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**WORKSHOP ON ISSUES RELATED TO ARTICLES 5, 7 AND 8
OF THE KYOTO PROTOCOL**

Bonn, 14-16 March 2000

PRELIMINARY OPTIONS FOR METHODOLOGIES TO APPLY ADJUSTMENTS

Working paper

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I. INTRODUCTION

A. Mandate

1. Article 5.1 of the Kyoto Protocol states that guidelines for national systems, which shall incorporate the methodologies specified in Article 5.2, shall be decided upon by the Conference of the Parties (COP) serving as the meeting of the Parties to the Protocol at its first session.
2. Article 5.2 of the Kyoto Protocol states that methodologies for estimating anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol shall be those accepted by the Intergovernmental Panel on Climate Change (IPCC) and agreed upon by the Conference of the Parties at its third session. Where such methodologies are not used, appropriate adjustments shall be applied according to methodologies agreed upon by the Conference of the Parties serving as the meeting of the Parties to the Protocol at its first session.
3. The Subsidiary Body for Scientific and Technological Advice (SBSTA), at its eleventh session, recalled Article 5.2 of the Kyoto Protocol and took note of submissions by Parties on the issue of adjustments. It considered that adjustments referred to in this Article should only be applied when inventory data submitted by Parties are incomplete and/or are calculated in a way that is not consistent with the IPCC 1996 Revised Guidelines as elaborated by any good practice agreed upon by the COP. It noted that these adjustments would result in substitution of a revised technical estimate for the purpose of accounting of the Parties' emissions and assigned amounts. It also considered that adjustments related to Article 5.2 could be an element of the review process under Article 8 of the Kyoto Protocol. The methodologies and procedures of adjustments, including the question of who should apply these adjustments, should be further examined in the preparatory work related to Articles 5 and 8 of the Kyoto Protocol (FCCC/SBSTA/1999/14, para. 51 (i)).
4. At the same session, the SBSTA requested the secretariat to prepare documentation for consideration at the workshop on Articles 5, 7 and 8, to be held 14 to 16 March 2000 in Bonn, on preliminary options for methodologies to apply adjustments (FCCC/SBSTA/1999/14, para. 51 (c)).
5. The SBSTA also requested the secretariat to provide an initial draft on modalities for adjustments under Article 5.2, taking into consideration information from the workshop, for consideration by the SBSTA at its twelfth session (FCCC/SBSTA/1999/14, para. 51 (d)).

B. Scope

6. This working paper presents options for methodologies to apply adjustments in response to the above mandate. It focuses on methodologies to obtain revised technical estimates of emissions. The preliminary information contained herein is based on a limited number of countries and sources. This working paper summarizes the main findings of reports prepared by consultants for the secretariat. The full reports of the consultants on the IPCC source categories "fuel combustion

activities”¹, “fugitive emissions from fuels”, “industrial processes”, “agriculture” and “waste” are available as working papers 3 (a) to 3 (f) (2000) (see also annex). These reports do not necessarily reflect the views of the secretariat. The responsibility for the text remains with the authors.

7. The experts were instructed to search for methods to obtain revised technical estimates of emissions that:

(a) Can be performed objectively without assumptions, i.e. being independent of the person performing the estimation and ensuring transparency; and

(b) Are based on readily available data from Parties or other authoritative sources, e.g. IPCC default emission factors, or international statistics.

8. The secretariat assumed that approaches which could be applied regardless of the problem would be less complex, more replicable and more transparent than problem specific approaches. To decrease the complexity of the task in the limited given time-frame, the consultants were instructed to put emphasis on simple approaches that could be used regardless of the identified problem. The emission estimates obtained would fill the gaps or substitute the estimates in question. Where problem-independent approaches were not possible, problem-specific solutions were to be presented.

9. The consultants were instructed to consider at least the following methods, the selection of methods being based on the preliminary views of Parties at the point of initiation of this project (FCCC/SBSTA/1999/MISC.9 and Add.1):

(a) Calculation of source emissions according to IPCC tier 1 methods using data from external sources (activity data, emission factors);

(b) Estimation of emissions based on averages over countries included in Annex B to the Kyoto Protocol. The average emission rate of several Parties would be applied to an emission driver of one Party such as gross domestic product (GDP), population etc;

(c) Estimation of emissions of one gas or source category based on the linkage to emissions of another gas or source category. This could be the case, for example, where the same activity data are usually used to calculate the emissions of several gases or categories;

(d) Extrapolation of emissions according to a defined methodology based on the linkage of emissions with a driving indicator or growth factor;

¹ The work on the category “fuel combustion activities” was split between three consultants. One worked on the estimation of CO₂ emissions according to the IPCC categories based on available international energy data, the second worked on the split of fuel use according to IPCC sectors, CO₂ emissions per capita as well as CH₄ and N₂O emissions, while the third worked on interpolation, extrapolation and approximation using drivers.

