2005 Lower Fraser Valley Air Emissions Inventory & Forecast and Backcast Executive Summary

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Autumn leaves cover photograph: Neil Guernsey
Tugboat and fireplace cover photographs: Laurie Bates-Frymel
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Executive Summary

The 2005 emission inventory provides information on the types of air emission sources in the Metropolitan Vancouver region, their location and the amount of air contaminants emitted, for the year 2005. The emission inventory is an essential tool for air quality management in the region.

Another essential tool is a forecast and backcast of emissions. Emission backcasting involves updating previous emission inventories using current methodologies so that they can be reliably compared with the 2005 inventory. Emission forecasting is the process of estimating future emissions by projecting changes in activity (growth or decline) combined with changes in emission rates or controls. The forecast allows for an assessment of future air emission levels and impacts of emission reduction measures.

Together, the 2005 inventory and the forecast and backcast data can be used to identify where significant progress has been made in reducing emissions under the current Air Quality Management Plan (AQMP) for the Metro Vancouver area, and where additional action is warranted. This information is also essential for the development of an Air Quality Management Strategy for the entire Lower Fraser Valley (LFV) international airshed.

The emission inventory forecast and backcast is also used by other governments and academic researchers in regional and transboundary air quality modelling and in the development of provincial and national emission control programs.

This report provides the results of the 2005 LFV airshed emission inventory and emission forecast and backcast. The backcast includes emission inventories for 1990, 1995 and 2000, while the forecast presents emissions to the year 2030, in five-year increments.

Study Area

The LFV airshed encompasses virtually the entire Metro Vancouver area, the south-western portion of the Fraser Valley Regional District (FVRD) and Whatcom County in the State of Washington.

Common Air Contaminants

The ***common air contaminants*** addressed in this inventory include:

- Carbon monoxide (CO)
- Nitrogen oxides (NOx)
- Total particulate matter (PM)[1]
- Sulphur oxides (SOx)
- Volatile organic compounds (VOC)

Ammonia (NH_3) is also included, due to its role in secondary particulate matter formation.

An overview of the health effects of each contaminant is provided in the next section.

Greenhouse Gases

Greenhouse gases are believed to contribute to global climate change, a shifting of the world's climate systems to wider extremes and variability. Greenhouse gases included in the emission inventory are:

- Carbon dioxide (CO_2)
- Methane (CH_4)
- Nitrous oxide (N_2O)

Sources of Emissions

The 2005 emission inventory, forecast and backcast cover three main categories of emissions: point, area, and mobile sources:

- ***Point Sources*** - This category represents emissions from industrial facilities or utilities operating under an air discharge permit or regulation issued by Metro Vancouver or the BC Ministry of Environment (BCMOE), or under a Solid Waste Management Plan authorized by BCMOE, or under the jurisdiction of the Washington State

[1] Total particulate matter is made up of particles of all sizes, including the two most familiar size fractions, namely PM_{10} and $PM_{2.5}$. PM_{10}, or inhalable particulate matter, refers to particles smaller than 10 microns and $PM_{2.5}$, or fine particulate matter, refers to particles smaller than 2.5 microns.

Department of Ecology or Northwest Clean Air Agency.

- ***Area Sources*** - This category represents emissions from light industrial, residential, commercial and institutional sources which are normally not required to obtain an air discharge permit.

- ***Mobile Sources*** - This category represents emissions primarily from mobile sources involved in the transportation of people and goods, including passenger cars, trucks, buses, and motorcycles, other mobile sources, including aircraft, marine vessels, railways, and non-road engines such as construction and lawn and garden equipment.

Potential Health Effects of Common Air Contaminants

Adverse health effects related to elevated exposure to common air contaminants can include the following:

Carbon Monoxide (CO)
CO can reduce the ability of the blood to carry oxygen to the heart, brain, and other tissues, resulting in impaired performance, respiratory failure, and death.

Nitrogen Oxides (NOx)
NOx can irritate the lungs and lower resistance to respiratory infections. Under certain weather conditions, NOx can also react with other chemicals to form ground-level ozone, acid rain, and secondary particulate matter.

Particulate Matter less than or equal to 2.5 microns ($PM_{2.5}$)
$PM_{2.5}$ can be breathed deep into the lungs and contain substances that are particularly harmful to human health. Scientific studies have linked these small particles to premature death, aggravated asthma, acute respiratory symptoms, and chronic bronchitis. As well, they scatter light in the atmosphere and reduce visibility.

