Enhancing the Comparability of the Air Emission Inventories in Canada, Mexico and the United States

The Commission for Environmental Cooperation

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Introduction

Air emission inventories are essential elements in reducing air pollution in North America. There is an increasing awareness that ground-level ozone, acid rain, particulate aerosols, greenhouse gases and other pollutants cause public health and environmental damage over urban areas and large regions of North America (as well as the globe), and will require international cooperation and information exchange to find effective solutions. An air emission inventory provides air quality planners, research scientists, industry managers, public health officials, and environmentalists, the basic tools to determine the sources of air pollutants, the relative roles of different sources, and the trends over time of air emissions.

Our current emission inventories are increasingly sophisticated, with improvements in the level of detail, frequency of updating, and public access. Emission inventories, however, also vary considerably in different regions of North America in their methodology, level of detail and public availability of the emissions information. The need to develop regional plans to reduce visible haze, fine particles, and smog is creating greater pressure for developing high quality, comprehensive and current emission inventories that can be exchanged across international boundaries. These emission inventories must be compatible so that they can be more easily incorporated into regional, bilateral and trilateral initiatives. With these compatible, high quality inventories we can begin to develop equitable policies to address regional air pollution and provide the public with comparable information on pollution sources located throughout North America.

There are a number of practical reasons for developing a trinational overview of air emissions inventories in North America. These include:

- Domestic regulatory and statutory planning requirements that involve atmospheric modeling of airsheds across international boundaries.
- The need for sufficiently detailed information that allows planners to focus on where effective and practical reduction targets exist, such as knowing whether emissions arise from combustion or process activities within a facility or by natural or man made sources.
- Provide transparent data reporting of comparable quality across the three NAFTA countries that can be used for tracking compliance with possible future North American emissions trading programs.
- Allow countries and the public to track criteria air and greenhouse gas emission trends, hence monitor the effectiveness of control measures across North America.

Provide the public with readily accessible information on air pollutants and greenhouse gases emitted in their local communities or across the continent.

The environment ministers of Canada, Mexico and the United States recognized these needs at their June 2001 meeting in Guadalajara, Mexico. At the meeting, the environment ministers, acting in their capacity as Council of the Commission for Environmental Cooperation, adopted a resolution promoting comparability of North American air emission inventories.

This report summarizes the current state of the air emission inventories in Canada, Mexico and the United States to stimulate discussions on ways to enhance the comparability of air emission inventories.

Background of the Commission for Environmental Cooperation

The Commission for Environmental Cooperation (CEC) is a trilateral organization, mandated under the terms of the North America Agreement on Environmental Cooperation, which facilitates cooperation and public participation in fostering the conservation, protection and enhancement of the North American environment for the benefit of present and future generations, in the context of increasing economic, trade and social links among Canada, Mexico, and the United States. The environment ministers from the three countries direct the work of the CEC. For more information on the CEC, please see <http://www.cec.org/>.

Earlier reports and programs of the CEC have laid the way for trilateral cooperation on air pollution:

- The report *Continental Pollutant Pathways: An Agenda for Cooperation to Address Long-range Transport of Air Pollution in North America* laid out a blueprint for trilateral cooperation in addressing cross-border air pollution transport.
- The report *Long-range Transport of Ground-level Ozone and Its Precursors* documented the large distances that pollutants can travel from their sources in eastern North America to downwind locations that feel their effects.
- The report *The Long-range Air Transport of Dioxin from North American Sources to Ecologically Vulnerable Receptors in Nunavut, Arctic Canada* used innovative modeling and developed a trilateral dioxin inventory to track dioxins from their sources to deposition locations in the Canadian polar territory of Nunavut.
- The Sound Management of Chemicals program develops North American Regional Action Plans (NARAPs) to reduce toxic chemicals such as PCBs, mercury and DDT.
- The pollutant release and transfer register (PRTR) program provides a North American picture of releases and transfers for approximately 165 chemicals commonly reported to the Canadian National Pollutant Release Inventory, the US Toxics Release Inventory and wherever possible from the Mexican *Registro de Emisiones y Transferencia de Contaminantes.*

The concerns over public health and environmental effects from air pollution are driving agencies to develop urban and regional plans for smog, haze and toxics. The creation of these plans requires high quality, comprehensive and consistent emission inventories. To maximize resources, experiences and ideas, the CEC invites governmental representatives, industry and business groups, public health and environmental organizations, as well as other interested parties to work together to enhance the comparability of air emission inventories.

Scope of this Report

The goal of this report is to provide sufficient background information on emission inventories in the three countries to stimulate discussions on areas to enhance comparability of emission inventories. This report:

- Describes the elements of an emission inventory and characteristics of air contaminants and greenhouse gases
- Identifies the current state of air emission inventories in Canada, Mexico, and the United States
- Presents a case study using emission data from utilities to illustrate the current challenges and opportunities in integrating inventories in North America
- Discusses the need for more comparable inventories in North America
- Suggests potential areas of opportunity to enhance emission inventories for discussion

The air contaminants discussed in this report include (by alphabetical order):

- ammonia
- carbon monoxide
- hydrocarbons
- lead
- nitrogen oxides (nitric oxide and /or nitrogen dioxides),
- particulate matter (total suspended particulates, PM_{10}, and/or $PM_{2.5}$),
- sulfur dioxide and/or sulfur oxides,
- volatile organic compounds

Also included is a general description of greenhouse gases and inventories.

This report stems from the CEC Council Resolution 01-05: Promoting the Comparability of Air Emission Inventories, which was signed by the environment ministers of the three NAFTA countries in June 2001. The Council "agrees to work toward a trinational inventory for air emissions including sulfur dioxide (SO_2), nitrogen oxides (NO_x), carbon monoxide (CO), volatile organic compounds (VOCs), particulate aerosols and greenhouse gases." (For the text of the Council Resolution, see Appendix A.) This report is a first step towards fulfilling this CEC Council Resolution.

This report focuses primarily on air emission inventories. As many inventories are integrating criteria air contaminants, greenhouse gases and toxic inventories, these other

air inventories are briefly discussed. Ambient monitoring data, another source of information about air pollution, is not the subject of this report. Sources of pollution included in this report are point, area, mobile, and natural (biogenic) sources.

In the fall of 2001, governmental representatives will discuss this report and their ideas and priorities for areas of comparability. Following this meeting, a group of environment and public health nongovernmental organizations, business and industry, provincial, state and municipal governments, academia and policy experts will discuss the report and future steps in emission inventories.

Organization of this Report

This report is geared towards two audiences, people generally interested in air pollution and people interested in emission inventories and modeling. For people with a general knowledge, all chapters may be of interest. People familiar with emission inventories and modeling may chose to go directly to Chapter 2, and skip the background material on inventories and contaminants presented in Chapter 1.

Comments on this report and the CEC Air Program are welcome. Please contact:

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1 What are Emission Inventories? What are Criteria Air Contaminants?

1.1 What are emission inventories?

An emission inventory is a current, comprehensive listing by source of air pollutant emissions and covers a specific geographic area for a specific time interval (EPA 1999).

An emission inventory usually contains:

- A summary of emission estimates by source
- Information on the purpose of the inventory
- Geographic area covered by the inventory
- Time interval (annual, seasonal, daily)
- Population, employment and economic data used to estimate emissions

Emission inventories are made up of four types of information:

- Point sources: generally large stationary sources such as an industrial facility which emits more than a specified amount of a contaminant such as 100 tons/year
- Area sources: all other stationary sources, often sources too small to track individually, such as small gas stations, solvent usage and fertilizer application
- Mobile sources: any kind of vehicle or equipment with a gasoline or diesel engine such as cars, tractors, airplanes and ships. On-road mobile sources are licensed for use on highways or roadways. Off-road or non-road mobile sources are all other mobile sources.
- Biogenic sources: including, such as soil microbe and vegetation sources.

Different methods are used to estimate emissions for each of these types of sources. Generally, point source information is gathered either from mandatory reporting by facilities, or voluntary reporting through questionnaires, interviews or surveys. A variety of models and methods are then used to estimate emissions.

Area sources are estimated using a variety of methods, including emission factors, activity data, representative surveys and adjusted data from previous inventories. Since area sources are so diverse, data used to estimate area sources comes from a wide range of databases and studies.

Data used to estimate emissions from mobile sources comes from estimates of vehicle miles traveled, local activity data, emission factors and mass balances. Often a mathematical model is used to estimate on-road emissions, such as the US EPA's MOBILE 5 or MOBILE 6. Non-road emissions are modeled often using EPA's NONROAD model.

Biogenic emissions are often modeled using EPA's Biogenic Emission Inventory System (BEIS). It is important to know which version of the BEIS model is being used to develop biogenic VOC inventories, as the revised version BEIS2 significantly increases isoprene emissions from trees over the initial BEIS model. Isoprene is a very reactive natural hydrocarbon that can have a significant influence on ozone formation, so the choice of BEIS model can influence the perceived effectiveness of ozone control strategies in locations with significant isoprene sources. The US EPA is also planning to introduce a third revision of the system (BEIS3) that will likely further change estimates of biogenic emissions like isoprene from the previous versions.

For each category of source, the inventory should include:

- The procedures used to collect the data
- Sources of the data
- Copies of questionnaires and results
- Citations for all emission factors
- Identification of methods used to calculate emissions
- Complete documentation of all assumptions
- Identification of sources not included in the inventory
- List of references

Estimates of emissions are presented in source categories such as industrial and transportation sources. Each of these source categories can be further subdivided into finer and finer levels of detail. For example, industrial sources can be subdivided into chemical and allied product manufacturing, which can be further subdivided into inorganic chemical manufacturing, and further subdivided again into lead oxide and pigments.

1.2 How are emission inventories used?

Emission inventories can be used for a number of different purposes including:

- Defining the "most important" air pollution sources
- Evaluating Air Quality Management Plans
- Assessing the effectiveness of existing and proposed air pollution policies
- Providing a sense of trends over time
- Determining compliance with emission regulations
- Providing input into predicting the concentration of a pollutant in air
- Providing input for studies on health and environmental effects
- Assisting in designing operating permits
- Assisting in evaluating the effect of new sources
- Helping guide the location of new air quality monitors
- Keeping track of compliance with existing emission trading programs
- Establishing baselines for future emission trading programs

Determining the use of the inventory is an essential step towards the development and evolution of an inventory.

1.3 What are the characteristics of an effective emission inventory?

Emission inventories can vary tremendously in size and scope. Some agencies may survey less than 100 point sources every three years, yet the inventory may be adequate to answer basic questions on air quality management. Other inventories may require a 100-page manual to help guide the collection and transfer of emission data.

The following table (1) outlines the characteristics that define an effective emission inventory.

Table 1: Characteristics of an Effective Emission Inventory

Characteristics of an Effective Emission Inventory
• Comprehensive
• Comparable
• Current
• Consistent
• High quality
• Publicly accessible
• Transparent
• Accurate
• Limited data confidentiality and an indication of what is held confidential
• Standardized, electronic database

1.4 Why is an effective emission inventory important?

An effective emission inventory is the foundation for all air quality programs. With an effective emission inventory, effective plans to reduce air pollution can be made. When an emission inventory is not effective, perhaps not current or comprehensive, then a regulation, policy or plan may not reduce air pollution, may result in continuing exposure to levels of air pollution known to have health effects, may continue to damage the environment, or may cause the wrong industry or business to retool. Investing in emission inventories will pay dividends in effective plans to reduce air pollution.

1.5 What are criteria air contaminants?

One of the chief reasons for developing emission inventories is to help devise control strategies for a regulated group of air pollutants called criteria air contaminants (or criteria air pollutants). The criteria contaminants are typically defined by law, regulation or program, so may vary according to the country. This section provides a brief description of the characteristics, sources and health and environmental effects of criteria

air contaminants and their precursors (organized by alphabetical order). For more information on the health or environmental effects, please refer to:

- Environment Canada site at <http://www.ec.gc.ca/>
- US Environmental Protection Agency site at <http://www.epa.gov/>
- Mexican Instituto Nacional de Ecología site at <http://www.ine.gob.mx/>
- Environmental Defense Scorecard site at <http://www.scorecard.org/chemical-profiles/>

Ammonia (NH_3)

Ammonia is included in some emission inventories as it is a precursor to secondary particulates such as ammonium sulfate and ammonium nitrate. Knowing the emissions of ammonia will be important for modeling reduction strategies of fine particle matter, a criteria air contaminant in Canada and the US. Many emission inventories of ammonia are just being developed or improved.

Most ammonia is emitted from agricultural sources such as livestock and fertilizer use.

Ammonia is included in emission inventories in Canada and the US.

Carbon Monoxide (CO)

Carbon monoxide is a colorless, odorless and poisonous gas. When fuel is burned incompletely, carbon monoxide often results. Most carbon monoxide is produced from vehicles, wood burning stoves, incinerators and industrial boilers (EPA 1999).

Carbon monoxide enters the blood and reduces the delivery of oxygen to the organs and tissues. Exposure to high levels of carbon monoxide has been linked to impaired vision, decreased work capacity, decreased learning ability and decreased performance of difficult tasks (OMOE 2001).

Carbon monoxide is included in air contaminant inventories in Canada, Mexico and the United States. Carbon monoxide is considered a criteria air contaminant in Mexico and the US.

Lead

Lead is a metal that can combine to form many different compounds. Lead and its compounds are considered possibly carcinogenic by the International Agency for Research on Cancer. Exposure to lead can cause a number of health effects including anemia, developmental disorders, reduced IQ and metabolic disorders.

Lead is often emitted from smelters and battery plants.

Lead is considered a criteria air contaminant in Mexico and the US and is included in the US inventory and in some urban inventories in Mexico, such as that of Monterrey (for mobile sources only). Lead is not included in the criteria air contaminant emission inventory in Canada.

In Canada, emissions of lead and its compounds from point sources are required to be reported to the National Pollutant Releases Inventory. In the US, emissions of lead and other lead compounds are required to be reported to the Toxics Release Inventory. In Mexico, emissions of lead can be voluntarily reported to the *Registro de Emisiones y Transferencia de Contaminantes.*

Nitrogen Oxides (NO_X)

Nitrogen oxides (NO_x) are a group of gases, consisting of nitrogen dioxide (NO_2) and nitric oxide (NO). Nitrogen dioxide is a reddish brown gas with a pungent and irritating odor (OMOE 2001). It can change in the atmosphere to form nitric acid and toxic nitrates, which can contribute to increased levels of respirable particulates. NO_2 is also one of the building blocks of ozone, a major component of smog.

