Pathways to climate stabilisation

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Abstract

Global climate warming mitigation efforts are more likely to be successful if they

are based on per capita emissions rather than on complex negotiated emission

rights. I propose a path to temperature stabilisation optimised for each country

and reaching a common per capita rate of greenhouse gas emissions by the

end of the 21st century. Consistent emission pathways for given levels of

temperature stabilisation are calculated by use of a simple model that is

consistent with the circulation models and data sets surveyed by the

Intergovernmental Panel on Climate Change. The allowable emissions are

detailed on a regional level and on individual country level. I discuss the merits

of this type of approach relative to other policy approaches, as well as some of

the objections that may be voiced.

1 Introduction

Country-by-country individual CO_2-emission targets, such as those recently suggested

by the EU, are bound to create problems, both as concerns agreement, extendibility to

the rest of the world, and probability of actually being carried through. The individual targets are based on factors such as current economic situation and growth, and to some extent the present use of renewable or nuclear energy. When non-compliance becomes evident, we will hear excuses such as "our economic growth was higher (or lower) than assumed in setting the targets" or "our targets were anyway set too high in comparison with those of Romania".

Let me suggest instead an approach, which is both simple and easy to understand, and which therefore has a chance of working in the real world, namely to introduce a common ceiling on per capita greenhouse gas emissions, along with optimal pathways allowing each country to reach the ceiling before a specified date. The advantages of a per capita approach have been aired in connection with previous climate summits, but no political action has pursued. A number of possible objections to the idea will be discussed below. First I use the IPCC modelling methodology to explore the characteristics of such an approach to climate stabilization.

2 Pathways derived from simple climate model calculations

The models reviewed by IPCC try to establish a connection between stabilisation of the global temperature average (and other climate impacts) at a given level, the corresponding equilibrium concentration of greenhouse gases in the atmosphere, and the allowable CO_2-emissions and other climate-altering human activities, that policies have to ensure in order to reach stabilisation at the desired level. The general circulation models used in climate science proceeds from given emissions to calculated atmospheric concentrations, from which temperature changes are determined. Thus one would have to look at many calculations with specific emission assumptions in order to

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find those, for which the average temperature reaches say 1.5°C above the year-2000 average temperature level (which translates to some 2.1°C above the pre-industrial level). They would require a stable 450 ppm level of CO_2 in the atmosphere (some 500 ppm if other greenhouse gases are included), with the uncertainty induced mainly by model accuracy but also by the different residence time of different greenhouse gases and the changes in cooling associated with particulate emissions from industry or from volcanoes. It follows that anthropogenic emissions of greenhouse gases would have to be radically reduced (Solomon *et al* , 2007; Metz *et al.*, 2007). The reverse calculation from a given temperature stabilisation to the implied allowable emissions profiles (emissions as function of time) is not unique but requires additional assumptions, such as mitigation costs and technology readiness, in order to allow the determination of an optimal path to stabilisation.

Figure 1 shows such global average stabilisation routes calculated in terms of CO_2 emission profiles of various policies for reaching a stable situation before year 2100, with average surface temperature increases in the range of 1.0 to 2.5°C. These temperature rises are relative to year 2000 and the model assumes similar reduction in other greenhouse gases. The emissions in Fig. 1 are shown per capita, i.e. global emissions divided by global population for a given year. The historic data are those used by the IPCC, and the 21st century values are calculated using a simple model called the Java Climate Model (Matthews, 2008). It very well reproduces the results of earlier IPCC assessments and the results given in Fig. 1 are consistent with the simulations presented in the most recent IPCC report (Metz *et al.*, 2007). Detailed comparison is not possible because the IPCC report only gives ranges of results for a selection of literature emission scenarios, whereas the present calculation determines the emissions leading to

a precise level of warming dynamically by iterating the approach to stabilization. The present calculation uses a population development reaching 10^{10} by the end of the 21st century, like in the IPCC "B2" scenario (Metz *et al.*, 2007). The calculation behind Fig. 1 further assumes that per capita emissions converge towards a common value and reach it at or shortly after year 2100. The emission pathway to be followed by different regions of the world is depicted in Fig. 2, for the 1.5°C warming calculation of Fig. 1. The same on an individual country level is contained in spreadsheet-form in the Electronic Annex, along with the input data for the computer model. The calculation takes into account the ability of different economies to mitigate greenhouse gas emissions, and mitigation therefore starts a little earlier in the most technologically advanced regions.