Sulphur Oxides (SOx)
SOx can cause health effects such as breathing difficulties, aggravation of existing respiratory and cardiovascular disease, and mortality. SOx can also interact with other compounds in the air to form secondary particulate matter and can lead to acid rain.

Volatile Organic Compounds (VOC)
Some VOCs can have a potential carcinogenic or toxic effect and can also react with NOx in the atmosphere to form ground-level ozone, a key constituent of smog.

Scope of the 2005 Emission Inventory and Forecast and Backcast

The forecast and backcast of the 2005 emission inventory was performed under different sets of assumptions for three scenarios: the moderate scenario, the high scenario and the low scenario.

The moderate scenario was based on the best available information, representing the most realistic forecast values. It utilized projections from numerous sources on variables such as change in population, economy, kilometres travelled, fuel consumed and future growth. The moderate scenario also incorporated all current and committed federal, provincial and regional activities and measures (e.g. federal government regulations, BC proposed greenhouse gas tailpipe emission standards (2009-2016), Metro Vancouver proposed Boiler and Heater Regulation, etc.)

Depending on the level of uncertainty and what details were available during this study, some of the planned emission reduction measures were included in a low or high scenario, rather than in the moderate scenario. These scenarios provide high and low “bracketing” around the moderate scenario and allow for an analysis of the impact on emissions from factors such as growth in population and economy.

Emission estimates and forecasts are only as good as the data and best methodology available at the time. Part of the effort involved in emissions inventories is to seek ways to improve the available data and methodology. In 2005, emission estimates for some sectors have been revised to incorporate updated methodology and data, resulting in substantial changes to the emission estimates. It is important to note for these sectors, these emission changes are due mainly to updated methodology and/or data, which include:

- United States Environmental Protection Agency methodology for calculating fugitive dust emissions associated with the handling and storage of bulk commodities
- Updated methodology for calculating fugitive dust from the construction and demolition sector
- Updated data for the solvent evaporation sector
- A year-long comprehensive set of surveyed data and updated methodology used in preparing the ocean-going marine vessel emission inventory

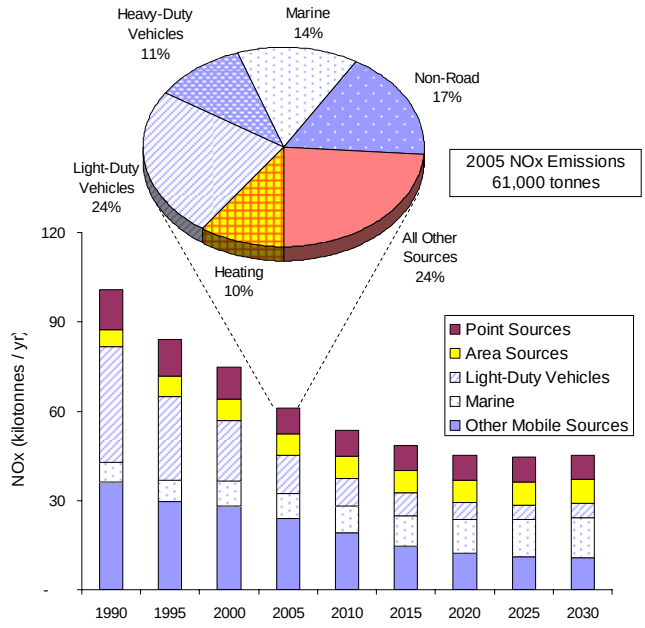
Summary of Individual Contaminants and their Emission Trends

The results of the 2005 emission inventory for some of the individual contaminants and their emission trends are summarized below. Note that more detail is contained in the main body and appendix of this report, including emission estimates by source and region.

