Long-term greenhouse gas emission reductions – what's possible, what's necessary?

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Viewpoint

Abstract

Climate is changing (WMO 2003) and there is increasing evidence that this is due to human activity (IPCC 2001). One way to react is to reduce greenhouse gas emissions into the atmosphere. Though this approach generally does not cause much objection, disagreements do occur when concrete emission targets are to be set. Against this background, the following article provides an arithmetic approach for the determination of long-term emission targets where the US and the EU are studied as examples.

Key words

Emission reductions, GHG emission intensity, economic growth

Introduction

There seems to be a consensus that absolute GHG emissions should be limited in order to prevent negative impacts from climate change; Art. 2 of the United Nations Framework Convention on Climate Change (UNFCCC 1992) stipulates the objective as follows:

> *The ultimate objective of this Convention and any related legal instruments that the Conference of the Parties may adopt is to achieve, in accordance with the relevant provisions of the Convention, stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner.*

However, there is disagreement about the concrete time of and responsibility for the emission reductions compared to the business-as-usual path. The standpoint of the individual to these questions may vary depending on a number of reasons, as for example attitude towards risk, the discount rate considered as appropriate or the justice principle that one believes to be appropriate. However, apart from these individual attitudes, one may look at this issue from a more objective point of view, as for example an arithmetic analysis of what seems feasible regarding long-term emission targets. In this context, the long-term perspective is determined from the policy makers' point of view. Political decision makers are generally most concerned about the very near future, or more precisely the next elections. The long-term perspective used in this framework thus differs considerably compared to the others such as a long-term horizon used in climatology.

Emission intensity and mid-term targets until 2010

Following Sun (2002, p. 83) CO_2 emissions are the product of emission intensity and GDP, where the *emission intensity* is defined as *emissions per GDP*. Consequently, two options are available for reducing absolute emissions: Firstly, to reduce GDP, or secondly, to reduce emission intensity. Regarding the Kyoto-targets Sun (2002, p 83) states that "… an economic recession is discounted as an undesirable method for achieving the Kyoto Protocol…". Thus, the only way to realise absolute emission reductions until 2010 is to decrease emission intensity.

Indeed, currently policy makers rather seem to be keen in increasing GDP, especially as they hope to reduce unemployment this way. With growing GDP, however, not only must emissions be reduced compared to current levels but also compared to future (increasing business-as-usual) emissions. Consequently, reductions in emission intensity must be increased depending on the growth as depicted Figure 1

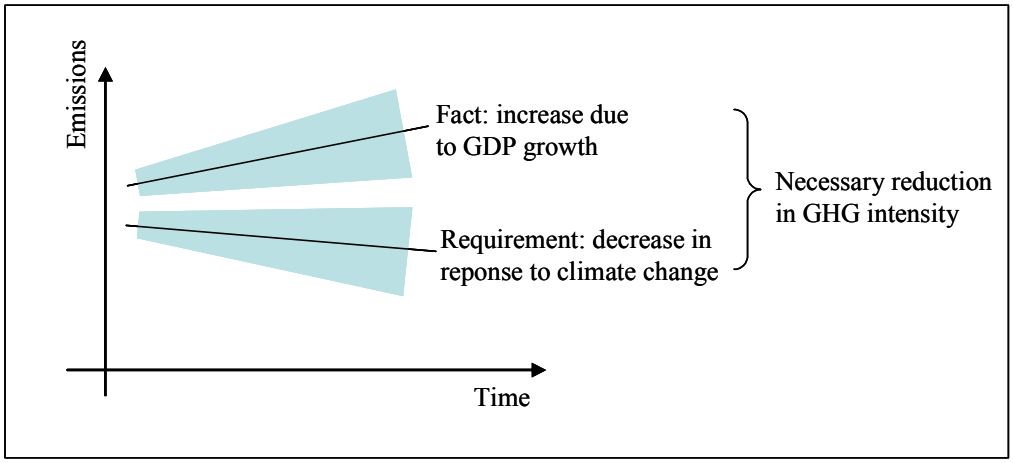

Fig. 1: Factors influencing necessary reductions in GHG intensity

Sun (2002) formalises this aspect for the emission targets defined in the Kyoto-Protocol as follows:

$$(1) \qquad E^{2010} = I^{1997}(1-\beta)^{13} GDP^{1997}(1+\lambda)^{13} \leq E^{1990}(1-k^*)$$

where E^{2010} = emission target in 2010 (2010 target year in place of the first commitment period from 2008 to 2012), I^{1997} = emission intensity in the reference year 1997 (t / $), GDP^{1997} = Gross Domestic Product in the reference year 1997, E^{1990} = emissions in the base year 1990, β = average annual reduction rate of GHG intensity, λ = average annual GDP growth rate, E^{1990} = emissions in the Kyoto base year 1990, k^* = overall reduction rate for the target year 2010 compared to the base year 1990

Based on data for CO_2, he studies different GDP growth-rates and the resulting necessary decreases for the emission intensity. Comparing the result with changes in CO_2 emission intensity for the years 1972 to 1998, he concludes that "… we are running out of time in our obligations to the needs of future generations." (Sun 2002, p. 84).