During combustion, NO_X are created. Transportation, utilities, incineration and primary metal production are large sources of NO_X (OMOE 2001). NO_X can also be created naturally, through lightning and from bacterial decomposition in soil. These natural sources of NO_X are called biogenic sources. With regard to ozone pollution episodes, biogenic sources of NO_x are relatively insignificant compared to NO_x emissions from human activity.

Nitrogen oxides can irritate the lungs, cause bronchitis and pneumonia and increase susceptibility to respiratory infection (OMOE 2001; EPA 1999). Nitrogen oxides can change into nitric acid that can acidify lakes, rivers, streams and soils. Nitric acid can damage trees and crops. Nitric acid can also damage metals, destroy rubber and other materials.

Nitrogen oxides are therefore of concern because of their role as a building block of ozone, contributing to acid rain and forming particulates.

Nitrogen oxides are included in air contaminant inventories in all three North American countries. Nitrogen dioxide is considered a criteria air contaminant in Mexico and the US. The Canadian government recently gave notice that it intends to declare nitric oxide and nitrogen dioxide toxic under the Canadian Environmental Protection Act.

Ozone

Ozone is a colorless gas and is a major component of smog. Ozone is not directly emitted into the atmosphere, but is formed in the atmosphere. Ozone is created when its building blocks, nitrogen oxides and volatile organic compounds interact in the atmosphere in the presence of sunlight. Ground-level ozone behaves differently than the ozone layer high above the earth that screens out the sun's harmful ultraviolet rays.

Ozone levels can vary over the day, week and month and from year to year. Generally ozone levels are highest in the afternoon and early evening during the summer. Due to its latitude, Mexico has the highest ozone levels in the early afternoon. Like many air pollutants, ozone does not respect boundaries and can drift far from its source.

Ozone can cause serious health effects, even low levels of ozone can cause inflammation of the lungs and airways. Asthma attacks increase, chest tightness increases and lung functioning decreases with rising ozone levels. Visits to the emergency room for asthma and acute admissions for respiratory illness tend to increase when ozone levels rise. Healthy people lose about 10 percent of their lung function at 120 ppb of ozone, and about a six percent loss at 80 ppb (OMA 2001). People with respiratory illness, asthma and heart problems are at a higher risk as the ozone levels increase (OMOE 2001). Children and people who exercise or work outside are also sensitive to increases in ozone levels (American Lung Association 2001). Ozone has been linked with premature death. Recent evaluations of ozone have found that there is no "safe" level for ozone or any "threshold" for ozone (OMA 2001; MIT 2000).

Ozone can also damage agricultural crops, forests, garden plants and trees.

Ozone itself is not part of emission inventories in any of the three countries, as it is not emitted directly into the atmosphere. One of the precursors of ozone, NO_x is part of air emission inventories in all three countries. VOCs are included in Canadian and US inventories and a similar measure, total hydrocarbons is included in Mexican inventories. Ozone is considered a criteria air contaminant in Mexico and the US.

A Canada-wide Standard of 65 parts per billion of ozone to be achieved by 2010 has been recently adopted by the federal government, provinces (except Quebec) and territories. In June 2001, the federal government gave notice that it intends to declare ozone toxic under the Canadian Environmental Protection Act.

In the US, the new 0.08-ppm eight-hour standard for ozone was challenged and has been upheld by the Supreme Court. The older standard was based on one-hour average concentration of 0.12 ppm or 235 micrograms per cubic meter of air. In Mexico, the same eight-hour standard is expected to be published in the short term.

Particles

Particulate matter is all air borne solid and liquid particles, except pure water, that are microscopic in size. Particulate matter can range in size. The largest particles, called total particulate matter or total suspended particulates, measure less than 100 micrometers. Smaller particulates are called PM_{10}, which are particulates less than 10 micrometers in diameter. PM_{10} is also called inhalable particulates or coarse particulates. Coarse particulates can be emitted from unpaved roads, fires and windblown dust from construction sites. Even smaller particulates are called $PM_{2.5}$, which are particulates less than 2.5 micrometers in size. $PM_{2.5}$ is also known as respirable particulates or fine particulates. Fine particulates are generally emitted from combustion sources. $PM_{2.5}$ can remain suspended in the air for long periods of time, and so travel far from its source.

Scientists call particulates many different names. The following table (2) outlines the different types of particulates and their names.

Table 2: A Description of the Various Sizes and Names for Particulates

Name	**Description**	**Also Called**	**Health concerns**
Total suspended Particulate	Less than 100 micrometers	Total particulate, Particulate matter	Usually too large to cause health concern Of local concern, usually deposited near source
PM_{10}	Less than 10 micrometers	Inhalable, Coarse	Of health concern
$PM_{2.5}$	Less than 2.5 micrometers	Respirable, Fine, Acid aerosols (if contain acid)	Of significant health concern, Can be transported large distances

Particulates can contain many different types of chemicals such as sulfates, nitrates, ammonia, trace metals and carbon compounds.

Particulates can be emitted directly into the atmosphere earning the name primary particulates, or they can be formed in the atmosphere through chemical and physical reactions, and are known as secondary particulates. Often the gases sulfur dioxide, nitrogen oxides and volatile organic compounds and ammonia create secondary particulates.

In general, the size of particulate matter is inversely proportional to its effect on human health because the smaller the particulate, the more likely it is to be carried deep into the lungs. Because of this ability to travel deep into the lungs, scientists are especially concerned about the effects of the smallest particulates ($PM_{2.5}$).

Numerous studies have linked particulate matter to cardiac and respiratory problems such as asthma, bronchitis and emphysema. Children, the elderly and people with existing respiratory conditions are especially sensitive to health effect from particulates. Many

scientists believe there is no threshold or safe level for exposure to particulate matter (OMA 2001).

Particulates can also reduce visibility by scattering and absorbing light. This reduced visibility or regional haze is becoming a significant problem in many areas in North America. Much of the haze is due to secondary particulate matter, which is formed when gases, especially sulfur oxides, convert in the atmosphere. The US has recently developed regulations to combat regional haze.

PM_{10} has recently been declared toxic under the Canadian Environmental Protection Act. This designation sets in process a requirement to develop plans to control and reduce particulates. A Canada-wide Standard for $PM_{2.5}$ of 30 $\mu g/m^3$, 24-hour averaging time, by the year 2010 has also recently been adopted.

In the US, the National Ambient Air Quality Standards for particles are currently under review. The current standards set in 1997 are annual $PM_{2.5}$ standard of 15 micrograms per cubic meter and a 24-hour standard set at 65 micrograms per cubic meter. The annual PM_{10} standard is 50 μg/m3 and the 24-hour PM_{10} standard is 150 micrograms per cubic meter, looking at the 99^{th} percentile of measurements collected over three years. A draft Air Quality Criteria Document has been produced which assesses the scientific data about the health and environmental effects of particulates. A revised Criteria Document is expected in late 2001. A recommendation about whether to revise or retain the existing particulate standards is expected in early 2002.

In Mexico, there is a health-related standard for Total Suspended Particles set at 260 $\mu g/m^3$ in 24 hours and 75 $\mu g/m^3$ as annual average, and a PM_{10} standard set at 150 $\mu g/m^3$ in 24 hours and 50 $\mu g/m^3$ as annual average.

Table 3: Current state of particulate emission reporting in inventories in North America

Particulate Emissions	**Canada**	**Mexico**	**US**
Total Particulate matter	X	X	
PM_{10}	X	X (only for Mexico City, Mexicali and Tijuana)	X
$PM_{2.5}$	X		X

$PM_{2.5}$ will be included in updates of inventories in Mexico.

Sulfur Dioxide (SO_2)

Sulfur dioxide (SO_2) is a colorless, pungent gas. SO_2 can change to sulfur trioxide that can further change into sulfuric acid mist. SO_2 can also be oxidized to form acid aerosols.

SO_2 is emitted from smelters, utilities, steel mills, refineries and pulp and paper mills. SO_2 also comes from mobile sources burning high-sulfur fuels.

When high levels of SO_2 are inhaled, breathing problems, respiratory illness, changes in lung tissue and increased respiratory and cardiovascular diseases can occur (OMOE 2001). People with asthma, chronic lung and heart disease may be especially sensitive to SO_2.

SO_2 and NO_x are the main causes of acid rain. Sulfur compounds in the air also contribute to regional haze or visibility problems in areas of North America.

Sulfur oxides are included in emission inventories in Canada. Sulfur dioxide is included in inventories in Mexico and the United States.

Volatile Organic Compounds (VOCs)

Volatile Organic compounds are a family of chemicals that share one characteristic, they evaporate or volatilize into the air. VOCs are one of the building blocks of ozone, a major component of smog. VOCs differ in their reactivity, their ability to create ozone.

VOCs come from a wide range of sources including gasoline, chemical manufacturing and solvent use. There are also significant sources of VOCs including vegetation and forest fires.

Historically, there have been different definitions of VOCs and subsequently different lists of chemicals considered VOCs. Currently, the recent definition of VOCs in Canada and Mexico is similar to EPA's regulatory definition of VOCs (40 CFR 51.100) and the list of chemicals not considered VOCs are the similar in all countries. In the US, VOCs means any "compound of carbon, excluding carbon monoxide, carbon dioxide, carbonic acid, metallic carbides or carbonates and ammonium carbonate, which participates in atmospheric chemical reactions". Under this definition, EPA excludes methane, ethane, methylene chloride, 1,1,1-trichloroethane, several Freon compounds, acetone, perchloroethylene and other chemicals. Several of these chemicals are emitted in large quantities and may play a role in formation of ozone (EPA 1999a). Based on historical tests, ethane was chosen as the benchmark species to separate compounds considered reactive from those compounds considered negligibly reactive. Some chemicals have been determined to have negligible photochemical reactivity and are listed in Appendix B. The EPA currently has over 15 petitions to exclude specific chemicals from being considered VOCs. EPA has commenced a "multi-year review" to determine whether its policy and methods to define VOCs requires revision.

Some VOCs (butadiene, acrolein, acryonitrile and 1,3-butadiene) have recently been declared toxic under the Canadian Environmental Protection Act. In the proposal to require mandatory reporting of criteria air contaminants, VOCs are defined as "compounds that participate in atmospheric photochemical reactions, excluding those substances listed in the Notice of Intent, Part 1, 9 June 2001, p.1879–1881." These substances that are not considered VOCs in Canada include methane, ethane, methylene chloride, CFCs and HCFCs, acetone, perchloroethylene and other chemicals. The chemical list is the same as for the US. The Ontario definition of VOCs is slightly different as it also references vapor pressure, but this may make little difference in the list of VOCs (see Appendix B).

VOCs are included in emission inventories in Canada and the US. Mexico includes total hydrocarbons in its emission inventories. The VOCs definition is included in the Mexican methodology for the development of emissions inventories (INE 2001).

1.6 What are greenhouse gases?

Greenhouse gases include:

- Carbon dioxide (CO_2)
- Methane (CH_4)
- Nitrous oxide (N_2O)
- Chlorofluorocarbons (CFCs)
- Hydrofluorocarbons (HFCs)
- Perfluorocarbons (PFCs)
- Sulfur hexafluoride (SF_6)

The relative potential for these gases to contribute to global warming depends on their global warming potentials. Global warming potentials are a relative measure of the warming effect that a particular type of greenhouse gas might have when present in the atmosphere (Environment Canada 1999). Carbon dioxide is assigned a global warming potential of one, and other greenhouses gases are measured against carbon dioxide. Some gases like perfluorocarbons and sulfur hexafluoride that are often emitted in small quantities, but have large global warming potentials and long atmospheric lifetimes, can be a significant concern.

The greenhouse gas emitted in the largest amount is carbon dioxide, and arises largely from the burning of fossil fuels (EPA 2001b). Decomposition of waste in landfills, manure and fermentation in livestock, natural gas systems and coal mining are sources of methane. Emissions of nitrous oxide include agricultural soil and transportation. Aluminum smelters are a source of perfluorocarbons. Sulfur hexafluoride sources include electrical transmission and distribution systems that use sulfur hexafluoride as an insulator (EPA 2000a).

Many of the criteria air contaminants also play an indirect role in global warming. They can react with other chemicals to form greenhouse gases, alter the lifetimes of other greenhouse gases, or influence the formation and destruction of both ground-level and stratospheric ozone, which in turn affects the earth's ability to heat or cool. Sulfur dioxide can form sulfate aerosols that can scatter the sunlight back into space, affect cloud formation and affect chemical reactions. Although there are many uncertainties about the overall effect of sulfur dioxide emissions, unlike other criteria air contaminants, they may play a role in reducing global warming (EPA 2001b).

Inventories are an essential part of the international, national and local plans to address climate change. A detailed, comprehensive and consistent approach to developing greenhouse gas inventories has been established under the United Nations Framework Convention on Climate Change. The Intergovernmental Panel on Climate Change (IPCC) has published "Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories" which provides methodologies to estimate greenhouse gas emissions, common source categories and minimum default approaches. More recently, in May 2000, the IPCC finalized a set of good practices to provide direction to countries to produce emission estimate that are as accurate, with the least uncertainty as possible.

The report, Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (Good Practice) describes:

- the most appropriate estimation method to be used under the IPCC guidelines
- the required quality control and quality assurance measures
- the proposed assessment and documentation of data and information and
- the quantification and tracking of uncertainties for each source category and the entire inventory.

The Good Practice guidance is available at <http://www.ipcc-nggip.iges.or.jp/public/gp/gpgaum.htm>

Having an agreed-upon guideline and guidance for greenhouse gas inventories has resulted in national estimates of greenhouse gases that can be compared on a global basis. This international methodology for estimating greenhouse gases is unique. Other inventories such as pollutant release and transfer inventories and criteria air contaminant inventories do not have specific, detailed international guidelines for their development. Generally these inventories have been driven to serve local, state or national needs, rather than international needs. The greenhouse gas inventories generally present aggregated emissions at the sectoral or regional or national levels, rather than facility-specific data. For more information on greenhouse gases, see:

- United Nations Framework Convention on Climate Change at <http://www.unfccc.de/>
- International Panel on Climate Change at <http://www.ipcc.ch/>

Under the Framework Convention, as many criteria air contaminants also play a role in climate change, countries are also encouraged to report for some criteria air contaminants such as:

- Sulfur dioxide
- Ozone precursors
- Nitrogen oxides
- Carbon monoxide
- Non-methane volatile organic compounds (NMVOCs)

2 The Current State of Air Contaminants Inventories in North America

This chapter describes the current state of emission inventories in Canada, Mexico and the US.