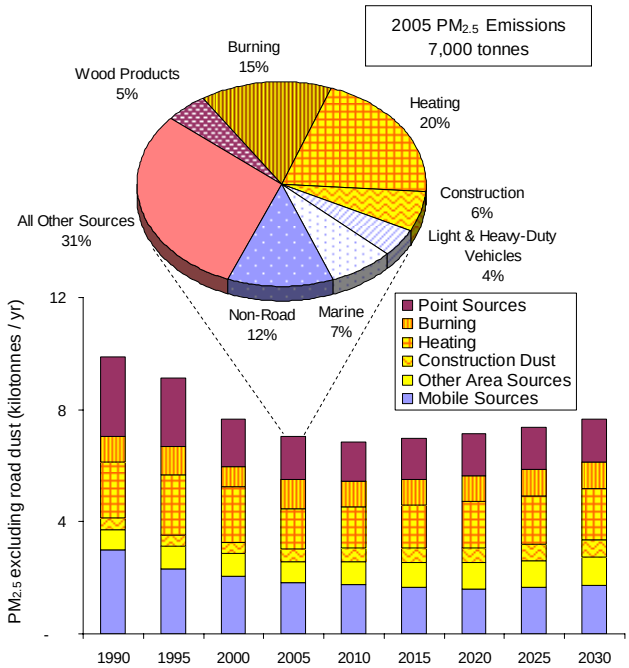
Nitrogen Oxides (NOx)
NOx emissions decline from 1990 through to 2020, and then level off. The decline in emissions from light-duty vehicles after 1990 is largely due to improved vehicle emission standards and AirCare vehicle inspection and maintenance program.

Mobile sources are the main contributors of NOx emissions. Until 2010, cars and light trucks are the main source of NOx.

By 2015, marine vessels are projected to become a dominant source of NOx emissions. The anticipated increase in marine vessel emissions is due to the combined effects of the projected growth in shipping and the fact that emission reduction measures for this sector are not at the same stage of development as those for some other major sectors, such as onroad vehicles.



Fine Particulate ($PM_{2.5}$)
Since 1990, $PM_{2.5}$ emissions have decreased steadily. Reductions from the petroleum refining and wood products sectors coupled with

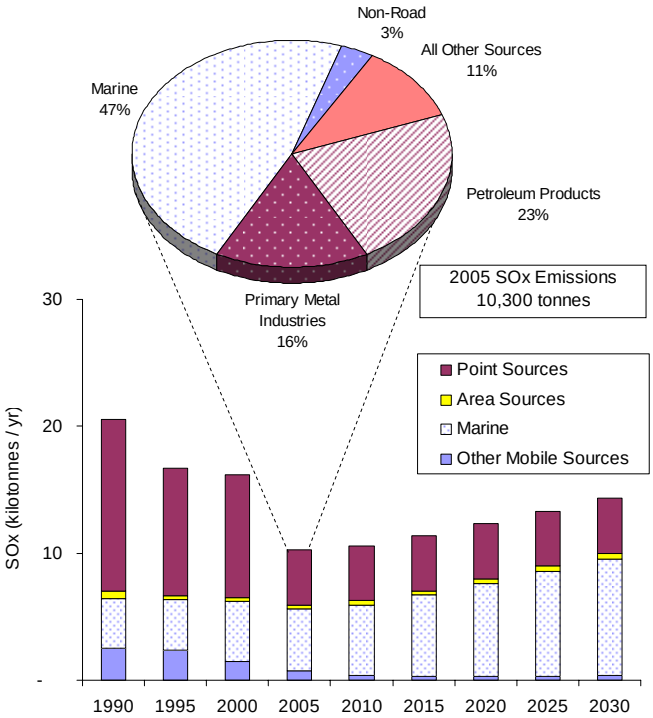


reductions from light and heavy-duty vehicles have driven the declining trend. However, the

forecast of $PM_{2.5}$ emissions shows a steadily increasing trend from 2010 to 2030.

