14 October 1998

ENGLISH ONLY

UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE

SUBSIDIARY BODY FOR SCIENTIFIC AND TECHNOLOGICAL ADVICE
Ninth session
Buenos Aires, 2-13 November 1998
Item 4 of the provisional agenda

OTHER MATTERS

Approaches to resolving methodological issues related to national communications from Annex I Parties

Additional submissions by Parties

Note by the secretariat

Addendum

1. In addition to the submissions included in document FCCC/SBSTA/1998/MISC.6,[1] three submissions have been received.

2. In accordance with the procedure for miscellaneous documents, these submissions are attached and are reproduced in the language in which they were received and without formal editing.

[1] Previous submissions from Parties on this issue, made in response to a similar request from the SBSTA at its seventh session (see FCCC/SBSTA/1997/14, para. 16 (a)), are available in document FCCC/SBSTA/1998/MISC.2.

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PAPER NO.1: CANADA

METHODOLOGICAL ISSUES
INVENTORIES AND UNCERTAINTIES

Introduction

As requested by SBSTA and contained in document FCCC/SBSTA/1998/6, Canada would like to offer its views on dealing with methodological issues related to inventories, in particular, those related to uncertainties.

Canada believes that greenhouse gas inventories are a key element in measuring progress towards achieving the ultimate goal of the UNFCCC. As such, Canada believes that comprehensive, accurate, and reliable estimates of emissions and removals of all greenhouse gases are more important than ever, and efforts to improve these estimates must continue.

As agreed to in Kyoto, the current 1996 IPCC methodological guidelines, which are flexible and encourage parties to use their own data and methods, should be used as the basis upon which to develop emission estimates.

While Canada has always supported this view, we also feel, along with many other Parties, that future changes in the Guidelines are necessary. In this regard, Canada would like to propose that improved methods for inventorying **all anthropogenic sources and sinks** of greenhouse gases be developed based on the work of the IPCC and other expert groups and that the Parties adopt revised guidelines on the use of these methods as soon as practicable.

Currently, determinations of compliance will be based on each Party's emissions inventory, which should be prepared using methods designed specifically for this purpose, i.e., the 1996 Revised IPCC Guidelines. As always, the emphasis must be on ensuring that the emission inventories are transparent, comparable and complete. Nevertheless, given the variety of methods currently available within the Guidelines themselves for preparing inventories for each anthropogenic source and sink, and the different uncertainties associated with each method, the issue of uncertainty[1] needs to be addressed prior to the start of the first commitment period.

Prior to Kyoto, Canada provided suggestions on dealing with uncertainties. To reiterate, as a starting point, Canada would like to propose that Parties provide a quantitative estimate of the uncertainties associated with their greenhouse gas inventories using appropriate methodologies to be developed based on the work of the IPCC and other expert Groups and that the Parties adopt these methodologies as soon as practicable.

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[1]Defined as "*A statement of a range of values of the quantity in question, usually expressed as a number to be added to or subtracted from the basic value, or simply as a pair of numbers expressing the limits of the range.*" In either case, the range so described expresses the set of values in which the true value of the estimated quantity is felt to be fairly sure to fall, which can be at a probability level of 95%, but not necessarily so.

These revised methodologies and guidelines could be used to establish an approach in which all Parties could be assured that those anthropogenic sources and sinks for which a measure of certainty is less precise are, in fact, in compliance. Ideally, it is hoped that a table of scaling factors by source, gas and methodology would be developed by the IPCC, or other expert group along with appropriate uncertainty values for each of the methods.

These scaling factors would then be applied against country emission estimates in much the same way GWPs are used now. In effect, the weighting or scaling of emissions would not only recognize and deal with the significant differences in the accuracy of estimates and the measurement/verification of emissions and reductions, it would also provide an equitable way in which to offset emission increases from well defined sources with reductions made in less well defined areas, as well as ensure that a country is meeting its stated commitment. Ideally, such a weighting system could also be used for point or project level sources and in a trading system.

