Non-CO_2 GHG Emissions and Projections from Developed Countries

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Introduction

Globally, emissions of methane (CH_4), nitrous oxide (N_2O), and the high GWP gases (HFC, PFC, SF_6) account for approximately 30 percent of the enhanced greenhouse effect (including Montreal Protocol gases) since pre-industrial times.[I] These non-CO_2 GHGs, when when evaluated in terms of global warming potential equivalents, account for a fifth of U.S. annual emissions and account for even larger percentages in countries where agriculture dominates the economy.

Additionally, the non-CO_2 greenhouse gases, when reduced in combination with CO_2, can provide short and long term environmental benefits and lower total costs of mitigation efforts. Recent studies confirm the advantages of a multi-gas approach to greenhouse gas mitigation. A recent Science article, written by NASA scientists, reaffirms the importance of reducing the shorter-lived (e.g. methane (CH_4)) and more potent greenhouse gases in addition to CO_2. [II] Researchers affiliated with the Massachusetts Institute of Technology demonstrated that the "inclusion of sinks and abatement opportunities from gases other than CO_2 could reduce the [global] cost of meeting the Kyoto Protocol by 60%. [III]

Until this year, comprehensive and comparable estimates for these gases were only available from top down modeling efforts or estimations using basic methods. Both approaches are of limited usefulness in economic analysis because they do not reflect country-specific information and situations. Recognizing the importance of the non-CO_2 GHGs and the lack of widely available, consistent information, U.S. EPA examined non-CO_2 greenhouse gas emissions and projections out to 2010 for 36 developed countries shown in Figure 1. This report, 'Emissions and Projections of Non-CO_2 Greenhouse Gases for Developed Countries: 1990-2010', compiles data from the highest quality, publicly available, country-submitted estimates.[IV] Periodic updates to estimates are planned based on improvements in the IPCC methodologies and new or revised country data. All projections in the study are "business as usual", in that they exclude the estimated impacts of additional climate policies. This report is the first part of EPA's broader, on-going effort to develop global bottom up, country by country emissions and projections using each country's best estimate. Once complete, the global database will provide a readily comparable, comprehensive set of data on the non-CO_2 greenhouse gases, which can be used to understand country and global contributions to climate change, areas of mitigation potential, and current progress towards GHG reduction.

Figure 1 – List of Developed Countries included in analysis.

Other	EU-15	Other Europe
United States	Austria	Iceland
Australia/New Zealand	Belgium	Liechtenstein
Japan	Denmark	Monaco
Russia	Finland	Norway
Canada	France	Switzerland
	Germany	Bulgaria
	Greece	Croatia
	Ireland	Czech Republic
	Italy	Estonia
	Luxembourg	Hungary
	Netherlands	Latvia
	Portugal	Lithuania
	Spain	Poland
	Sweden	Romania
	United Kingdom	Slovakia
		Slovenia
		Ukraine

Background

All developed countries that are parties to the United Nations Framework Convention on Climate Change (UNFCCC) have agreed to submit an annual national inventory of all anthropogenic sources and sinks covered by the Convention. The inventory must include a time series for all sources and sinks of the six greenhouse gases (Carbon Dioxide – CO_2, Methane – CH_4, Nitrous Oxide – N_2O, Sulfur Hexaflouride – SF_6, Hydrofluorocarbons – HFCs, and Perfluorocarbons –PFCs) listed in the IPCC guidelines. In addition, every 4-5 years each Party is obligated to submit a National Communication, which provides projections of emissions and quantifies the estimated effects of climate change mitigation policies.

