass combustion for energy purposes is reported as a memo item of the UNFCCC's Common Reporting Format (CRF) table for information only." (Part 2, p. 28) In general, "CO_2 emissions of biogenic origin are not reported if they are reported elsewhere in the inventory or if the corresponding CO_2 uptake is not reported in the inventory (e.g., annual crops)." (NIR Pt.1, p. 194). p. 95 of NIR Pt. 1 states, "As per the UNFCCC reporting guidelines, CO_2 emissions from the combustion of biomass used to produce energy are not included in the Energy Sector totals but are reported separately as memo items. They are accounted for in the LULUCF Sector and are recorded as a loss	Yes, biogenic CO_2 is accounted for and presented as a line item in the Energy sector for informational purposes. "In accordance with IPCC methodologies, biomass emissions are calculated by accounting for net carbon fluxes from changes in biogenic C reservoirs in wooded or crop lands (and included in the LULUCF sector/chapter)." "In line with the reporting requirements for inventories submitted under the UNFCCC, CO_2 emissions from biomass combustion have been estimated separately from fossil fuel CO_2 emissions and are not directly included in the energy sector contributions to US totals. In accordance with IPCC methodological guidelines, any such emissions are calculated by accounting for net carbon (C) fluxes from changes in biogenic C reservoirs in wooded or crop lands." That is, they are accounted for in the LULUCF chapter. (NIR, p. 3-59) Emissions from lime regenerated from spent pulping liquors at pulp mills are recorded as a change in forest stock in LULUCF, since the emissions are biogenic. (NIR p. 4-10). "When wastes of biogenic origin	Yes, biogenic CO_2 is accounted for and included as a line item in the energy sector. They estimate non-biogenic sources of CO_2 emissions from incineration of wastes. (4th NC, p. 83).

		of biomass (forest) stocks. CH_4 and N_2O emissions from the combustion of biomass fuels for energy are reported in the fuel combustion section in the appropriate categories." Emissions from lime regenerated from spent pulping liquors at pulp mills are recorded as a change in forest stock in LULUCF, since the emissions are biogenic. (NIR Pt.1, p. 105). Biogenic CO_2 emissions from MSW and sludge incineration are not counted. (NIR Pt. 1, p. 203) CO_2 from biomass combustion for energy purposes is reported as a memo item of the UNFCCC's Common Reporting Format (CRF) table for information only.	(such as yard trimmings and food scraps) are landfilled and do not completely decompose, the C that remains is effectively removed from the global C cycle." (NIR p. 7-56) In accordance with IPCC methodological guidelines, any such emissions are calculated by accounting for net carbon (C) fluxes from changes in biogenic C reservoirs in wooded or crop lands.	

APPENDIX E: Subnational GHG Inventory Assessment

This table contains comparability metrics that apply to subnational GHG inventories in Canada, the US, and Mexico, and identifies key differences between each country's subnational and national GHG emissions inventories.

Table 22. Comparability of Subnational GHG Inventories to National Inventories

	United States		Canada		Mexico	
Category	**US States**	**Key Differences Identified with US National Inventory**	**Canadian Provinces**	**Key Differences Identified with Canada National Inventory**	**Mexican States**	**Key Differences Identified with Mexico National Inventory**
Scope: Sector & GHG Coverage						
GHG Coverage	Primarily includes CO_2, CH_4 and N_2O; sometimes HFC, PFC, and SF_6 are estimated in the Industrial Processes sector.	All 6 are covered at the state-level; however, not as many sources are included under the HFC, PFC, and SF_6; the level of detail is greater in the national inventory.	Ranges from 3 (CO_2, CH_4 and N_2O) to 6 major GHGs. One province reports in CO_2e-only.	The level of detail included in the NIR is greater than the level of detail in the provincial inventories.	Ranges from CO_2, CH_4 and N_2O (Chiapas) to all 6 Kyoto gases (remaining)	Some state inventories do not include fluorinated gases.
Sector Coverage		All of the major sectors are included by both national and subnational inventories. Subnational inventories tend to include fewer emission source categories than the national inventory because not all states have all source categories.		All of the major sectors are included by both national and subnational inventories. Subnational inventories tend to include fewer emission source categories than the national inventory because not all states have all source categories.		All of the major sectors are included by both national and subnational inventories. Subnational inventories tend to include fewer emission source categories than the national inventory because not all states have all source categories.

Energy	Yes		Yes		Yes	
Industrial Processes and Solvents	Yes		Yes		Yes	
Agriculture	Yes		Yes		Yes	
Land Use, Land Use Change, and Forestry	Yes		Included for Manitoba and Northwest Territories but not for Quebec	LULUCF is included for the NIR for all provinces	Yes	
Waste	Yes		Yes		Yes	
Other	NA		NA		NA	
Geographical Coverage	31 states have completed GHG inventories.	US Territories are included in the energy sector of the national inventory; however they do not prepare subnational GHG inventories.	At least 5 of 13 provinces and territories have completed inventories or compiled reported emissions. The provinces that have completed these reports are: Alberta, British Columbia, Manitoba, Northwest Territories, and Quebec.	The NIR covers all provinces within Canada at least a high level.	At least 10 of 31 Mexican states have compiled GHG emissions inventories, and several others have GHG inventories or Climate Action Plans in development. Completed inventories include Chiapas, Sonora, Baja California, Coahuila, Nuevo León, Chihuahua, Tamaulipas, Veracruz, Distrito Federal, and Guanajuato.	
Emissions Estimation Methods & Data Source						
Methodology Used (Describe if not just default approach)	Methodology follows IPCC Guidelines (2006); National Inventory Report		2006 IPCC Guidelines; National Inventory Report		Four inventories use 2006 IPCC Guidelines (Baja California, Nuevo León, Chihuahua and Tamaulipas). Others use EPA	A number of Mexican state inventories use 2006 IPCC Guidelines methods, as opposed to IPCC 1996 methods. The

					inventory methods and those in the INEGEI (National GHG Emissions Inventory), which are based on IPCC 1996 IPCC Guidelines	inventories prepared by CCS have tables comparing methods for main emission sources to those of the national inventory.
IPCC Tier Levels	Tier 1 and Tier 2 (depending on data availability) Energy: Tier 1 for fossil fuel combustion, Tier 2 for transportation (if state-level data/emission factors are available); With GHG reporting rule beginning, some states might have Tier 3 estimates IP & Solvents: Mostly Tier 1; With GHG reporting rule, some states might have Tier 3 estimates Agriculture: Mostly Tier 1 LULUCF: Tier 1 and/or Tier 2 depending on state-specific data/studies conducted	The national-level inventory uses higher tier levels due to greater data availability.	Tiers 1, 2, and 3 (Some provincial inventories use results from the NIR and present them as their own provincial inventories). Mostly Tier 1 and 2.	Most provinces use Tier 1 and Tier 2 IPCC levels. British Columbia and Manitoba use the NIR data for their provincial reports and therefore use the same tiers as the NIR.	Tier 1	Mexico's subnational inventories use all tier 1 methods, while the national inventory uses some Tier 2 methods, depending on the source.

	Waste: Tier 1 and/or Tier 2					
Description of Higher Tier Methods	Higher Tier methods involve both state-specific (or facility-specific) data and emission factors. The GHGRP will provide data at a higher Tier level.		NA		NA	
Country-Specific (CS) or Default (D) Emission Factors Used?	Mostly default national-level factors are used since most states do not have the resources to develop state or process specific emission factors. To estimate emissions from fossil fuel combustion, national factors are typically used.		CS, D		Primarily D, some CS where available	Both use mainly D, some CS if available
Proprietary Data?	None identified.	The National-level inventory uses proprietary data from voluntary reporting programs for some sources; and these data are unavailable at the state level.	Yes. Numerous source categories rely on confidential business information and business sensitive data provided to Environment Canada and provincial governments for the NIR and provincial inventories by industry.		None identified.	

