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METHODOLOGICAL ISSUES

TEMPERATURE ADJUSTMENTS

Technical Paper

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CONTENTS[1]

Annexes

[1] This report has been prepared with the help of an external consultant, Mr. Niklas Höhne.

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 related to temperature fluctuations and their implications. The paper 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 short summary may be found in the progress report on methodological issues (FCCC/SBSTA/1997/9).

II. 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).

4. 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 hydro-power; 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.

5. 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.

6. 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).

7. 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 hydro-power may limit the demand for electricity from other sources.

III. METHODOLOGIES

A. Methods used by Parties

8. To adjust emissions due to the variable use of space heating, Parties used two different adjustment methods with small individual variations. Both methods have in common the calculation of a temperature index called “heating degree day” (HDD) index. One method, approach A, applies adjustments only to fuel used for space heating. The second method, approach B, uses regression analysis to also consider the influence of other variables.

Calculation of a temperature index

9. 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:

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

10. 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 historical data that indicates when heating will be used, for example, 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.

11. 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.[2] 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 only applied when temperatures are considerably below the base temperature.

12. The HDD index is a common weather index used by 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.[3] 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.

13. Variations in base and threshold temperatures lead to different absolute values and different relative fluctuations. Changing the reference or base temperature of 20ºC to 17ºC changes the relative deviation from the average by about 20%.[4] Using different base and threshold temperatures can influence whether a year is below or above the average.

14. 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 use of air conditioning.

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[2] In this case, the 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 threshold temperature.

[3] In addition, the definition of the average temperature of a day may vary sightly.

[4] 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 is, however, 10% above the average when using a base temperature of 17ºC.

Approach A - Adjustment for space heating fuel

15. This approach applies adjustments for fuel used only for space heating. Fuel used for other purposes is unadjusted. The approach requires 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)

16. 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

17. This approach requires that the relationship between the HDD index and the total use of fuels be defined by a 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[5]:

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

[5] The given formula represents a simple example. More complex as well as non-linear functions with more and other parameters could be chosen.

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

18. The equation can be used to estimate the adjusted fuel consumption using the average value of heating degree 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

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

B. Alternative method - Averaging

20. While Parties have not used "averaging" as a means of adjusting inventories, this method could be used thereby taking account of all the factors affecting emissions over several years. In the Ad Hoc Group on the Berlin Mandate (AGBM), possible quantitative emission limitation reduction objectives have been proposed to be formulated in terms of average emissions or budgets, instead of targets for a single year. Annex I provides further information about methods for and implications of averaging.

IV. ADJUSTMENTS IN NATIONAL COMMUNICATIONS

21. 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 and the temperature adjustment method used; 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.

22. 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.

23. 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.

24. 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 hydro-power 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.

25. 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.

26. 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 hydro-power, and therefore on precipitation. Temperature and hydro-power adjustments led to a maximum increase of emissions of +3.9% for the year 1990.

27. 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 and fuel consumption for space heating was derived through simulations (0.78) and empirical analyses (0.6 to 0.9, dependent on the buildings and consumer behaviour).[6] 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.

28. 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%.

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[6] Bundesamt für Energiewirtschaft. “Klimanormierung Gebäudemodel Schweiz”, Büro CUB, Juli 1995.

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

Country	Location in national communication	Cause for adjustment	Temperature adjustment method, Elasticity (E), base / threshold temperature (BT/TT)	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	Approach B	+ 6% (temperature-adjusted)	+ 7% (1994) (temperature-adjusted)	+ 0.23%	- 3% (temperature-adjusted)
Belgium	Projections chapter - First communication	Heating	Approach A	+ 3.9%	only value for 1990 provided	+ 6.1%	
Denmark	Inventory chapter - First communication	Hydro-power	N.A.[7]	+ 12.0% (electricity-adjusted)	+ 12.0% (1990) (electricity-adjusted)	+ 21.3%	+ 1.4% (electricity-adjusted)
The Netherlands	Inventory chapter	Heating	Approach A, E: 1 BT:18ºC TT:18ºC	+ 3.8%	+ 3.8% (1990)	+ 9.4%	+ 6.8%
Sweden	Appendix Second communication	Heating hydro-power	Approach A E:0.6 BT:17ºC TT:10	+ 3.9% (incl. water runoff)	+ 3.9% (1990)	+ 4.8%	+ 1.1% (incl. water runoff)
Switzerland	Projections chapter - Second communication	Heating	Approach A E:0.7 BT:20ºC TT:12ºC	+ 2.2%	only value for 1990 provided	- 3.9%	
The United States of America	Projections chapter - Second communication	Heating; cooling	N.A.	+ 1.25%	only value for 1990 provided	+ 5.0%	

IV. CASE STUDIES

29. In the following section, four cases examine the implications of applying the adjustment methods to the emission data of Parties. The countries were chosen because data was available and because they represent geographically small, medium and large countries.