- (e) Linear or other simple interpolation and extrapolation.²

10. The consultants had access to the greenhouse gas emissions database of the UNFCCC and further detailed inventories of selected countries. They were also provided with access to other United Nations data sources. The experts were instructed to collect any additional data necessary to perform the estimates, including data on drivers. The estimation according to these methods was to be performed and compared with estimates reported by Parties to judge their reliability, accuracy and comparability.

C. Possible action by the participants attending the workshop

11. Participants in the workshop may wish to take the information in this paper into account when considering issues related to methodologies and to the process of adjustments under Article 5.1 and 5.2 of the Kyoto Protocol.

12. Participants may also wish to consider this paper and the reports by the consultants with a view to determining whether any additional analysis is needed and the time-frame for such analysis. If further analysis is deemed necessary, participants may wish to consider who should undertake such work, including possibly the National Greenhouse Gas Inventories Programme of the IPCC.

13. The reports by the consultants may also provide useful background information relevant to the technical review of inventories and may be considered in the development of guidance for such a review.

II. FINDINGS OF THE CONSULTANTS

A. Method-specific findings

Interpolation

14. If emissions for the years around the questionable estimate are available, trivial linear interpolation could be regarded as the preferred option. This is the only method where the emission estimate can be calculated completely objectively without the use of assumptions. It is, however, only applicable for the cases where emission estimates of the adjacent years are available.

Extrapolation

15. If emissions estimates are available for some years, the missing estimates can be extrapolated. The results depend on the type of extrapolation chosen for example linear or polynomial and also the number existing emission estimates considered. The difference between the estimates extrapolated for one year and those reported by Parties for that year was found to be up to 10 per cent.

² Interpolation and extrapolation with and without drivers is covered by the IPCC good practice report. It was included here to be tested throughout the sectors with available data.

Extrapolation using drivers

16. If the estimates are available for one year, for most sectors these could be extrapolated for other years using an index of the driving force. Detailed analysis of the relationship between emissions estimates and drivers can be found in the individual consultants' report. The difference between the estimates obtained using drivers and those reported by Parties was found to be about 5 to 15 per cent. This method is generally more accurate for higher levels of aggregation, i.e. the first and second level of IPCC source categories. However, it is not likely that methods could be developed into guidelines valid for all countries, emissions and time periods. Therefore, experienced personnel may have to perform the estimation case by case. In some situations it may be more time consuming to find significant relations between the driver and the emissions, than to calculate the emissions using IPCC methods.

IPCC tier 1 methods

17. For most emission source categories, international activity data and IPCC default emission factors are available to estimate emissions according the simplest IPCC method (tier 1). However, these emission estimates depend on the quality of the activity data used and whether the default emission factors reflect the national circumstances of that country. The quality of the international activity data varies for sectors and countries. Default emission factors are in most cases given as ranges. For many sectors, additional assumptions have to be made.

18. Therefore, the accuracy of the estimates obtained using defaults varies between sectors. For fuel combustion activities, a method was developed to obtain CO₂ emissions split into IPCC sectors based on international energy data. The total emissions from fuel combustion estimated using this approach were around 5 per cent different to those reported by Parties. Emissions from agriculture for the tested examples using international activity data and default emission factors differed by a factor of 2 to 10 from the values reported by Parties.

Estimation of emissions based on Annex B averages

19. Estimation of emissions based on averages over countries included in Annex B to the Kyoto Protocol could be applied. Using this method, national circumstances are not taken into account. Higher accuracy can be obtained by grouping countries with similar circumstances into clusters and applying an average of the countries included in these clusters. In the selection of the cluster composition, assumptions may have to be made. The composition of the clusters would be different for the source categories.

20. No significant advantage is gained if Annex B average emission factors are used in IPCC tier 1 methods instead of default values. The only advantage would be that one less assumption would have to be made, if defaults are given as ranges.