Comparability

In order to compare emissions of different GHGs on an equivalent basis, the IPCC has developed the Global Warming Potential (GWP) concept. This allows all direct greenhouse gases to be expressed in terms of a mass of carbon dioxide with an equivalent heating effect by means of the GWP conversion ratio. A fairly large uncertainty is associated with GWP numbers - recently, it has been estimated that the uncertainty averages about 35%.

Though conversion to CO_2 equivalence via the GWPs increases estimate uncertainty, it is not the only inequity introduced when comparing greenhouse gases.

At a recent IPCC Expert Group meeting on GHG data quality, estimates were provided on the likely confidence of international inventories. Considering only energy sources, CO_2 emissions were estimated to have an overall uncertainty of better than 10%, CH_4 about 30% and N_2O between 30 and 70%.

Uncertainties in emission estimates do not necessarily follow a normal, Gaussian distribution for random variables. Thus, specialized statistical analysis techniques must often be used to determine the accuracy of emission estimates.

Uncertainty in emission inventories do not only vary considerably from gas to gas and sector to sector. The confidence in estimates associated with"biological" emissions is generally much lower than that associated with man-made processes. For instance, the overall estimate for CO_2 uncertainty within the Canadian Inventory is 4%, a typical value for fossil fuel combustion processes. Carbon dioxide emissions from the burning of biomass have been estimated to have an uncertainty ranging from 30% for industrial wood waste to 40% for residential fuel wood combustion. Estimates for worldwide carbon dioxide release from biomass burning range from 0.4 to 2.9 billion tonnes per year in the 1980's, an even greater confidence interval.

The 1996 Revised IPCC guidelines contain methodologies for determining carbon dioxide emissions and sequestration by managed forests, land-use changes and biomass burning, as well as significant additional sources of N_2O emissions from agricultural activities. Rough estimates on the uncertainty associated with the CO_2 sources and removals place them at 50%, while agricultural N_2O is considered to have a likely uncertainty of between 60 and 80%.

The introduction of these sources increases the comprehensiveness of coverage and adds flexibility for Parties to the Convention to meet targets. In particular, adding biological sinks to the portfolio of emission reductions options offers the possibility of utilizing cost-effective measures such as planting trees and improving soil carbon dioxide uptake. Unfortunately, the flexibility is added at the risk of increasing uncertainty in inventory estimates and heightening the difficulty of verifying their accuracy. On the other hand, the inclusion of all sources and sinks provides incentives to improve the accuracy of estimates.

The question which then arises is this - can emissions and sinks of vastly differing uncertainty be made *equivalent* in legally-binding commitments between the Parties to the Climate Change Convention?

Given the timeframes involved, it is doubtful though, that improvements in methods and data alone will resolve the concerns surrounding the large inequities and verification difficulties that characterise the single basket alternative embraced by the Kyoto. Some fresh thinking is required to determine an approach to mitigate these problems. Canada would like to offer one possible way in which to deal quantitatively with the significant differences in the accuracy of various emission estimates.

An Equitable Inventory System to Deal With Estimates of Varying Accuracy

Suggested here is set of accounting rules which attempt to address the problem of inequity between inventories of varying uncertainties. A fundamental requirement to this approach is that the statistical uncertainty (precision) associated with the estimates, by gas and by sector, be known. It is proposed that emission targets for a Party be adjusted downward if its estimates don't meet minimum standards of precision. A resulting benefit is that the system would promote improvement in data quality.

For example, consider the situation with reference to Article 3.1 of the Kyoto Protocol. Let a Party's Emission Limit (E_L) be defined as its commitment in the budget period. Let that same Party's Emission Target (E_T) be defined as an adjusted commitment which takes into account the uncertainty associated with its inventory.

The actual uncertainty of GHG estimates is important, because it can be used to ensure that emissions are actually at or below the levels they are reported to be. In other words, a given level of precision carries with it a corresponding degree of confidence about whether or not a Party is in compliance with its commitment.

