Calculating Greenhouse Gas Emissions for the Yukon
An Inventory of Methodologies

Prepared for
Yukon Climate Change Coordinating Committee

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ACKNOWLEDGEMENT and DISCLAIMER

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Executive Summary

Through the Yukon Climate Change Coordinating Committee, the Yukon Government is working towards a climate change action plan for the Yukon. Calculating the greenhouse gas (GHG) emissions for the Yukon is one of most challenging and critical steps in the development of the action plan. Accurate data is needed to identify emission sources and baseline emission levels, establish GHG reduction targets and monitor progress in meeting those targets.

A *Greenhouse Gas Inventory for the Yukon* was prepared in 1999. While the Inventory was extensive, a number of data gaps and uncertainties surfaced. As such, the Yukon Government directed further research on inventory methodologies.

This paper presents the results of a comparative analysis of different approaches to conducting an inventory of GHG emissions. One of the findings of this analysis is that most of the provinces have built their climate change action plans upon the results of national inventories, while the territories have opted to conduct independent inventories.

Another finding of this research is the leading sources on inventory methodologies. *Canada's Greenhouse Gas Inventory* follows the International Panel on Climate Change guidelines for inventories and reports on emission levels for the country, provinces and territories. This is the most comprehensive source of information on inventory data sources and calculations. *Canada's Emissions Outlook* is an authority on forecasting future GHG emission levels. The *Greenhouse Gas Emission Inventory for the Northwest Territories* integrates national methodologies with local data sources.

The 1999 *Greenhouse Gas Inventory for the Yukon* is a good starting point for understanding climate change and developing a Yukon climate change action plan. But there is more work to be done. The comparative analysis of inventory methodologies for this paper suggests a need to address the data gaps and reconsider some of the emission data sources, calculations and reporting formats in the 1999 Yukon Inventory.

The following recommendations are for consideration by the Yukon Climate Change Coordinating Committee.

1. Evaluate the accuracy and completeness of GHG emissions data from national inventories and determine if it is suitable for a Yukon Inventory.

2. Conduct an inventory of GHG emissions for the Yukon if it is considered to be necessary to address data gaps or inaccuracies in the national inventories.

3. Should the Yukon Government decide to conduct an inventory of GHG emissions for the Yukon, it is recommended that the inventory be carried out accordingly.
    - Review information on GHG emissions in the Yukon to identify the most relevant national, territorial or municipal data sources.
    - Report on the sector categories and adopt the calculations and emission factors from *Canada's Greenhouse Gas Inventory.*
    - Forecast future GHG emission levels using the same approach taken in *Canada's Emission Outlook.*

Contents

Introduction

Through the Yukon Climate Change Coordinating Committee, the Yukon Government is working towards a climate change action plan for the Yukon. Calculating the greenhouse gas (GHG) emissions for the Yukon is one of most challenging and critical steps in the development of the action plan. Accurate data is needed to identify emission sources and baseline emission levels, establish GHG reduction targets and monitor progress in meeting those targets.

A *Greenhouse Gas Inventory for the Yukon* was prepared in 1999. While the Inventory was extensive, a number of data gaps and uncertainties surfaced. Recent analysis has shown that the emission levels reported in the Yukon Inventory are inconsistent with studies at the national level. As such, the Yukon Government determined it would be appropriate to examine how other jurisdictions have conducted inventories.

This paper contains a review of inventory methodologies that have been followed by the International Panel on Climate Change (IPCC) and other jurisdictions across Canada for conducting inventories of GHG emissions. A comparative analysis has been done to identify the strengths, weaknesses and opportunities for improving the 1999 Yukon Inventory. This leads to a set of recommendations for compiling data and reporting on GHG emission levels for the Yukon.

Why do an inventory of GHG emissions?

Decades of scientific research have greatly improved our understanding of climate change. We know that GHG emissions from the energy and transportation sectors have the most significant impact on climate change. Industry, agriculture, forestry and waste can also be a factor. In spite of these trends, GHG emissions are not the same everywhere. The number of people, types of industries, sources of power and efficiency of vehicles are only a few of the variables that influence GHG emissions. Jurisdictions inventory these activities to fully understand their contribution to climate change.

In addition to identifying the causes of climate change, an inventory of GHG emissions can help find the solutions. An inventory is a logical first step in the development of a climate change action plan. Without information on all of the sources of GHG emissions, an action plan may not focus on the key issues. Knowing where most of the emissions come from in a jurisdiction provides an opportunity to target resources towards those initiatives that could produce the greatest results. Clearly, this is the most effective and efficient way of designing climate change policies and programs.

Canada's target under the Kyoto Protocol is to reduce GHG emissions to 6% below 1990 levels by 2008-2012. A GHG inventory could describe the 1990 baseline levels as well as the current emission levels. It can also be used as a basis to forecast future emissions for business as usual scenario. Alternatively, an inventory can be used to forecast the emission reductions that could be achieved by implementing specific climate change initiatives.

An increasing number of jurisdictions are beginning to rely on inventories to understand the sources of emissions that contribute to climate change. This provides an opportunity to monitor emission trends within a jurisdiction over time and forecast future levels. Inventories for jurisdictions such as the Yukon also facilitate a comparison with other jurisdictions. Inventories are the foundation for future action on climate change.

Conducting an inventory

A number of inventory reports for Canada and the provinces and territories were reviewed to identify common threads among jurisdictions for reporting GHG emissions. While the specific findings will be reported in later sections of this paper, it is also possible to draw some general conclusions about conducting an emissions inventory.