21. The condition that national circumstances are similar does not often apply. CO₂ emissions per capita or per GDP is an obvious example. Also for fugitive emissions from fuels, emission factors may vary dramatically between countries depending on the design and operating practice, types of oil and gas activity, age of equipment, and environmental regulation. The same applies for the waste

category, if one Party is phasing out landfilling in favour of composting and incineration, and one is using landfilling as the major option. Agricultural emissions are highly dependent on the national circumstances and practices.

22. The difference between emissions estimated using Annex B averages and those reported by Parties ranged from 10 per cent to a factor of 2 for the selected source categories.

Linkage of emissions between gases or source categories

23. Estimation of emissions of one gas or source category based on the linkage to emissions of another gas or source category can only be applied in a limited number of cases. For fuel combustion activities, CH₄ and N₂O can be calculated from CO₂ emissions; the results are similar to using IPCC default emission factors. For some agricultural sources the ratio between nitrogen and carbon contained in the residue is part of the IPCC tier 1 method. A link between the CH₄ emissions and N₂O emissions from manure management systems in terms of a ratio cannot be made since emissions of those gases depend on different factors. However, an increase in emissions of one gas would result in an increase in the other.

B. Source-specific findings

24. The table below (pp. 8 - 11) provides an overview of the sector-specific findings of the experts.

III. PRELIMINARY CONCLUSIONS

25. The following preliminary conclusions can be drawn from the work of the consultants:

(a) Potential conflict may exist between goals such as transparency, replicability, simplicity and accuracy with respect to methods to apply adjustments;

(b) In many cases transparent, replicable and simple methods to apply adjustments that can be performed without using assumptions do not exist;

(c) Estimates developed in close collaboration with experts of the Party are likely to be of higher quality and accuracy than methods applied without the participation of experts from the Party;

(d) A complex set of methods for all problems with emissions of all gases in all sectors and countries would have to be developed in order to reach highly accurate results when applying adjustments. However, generic approaches that can be applied regardless of the type of problem, may have limited applicability.

(e) Developing accurate adjustments relating to problems in some sectors, gases and countries may require experienced experts using a case by case approach. This would include making specific assumptions and taking into consideration information provided by the concerned Party.

Guidance on how to choose the appropriate assumptions may be needed;³

(f) Every effort should be made during the review process to correct identified problems before a decision on the need for an adjustment is taken. This would reduce the number of adjustments and make the adjustment process more transparent and manageable as well as faster.⁴

26. Further analysis may be necessary to take conclusions on the matter.

³ The IPCC National Greenhouse Gas Inventories Programme is developing an emission factor database, which could be of value in this regard.

⁴ Assessment of the time required to calculate a revised technical estimate was not within the scope of this paper. However, it may be a relevant element in the design of the adjustment process. See also figure 1 in working paper 4 (2000)

Sector-specific findings of the experts

(Note that the sample size of examined countries was limited in most cases; see specific reports of the consultants for details.)

Sector	Source	Gas	Tier 1 IPCC method			Estimation based on Annex B average		Extrapolation using drivers		Comments
			Default emission factors available?	All necessary activity data available from international sources?	Difference to the estimates reported by Parties	Index	Difference to the estimates reported by Parties	Index	Difference to the estimates reported by Parties	
1A Energy, fuel combustion activities	Total	CO ₂	Yes, per fuel	Yes (quality depending on country)	Around ± 5%	Average per capita emissions if grouped in clusters	± 15%	GDP	±few % (inside) ⁵ ±15% (outside)	- If international energy data are available, they are usually reported and already used by the Party. - Differences to national estimates are due to differences in energy data used and allocation to sectors
	Total	CH ₄ / N ₂ O	Yes, per technology	Fuel consumption available but not combustion technology	Factor of 2	Average emission factors same as default emission factors		Fuel consumption	± 5%	- Emission factors are technology dependent
	Sectoral breakdown (Energy Industries, manufacturing industries and construction, transport, other sectors)	CO ₂	Yes, per fuel	Breakdown not available for all countries	Less accurate than total fuel combustion, up to ±15%	Split of total fuel use into sectors based on Annex B averages possible	Difference not assessed	Electricity production Industry: IEA industry indicator Residential: Population	±5% (inside), ±15% (outside) ± 20% a few % (inside) ±15% (outside)	- Total fuel consumption is more accurate than sectoral breakdown. However to calculate CH ₄ and N ₂ O emissions, sectoral breakdown would provide for more accurate emissions

⁵ 'Inside' refers to the situation where emission estimates of the two adjacent years are available. 'Outside' refers to the situation where emission estimates are only available for one adjacent year.