The Intergovernmental Panel on Climate Change (IPCC) developed methodological guidance for countries to ensure consistency and comparability of estimates. The *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories* and recently completed *Good Practice Guidance* outline the sources and a selection of methodological approaches for estimation.[V,VI] The general approach for IPCC methodologies is to multiply an emissions factor for the source by the activity data: for example, emissions per capita multiplied by the population. The IPCC guidelines generally provide two or three levels, or tiers, of evaluation for each source, generally described as:

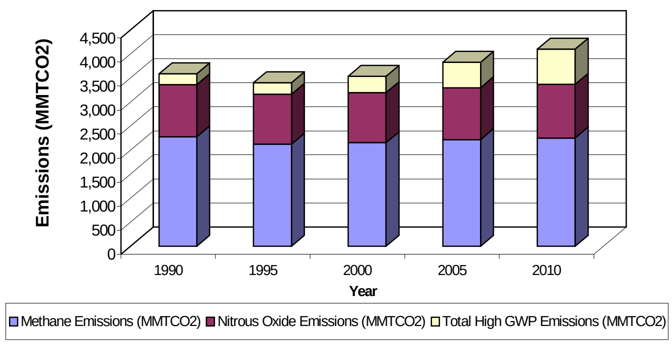
- Tier one uses default emission factors and aggregate activity data.

- Tier two used country specific emission factors and disaggregated activity data
- Tier three uses highly disaggregated, direct measurements.

Usually, the higher the tier, the more specific the factor or data. In the United States,. most key, or important, sources use at least a Tier 2 methodology.[VII] Most other developed countries also use the higher tier methods for important sources. In practice, the tiers are points on a continuum and countries can use a combination of tiers, either within a source estimate or within the national inventory. Regardless of approach, however, a country must ensure consistency and completeness throughout the estimate and the time series.

International emissions and projections

Figure 2 – BAU Non-CO2 Emissions & Projections to 2010.



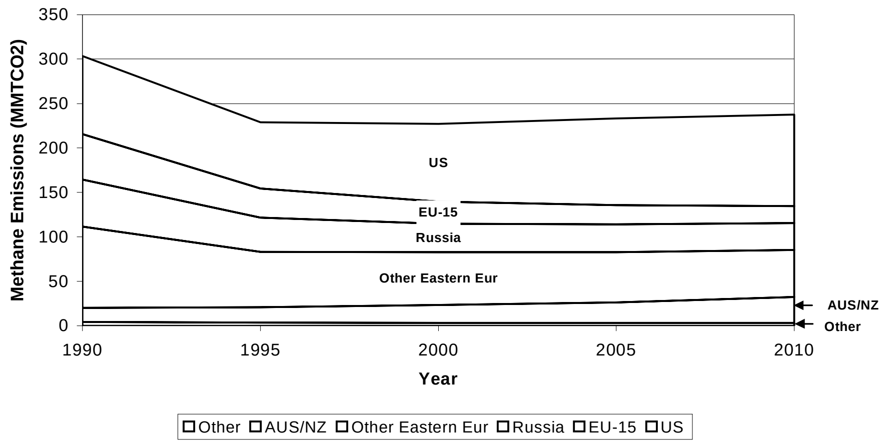
Business as Usual emissions in developed countries are projected at 4059 Million Metric Tons of CO_2 equivalent ($MMTCO_2$) in 2010, an increase in emissions of approximately 13 % from 1990. Close examination of the trends during the period for different groups of non-CO2 gases reveals some interesting information. For example, as Figure 2 shows, methane and nitrous oxide emissions in 2010 will remain fairly close to 1990 levels. However, emissions of these gases actually declined from 1990 10 1995. Substitutes for Ozone Depleting Substances (ODS), although small in the base-year, become an important contributor by 2010, and have experienced steady emissions growth since 1995.

There are three main driving forces for the non-CO_2 GHG trends for the developed countries. First, the economic transitioning of several countries resulted in an emissions decline for methane and nitrous oxide. Since 1995, however, emissions have been increasing as the economies recover. Secondly, the coal industry is being restructured in a number of countries, resulting in sustained decreased emissions. The growth of emissions of High GWP gases is due to the phase out of Ozone Depleting Substances and strong predicted growth in other industrial applications.