Vintage of Most Recent Activity Data	Energy: EIA State Energy Data (released in 2011, data through 2009) IP & Solvents: Varies by process; most data available through 2009. Agriculture: Varies by animal and crop type, however most data from USDA NASS is available through 2010. LULUCF: Data available through 2009 Waste: Varies widely by state or locality; national data sources are not available for waste.	National inventory has most up to date activity data.	2006-2009	National Inventory Report has the most consistent up-to-date information. Depends on province.	Typically 2000-2005, depending on the sector.	
Uncertainty	Uncertainty is not estimated by most states.	Estimated at the national level, but typically not by states.	Not reported	Not reported for provincial inventories, included in NIR.	Uncertainty is not estimated by most states.	Uncertainty is estimated for the national inventory, but not for the subnational inventories.
Transparency: Documentation of Methods	Methodologies are typically well documented.	National inventory has better documentation of methodologies.	Methodologies are typically well documented.		Yes - 6 of 7 inventories have detailed documentation of methodologies	

Models Used	Most states use EPA's State Inventory Tool and note where any deviations from the tool exist.	Models are used to a greater extent at the national level then at the state level.	Canada's Mobile Greenhouse Gas Emission Model (MGEM); Scholl Canyon model; Canadian Forest Service Carbon Budget Model (CBM)		EPA's State Inventory Tool, First Order Decay Model (2006 IPCC Guidelines), IPCC Waste Model	
Data Sources	Federal agency data sources are used (such as EIA's State Energy Data); however, if state-specific data exists, that is the preferred data source and used in place of the federal agency statistics.	National-level data is scaled down for some sources to estimate state-level activity data.	Wide variety, including: federal departments (e.g., Statistics Canada, NRCan, Environment Canada); provincial ministries; census data; inventories and other reports from industry associations, institutes, and research centres; private sector consulting; academic institutions; peer-reviewed journals and literature;		Instituto Nacional de Ecología (INE), Secretaría de Medio Ambiente y Recursos Naturales (Semarnat), PEMEX Gas y Petroquimica, PEMEX Refinación, Secretaría de Energia (Sener), Comisión Federal de Electricidad (CFE), Secretaría de Agricultura, Ganaderia, Desarrollo Rural, Pesca y Alimentación (Sagarpa), Comisión Nacional Forestal (Conafor), Comisión Nacional del Agua (Conagua) Instituto Nacional de Estadística y Geografía (Inegi)	Both use national agencies.
Other Items	NA		Some provinces, such as British Columbia and Manitoba, present finished results from	Some provinces such as British Columbia and Manitoba present finished results from	NA	

			the NIR as their own provincial GHG inventory. Others, such as the Northwest Territories, create their own separate GHG inventory with differing results from the NIR.	the NIR as their own provincial GHG inventory. Other provinces such as the Northwest Territories create their own separate GHG inventory with differing results from the NIR.		
Inventory Processes/Systems						
Lead Agency	Many state-level GHG inventories were developed by states working/contracting with the Center for Climate Strategies using the State Inventory Tools (http://www.climatestrategies.us/library/library/index/50). Since these were developed (circa 2007/2008), states have adopted, updated, and improved these inventories to account for updated data and methodology.		Regions have individual Ministries of the Environment		Center for Climate Strategies (CCS) prepared 6 inventories; Conservation International; Universities	The National Institute of Ecology prepares the national inventory, whereas state inventories are prepared by state environmental agencies and their consultants.

Procedural Arrangements (data sharing and integration with other agencies, other issues)	Since there are many common data elements between air pollution inventories and GHG inventories, many state and local air pollution departments are tasked/responsible with collecting data that could be used in both an air pollution inventory and their GHG inventory. State transportation and energy departments also have significant input into the inventory process as they often times have state-specific data and/or models that are used to estimate emissions.		Provincial: Ministry of Forests and Range; Ministry of Agriculture and Lands; Ministry of Energy, Mines and Petroleum Resources Federal: Environment Canada; Canadian Forest Service (NRCan); Agriculture and Agri-Food Canada; Statistics Canada		State environmental agencies and their consultants work with state government and universities to prepare state inventories.	
Legal Arrangements (contracts, MOUs)	NA		Varies: Some provinces use a threshold for reporting and require all those emitters to report, while some provinces have no agreements.	Legal arrangements exist so that national data comes from more facilities than provincial data.	NA	
Description of Data Management System: Available Tools and Capacity	NA		NA		NA	

Recordkeeping and Archiving Procedures	NA		NA		NA	
QAQC Process/Quality Management	NA		Similar to NIR		Inventories use a basic framework for QAQC, and focus primarily on transparency and consistency.	The QAQC process for the national inventory is more developed than at the subnational level.
Participation and Review	NA		NIR data is reviewed in the NIR process. Some provinces such as British Columbia and Manitoba use the NIR results directly for their inventories and therefore these inventories indirectly have public comment periods.	Many provincial inventories have no formal public comment periods. The NIR does solicit comments from the public.	Report data sources, methods, and key assumptions are open to review	
Verification	NA		None additional to NIR, as some provinces use NIR results for their own provincial inventories.	The NIR and data used from the NIR in provincial inventories goes through a formal verification process.	None identified.	
Inventory Publication / Reporting Purpose (Communication, Education & Outreach)	Most states post their inventories on the state department of environment's website, or if they were developed by the Center for Climate Strategies they are posted on the CCS website. In many instances, the GHG inventory is the beginning point	National inventory is submitted to the UN.	Outreach is accomplished through provincial websites that distribute GHG inventories.	The NIR is submitted to the UN.	The 6 inventories prepared by CCS are available online. The executive summary of Chiapas's inventory is available online. In addition, many states have individual climate change websites.	

	for a state to develop a climate action plan to reduce GHG emissions (http://www.climatestrategies.us/policy_tracker/state/).					
Main Drivers/Objectives						
Promote Reductions / Mitigation	GHG inventories at the state-level are often an initial (and necessary) step in the climate action planning process. States and localities first estimate emissions to evaluate the number of sources as well as the magnitude of emissions.	State inventories can be included in a state climate action plan, whereas this does not happen at the national level.	GHG inventories are used for Climate Action Plans, and government planning and initiatives such as Carbon Neutral Government, Forest Carbon Offset Protocol, and energy planning.	Provincial inventories largely used to fuel many different mitigation initiatives, whereas the NIR is mostly used to frame national emissions, meet UN obligations, and in developing climate change policy.	The inventory and forecast estimates serve as a starting point to assist states with an initial comprehensive understanding of each state's current and possible future GHG emissions	State inventories are more likely to be included in a state climate action plan, whereas this does not happen at the national level.
National, Bi-lateral Agreements, Markets	While the WCI does not *require* compiling a GHG inventory for each state, the initiative requires reporting of GHG emissions by the largest emitters (WCI beginning in 2012). For the RGGI, the ten states participating in RGGI have		Markets and agreements include: International Carbon Action Partnership, Western Climate Initiative (WCI), and the Climate Registry.		Climate Action Reserve.	

	established a regional cap on CO_2 emissions from the power sector and are requiring power plants to possess a tradable CO_2 allowance for each ton of CO_2 they emit, and to invest auction proceeds in energy efficiency and renewable energy programs. States participating in RGGI have adopted regulations to limit CO_2 emissions from electric power plants, establish participation in CO_2 allowance auctions, create CO_2 allowances and determine appropriate allowance allocations (http://www.rggi.org/design/regulations).					
Legal Requirements	NA		No provinces have legal requirements to create GHG inventories, though some do participate in regional agreements such as the International Carbon Action Partnership,	The authority to compile the NIR is provided under the Canadian Environmental Protection Act. Legal requirements for provinces to create GHG inventories were not identified.	None identified.	