Sector	Source	Gas	Tier 1 IPCC method			Estimation based on Annex B average		Extrapolation using drivers		Comments
			Default emission factors available?	All necessary activity data available from international sources?	Difference to the estimates reported by Parties	Index	Difference to the estimates reported by Parties	Index	Difference to the estimates reported by Parties	
1B Energy, fugitive emissions	Solid fuels	CH ₄	Yes, range for surface and range for underground mining	Ratio between underground and surface mining not available	Not quantitatively assessed	Emission factors may vary dramatically between countries.		Coal production	Not quantitatively assessed	- Emissions are very country specific and depend on mine and operating practice
	Oil and natural gas	CH ₄	For infrastructure and equipment	Data on infrastructure and equipment not available	Not quantitatively assessed	Emission factors may vary dramatically between countries. Metres of pipeline per capita may provide upper limit.		Oil and gas production	Not quantitatively assessed	- Emissions are very country specific and depend on design and operating practice, types of oil and gas activity, age of equipment, environmental regulation
2 Industrial processes	2A Mineral products	CO ₂	Not finalized							
	2B Chemical industry	CO ₂	Not finalized							
	2C Metal production	CO ₂	Not finalized							
	2D other production		Not considered							
	2E Production of halocarbons and SF6		Not considered							
	2F Consumption of halocarbons and SF6		Not considered							

Sector	Source	Gas	Tier 1 IPCC method			Estimation based on Annex B average		Extrapolation using drivers		Comments
			Default emission factors available?	All necessary activity data available from international sources?	Difference to the estimates reported by Parties	Index	Difference to the estimates reported by Parties	Index	Difference to the estimates reported by Parties	
4 Agriculture	4A Enteric fermentation	CH ₄	Yes, up to 80% different to national factors	Animal population from FAO. Does not separate dairy and non-dairy cattle	Around ±30%	Animal population, Annex B average emission factor - per livestock - per livestock unit	~20% up to 10%	Exponential growth rate of animal population	10%	
	4B Manure management	CH ₄	Yes, not country specific	Animal population from FAO. Does not separate dairy and non-dairy cattle	Factor 2 to 10	Animal population, Annex B average emission factor per livestock		Animal population	A few %	Emission factors are highly dependant on the national circumstances and practices and are reported as being uncertain
	4B Manure management	N ₂ O	Yes, not country specific	Animal population from FAO. Does not separate dairy and non-dairy cattle	Factor of 7	Animal population, Annex B average emission factor per livestock	Factor 2	Animal population	5%	
	4C Rice cultivation	CH ₄	Yes, not for all countries	Harvested rice area from FAO	50%	Harvested rice area and average Annex B emission factor	Factor 2	Harvested rice area	10%	Emission factors depend on a country's various water regimes and fertilizer characteristics
	4D Agricultural soils	N ₂ O	Yes	Fertilizer input, livestock, crop production, cultivated area from FAO	50%	Fertilizer input, Annex B average emission factor	Factor 2	linear relation between nitrogen input and emissions	A few %	Emissions depend on different fertilizer application method
	4E Prescribed burning of savanna	CH ₄ and N ₂ O	Yes	Area of savanna burned not available	--	No published index found	–	No published index found	--	

[illegible]

Annex**LIST OF EXPERT REPORTS**

Symbol	Title	Author
Working paper 3 (a) (2000)	Fuel combustion activities: Sectoral breakdown of emissions based on international energy data	Tim Simmons
Working paper 3 (b) (2000)	Fuel combustion activities: Breakdown of aggregated fuel data, estimating CO ₂ emissions from per capita emissions, CH ₄ and N ₂ O emissions from fuel combustion	Ijaz Hossain
Working paper 3 (c) (2000)	Fuel combustion activities: Interpolation, extrapolation and approximation using drivers	Milos Tichy
Working paper 3 (d) (2000)	Fugitive emissions from fuels	David Picard
Working paper 3 (e) (2000)	Industrial processes	Tinus Pulles
Working paper 3 (f) (2000)	Agriculture	Dong Hongmin
Working paper 3 (g) (2000)	Waste	Michiel Doorn