The years to be reported in an inventory are often dictated by the availability of data. Given the reference to 1990 levels in the Kyoto Protocol, it is often chosen as the baseline year for data collection. An inventory typically reports on the sectors that produce the greatest amount of GHG emissions. There is little consistency however, in the sectors reported in provincial and territorial climate change inventories. The data sources are also varied. Inventories for the territories have incorporated data from local and territorial sources, whereas the provincial inventories tend to use national data. There is less variation among the methods used to calculate emissions.

The IPCC has produced a set of guidelines for GHG inventories. This was obviously a response to the divergent methods being used to collect and report data. From an international perspective, consistency is essential for comparing data from jurisdictions and for monitoring their progress in meeting targets established in the Kyoto Protocol. The IPCC recommends that a four-step process be followed to conduct an inventory of GHG emissions.

1. Adopt the sector categories and time periods in the IPCC framework for reporting emission sources and sinks.
2. Compile the data required for the sector and summary emissions tables and worksheets.
3. Verify the inventory results against other data sources and compare the calculations and emission factors with other inventory methods.
4. Document the results of the inventory, data sources and describe any differences from the IPCC guidelines.

Although the IPCC guidelines were developed for national inventories, the methods could certainly be used to report provincial and territorial GHG emissions. In light of the challenges of collecting data, calculating emissions and reporting results, the IPCC guidelines provide a useful tool for conducting an inventory. That is why this review of inventory methodologies has considered the IPCC guidelines as well as the approaches taken in Canadian, provincial and territorial inventories.

Greenhouse gas inventory for the Yukon

An inventory of GHG emissions was completed for the Yukon in 1999[1]. It was based on a review of inventories for other jurisdictions and consultations with local stakeholders to develop a Yukon-specific approach for data collection and analysis. This inventory reported on GHG emissions for most sectors, identified information gaps and recommended next steps for completing the data collection and analysis.

The data sources, calculations and emission factors were documented for the emissions noted in the transportation, energy and industry categories. Such details were not available for other GHG emission sources such as waste and forestry. Table 1 identifies

[1] Jennifer Jones and Sue Moodie of Yukon Conservation Society conducted this inventory.

the data sources and calculations that were included in the Yukon inventory report. Further details on the data sources and calculations are provided in Appendix A.

Table 1 Yukon's inventory methodologies

Sector	Data Sources	Calculations
Transportation		
Road	X	X
Air	X	X
Energy		
Diesel electricity	X	X
Heating fuel	X	X
Propane	X	
Producer consumption	X	X
Industry		
Upstream oil and gas	X	
Other	X	

The Yukon inventory compiled data for 1990, 1995 and 1997/98. The fiscal year was chosen because the 1998 data was not entirely available at the time of the inventory. Only the 1995 GHG emissions were summarized in the inventory, as shown in Table 2. Note that the emissions are expressed in terms of kilotonnes (kt) of carbon dioxide (CO_2) equivalent[2].

Table 2 Yukon's inventory of GHG emissions, 1995

Sector	Emissions kt CO_2 equivalent	Percent of Total Emissions
Transportation		
Gasoline	182	25
Diesel	139	19
Off-road diesel	87	12
Aviation turbo	16	2
Aviation gasoline	9	1
Energy		
Diesel electricity	54	7
Heating fuel	108	15
Propane	34	5
Producer consumption	70	10
Industry		
Upstream oil and gas	24	3
Other	7	1
Total	**730**	100

Review of inventory methodologies

Canada's inventory

Environment Canada has completed national inventories for the period 1990 to 1998. The 1997 inventory was examined more closely for this research because it provided the greatest detail on methodologies. It also reported provincial and territorial emissions. The Environment Canada inventory was done according to the IPCC guidelines – it is

[2] Methane (CH_4) emissions are multiplied by 21 and nitrous oxide (N_2O) by 310 to calculate the CO_2 equivalent.

the national inventory for Canada. It reports emissions for the IPCC sector categories: energy, industrial processes, solvents and other product use, agriculture, land use change and forestry, and waste. The emission calculations are also consistent with the IPCC guidelines. Table 3 identifies the data sources and calculations that were included in Canada's inventory report. Further details on the data sources and calculations are provided in Appendix A.

Table 3 Canada's inventory methodologies

Sector	Data Sources	Calculations
Energy		
Fossil fuel industry	X	X
Electricity/steam	X	X
Mining	X	X
Manufacturing	X	X
Construction	X	X
Transportation		
Road	X	X
Air	X	X
Marine	X	X
Rail	X	X
Pipelines	X	X
Residential/Commercial/Institutional	X	X
Other		
Residential and industrial fuelwood	X	X
Fugitive		
Oil and gas	X	
Industrial processes		
Other production	X	
Solvent and other product use	X	
Land use change and forestry	X	
Waste	X	X

The Environment Canada inventories for 1990 to 1998 include an analysis of emissions for every province. Unfortunately, energy data was reported collectively for the Yukon and Northwest Territories in 1990 and 1991. As a result, inventories of GHG emissions in the Yukon have been completed for 1992 to 1996.

The 1995 inventory is shown in Table 4 to facilitate comparison with the Yukon inventory for the same year.

Emissions outlook for Canada

While the other inventories reviewed in this paper are based on an in-depth analysis of emissions from each sector, *Canada's Emission Outlook* has taken a different approach. The Natural Resources Canada Analysis and Modelling Group used a single data source for energy consumption and emissions – the Statistics Canada *Energy Demand/ Supply Quarterly Report.* Emissions forecasts were calculated using growth rate indicators for population, households and industry/service employment.