Long-term emission targets until 2050

It goes without saying that the main idea of this discussion for the first commitment period of the Kyoto Protocol is generally also true for any future emission target. Especially in the context of a longer term perspective it is worthwhile to remember that

limits to growth have been proposed (Meadows et al. 1972), at least with regard to material products.[1] Although one of the results of the report, the concept of "sustainable development", has entered the political stage and is almost omnipresent today, it does not seem human kind has drawn the obvious conclusions (see Meadows et al. 2004).[2] This is why I use growth rates, which are currently realised, also in the long-term analysis below. The approach proposed is also applicable in a world where only the service sector is growing[3] or even in a state of global equilibrium as long as absolute GHG emission reductions are still required.

With regard to this target, no binding long-term commitments, i.e. commitments until 2050, have been made by any government. Only hesitantly do they address this issue. In the run-up of the negotiations in Kyoto, the EU-Council concluded that "…given the serious risk of such an increase [of global average temperature] and particularly the very high rate of change, the Council believes that global average temperatures should not exceed 2 degrees above pre-industrial level and that therefore concentration levels lower than 550 ppm CO_2 should guide global limitation and reduction efforts" (EU Council 1996). However, no link regarding absolute emission limitation was made. Recently the UK government accepted "…the Royal Commission on Environmental Pollution's (RCEP's) recommendation that the UK should put itself on a path towards a reduction in carbon dioxide emissions of some 60 % from current levels by about 2050" (UK 2003, p. 4 and RCEP 2003).

However, although future GDP growth is unknown, policy makers might be interested in what such absolute targets imply regarding the emission intensity introduced above.

[1] According to the report "a state of global equilibrium" with a stable world GNP is possible.
[2] In this context Slesser writes already 1972: "Practically no economist has given serious thought to the problems of economic stability. For one thing, stability is read as stagnation, and for another, it is hard to find an employer who is interested in economic equilibrium. It has no appeal to governments, politicians, board chairmen, company presidents or even to used car salesmen…" (Slesser 1972 p. 719). It does not seem that economic equilibrium is appealing at the beginning of this millennium neither.
[3] Especially when one assumes that the additional activities within this sector result in (at least some) emissions.

By transforming equation (1) to

$$(2) \qquad \beta \geq 1 - \left[\frac{E^{1990}(1-k)}{I_e^T GDP^T (1+\lambda)^t} \right]^{\frac{1}{t}}$$

where T = reference year, t = number of years between target year X and base year 1990

it is possible to quantify the necessary decrease in emission intensity for any emission target E^X in year X which is defined as follows:

$$(3) \qquad E^X = E^{1990}(1-k)$$

Using these equations, Table 1 shows the necessary decrease in emission intensity for the US and Europe (EU 15) depending on GDP growth rate λ and reduction rate *k* for the target year 2050. Note that emission data comprise the whole basket of GHG emissions as defined in the Kyoto-Protocol.

Tab. 1: Required annual reduction in emission intensity depending on the emission target and the growth in GDP

Overall emission reduction rate	Average annual real GDP growth rate (λ in %)					
for 2050 compared to 1990	1		2,5		5	
(k in %)	US	EU	US	EU	US	EU
25	1,66	1,61	3,10	3,05	5,41	5,36
30	1,80	1,74	3,23	3,18	5,54	5,49
35	1,94	1,89	3,38	3,33	5,68	5,63
40	2,10	2,05	3,53	3,48	5,83	5,78
45	2,27	2,22	3,70	3,65	5,99	5,94
50	2,45	2,40	3,88	3,83	6,17	6,12
55	2,66	2,61	4,08	4,03	6,37	6,32
60	2,89	2,84	4,31	4,26	6,59	6,54

*) β, k and λ as defined in equation 2, T = 2000; GDP in 1995 prices and exchange rates (see also Figure 2)

Comparing the results in Table 1, it is interesting to see that the required reduction in emission intensity for the same overall emission target and the same GDP growth rate is

quite similar for the US and the EU, although their attitude towards climate change, or at least towards the Kyoto-Protocol, is very different. If the reduction in emission intensity was a commonly accepted criterion to judge on the fairness of burden sharing, the US and the EU should accept the same overall emission target. However, as Sun (2000) pointed out, one has to remember that there are different factors influencing distinct emission intensities. Furthermore, it goes without saying that the future development of GDP may differ between the two regions, which in turn may result retrospectively in an unfair burden sharing when looking back in 2050.

Apart from the comparison between the US and the EU it is also interesting to discuss the absolute level. Figure 2 shows the change of emission intensity for the US and the EU respectively for the years 1991to 2001.

As can be seen, the annual average reduction in emission intensity compared to the previous year was 1.8 % and 2.4 % for the US and the EU respectively. One may discuss whether additional policies to curb emissions introduced in the 1990ties have already become effective or whether only “no-regret measures” with regard to abatement costs were introduced. Especially in the latter case, it seems obvious that the figures from the past form the upper boundary for the future development of the emission intensity as the potential of these no-regret measures is limited.