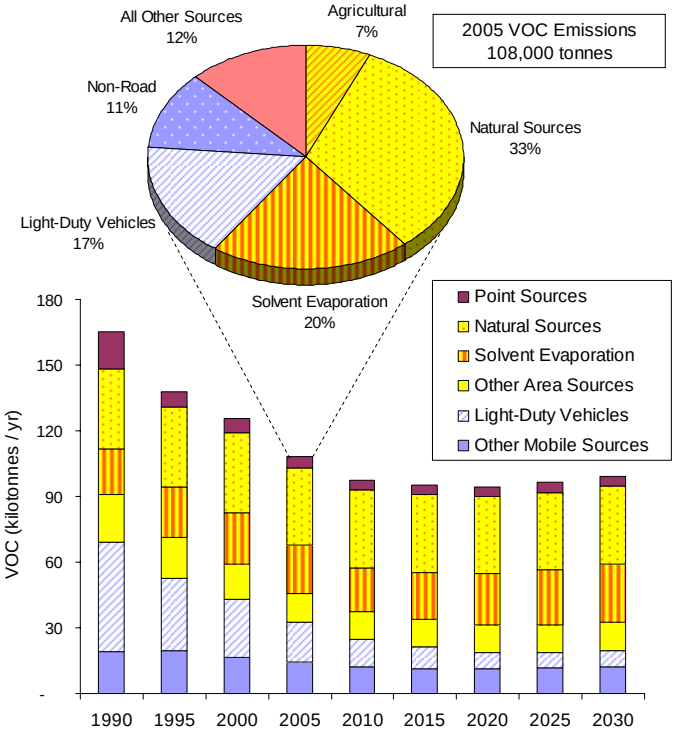
Heating (e.g. buildings), burning, and marine vessels are anticipated to be the main sources of $PM_{2.5}$ emissions in the future.

Sulphur Oxides (SOx)
SOx emissions declined from 1990 to 2005, largely as a result of reduced sulphur in onroad fuels, the shutdown of several Metro Vancouver refineries, and reduced emissions from the cement plants and primary metals industry (aluminum smelter in Whatcom County).



A projected increase in SOx emissions is mainly due to increased emissions from marine vessels. SOx emissions are directly related to fuel consumption and the sulphur content of the fuel. Hence, increased activity in the marine sector, combined with unchanging fuel sulphur contents, results in steadily increasing marine SOx emissions. Other main contributors of SOx emissions in the future include point sources such as the petroleum refining and primary metals industries.

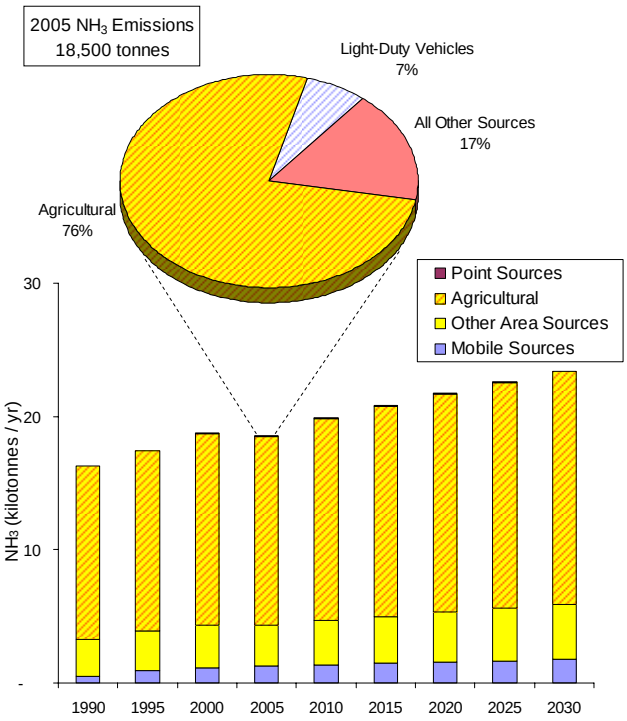
Volatile Organic Compounds (VOC)
VOC emissions declined between 1990-2005. With the steady decline in VOC emissions from cars and light trucks between 1990-2015, due to improved vehicle emission regulations, natural sources like trees and vegetation have become the main contributor of VOC emissions.