Table 5 identifies the data sources and calculations that were included in the Emissions Outlook. Further details on the data sources and calculations for the emissions inventory and forecast are provided in Appendix A

Table 4 Canada's inventory of GHG emissions for the Yukon, 1995

Sector	Emissions kt CO_2 equivalent	Percent of Total Emissions
Energy		
Fuel combustion		
Fossil fuel industries	68	7.0
Electricity/steam generation	34	3.5
Mining	9	0.9
Manufacturing	1	0.1
Construction	4	0.4
Transportation		
Gasoline automobiles	74	7.6
Light-duty gasoline trucks	43	4.4
Heavy-duty gasoline vehicles	9	0.9
Motorcycles	0	0
Off-road gasoline vehicles	11	1.1
Diesel automobiles	1	0.1
Light-duty diesel trucks	1	0.1
Heavy-duty diesel vehicles	113	11.6
Off-road diesel vehicles	25	2.6
Propane/natural gas vehicles	5	0.5
Domestic air	25	2.6
Domestic marine	0	0
Domestic rail	0	0
Pipelines	0	0
Residential	20	2.1
Commercial and institutional	51	5.2
Other	8	0.8
Fugitive		
Solid fuels (i.e. coal mining)	0	0
Oil and gas	42	4.3
Industrial processes	0	0
Non-metallic mineral production	0	0
Ammonia, adipic acid, nitric acid	0	0
Ferrous metal production	0	0
Aluminum and magnesium	0	0
Other production	2	0.2
Solvent and other product use	0	0
Agriculture	0	0
Enteric fermentation	0	0
Manure management	0	0
Agricultural soils	0	0
Land use change and forestry*	420	43.2
Waste		
Solid waste disposal on land	4	0.4
Wastewater handling	4	0.4
Waste incineration	0	0
Total	**973**	100

*Emissions from prescribed and other fires (this is much higher for 1995 than other years)

Table 5 Canada's emissions outlook methodologies

Sector	Data Sources	Calculations
1996 emissions All sector categories	X	X
2000 to 2020 emissions forecast All sector categories	X	X

The emissions outlook reported on data for all of Canada as well as the provinces and territories. This includes GHG emissions for the Yukon in 1996, Table 6, and forecast emission levels for 2000, 2005, 2010, 2015 and 2020.

Table 6 Canada's emissions outlook for the Yukon, 1996

Sector	Emissions kt CO_2 equivalent	Percent of Total Emissions
Residential and commercial		
Natural gas	8.9	1.5
Refined petroleum products	124.3	21.3
Industrial		
Natural gas	2.1	0.3
Refined petroleum products	106.0	18.2
Transportation		
Motor gasoline road	107.0	18.3
Diesel fuel road	27.8	4.8
Aviation gas	2.6	0.4
Aviation turbo	16.0	2.7
Natural liquids road	0.9	0.2
Producer consumption		
Natural gas	53.0	9.1
Natural gas liquids	0.2	<0.1
Conversion requirements		
Refined petroleum products	99.6	17.1
Industrial processes	1.0	0.1
Other gases CH_4, N_2O	33.0	5.7
Total	**583.4**	100

Northwest Territories

The Government of the Northwest Territories commissioned a study of GHG emissions in 1998 by Ferguson Simek Clark. The report, *Greenhouse Gas Emission Forecast for the Northwest Territories,* included an inventory of emissions for 1996 and 1997, as well as forecast emissions for 1998 to 2013.

The GHG inventory was updated in 1999 to separate the emissions for the Northwest Territories and Nunavut. This report was called *Greenhouse Gas Emissions in 1996 for the Northwest Territories and Nunavut.* Since the 1999 inventory also reviewed and revised the calculation methodologies, it has been the source of Northwest Territories inventory information for this paper.

Table 5 identifies the data sources and calculations that were included in the GHG emissions inventory for the Northwest Territories. Further details on the data sources and calculations are provided in Appendix A. The 1996 emission levels for the Northwest Territories are shown in Table 8.

Table 7 Northwest Territories inventory methodologies

Sector	Data Sources	Calculations
Industrial processes		
Upstream oil and gas	X	X
Fuel combustion - stationary		
Power generation	X	X
Industrial	X	X
Commercial	X	X
Residential	X	X
Public administration	X	X
Producer consumption	X	X
Residential fuelwood	X	X
Industrial fuelwood	X	X
Fuel combustion - mobile		
Road	X	X
Air	X	X
Rail	X	X
Marine	X	X
Incineration	X	X
Miscellaneous		
Prescribed burning	X	X
Aneasthetics and propellants	X	X

Other Jurisdictions

All provinces and territories were contacted for information on their GHG inventory methodologies. Only some of the jurisdictions responded to the request for information, or had the relevant material available on their Internet site. As such, Newfoundland, New Brunswick, Nova Scotia, Prince Edward Island, Ontario and Manitoba have not been included in this review. The following is a summary of the key findings from the other jurisdictions.

British Columbia

The report by the Natural Resources Canada Analysis and Modelling Group entitled *Canada's Emissions Outlook: Update* provided all of the GHG emissions data for the *British Columbia Climate Change Business Plan, 2000/01 – 2002/03*. The province has not conducted an inventory of GHG emissions for British Columbia.