			Western Climate Initiative (WCI), and the Climate Registry.			
Government-Industry Relationships (e.g., nationalized/utilities)	NA	Voluntary reporting programs are more prevalent at the national level (magnesium, aluminum, semiconductors, electric power T&D).	Those large emitters and those that report for the NIR also have reporting relationships to each respective province.		NA	

APPENDIX F: $PM_{2.5}$ and Black Carbon SPECIATE4.2 Source Profiles

This table is developed from EPA's SPECIATE v4.2 based on the supplementary information provided by Chow et al. (2011) and revised per communication with EPA experts. This set of speciation profiles provides the foundation for estimating black carbon emissions from $PM_{2.5}$ inventory data. As noted, communication with Canadian experts suggested different speciation profiles were used for some sources within biomass combustion.

Table 23. Speciation Profiles for Estimating Black Carbon Emissions

Source Category	SPECIATE Source Profile ID	SPECIATE v4.2 (%)
Stationary Sources		
Lignite Coal Combustion	4367	2.72
Bituminous Coal Combustion	91048	1.7
Anthracite Coal Combustion (average of Lignite, Bituminous, and Subbituminous Coal Combustion)	91048, 92084, 4367	2.1
Unspecified Coal Combustion (average of Bituminous and Subbituminous)	91048, 92084	1.79
Subbituminous Coal Combustion	92084	1.88
Aluminum Production	92002	2.3
Secondary Aluminum	92076	0.19
Ammonium Nitrate Production	92003	0
Asphalt Manufacturing	92005	5.72
Asphalt Roofing	92006	0.01
Calcium Carbide Furnace	92011	1.2
Cast Iron Cupola	92012	1
Catalytic Cracking	92013	0.07
Cement Production	92014	2.96
Charcoal Manufacturing	92016	5.2
Chemical Manufacturing	92017	1.83
Coke Calciner	92019	0
Copper Production	92021	0
Distillate Oil Combustion	92025	10
Electric Arc Furnace	92026	0.36
Ferromanganese Furnace	92027	10.12
Fiberglass Manufacture	92028	2
Food & Agriculture - Handling	92030	0.18
Food & Agriculture - Drying	92031	0
Glass Furnace	92033	0.06
Gypsum Manufacture	92034	0
Heat Treating	92036	1
Industrial Manufacturing – Avg	92037	0.89
Kraft Recovery Furnace	92041	1.53

Lead Production	92043	0
Mineral Products - Avg	92047	1.47
Natural Gas Combustion (LPG)	NA[c]	13
Petroleum Industry - Avg	92054	0
Pulp & Paper - Avg	92061	2.63
Secondary Copper	92077	0.1
Secondary Lead	92078	0
Solid Waste Combustion	92082	1.52
Surface Coating	92085	0.7
Wood-fired Boiler	92091	13.8
Wood Product Drying	92092	4.38
Wood Product Sanding	92093	6
Wood Product Sawing	92094	3.8
Mining and Quarrying (Gold mining average)	3466-3475	0.32
Gas Process Heater	NA[d]	6.3
Gas-fired Internal Combustion Co-generation	NA[d]	2.5
Area Sources		
Agricultural Burning (Canada applies a different speciation profile)	92000	10.9
Wildfires (Canada applies a different speciation profile)	92090	9.49
Sludge Combustion	92081	1.52
Slash Burning	92080	5.95
Prescribed Burning	92059	10.93
Residential Coal Combustion	92062	23.95
Residential Natural Gas Combustion (LPG)	92063	0
Residential Wood Combustion: Hard/Softwood	92068	5.58
Residential Wood Combustion: Synthetic	92071	12.5
Residual Oil Combustion	92072	1
Charbroiling	92015	4.06
Meat Frying	92046	0
Potato Deep-Frying	92058	4
Agricultural Soil	92001	0.02
Brake Lining Dust	92009	2.61
Construction Dust	92020	0
Paved Road Dust	92053	1.04
Sand and Gravel	92073	0
Tire Dust	92087	22
Unpaved Road Dust	92088	0.1
Mobile Sources		
On-road Gasoline Exhaust	92050	20.8
On-road Gasoline Exhaust (United States) (LDGV)*	91022	NA
Non-catalyst Gasoline Exhaust	92049	10.01
Heavy-Duty Diesel (HDDV)	92035	77.12

Light-Duty Diesel (LDDV)	92042	57.48
Aircraft	3861	76
Aircraft (United States)*	Used a BC/$PM_{2.5}$ ratio of 13% with no speciation profile	

*Provided by communication with US black carbon experts.

APPENDIX G: Black Carbon Sector-Level Matrix

This table contains the comparability matrix that applies to individual emission sources within each country's national BC and $PM_{2.5}$, where applicable, emissions inventories.

Table 24. Assessment of Emissions Estimation Methods & Data Sources for Canada, US, and Mexico Black Carbon Inventory

		Canada	United States	Mexico
A. Scope and Accounting Methods				
Power Generation / Fossil Fuel Combustion				
	Definition	Electricity and heat generation	Natural gas combustion, bituminous combustion, sub-bituminous combustion, distillate oil combustion, wood-fired boiler, process gas combustion, $PMSO_2$-controlled lignite combustion	Utilities - electricity generation
	BC (or $PM_{2.5}$ Emissions) and Percentage of Total	210 metric tonnes BC (0.3%) (2006 inventory, EC 2011c, p. 4)	39,484 metric tonnes BC (7%) (2005 inventory, EPA 2011b, p. 4-10)	62,885 metric tonnes $PM_{2.5}$ (3%) (Semarnat 2006)
	Data Gathering and Observations for $PM_{2.5}$	Facilities may use different methods to determine how much of a particular substance they release, dispose of or recycle. These methods may vary depending on the substance or the facility and may also change from year to year. Estimation and direct measurement are examples of these methods. Used annual emissions from facilities reporting to NPRI. Annual emissions from upstream oil and gas sources. [ORL_POINT2006_Mar08; ORL_UOG2006_Mar08 of the Pollution Data Division (PDD)]	$PM_{2.5}$ emissions from NEI estimated by the filterable (solid) and condensable (gaseous) fractions of direct $PM_{2.5}$ emitted.	$PM_{2.5}$ emissions for INEM
	$PM_{2.5}$ Data Quality			Not determined
	Methodology for Estimating $PM_{2.5}$ Emissions	EPA AP-42 emission factors are applied to activity data to determine $PM_{2.5}$ emissions.	For most stationary sources, $PM_{2.5}$ emissions are derived using a scaling factor applied to a collection of filterable total PM and the PM_{10} size fractions. Some local/state and site-specific standards also require testing for PM_{10} and $PM_{2.5}$ mass. EPA's AP-42 emission factors are used. (EPA 2011b, Appendix 1-12) Basic method for estimating $PM_{2.5}$ emissions was multiplying activity data by an AP-42 emission factor. More recently, a FIRE 6.25 Data System has	Emissions of $PM_{2.5}$ from combustion are mostly estimated using emission factors from EPA (AP-42), in a few cases $PM_{2.5}$ ratios from CARB are applied with respect to PST.