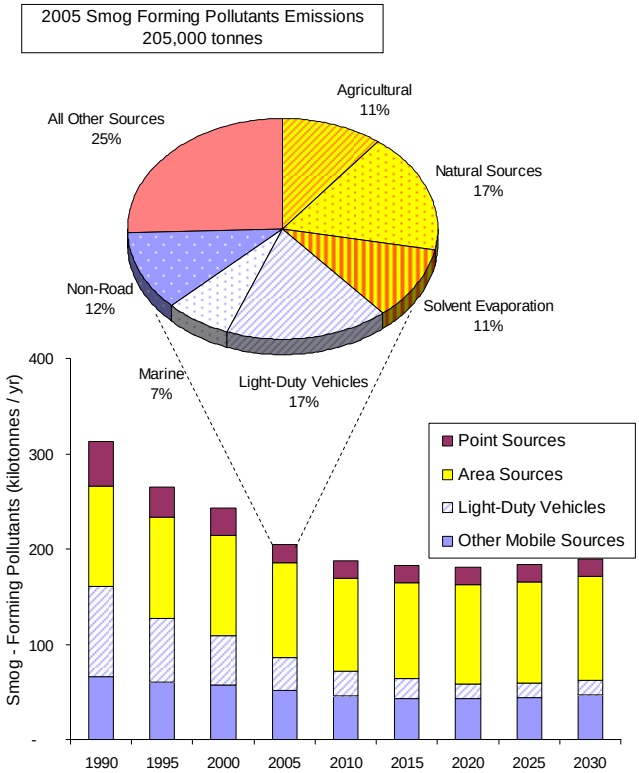


In 2005, the solvent evaporation sector (e.g. industrial, commercial, and consumer products like paints, stains, varnishes, solvents, and thinners) became the main anthropogenic source of VOCs, also overtaking cars and light trucks. In the future, solvent use is projected to still be a significant source of VOC emissions, even with the federal government's proposed regulations for volatile organic compounds in consumer and commercial products in place.

Ammonia (NH_3)
NH_3, along with SOx, NOx and some VOCs, can react in the atmosphere to form secondary $PM_{2.5}$, thus contributing to visibility impairment and the health effects associated with $PM_{2.5}$.

NH_3 emissions are projected to steadily increase from 1990 to 2030 due to an increase in light-duty vehicle use and agricultural activity. Area sources, in particular agricultural sources (e.g. manure handling and storage, and fertilizer application) contribute the largest amount of NH_3 in the region for all years. Other sources such as cars and light trucks and miscellaneous sources (e.g. pets, humans, refrigerants) play smaller roles.

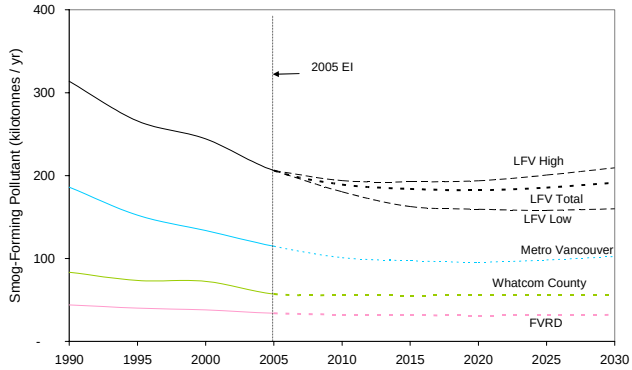




Smog-Forming Pollutants

In order to provide a simplified, aggregate indicator of where "emissions" may be heading, we have summed the emissions of the principal "smog-forming pollutants", namely NOx, VOC, $PM_{2.5}$, SOx and NH_3. These are the major contributors to the formation of ground-level ozone and fine particulate matter, and to the degradation of visibility.

Overall, the trend in smog-forming pollutant emissions decreases until 2020, after which emissions begin to rise. In 2030, solvent evaporation is projected to be the largest source, followed by agricultural sources and marine vessels. The predominance of these sources is due to a projected corresponding change in activity in these sectors, as well as emission reductions resulting from regulations in other sectors such as onroad motor vehicles and non-road engines.



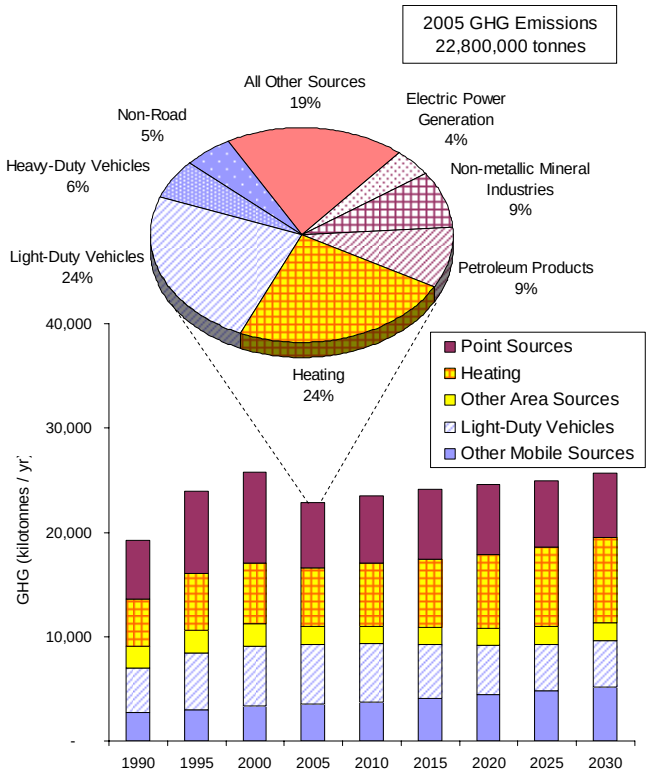
Greenhouse Gases (GHGs)