Alberta

As in the case of British Columbia, the *Emissions Outlook* by Natural Resources Canada has provided the GHG emissions data and forecast for Alberta's climate change strategy. Although there is no evidence that an inventory of GHG emissions was done by the province, some research has been carried out. In 1999, Alberta Agriculture, Food and Rural Development conducted a review of *Greenhouse Gas Emissions from Livestock in Alberta*.

Saskatchewan

Saskatchewan Energy and Mines have adopted the methodologies from *Canada's Greenhouse Gas Inventory* by Environment Canada. The primary data source for their inventory, as in the case of the national inventory, is Statistics Canada's *Quarterly Report on Energy Supply and Demand* (Loseth, communication, 2000).

Table 8 Northwest Territories inventory of GHG emissions, 1996

Sector	Emissions kt CO_2 equivalent	Percent of Total Emissions
Industrial processes		
Natural gas distribution		
Upstream oil and gas	46	4.2
Cement/Lime production		
Other non-energy use		
Coal mining		
Chemical production		
Fuel combustion – stationary		
Power generation	144	13.2
Industrial	16	1.5
Commercial	248	22.8
Residential	114	10.5
Agriculture		
Public administration	85	7.8
Steam generation		
Producer consumption	17	1.6
Other		
Residential fuelwood	48	4.4
Industrial fuelwood	1	0.1
Spent pulping liquors		
Fuel combustion – mobile		
Automobiles	67	6.1
Light duty gasoline trucks		
Heavy duty gasoline trucks	4	0.4
Motorcycles		
Off-road gasoline	0	0
Light duty diesel automobiles	5	4.6
Light duty diesel trucks		
Heavy duty diesel vehicles	10	0.9
Off-road diesel		
Air	222	20.4
Rail	1	0.1
Marine	57	5.2
Other		
Incineration		
Municipal solid waste	3	0.2
Agriculture		
Livestock/manure		
Fertilizer use		
Soils		
Miscellaneous		
Prescribed burning		
Wastewater/compost		
Landfills		
Aneasthetics/propellants	1	0.1
Total	**1,090**	100

Quebec

The *Quebec Action Plan on Climate Change, 2000 – 2002* references three sources of data on GHG emissions. The total GHG emissions for Quebec and other provinces come from *Canada's Greenhouse Gas Inventory*. An inventory by the Ministry of Environment for Quebec resulted in different emission levels for the sector categories

than the Environment Canada inventory, but the total emissions were the same. The report on the data sources and methodologies for the inventory by Ministry is not yet available. Forecasts for future emission levels were based on the Natural Resources Canada *Emissions Outlook.*

Municipalities

The Federation of Canadian Municipalities Partners for Climate Protection Program "is a group of municipal and regional governments across Canada working together to reduce GHG emissions produced locally". The City of Whitehorse is a member of this program.

Municipalities are provided with free software for conducting an inventory of GHG emissions and forecasting future emission levels. The City of Whitehorse will use this software for an inventory of GHG emissions for municipal operations and the community. Emission levels are calculated once the following information is input to the software:

- Residential, commercial, industry and transportation electricity and fuel consumption;
- Vehicle kilometers traveled by different vehicle types;
- Amount of waste sent to landfill, waste composition and methane recovery; and
- Other carbon dioxide, methane and nitrous oxide emissions.

The inventory reports on emissions for six sectors: residential, commercial, industry, transportation, waste and other. Municipalities are recommended to use 1990 as the base year for the inventory. Emission forecasts are generated for the year 2010.

Comparative Analysis

Reporting Emissions

The baseline year for inventories of GHG emissions is 1990, provided data is available. *Canada's Greenhouse Gas Inventory* by Environment Canada has established inventories for all provinces from 1990 to 1996. Environment Canada reports on GHG emissions collectively for the territories in 1990 and 1991, with a separate inventory for the Yukon beginning in 1992. The Natural Resources Canada *Emissions Outlook* includes a 1996 inventory and forecasts for 2000, 2005, 2010, 2015 and 2020. The inventory by the Northwest Territories reported on 1996 data and forecasted annual emission levels for 1997 to 2013.

In comparison, data for 1990, 1995 and 1997/98 was gathered for the Yukon Inventory. The GHG emission levels for 1995 were reported in the inventory, but the 1990 data was incomplete. Collecting data for the 1997/98 fiscal year is contrary to the IPCC guidelines which state data should be based on the calendar year. The Yukon Inventory did not forecast future emission levels.

The sector categories reported in GHG emission inventories are intended to group the most significant sources and similar types of emissions. As shown in Table 9, the inventories for Canada, the Yukon and Northwest Territories report emissions for approximately the same number of categories – with less consistent emphasis on emission sources. Energy is obviously a category for all of the inventories but it is represented in different ways. Other sectors such as agriculture, forestry and waste are highlighted in some of the inventories.

Table 9 Sector categories reported in GHG emission inventories

Sector	Canada's Inventory	Emissions Outlook	Yukon	Northwest Territories
Energy	X		X	X
Industrial Processes	X	X		X
Solvent and Other Product Use	X			X
Agriculture	X			X
Land Use Change, Forestry	X			
Waste	X			X
Residential and Commercial	X	X		X
Industrial	X	X	X	X
Transportation	X	X	X	X
Producer Consumption		X	X	X
Conversion Requirements		X		
Other Gases		X		
Other			X	
Fuel Combustion – Stationary				X
Fuel Combustion – Mobile				X
Incineration	X			X
Miscellaneous				X

Data Sources and Calculations

Jurisdictions in Canada have followed three paths for conducting an inventory of GHG emissions. They adopt the emission levels from *Canada's Greenhouse Gas Inventory, Canada's Emissions Outlook*, or they follow another approach. The four provinces listed in Table 10 used three different methods for their inventories. While there is no single source for provincial inventory data, British Columbia, Alberta and Saskatchewan have relied on GHG emissions data from national inventories. Quebec is the only province to have completed their own inventory, which they used in conjunction with national data.