2.1 The Current State of Air Emission Inventories in Canada

In Canada, there is one national inventory of criteria air contaminants, which is maintained by the federal environment department, Environment Canada, with the assistance of federal, provincial and regional agencies. This inventory, called the Criteria Air Contaminants Emission Inventory, covers the following contaminants (listed in alphabetical order):

- Ammonia (NH_3)
- Carbon monoxide (CO)
- Nitrogen Oxides (NO_x)
- Particulate matter (PM_{10})
- Particulate matter ($PM_{2.5}$)
- Sulfur oxides (SO_x)
- Total particulate matter

Base Year and Frequency of Updating

The Canadian inventory is constantly being updated, with a major update every five years. The most recent, publicly available inventory for criteria air contaminants is for the year 1995. The most recent version of the 1995 inventory is December 1999.

Environment Canada substantially revised the 1995 inventory from the earlier 1990 inventory. Because of the substantial revisions, only the sulfur oxides emissions can be compared to earlier inventories. Environment Canada is currently developing the 2000 emission inventory, and expects to release it in spring 2002. Environment Canada is also preparing an analysis of trends in criteria air contaminants from 1985–1995 and expects to release it in spring 2002.

Source Categories

Environment Canada presents the Canadian Criteria Air Contaminants Emission Inventory for six main source categories:

- Industrial sources
- Non-industrial fuel combustion

- Transportation
- Incineration
- Miscellaneous
- Open sources

The inventory further subdivides each of these six main categories. The inventory codes the sector subdivisions using both US and Canadian standard industrial classification (SIC) codes, and will use North American Industry Classification System (NAICS) codes in the future. The inventory also codes point sources using the US source classification codes (SCC), which are process-level codes that describe the equipment or operation emitting pollutants.

The emission inventory can be broken down by:

- Specific contaminants
- Source category
- Province
- By Troposphere Ozone Management Areas (TOMAS): those areas with elevated smog levels, including the Lower Fraser valley and the Windsor to Quebec City corridor, for some contaminants

The emission inventory can also be presented as a national map for each contaminant.

Development of the Inventory

The Pollution Data Branch of Environment Canada prepares the emission inventory, with assistance from:

- Other federal departments such as Statistics Canada
- Provincial environmental departments
- Some municipal and regional environmental departments

The development and updating of the emission inventory involves working closely with all these groups, through a coordinating body called the Emissions and Projections Working Group (EPWG). This coordinating group of governmental representatives discusses the technical details and emerging needs of the criteria air contaminants inventory in monthly teleconferences and regular meetings. A broader stakeholder group consisting of industry, nongovernmental and health organizations are periodically consulted. For more information on EPWG, see <http://www.ccme.ca/3e_priorities/EPWG>. Some members of the working group also work with other inventories such as the National Pollutant Release Inventory and the Greenhouse Gas Inventory, which allows informal integration among the inventories. The Environment Canada staff for the three inventories is located together, increasing the communication among the inventories. The EPWG also reports to the National Air Issues Coordinating Committee, which discusses overall air quality plans and programs.

The (Canadian) Criteria Air Contaminants Emission Inventory is prepared using a combination of guidance manuals, such as Environment Canada's *1995 Criteria Contaminants Emission Inventory Guidebook*, as well as previous experience and consultation through the working group. Generally, provinces develop and verify point source data and the federal government estimates emissions from mobile and area sources for each province. Some guidance documents are available at <http://www.ec.gc.ca/pdb/ape/>.

The point source emissions are developed through a variety of methods: use of special studies, emission monitoring data, emission factors derived from US or European estimates, best engineering judgment, and other methods. Mobile sources are estimated using the EPA MOBILE5 model for the 1995 inventory and will use the updated MOBILE6 model for the 2000 inventory. For information on the EPA MOBILE models, see <http://www.epa.gov/otaq/models.htm>. Fuel consumption data and other information come from Statistics Canada and other federal departments.

Uses of the Inventory

The Criteria Air Contaminants Emission Inventory is used in many different ways. It supports decisions within Environment Canada on emission reduction programs and regulations, government programs on climate change, smog, acidifying emissions and air toxics. The inventory supports monitoring programs and national and international agreements, protocols and conventions including Canadian Air Quality Agreement, the Canada/US Air Quality Accord and the NO_x/VOC Management Plan.

Summary of Emissions

A summary of the 1995 Canadian Criteria Air Contaminants Emission Inventory is presented in Table 4. The amounts of criteria air contaminants are expressed in metric tonnes, each of which is equivalent to 1000 kilograms or 2205 pounds or 1.102 short tons.

Table 4: Summary of Criteria Air Contaminant Emissions for Canada for 1995
(in metric tonnes)

Source category	CO	NO_x	Particulate	PM_{10}	$PM_{2.5}$	SO_x	VOC
Industrial sources	2,177,266	620,351	621,171	287,258	171,849	1,949,617	940,821
Non-industrial fuel combustion	1,078,622	333,210	224,868	179,141	156,881	566,445	407,112
Transportation	6,707,715	1,290,214	97,580	95,524	83,276	135,686	734,412
Incineration	46,656	2,550	2,510	1,476	1,149	1,253	6,255
Miscellaneous	14,239	1,068	21,472	14,368	9,232	2	549,731
Open sources	7,103,338	216,578	14,716,862	4,792,926	1,096,763	569	936,871
National Total	**17,127,836**	**2,463,971**	**15,684,465**	**5,370,694**	**1,519,149**	**2,653,571**	**3,575,202**

Source: Environment Canada 2001

Availability of Information

The emission inventory and information is available in English and French. Information is available from the head office of Environment Canada in Hull, Quebec, or on the Web at <http://www.ec.gc.ca/pdb/ape/cape_home_e.cfm>.

The emission inventory is considered public information at the sectoral level. Some provinces and facilities restrict the availability of the information at the facility level through formal agreement or informal arrangements. Other provinces allow facility-specific information to be publicly available either through the Web or upon request.

New and Future Directions

In the future, Environment Canada will more closely integrate the Criteria Air Contaminants Emissions Inventory with the National Pollutant Release Inventory (NPRI). Starting in the year 2002, Environment Canada will require point sources meeting certain thresholds to annually report on air releases of criteria air contaminants to the existing NPRI. A point source meeting one or all contaminant thresholds must report criteria air contaminants to the NPRI if employees worked a total of 20,000 hours during the year (equivalent to 10 full time employees). With the reporting to the NPRI, Canada will have for the first time annual, mandatory, publicly available, nationwide reporting of criteria air contaminants released by facilities.

The proposal for the addition of criteria air contaminants to the NPRI is out for public comment until September 2001 with a final decision in fall/winter 2001. The full text of the proposed changes “First Report of the National Pollutant Release Inventory Stakeholder Work Group on Substances (2001–2002)” can be found at <http://www.ec.gc.ca/pdb/npri>. A number of important decisions on how criteria air

contaminants will be reported are under discussion. The proposed thresholds for reporting of criteria air contaminants are outlined in Table 5.

Table 5: The Proposed Thresholds for Reporting of Criteria Air Contaminants to NPRI

Criteria Air Contaminant	**Reported as**	**Release Threshold**	**Compatible with**
Sulfur oxides: (SO_2, SO_3, SO_4)	Sulfur dioxide (SO_2)	20 tonnes	United Nations Economic Commission for Europe (UNECE) US EPA
Nitrogen oxides: Nitric oxide (NO) and nitrogen dioxide (NO_2)	Nitrogen dioxide (NO_2)	20 tonnes	US EPA Ozone Annex to the Canada-US Quality Air Agreement UNECE
Carbon monoxide (CO)	Carbon monoxide (CO)	20 tonnes	US EPA
Volatile organic compounds (VOCs): VOCs that participate in atmospheric photochemical reactions Excluding those substances listed in the Notice of Intent in the *Canada Gazette*, part 1, 9 June 2001	Total VOCs	10 tonnes	Similar to Ontario regulation (except for reference to vapor pressure) US EPA, UNECE
Total particulate matter (TPM) is any airborne finely divided solid or liquid material with an aerodynamic diameter smaller than 100 micrometers (includes PM_{10} and $PM_{2.5}$)	Total particulate matter	20 tonnes	Definition is consistent with national and provincial monitoring networks and national inventory
PM_{10} is any particulate matter with an aerodynamic diameter less than or equal to a nominal 10 micrometers (includes $PM_{2.5}$). Only primary releases are reportable	PM_{10}	0.5 tonnes	Threshold is consistent with Ontario MOE US EPA, UNECE
$PM_{2.5}$ is any particulate matter with an aerodynamic diameter of less than or equal to a nominal 2.5 micrometers. Only primary releases are reportable	$PM_{2.5}$	0.3 tonnes	Definition is consistent with US EPA Threshold is consistent with Ontario MOE UNECE

Four additional proposed changes would also increase the sources reporting criteria air contaminants to NPRI. Any facility with combustion equipment with a nameplate capacity of greater than 3 million BTUs could be subject to reporting. The facility would be required to report criteria air contaminants regardless of number of employees, therefore the current 20,000 hours/10 people threshold would not apply. This proposed change is consistent with Ontario Ministry of the Environment reporting and would potentially affect a large number of facilities.

A second proposed change would require reporting from facilities involved in vehicle maintenance and repair, which had been previously exempted.

A third proposed change would require reporting from fuel distribution terminals, which had previously been exempted.

A fourth proposed change will require facilities to report on temporal variation and stack information for the 2002 reporting year. For the year 2003, speciation of VOCs will be required. Reporting of fuel quantities and the break out between combustion and non-combustion data are also under consideration.

All of the proposed changes would significantly increase the amount, quality and frequency of data now used to calculate criteria air contaminants in the emission inventory. Facilities would report on the criteria air contaminants for the 2002 calendar year, with reports due in summer 2003. This new source of information will allow an updated version of the 2000 inventory to be prepared, or be incorporated into the 2005 inventory.

Environment Canada has also committed to consider adding the greenhouse gases to the NPRI for the 2003 reporting year. A work group has been formed to propose options for this integration. If greenhouse gases were to be added, this will result in a one-window approach for the collection of PRTR, criteria air contaminant and greenhouse gas data from facilities in Canada.

For more information on Canada's Air Contaminant Emission Inventory:
Web site <http://www.ec.gc.ca/pdb/ape/cape_home_e.cfm>
Marc Deslauriers, Chief, Emission Inventory, tel: (819) 994-3069
For more information about the proposal to add CAC to NPRI:
Web site: <http://www.ec.gc.ca/pdb/npri/npri_consult_e.cfm>

Other Canadian Air Emission Inventories

Canada also has two other national air contaminant inventories:

- The National Pollutant Release Inventory. An annual inventory of releases of 268 substances to the air, land, water and underground injection and transfers to disposal and recycling. Mandatory reporting for approximately 2000 facilities across Canada. Data is collected by Environment Canada, and made publicly available. For information on NPRI, see <http://www.ec.gc.ca/pdb/npri/>.

- The Greenhouse Gas Emission Inventory. An annual inventory of greenhouse gases including carbon dioxide, methane, nitrous oxide, sulfur hexafluoride, perfluorocarbons, and hydrofluorocarbons. The most recent publicly available data is from the year 1999. The inventory follows the methodology developed by the United Nations Framework Convention on Climate Change. Data is broken down into six main categories and by greenhouse gas. In 1998, Canadians released about 699 million metric tonnes of carbon dioxide equivalent (EC 2000). For more information, see <http://www.ec.gc.ca/pdb/ghg/ghg_home_e.cfm/>.

Provincial Inventories

Many provinces and some regions have developed their own inventories of criteria air contaminants. These vary in level of detail, sector coverage and frequency of updating. Most are developed to provide data for provincial air quality programs such as ozone, acid rain and particulates, to determine time trends and to verify data for the national inventory. Some of the provincial inventories consider facility-specific emissions information to be confidential and therefore provide only sectoral-level analysis. Other provinces provide facility-specific data. Only a handful of provincial emission inventories provide facility specify data easily accessible on the Internet.

A recent survey of emission inventories in Canada done for the Canadian Council of Ministers of the Environment found 39 emission inventories in Canada, 3 regional, 6 industrial, 14 provincial, 3 territorial and 13 federal. Of these 39 emission inventories, 27 were publicly available. For a matrix describing the state of federal, provincial, industrial emission inventories, please see " Matrix of air release inventories and related programs in Canada" (February 2000), released by the Canadian Council of Ministers of the Environment, which is available from <http://www.ccme.ca/3e_priorities/EPWG/>.

The province of British Columbia is in the process of developing a 2000 inventory and is updating specific sources including permitted sources, prescribed burning and fires. Reporting is voluntary, and the province is asking approximately 250 of its estimated 900 point sources to report emissions for the 2000 inventory. Environment Canada is developing area and mobile sources for British Columbia's 2000 inventory.

Previously, the province has posted its emission inventory on the Web, which has increased media interest, allowed for public access and research, helped to identify and correct errors, reduced paper costs, reduced time spent on inquiries, and increased access for air quality modelers. For information on British Columbia's 1995 emission inventory, which includes both criteria air contaminants and greenhouse gases at the facility level, by sector, by region, and by contaminant, see <http://www.elp.gov.bc.ca/wdp/edpa/ar/airquality/inventory/>.

For information on Greater Vancouver Region and District emission inventory for 1999, which includes both criteria air contaminants and greenhouse gases at the facility level, by sector, by region and by contaminant, see <http://www.gvrd.bc.ca/services/air/emissions/inventory.html>.

Alberta requires mandatory reporting for approximately 500 major point sources for two criteria air contaminants, sulfur dioxide and nitrogen oxides, on an annual and sometimes monthly basis. These data are publicly available at the facility level upon request. Reporting for other criteria air contaminants varies by facility and industrial sector. Environment Canada estimates area and mobile sources with input from the province.

Urban emission inventories are being developed for Calgary and Edmonton. Alberta is exploring web-based reporting systems.

Quebec has an annual emission inventory process. A voluntary questionnaire is sent to major point sources early in the year to seek emission estimates. Quebec has a 100 percent response rate. Information on production and fuel use are requested, and based on these data, the provincial government estimates emissions. Emission data are made publicly available upon request.