		Canada	United States	Mexico
			been used to store emission factors (EPA 2011b, Appendix 2-2)	
	Black Carbon Monitoring and Observations	N/A	N/A	Not done
	Methodology/Model for Estimating BC Emissions	Speciation profiles obtained from US EPA's SPECIATE4.2 database to approximate BC mass fractions for specific Source Category Codes (SCC). These mass fractions were multiplied by Canada's overall $PM_{2.5}$ emissions to determine BC emissions (Arctic Council 2011, p. 3-18 and 3-19)	SPECIATE	Not done
	Source Profile Used (What is it based on?)		Speciation profiles applied as discussed in Reff et al. (2009) Natural gas combustion BC emissions use BC/$PM_{2.5}$ ratio of 0.38, which leads to relatively large BC emissions estimates (EPA 2011b, p. 4-14)	Not determined
	Key Uncertainties			
	$PM_{2.5}$		Some $PM_{2.5}$ emission factors are more reliable than others (NARSTO 2002) Level of uncertainty associated with the methodology estimating condensable PM by source category The activity levels used in estimating $PM_{2.5}$ emissions Scaling of PM to $PM_{2.5}$	Not determined
	Black Carbon	Possible improvements: The profiles relating to both ECa (apparent elemental carbon) and OC are relatively generic and may be improved upon further research and improve surrogates used for spatial allocation of emission estimates (Arctic Council 2011, p. 3-22)		Not determined
	Comparable to Other Country Sectors			
2.	**Biomass combustion**			

		Canada	United States	Mexico
2A	**Wildfires**			
	Definition	Forest fires	Wildfires	
	BC (or $PM_{2.5}$ Emissions) and Percentage of Total	20,050 metric tonnes BC (27%) (2006 inventory, EC 2011c, p. 4)	137,761 metric tonnes BC (24%) (based on 2002 RPO estimates as provided by EPA 2011b, p. 4-10)	53,628 metric tonnes $PM_{2.5}$ (5.6%) (Semarnat 2006)
	Data Gathering and Observations for $PM_{2.5}$	Activity data used in the PM-inventory is area burned (used ORL_FORESTFIRE2006 of the pollution data division (PDD)). Biomass consumed per area burned is set as a constant for all of Canada (EC 2011c, p.11) BC emissions from forest fires were estimated using a constant value of biomass consumed per area burned for all of Canada (Arctic Council 2011, p. 3-19)	Open biomass burning (wildfires, agricultural burning, and prescribed burning) emissions inventory from Regional Planning Organizations (RPOS) in 2002 (EPA 2011b, p. 4-3)	$PM_{2.5}$ emissions from INEM
	$PM_{2.5}$ Data Quality			
	Methodology for Estimating $PM_{2.5}$ Emissions	$PM_{2.5}$ emission factor (mass basis) is a constant regardless of year, location, burning conditions, or completeness of the burn (EC 2011c, p. 11)	For most stationary sources, $PM_{2.5}$ emissions are derived using a scaling factor applied to a collection of filterable total PM and the PM_{10} size fractions. Some local/state and site-specific standards also require testing for PM_{10} and $PM_{2.5}$ mass. EPA's AP-42 emission factors are used. (EPA 2011b, Appendix 1-12) Basic method for estimating $PM_{2.5}$ emissions was multiplying activity data by an AP-42 emission factor. More recently, a FIRE 6.25 Data System has been used to store emission factors (EPA 2011b, A 2-2)	Emission factors from FIRE 6.22 FIRE 6.23 AIR CHIEF 12 and CARB 2002
	Black Carbon Monitoring and Observations	N/A	N/A	
	Methodology/Model for Estimating BC Emissions	EPA's SPECIATE database	SPECIATE	BC is not determined
	Source Profile Used (What is it based on?)	$PM_{2.5}$ elemental carbon (ECa) profile in SPECIATE is derived from a small set of experimental data, which is not representative of emissions from northern wildfires (EC 2011c, p. 11)	Speciation profiles applied as discussed in Reff et al. (2009)	

		Canada	United States	Mexico
	Key Uncertainties		Estimating accurate activity levels…"considerable effort has been devoted recently to the characterization of emissions and activity patterns for non-point sources. Another example is the estimation of emissions from fires, which depends upon knowledge of the time, location, and areal extent of the burn, fuel loading, types of combustible material and moisture content. Recent efforts by EPA include the use of process modeling and remote sensing data to better estimate fire activity patterns and emissions from fires (BlueSkyFramework 2009)."(EPA 2011b, Appendix 2-4)	
	$PM_{2.5}$	$PM_{2.5}$ EFs are constant, and do not take into account varying factors such as year and location (EC 2011c, p. 11)	Estimates are only from 2002 (EPA 2011b, p. 4-3) Most AP-42 emissions factors do not quantify the condensable fraction of total $PM_{2.5}$ emissions. "Gap filling" techniques are used to estimate condensable $PM_{2.5}$ which introduces uncertainty in the emission estimates (EPA 2011b, Appendix 2-3)	
	Black Carbon	$PM_{2.5}$ elemental carbon profile in SPECIATE is derived from a small set of experimental data, which is not representative of emissions from northern wildfires (EC 2011c, p. 11)		Not determined
	Comparable to Other Country Sectors	Area	Area	
2B	**Agricultural Burning/Prescribed**			
	Definition	Agriculture (prescribed burning)	Agricultural burning, prescribed burning	
	BC (or $PM_{2.5}$ Emissions) and Percentage of Total	440 metric tonnes BC (0.6%) (2006 inventory, EC 2011c, p. 4)	66,000 metric tonnes BC (11%) (based on 2002 RPO estimates as provided by EPA 2011b, p. 4-3)	
	Data Gathering and Observations for $PM_{2.5}$	$PM_{2.5}$ emissions from NPRI - air pollutant emission summaries and trends are compiled using emissions reported by facilities to the NPRI as well as emissions estimated by Environment Canada using the latest published statistics or other sources of information such as surveys and reports (http://www.ec.gc.ca/inrp-npri/default.asp?lang=En&n=5C71562D-1) (Using ORL_SLASHBURNING 2006 of Pollution Data Division (PDD))	Open biomass burning (wildfires, agricultural burning, and prescribed burning) Emissions inventory from Regional Planning Organizations (RPOS) in 2002 (EPA 2011b) Biomass burning is a nonpoint source category classified as stationary sources in the NEI. (EPA 2011b, Appendix 2-2)	$PM_{2.5}$ emissions from INEM
	$PM_{2.5}$ Data Quality			

		Canada	United States	Mexico
	Methodology for Estimating $PM_{2.5}$ Emissions	Emissions from residue burning on agricultural land estimated by applying an emission factor directly to the residue biomass burned each year (Arctic Council 2011, p. 3-22)	For most stationary sources, $PM_{2.5}$ emissions are derived using a scaling factor applied to a collection of filterable total PM and the PM_{10} size fractions. Some local/state and site-specific standards also require testing for PM_{10} and $PM_{2.5}$ mass. EPA's AP-42 emission factors are used. (EPA 2011a, Appendix 1-12) Basic method for estimating $PM_{2.5}$ emissions was multiplying activity data by an AP-42 emission factor. More recently, a FIRE 6.25 Data System has been used to store emission factors (EPA 2011a, Appendix 2-2)	Emission factors from FIRE 6.22 FIRE 6.23 AIR CHIEF 12 and CARB 2002
	Black Carbon Monitoring and Observations	N/A	N/A	
	Methodology/Model for Estimating BC Emissions	Agricultural (Crop burning) BC emissions were calculated by EC's GHG Division by using the emission factor from Andreae & Merlet 2001, based on dry matter burned for different crops (EC 2011c, p. 10)	SPECIATE	BC is not determined
	Source Profile Used (What is it based on?)		Speciation profiles applied as discussed in Reff et al. (2009)	
	Key Uncertainties			
	$PM_{2.5}$		Estimates are only from 2002 (EPA 2011b, p. 4-3) Most AP-42 emissions factors do not quantify the condensable fraction of total $PM_{2.5}$ emissions. "Gap filling" techniques are used to estimate condensable $PM_{2.5}$ which introduces uncertainty in the emission estimates (EPA 2011b, Appendix 2-3)	
	Black Carbon	Could be improved by: further refining estimates of the fractions of PM that are BC and OC; developing improved ways of spatially allocating estimates; and obtaining better estimates of PM from forest fires		
	Comparable to Other Country Sectors	Area	Area	
3.	**Mobile On-Road**			
	Definition	Road transport gasoline, road transport diesel	On-road diesel, on-road gasoline, tire, brakewear This includes passenger cars, motorcycles, minivans, sport-utility vehicles, light-duty trucks, heavy-duty trucks, and buses.	Motor Vehicles, transportation