Suppose that we would like to ensure, regardless of the precision in the inventories, that no Party will exceed its Emission Limits by more than 10%. Suppose further, for the purposes of this discussion only, that emission estimates are normally distributed. Investigations have shown that if a Party's emission estimates are known to have 10% uncertainty, no adjustment needs to be applied to the Emission Limit (as might be expected). On the other hand, if emissions are only known within 20%, the Emission Limit must be adjusted so that a lower Emission Target is set. In fact, for this situation the following formula applies if uncertainties are known with a 95% confidence:

$$E_T = E_L \{(1+B)/[1+(z*x/196)]\} \qquad (1)$$

where, 1+B = the upper bound (maximum allowed quantity under any circumstance). In this case B = 0.1
x = percentage uncertainty associated with the estimate
z = 1.648 (corresponding percentile of normal distribution with 95% confidence). Other 'z' values can be applied if uncertainty is known only at a lower confidence level.

From this formula, the following table can be constructed:

Ratio of Emission Target to Emission Limit (E_T/E_L)*

Uncertainty in Emission Estimate*	**10%**	**20%**	**30%**	**40%**	**50%**	**80%**
	1	0.94	0.88	0.82	0.77	0.66

* Adjustment factor to ensure emissions never exceed the Limit by more than 10%.
** Assuming 95% confidence and normal distribution

Thus, if a Party's estimated emissions have a 20% uncertainty level, to ensure that its actual emissions do not exceed its limit by more than 10%, the Target must be 0.94 times the Limit. So, the Party would be restricted to 94% of its commitment in the budget period. For example, if its emissions were estimated to be 100 Mt CO_2-equivalent in 1990, and the Party was committed to a 5% reduction, its Target would be (100 - 5) x 0.94, or 89 Mt per year in the budget period.

Though other methods of developing an adjustment are possible, it is thought that the one presented here is feasible, reasonably simple and statistically verifiable. These, Canada believes, are minimum requirements which any adjustment methodology must meet.

In general, a Party's emission Limit is composed of the sum of the carbon dioxide equivalent of a number of different gases. Obviously, the GWPs associated with these gases contribute to the uncertainty of the sum. However, as all Parties must use the same factors, little bias is likely to be introduced if the precision of the GWPs is ignored. This, then, is the approach

suggested. Uncertainty calculations would be based on the sum of emission estimates scaled by fixed GWP constants. With the constants being idealized as having perfect precision, uncertainty would be tied to the raw emissions only.

As discussed previously, the uncertainty associated with emission estimates varies widely, depending on the gas, sector and methodology. It is envisioned that the above adjustment could be applied at any level of aggregation within an inventory - by gas, by sector or by project. Just as a party is free to choose where emission reductions will come from, it is also free to place caps on individual sectors or any other component of its inventory. After dividing its Limit into component caps for all uniquely definable sources, removals or reductions, adjusted caps could then be set up. It is likely that the same, or similar mathematics as that shown for total inventory adjustments could be applied to the sectors.

If applied on a sector basis, the fraction used to determine the "upper bound" ('B' in equation *1*) can be redefined as a precision standard. For instance, if current estimation methodologies do not allow better than 60% precision on N_2O emissions from agricultural soils, setting a 10% standard seems highly impractical, since it will probably be impossible for anyone to achieve. In this case, it would make more sense to set 60% uncertainty as the standard, and therefore 'B' would become 0.6. Parties would then only need to ensure that these emissions did not exceed 1.6 times the sector limit (cap). Thus, targets for N_2O from soils would need to be adjusted downwards only if their uncertainty exceeded 60%. 'B' of formula *1*, then, would be the benchmark.

Clearly, these benchmark uncertainties must first be established. This could be accomplished by an international compliance review group, an arm of the IPCC. The benchmark might be an average uncertainty for worldwide emission estimates. This is somewhat similar to the approach advocated by the United States in their additional proposal to the Berlin Mandate and available in document FCCC/AGBM/1997/MISC.1/Add.4. in which is stated "*the Parties shall, not later than their first Meeting, decide on agreed best available methods for the measurement by Parties of anthropogenic emissions by sources, and removals by sinks, of greenhouse gases, taking into account the best available methods determined by the IPCC and other expert bodies. They shall also decide on appropriate adjustments to measurements of emissions and removals where agreed best available methods have not been used.*" In the US proposal, a *discounting* protocol is suggested whereby for those sources/inventories where the best methods have not been used, a given estimate will be increased as a penalty measure to reflect its inherent uncertainty.