Ontario has just started a mandatory emission-reporting program for criteria air contaminants, greenhouse gases and toxics. Starting in May 2000, utilities were the first sector required to report on air emissions of 28 pollutants. In May 2001, the program was expanded to require reporting on 358 chemicals by the utilities. On January 2001, large industrial, institutional, commercial and municipal sources will start monitoring and reporting on 358 chemicals. Smaller industrial, commercial and municipal sources will start monitoring in January 2002. Sector-specific contaminants lists have been produced. The criteria air contaminants and the greenhouse gases have release-based thresholds, while other air contaminants have thresholds based on the amount of chemical manufactured, processed or otherwise used. Thresholds are: carbon monoxide, 20,000 kilograms per year; nitrogen oxides (expressed as NO), 14,000 kg/year; particulate matter, 20,000 kg/year; PM_{10} 500kg/yr, $PM_{2.5}$ 300 kg/year; sulfur dioxide, 20,000 kg and VOCs are 10,000 kg/year. Ontario's definition of VOCs is similar to that of the US EPA but with an additional vapor pressure limit of 0.01 kilopascals or greater at 25^{o}C. Ontario is working with the federal government to integrate reporting requirements with NPRI. Data will be publicly available on the Internet. For more information, see <http://www.ene.gov.on.ca/>.

2.2 The Current State of Air Emission Inventories in the United States

There is one main national inventory of criteria air pollutants in the US, maintained by the US Environmental Protection Agency, with the assistance of state, local, tribal and regional agencies. This inventory, now officially called the National Emission Inventory (NEI), covers the following criteria air pollutants and their precursors (listed in alphabetical order):

- Ammonia (NH_3)
- Carbon monoxide (CO)
- Lead (Pb)
- Nitrogen oxides (NO_x)
- Particulate matter (PM_{10})
- Particulate matter ($PM_{2.5}$)
- Sulfur dioxide (SO_2)
- Volatile organic compounds (VOCs)

Strictly speaking, a pollutant is considered a criteria air pollutant if EPA has established a national ambient air quality standard (NAAQS) under the US Clean Air Act for the pollutant in order to protect human health and welfare. Ozone, carbon monoxide, nitrogen dioxide, sulfur dioxide, lead and particulate matter all have national ambient air quality standards, and so these six pollutants are considered criteria air pollutants.

Ozone, while a criteria air pollutant, is not included in the national emission inventory, as it not emitted directly into the air. The ozone precursors, NO_x and VOCs, however, are included. Ozone is formed by chemical reactions in the atmosphere involving NO_x and VOCs in the presence of heat and sunlight. The list of VOCs reported to the inventory is based on the EPA definition of VOCs, which excludes chemicals considered negligibly photochemically reactive, such as methane, ethane, methylene chloride and other chemicals.

Ammonia is included in the NEI because it is a precursor for secondary particles such as ammonium sulfate and ammonium nitrate.

Nitrogen dioxide is a criteria air pollutant. Emissions of nitrogen oxides (NO_x), which include both nitrogen dioxide (NO_2) and nitric oxide (NO), are reported as weight equivalent nitrogen dioxide. The actual tons of NO are converted to their NO_2 mass equivalent when reported in the national inventory (EPA 2000).

The US emission inventory program has made important changes over the past few years. The new 1999 National Emission Inventory now includes both the criteria air pollutants and their precursors and approximately 188 chemicals considered hazardous air pollutants under the Clean Air Act Amendments. Lead emissions are now contained in the hazardous pollutants part of the inventory. In the previous 1996 inventory, these were two separate inventories, one for criteria air pollutants known as National Emission Trends (NET) and one for hazardous air pollutants, known as the National Toxics Inventory (NTI).

Base Year and Frequency of Updating

The US inventory is constantly being updated to reflect revisions in methodologies for estimating emissions as well as to reflect more accurate emissions data reported by the states or other reporting agencies, with a major update by EPA every three years. The most recent, publicly available inventory for criteria air pollutants and their precursors is for 1999. A revised version (version 2) of the 1999 inventory is expected in fall 2001.

Subsequent inventories will be at three-year intervals (2002, 2005, 2008, etc…). EPA's three-year update in 2005 will coincide with the five-year 2005 inventory update by Environment Canada.

Estimates of criteria air pollutant emissions are available starting for the year 1985. Emissions of nitrogen oxides, sulfur oxides and VOCs have been extrapolated back to

1900. A summary of national air pollution trends is also produced annually. The latest trend summary presenting annual emission of criteria air pollutants from 1970, 1975, 1980, 1985, 1989, 1990–1999, is available on the Web at <http://www.epa.gov./ttn/chief/>. The last major report describing the criteria air pollutants and their trends was the *National Air Pollution Emission Trends 1900–1998* (EPA-454/R-00-002) available from the same EPA web site or CHIEF help desk.

Source Categories

The US National Emission Inventory is generally presented for ten main source categories:

- Fuel combustion
- Industrial processes
- Solvent utilization
- Storage and transport
- Waste disposal and recycling
- On-road vehicles
- Non-road engines and vehicles
- Natural sources
- Miscellaneous
- Open sources

The inventory subdivides each of these main categories. Point sources are also coded using the North American Industry Classification System (NAICS) and the US Source Classification codes (SCC), which are process-level codes that describe the equipment or operation emitting pollutants.

The NEI reports emissions from individual point sources whose emissions exceed certain thresholds. Point sources are divided into two types: Type A, larger sources for which states must submit annual emissions and Type B, smaller sources, for which states may submit data every three years, or report one-third of sources every year. The thresholds used to determine point sources are:

Pollutant	**Emission Threshold For Point Sources** (short tons per year)
Ammonia	100
Carbon monoxide	1,000
Nitrogen oxides	100
Sulfur oxides	100
PM_{10}	100
$PM_{2.5}$	100
Lead	5
VOCs	100

Source: EPA 2000b, Consolidated Emission Reporting Rule

The NEI reports aggregated area and mobile source emissions for each pollutant at the county level.

The emission inventory can be broken down by:

- Specific pollutant
- Source category
- Facility
- Year
- State
- County

Both the emission estimates and air quality measurements are available as maps or charts in a number of different formats on the Air Graphics site of EPA at <http://www.epa.gov/agweb/>.

Development of the Inventory

The development and updating of the NEI is a joint activity, managed by the US Environmental Protection Agency, with assistance from:

- Other federal departments
- State, territorial, local and tribal environmental departments

Section 110 of the Clean Air Act requires states with areas that do not meet air quality standards (called "nonattainment areas") to develop written plans for reducing air pollution that will bring the nonattainment areas into compliance with the relevant National Ambient Air Quality Standard (NAAQS). This plan, called a State Implementation Plan (SIP), is an important document describing the current air quality in the state and the measures the state will pursue to achieve compliance with a NAAQS. Emission inventories are a vital part of the development of a SIP because they serve as the basis for a state's decisions on what sources contribute to nonattainment and what sources should reduce their emissions. Under the Clean Air Act, states are required to compile and submit certain elements of emission inventories as part of their SIP.

Recently, the US EPA promulgated new health standards for ozone and $PM_{2.5}$, as well as adopted a regional haze rule to improve visibility in certain "pristine" areas of the US (called "Class I areas" in the Clean Air Act). As a result of these new standards and rules, States will need to develop three basic kinds of inventories, a base year inventory, a periodic inventory (a periodic update of the base year) and a modeling inventory (EPA 1999b). The base year inventory is the main inventory and is required to be comprehensive, accurate and current for all actual emissions. The base year inventory includes emission estimates from stationary point and area sources (including both human activity and natural sources), as well as both on-road and off-road mobile sources. EPA suggests 1999 as the base year for the state emission inventories for ozone. For regional haze plans, EPA recommends 2002 as the base year. States were advised to begin collecting data for inventories of direct emissions of $PM_{2.5}$ and its precursors for the inventory year 1999 (EPA 2000b).

Overall trends in emissions are determined from the periodic inventory, which is the base year inventory modified every three years.

Modeling inventories are required to demonstrate attainment of the NAAQS or regional haze rule. A modeling inventory is an inventory that has been prepared for use in air quality models that assist air quality planners in assessing how much and from where emissions must be reduced to meet air quality goals.

Emission estimates are needed for all counties within a state. A state may develop these county-wide emission estimates or use the EPA National Emission Inventory.

EPA has prepared a Consolidated Emissions Reporting Rule (CERR) to improve and simplify the reporting of emission inventory information (EPA 2000b). EPA issued the proposed CERR on 23 May 2000, to consolidate various air emission reporting requirements, which should provide more consistent data and improved reporting efficiency (EPA 1999b). It provides a summary of the data elements that states must report for point sources, area, mobile and biogenic sources. The CERR also adds several new requirements:

1) States would be required to prepare an inventory for mobile and area sources for all counties within the state, not just those in non-attainment areas.
2) States would be required to estimate emissions for new pollutants, $PM_{2.5}$ and its precursors.

States are also required to submit an inventory preparation plan to EPA which describes how the inventory is developed, what it includes—such as the base year, the pollutants, the boundaries, the spatial and temporal scales, the application of controls (such as rule effectiveness and rule penetration), the definition of VOCs and what VOCs are included, and the assumptions made in developing the inventory (EPA 1999b). The inventory preparation plan should also include a schedule for development of the inventories.

Uses of the Inventory

As the 1999 NEI contain both criteria air pollutants and hazardous air pollutants, it will be used for regional and local scale air quality modeling and human exposure modeling. The inventory will be used to model concentrations, exposures and risks for the National Air Toxics Assessments, provide estimates for the Air quality and Emission trends report, support regulatory analysis of TIER 2 standards for automobile engines and the Heavy-duty Engine and Diesel Fuel Sulfur Rule. It will also help implement some sections of the Clean Air Act Amendments (EPA 2001).

Summary of Emissions

A summary of the 1999 US National Emissions Inventory is presented in Table 6.

Table 6: Summary of National Pollutant Emission Estimates in the US for 1999
(emissions in thousands of metric tonnes; totals may not add due to rounding)

Source Category	CO	Lead	NO_x	VOCs	PM_{10}	$PM_{2.5}$	SO_2	NH_3
Fuel Combustion	4,827	0.454	9,094	820	933	695	14,594	44
Industrial Processes	68,841	2.868	854	7,252	1,146	828	1,347	262
Transportation	68,162	0.486	12,793	7,736	683	580	1,178	245
Miscellaneous	8,506		290	649	18,715	4,040	11	3,920
Agriculture and Forestry					4,433	860		
Other Combustion					913	791		
Livestock, Agriculture								3,222
Fertilizer								697
Natural Sources								32
Total	88,379	3.808	23,031	16,458	21,477	6,143	17,112	4,502

Source: NEI 1999

Availability of Information

The NEI is a publicly available database, accessible on the Web. Data are available in English at the facility, county, contaminant levels for a variety of years. To access the inventory, see the EPA web site at <http://www.epa.gov/ttn/chief/>.

New and Future Directions

The Emission Inventory Improvement Program (EIIP) assists with the development of emission inventories in the US. The goal of EIIP is to provide cost effective, reliable inventories by improving the quality of emissions information and developing systems for collecting, calculating and reporting emissions data. EIIP seeks to develop a set of preferred and alternative methods for all inventory tasks (EIIP 2001). The development of these methods will help increase the consistency of the emission data and the usefulness of emission information. EIIP is a joint effort of the State and Territorial Air Pollution Program Administrators (STAPPA) and the Local Air Pollution Control Officials (ALAPCO). For more information on EIIP, see <http://www.epa.gov/ttn/chief/eiip/>.

EIIP has developed a list of high priority projects for the improvement of emission inventories to meet the additional needs posed by new air quality standards for PM, haze and ozone. Some of these projects are now underway (see Table 7).

Table 7: Projects Considered High Priority for Action by the Emission Inventory Improvement Project

Area	Project Description
Toxics	Publish toxics emission estimation guidance documents for point, area and mobile sources
Particulate matter	Develop guidance documents for preparing PM inventories
	Develop an algorithm for determining transportable fraction of fine PM to reconcile emissions data with monitoring data
	Develop guidance documents for preparing regional haze inventories
Training	Conduct an annual emission inventory workshop for exchange of technical information and staff training
	Establish Implementation Task Force to evaluate need for benchmarking, mentoring and development/coordination of formalized training programs
Mobile sources	Conduct top down evaluation of MOBILE emission model using ambient monitoring data
	Solicit EPA office of Mobile Sources participation in EIIP to enhance interaction with state and local agencies when developing mobile source emission estimation tools
Modeling profiles	Develop/improve temporal, spatial and speciation profiles for emissions modeling to increase confidence in air quality modeling results
Projections	Improve current projection methodology to provide more reliable emission projection forecasts
Area sources	Develop criteria for establishing when surveys are needed to collect area and non-road activity source data
	Update area and non-road source emission factors
Biogenics emissions	Update guidance to reflect the new BEIS3 model
Data management	Develop data transfer protocols
	Complete development of process classification code system essential for new data management systems
Quality assurance	Promote integration of emission inventories to resolve criteria and toxic pollution source differences
	Develop a default source categorization system to allow more valid emission comparisons among inventories

Other US Air Emission Inventories

The US also has a number of other national air emission inventories including:

The Inventory of US Greenhouse Gas Emissions and Sinks. This national inventory of greenhouse gases contains 1999 data and trends from 1990–1999. This inventory forms the basis of an annual report submitted to the United Nations as part of the commitments under the Framework Convention on Climate Change. This inventory uses methodologies consistent with those recommended under the Intergovernmental Panel on Climate Change (EPA 2001b). The US total greenhouse gas emissions in 1999 were 6,746 (teragrams) or million metric tonnes of carbon dioxide equivalents. The inventory and description of methods used is referenced in the *Inventory of US Greenhouse Gas Emission and Sinks: 1990–1999,* US EPA 236-R-01-001, April 2001 and also available at <http://www.epa.gov/globalwarming/publications/emissions/>.

US Toxics Release Inventory: An annual, mandatory reporting of over 500 chemicals released to the air, land, water and injected underground, or transferred off-site. Many of these chemicals are considered VOCs. Data and information on the TRI can be found at <http://www.epa.gov/triexplorer/>.