		Canada	United States	Mexico
	BC (or $PM_{2.5}$ Emissions) and Percentage of Total	6,340 metric tonnes BC (8%) (2006 inventory, EC 2011c, p. 4)	153,913 metric tonnes BC (27 %) (2005 inventory, EPA 2011b, p. 4-10)	18,845 metric tonnes $PM_{2.5}$ (2%) (Semarnat 2006)
	Data Gathering and Observations for $PM_{2.5}$	$PM_{2.5}$ emissions from NPRI (Using monthly mobile inventories, e.g., ORL_ONROAD2006B00_Jan,… of Pollution Data Division (PDD)) On-road mobile inventories for $PM_{2.5}$ emissions contain average day emissions by month from on-road mobile sources;	N/A (BC emissions are measured directly)	Exhaust emissions from vehicles that travel on roadways, including private automobiles, motorcycles, taxis, buses, and heavy-duty diesel trucks (Semarnat 2006, 2-5); Estimates of $PM_{2.5}$ were determined using MOBILE6.2 Mexico
	$PM_{2.5}$ Data Quality		N/A (BC emissions are measured directly)	
	Methodology for Estimating $PM_{2.5}$ Emissions	EPA AP-42 emission factors are applied to activity data to determine $PM_{2.5}$ emissions.	N/A	Motor vehicle activity data (VKT) limited on state and municipality level. VKT estimated using vehicle registration statistics combined with limited traffic count statistics, informal surveys, and anecdotal information; fuel data also used. Fleet age distribution determined from registration data and vehicle remote sensing data from major cities (Semarnat 2006, p. 5-1 through 5-6) MOBILE6.2 Mexico Land use and Vegetation Series IV (INEGEI 2009).
	Black Carbon Monitoring and Observations	N/A	Mobile source emissions of BC are almost always measured as ECa, but there is no official EPA recommended measurement method. BC is measured as a particulate matter component for both gasoline and diesel vehicles. (EPA 2011b, Appendix 1-13 through 1-14)	
	Methodology/Model for Estimating BC Emissions	Transportation emissions were developed using an internal MOBILE6.2 model revised to reflect Canadian conditionings. (Arctic Council 2011, p. 3-19)	BC emissions are estimated directly through mobile models (EPA 2010a) MOVES2010 (update of MOBILE6.2) model directly calculates BC emissions (EPA 2011b, Appendix 2-6)	Motor vehicle emissions estimated using vehicle classifications from the MOBILE6-Mexico emission factor model. Emissions for $PM_{2.5}$ were calculated using daily per capita emission rates based on travel demand models for seven representative urban areas and EFs from MOBILE6-Mexico. $PM_{2.5}$ emissions were adjusted to account for gasoline and diesel sulfur contents from PEMEX (Semarnat 2006, p. 5-1 through 5-4)

		Canada	United States	Mexico
	Source Profile Used (What is it based on?)	$PM_{2.5}$ elemental carbon (ECa) profile in SPECIATE 4.2 database (Arctic Council 2011, p. 3-19)	On-road emissions use MOVES2010 (motor vehicle emission simulator) model which accurately predicts national consumption of gasoline and diesel fuels based on vehicle population and activity data (EPA 2011a, p. 4-16) This model directly calculates BC emissions and accounts for the significantly reduced BC fraction emitted from on-road diesels due to application of diesel particulate filters (EPA 2011b, Appendix 2-7)	N/A
	Key Uncertainties			N/A
	$PM_{2.5}$		N/A (BC emissions are measured directly)	N/A
	Black Carbon	Possible improvements: The profiles relating to both ECa and OC are relatively generic and may be improved upon further research and improve surrogates used for spatial allocation of emission estimates (Arctic Council 2011, p. 3-22)	Considerable variability in BC emissions due to diverse technologies and applications of vehicles and engines (EPA 2011b, Appendix 1-13)	N/A
	Comparable to Other Country Sectors			
4.	**Mobile Non-Road**			
	Definition	Mobile Non-Road: aviation, marine, rail, off-road gasoline/Lp./CNG, off-road diesel	NONROAD model categories include recreational marine and land-based vehicles, farm and construction machinery, industrial, commercial, logging, and lawn and garden equipment. Aircraft ground support equipment and rail maintenance equipment are also included in NONROAD. EPA 2011b: Nonroad diesel, nonroad gasoline, locomotive, commercial marine (C1 & C2), commercial marine (C3), aircraft, brakewear	
	BC (or $PM_{2.5}$ Emissions) and Percentage of Total	32,670 metric tonnes BC (43%) (2006 inventory, EC 2011c, p. 4)	148,542 metric tonnes BC (26 %) (2005 inventory, EPA 2011b, p. 4-10)	*36,123 metric tonnes $PM_{2.5}$ (4%)* *(Semarnat 2006)*

		Canada	United States	Mexico
	Data Gathering and Observations for $PM_{2.5}$	$PM_{2.5}$ emissions from NPRI $PM_{2.5}$ emissions inventories: aviation landing and take-off, marine sources, off-road marine sources, rail sources (Using ORL_AIRCRAFT_LTO2006_Mar08; ORL_MARINE_C3_2006_Mar08; ORL_MARINE_noC3_2006_Mar08; ORL_OFFROAD2006_Mar08; ORL_RAIL2006_Mar08 of the Pollution Data Division (PDD))	Usage data and engine output for a variety of NONROAD2008 sources (EPA 2011b, Appendix 2-7)	Activity data came from: US equipment population estimates modified for the NONROAD-Mexico emissions model for agricultural and construction equipment; annual diesel fuel use; standard inputs to reflect Mexico-specific conditions into NONROAD-Mexico model (ambient temperature, fuel quality, altitude) (Semarnat 2006, 6.2 through 6.3)
	$PM_{2.5}$ Data Quality			
	Methodology for Estimating $PM_{2.5}$ Emissions	Off-road source (lawnmowers, off-road trucks, etc.) are estimated using NONROAD model.	PM emissions are estimated from the NONROAD2008 model which incorporates emission factors (in grams per brake-horsepower-hour, BHP-hr), engine output and usage data for a wide number of NONROAD sources (EPA 2011b, Appendix 2-7) Locomotives: locomotive fuel use data from DOE EIA and available emission factors (EPA 2008, p. 10) Aircraft: PM emissions were speciated into HAP components, Federal Aviation Administration (FAA) landing and take-off (LTO) data and EPA approved emission factors (EPA 2008, p. 8) Commercial Marine: port data Waterway Network Ship Traffic, Energy, and Environmental Model (STEEM) (EPA 2008, p. 9)	Estimated horsepower-hours of operation for each equipment type/fuel/hop range combination used with NONROAD-Mexico emission factor model (Semarnat 2006, 6.2)
	Black Carbon Monitoring and Observations	N/A		N/A
	Methodology/Model for Estimating BC Emissions	BC emissions for other off-road sources determined from $PM_{2.5}$ emissions and SPECIATE profile. Emissions for commercial marine, aviation, and railroad sources are done distinctly (outside of NONROAD) (Comments from Environment Canada experts)	BC emissions are estimated based on PM emissions estimates from the NONROAD model	N/A