Canada, however, feels that this is an incomplete and perhaps, inappropriate way in which to deal with uncertainties because it makes incorrect and unverifiable assumptions, namely;

1/ That all so-called best approaches have similar uncertainties, regardless of the sector and source and,

2/ All best approaches are detailed in the IPCC methodologies and are similar, when in fact, the IPCC methodologies are designed to be flexible thereby permitting a country to use what it feels is a better method for estimating emissions. Unfortunately, not all these

so-called better methods are well documented.

It is envisaged that an appropriate adjustment methodology would examine all methodologies, and in so doing provide a means of ensuring that equitable adjustments are indeed made.

Given the various sources of data used to develop emission estimates, studies conducted to date conclude that there is no one '*best method'* for many sources. The uncertainty of all inventories estimated by the '*method*' may not be the same because there will be differences in underlying data sources and quality. In fact, **the quality of data may be more important than the 'method'.**

Two further points may be mentioned with respect to this first question. The same method may not be the best across all countries, and it is difficult to identify, which method is the best. In addition, different levels of disaggregation may be more important than the "*method*" in some cases.

Obviously, the precision of emission estimates can't be fully utilized until further quantitative assessments of inventory uncertainty have been performed. Canada proposes that such estimates be provided by all parties, based on new guidelines developed by the IPCC. These guidelines could be developed in parallel with the process of establishing benchmark uncertainties.

One of the difficulties in developing statistical uncertainties associated with emissions estimates is that some distributions may be non-normal, or even non-symmetrical. For these distributions, neither the mean (the best estimate of the emission) nor the uncertainty are as easy to evaluate. In such cases, however, Monte Carlo simulation techniques can be utilized. Canada has utilized these methods for its last evaluation of the uncertainty associated with its Inventory and is investigating simplified means of applying the techniques. Though formula *1* only applies to normal distributions, it is believed that the same adjustment techniques can be developed for non-normal distributions as well.

It is important to consider the nature of uncertainty in emission estimates. It may arise from such sources as (1) failure to understand the causes of emissions/removals (i.e., imperfect understanding of the processes involved); (2) poor quality input data for activity levels and emission factors; or (3) a failure to identify all the relevant source and sink activity. Developing verifiable statistical estimates is most difficult when their imprecision arises from sources (1) and (3). Those estimates which have the least certainty, are of the emissions or removals which are most poorly understood. In these cases, quantification of the uncertainty will also be imprecise.

It is important to identify such cases in order to differentiate them from others for which better uncertainty information is available. A lower confidence level can then be associated with these less well-understood data. If a confidence level can be provided, even if it is determined to be much lower than 95%, an adjustment of the type discussed above can be developed for such emissions, removals or reductions. Again, this underscores the need for better quantitative uncertainty information.

As mentioned earlier, Canada proposes that a standard set of benchmarks be set up. These benchmark uncertainty values, along with their characteristic confidence level, could be determined by analysis and evaluation of all standard emission methodologies.

Parties would then be responsible for calculating the precision of their own inventory estimates. The IPCC would provide guidance through rules-of-thumb, which would be available for as many methodologies as possible. If a rule-of-thumb was not available for the estimate considered, a verifiable evaluation of each specific emission estimate (by gas, project and/or sector) would be required. Parties' emissions uncertainties, as associated with each estimate, would then be compared to the established standards.

Total inventory uncertainty can be developed by applying statistical rules applicable to the sum of a series of individual estimates. Thus, sector, project and top-down estimates could be combined with their respective uncertainties in order to determine total inventory uncertainty for each Party. Computer software, using built-in statistical packages which are able to handle non-normal distributions could be developed for such purposes.

It is Canada's belief that the general approach outlined here would allow greater confidence, verifiability and equity in greenhouse gas estimates. These are keys to satisfying the requirements of the Kyoto Protocol (see, for example, Article 7.1).