2.3 The Current State of Air Emission Inventories in Mexico

Development of Inventories

The federal government, under the Mexican environmental law, is required to integrate and update emission inventories for sources under federal jurisdiction. States are authorized to develop emission inventories for all other sources, including mobile, area sources and point sources not under federal control. This division of responsibility is also reflected in some state laws such as the "Ley Ambiental del Distrito Federal" 13 January 2000 Title 5, Chapter III, article 133.

The federal government's environmental secretariat, called the *Secretaría de Medio Ambiente y Recursos Naturales* (Semarnat), and the Western Governors' Association have cooperated in developing methodologies for air emission inventories in Mexico since 1994. Emission inventory manuals developed for this program can be downloaded in Spanish at <http://www.ine.gob.mx/dggia/cal_aire/espanol/pubinv.htm> or in English at <http://www.epa.gov/ttn/catc/cica/cicaeng.html>. This has helped increase the consistency and comparability of emission inventories. Methods have been developed to take into account unique Mexican source categories such as brick kilns, street vendor cooking devices, auto body repair shops, scrap tire combustion, waste materials used for heating and open sewage impoundments.

There is no comprehensive national air emissions inventory for most air pollutants in Mexico. There are, however, emission inventories for seven of the major cities and regions in Mexico. These urban inventories are coordinated by Semarnat. Semarnat's goal is to complete inventories for all cities over 500,000 people and for all significant industrial corridors.

The cities in Mexico with emission inventories include:

- Mexico City and region
- Monterrey
- Guadalajara
- Toluca
- Ciudad Juárez
- Mexicali
- Tijuana

The present strategy is to update the existing inventories and to start on at least six additional urban inventories: Puebla, Querétaro, San Luis Potosí, Tlaxcala, Comarca Lagunera and Caotzacoalcos. Much of the experienced gained in Mexico has been through the development and regular updating of the emissions inventory for the Mexico City metropolitan area.

A new inventory is also being developed for the industrial corridor, Celaya-Irapuato-Salamanca-Guanajuato.

Contaminants Covered

The following contaminants are included in all the city inventories, except as noted:

- Carbon monoxide
- Total hydrocarbons
- Lead (Monterrey only)
- Nitrogen oxides
- Total suspended particulates (Monterrey, Guadalajara, Toluca and Cuidad Juárez)
- PM_{10} (Mexico City, Mexicali and Tijuana)
- Sulfur dioxide

Base Year and Frequency of Updating

Each city has a different base year for the criteria air contaminants inventory:

- Mexico City (metropolitan area): 1998
- Monterrey: 1995
- Guadalajara:1995
- Toluca (Valley Metropolitan Area): 1996
- Ciudad Juárez: 1996
- Mexicali: 1996
- Tijuana: 1998

While there is no legislated period for updating emission inventories, inventories are generally to be updated every two years. An update of the 1998 inventories for Ciudad Juárez, Monterrey, Guadalajara and Mexicali may be finalized in 2001.

The most advanced and comprehensive emission inventory is for the metropolitan zone of Mexico City. This inventory covers the city and urbanized suburban areas in the State of Mexico, an area containing approximately one-fourth the population of Mexico. The *Gobierno del Distrito federal* (the government of the Federal District) developed the inventory in cooperation with the *Instituto Nacional de Ecología* (National Institute of Ecology) and the *Gobierno del Estado de México* (government of the State of Mexico). The inventory developers surveyed local sources to adapt standard estimation emission

factors and models (such as EPA's AP-42) for local conditions. They also adapted MOBILE5 model for local Mexico City conditions. Planning for the emission inventory for 2000 for Mexico City has started and will include additional municipalities in the State of Mexico and also the State of Hidalgo. The third ProAire (air quality management program) for the Mexico City region is expected towards the end of 2001. The preliminary emissions inventory for Mexico City area is available at <http://www.sma.df.gob.mx/menu.htm>.

In addition to the Semarnat inventory for Monterrey, there is another inventory for Monterrey produced by the State of Nuevo León. This inventory was based on techniques developed by international organizations. In recent years, efforts have been made to put the two inventories together.

Source Categories

The source categories generally used in the inventories in Mexico are:

- Industrial emission
- Services
- Transportation
- Vegetation and soils

Each of these source categories is further subdivided into approximately 15 subcategories for industry, services and transportation. Categories used in each city inventory may change depending upon the specific activities in the city (i.e., brick kilns, agriculture, etc.).

Estimates of emissions from point sources comes from permit data, industrial surveys, emission factors, engineering estimates and mandatory reporting of some criteria air contaminants (SO_2, NO_x, CO, particulates and VOCs) by federal facilities as part of the *Cedula de Operación Anual* (Annual Certificate of Operation—COA). The 11 industrial sectors subject to mandatory reporting under federal authority include: petroleum, chemical and petro chemical, paints and dyes, metallurgy (including iron and steel), automobile manufacture, cellulose and paper, cement and limestone, asbestos, glass, electric power generation and hazardous waste management. Reporting on carbon monoxide, carbon dioxide and unburned hydrocarbons is currently voluntary. In general, public access to source specific pollutant information is not readily available.

The first cycle of COA reporting collected data for the base year 1997. Reporting improved slightly in 1998 with 2,677 facilities reporting. However, less than 60 percent of these forms (1,529) were entered into the database, as they were from facilities under state jurisdiction, lacked a valid official environmental number, or did not contain complete information. Table 8 provides emission data from facilities reporting to COA in 1998.

Table 8: Emissions of criteria air contaminants reported by certain Mexican industries on the COA for 1998

Information Reported	Number of facilities reporting	Amount in tonnes
General facility information	1,239	
Atmospheric pollution	805	
Sulfur dioxide	323	2,940,282
Nitrogen oxide	362	1,828,694
Particulates	573	959,272
VOCs	149	15,030

Source: *Taking Stock 98*, Commission for Environmental Cooperation.

Examples of local jurisdiction point sources are food and beverages, wood furniture manufacturing, bicycles manufacturing, and others.

Mobile sources emissions are estimated using emission factors and EPA MOBILE5 model for on-road vehicles. Often the model has been modified for a particular city, such as Mexico City, Monterrey and Ciudad Juárez (modified mobile source models available on the Web at <http://www.ine.gob.mx/dggia/cal_aire/espanol/pubsof.html/>.

Area sources such as combustion sources are often based on EPA's AP-42 with fuel use data provided by the Mexican petroleum company, PEMEX. For the Mexico City metropolitan area, emission factors such as solvents consumption or traffic paint, have been adapted to local conditions.

Currently, biogenic emissions are estimated using the EPA model BEIS. For some more recent inventories such as Mexico City 1998 inventory, the version BEIS2.2 was used. Biogenic emissions have been estimated for Mexico City, Mexicali, and Tijuana and are becoming more commonly incorporated into urban inventories in Mexico.

Uses of the Inventory

The inventories are used for air quality modeling, for developing the third Air Quality Management Program (ProAire) and for assessing effectiveness of current controls and programs. For some cities, such as Mexico City, the emission inventories are used as part of the smog alarm plan. The inventories help identify industries and activities to be controlled when the air quality reaches certain trigger levels.

Summary of the Emissions

Emissions of criteria air contaminants from Mexican urban inventories are presented in Table 9.

Table 9: Summary of Emissions of Criteria Air Contaminants from Mexican Urban Inventories (emissions in metric tonnes/year)

City	Parti-culates*	SO_2	CO	NO_x	HC	Lead	PM_{10}
Mexico City (1998)		22,466	1,768,836	205,885	475,022	N/A	19,889
Monterrey (1995)	815,628	30,466	907,762	53,275	125,375	116	N/A
Guadalajara (1995)	301,784	8,085	898,042	37,186	143,835	N/A	N/A
Toluca (1996)	123,375	1,522	268,742	21,389	46,481	N/A	N/A
Ciudad Juárez (1996)	46,607	4,146	452,760	26,115	76,132	N/A	N/A
Mexicali (1996)	N/A	3,797	266,738	18,547	51,411	N/A	84,989
Tijuana (1998)	N/A	30,208	299,691	28,796	77,736	N/A	29,349

* Total Suspended Particulates

N/A means not applicable

Availability of Information

Inventories for most of the cities are available on the Web at <http://www.ine.gob.mx/dggia/cal_aire/espanol/invent.html>. The inventory for Tijuana should be posted in the near future.

Most of the inventories for the cities in Mexico are publicly available at the source category level. Emissions from individual facilities are generally not available.

The inventories, methodologies, reports and software are available from the Web at <http://www.ine.gob.mx/dggia/cal_aire/espanol/index.html>. The most recent Mexico City area inventory can be found at <http://www.sma.df.gob.mx/menu.htm>. Some of the material is available in English as well as Spanish.

New and Future Directions

The existing inventories are being refined with the addition of more sources, dividing sectors and refining methodology and input data.

The *Centro de Ciencias de la Atmósfera* (Center for Atmospheric Research) at the National Autonomous University of Mexico (UNAM) is defining emission factors for biogenic emissions. An updated and improved database on land use has been completed.

It is planned that the base year 2000 emission inventory for Mexico City will expand particulate emissions reporting to include $PM_{2.5}$ for the first time, estimate the two to five hydrocarbons emitted in the largest quantities from certain industrial sectors and include

non-methane hydrocarbons and methane. This would allow industries that release reactive hydrocarbons to be identified so that they could then be controlled during a smog alert. Estimates of emissions from mobile sources would be expanded to include fuels used and vehicle weight.

Efforts are made towards the use of a unique methodology (INE 2001), database consolidation, the application of QA/QC techniques and the elaboration of a national level emissions inventory.

Other Mexican Air Emission Inventories

Mexico has a number of other inventories, including:

A National Greenhouse Gas Inventory is produced by the Instituto Nacional de Ecología (INE), following the methodology from International Panel on Climate Change to meet Mexico's international obligations. The pollutants include carbon dioxide, methane, nitrous oxide, non-methane VOCs, carbon monoxide and nitrogen oxides. The base year of inventory is 1990, with a revision generally every five years. A new inventory has recently been released (in July 2001) and will be available at <http://www.ine.gob.mx/>.

The base year 1998 emissions inventory for Mexico City includes an estimated greenhouse gases inventory for CO_2 and CH_4 from the combustion of industrial, residential, transport and commercial sources and from the decay of municipal wastes in landfills.

A specific inventory of greenhouse gases in the metropolitan zone of Mexico City will be completed by the end of 2001. This inventory will use the 1996 base year and projections to 2012 as part of the strategic actions on climate change. The inventory includes levels of greenhouse gases, such as CO_2, CH_4, N_2O and NO_x.

A toxics inventory for Ambos Nogales was produced to assess the health of the people in the Ambos Nogales area in the mid-1990s. This inventory covered 113 individual hazardous air pollutants, including 25 compounds often considered VOCs.

Registro de Emisiones y Transferencia de Contaminantes is an inventory of emissions to air, land and water of approximately 100 pollutants from federally controlled facilities. Currently reporting is voluntary, but the government has made a commitment to develop a bill for the upcoming Congress that would make reporting mandatory.

3 Case Study of Integrating Inventories in North America: Utilities

This chapter explores the data available on emissions from utilities in Canada, Mexico and the United States. The goal of the chapter is to match utility emission data to demonstrate both the opportunities that increased comparability of emission inventories could provide and the barriers that currently exist in comparing emission inventories.

The current status of information on emissions from utilities in the three countries is presented in Table 10.

Table 10: The current status of information on air emissions for utilities in Canada, Mexico and the United States

√ Indicates data are publicly available
≈ Indicates not all data are publicly available or collected
X Indicates data are not publicly available

Data Available on Utilities		**Canada**	**Mexico**	**United States**
Energy mix of country		√	√	√
Location of utilities		√	√	√
Stack characteristics of utilities		≈	≈	√
Criteria air contaminants	Sector-level data	√	≈	√
	Facility-specific data	≈	X	√
	Inventory year	1995	Various	1999
	Spatial scale	National	Urban	National
Greenhouse gases	Sector-level data	√	√	√
	Facility-specific data	≈	X	√
	Inventory year	1998	1990	1999
	Uses common methodology	√	√	√
Toxic pollutants	Sector-level data	√	≈	√
	Facility-specific data	√	X	√
	Reporting year	1999	1999	1999
	Public available database	√	≈	√
	Type of reporting system	Mandatory	Voluntary	Mandatory

3.1. Criteria Air Contaminants

Some information on the emissions of criteria air contaminants from utilities is available from the inventories in all three countries. However, the type of information varies in level of detail, reporting year and methodology.

3.1.1 Criteria Air Contaminants emissions from utilities in Canada

In Canada, publicly available information on criteria air contaminants is available for the utility sector on a national and provincial basis. Emissions from a particular utility are not available from the national inventory. Most, but not all, provincial governments will provide criteria air contaminants data for individual utilities upon request. These provincial emission estimates vary widely in their frequency of updating, methods of estimation and number of sources covered. Most of the provincial estimates are collected using a voluntary survey approach, with the exception of a few provinces, which require mandatory reporting.

To access the provincial data it is often necessary to locate, contact and then make a formal request for specific types of information to a provincial government representative. The official then compiles the data and forwards it. Only a few provinces such as British Columbia have full emission inventories available on the Internet. This somewhat cumbersome system of information retrieval is also hampered by some provinces treating the facility data as confidential. This makes it difficult to put together a national picture of emissions of criteria air contaminants from individual facilities using common methodology and reporting year.

This difficulty in obtaining emissions from individual utilities across Canada will change in the future. Mandatory, annual reporting of criteria air contaminants from utilities and other facilities, which meet certain thresholds, is proposed for the 2002-reporting year. This proposal to add reporting of criteria air contaminants to the National Pollutant Release Inventory can be found at <http://www.ec.gc.ca/pdb/npri/npri_consult_e.htm>.

The emissions from utilities in provinces across Canada from the national inventory are presented in Table 11.