The Yukon and Northwest Territories are among the few jurisdictions that have taken the initiative to complete a GHG emissions inventory. This could indicate a concern that the national inventories do not adequately describe the emission sources or levels in northern Canada. Or it may reflect dissatisfaction with the availability of baseline data – 1992 for the territories and 1990 for the provinces. As such, the national data sources could be more comprehensive for the provinces than the territories.

Table 10 GHG emission inventory methodologies

Jurisdiction	Canada's Inventory	Emissions Outlook	Other Approach
Yukon			X
Northwest Territories			X
British Columbia		X	
Alberta		X	
Saskatchewan	X		
Quebec	X	X	X
Municipalities			X

Clearly, the data sources used for an inventory will influence the results. National data is readily available and can be compared with other jurisdictions. On the other hand, data from provincial and territorial sources often has the advantage of being more accurate

because of the greater level of detail. Gasoline and diesel fuel sales for the Yukon provide an example of the potential inconsistencies between data sources. The fuel sales used to calculate vehicle emissions for the Yukon inventory were 30 percent higher than the *Emissions Outlook*. The inventory relied on data from the Yukon Finance Department and the outlook collected information from Statistics Canada.

The data sources and calculations were documented in a previous section of this paper to provide a resource for conducting an inventory of GHG emissions. The inventory by Environment Canada should be regarded as the authority on emission calculations because it meets the IPCC guidelines. The Northwest Territories inventory has incorporated nearly all of the calculations from *Canada's Inventory*. The inventory by the Northwest Territories has balanced national data and methodologies with some territorial information sources.

This review of inventory methodologies has identified a number of opportunities for improving the Yukon Inventory. The Yukon data sources and calculations for the air, diesel electricity, propane and heating fuel categories are consistent with the other inventories. Inconsistencies in the data sources, calculations and/or emission factors for the road and producer consumption categories indicate a need to review these Yukon inventory methodologies. Incorporating the Environment Canada and Northwest Territory inventory methods could fill the Yukon Inventory data gaps for fuelwood, marine, open burning, waste landfills, prescribed burning, forest fires, and solvents such as anaesthetics and propellants.

Inventory Results

Since the *Greenhouse Gas Inventory for the Yukon* was completed, Environment Canada and Natural Resources Canada released two independent studies of GHG emissions for the Yukon. The results from these inventories are compared in Table 11. The data from *Canada's Inventory* indicated much higher emission levels than the Yukon Inventory in 1995 and the *Emissions Outlook* in 1996.

Table 11 Comparing GHG emission inventories for the Yukon

Source	Year	GHG Emissions
Yukon Inventory	1995	730
Canada's Inventory	1995	973
Emissions Outlook	1996	583
Canada's Inventory	1996	638

It is difficult to compare the emissions by sector because each inventory is organized by different categories. The primary reason for the higher emission levels in *Canada's Inventory* is the 420 kilotonnes of carbon dioxide from prescribed burning and forest fires. The Yukon Inventory did not include an estimate of emissions from this source. That would suggest that the other emission categories were underestimated by Environment Canada or overestimated in the Yukon inventory. As stated previously, the lower estimates from the *Emissions Outlook* is the result of conflicting fuel sales data.

The inventory results for the Northwest Territories are illustrated in Table 12. In contrast with the Yukon experience, emission levels for the Northwest Territories inventory are lower than the *Emissions Outlook*. The high levels reported in *Canada's Inventory* are misleading because it includes both the Northwest Territories and Nunavut.

Table 12 Comparing GHG emission inventories for the Northwest Territories

Source	Year	GHG Emissions
Northwest Territories Inventory	1996	1,090
Canada's Inventory	1996	2,100
Emissions Outlook	1996	1,538

Considering the size of the Yukon population and economy, the GHG emissions from this jurisdiction would be expected to be much lower than the rest of the provinces and territories. Table 13 demonstrates that this is indeed the case. According to the 1996 data from *Canada's Inventory*, the Yukon contributes 0.1 percent of the GHG emissions in the country.

Table 13 Provincial and territorial GHG emission levels, 1996

Jurisdiction	Emissions kt CO_2 equivalent	Percent of Total Emissions
Newfoundland	8,360	1.2
Prince Edward Island	1,990	0.3
Nova Scotia	19,400	2.9
New Brunswick	16,800	2.5
Quebec	87,000	13
Ontario	191,000	28.5
Manitoba	22,300	3.3
Saskatchewan	59,300	8.8
Alberta	199,000	29.7
British Columbia	62,400	9.3
Northwest Territories, Nunavut	2,100	0.3
Yukon	638	0.1
Canada	670,288	100

Source: Canada's Greenhouse Gas Inventory, 1997

Natural Resources Canada forecasts GHG emissions in the Yukon and Canada will grow at a similar rate. It is estimated that emission levels will increase by 25.9 percent for the Yukon and 26.1 percent for the rest of Canada between 1996 and 2020.