The stabilization corresponding to the 1.5°C case of Fig. 1 can thus be achieved by imposing the increasingly strict (as function of time) per-capita emission limits as shown in Fig. 2 for each region of the world or for each country. The limits start at the current level of emissions and converge to the common goal value by the end of the 21st century. Legislation can be introduced in each country to impose the diminishing ceiling either individually or collectively. The time-wise accumulated emissions on a regional basis are given in Table 1, but it would be wise to monitor compliance by requiring the sliding targets to be met say by the end of each decade, in order to detect any non-compliance and implement penalties such as trade embargos, provided these measures have been agreed. The concurrent reduction of non-CO_2 greenhouse gas emissions is shown in Fig. 3, for the 1.5°C case.

Clearly, not only emissions from national activities (raw materials extraction, production, transport and consumption) should be considered, but also emissions from

international air and ship traffic. To include these emissions in the national emission budget of each country, which also includes the corresponding transport activity in its activity measure (such as GNP), is a straightforward extension of the current method of accounting in the international climate negotiations. It would substantially increase emission counts for countries with large shipping industries, such as Denmark, but would similarly show up as economic activity in GNP accounting. There are at least two other ways of allocating emissions. *a*: to ascribe emissions to the financial owners of each activity, or *b*: to ascribe the emissions to those using or benefiting from the product or service causing the emissions (along its life-cycle). Providing data for these alternative accounting principles is more difficult that for the method currently in use, but not impossible given the wealth of statistical data available (for *a*, emissions from enterprises would be distributed on shareholders according to country affiliation, while for *b*, the emissions from production and transport would be distributed on the final consumers according to country or residence, as derived from trade statistics). Method *b* would increase emission allocations to countries outsourcing energy-intensive production to other parts of the world, and would decrease emissions for those developing countries carrying out such energy-intensive production but exporting most of the products. The calculations presented in this communication all use the conventional accounting by country of performed activity.

Regarding the overall feasibility of achieving the necessary reductions in emission of greenhouse gases, several detailed scenarios have been worked out to show that the implied phasing out of emissions is indeed technically possible, economically affordable and compatible with continued increase in living standards, everywhere (Sørensen and Meibom, 2000; Sørensen, 2004; 2005; 2007).

3 Discussion of possible objections to the per capita approach

Are there caveats in this approach? Looking at the historical part of the per capita emissions in Fig. 1, one notes that the per capita emissions have risen remarkable little during the 20th century, obviously due to the explosive development of the world population and massive poverty in many parts of the world, with the associated smallness of emissions. Population increase is a main reason for the lack of success in creating economic welfare for all the inhabitants of the world, and economic disparity has increased rather than decreased. Does the population increase make it easier for the rich to continue high greenhouse gas emissions? The answer is that this is not the case even when the regional per capita emissions are used to regulate future emissions, as assumed in Fig. 2. Countries in North America or Australia will have to use their technological skills to accomplish a rapid but realistic decrease in emissions, while the less developed countries have lesser per capita reductions prescribed. However, there is no invitation to avoid using mitigating technology, because the current inefficient use of land and energy already lead to emissions above the target. These developing countries may complaint that the scheme does not allow them to increase their emissions to US levels before doing something about the problem, but that is precisely the intent: move directly towards the stable situation without detours that may form bad habits clouding the future efforts. The proposed ceilings are proper and realistic because a country seeking high economic growth must invest in new equipment and processes and thus may as well choose the right solution right away. Reasoning that the proper solutions are more expensive is false because the expenses will have to be paid anyway, and may be higher the longer one waits. It has also been suggested that the long-industrialized

countries should pay for the sins of the past (grand-fathering), but after all precise knowledge of the global warming effects has only been available for about 40 years, and the suggested scheme anyway demands a very rapid mitigation from the rich nations.