Table 11: 1995 Emissions of Criteria Air Contaminants from the Electric Power Generation (utilities) category in the Canadian Criteria Air Contaminants Inventory (emissions in metric tonnes)

Contaminant	New-found-land	Prince Ed-ward Island	Nova Scotia	New Bruns-wick	Quebec	Ont-ario	Mani-toba	Sask-atch-ewan	Alberta	British Colu-mbia	Yukon	North west Terri-tories	CANADA TOTAL
Particulates	1,262	22	1,910	786	44	5,797	1,113	57,530	9,665	528	13	128	**78,797**
PM_{10}	897	15	458	174	30	1,680	421	21,669	8,973	454	10	93	**34,874**
$PM_{2.5}$	656	12	281	120	24	719	210	7,309	8,777	427	9	90	**18,633**
NO_X	3,690	141	24,330	16,550	1,286	59,399	907	47,509	90,734	4,172	591	5,675	**254,985**
SO_X	15, 704	294	134,883	67,330	283	74,730	1,361	108,536	130,471	369	46	317	**534,323**
CO	403	25	941	1,122	326	3,026	163	2,940	7,972	6,851	156	1,435	**25,359**
VOC	57	3	126	173	43	311	20	369	1,101	573	20	183	**2,980**

Source: Environment Canada web site <http://www.ec.gc.ca/pdb/ape/provincial summaries/>. Inventory for 1995 updated to December 1999. SO_X based on SO_2 mass. NO_X based on NO_2 mass.

Another source of emission data for criteria air contaminants and their precursors from individual utilities is the National Pollutant Release Inventory. Facilities are required to annually report on releases and transfers of approximately 280 pollutants. Some of these reported compounds include sulfuric acid, nitric acid and certain individual VOCs. These pollutants can contribute to particulate and ozone formation in the air.

3.1.2 Criteria Air Contaminants emissions from utilities in Mexico

Data on criteria air emissions from utilities have two potential sources in Mexico: the urban air emission inventories and the *Cedula de Operacion Anual* (COA) reports. Only aggregate data at the sectoral level are available from both of these sources (Table 12).

The urban inventories contain specific utilities:

- Mexico City region inventory probably contains the 838 MW natural gas powered station Jorge Luque, Valle de Mexico.
- Monterrey inventory probably contains the 465 MW fuel oil and gas powered station, Monterrey.
- Ciudad Juárez inventory probably contains the 866 MW fuel oil powered station Salamanca and the 522 MW gas powered station Salamanca II.
- The Mexican urban inventories in Guadalajara and Toluca do not list utilities as a point source.

Table 12: Emissions of Criteria Air Contaminants from Utilities in Mexican Urban Inventories (emissions in tonnes per year)

Mexican Urban Inventory	Source	Particu-lates	PM_{10}	SO_2	CO	NO_x	HC
Zona Metropolitana de Monterrey, 1995	**Electric utilities**	308		3,432	594	11,432	52
	Total all Sources	815,628		30,466	907,762	53,275	125,375
Ciudad Juárez	**Electric utilities**	8		289	594	11,432	5
Inventories Zona Metropolitana del Valle de México, 1998	**Electric Utilities**		138	16	1,111	9,540	48
	Total point sources		3,093	12,442	9,213	26,988	23,980

Sources: Inventario de emisiones de la Zona Metropolitana de Monterrey. INE. Available at <http://www.ine.gob.mx/dggia/cal_aire/espanol/zmm.html>.
Inventario de Emisiones de la Zona Metropolitana del Valle de Mexico 1998 available from <http://www.sma.gob.mx/publicaciones/aire/inventario1998/parte07.pdf>.

Annual reporting of some criteria air contaminants data to COA is mandatory for certain sectors, such as electric power generation, which are under federal jurisdiction. Data on emissions of criteria air contaminants from individual facilities, although reported to

COA, are not yet publicly available. In addition, not all facilities are currently reporting to COA or are reflected in the database due to a number of factors.

Twenty-nine electric utility facilities reported to COA in 1998–99. The aggregate data reported by these utilities are available and are presented in Table 13. The utility sector accounts for the majority of the criteria air contaminants reported by the 1,191 facilities to COA in 1998–99. The utility sector accounted for the following amounts of the total reported to COA: 94% of the sulfur dioxide, 92% of the nitrogen oxides, 99% of the particulates, 65% of the carbon dioxide, 99% of the carbon monoxide and 10% of the hydrocarbons.

Table 13: Annual Emissions of Contaminants Reported to COA in 1998–99 from 1,191 Facilities (emissions in tonnes/year)

Industrial Source	Sulfur Dioxide	Nitrogen Oxides	Particulate	Hydro-carbon	Carbon Monoxide	Carbon dioxide	VOCs
Petroleum and Petro-Chemical	907	46,730	575	0.03	715	6,945	432
Chemical	956	406	127	42	723	35,982	67
Paints and Dyes	0.29	227	0.09	0.25	0.01	12	152
Metallurgy (includes iron and steel)	2501	534	769	8	1,865	5,002	0.55
Automobile Manufacture	61,368	11,824	717	1.72	2,482	17,465	142
Cellulose and Paper	1,159	1,474	327	267	17.36	5166	84.39
Cement and Limestone	879	1,491	39.39	15.90	2027	9,131	217
Asbestos	0.04	0.04	0.66	0	0	217.24	0.00024
Glass	195.24	952	190.01	0.07	132.30	74,187	0
Electric Power Generation	**993,567**	**752,325**	**446,731**	**38.48**	**559,501**	**293,649**	**0**
Hazardous Waste Treatment	3.16	14.83	47.77	0.05	2.19	1.23	7.23
Total reported to COA by all 1,191 facilities	**2,939,785**	**1,828,561**	**959,201**	**10,925**	**1,576,613**	**5,874,747**	**4,894**

Source*: 2 Informe Nacional de Emisiones y Transferencia de Contaminantes 1998–1999, RETC, INE, Semarnap, 2000* available from <http://www.ine.gob.mx/dggia/retc/>.

3.1.3 Criteria Air Contaminant emissions from utilities in the United States

In the US, a number of inventories contain data on criteria air contaminants from utilities. Data are available at the sectoral and facility level. These inventories include the:

- National Emission Inventory: The 1999 National Emission Inventory is presented by contaminant, sector, state, and point source. The inventory is available at <http://www.epa.gov/ttn/chief/>. Almost 1,500 utilities are considered point sources in the 1999 National Emission Inventory (under the US SIC code of 4911 Electric Services) (Table 14).

Table 14: 1999 Emissions of Criteria Air Contaminants from 1,499 Utilities in the US according to 1999 National Emission Inventory

Contaminant	**1999 Electric Services Point Source Emissions (tonnes/year)**	**Percent of total Emissions**
Carbon monoxide	395,589	8.22
Nitrogen oxides	5,250,713	64.06
PM_{10}	229,053	22.71
$PM_{2.5}$	127,889	20.94
Sulfur dioxide	11,489,483	77.74
VOC	49,637	2.66
Ammonia	9,863	5.57

Source: AIR Data query of the 1999 National Emission Inventory at <http://www.epa.gov/ttn/> using SIC 4911. Electric Services, net SIC report

- Acid Rain Program Emissions Scorecard: Contains emission data from power plants in the Acid Rain Program for sulfur dioxide, nitrogen oxides and carbon dioxide by unit, by state, by different regulatory phases and by coal and non-coal. The most recent data are from 2000. Not all utilities are part of the Acid Rain Program, so this data are a subset of the larger utility sector. The database is available at <http://www.epa.gov/airmarkets/emissions/score00/index.html> (Table 15).

Table 15: Emissions of criteria air contaminants from coal and non-coal units in the United States in 2000, as reported to Acid Rain Emissions Scorecard (in tonnes)

Type of Utility	CO_2	$N0_X$	SO_2
Coal units	1,927,684,480	4,162,872	9,712,784
Non-Coal Units	215,827,453	468,607	447,559

Source: State Summaries of Emissions and Heat Inputs, 2000 Acid Rain Program. Available at <http://www.epa.gov/airmarkets/emissions/scorecard00/>.

- Emissions and Generation Resource Integrated Databases (E-GRID): E-GRID integrates 18 different federal data sources on utilities and non-utilities to provide a complete databases of emissions, resource mix and stack characteristics for more than 4600 individual power plants, 2000 generating companies, states and regions of the power grid. E-GRID provides data on facility-specific emissions on nitrogen oxides, sulfur dioxide, carbon dioxide and mercury and emission rates in pounds per million British Thermal Units and pounds per megawatt hour. Generation, resource mix, heat input and capacity are also available. The most recent version, E-GRID 2000 contains data from 1996–98.

  This powerful, publicly available database allows for utility data to be presented nationally, regionally, by power control area, by state, by parent company, by electric generating company, by facility, by generator and by boiler (Table 16). Some data on non-utilities are also included. Available at <http://www.epa.gov/airmarkets/egrid/factsheet.html>.

Table 16: Annual emissions of criteria air contaminants in 1998 from US utilities as reported in E-GRID (tonnes)

	CO_2	$N0_X$	SO_2
US 1998 national utility emission total	2,333,530,266	5,836,840	12,318,298
Ozone season utility emission total		2,648,245	

Source: E-GRID 1998 file sequs98. EPA. Available from <http://www.epa.gov/airmarkets/egrid/>.

- Toxics Release Inventory (TRI): annual, mandatory reporting for utilities for over 600 contaminants, some of which are criteria air contaminants or precursors. The most recent available data are from 1999. Utilities were first required to report for the 1998-reporting year. Available from <http://www.epa.gov/triexplorer>.

3.2 Greenhouse Gases

In general, sector-level data on greenhouse gas emissions from utilities from the three countries are the only comparable information that can be obtained from current emission inventories. This data are required by all three countries to meet their international obligations under the Framework Convention for Climate Change, and uses similar methodology. However, the most recent year that matches for all three countries is 1990 (Canada has 1998 data available, Mexico has 1990 data available, and United States has 1999 data available).

Each country also has their own national greenhouse gas inventory, which provides sectoral data on the energy sector. Some utilities also report their greenhouse gas emissions on a voluntary basis to a variety of voluntary reporting programs.

Table 17 presents the matched greenhouse gas and other contaminants data for the three countries for the energy sector.

Table 17: Emissions of greenhouse gases and other air contaminants from the energy sector in Canada, Mexico and the United States in 1990 and 1998 as reported under the Framework Convention on Climate Change (emissions in gigagrams)

Emissions of Greenhouse Gases in gigagrams	**Canada**		**Mexico**	**United States**	
	1990	**1998**	**1990**	**1990**	**1998**
Carbon dioxide	144,599	181,201	108,473	1,747,763	2.106,379
Methane	2	2	3	23	26
Nitrous oxide	3	3	0	24	27
Carbon monoxide			281	329	377
Non-methane VOCs				43	48
Sulfur dioxide				14,432	11,990
Nitrogen oxides			298	6,045	5,535

Source: United Nations Convention on Climate Change

3.3 Toxic Contaminants

Data on emissions of toxic contaminants from individual utilities are publicly available in Canada and the US. In Canada, utilities and other facilities meeting certain thresholds are required to report annually. In Mexico, utilities can submit data on a voluntary basis to the RETC. In 1998, utilities reported for the first time to the US Toxics Release Inventory. Data are available for releases to air, water, land and underground injection and for transfers off the site of the facility for treatment, disposal and recycling and energy recovery.

Under the CEC Pollutant Release and Transfer Register program, the data on toxic contaminants in Canada, Mexico and the US are matched to the greatest extent possible.

The *Taking Stock* report summarizes the matched data and the online database allows queries of the matched Canadian and US data, based on 165 common chemicals. Comparable Mexican data are not yet available.

In the 1998 *Taking Stock* database, electric utilities in Canada and the US reported the largest amount of chemicals released to the air of all other sectors (368,750 tonnes) (Table 18). Over 40% of all releases to the air in North America in 1998 were reported by electric utilities (CEC 2001).

Table 18: 1998 Emissions of toxic contaminants from utilities in Canada and the US using the matched database in *Taking Stock 98* (emissions in tonnes)

	Canada		**United States**		**Canada and the US**	
	Air releases	Total on site releases	Air releases	Total on site releases	Air releases	Total on site releases
Emissions from matched 1998 database	17,014	18,813	351,736	404,825	368,750	423,637

Source: *Taking Stock* web site <http://www.cec.org/> search based on US SIC code 49, Electric utilities, emissions of 165 contaminants, 1998 data, Mexican data not yet available.

The Taking Stock *site also presents data from individual facilities. Table 19 presents the 15 utilities with the largest air releases in Canada and the US.*

Table 19: The 15 utilities with the largest air releases in Canada and the US (emissions in tonnes)

Name of utility	**Location**	**Air releases- 1998- tonnes**
Bowen Steam Electric Generating Plant, Southern Co.	Cartersville, Georgia	8,182
American Electric Power, John E. Amos Plant	Winfield, West Virginia	7,577
Roxboro Steam Electric Plant, Carolina Power and Light Co	Semora, North Carolina	6,863
American Electric Power, Mitchell Plant	Moundsville, West Virginia	5,925
Dayton Power and Light Co, J.M Stuart Station	Manchester, Ohio	5,806
Firstenergy, W.H. Sammis Plant	Stratton, Ohio	5,493
Brandon Shores and Wagner Complex, Baltimore Gas Electric Co	Baltimore, Maryland	5,185
Cardinal Plant, Cardinal Operating Company	Brilliant, Ohio	5,143
Ontario Power Generation Inc, Nanticoke Generating Station	Nanticoke, Ontario	4,855

Gulf Power Co, Plant Christ, Southern Co.	Pensacola, Florida	4,206
US TVA Paradise Fossil Plant	Drakesboro, Kentucky	4,120
Scherer Steam Electric Generating Plant	Juliette, Georgia	4,042
Kentucky Utilities Co- Ghentstation, LG and E Enrage Corp	Ghent, Kentucky	3,842
PSI Gibson Generating Station, Cinergy Corp	Princeton, Indiana	3,656
Detroit Edison Monroe Power Plant, DTE Energy	Monroe, Michigan	3,650
Subtotal		78,539
% of total		9%
Total of all sectors reporting		853,574

Source: *Taking Stock 98* (CEC 2001) available at <http://www.cec.org/>. Analyses are based on emissions of 165 contaminants, 1998 data

3.3.1 Toxic Contaminants emissions from utilities in Canada

Utilities are required to report their annual emissions of 268 pollutants to the National Pollutant Release Inventory. The most recent publicly available data are from 1999. Approximately 53 utilities reported to NPRI in 1999 (under NAICS: 2211 Electricity generation, transmission and distribution). NPRI identifies that the main air emissions from utilities in Canada in 1999 are:

- hydrochloric acid (9,652 tonnes)
- sulfuric acid (4, 016 tonnes)
- hydrofluoric acid (1,500 tonnes)

Emission data on releases of sulfuric acid and nitric acid from individual utilities can be found using the online data query function at <http://www.ec.gc.ca/pdb/npri/>. Another web site, Pollution watch, also provides NPRI data in a different format, using health, environmental and other ranking systems, which can be found at <http://www.pollutionwatch.org/>.