Summary and Recommendations

The key question regarding an inventory of GHG emissions is this – should the Yukon rely on the results of national inventories or conduct further research and analysis? The review of inventory methodologies for the provinces and territories did not provide a single answer to this question. Most of the provinces have elected to build their climate change action plans upon the results of national inventories, while the territories have opted to conduct independent research and analysis.

There are three leading sources on inventory methodologies. *Canada's Greenhouse Gas Inventory* follows the IPCC guidelines for inventories and reports on emission levels for the country, the provinces and territories. This is the most comprehensive source of information on inventory data sources and calculations. *Canada's Emissions Outlook* is an authority on forecasting future GHG emission levels. The *Greenhouse Gas Emission Inventory for the Northwest Territories* is an ideal model for the Yukon because it integrates national methodologies with local data sources.

The 1999 *Greenhouse Gas Inventory for the Yukon* is a good starting point for understanding climate change and developing a Yukon climate change action plan. But there is more work to be done. The comparative analysis of inventory methodologies for this paper suggests a need to address the data gaps and reconsider some of the emission data sources, calculations and reporting formats in the 1999 Yukon Inventory.

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3. Should the Yukon Government decide to conduct an inventory of GHG emissions for the Yukon, it is recommended that the inventory be carried out accordingly.
   - Review information on GHG emissions in the Yukon to identify the most relevant national, territorial or municipal data sources.
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Appendix A – Inventory Methodologies

Yukon Territory

Sector	Methodologies	
Transportation		
Road	Data	Gasoline gross fuels, diesel fuel sales
	Source	YTG Finance, Statistics Canada
	Reference	*Road Motor Vehicle Report*
	Calculation	Emissions = fuel sales x emission factor
	Emission factor	Gasoline: 2.5kg CO_2/L Diesel: 2.9kg CO_2/L
Air	Data	Aviation fuel sales
	Source	YTG Finance, Statistics Canada
	Reference	*Refined Petroleum Products Report*
	Calculation	Emissions = fuel sales x emission factor
	Emission factor	Gasoline: 2.33kg CO_2/L, 2.19g CH_4/L, 0.23 N_2O/L Turbo: 2.55kg CO_2/L, 0.08g CH_4/L, 0.25g N_2O /L
Energy		
Diesel electricity	Data	Electricity generated by diesel
	Source	Yukon Energy Company Ltd, Yukon Energy Corp.
	Calculation	Emissions = diesel consumption x emission factor
	Emission factor	2,730g CO_2/L, 0.26g CH_4/L, 0.4g N_2O /L
Heating fuel	Data	Distributor reports of fuel sales
	Source	YTG Finance
	Calculation	Emissions = fuel sales x emission factor
	Emission factor	2,830g CO_2/L, 0.214g CH_4/L, 0.006g N_2O/L
Propane	Data	Total sales for heating and other uses
	Source	YTG Finance
Producer Consumption	Data	Gas consumption at Kotaneelee gas field
	Source	YTG Economic Development
	Calculation	Emissions = gas consumption x emission factor
	Emission factor	49.68t CO_2/TJ, 0.07kg CH_4/TJ, 0.62kg N_2O/TJ
Industry		
Upstream oil and gas	Data	Estimate for the Yukon
	Source	Statistics Canada
	Reference	*Quarterly Report on Energy Supply-Demand*
Other		
	Data	Based on national estimates of other category
	Source	Environment Canada
	Reference	*GHG Emissions 1990-1995*

Canada's Inventory

Sector	Methodologies	
Energy		
Fossil fuel industry	Data	Amount of fuel consumed
Electricity/steam	Source	Statistics Canada
Mining	Reference	*Quarterly Report on Energy Supply-Demand*
Manufacturing	Calculation	Emissions = fuel combusted x emission factor
Construction	Emission factor	For energy and fuel categories (Appendix)
Transportation	Data	Fuel sales, #vehicles/category, distance traveled[3]
Road	Source	Statistics/Environment/Transport Canada
	Reference	*Quarterly Report on Energy Supply-Demand*
	Calculation	Emissions = fuel consumed* x emission factor
		*Vehicles x distance x fuel consumption ratio
	Emission factor	For vehicle categories (Appendix)
Air	Data	Aviation fuel sales
	Source	Statistics Canada
	Reference	*Quarterly Report on Energy Supply-Demand*
	Calculation	Emissions = fuel sales x emission factor
	Emission factor	Gasoline: 2.33kg CO_2/L, 2.19g CH_4/L, 0.23 N_2O/L
		Turbo: 2.55kg CO_2/L, 0.08g CH_4/L, 0.25g N_2O/L
Marine	Source	Statistics Canada
	Calculation	Emissions = fuel combusted x emission factor
	Emission factor	Gasoline: 2,360g CO_2/L, 1.3g CH_4/L, 0.06g N_2O/L
		Diesel: 2,730g CO_2/L, 0.15g CH_4/L, 1.0g N_2O/L
		Light oil: 2,830g CO_2/L, 0.3g CH_4/L, 0.07g N_2O/L
		Heavy oil: 3,090g CO_2/L, 0.3g CH_4/L, 0.08g N_2O/L
Rail	Source	Statistics Canada
	Calculation	Emissions = fuel combusted x emission factor
	Emission factor	Diesel: 2,730g CO_2/L, 0.15g CH_4/L, 1.1g N_2O/L
Pipelines	Data	Fuel consumption by pipelines
	Source	Statistics Canada
	Reference	*Quarterly Report on Energy Supply-Demand*
	Calculation	Emissions = consumption x emission factor
	Emission factor	Natural gas: 1,880gCO_2/m^3, 0.048gCH_4/m^3, 0.02 gN_2O/ m^3
Residential	Data	Amount of fuel consumed, heating degree days
Commercial	Source	Statistics Canada
Institutional	Reference	*Quarterly Report on Energy Supply-Demand*
	Calculation	Consumption x emission factor x heating degree days
	Emission factor	Natural gas: 1,800g CO_2/L, 0.43g CH_4/L, 0.02g N_2O/L
		Light oil (Res): 2,830g CO_2/L, 0.214g CH_4/L, 0.006g N_2O/L
		Light oil (Com): 2,830g CO_2/L, 0.026g CH_4/L, 0.013g N_2O/L
		Heavy oil: 3,090g CO_2/L, 0.06g CH_4/L, 0.013g N_2O/L
Other		
Residential and	Data	Wood burned, equipment type, degree days
Industrial fuelwood	Source	National Emissions Inventory Task Group
		Statistics Canada