Would a scheme like the proposed one encourage nations to increase their population in order to get higher emission allowances? That is hardly the case, because the greenhouse mitigation costs are in any case small compared to the efforts needed to create economic welfare for more people. There is also no reason to compensate regions with lower than average population density, as this is usually a consequence of land areas hard to populate (examples are in Arctic or desert regions). Avoiding overpopulation should in any case be a primary target in any region of the world. Population stabilization must be a strong international priority with efforts at least as serious as in the case of greenhouse gas emissions. The fact that food production growth until now has on average kept up with population increase (although not necessarily the distribution of food to all) does not mean that it will continue to be possible or environmentally sustainable (Friedlingstein, 2008).

The tradable emission-permits envisaged by some current greenhouse abatement schemes would hardly be needed for the scheme I suggest. They aim at having investments made in the order of increasing abatement cost and would typically move investments from the countries with large emissions to less developed nations, where the equipment installed may not be used properly and thus not be achieving the proposed emission reductions. The time-scale on which greenhouse gas emissions have to be dramatically reduced is so short, that fiddling with the succession of investments seems quite unimportant. The high-emission countries have the skills and should reduce

their own emissions as quickly as possible, which is exactly what the proposed scheme can accomplish. Tradable permits constitute an attempt to force the greenhouse problem into a framework of 19th century liberal economic theory, assuming that the market will solve any and all problems. We know that this is not true, and the global warming damage is a perfect example of the need to base political action on more than antiquated economic dogmas.

References and notes

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Electronic Annex: Spreadsheet with individual country emissions, and computer input file.

Table 1. Total allowable emissions for the entire 21st century and number of years that the allowed CO_2 emissions of each region could continue at constant 2007-level, provided that it is reduced to zero after that time span.

Stabilisation by 2100 at 1.5 deg. C above 2000-level	Accumulated emission allowance 2000-2100 (Gt CO_2)	Years to zero-CO_2 allowance at constant 2007-emissions
United States	255	42
Canada Australia New Zealand	44	30
Japan	65	49
West Europe	179	50
East Europe B	34	49
Russia Ukraine Belarus	78	39
Middle East	161	79
China	250	64
Other Asia	155	76
India	183	144
Latin America	86	41
Africa	213	115
Int. Ship/Air	80	95
World	1783	61

Figure captions

Figure 1. Per capita CO_2 emissions leading to a global warming between 1 and 2.5 °C

relative to year 2000. Population development indicated at top.

Figure 2. Regional per capita CO_2 emissions leading to stabilization of global warming

1.5 °C above the level in year 2000. Upper panel: current high-emission regions.

Lower panel: present low-emission regions.

Figure 3. Per capita total emissions expressed as CO_2-equivalent ones for the model

calculation leading to a global warming stabilising at 1.5 °C above the year-2000

average temperature, and for comparison the CO_2-emissions alone, used in

Figs. 1 and 2.

Per capita CO_2 emissions leading to a given global warming relative to year 2000

Regional per capita CO$_2$ emissions leading to 1.5 deg C globally above year-2000 level

Regional per capita CO$_2$ emissions leading to 1.5 deg C globally above year-2000 level

Per capita CO₂ emissions leading to 1.5 deg C global warming relative to year 2000

Calculations without and with non-fossil emissions

- – – 1.5 deg C
- ⋯⋯ 1.5 deg C (calculation including non-fossil emissions)

Year (world population in 10^9 indicated at top)