GHGs were highest in 2000, due in part to higher emissions from an electric power generation plant in Metro Vancouver. GHG emissions from this facility were significantly lower in 2005 and projected to remain low in the future due to decreased operations.

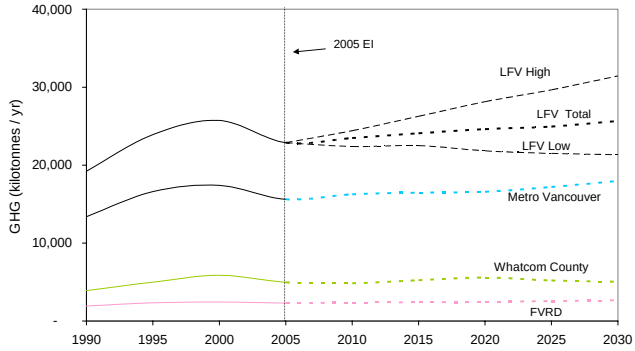
GHG emissions in the airshed are projected to increase between 2010-2030, primarily due to increasing population and economic activity. In 2005, light-duty vehicles and heating were the major sources of GHG emissions. Emissions from heating are projected to continue their climb to 2030, while GHG emissions from light-

duty vehicles are projected to start declining due to the proposed BC tailpipe standards.
The petroleum refining and cement industries, heavy trucks and buses, as well as other non-road equipment contribute significant amounts of GHG emissions as well.

Canada's Kyoto Protocol commitments call for a 6% reduction in 1990 GHG emissions by the 2008 - 2012 period. By contrast, 2010 GHG emissions are projected to be about 22% above 1990 levels in Metro Vancouver and FVRD. In November 2007, the BC Government adopted province-wide GHG reduction targets of 33% (from 2007) by 2020. By contrast, 2020 GHG emissions in Metro Vancouver and FVRD are projected to be 6% above 2005 levels. The development of regional GHG emission reduction strategies is currently underway to supplement other government efforts and curb this increasing trend in GHG emissions.

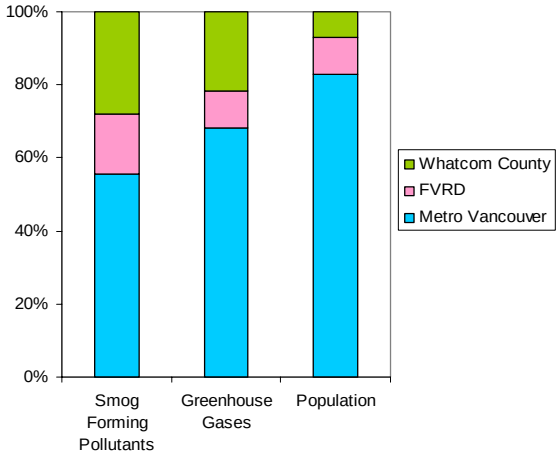


Although GHG emissions are steadily increasing, it is interesting to note that per capita GHG emissions are projected to decrease: from about 7 tonnes per year in 2005 to about 6 tonnes in 2030 for Metro Vancouver; from about 9 tonnes per year in 2005 to about 6.4 tonnes in 2030 for FVRD; and from about 28 tonnes per year in 2005 to about 19 tonnes in 2030 for Whatcom County. LFV per capita GHG emissions are about 9 tonnes in 2005 and projected to be about 7 tonnes in 2030.



Summary of Emissions by Political Region
Emissions of smog-forming pollutants, greenhouse gases, and population, for each of the political regions are shown below.

In 2005, Metro Vancouver, FVRD, and Whatcom County make up 83%, 10%, and 7% of the LFV population, respectively. The larger than expected contribution of Whatcom County to airshed emissions (relative to population) can be explained by the existence of more heavy industry in that area. This fact underscores the importance of air quality planning on an "international" basis in the airshed.