A. The Netherlands

30. The land surface of the Netherlands covers an area of 34 000 km^2. Since the moderate maritime climate characterized by cool summers and mild winters does not vary significantly over the area of the country, the HDD index is calculated from temperature measurements of one weather station in the geographical centre of the country. A base and threshold temperature of 18°C was used. The deviation from the 30-year average is shown in figure 1.

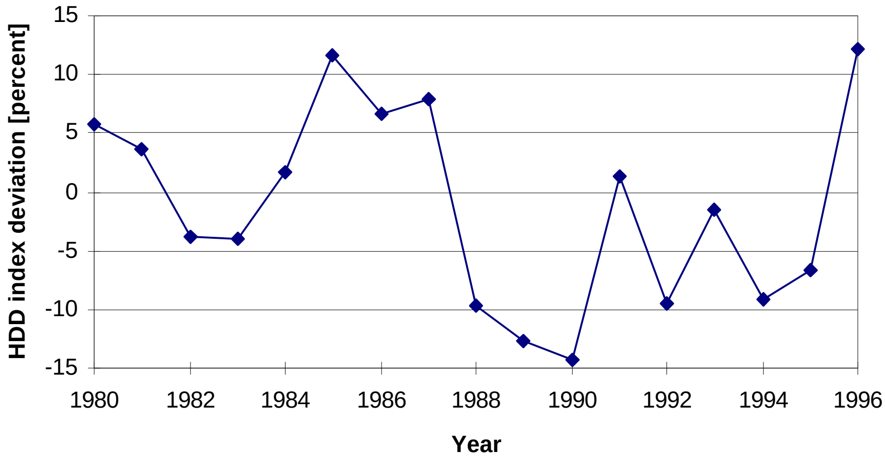
31. In addition to unadjusted inventory data, the Netherlands reported temperature-adjusted

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

emission data according to approach A using an elasticity of fuel consumption for space heating in relation to the HDD index of 1. Furthermore, regarding the HDD index, a 30-year moving average was used as opposed to a fixed average. Since space heating is almost entirely based on natural gas, only gas consumption was adjusted.

32. To assess the implication of applying approach B, the secretariat performed a regression on the gas consumption using only the HDD index as parameter (see annex II for detailed calculation). Unadjusted and adjusted emissions are shown in figure 2.

Figure 1. Deviation of heating degree day index from the fixed 30-year average in the Netherlands[8]



33. Both adjustment methods lead to similar results. Approach A assumes a constant relationship between the HDD index and fuel consumption and approach B smooths the gas consumption. GDP is also included in figure 2 as an indicator. Since it does not fluctuate significantly, economic factors do not seem to be responsible for the fluctuations of unadjusted emissions.

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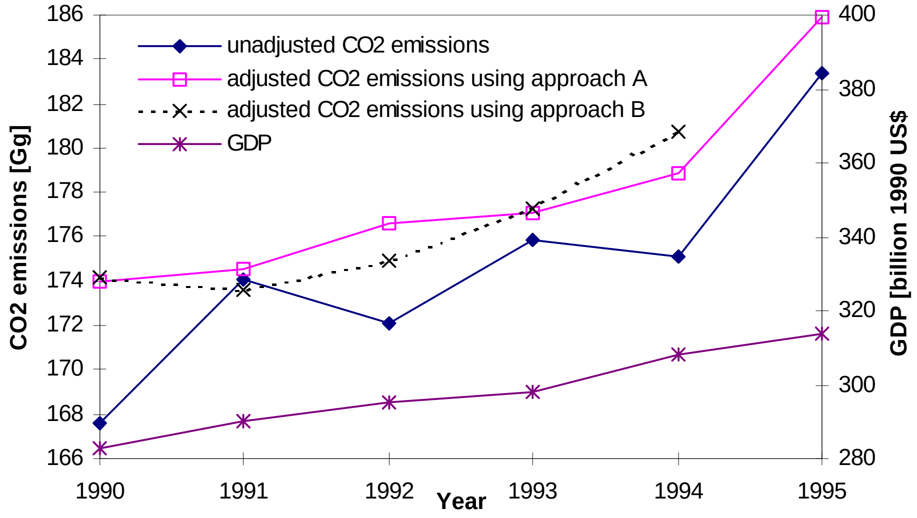
8 National Institute of Public Health and the Environment (RIVM), the Netherlands, Greenhouse gas emissions in the Netherlands 1990-95, J. Spakman et al., December 1996.