3.3.2 Toxic Contaminants from utilities in Mexico

In Mexico, utilities and other facilities can voluntarily report their emissions to the *Registro de Emisiones y Transferencia de Contaminantes (RETC).* This database is not yet publicly available. Information on the program and summaries of the data are available at <http://www.ine.gob.mx/dggia/retc/publicacion/informes/>.

3.3.3 Toxic Contaminants from utilities in United States

The most recent data on emissions of over 600 contaminants from utilities are for 1999 (see Table 20 for data on the first 10). This Toxics Release Inventory database is a public database searchable by facility, state, chemical and sector available at <http://www.epa.gov/triexplorer/>. Another web site also presents TRI data using ranking criteria, and can be viewed at <http://www.scorecard.org/>.

Table 20: Air emissions of the top ten contaminants from utilities as reported to TRI in 1999 (in pounds)

Contaminant	**Air Releases from Utilities in 1999 (pounds)**
Hydrochloric acid	615,428,784
Sulphuric acid	152,853,011
Hydrogen fluoride	58,264,893
Ammonia	4,435,805
Zinc (fume or dust)	2,404,456
Zinc compounds	2,255,717
Barium compounds	2,214,061
Nickel compounds	718,154
Nitric acid	577,740
Selenium compounds	506,966

From this exercise we can conclude:

1. In general, the higher the level of aggregation, the better the chances of matching emission data. Much more data are available at the source category level than the facility level in Canada and Mexico.
2. The greenhouse gases have the greatest amount of common methodology and reporting among the three emission inventories. Based on the 1990 emission submitted to the UN Framework on Climate Change, it appears that utilities in Mexico emit less carbon dioxide than Canada, and much less than utilities in the United States. This reflects the relative sizes of national electricity generation capacity in the three countries. Emission of greenhouse gases from all individual facilities are not available in Canada or Mexico.
3. The different spatial and temporal scales of the criteria air contaminant data make it difficult to match these emission inventories in the three countries. Canada and the US have national inventories and Mexico has a number of urban inventories. Data from the Canada national inventory for the utility sector are from 1995, from Mexico from a variety of years depending on the urban inventory, and from the US from 1999. In general, the emissions from the electricity generating sector in Mexico as reported to the RETC for 1998-1999 are higher than the estimated emissions from the Canadian Criteria Air Emission Inventory for 1995 and much lower than emissions from the electric services sector in the US for 1999.

4. The toxic contaminant inventories for Canada and the US can be matched to a considerable extent. These annual, mandatory, publicly accessible databases provide toxic emission data at the sectoral and facility level. The 1998 air emissions of 165 toxic contaminants from utilities in the US (351,736 tonnes) are higher than utilities in Canada (17,014 tonnes), which is in keeping with the relatively greater amount of electricity generation in the US. Mexico has the framework of a similar toxic reporting system, which may become mandatory. Public accessibility to the data at the facility level is under consideration in Mexico.
5. Many emission inventories produce different estimates of emissions for the utility sector. These differences in emissions can often be explained by differences in methodologies, definition of the source category or reporting year.
6. Often information on emissions is difficult to access, requiring sustained effort and experienced queries.
7. Many of the people working in the inventory field are eager to see changes, but often face considerable time and financial barriers.
8. Efforts to increase the comparability of data have started in two of the three air contaminant inventory areas: toxic contaminant inventories through the CEC PRTR efforts and greenhouse gases inventories through the international obligations under the UN Framework on Climate Change. It would seem timely to begin efforts to increase the comparability of air emissions for the remaining inventory: criteria air contaminants.

4 Toward More Comparable Emission Inventories in North America

There is an increasing need for consistent emission data on urban, regional, binational and trinational bases to help develop plans addressing ground-level ozone, particulates, acid rain, regional haze, climate change, and other shared air pollution problems. Air quality planners need common information to assess air pollution in local air basins split between two countries as well as to evaluate the long-range transport of pollutants crossing international borders over great distances. Furthermore, international emissions trading can be an important policy tool to address a number of environmental issues, such as acid rain and climate change. For this tool to work effectively will require a transparent and accurate accounting of each nation's air emissions on a source-specific level.

4.1 Why are Demands for Comparable Emission Inventories Increasing?

Demands for comparable emission inventories are increasing because emission inventories play a role in:

- Meeting international air quality obligations
- Meeting national, state, regional and local air planning obligations
- Evaluating regulations, policies and programs for effectiveness
- Measuring trends over time
- Reducing emissions which contribute to acid rain, smog and regional haze
- Assessing health effects
- Assisting in assessing compliance
- Improving air quality modeling
- Satisfying the public's right to know
- Supporting emission trading programs

International obligations such as the 1991 Air Quality Agreement between Canada and the US and its subsequent Ozone Annex are requiring expanded emission inventories to help evaluate progress towards their stated goals. For example, Canada committed itself to a permanent national cap for sulfur dioxide emissions of 3.2 million tonnes by 2000, and the US committed itself to a cap of 5.6 million short tons for industrial sources beginning in 1995 (IJC 2001). Emission inventories in the two countries need to be transparent, comparable, and publicly accessible to evaluate these goals.

Another significant international driver for emission inventories is the United Nations Framework Convention on Climate Change. Under this framework, countries are required to report annual emissions of greenhouse gases and encouraged to report criteria air contaminants. Many criteria air contaminants play an indirect role in global warming.

Emission inventories can also provide estimates of emissions over time, which is required to evaluate the effectiveness of programs and meet international obligations.

The interest and improvements in emission inventories are also driven by the increasing demands of improving air quality models. Emission inventories are used as inputs into many different air quality models. Increasingly these models are demanding information that has not traditionally been part of emission inventories. For example, often ozone models require information on the speciation of VOCs; hourly, daily, or seasonal changes in processes or activities; and detailed information on stack heights, flow rates and location. Emission inventories are changing to respond to these new requirements.

The public is interested in emissions from facilities in local neighborhoods. Emission inventories can provide a source of information on the quantity of emissions from the facility, the type of contaminants, and contacts for more information. Some emission inventories that are posted on the Web have received a huge number of "hits." The public demand for accessibility to emissions is driving new presentations of emission inventories and calls for more frequent updating and more comprehensive coverage.

Emission trading programs are increasing across North America, increasing the need for comprehensive and comparable emission inventories. Emission inventories are one of the cornerstones of an effective emission-trading program. The 1990 Clean Air Act Amendments in the US created a national SO_2 emissions cap and trading program for large stationary sources (mostly power plants) that is widely credited with reducing SO_2 emissions at much lower cost than originally projected. Emission trading of NO_x allowances is currently underway in the Ozone Transport Region of the northeastern United States. The US NO_x SIP Call also sets up a model NO_x Budget Trading Program for large stationary sources in a number of eastern states. Many discussions on how to address climate change include consideration of domestic and international greenhouse gas trading regimes.

4.2 Areas of Opportunity to Enhance Comparability of Emission Inventories in North America

While some similarities exist, there are important areas of difference among the three North American countries. Each inventory is continuously being updated, which presents an opportunity to make updates in a way that encourages comparability of emission inventories in North America.

As an aid to understanding the emission inventories in North America, Table 21 summarizes the characteristics of the three inventories.

Table 21: Summary of the characteristics of the emission inventories in Canada, Mexico and the United States

Characteristic	Canada	Mexico	United States
Name of inventory	National Criteria Air Contaminant Inventory	Urban Inventories named by each city (i.e., *Zona Metropolitana del Valle de Mexico)* Mexico City and Region Emission Inventory	National Emission Inventory
Contaminants included	Ammonia		Ammonia
	Carbon monoxide	Carbon monoxide	Carbon monoxide
		Lead (Monterrey only)	Lead
	Nitrogen oxides	Nitrogen oxides	Nitrogen oxides
	Total particulate matter	Total particulate matter (only for Toluca, Guadalajara and Monterrey)	
	PM_{10}	PM_{10} (only for Mexico City, Mexicali, Tijuana)	PM_{10}
	$PM_{2.5}$		$PM_{2.5}$
	Sulfur oxides		
		Sulfur dioxide	Sulfur dioxide
		Total hydrocarbons	
	VOCs		VOCs
Year of inventory	1995	Year varies by city (i.e., Mexico City 1998)	1999
Frequency of updating	Every five years	Every two years for Mexico City	Every three years
Classification of source categories**	Industrial sources	Industrial sources	Industrial processes
			Fuel combustion
	Non-industrial fuel combustion		
	Transportation	Transportation	Transportation
	Incineration		
	Miscellaneous		Miscellaneous
	Open sources		
		Services	
		Vegetation and soil	

Development of inventory	Federally coordinated with assistance from provinces, territories, and some regions	Federally coordinated with assistance from states and cities	Federally coordinated with assistance from states, tribal, territories and regions
Facility data available	No	No	Yes
Public availability	At sectoral level	At sectoral level	At facility level
Languages used	English and French	Spanish, some English	English
Web address	<http://www.ec.gc.ca/pdb/ape/cape_home_e.cfm>	<http://www.ine.gob.mx/dggia/cal_aire/espanol/invtemi.html>	<http://www.epa.gov/ttn/chief/>

* Note that the criteria air contaminants in Mexico and the US are ozone, carbon monoxide, nitrogen dioxide, sulfur dioxide, lead and particulate matter

** These source categories are used to present the inventory; some sources in one inventory may be covered under a different category in another inventory

As a first step in identifying opportunities to enhance comparability among emission inventories, it may be useful to focus on a few areas that are a high priority among the countries. These areas could be chosen from the following table of opportunities and should address:

- Common concepts, definitions and elements
- Common methodologies, estimates, procedures and models
- Inclusion of quality assurance/ quality control procedures

The discussion on areas of opportunities must also keep in mind two additional international initiatives that are aimed at enhancing comparability of emission inventories on a global rather than continental basis:

1) United Nations Framework Convention on Climate Change

New reporting guidelines and the requirement to submit an annual inventory report on greenhouse gases is increasing the need for more detailed inventories. Countries are also being encouraged to report on additional air contaminants through this Framework, including the criteria air contaminants. The revised IPCC guidelines and common reporting format developed under this Framework may be important to consider in the efforts to enhance North American inventories.

2) The Convention on Long-range Transboundary Air Pollution

The United Nations Economic Commission for Europe's Task Force on Emission Inventories and Projections has recently developed draft guidelines for estimating and reporting emission data. These guidelines could be used by countries to satisfy their obligations under a number of international treaties. The guidelines describe how emissions of sulfur compounds, nitrogen oxides, ammonia, non-methane VOCs, carbon monoxide, particulate matter (PM_{10}, $PM_{2.5}$ and total suspended particulate matter), heavy metals and persistent organic pollutants are to be reported. A nomenclature for reporting has been developed, which is different than that developed under either the European CORINAIR inventory or the Intergovernmental Panel for Climate Change (IPCC). Ideally, efforts to increase comparability among North American inventories would also work with these international efforts.

Table 11: Areas of Opportunity to Enhance the Comparability of Emission Inventories in North America

Element	Description	Areas of Opportunity
Contaminant covered	Each country has a slightly different list of contaminants covered in air emission inventories. All three countries have the following contaminants in their air emission inventories: • Carbon monoxide • Nitrogen oxides • PM_{10} (for Mexico City, Mexicali and Tijuana only)	Areas of opportunity include: • Begin to pull together information based on the contaminants common to all three inventories: carbon monoxide, nitrogen oxides and PM_{10}. Begin working to increase the comparability of contaminant data not currently comparable such as: **VOCs** • Consider standardizing the definition of a VOC or the lists of VOCs and hydrocarbons (some are legislated) • Improve chemical speciation of VOCs which would increase comparability and improve modeling **Sulfur oxide/sulfur dioxide** • Develop methods to express Canadian SO_x emissions in a way that matches the SO_2 emissions in the US and Mexican inventories **Particulate matter** • Consider increasing the inclusion of $PM_{2.5}$ into additional Mexican inventories • Refine particulate emissions inventory through improved particulate emission factors for some sources • More accurate estimation of condensable emissions • Review chemical speciation of PM from available monitoring to determine where emissions inventory needs most effort **Ammonia** • Consider developing an ammonia inventory in areas in Mexico where PM has large ammonium component • Continue the expansion and refining of ammonia inventories • Refine emission factors and activity data for agricultural and other sources

Year of inventory	All three countries update their inventories on a regular basis, however, the frequency of updating and the years of major versions do not always coincide. It is difficult to compare inventories from different years. This problem may lessen as inventories are produced and updated more frequently. The cycles are: Canada: every five years, with inventories in 1990, 1995, 2000, 2005 US: every three years, with inventories in 1999, 2002, 2005 Mexico: variable with the city, generally inventories every two years, i.e., Mexico City 1998, 2000	Areas of opportunity could include: • In the short term, consider using the 2000 Canadian inventory, the projected 2000 Mexico City inventory and the updated version of the 1999 US inventory as a basis for matching emissions • In the longer term, consider designating specific years for a version of the inventory to be available for North American comparisons (consider 2005) • Moving toward a similar cycle of updating • Testing to see the degree of difference caused by the different years • Updating a specific inventory using economic or other data to match the inventory year used by another country Making the assumption that the year makes minimal difference as a first step towards a general picture of criteria air contaminants in North America
Definition of point sources	Each country has different methods to define a point source, with thresholds that vary by contaminant: Canada: proposal for 20 tonnes for CO, SO_x, NO_x and total particulate matter, 10 tonnes for VOCs (reporting thresholds for NPRI) US: 1000 short tons for CO, 100 short tons for NO_2, SO_x, PM_{10} and $PM_{2.5}$ and VOCs	Areas of opportunity could be: • Moving towards a common definition of point sources • Analyzing the effect of different thresholds for selected sources • Comparing the Canadian databased on older thresholds which are more similar to the US thresholds with emissions collected under the proposed thresholds • Making the assumption that emissions not included in point sources are picked up in area sources, and so ignoring different thresholds used to define point sources
Source categories	Each country uses its own source categories to present the emission inventory. Some of these categories overlap in name, such as transportation. Other categories do not overlap in name, but have sources within the overall category that can be matched among countries, such as emissions from the chemical industry.	Areas of opportunity include: • Move towards a common source category • Developing a crosswalk among the three inventories to allow similar source categories to be matched (this could be done through a combination of description of the categories and matching the various source classification codes) • explore using a common coding system in future updates as a basis for comparisons, perhaps based on NAISC, European Systems, or Greenhouse gas inventory methods • Use the opportunity presented by the need to standardize CAC and HAP source categories in the US inventory to move towards including one coding system that is common to all inventories