		Canada	United States	Mexico
	Source Profile Used (What is it based on?)	$PM_{2.5}$ elemental carbon (ECa) profile in SPECIATE 4.2 database (Arctic Council 2011, p. 3-19)	Profile 92035 (nonroad diesel engines not equipped with diesel particulate filters) estimates 77% of PM is BC (EPA 2011b, Appendix 2-8) For gasoline engines, two-stroke engine emissions are estimated using profile 92049 from EPA's SPECIATE database (10% of the PM is BC) (EPA 2011b, Appendix 2-7 through 2-8) C1/C2 commercial marine vessels have 77% BC/PM speciation factor; C3 marine diesels have 1% BC speciation factor (EPA 2011b, Appendix 2-8 and A2-9)	N/A
	Key Uncertainties			
	$PM_{2.5}$			No reliable equipment population data were available for construction equipment in Mexico (surrogates were used); Nonroad category only includes agricultural and construction equipment; Activity data for agricultural sources available at state level, but not municipality level; construction sources activity data extrapolated from US data (Semarnat 2006, 6.1 through 6.4)
	Black Carbon	Possible improvements: The profiles relating to both ECa and OC are relatively generic and may be improved upon further research and improve surrogates used for spatial allocation of emission estimates (Arctic Council 2011, p. 3-22)		N/A
	Comparable to Other Country Sectors			
5	**Industry**			
	Definition	Petroleum refining, other energy industries (including pipelines), mining, and manufacturing industries & construction	Stationary diesel, cement production, chemical manufacturing, aluminum production, pulp and paper, industrial manufacturing, etc.	Manufacturing and other industrial processes
	BC (or $PM_{2.5}$ Emissions) and Percentage of Total	5,620 metric tonnes BC (7.4%) (2006 inventory, EC 2011c, p. 4)	5,520 metric tonnes BC (1%) (2005 inventory, EPA 2011b, p. 4-10)	11,231 metric tonnes $PM_{2.5}$ (1.2%) (Semarnat 2006)

		Canada	United States	Mexico
	Data Gathering and Observations for $PM_{2.5}$	$PM_{2.5}$ emissions from NPRI - Industry required to report total amounts of Criteria Air Contaminants (including $PM_{2.5}$) to the National Pollutant Release Inventory (NPRI). EPA's AP-42 emission factors are used. Annual emissions from upstream oil and gas sources. (ORL_POINT2006_Mar08; ORL_UOG2006_Mar08 of the Pollution Data Division (PDD))	$PM_{2.5}$ emissions from NEI estimated by the filterable (solid) and condensable (gaseous) fractions of direct $PM_{2.5}$ emitted.	$PM_{2.5}$ emissions for INEM
	$PM_{2.5}$ Data Quality	Reporting is required for any facility		Not determined
	Methodology for Estimating $PM_{2.5}$ Emissions	EPA AP-42 emission factors are applied to activity data to determine $PM_{2.5}$ emissions.	For most stationary sources, $PM_{2.5}$ emissions are derived using a scaling factor applied to a collection of filterable total PM and the PM_{10} size fractions. Some local/state and site-specific standards also require testing for PM_{10} and $PM_{2.5}$ mass. EPA's AP-42 emission factors are used. (EPA 2011b, Appendix 1-12) Basic method for estimating $PM_{2.5}$ emissions involved multiplying activity data by an AP-42 emission factor. More recently, a FIRE 6.25 Data System has been used to store emission factors (EPA 2011b, Appendix 2-2) BC emissions can be estimated coarsely from "top-down" measurements of activity at the state/national-level demographics, land use, and economic activity (such as construction industry) (EPA 2011b, Appendix 2-5) Direct $PM_{2.5}$ emissions from industrial sources in the United States are small compared to emissions of other co-emitted pollutants due to effective control technologies for PM emissions on a variety of stationary/industrial sources (EPA 2011b, p. 4-15)	For fine sources, $PM_{2.5}$ emissions from combustion are mostly estimated using emission factors from EPA (AP-42); in the case of $PM_{2.5}$ from process activities, emissions are estimated using emission factors from AP-42 and by $PM_{2.5}$ ratios from CARB with respect to PST.
	Black Carbon Monitoring and Observations			Not done
	Methodology/Model for Estimating BC Emissions	Speciation profiles obtained from US EPA's SPECIATE4.2 database to approximate BC mass fractions for specific Source Category Codes (SCC). These mass fractions were multiplied by Canada's overall $PM_{2.5}$ emissions to determine BC emissions (Arctic Council 2011, p. 3-18 and 3-19)	SPECIATE	Undefined

		Canada	United States	Mexico
	Source Profile Used (What is it based on?)			Do not have their own profiles
	Key Uncertainties			Not done
	$PM_{2.5}$		Most AP-42 emissions factors do not quantify the condensable fraction of total $PM_{2.5}$ emissions. "Gap filling" techniques are used to estimate condensable $PM_{2.5}$, which introduces uncertainty in the emission estimates (EPA 2011b, Appendix 2-3)	
	Black Carbon	Possible improvements: The profiles relating to both ECa and OC are relatively generic and may be improved upon further research and improve surrogates used for spatial allocation of emission estimates (Arctic Council 2011, p. 3-22)		
	Comparable to Other Country Sectors			
6	**Non-Industry**			
	Definition	Commercial and Institutional		Merchant wholesalers, nondurable goods, other services
	BC (or $PM_{2.5}$ Emissions) and Percentage of Total	880 metric tonnes BC (0.7%) (2006 inventory, EC 2011c, p.4)		
	Data Gathering and Observations for $PM_{2.5}$	$PM_{2.5}$ emissions from NPRI - Industry required to report total amounts of Criteria Air Contaminants (including $PM_{2.5}$) to the National Pollutant Release Inventory (NPRI). EPA's AP-42 emission factors are used.		Emission factors from FIRE 6.22 FIRE 6.23 AIR CHIEF 12 and CARB 2002
	$PM_{2.5}$ Data Quality			
	Methodology for Estimating $PM_{2.5}$ Emissions			
	Black Carbon Monitoring and Observations	N/A		
	Methodology/Model for Estimating BC Emissions	Speciation profiles obtained from US EPA's SPECIATE4.2 database to approximate BC mass fractions for specific Source Category Codes (SCC). These mass fractions were multiplied by Canada's overall $PM_{2.5}$ emissions to determine BC emissions (Arctic Council 2011, p. 3-18 and 3-19)		
	Source Profile Used (What is it based on?)			
	Key Uncertainties			
	$PM_{2.5}$			Emission factors from FIRE 6.22 FIRE 6.23 AIR CHIEF 12 and CARB 2002