Figure 2. Total CO_2 emissions (unadjusted, as adjusted using approach A in the second national communication and using approach B), and gross domestic product (GDP) of the Netherlands for the period 1990 to 1995[9].



34. Overall, the calculations indicate that space heating is the most important factor influencing the fluctuations of emissions of the Netherlands, since the application of both methods led to a smooth trend. The different methods provide comparable results, which differ by less than 1% of total emissions.

B. Germany

35. The Federal Republic of Germany comprises an area of 356 970 km², which is about ten times the size of the Netherlands, with moderate coastal climate in the north, continental climate in the east and south including frequent weather changes and predominantly west wind. The HDD index was calculated as the average of 20 weather stations of the main cities of Germany using 20°C as the base temperature and 15°C as threshold temperature. The deviation of the HDD index from the average ranging from -11% (1990) and +13% (1996) is shown in figure 3. The comparison with the corresponding figure of the Netherlands (figure 1) reveals similarities in HDD indices of these neighbour countries.

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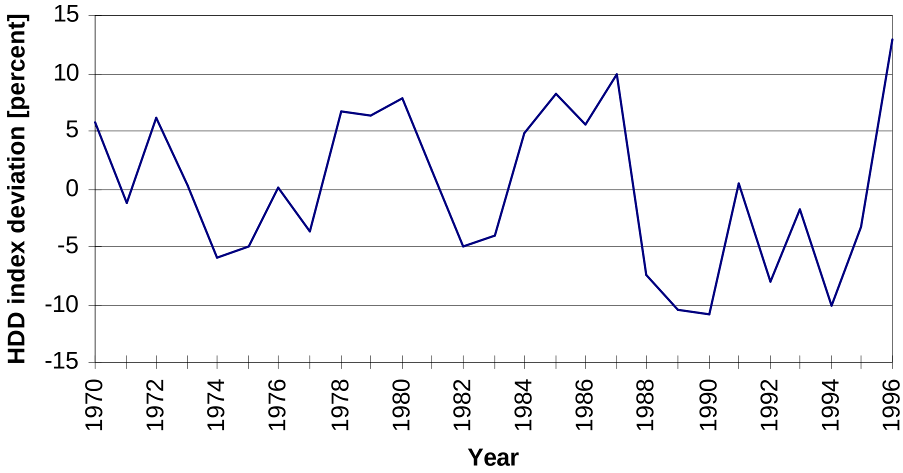
9 International Energy Agency, CO_2 Emissions from Fuel Combustion, 1997, Edition (forthcoming): (OECD, Paris).

Figure 3. Deviation of heating degree day index from the average in Germany



Source: German Weather Service DWD

36. To better understand domestic emissions, the German Institute for Economic Research (DIW) undertook a study to determine the extent to which the energy demand in Germany is associated with fluctuations in temperature.[10] Temperature-adjusted CO_2 emissions were calculated using approach A. The proportion of total fuel consumption used for space heating was derived from data provided by the association of German electricity utilities (VDEW) for each year. The elasticity of fuel consumption for space heating in relation to the HDD index was determined using consistent energy data from 1980 to 1994. Multiple regression with the two parameters GDP and HDD led to empirical elasticity values of 1.21 for oil, 0.84 for gas, 0.94 for coal and 0.73 for other fuels. An adjustment of up to 3.0% for the year 1990 was calculated. The results are shown in figure 4.