Area sources	Each country has a slightly different system for defining area sources. Some of the emission factors and activity data used to generate area source emissions can be improved.	Areas of opportunity here could be: • Developing a common methodology to determine area sources • Developing a cross walk to allow matching of area sources among countries
Mobile sources	Each country uses the same EPA model, MOBILE5 to estimate emissions from on-road emissions. All three countries are planning to move to MOBILE6, once it is available. However, even though the model is the same among countries, there are significant differences in the parameters used to customize the model.	Areas of opportunity include: • Analyze the difference in the parameters used for the MOBILE5 model among the three countries and the sensitivity of the model to these differences • Discuss the possibility of more comparable parameters being used as all countries move to MOBILE6, or describing why they should differ • Mobile emission modelers from three countries could choose to attend the same training program for MOBILE6 • Prepare a preliminary emission estimate of mobile source emissions in the three countries based on existing emission inventories
Spatial scales	For Canada and the US, national emissions can be broken down into smaller spatial scales such as provinces or states. Some inventories can break emissions down further into regional or county level. Mexican emission inventories are available at the city scale. For some air quality models a higher degree of spatial resolution is necessary.	Areas of opportunity include: • Consider the development of a Mexican national emission inventory • Harnessing efforts of provinces, states and regions to collect comparable information to improve the spatial scales of inventories. • Share information on point source locations using a coordinate system adaptable for modeling needs.
Temporal scales	Emission inventories in all countries are usually based on annual emissions. Some inventories can break this down into seasonal emissions. Many air quality models require more detailed information on emissions over time such as hourly, daily, weekly, weekend, and seasonal. This more detailed temporal information is not often currently available from emission inventories.	Areas of opportunity include: • Sharing information on the changes in emissions over time for contaminants and sectors • Sharing the effort to improve the temporal resolution of emissions through surveys, modeling and monitoring.

Development of inventory	While the emission inventory is coordinated nationally, all countries rely on information from other jurisdictions such as states and regions.	Areas of opportunity include: • Development of joint methodologies • Development of compatible data exchange systems • Development of international methodologies similar to greenhouse gas reporting • Sharing of emission estimation guidance manuals and procedures • Creation of a web site to exchange inventories, changes, events • Creation of a list serve for criteria air contaminant inventory information
Public accessibility	While all countries make their inventory available on the Internet, in Canada and Mexico, facility-specific information on criteria air contaminants is generally not available at this time	Areas of opportunity include: • Working together to increase access to facility-specific information on criteria air contaminants • Encouraging increased facility reporting in Canada and Mexico • Increased access to methodology and background documents
Uses of inventory	All counties have unique applications of emission inventories, but in general they are all used for air quality modeling, tracking emission trends over time, development of air quality plans and meeting national and international obligations	Areas of opportunity include: • Development of regional cross-border inventories for air quality plans • Development of international methodologies • Broadening of ideas and expertise at regular technical exchanges • Development of web site to document progress on matching North American emissions, linked to established inventory sites • Establish a work group to explore and implement areas of comparability in emission inventories
Other inventories	Canada and the US have three major national air emission inventories: PRTR, criteria air contaminants and greenhouse gas inventories. Mexico has one major national inventory, the greenhouse gas inventory, and several urban criteria air contaminants inventories and a voluntary PRTR	Areas of opportunity include: • Closer integration of PRTR, criteria air contaminants and greenhouse gas inventories within a country and then across countries • Consider the experience of other regions such as Europe which are working towards integrated inventories • Consider the experience of other contaminants such as greenhouse gases which have developed common methodology and reporting

4.3 Conclusions

Currently, North American emission inventories differ in the contaminants included, the base year and frequency of updating, the methodologies used to develop estimates, the source categories, the public availability of data, and the languages used. Therefore, there are areas of opportunity to enhance comparability of North American emission inventories. Some of these areas are outlined in Table 11 and include a number of possible options, such as comparing emissions using one contaminant, one sector or one region, or working together on specific areas to improve inventories such as particulate and ammonia inventories.

The need for consistent, comparable inventories is increasing in North America. In some countries, this need is driven by new regulations such as the regional haze rule and NO_x SIP Call. In other countries, new programs such as adding criteria air contaminants to NPRI will result in mandatory, annual, publicly available information on emissions of criteria air contaminants from facilities in Canada. International obligations such as the Canada-US Ozone Annex and UN Framework Convention on Climate Change also drive the need for comparable emission inventories. Countries and regions are starting to design and implement emission trading programs, which require high quality information from emission inventories. New air quality models require specific information on temporal, seasonal scales and chemical speciation not often collected in inventories. No matter what the driver, across North America, emission inventories are receiving increasing attention and increased pressures to fill new niches and uses.

Because of these increasing pressures for high quality, consistent, comparable emission inventories, it is timely to work together on a trilateral basis to enhance the comparability of emission inventories to improve air quality planning and programs. This trilateral cooperation can reap benefits for participants: inventory developers can share ideas and information, conserve time and resources by avoiding recreating the wheel, and be aware of the latest in inventory developments. National governments can monitor the emerging pressures in other countries and learn new methods of responding. Regional agencies can save time and resources in developing emission inventories by pooling ideas and tools. The public can understand the overall picture of air contaminants at different levels: community, state, nation and continental.

This paper has provided a brief overview of air contaminants, the current state of emission inventories in the three countries and areas of opportunity to enhance comparability of emission inventories in North America. With the increasing demands placed on emission inventories, the CEC invites governmental representatives, nongovernmental representatives, industry and business to join together to explore ways to enhance comparability of emission inventories in North America.

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- Inventario de Precursores de Ozono y Monóxido de Carbono para la Zona Metropolitana de la Ciudad de México, 1995
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Appendix A. CEC Council Resolution 01-05: Promoting the Comparability of Air Emission Inventories

(signed by the environment ministers of Canada, Mexico and the US in June 2001)

THE COUNCIL:

FURTHERING the objectives of the North American Agreement on Environmental Cooperation (CEC) and consistent with the provisions of NAAEC ARTICLE 10 (2)(a) concerning three comparability of techniques and methodologies for the gathering, analysis, management and electronic communication of data;

AWARE OF the clear and widespread harm to human health and the environment that ground-level ozone, acid rain and particulate aerosols pose over large regions of North America;

RECOGNIZING the importance of preventing and minimizing polluting air emissions from industrial, transportation and other sources in order to protect the environment and the human health of present and future generations;

RECOGNIZING that each of the countries of North America have their own ambient air quality standards, objectives or guidelines for carbon monoxide (CO), sulfur dioxide (SO_2), ozone (O_3), nitrogen oxides (NO_2), particulate aerosol, as well as other pollutants, and National Communications required under the United Nations Framework for Climate Change to address carbon dioxide (CO_2) and other greenhouse gases;

AWARE of the need for air emissions information to support regional transboundary air quality planning activities:

TAKING INTO ACCOUNT and BUILDING UPON current CEC projects, such as air quality tools and the pollutant release and transfer register, existing bilateral and multilateral agreements and activities as well as the work of relevant international organizations to enhance cooperation on issues relating to the comparability of methodologies for data collection and analysis;

AFFIRMING the importance of source-specific information on sources of primary and secondary air emissions across state, provincial and national, borders, and the need for a higher degree of data comparability for the sound management of transboundary air pollutants and regional environmental planning;

ACKNOWLEDGING the desirability of enhanced capacity in areas of data collection in order to achieve a desired level of data comparability and information exchange;

AWARE that each national program has developed a unique process for the collection and modification of environmental data sets and that the responsibility for designing and implementing national air emissions inventories rests with each country; and

RECOGNIZING that the basic elements of national air emission inventories include: standardized databases, limited data confidentiality, an indication of what are held confidential and a mechanism for public feedback:

HEREBY:

AGREES to work toward a trinational inventory for air emissions including sulfur dioxide (SO_2), nitrogen oxides (NO_x), carbon monoxide (CO), volatile organic compounds (VOCs), particulate aerosols and greenhouse gases

DECIDES to build upon experience gained through the publication of CEC annual report on pollutant releases and transfers in North America (the *Taking Stock* report) which is based on information collected through national pollutant release and transfer register programs

AGREES to produce a periodic report to the CEC summarizing publicly available information from North American Air Emission Inventories and

DIRECTS the Secretariat to work with the parties to implement the following:

1. assessing progress in enhancing the comparability of air emissions inventories in North America
2. improving the comparability of definitions and nomenclature, the scope and resolution of shared inventories, emission estimation techniques, the treatment of confidential business information, database structure and reporting formats;
3. developing recommendations to improve dissemination of air emissions data, including facilitating user access to and comprehension of air emissions data and associated relevant information as well as measures relating to joint approaches to technical information and cooperation
4. encouraging complementary national approaches and timetables to enhance air emissions inventories in a manner that respects the different economic, political and regulatory circumstances of the Parties
5. encouraging and providing meaningful public and governmental participation—including that of environment and public health nongovernmental organizations, business and industry, provincial, state and municipal governments, academia and technical and policy experts—in developing its recommendation for enhanced comparability
6. coordinating activities with existing national and international work groups and other organizations convening meetings of trilateral experts to discuss implementation of this resolution

Appendix B. Definition of Volatile Organic Compounds in Canada, the United States and other Jurisdictions

Canada's Definition of VOCs:

A definition of VOCs has recently been proposed under the Canadian Environmental Protection Act. In the Annex to the Notice of Intent, 9 June 2001, VOCs are defined as "compounds that participate in atmospheric photochemical reactions, excluding the following:

- methane
- ethane
- methylene chloride (dichloromethane),
- 1,1,1-trichloroethane (methyl chloroform),
- trichlorofluoromethane (CFC-11),
- dichlorodifluoromethane (CFC-12),
- 1,1,2-trichloro-1,2,2-trifluroethane (CFC-113),
- CFC-114
- CFC-115
- chlorodifluoromethane (HCFC-22),
- HCFC-31
- HCFC-123
- HCFC-123a
- HCFC-124
- HFC-134a
- HCFC-141b
- HCFC-142b
- HCFC-151a
- HCFC-225ca
- HCFC-225cb
- trifluoromethane (HFC-23)
- difluoromethane (HFC-32)
- HFC-43-10mee
- HFC-125
- HFC-134
- HFC-143a
- HFC-152a
- ethylfluoride (HFC-161)
- HFC-236fa
- HFC-245ca
- HFC-245ea

- HFC-245eb
- HFC-245fa
- HFC-236ea
- HFC-365mfc
- parachlorobenzotrifluoride (PCBTF)
- cyclic, branched or linear completely methylated siloxanes
- acetone
- perchloroethylene (tetrachloroethylene)
- $C_4F_9OCH_3$
- $((CF_3)_2CFCF_2OCH_3)$
- C4F9OC2H5
- $((CF_3)_2CFCF_2\ C_2H_5)$
- methyl acetate and perfluorocarbon compounds that fall into the following classes, namely,
  - ◊ cyclic, branched or linear completely fluorinated alkanes
  - ◊ cyclic, branched or linear completely fluorinated ethers with no unsaturations
  - ◊ cyclic, branched or linear completely fluorinated tertiary amines with no unsaturations, and
  - ◊ sulfur containing perfluorocarbons with no unsaturations and with sulfur bonds only to carbon and fluorine"

Definition of VOCs in the United States:

VOCs are defined in the Code of Federal Regulations, Title 40: Protection of the Environment, Part 51- Requirements for Preparation, Adoption and Submittal of Implementation Plans, Subpart F: Procedural requirements. Subsection 51.100 Definitions (40 CFR 51.100) Revised in July 1, 2000.
For full text, see <http://frwebgate.access.gpo.gov/cgi-bin/get-cfr.cgi/>.

VOCs mean any "compound of carbon, excluding carbon monoxide, carbon dioxide, carbonic acid, metallic carbides or carbonates and ammonium carbonate, which participates in atmospheric chemical reactions. This includes any such organic compound other than the following, which have been determined to have negligible photochemical reactivity: methane, ethane, methylene chloride (dichloromethane), 1,1,1- trichloroethane (methyl chloroform), 1,1,2-trichloro-1,2,2-trifluroethane (CFC-113), trichlorofluoromethane (CFC-11), dichlorodifluoromethane (CFC-12), chlorodifluoromethane (HCFC-22), trifluromethane (HFC-23), CFC-114, CFC-115, HCFC-123, HFC-134a, HCFC-141b, HCFC-142b, HCFC-124, HFC-125, HFC-134, HFC-143a, HFC-152a, parachlorobenzotrifluoride (PCBTF), cyclic, branched or linear completely methylated siloxanes, acetone, perchloroethylene (tetrachloroethylene), HCFC-225ca, HCFC-225cb, HFC-43-10mee, difluoromethane (HFC-32), ethylfluoride (HFC-161), HFC-236fa, HFC-245ca, HFC-245ea, HFC-245eb, HFC-245fa, HFC-236ea, HFC-365mfc, HCFC-31, HCFC-151a, HCFC-123a,

$C_4F_9OCH_3$, ($(CF_3)_2CFCF_2OCH_3$), $C_4F_9OC_2H_5$, ($(CF_3)_2CFCF_2\ C_2H_5$) and methyl acetate and perfluorocarbon compounds that fall into the following classes, namely,

- cyclic, branched or linear completely fluorinated alkanes
- cyclic, branched or linear completely fluorinated ethers with no unsaturations
- cyclic, branched or linear completely fluorinated tertiary amines with no unsaturations, and
- sulfur containing perfluorocarbons with no unsaturations and with sulfur bonds only to carbon and fluorine

United Nations Economic Commission for Europe
Draft Guidelines for estimating and reporting on emission data
Definition of non-methane VOCs
(EB.AIR/GE.1/2001/6) (29 June 2001)

Non-methane volatile organic compounds [VOC] means "any organic compound having at 293.15ºK a vapor pressure of 0.01kP or more, or having a corresponding volatility under their particular conditions of use. For the purposes of these guidelines, the fraction of creosote which exceeds this…vapor pressure at 293.15ºK shall be considered a VOC."