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METHODOLOGICAL ISSUES

Progress report

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I. INTRODUCTION

A. Mandate

1. At its fourth session, the Subsidiary Body for Scientific and Technological Advice (SBSTA) requested the secretariat to compile and synthesize information on emissions affected by weather and electricity trade, as well as the methodologies used for adjustments, from the national communications submitted by Parties and the in-depth reviews (FCCC/SBSTA/1996/20).

B. Scope of the note

2. This paper elaborates on the issue of adjustments to national greenhouse gas (GHG) inventories and projections, in particular to those related to temperature fluctuations. In preparing this paper, the secretariat compiled information on adjustments submitted by Parties in the first and second national communications; in total, seven Parties provided unadjusted and adjusted data on GHG emission inventories and/or projections. It also analysed the limitations of various methods and their implications. Detailed analyses may be found in technical paper TP/1997/2.1/

C. Background

3. The Conference of the Parties (COP), at its second session, decided that Parties included in Annex I to the Convention should use the revised guidelines for the preparation of their second national communications (FCCC/CP/1996/15/Add.1, decision 9/CP.2). The revised guidelines state that if Parties carry out any adjustments to inventory data, for example, due to climate variations or electricity trades, these adjustments should be reported in a transparent manner, with a clear indication of the method followed. At its fourth session, the SBSTA stressed the necessity of reporting inventories in mass units without adjustments, according to the guidelines. In relation to this, it concluded that adjustments are to be regarded as important information in relation to the monitoring of emission trends and the performance of policies and measures, and should be reported separately (FCCC/SBSTA/1997/4).

D. Possible action by the SBSTA

4. The SBSTA may wish to consider several approaches related to issues referred to in this note, such as:

1/Technical paper (TP/1997/2) was sent to experts for review and comments. The experts were nominated by governments. It was also sent to analysts from Annex I Parties, who co-operated with the secretariat by providing additional data and information.

(a) Taking no further action, and leaving it up to individual Parties for their own purposes to apply any adjustments, consistent with the guidelines from the COP; and/or

(b) Making recommendations to the COP, in co-operation with the Subsidiary Body for Implementation (SBI), for further guidelines regarding the reporting and use of adjusted emission data; and/or

(c) Advising the Ad Hoc Group on the Berlin Mandate (AGBM) and the SBI to consider the implications of adjustments for their own work; and/or

(d) Deferring the consideration of the issues to a future session and requesting Parties to submit comments on this subject.

II. ADJUSTMENTS

5. National emissions, in their development over time, usually show year-to-year variations in addition to a longer-term trend. For example, variations in winter temperatures influence fuel use for heating, and variations in summer temperatures influence energy demand for air-conditioning. Another example is the fluctuation in the amount of precipitation, which influences the availability of hydropower; this, in turn, may have an impact on the use of alternative energy sources for electricity production, such as coal. Yet another example is fluctuations in industrial production, which have consequences for energy use in production and transport.

6. Parties, in their analysis of emissions, may try to distinguish these short-term fluctuations from the longer-term developments. Indeed, in their projections of emissions over the period 1990-2000, some Parties have reported adjustments to their inventory for the base year, in order to reflect “normal” or “average” conditions, rather than the actual situation.

7. Separating the short-term fluctuations from the general trend has a number of potential applications. In general, it helps to develop a better understanding of the shorter and longer-term factors that determine the development of national emissions. This understanding then helps in the development of policies and measures, and in assessing their effects, or in making projections of future emissions. Furthermore, an undisturbed view of the general trend would be of relevance in view of the commitment in Article 4.2(a) of developed countries, to take the lead in modifying longer-term trends in anthropogenic emissions. At the same time, it would need to be clarified what adjustments, if any, would be appropriate in assessing progress towards reaching the quantitative aim in Article 4.2(b).

8. The fact that fluctuations occur as a result of external factors, including natural variability of weather and climate, does not mean that their related emissions are beyond control. For example, improving the thermal insulation of buildings and/or improving the

efficiency of heat supply may limit short-term fluctuations as well as longer-term emissions. Also, more efficient use of electricity from hydropower may limit the demand for electricity from other sources.

III. ADJUSTMENTS IN NATIONAL COMMUNICATIONS

9. Seven Parties submitted information on temperature adjustments to the secretariat (Table 1). The table indicates where information may be found in the national communications; the cause of the adjustments; the percentage change in total national CO_2 emissions due to adjustments (excluding land-use change and forestry) for the year 1990; the maximum adjustment in any year; and the percentage change in total national CO_2 emissions (excluding land-use change and forestry) between the years 1990 and 1995, both unadjusted and adjusted. The specific methods used by Parties are described in annex I.