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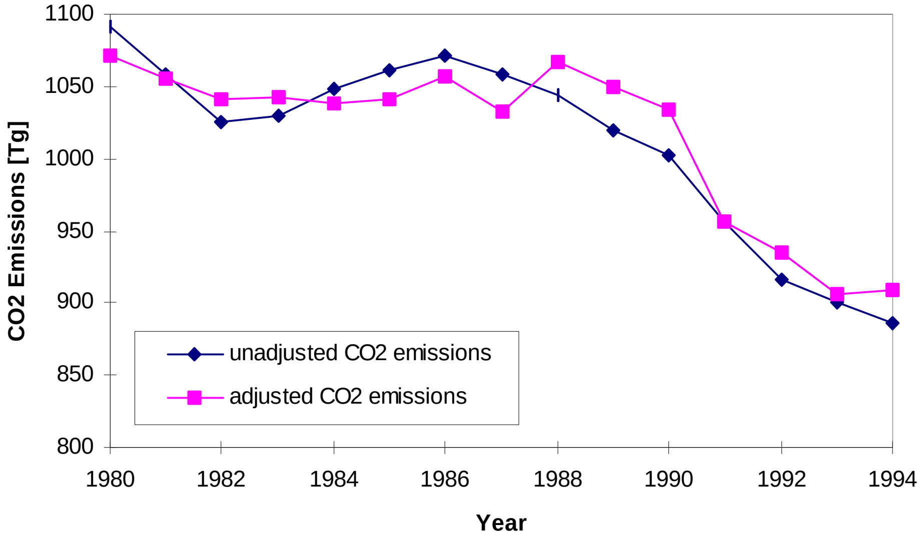
[10] German Institute for Economic Research (DIW), Energienachfrage in Deutschland in Abhängigkeit von Temperaturschwankungen und saisonalen Sondereffekten (Energy demand in Germany, dependent on fluctuations in temperature and other seasonal effects), 1995.

Figure 4. Unadjusted and adjusted CO_2 emissions of Germany according to DIW



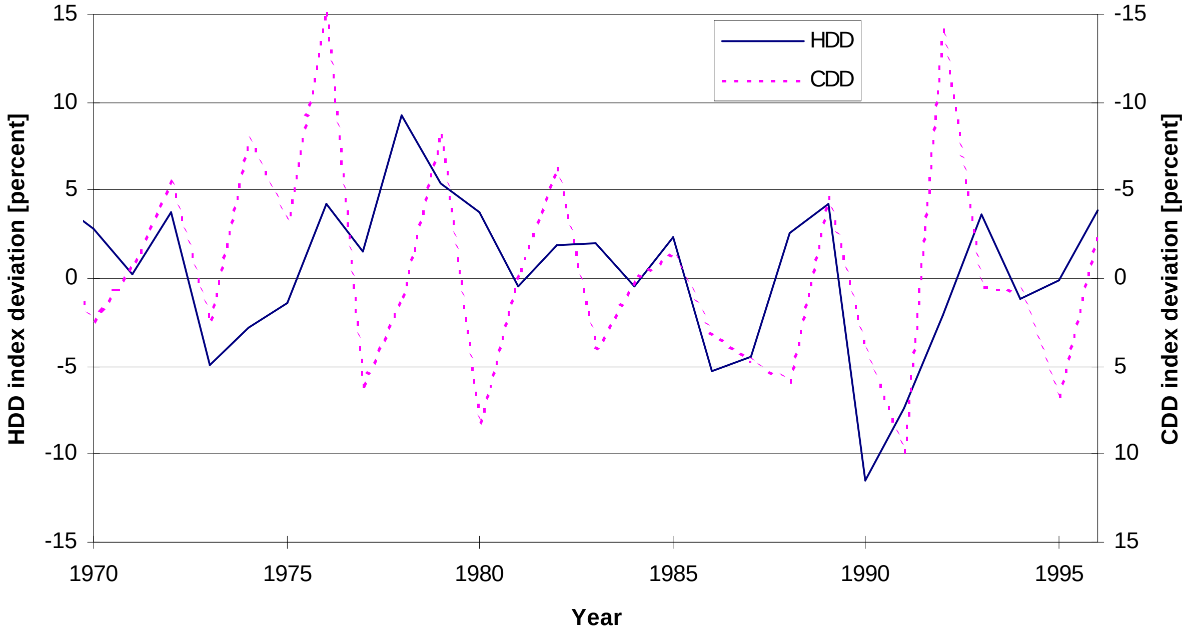
C. The United States of America

37. The United States of America (USA), as a large country (9 363 000 km^2), covers different climatic zones and areas, where space cooling as well as space heating may be an important factor influencing emissions.

38. Heating and cooling degree day indices are calculated with the base temperature of 65°F, corresponding to 18.3°C. The values for different states fluctuate ±10% as does the national population weighted value. This demonstrates that by averaging heating degree days over a large country, the fluctuations are not eliminated. Since the elasticity of fuel used for space heating in relation to the HDD index may significantly change between areas, the adjustment would need to be performed on a state level or even smaller, rather than on a national level, to reach high accuracy.

39. The deviation from the average of the heating and cooling degree day indices are shown in figure 5. The deviation of cooling degree day index from the average is displayed negatively. The figure suggests that cold years with a large number of heating degree days tend to also have a small number of cooling degree days. It can also be observed that the cooling degree day index fluctuates more than the HDD index.