		Canada	United States	Mexico
	Black Carbon	Possible improvements: The profiles relating to both ECa and OC are relatively generic and may be improved upon further research and improve surrogates used for spatial allocation of emission estimates (Arctic Council 2011, p. 3-22)		
	Comparable to Other Country Sectors			
7	**Residential**			
	Definition	Residential includes residential coal and wood burning, other.	Residential heating/cooking includes: residential wood oil, coal, and natural gas consumption	Only wood burning, coal was not considered except for street food vending charcoal, but not in residential
	BC (or $PM_{2.5}$ Emissions) and Percentage of Total	8,100 metric tonne sBC (47%) (2006 inventory, EC 2011c, p. 4)	20,690 metric tonnes BC (4%) (2005 inventory, EPA 2011b, p. 4-10)	
	Data Gathering and Observations for $PM_{2.5}$	$PM_{2.5}$ emissions from NPRI - air pollutant emission summaries and trends are compiled using emissions reported by facilities to the NPRI as well as emissions estimated by Environment Canada using the latest published statistics or other sources of information such as surveys and reports (http://www.ec.gc.ca/inrp-npri/default.asp?lang=En&n=5C71562D-1) (Using ORL_FUELWOOD_2005 for emissions from forest fires)	Biomass burning is a nonpoint source category classified as stationary sources in the NEI. (EPA 2011b, Appendix 2-2)	$PM_{2.5}$ emissions from INEM
	$PM_{2.5}$ Data Quality			
	Methodology for Estimating $PM_{2.5}$ Emissions	EPA AP-42 emission factors are applied to activity data to determine $PM_{2.5}$ emissions.	For most stationary sources, $PM_{2.5}$ emissions are derived using a scaling factor applied to a collection of filterable total PM and the PM_{10} size fractions. Some local/state and site-specific standards also require testing for PM_{10} and $PM_{2.5}$ mass. EPA's AP-42 emission factors are used. (EPA 2011b, Appendix 1-12) Basic method for estimating $PM_{2.5}$ emissions was multiplying activity data by an AP-42 emission factor. More recently, a FIRE 6.25 Data System has been used to store emission factors (EPA 2011b, Appendix 2-2)	Emission factors from EPA 2001
	Black Carbon Monitoring and Observations	N/A	N/A	

		Canada	United States	Mexico
	Methodology/Model for Estimating BC Emissions	Speciation profiles obtained from US EPA's SPECIATE4.2 database to approximate BC mass fractions for specific Source Category Codes (SCC). These mass fractions were multiplied by Canada's overall $PM_{2.5}$ emissions to determine BC emissions (Arctic Council 2011, p. 3-18 and 3-19)	SPECIATE	
	Source Profile Used (What is it based on?)		Speciation profiles applied as discussed in Reff et al. (2009)	
	Key Uncertainties			
	$PM_{2.5}$		Estimates are only from 2002 (EPA 2011b, p. 4-3) Most AP-42 emissions factors do not quantify the condensable fraction of total $PM_{2.5}$ emissions. "Gap filling" techniques are used to estimate condensable $PM_{2.5}$ which introduces uncertainty in the emission estimates (EPA 2011b, Appendix 2-3)	
	Black Carbon	Possible improvements: The profiles relating to both ECa and OC are relatively generic and may be improved upon further research and improve surrogates used for spatial allocation of emission estimates (Arctic Council 2011, p. 3-22)	"Quantification of emissions from this source category has been approached through acquisition of data on how fuel is burned in fireplaces and woodstoves using national consumption estimates. Where this source is large contributor to PM, local surveys of firewood use are used to supplement and improve activity level estimates." (EPA 2011b, Appendix 2-5)	
	Comparable to Other Country Sectors	Area	Area	
8	**Dust**			
	Definition	Road dust	Paved road dust, unpaved road dust	Fugitive dust
	BC (or $PM_{2.5}$ Emissions) and Percentage of Total	550 metric tonnes BC (0.7%) (2006 inventory, EC 2011c, p. 4)	887 metric tonnes BC (0.2%) (2005 inventory, EPA 2011b, p. 4-10)	*27,279 metric tonnes $PM_{2.5}$ (3%)* *(Semarnat 2006)*

		Canada	United States	Mexico
	Data Gathering and Observations for $PM_{2.5}$	$PM_{2.5}$ emissions from NPRI - air pollutant emission summaries and trends are compiled using emissions reported by facilities to the NPRI, as well as emissions estimated by Environment Canada using the latest published statistics or other sources of information such as surveys and reports (http://www.ec.gc.ca/inrp-npri/default.asp?lang=En&n=5C71562D-1) $PM_{2.5}$ emissions inventories: fugitive dust, fugitive dust from construction activities, and fugitive dust from paved and unpaved roads (Arctic Council 2011, p.A-8) (Using ORL_ADUST2006_TF25; ORL_CONSTRUCTION2006_TF; ORL_ROAD2006_TF of Pollution Data Division (PDD))	$PM_{2.5}$ emissions from NEI estimated by the filterable (solid) and condensable (gaseous) fractions of direct $PM_{2.5}$ emitted.	Determined using the National Emissions Inventories Program of Mexico (Radian 1997)
	$PM_{2.5}$ Data Quality			
	Methodology for Estimating $PM_{2.5}$ Emissions			
	Black Carbon Monitoring and Observations	N/A		
	Methodology/Model for Estimating BC Emissions		SPECIATE	
	Source Profile Used (What is it based on?)			
	Key Uncertainties			
	$PM_{2.5}$		Most AP-42 emissions factors do not quantify the condensable fraction of total $PM_{2.5}$ emissions. "Gap filling" techniques are used to estimate condensable $PM_{2.5}$ which introduces uncertainty in the emission estimates (EPA 2011b, Appendix 2-3)	
	Black Carbon			
	Comparable to Other Country Sectors			
9	**Other**			
	Definition	Forestry and waste	Charbroiling, wood products-drying, paved road dust, dairy soil, wood products-sawing, unpaved road dust, wood products-sanding, fly ash, asphalt manufacturing, etc.	

		Canada	United States	Mexico
	BC (or $PM_{2.5}$ Emissions) and Percentage of Total	50 metric tonnes BC (0.04%) (2006 inventory, EC 2011c, p. 4)	6,117 metric tonnes BC (1%) (2005 inventory, EPA 2011b, p. 4-10)	
	Data Gathering and Observations for $PM_{2.5}$	$PM_{2.5}$ emissions from NPRI	$PM_{2.5}$ emissions from NEI estimated by the filterable (solid) and condensable (gaseous) fractions of direct $PM_{2.5}$ emitted	Determined using the National Emissions Inventories Program of Mexico (Radian 1997)
	$PM_{2.5}$ Data Quality			
	Methodology for Estimating $PM_{2.5}$ Emissions	EPA AP-42 emission factors are applied to activity data to determine $PM_{2.5}$ emissions		
	Black Carbon Monitoring and Observations	N/A		
	Methodology/Model for Estimating BC Emissions		SPECIATE	
	Source Profile Used (What is it based on?)	SPECIATE/Canada-specific EF taken by specific SCC codes and cross-references using the cross-reference file (EC 2011c, p.9) BC emissions from forest fires were calculated using a constant value of biomass consumed per area burned for all of Canada (Arctic Council 2011, p. 3-19)		
	Key Uncertainties			
	$PM_{2.5}$		Most AP-42 emissions factors do not quantify the condensable fraction of total $PM_{2.5}$ emissions. "Gap filling" techniques are used to estimate condensable $PM_{2.5}$, which introduces uncertainty in the emission estimates (EPA 2011a, Appendix 2-3)	
	Black Carbon			
	Comparable to Other Country Sectors			
10	**Fixed/Point**			
	Definition			Stationary industrial facilities, including chemical manufacturing, food manufacturing, pulp and paper manufacturing, electrical energy generation, hazardous waste treatment, federal airports/train/bus stations, etc.
	BC (or $PM_{2.5}$ Emissions) and Percentage of Total			199,050 metric tonnes $PM_{2.5}$ (35%)