[3] Estimates for average distance traveled by each class of vehicle are available from Environment Canada.

	Reference	*Canadian Facts, 1997* *Quarterly Report on Energy Supply and Demand*
	Calculation	Emissions = wood burned x emission factor
	Emission factor	For types of wood burning equipment (Appendix) Industrial: 1,500g CO_2/kg, 0.15g CH_4/kg, 0.16g N_2O/kg
Fugitive Oil and gas	Source Reference	Clearstone Engineering Report *Emissions from Upstream Oil and Gas Industry*
Industrial processes Other production	Source Reference	Statistics Canada *Quarterly Report on Energy Supply-Demand*
Solvent and other product use	Calculation Emission factor	Emissions = population x per capita emission factor Anaesthetics: 46.22g per capita Propellants: 2.38g per capita
Land use change and forestry	Data Source Reference	Deforestation, cropland abandonment, forest fires Sellers and Wellisch, 1998 *GHG Contribution of Canada's Land Use Change and Forestry Activities*
Waste	Data Source Reference Calculation Emission factor	Per capita waste generation, population Environment Canada *Methane Emissions from Landfills* Emissions = per capita waste x population x methane Methane emission factor for Yukon is 0.003

Emissions Outlook

Sector	Methodologies	
1996 Emissions All sector categories	Data Source Reference Calculation	Residential, commercial, industrial, transportation Statistics Canada *Energy Demand/Supply Quarterly Report* Emissions = energy demand x emission factors
2000 to 2020 Emissions forecast All sector categories	Data Source Reference Calculation Growth rate	Population, households, industry/service employment YTG Statistics, Conference Board of Canada *Report on the Yukon Economy* Emissions = energy demand x growth rate Population: 1996-2020 = 1.7 Households: 1996-2020 = 2.0 Industry employment: 1996-2010 = 1.3, 2010-20 = 1.2 Service employment: 1996-2010 = 1.3, 2010-20 = 1.2

Northwest Territories Inventory

Sector	Methodologies	
Industrial processes Upstream oil and gas	Data Source Calculation Emission factor	Gas field production Clearstone Engineering Emissions = fuel volume x emission factor Oil: 7.69g CO_2/L, 0.725g CH_4/L, 0.00lg N_2O/L Gasoline: 0.0001g CO_2/L, 0.005g CH_4/L
Fuel combustion - stationary Power generation	Data Source Calculation Emission factor	Commercial power generation NWT Power Corporation, Northland Utilities Emissions = fuel consumption x emission factor Diesel: 2,730g CO_2/L, 0.26g CH_4/L, 0.4g N_2O/L Bunker C: 2,730g CO_2/L, 0.26g CH_4/L, 0.4g N_2O/L Natural gas: 1.88g CO_2/L, 0.00002 N_2O/L
Industrial	Data Source Calculation Emission factor	Fuel oil purchased by mining industry Ekati Mine Emissions = fuel consumption x emission factor Diesel: 2,730g CO_2/L, 0.26g CH_4/L, 0.4g N_2O/L
Commercial	Data Source Calculation Emission factor	Fuel purchased by commercial sector Statistics Canada Emissions = fuel consumption x emission factor Light oil: 0.0028gCO_2/L, 2.6x10^{-8}gCH_4/L, 1.3x10^{-8}gN_2O/L Natural gas: 1.9x10^{-6}g CO_2/L, 4.3x10^{-11}g CH_4/L, 2x10^{-11} g N_2O/L Diesel: 2.7x10^{-3}g CO_2/L, 2.6x10^{-7}g CH_4/L, 4x10^{-7}g N_2O/L
Residential	Data Source Calculation Emission factor	Residential fuel consumption Statistics Canada Emissions = fuel consumption x emission factor Light oil: 0.0028g CO_2/L, 2.1x10^{-7}g CH_4/L, 6x10^{-9}g N_2O/L Natural gas: 1.9x10^{-6}g CO_2/L, 4.3x10^{-11}g CH_4/L, 2x10^{-11}g N_2O/L
Public administration	Data Source Calculation Emission factor	Public administration fuel consumption Statistics Canada E = fuel consumption x emission factor Diesel: 0.0027g CO_2/L, 2.6-7g CH_4/L, 4-7g N_2O/L Light oil: 0.0028g CO_2/L, 2.6-8g CH_4/L, 1.3-8g N_2O/L
Producer Consumption	Data Source Calculation Emission factor	Gas consumed by oil and gas producers Clearstone Engineering Emissions = fuel consumption x emission factor Gasoline: 0.059g CO_2/L, 0.00047g CH_4/L, .6-5g N_2O/L Oil: 2.17g CO_2/L, 0.009g CH_4/L
Residential fuelwood Industrial fuelwood	Data Source Reference Calculation Emission factor	Mass, density and volume of wood burned National Emissions Inventory Task Group *Criteria Air Contaminants Emissions Inventory* Emissions = mass of wood x emission factor 0.001466g CO_2/kg