Figure 5. Deviation of heating and cooling degree day indices from the average in the USA



Source: National Oceanic and Atmospheric Administration NOAA, USA.

40. The USA provided unadjusted emissions data for the years 1990 to 1995 in its second national communication. In the section on projections, it was stated that temperature adjustments would influence CO_2 emissions by a maximum of 1.5%.[11] The International Energy Agency (IEA) also has estimated CO_2 emissions from only the energy sector in the USA.[12] These estimates and data on gross domestic product are shown in figure 6.

41. The long-term fluctuations generally correspond to changes in GDP and are largely compared to the estimated influence on emissions due to changes in the amount of space heating or space cooling.

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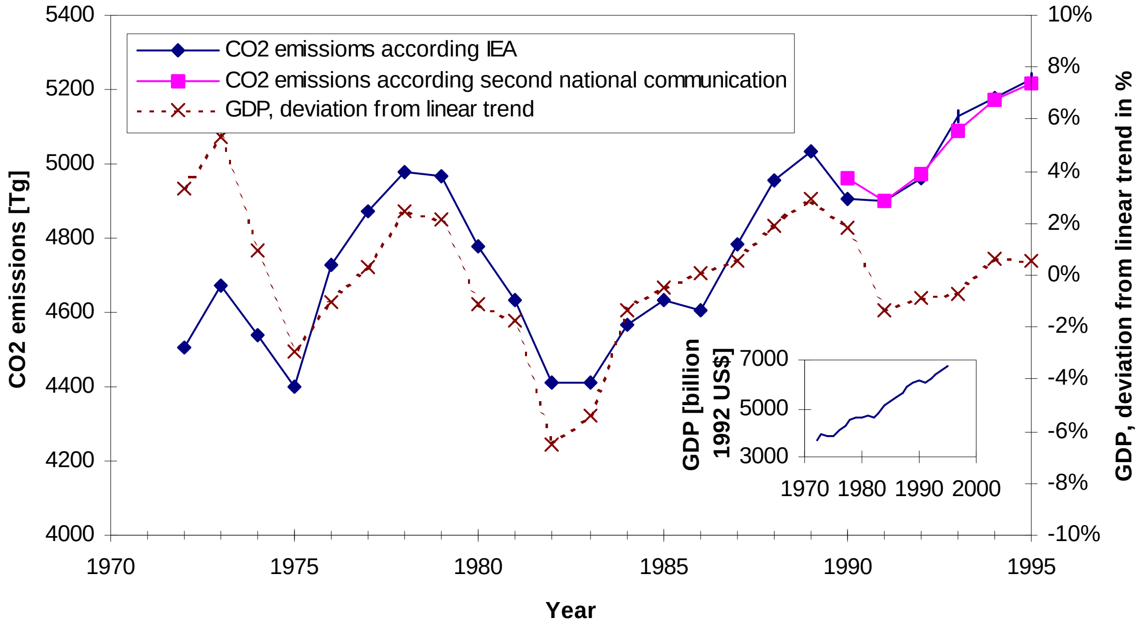
[11] A similar result is achieved by estimating the possible implications of temperature adjustments: The residential and the commercial sector hold together 38% of the primary energy consumption of the USA. If it is assumed that 50% of the energy in the residential and commercial sectors is used for space heating, 19% of the total emissions are temperature dependent. National heating degree day values vary ±10%, which leads to a maximum deviation of ±2% of energy use influenced by temperature. A temperature adjustment in regard to space heating will change the emissions of the USA by a maximum of roughly ±2%. Similarly, the effect of cooling can be roughly estimated: 11% of national primary energy is used for electricity generation for the residential sector and 7% for electricity generation for the commercial sector. If it is assumed that households use 15% of their electricity for air conditioning, and commercial buildings 50%, then 5% of all primary energy is used for air conditioning. Since cooling degree days fluctuate by ±10%, the influence of temperature leads to a change in emissions up to ±0.5% due to space cooling.
(Sources on energy data: Energy information Administration, U.S. Department of Energy, State Energy Data Report 1994, October 1996 and Annual Energy review 1996, 1997).

[12] International Energy Agency, CO_2 Emissions from Fuel Combustion, 1997, Edition (forthcoming): (OECD, Paris).