PAPER NO. 2: NORWAY

METHODOLOGICAL ISSUES RELATED TO GHG INVENTORIES

The development of representative, complete and transparent national emission inventories, comparable between countries, including all relevant sources and sinks, is important for the success of the Framework Convention on Climate Change (FCCC). We believe that the 1996 IPCC Inventory Guidelines with its tiered approach (optional methods at different levels of complexity with corresponding need for detailed national data) has proved to be a valuable tool when reporting GHG emissions to the FCCC. The lowest tier will provide a simple default method, while Parties with more detailed information available are encouraged to use a higher tier. The highest tier corresponds to a well documented national methodology if this can provide more representative results than a lower tier methodology. This principle, with several optional tiers, including well documented national methodologies, should remain the basis for the reporting framework.

Ensuring complete and representative national emission inventories.

Comparison of the Norwegian national methodology with the IPCC reference approach (based on the default methods), submitted to the FCCC in August 1998 in response to the SBSTA request, has shown that the IPCC default methods are not fully complete with regard to source categories. Thus, there are some sources of GHG emissions in the Norwegian inventory which are not included in the lower tiers of the IPCC methodology. The Norwegian emission inventory is based on country specific data and methodologies, where available and in accordance with the IPCC 1996 Guidelines. This approach has proven more complete and representative than the IPCC reference approach. We believe that this conclusion may be valid for most Parties were national methodologies have been developed.

Extending the IPCC guidelines to include a detailed description of methodologies for most sources which could be relevant for all Parties should be a long term goal. Still it will be difficult to accomplish. We must expect that the extent to which Parties use national methodologies will increase in the coming years e.g. due to the implementation of various measures and technologies in fulfilling the national commitments under the Kyoto Protocol. Given the flexibility built into the IPCC 1996 Guidelines, further specifications could be given for the presentation of data to enhance the comparability. This could include specifications of when national methodologies should be used.

Almost all parties had recalculated their emission inventory in their base year in the second national communication, (SBI/1997/19/Annex 1, paragraph 20). An evaluating of Partie’s compliance with their commitments, by comparing base year and commitment period, must be on the basis of the same methodologies. Any revision of methodology must be followed by recalculation of the inventory in the base year.

The secretariat notes that the inventories reported by the Parties so far are not complete (SBI/1997/19/Annex 1, paragraph 13) with regard to inclusion of all sources. Norway believes this problem may be partly solved by developing clear criteria for the use of "source estimated to be zero (0)", "not estimated (NE)" and "not occurring (NO)" in the IPCC

emission reporting tables.

Transparency of the inventory calculations and comparability of the reported emissions.

The use of national methodologies by Parties does contribute to complete and representative inventories, but may reduce transparency in the inventory calculations if appropriate documentation is not provided. There could be a trade off between these two aspects. A mandatory use of the same methodology or tier for all Parties, will at this stage, however, imply use of the lower tier default method. We do not believe this will be satisfactory for reporting changes in emission trends and satisfy the need for compliance with the Kyoto Protocol.

In the FCCC guidelines there are several requirements to obtain transparency. The main requirement is to include "enough information to reconstruct the inventory….". After some years of reporting, we recognise that this only seems practically feasible in broad terms and not in all details. This is primarily due to the integrated approach used by many Parties where activity data are drawn from a large national database which also contains data on other sources and activities not relevant for GHG emissions. If the relevant data were to be extracted from the database and submitted to the FCCC, the diversity of formats used by Parties could still make the reconstruction difficult to manage for the FCCC.

It may in principal be possible to develop a common reporting format, in addition to the data tables provided at present, showing completely disaggregated data. However, Norway believes this will not contribute substantially to increased transparency. The level of detail in the CORINAIR reporting may be seen as a possible compromise, where activity data and emission factors on a fairly disaggregated level are submitted in a standard format, and where activity data may be classified as confidential. Norway suggests that such a format be considered for the FCCC reporting.

There are, however, other simpler means to verify and validate the inventories. The main purpose of the requirement to include "enough information to reconstruct the inventory…." is to build confidence in the reported emissions. Norway believes transparency will be greatly increased if Parties are required to explain the year to year development of their emissions for each of the source categories.