Fuel combustion - mobile		
Road	Data	Vehicles, distance traveled, fuel consumption
	Source	NWT Transportation, Environment/Transport Canada
	Reference	*Trends in Canada's GHG emissions 1990-95*
	Calculation	Emissions = vehicles x distance x fuel consumption
	Emission factor	For vehicle categories (Appendix)
Air	Data	Aviation fuel sales
	Source	Statistics Canada
	Reference	*Aircraft Movement Statistics*
	Calculation	Emissions = fuel sales x emission factor
	Emission factor	Gasoline: 2.33kg CO_2/L, 2.19g CH_4/L, 0.23 N_2O/L Turbo: 2.55kg CO_2/L, 0.08g CH_4/L, 0.25g N_2O/L
Rail	Data	Fuel consumed by rail line
	Source	Statistics Canada
	Calculation	Emissions = fuel consumption x emission factor
	Emission factor	Diesel: 0.0027g CO_2/L, $2.6x10^{-7}$g CH_4/L, $4x10^{-7}$g N_2O/L
Marine	Data	Fuel consumed by ships
	Source	Statistics Canada
	Calculation	Emissions = fuel consumption x emission factor
	Emission factor	Diesel: 0.0027g CO_2/L, $2.6x10^{-7}$g CH_4/L, $4x10^{-7}$g N_2O/L
Incineration		
	Data	Per capita solid waste generation
	Source	Heinke and Wong Study,
	Calculation	Emissions = per capita waste x burning efficiency, 90% x carbon, 25% x waste converted to CO_2, 50%
	Emission factor	0.000169g CO_2/kg
Miscellaneous		
Prescribed burning	Data	Area of prescribed burn
	Source	NWT Resources, Wildlife, Economic Development
	Calculation	Emissions = hectares x emission factor
Anaesthetics Propellants	Data	Population
	Calculation	Emissions = population x per capita emission factor
	Emission factor	Aneasthetics: 46.22g per capita Propellants: 2.38g per capita

Appendix C – Emission factors

Category	Description	Emission Factor		
		CO_2	CH_4	N_2O
Energy Fuel	Natural gas	1,880 g/m^3	0.0048	0.02
	Utility boiler	1,880 g/m^3	0.048	0.02
	Industrial boiler	1,880 g/m^3	0.043	0.02
	Commercial boiler	1,880 g/m^3	0.043	0.02
	Residential boiler	1,880 g/m^3	0.043	0.02
	Other			
	Refinery fuel, industrial energy	2,000 g/m^3		0.00002
	Petroleum coke, liquid derived	4,200 g/L	0.12	
	Petroleum coke, catalytic cracker	3,800 g/L		
	Coal			
	Conventional utility boiler	0.015 l/kg	0.05	
	Fluidized combustion system	0.015 l/kg	2.11	
	Conventional heating system	0.015 l/kg	0.11	
Energy Transportation	Motor gasoline			
	Light-duty automobiles			
	Three-way catalyst	2,360 g/L	0.25	0.21
	New three-way catalyst	2,360 g/L	0.32	0.25
	Aged three-way catalyst	2,360 g/L	0.32	0.58
	Oxidation catalyst	2,360 g/L	0.42	0.20
	Non-catalyst	2,360 g/L	0.52	0.046
	Light-duty gasoline trucks			
	Heavy-duty catalyst	2,360 g/L	0.19	0.39
	New heavy-duty catalyst	2,360 g/L	0.41	0.45
	Aged heavy-duty catalyst	2,360 g/L	0.41	1
	Oxidation catalyst	2,360 g/L	0.44	0.2
	Non-catalyst	2,360 g/L	0.56	0.046
	Motorcycles			
	Non-catalytic controlled	2,360 g/L	1.4	0.046
	Uncontrolled	2,360 g/L	2.3	0.046
	Light-duty diesel autos			
	Advance control	2,730 g/L	0.05	0.1
	Moderate control	2,730 g/L	0.07	0.1
	Uncontrolled	2,730 g/L	0.1	0.1
	Light-duty diesel trucks	2,730 g/L	0.07	0.1
	Heavy-duty diesel vehicles			
	Advance control	2,730 g/L	0.12	0.1
	Moderate control	2,730 g/L	0.13	0.1
	Uncontrolled	2,730 g/L	0.15	0.1
	Natural gas vehicles	2 g/L	0.7	0.1
	Off road vehicles			
	Gasoline	2,360 g/L	3	0.06
	Diesel	2,730 g/L	0.14	0.09
Fuelwood	Conventional stoves	1,500 g/kg	15	0.16
	Conventional fireplaces	1,500 g/kg	15	0.16
	Fireplaces with inserts	1,500 g/kg	8	0.16
	Fireplaces with catalytic controls	1,500 g/kg	5.8	0.16

(Canada's Greenhouse Gas Inventory: 1997 Emissions and Removals with Trends)