Figure 6. CO_2 emissions and deviation of the gross domestic product of the USA[13]



V. DISCUSSION

42. 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 section III. In so doing, Parties may wish to consider the possible uses of such methods. In this regard, at least four uses may be envisaged. First of all, these methods may be used to inform other Parties about the effects of temperature fluctuations and other specific influences on annual emissions, in addition to the general trend. They may also be useful in assessing the effects of policies and measures to mitigate emissions in specific sectors at the national level. Further, they may be used to make projections of GHGs in a more consistent manner. Finally, the methods could be useful in assessing the progress made regarding commitments and aims.

43. The first method, that is approach A, is the heating degree day method with fuel used for space heating. It may be used to adjust annual emission inventories and projections of future emissions. The adjustments can be applied very accurately and in great detail, in space or time, provided that national data on fuels used for space heating, on consumer behaviour and stock of buildings are available. In the case national data are not available, applying possible default values would lead to a maximum error of 25% of the correction or 1.75% of total emissions.[14]

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[13] Bureau of Economic Analysis, Survey of current business, USA, August 1997.

[14] Choice of base temperature leads to an uncertainty up to ±10% of relative heating degree days and therefore of the correction. Variation of the elasticity between 1 and 0.5 lead to an uncertainty of up to ±25%. Since the choice

(continued...)

However, historical and/or modelling data on fuel used for space heating have to be available. The approach can support all of the above uses and may have the additional advantage of measuring the effectiveness of policies directed at the space heating sector.

44. 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 a considerable amount of historical data and more complex analysis. As such, it may provide more comprehensive but less accurate information about emissions fluctuations. It could be used to assist in assessing the progress a Party is making regarding its commitments.

45. A simple alternative to the above methods would be averaging emissions over a number of years, as discussed in annex I. It requires no additional data other than that which is required to report annual emissions and it inherently adjusts for all factors influencing emissions in a given period. 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. Averaging emissions as well as other adjustments may change perceptions in the future about how well Parties succeeded in achieving their aims.

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[14] (...continued)
of base / threshold temperatures and elasticity is not independent, an overall maximum error of ±25% can be estimated. If the correction, which is the part added or subtracted to the actual emissions, is ±25% uncertain, and the maximum correction here observed is 7%, then the maximum uncertainty of total adjusted emissions is 0.25 x 0.07 = 0.0175 or ±1.75%.

Annex I

AVERAGES

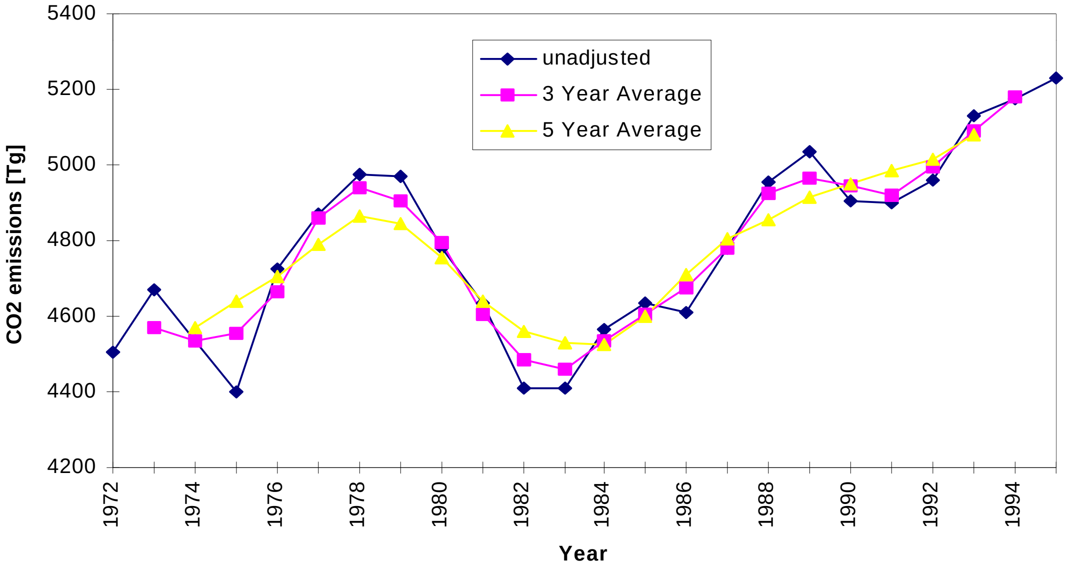
1. Averaging emissions over several years may serve the same purpose as temperature adjustments if used to assist in assessing the progress a Party is making regarding its commitments. Averaging could be used to reduce fluctuations due to all the factors affecting emissions. In the AGBM, possible quantitative emission limitation reduction objectives (QELROs) have been proposed in terms of average emissions or budgets, instead of single year targets. The implications of different averaging methods on assessing compliance with a target is discussed in this annex.