For CH_4 and N_2O, the overall moderate change in total emissions from 1990 to 2010 obscures the dynamic changes occurring in the individual sectors and countries. As noted above, in aggregate, most methane and nitrous oxide sources show a decline in emissions from 1990 to 1995 with an increase in the following year, resulting in a near stabilization from 1990 levels by 2010. The dip in emissions in 1995 is very pronounced in several countries that are undergoing economic restructuring.

In the early 1990s, Eastern Europe and the countries of the Former Soviet Union began their rapid economic transformations, leading to a downturn in many sectors, particularly agriculture and livestock. According to the most recent projections submitted to the UNFCCC (contained in the National Communication), these countries expected their economic recovery to be well underway by 2000, explaining the fall and subsequent rise in emissions. Based on actual experience, it is possible that these projections are overstated, because in many cases the economies are not recovering as quickly as formerly expected. Most other developed countries are experiencing a restructuring in the livestock sector, leading to decreased production and herd size.

Figure 3 – Methane Emissions from Coal Mining: 1990-2010.



Additional restructuring occurred in the coal sectors of the aforementioned transitioning countries as well as in other European countries. Many European countries have closed many of the gassiest underground mines, significantly reducing methane emissions. Unlike the other sectors, emissions are not expected to increase as quickly since many of the mines are expected to be closed for the foreseeable future due to the removal of subsidies and other economic reasons.

Despite the impact of major economic and sector restructuring, total developed country methane emissions are projected to increase to 1990 levels by 2010, as shown in Figure 2, under a BAU scenario. This results from the expected economic recovery in EITs, high industrial and agricultural growth in other regions, and large stable emissions from landfilling and natural gas. The large emissions from natural gas and landfills result mainly from the size of these industries in Russia, the United States, Ukraine, and Canada. Many developed countries with large populations rely on landfilling as a means of solid waste disposal (e.g., the U.S., EU-15, and increasingly, Eastern European countries). Significant efforts are underway in most countries to improve waste management practices, resulting in a relatively stable emission rate in spite of overall economic and population growth in those countries.

As shown in Figure 2, nitrous oxide emissions decreased only slightly between 1990 and 1995 despite the economic restructuring in several developed countries. Large agricultural countries with growing economies and populations, such as the U.S. and EU-15, offset the emission reductions experienced by others. At the source level another significant change is occurring as the principal source of emissions shifts from industrial processes to mobile sources. In 1990, industrial processes were the second largest source, accounting for about 15 percent of total emissions. However, these emissions drop dramatically from 1990 to 2000 and are expected to stay near 2000 levels. Total N_2O emissions stay level despite this decrease because of the dramatic increase in mobile source emissions.

Unlike the other two gases, emissions of High GWP gases are expected to grow significantly over this period due to the phase out of Ozone Depleting Substances (ODS) under the Montreal Protocol, and strong predicted growth in other applications such as the semiconductor industry. As ODSs are phased out in developed countries, other gases, including HFCs and PFCs, are substituted. There is uncertainty in the rate of growth, however, related to the choice of chemicals and the possibility that new technologies or operating procedures could eliminate or decrease the need for these gases. In the BAU case the increase in these sectors offsets the leveling off in nitrous oxide emissions and overall reduction in methane. As noted earlier, these projections do not include climate initiatives and the semiconductor industry has recently implemented an aggressive voluntary reduction plan.

Benefits of more detailed bottom-up approaches

Although some of the non-CO_2 sources are not as well understood as energy-related CO_2, many steps have been and can be taken improve the accuracy and precision of emission estimates. As recommended in the IPCC Good Practice Guidance, countries should devote more time and resources to key non-CO_2 sources than to less important sources. This could include gathering more disaggregated activity data, developing country-specific emission factors, or using direct measurements. For example, if coal mining is a significant source of CH_4 emissions, a country should use a Tier 3 methodology and collect directly measured vented methane, which they should have collected for safety reasons. For most countries, the top 10-15 underground mines represent 80-90% of total underground emissions so measurement data from a small portion of the total underground mines can significantly improve the estimate. This is particularly important in developing countries and Economies in Transition (EITs) because the IPCC emission factors may not be representative of unique national circumstances.