Given this experience from the past and assuming for example that the future real annual average GDP growth is somewhere around 2.5 %, one can see in Table 1 that a 50 % reduction target compared to 1990 as suggested by the UK is already very ambitious. The required reduction in emission intensity would be 3.88 and 3.83 for the US and the EU respectively.

Or put more general: ambitious and necessary reductions of GHG emissions to achieve stabilisation of atmospheric greenhouse gas concentrations require stringent additional measures to reduce emission intensity – especially if decision makers continue to believe in high GDP growth rates to be desirable.

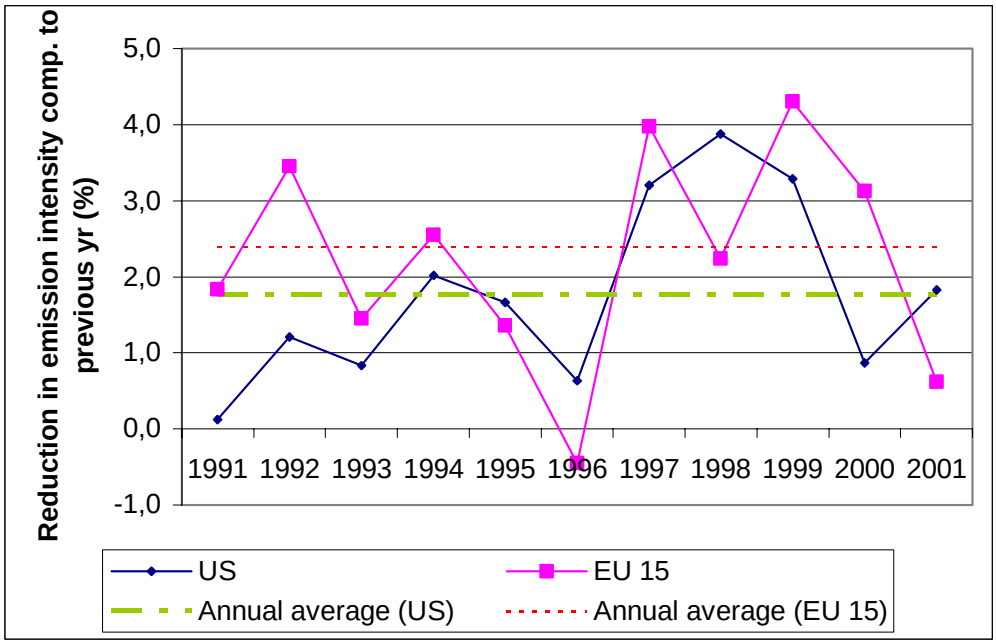

Fig. 2: Reduction in emission intensity for the US and the EU compared to previous year (GDP in 1995 prices and exchange rates)

Data: Emissions: US EPA (2003), EEA (2003), GDP: OECD (2004)

References

EEA (2003) Annual European Community Greenhouse Gas Inventory 1990-2001 and Inventory Report 2003 (final draft), European Environment Agency, (electronic version)

EU Council (1998) COMMUNITY STRATEGY ON CLIMATE CHANGE - Council conclusions, Press Release: Luxembourg (16/6/1998) - Press:205 Nr: 09402/98

IPCC (2001), Climate Change 2001 The Scientific Basis, Cambridge University Press, Cambridge

Meadows, Donella H.; Meadows, Dennis L.; Randers, Jorgen (2004) The Limits to Growth: The 30-Year Update, Chelsea Green Publishing, White River Junction

Meadows, Donella H.; Meadows, Dennis L.; Randers, Jorgen; Behrens, William W. (2004) The Limits to Growth: A Report for the Club of Rome's Project on the Predicament of Mankind, Universe Books, New York

OECD (2004) OECD Main Economic Indicators, data taken from datastream on March 1, 2004

RCEP (2003) THE SCIENTIFIC CASE FOR SETTING A LONG-TERM EMISSION REDUCTION TARGET, Royal Commission on Environmental Pollution

Slesser, Malcom (1972) Disaster Postponed, in: International Organisation, 26, 4, pp. 719 - 728

Sun, Jiwu (2002) The Kyoto negotiations on climate change – an arithmetic perspective, in: Energy Policy 30, pp. 83-85

Sun, Jiwu (2000) Is CO_2 emission intensity comparable?, in: Energy Policy 28, pp. 1081-1084

UK (2003) ENERGY WHITE PAPER Our energy future – creating a low carbon economy, Department for Trade and Industry, Norwich

UNFCCC (1992) United Nations Convention on Climate Change, United Nations, retrievable on: www.unfccc.org

US EPA (2003) Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 – 2001, (electronic version)

WMO (2003) ACCORDING TO THE WORLD METEOROLOGICAL ORGANIZATION, EXTREME WEATHER EVENTS MIGHT INCREASE, Press release No. 695, World Meteorological Organization