2. As an alternative to using emissions of single years for comparison, emissions could be averaged over a period around a year (moving average). Averaging periods of three or five years could be used with the aim to reduce short-term fluctuations and reveal the long-term trend. The averaging period has to be chosen in the light of the nature of the fluctuations and the number of years observed.

3. For illustrative purposes, figure 1 shows the implications of applying a three- and five-year moving average to the CO_2 emissions from fuel combustion of the USA as estimated by the IEA.[1] Shown are the emissions of the years 1972 to 1995 in relation to the emissions 1990. It can be observed that the fluctuations around the year 1990 are reduced using a three-year average and eliminated using a five-year average.

[1] International Energy Agency, CO_2 Emissions from Fuel Combustion, 1997, Edition (forthcoming): (OECD, Paris).

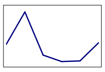
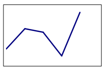
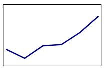
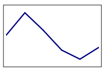
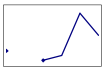
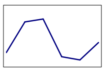
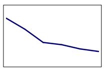
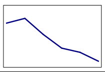
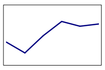
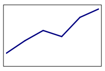
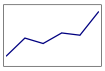
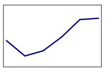
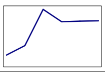
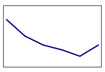
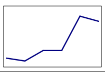
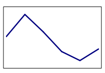
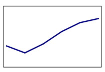
Figure 1. CO_2 emissions from fuel combustion of the USA, three- and five-year moving average (1990=100)



4. Using averages may be limited if data prior to 1990 is not available. However, to illustrate how perceptions about emissions would change should different averages be used for comparisons, three different types of comparisons are provided (table 1). These include the percentage change in emissions between the single years 1990 and 1995, the percentage change in the average of emissions between 1991 and 1995 as compared to 1990 and the percentage change in emissions between the average 1990-92 and 1993-95. Also included are miniature images of emission trends for the period 1990 to 1995.

5. In the context of QELROs, the total emissions allocated to a country over some period of time would be called a budget. Quantifying the change in emissions would necessitate comparing the budget to emissions of a single base year or the average emissions around some base year. A budget takes into account the development of the emissions during the observed period as illustrated in figures 2 (a-e). Figure 2 (a) shows a 10% reduction in emissions between a single base year and a single target year. Figures 2 (b-e) illustrate the change in emissions between a single base year and the average emissions resulting from different paths over a ten-year period. Figures 2 (f-i) illustrate the change in emissions between the average of the first and second five-year period. Similarly, the average emissions around a base year could be compared to the average emissions at some point in the future.