10. Austria included, in its second national communication, a chapter on possible adjustments to the greenhouse gas inventory. A regression analysis revealed a statistically significant relation between fuel consumption and two parameters, namely, the heating degree day (HDD) index and an index of industrial production. Both adjustments are of the same order of magnitude.

11. The national communication from Belgium notes that, in order to “clearly define the objectives regarding CO_2 emissions, the problem of fluctuations due to temperature has to be solved”. A temperature-adjusted base year (1990) was used in the projections; however, emission inventory data were not adjusted.

12. In Denmark, fluctuations in electricity trade, as driven by precipitation and water runoff in Scandinavia, lead to higher variations in emissions than fluctuations in temperature. If sufficient water is available, Denmark imports electricity produced from hydropower in other Scandinavian countries. In dry years, electricity is generated domestically by fossil fuel power plants. In the inventory chapter of its first national communication, Denmark reported that,
for 1990, electricity imports caused emissions to be 12% lower than if they had been produced by fossil fuel plants.

13. The emissions inventory of the second national communication from the Netherlands contains a separate column with the temperature-adjusted data. The calculation is facilitated by the fact that nearly 100% of the space heating is based on natural gas.

14. Sweden reported, in an appendix to its second national communication, additional temperature-and water runoff-adjusted inventory data. The electricity market of Sweden depends strongly on hydropower, and therefore on precipitation. Temperature and hydropower adjustments led to a maximum increase of emissions of +3.9% for the year 1990.

15. The projections in the second national communication of Switzerland are based on temperature-adjusted energy data using 1990 as a base year. The relation between the HDD index (see annex I) and fuel consumption for space heating was derived through simulations and empirical analyses.2/ Monthly corrections, instead of yearly corrections, led to greater accuracy. Other factors apart from temperature, such as wind, solar radiation and humidity, had no significant influence on the fuel consumption.

16. The United States of America noted, in the chapter on projections in its second national communication, that temperature adjustments for heating and cooling could raise or lower the emissions by plus or minus 20 million metric tons of carbon, or about ±1.5%.

Table 1: Summary of adjustments to CO_2 emissions and projections by Parties

Country	***Location in national communication***	***Cause for adjustment***	***Change in CO_2*** emissions due to adjustments for 1990	Maximum adjustment (year)	Change of unadjusted emissions (1990-95)	Change of adjusted emissions (1990-95)
Austria	Additional chapter - Second communication	Heating; industrial production index	+ 6% (temperature-adjusted)	+ 7% (1994) (temperature-adjusted)	+ 0.23%	- 3% (temperature-adjusted)
Belgium	Projections chapter - First communication	Heating	+ 3.9%	only value for 1990 provided	+ 6.1%	
Denmark	Inventory chapter - First communication	Hydropower	+ 12.0% (electricity-adjusted)	+ 12.0% (1990) (electricity-adjusted)	+ 21.3%	+ 1.4% (electricity-adjusted)
The Netherlands	Inventory chapter	Heating	+ 3.8%	+ 3.8% (1990)	+ 9.4%	+ 6.8%
Sweden	Appendix Second communication	Heating hydropower	+ 3.9% (incl. water runoff)	+ 3.9% (1990)	+ 4.8%	+ 1.1% (incl. water runoff)
Switzerland	Projections chapter - Second communication	Heating	+ 2.2%	only value for 1990 provided	- 3.9%	
The United States of America	Projections chapter - Second communication	Heating; cooling	+ 1.25%	***only value for 1990 provided***	***+ 5.0%***	

2/Bundesamt für Energiewirtschaft. "Klimanormierung Gebäudemodel Schweiz", Büro CUB, Juli 1995.

IV. DISCUSSION

17. Bearing in mind that adjusted data may currently be provided by Parties on an optional basis, Parties may, nevertheless, wish to consider whether there is a need to further elaborate on a common approach to applying the methods described in annex I. In so doing, Parties may wish to consider the possible uses of such methods. In this regard, at least four uses may be envisaged:

(a) To inform other Parties about the effects of temperature fluctuations and other specific influences on annual emissions, in addition to the general trend;

(b) As a basis for methodologies to assess the effects of policies and measures to mitigate emissions;

(c) To make projections of GHGs in a more consistent manner; and

(d) To assist in assessing the progress a Party is making regarding its commitments and aims.

18. With respect to the latter use (d), it may be noted that the technical paper TP/1997/2 also contains some calculations regarding averaging of yearly values of national emissions. Annex II and III summarize some results.