As more countries implement the improvements recommended in the IPCC Guidelines and Good Practice Guidance, bottom-up inventory estimates for non-CO_2 greenhouse gases will offer a more precise and accurate view of global emissions. Therefore, in this report EPA utilizes these bottom-up, country-submitted estimates instead of Tier 1 default estimates.

Issues in Compiling International Non-CO_2 Emissions & Projections

Maintaining rigor and consistency is of utmost importance in the compilation of non-CO_2 emissions and projections to ensure the ability to compare countries and sources, and to perform economic analysis. Although most country submissions to the UNFCCC use the

IPCC Guidelines, maintaining a consistent time series was difficult in this analysis for several reasons.

First, the Guidelines were significantly revised in 1996 and most countries were not able to adopt the new methodologies for use in the National Communication (NC) they submitted in 1997. Consequently, some estimates of the available county-specific estimates and projections do not reflect the significant methodological improvements to sources such as agricultural soils. Unless a country noted adoption of the 1996 Revised Guidelines, U.S. EPA recalculated estimates of N_2O emissions from soils to ensure that agricultural estimates and projections were based on the most recent methodology.

Second, for many countries the most recent inventory submitted to the UNFCCC may not be consistent with the projections contained in their 1997 NC submission. Countries submit historical emission data annually, but projections only at 3-4 year intervals. In some cases, therefore, the most recent historical estimates may be inconsistent with the most recent projections. In these cases, the projections are scaled to the updated inventory using the growth rates projected in the national communications.

Finally, since a major use of the data is to analyze mitigation options in developed countries, countries' business as usual projections should exclude the anticipated effects of climate initiatives. Many countries only provide projections with measures included. EPA adjusted these emissions on a source by source basis, depending on the amount of information available on the included measures. For example, three European countries projections for methane from landfills were adjusted upwards to remove from the BAU scenario the effects of reduction measures.

Conclusion

Non-CO_2 greenhouse gas emissions are projected to increase slightly by 2010 for the developed countries. These sources have numerous drivers that can only be understood by completing detailed source by source, country by country analysis. Economic restructuring, sector restructuring, and the growth in industries that emit High GWP gases drive the trends. As seen in the results shown earlier, the overall increase in High GWP emissions may mask the source level and individual country declines.

This compilation of non-CO_2 BAU emissions and projections for developed countries is the first detailed bottom-up analysis using each country's best estimate. It provides a consistent and comprehensive estimate of non-CO_2 GHGs that can be used to understand country contributions to climate change, mitigation opportunities, and progress towards the UNFCCC commitments.

[I] IPCC (1996), *Climate Change 1995: The Science of Climate Change*, Contribution of Working Group I to the Second Assessment Report of the IPCC, Cambridge, 1996.
[II] Hansen (2000). Hansen, J. et al, '*Global warming in the twenty first century: An alternative scenario*', Proceedings of the National Academy of Sciences, June 2000.
[III] Reilly (1999). Reilly, J. et al, *Multi-Gas Assessment of the Kyoto Protocol*, Nature 401, pp. 549-555 (October 7, 1999).

[IV] EPA (draft 2001b). *Non-CO_2 Greenhouse Gas Emissions & Projections for Developed Countries: 1990-2010*, U.S. Environmental Protection Agency, Washington, D.C.

[V] IPCC (Intergovernmental Panel on Climate Change) (2000). *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories*, Intergovernmental Panel on Climate Change, Washington, D.C, 2000. (http://www.ipcc.ch/pub/guide.htm)

[VI] IPCC (1997). *IPCC Guidelines for National Greenhouse Gas Inventories, 3 volumes: Vol. 1, Reporting Instructions; Vol. 2, Workbook; Vol. 3, Reference Manual*. Intergovernmental Panel on Climate Change, United Nations Environment Programme, Organization for Economic Co-Operation and Development, International Energy Agency. Paris, France. (http://www.ipcc.ch/pub/guide.htm)