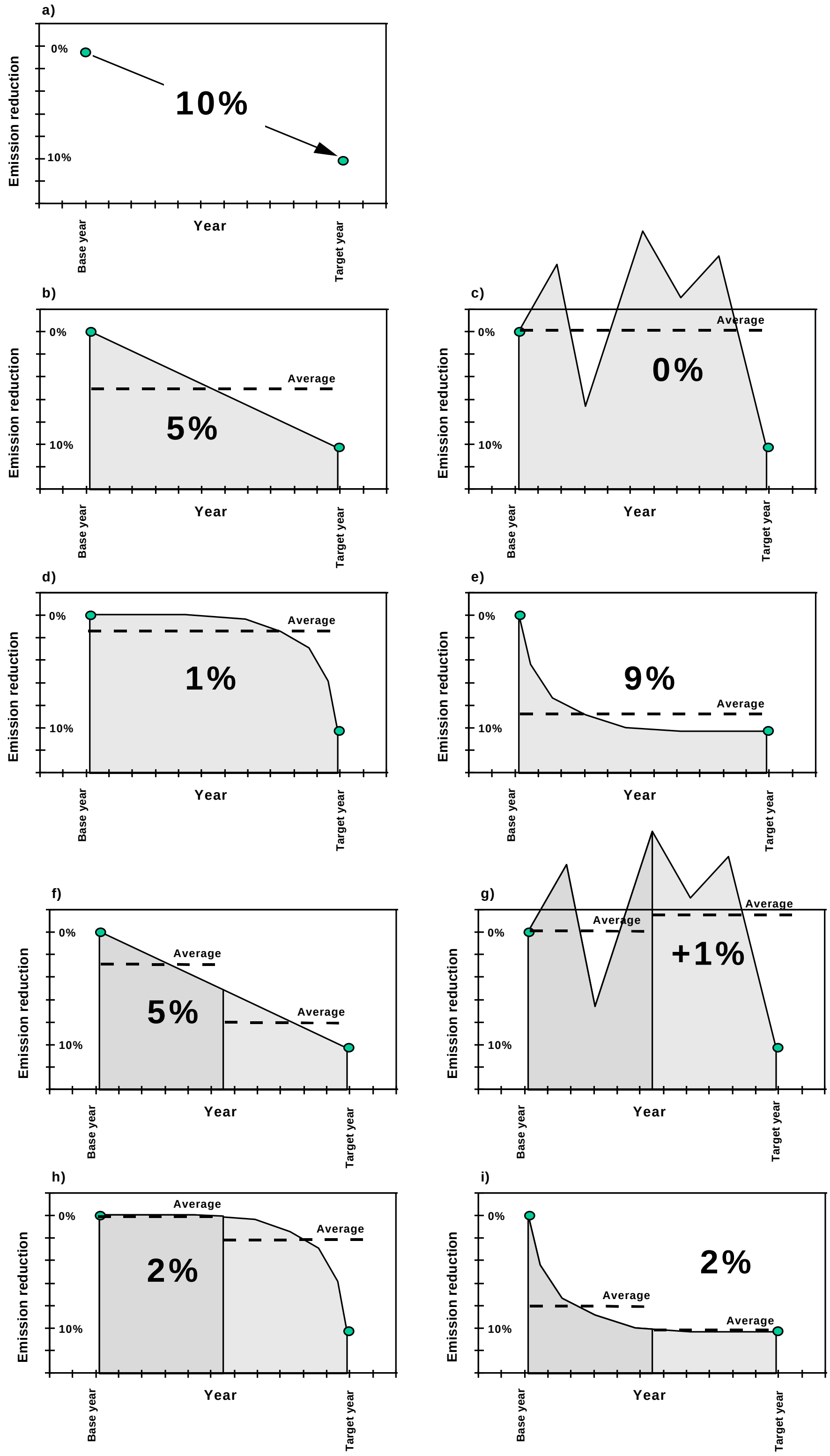
Table 1. Percentage change in CO_2 emissions based on single years, the difference between 1990 and a five-year average as well as two three-year averages[2]

Country	[3]	Percentage change in emissions between 1990 and 1995	Percentage change in emissions between 1990 and average 1991-95	Percentage change in emissions between average 1990-92 and average 1993-95
Austria		0.2	-0.6	-4.2
Belgium		N.A.	N.A.	N.A.
Canada		7.7	2.3	4.7
Czech Republic		-22.1	-17.2	-14.7
Finland		4.2	N.A.	N.A.
France		1.8	2.3	-4.0
Germany		-11.8	-8.9	-6.8
United Kingdom of Great Britain and Northern Ireland		-6.9	-3.6	-5.3
Iceland		6.3	3.5	6.8
Ireland		10.5	6.3	4.7
The Netherlands		9.5	5.1	4.0
Norway		6.6	1.2	7.4
New Zealand		7.4	6.7	3.2
Slovakia		-19.2	-20.1	-14.3
Sweden		4.8	2.4	3.6
Switzerland		-2.0	-0.8	-4.1
United States of America		5.0	2.2	4.3

[2] Based on data submitted by the Parties (FCCC/SBI/1997/19).

[3] Miniature images show the emission trends for the period 1990 to 1995.

Figure 2. Reduction in emissions between a single base year and a single target year (a), change in emissions between a single base year and the average emissions resulting from different paths over a ten-year period (b-e) and change in emissions between the averages of the first and second five-year period (f-i)



Annex II

CALCULATION OF METHOD B FOR THE NETHERLANDS

1. Since the complete dis-aggregated fuel consumption data for a long period was not available, only a simple analysis was performed without recalculating the inventory. The unadjusted gas consumption[1] was adjusted according to method B and the difference due to the adjustment was added to the unadjusted emissions.

2. To obtain the adjusted gas consumption, a multiple linear regression was performed in order to obtain the simple relations:

$$C = a + b \cdot HDD + c \cdot TREND$$

C:	uncorrected fuel consumption
HDD:	heating degree day index of the considered year
TREND:	trend variable increasing by one each year
a,b,c:	constants determined by the analysis

$$C_{norm} = a + b \cdot HDD_{norm} + c \cdot TREND$$

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

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[1] Received from Centraal Bureau voor de Statistiek (CBS), the Netherlands.