Explanatory notes

The following ISO country codes have been used:

Austria	AUT
Belgium	BEL
Canada	CAN
Czech Republic	CZE
Finland	FIN
France	FRA
Germany	DEU
Iceland	ISL
Ireland	IRL
Netherlands	NLD
New Zealand	NZL
Norway	NOR
Slovakia	SVK
Sweden	SWE
Switzerland	CHE
United Kingdom of Great Britain and Northern Ireland	GBR
United States of America	USA

Annex I

Methodologies used by Parties

Calculation of a temperature index

1. An essential step used by all Parties, when adjusting for temperature variations, is to calculate what is called a “heating degree day” (HDD) index.
It is defined as:

$$HDD = \sum_i (18^{\circ}\mathrm{C} - T_i)$$

2. Based on the above, an annual heating degree day value is arrived at by calculating the differences between a reference or base temperature (for example, 18ºC) and the average temperature T_i for all the days i of one year, whose average temperature is below the base temperature. The reference temperature is based on the experience that heating will be operated if the temperature falls below a certain value, e.g. 18ºC, as a daily average. The annual total of heating degree days is higher for cold years, and lower for warm years.

3. Some Parties, while using the above method for the winter period, employ a slightly different method, incorporating a threshold temperature, to calculate the HDD index for the spring and autumn. This method is slightly more accurate as it takes into account the increased use of space heating if the average outdoor temperature is below the base temperature but also allows for the fact that in the spring and autumn, space heating is applied at an average temperature considerably below the base temperature.

4. The HDD index is a common weather index used in all of the Parties. Nevertheless, base temperatures vary from 20ºC in Switzerland to 17ºC in Sweden. Threshold temperatures, where applied, range from 10ºC to 15ºC. In geographically large countries, the annual heating degree day values are aggregated to an average national value by weighting the values for different weather stations according to the surrounding population.

5. Variations in base and threshold temperatures lead to different absolute values and different relative fluctuations. Changing the base temperature of 20ºC to 17ºC changes the relative deviation from the average by about 20%.[1] Using different base and threshold temperatures can influence whether a year is below or above the average.

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[1] The influence of the choice of base temperature can be roughly estimated by assuming that heating is used for a period of 200 days a year. Changing the base temperature from 20ºC to 17ºC would decrease the total annual heating degree day value by around 200x(20-17). For German circumstances, this would be equivalent to changing the deviation from the average by about a fifth. For example, a year with an HDD index 8% higher than the average year calculated using a base temperature of 20ºC, however, 10% above the average when using a base temperature of 17ºC.

6. The implications of a greater use of air-conditioning in years with hot summers can be calculated by the same method, using cooling degree days instead of heating degree days. Thus, the annual total of cooling degree days (CDD) index is calculated by summing the differences of the average temperature T_i and a base temperature (for example, 18ºC) for all days *i* of one year, whose average temperature is above the base temperature. However, the CDD index does not reflect the energy consumption by air-conditioning systems as accurately as the HDD index reflects the fuel consumption, because other meteorological variables, such as humidity, are closely related to the effectiveness of air-conditioning.

Approach A - Adjustment for space heating fuel

7. This approach applies adjustments for fuel used only for space heating. Fuel used for other purposes is unadjusted. The approach required data on fuel consumption for space heating from national energy statistics. A linear relationship is assumed between heating degree days and fuel consumption for space heating. For example, if the HDD index is 1% above the average, the fuel consumption used for space heating is also 1% above normal. This corresponds to an elasticity of 1 with respect to the fuel consumption for space heating. The base and threshold temperatures for calculating the heating degree days are chosen to best satisfy this relation. In some cases an elasticity of 0.5 to 0.7 is assumed, that is a 1% increase of the HDD index results in a 0.5% to 0.7% increase in emissions. The fuel consumption is then adjusted by the formula:

$$C_{norm} = C \cdot a \cdot \frac{1}{E \cdot \left(\frac{HDD}{HDD_{norm}} - 1 \right) + 1} + C \cdot (1 - a)$$

C:	uncorrected fuel consumption
C_{norm}:	corrected fuel consumption
HDD:	heating degree day index of the considered year
HDD_{norm}:	average heating degree day index over several years
E:	elasticity of fuel consumption used for space heating in relation to heating degree days (between 1 and 0.5)
a:	the proportion of total fuel consumption used for space heating (between 0 and 1)

8. To use this approach, data on the proportion of total fuel consumption used for space heating and the elasticity of consumption of those fuels with respect to the heating degree days, is needed.