		Canada	United States	Mexico
	Data Gathering and Observations for $PM_{2.5}$			Emissions data identified from: federal COAs, state COAs, National Power Plant Inventory for 1999, DATGEN, and INTEGRA (3-3 through 3-5) Point sources in this inventory are limited to facilities that emit 10 Mg/year or more within the six northern states, and at least 1.5 Mg/year for PM_{10} in other parts of the country (p. 58) Point sources under state or municipal jurisdiction are required to report under Semarnat (3-3)
	$PM_{2.5}$ Data Quality			
	Methodology for Estimating $PM_{2.5}$ Emissions			For facilities using combustible fuels (i.e., fuel oil no. 6), AP-42 size ratios were used to estimate PM emissions (p. 45) For most PM process emissions, California Air Resources Board PM_{10}/$PM_{2.5}$ ratios were used (3-9)
	Black Carbon Monitoring and Observations			N/A
	Methodology/Model for Estimating BC Emissions			N/A
	Source Profile Used (What is it based on?)			N/A
	Key Uncertainties			
	$PM_{2.5}$			Information on annual emissions was often incomplete, incorrect, or inconsistent for state facilities (3-10) Detailed information at facility level was very limited; more data available from federal facilities. Seven states had no point source emissions data available. (3-22)
	Black Carbon			N/A
	Comparable to Other Country Sectors			Industry, Non-Industry, Electricity Generation
11	**Area**			

		Canada	United States	Mexico
	Definition			Small industrial facilities that are not classified as point sources; disperse activities such as dry cleaners, consumer solvents; and fugitive sources of particulate matter such as agricultural tilling, vehicle travel on unpaved roads, and windblown dust. (Semarnat 2006, 2-5) For $PM_{2.5}$, area sources include: residential wood fuel combustion, agricultural tilling, open burning waste/wildfires, agricultural burning, charbroiling/street vendors, remaining area sources **To maintain comparability with the United States and Canada, the emissions from locomotive, aircraft, and commercial marine vehicles were moved to the Mobile Non-road source category
	BC (or $PM_{2.5}$ Emissions) and Percentage of Total			317,577 metric tonnes $PM_{2.5}$ (55%)
	Data Gathering and Observations for $PM_{2.5}$			Extensive data collection carried out and multiple organizations, agencies, and technical sources were contacted. Data collection and emission calculations were performed simultaneously for the entire country. Area source inventory was reconciled with industrial point source inventory to avoid double-counting (4-3 through 4-5) National-level statistics (fuel use, surface coating quantities, dry cleaning solvents) (8-16)
	$PM_{2.5}$ Data Quality			
	Methodology for Estimating $PM_{2.5}$ Emissions			Emissions were calculated using activity data and an emission factor from Mexico Emissions Inventory Program Manuals, Emissions Inventory Improvement Program documents, AP-42, and special studies conducted in the United States and Mexico for specific sources) (4-3)
	Black Carbon Monitoring and Observations			N/A
	Methodology/Model for Estimating BC Emissions			N/A
	Source Profile Used (What is it			N/A

		Canada	United States	Mexico
	based on?)			
	Key Uncertainties			
	$PM_{2.5}$			National- or state-level activity data used rather than municipality-level data (4-19)
	Black Carbon			N/A
	Comparable to Other Country Sectors			Residential, Biomass combustion

APPENDIX H: Abbreviations

AGEM	Aviation Greenhouse Gas Emission Model
AP-42	compilation of Air Pollutant Emission Factors
B_o	maximum biodegradability (in m^3 CH_4 produced per kg volatile solids)
BC	black carbon
BHP-hr	Brake-horsepower-hour
C	carbon
CABM	Canadian Aerosol Baseline Measurement Program
CARB	California Air Resources Board
Canacem	*Cámara Nacional del Cemento*
CAPMoN	Canadian Air and Precipitation Monitoring Network
CCS `	Center for Climate Strategies
CCSP	US Climate Change Science Program
CEC	Commission on Environmental Cooperation
CH_4	methane
CNG	compressed natural gas
CO	carbon monoxide
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
COA	*Cédula de Operación*
COD	chemical oxygen demand
Conafor	*Comisión Nacional Forestal*
COP	UNFCCC Conference of Parties
CRF	Common Reporting Format
CS	country-specific
CSN	Chemical Speciation Network
DOC	degradable organic content
DOE	US Department of Energy
EC	Environment Canada
ECa	Apparent elemental carbon
EF	emission factor
EFDB	IPCC Emissions Factor Database
EIA	Energy Information Administration
EPA	US Environmental Protection Agency
FOD	first-order decay
GHG	Greenhouse gas
GWP	Global Warming Potential
ha	hectare
HCFC	hydrochlorofluorocarbon
HFC	hydrofluorocarbon
HDDV	heavy-duty diesel vehicle
IE	included elsewhere
IMPROVE	Interagency Monitoring of Protected Visual Environments
INE	*Instituto Nacional de Ecología*
INEGEI	*Inventario Nacional de Emisiones de Gases de Efecto Invernadero*
Inegi	*Instituto Nacional de Estadística y Geografía*
INEM	*Inventario Nacional de Emisiones de México* (Mexico's National Emissions Inventory)
INFyS	*Inventario Nacional Forestal y Suelos*

IP	industrial processes
IPCC	Intergovernmental Panel on Climate Change
KCA	Key Category Analysis
LDDV	light-duty diesel vehicle
LDGV	light-duty gasoline vehicle
LP	liquefied petroleum
LTO	landing and take-off
LULUCF	land use, land-use change and forestry
M	modeled
MCF	methane conversion factor
MGEM	Canada's Mobile Greenhouse Gas Emission Model
MOU	memorandum of understanding
MOVES2010	Motor Vehicle Emission Simulator
MSW	municipal solid waste
N	nitrogen
N_2O	nitrous oxide
NA	not applicable
NAAEC	North American Agreement on Environmental Cooperation
NAPS	National Air Pollution Surveillance Network
NASS	National Agricultural Statistics Service
NE	not estimated
NEI	National Emissions Inventory (US)
NIR	National Inventory Report
NMVOC	non-methane volatile organic compound
NO	not occurring
NO_x	nitrogen oxide
NRCan/CFS	Canadian Forest Service of Natural Resources Canada
NPRI	National Pollutant Release Inventory (Canada)
NRCan	Natural Resources Canada
OC	organic carbon
ODS	ozone-depleting substances
PEACC	*Programas Estatales de Acción ante el Cambio Climático*
PECC	*Programa Especial de Cambio Climático*
PFC	perfluorocarbon
PM	particulate matter
$PM_{2.5}$	particulate matter, diameter up to 2.5 micrometers
PRP	pasture, range and paddock
QA/QC	quality assurance/quality control
RA	Reference Approach
RGGI	Regional Greenhouse Gas Initiative
RPO(s)	Regional Planning Organizations
SA	sectoral approach
SAR	IPCC Second Assessment Report
SCC	source category codes
Sedesol	*Secretaría de Desarrollo Social*
Semarnat	*Secretaría de Medio Ambiente y Recursos Naturales*
SF_6	sulfur hexafluoride
SIT	EPA's State Inventory Tools
SOC	soil organic carbon [*Carbono Orgánica de Suelo*—COS]

SO_x	sulphur oxide
T&D	transmission and distribution
tCO_2e	tonnes of CO_2e (metric tons)
ULSD	ultra low-sulfur diesel
UNEP/WMO	United Nations Environment Program/World Meteorological Organization
UNFCCC	United Nations Framework Convention on Climate Change
UOG	upstream oil and gas
USDA	US Department of Agriculture
VKT	vehicle kilometers traveled (motor vehicle activity data)
WCI	Western Climate Initiative