Conclusions

The emission inventory and associated trend analysis is an essential tool in Metro Vancouver's integrated air quality management program. Together, they allow for:

- identification of where action is warranted in the airshed, both today and in the future;
- assessment of where significant progress has been made in reducing emissions; and
- projection of future air emission levels and anticipated impacts of emission reduction measures.

An analysis of the emission inventory forecast results indicates a few key findings:

Smog-Forming Pollutants

- In 2005, light-duty vehicles were still the largest source of smog-forming pollutants, followed by non-road equipment, solvent evaporation and marine vessels.
- Overall, smog-forming pollutants show a declining trend until 2020, after which emissions begin to rise.
- New and existing federal emission standards are expected to reduce smog-forming pollutant emissions from motor vehicles and non-road engines.
- In 2030, solvent evaporation is projected to be the largest source of smog-forming pollutants, followed by agricultural sources and marine vessels. The predominance of these sources is due to a projected corresponding change in activity in these sectors, as well as a decrease in emissions from onroad motor vehicles and non-road engines as a result of regulations.
- NOx emissions are projected to decrease continuously over the 25 year forecast period, primarily due to strict emission standards for light and heavy duty vehicles and non-road engines and equipment. Marine vessels remain as the only major source of NOx with projected increase in emissions.
- There was a substantial decrease in $PM_{2.5}$ emissions between 1990 and 2005, due to reduced emissions from mobile and point sources. However, $PM_{2.5}$ emissions are projected to increase between 2010 and 2030 due to expected increases in the marine sector and area sources (e.g. heating, construction, burning) driven by growth in population and economic activity.
- SOx emissions declined substantially between 2000 and 2005. This was due to improved emissions control at refineries (both in Metro Vancouver and Whatcom County) and reduced production at the smelter in Whatcom County. Marine vessels became the most significant source of SOx emissions in 2005, and in the absence of new measures, their share is projected to increase substantially.
- VOC emissions show a declining trend until 2010, after which the emissions are projected to increase due to increase in solvent evaporation.
- NH_3 emissions are projected to continue to increase in the future. Agricultural activities such as manure handling and fertilizer application are the major contributors to the ammonia emissions in the LFV.

Greenhouse Gases

- In Metro Vancouver and FVRD, on-road vehicles and heating (e.g. buildings) are the two major sources of greenhouse gas emissions. Two cement plants also contribute significantly to the GHG emissions in Metro Vancouver. In Whatcom County, industrial sources such as refineries, the aluminum smelter and power plants are the most significant sources of GHG emissions.
- With the implementation of the proposed tail-pipe standards, emissions from light-duty vehicles are projected to decline, with heating becoming the number one source of GHG emissions. GHG emissions from heavy-duty vehicles, non-road engines, marine vessels and aircraft are also projected to increase steadily.

- GHG emissions have increased steadily between 1990 and 2000 in Metro Vancouver. In 2005, there was some reduction in GHG emissions due to reduced production at an electric power generation plant in Metro Vancouver and some reduction in fuel consumption (i.e. natural gas and gasoline) due to rising fuel prices.

- GHG emissions in both Metro Vancouver and the FVRD have increased steadily from 1990 to 2010 – the time period for commitments under the Kyoto Protocol. While the Kyoto target called for a national reduction of six percent from 1990 levels by 2008 – 2012, GHG emissions in Metro Vancouver and FVRD will have risen by 22% over that time frame.

- In BC, the Kyoto targets have been superceded by a provincial GHG target of 33% reduction (from 2007 levels) by 2020. With the implementation of the planned federal and provincial measures, the GHG emissions in the Canadian LFV are projected to hold fairly steady at 2007 levels. Therefore, there is a need for additional measures to be implemented in Metro Vancouver and FVRD in order to meet the Provincial GHG target of 33% reduction by 2020.

Information from this emission forecast may play an important role in developing and implementing emission reduction measures for Metro Vancouver.

Additionally, as major GHG emission sources such as heating (e.g. buildings) and others continue to increase their activity, and as we move into an era of GHG regulations under Federal and Provincial initiatives, information from this emissions forecast will also be important in assessing what levels of GHG emission reductions may be feasible for this region.

Additional Information

Questions and comments concerning the information presented in this report can be addressed to:

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