Approach B - Regression analysis

9. This approach requires that the relationship between the HDD index and the total use of fuels be defined by regression analysis of fuel data. If factors in addition to temperature are influencing the emissions, a multiple regression for the heating degree day index and

other relevant factors is undertaken. The output of the regression analysis is a relationship describing the uncorrected fuel consumption as a function of the HDD index and the other relevant parameters. A simple example for such a relation with the gross domestic product (GDP) as an additional parameter would be the following:

$$C = a \cdot HDD + b \cdot GDP + \ldots$$

C:	uncorrected fuel consumption
HDD:	heating degree days index of the considered year
GDP:	gross domestic product of the considered year
a,b:	constants determined by the analysis

10. The equation can be used to estimate the adjusted fuel consumption using the average value of the HDD day index instead of the actual value.

$$C_{norm} = a \cdot HDD_{norm} + b \cdot GDP + \ldots$$

C_{norm}:	corrected fuel consumption of the considered year
HDD_{norm}:	average heating degree day index over several years

11. This approach requires energy and economic data sufficient to perform a statistically significant regression.

Applications

12. The first method, that is, the heating degree day method with fuel used for space heating may be used to adjust annual emission inventories and projections of future emissions, provided that economic models supply the data. However, historical and/or modelling data on fuel used for space heating may not be available in some countries. This approach supports all four uses listed on page 6 and may have the additional advantage of reflecting the effectiveness of policies directed at the space heating sector.

13. The second method, that is, the use of regression analysis, has the advantage of being able to accommodate other factors that influence emissions, such as precipitation and economic variables, *inter alia*, gross domestic product or industrial production. It requires considerable amount of historical data and more complex analysis. As such, it may provide more comprehensive information about emissions fluctuations. It has its limitations for projections where the fluctuations are inherently high, such as those associated with rainfall. It could be used to assist in assessing the progress a Party is making regarding its commitments.

14. A simple alternative to the above methods would be averaging emissions over a number of years. It requires no additional data other than that which is required to report annual emissions. A disadvantage is that progress towards reaching an aim cannot be determined until one or more years after a target year, although this may not be the case for a budget. The method of averaging, as discussed in TP/1997/2, may be considered as a tool

in assessing compliance. An example of the effect of averaging emissions is shown in annex II and III.

Annex II

Percentage change in CO_2 emissions based on a five-year average and single year

Country	CO_2 emissions 1990 [Gg]	Average CO_2 emissions (1991-95) [Gg]	CO_2 emissions 1995 [Gg]	Percentage change in emissions between 1990 and average 1991-95 / -1 in %	Percentage change in emissions (1990-95) / -1 in %
AUT	61880	61516	62020	-0.6	0.2
BEL	116090	N.A.[2]	N.A.	N.A.	N.A.
CAN	464000	474505	499526	2.3	7.7
CHE	45070	44712	44170	-0.8	-2.0
CZE	165490	136955	128817	-17.2	-22.1
DEU	1014155	923822	894500	-8.9	-11.8
FIN	53800	N.A.	56050	N.A.	4.2
FRA	378379	387193	385347	2.3	1.8
GBR	583747	562927	543338	-3.6	-6.9
ISL	2147	2223	2282	3.5	6.3
IRL	30719	32642	33931	6.3	10.5
NLD	167550	176140	183400	5.1	9.5
NOR	35544	35969	37880	1.2	6.6
NZL	25476	27186	27367	6.7	7.4
SVK	60032	47973	48516	-20.1	-19.2
SWE	55445	56762	58108	2.4	4.8
USA	4965510	5073336	5214710	2.2	5.0

[2] N.A. : non-available.

Annex III

Percentage change in CO_2 emissions based on a three-year average baseline and target

Country	Average CO_2 emissions (1990-92) [Gg]	Average CO_2 emissions (1993-95) [Gg]	Percentage change in emissions between average 1990-92 and average 1993-95 (in %)
AUT	62887	60267	-4.2
BEL	117855	N.A.	N.A.
CAN	462000	483509	4.7
CHE	45717	43827	-4.1
CZE	152951	130471	-14.7
DEU	971988	905767	-6.8
FIN	N.A.	56137	N.A.
FRA	393635	377812	-4.0
GBR	581734	551061	-5.3
ISL	2138	2283	6.8
IRL	31578	33064	4.7
NLD	171250	178167	4.0
NOR	34611	37185	7.4
NZL	26479	27323	3.2
SVK	53837	46128	-14.3
SWE	55548	57536	3.6
USA	4949607	5161123	4.3

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