Further, calculation of an «average emission factor» as an emission indicator for each of the current source categories in the IPCC reporting guidelines will also increase comparability. Calculation based on such indicators is an easy task and was included in the 1995 IPCC Inventory Guideline. It is not included in the revised 1996 IPCC Guidelines, but could be requested in the FCCC reporting guidelines.

Requiring calculations using the IPCC reference approach (based on the simplest default methods) for comparison for the entire inventory will greatly increase the amount of resources needed to prepare the yearly reporting, if not limited to the most significant emission sources in the individual inventories. Such sources may be selected by performing a sensitivity analysis. Limited to the parts of the inventory to which the total emissions are most sensitive, comparison with the reference approach may be a reasonable task. We believe that a common

method for such sensitivity analyses can be developed and that the results of such analyses will increase the transparency of the inventories.

Norway welcomes the former conclusion of SBSTA on reporting of actual emissions in addition to potential emissions of the «new» gases - HFCs, PFCs and SF_6. Many Parties will still have difficulties completing the calculation for actual emissions, and further work may be necessary to make the SBSTA conclusion operational. Norway will at the end of the year finalise the development of a methodology to estimate actual emissions from these gases and will submit relevant information on this issue to the FCCC secretariat.

Priorities for the development of inventory methodologies raising from the Kyoto Protocol.

As a result of the Kyoto Protocol further development of the Norwegian inventory has been initiated. Currently Norway is revising the methodologies for estimating emissions of methane from waste, CO_2 from industrial processes, PFCs from the aluminium industry and actual emissions of HFCs from refrigeration, foam blowing, air conditioning etc. Refining the methods for estimation of greenhouse gas emissions in these areas is our main priority for further development of the IPCC Guidelines as well. A short description of the purpose and reason for this is given in the next two paragraphs.

There is a general effort in Norway to reduce the amount of waste generated, and specially the amount disposed in landfills. The method currently in use in the IPCC Guidelines estimates methane emissions on the basis of generated waste. This will give a good estimate in periods when the waste generated is about constant. In a period with gradual reduction in waste, however, such an approach will neither reflect the actual emissions, nor the effect of policies and measure implemented in order to reduce the amount of waste disposed in landfills.

The emission factors for CO_2 from industrial processes are being evaluated due to the introduction of new technology. The work has been initiated by the industry itself, emphasising accuracy of the emissions in a period with large focus on the evaluation of reduction measures. The emission factors for PFCs from the production of aluminium are evaluated. This evaluation is a direct result of the agreement on GHG reduction in the aluminium sector between this industry and the Ministry of Environment in 1997.

Evaluating methodologies and emission factors relative to national conditions will in general reduce the uncertainty of the inventory. Developing local emission factors is also a necessary first step in estimating the uncertainty. The methodology for estimating uncertainty in the IPCC Inventory Guidelines is now under review by the IPCC. Norway believes this could also be developed with several tiers as for the emission inventory methods. The lowest tier might for instance reflect an enhancement of the existing classification of "high", "medium" and "low" confidence levels by developing simple criterias for each category. The higher tier might on the other hand be based on a numerical method.

PAPER NO. 3: SOUTH AFRICA

1. Clarity on methodologies used to estimate anthropogenic emissions by sources (and removals by sinks) of all gasses, including those not under the Montreal Protocol.

2. There should be an internationally acceptable framework for interim/preliminary inventories in Annex I countries (including internationally accepted method development).

3. Scientific and economic qualifications of the methodologies (as revised by IPCC) from "fuel" combustion, industrial processes, agricultural soils and land-use change and forestry (LUCF).

In terms of the compilation and synthesis of second national communications from Annex I Parties:

1. There should be the development (internationally agreed) of rules/methodology/software for the calculation/estimation and referring of national GHG emission.

2. A data management system for collection, review and reporting. (For developing countries, pilot projects and capacity building assistance to be provided):
- timeframes;
- national work programmes to be established;
- international funding (GEF), etc, to be made more accessible and "user-friendly";
- auditing and verification;
- differentiated capabilities and responsibilities.

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