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EU 2020 climate target: 20% reduction requires five-fold increase in impact of CO_2 policies

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Summary

In this paper we quantify the impact of environmental policies on greenhouse gas emissions in the EU between 1990 and 2005. We estimate that without environmental policies in the EU during this period, emissions of the six greenhouse gases under the Kyoto protocol would have been approximately *7%* higher in 2005 than they were in reality. This emission reduction amounts to some 380 Mt CO_2-eq and is the explicit result of environmental policies in Europe. For the 2006-2020 period, we have calculated that an additional policy effort of 1100 Mt CO_2-eq will be required. We estimated this number by comparing a baseline (business as usual) emission in 2020 with the EU's recent ambition to attain a 20% reduction of greenhouse gas emissions in 2020 compared to 1990. By combining these ex-post and ex-ante calculations, we determined that achieving the 2020 climate target will require the EU policy impact on greenhouse gas emissions to increase by *a factor of three* halfway between 1990 and 2020. For CO_2, the policy impact must increase by a *factor of almost five*. This difference is because reductions of non-CO_2 greenhouse gases will have a much smaller share in the required future emission reductions than was the case between 1990 and 2005.

Introduction

Ex-ante estimates of the potential impacts of environmental policies are a core output of scenario analyses. Generally speaking, in such studies simulation models are used to construct a baseline or 'business as usual' development from assumptions concerning economic growth, energy demand, technology development and policy implementation (EEA, 2005a). On top of such a baseline, the expected impacts of single policies, or packages, are evaluated. This process of ex-ante evaluations links up directly with EU policy making. Examples include the RAINS scenarios that are used in the Clean Air For Europe programme (Amann et al., 2004) and the PRIMES scenarios that are important inputs to EU energy and climate policies (EC, 2003).

Ex-post policy evaluations hind cast the effectiveness of policies in place and have the potential to function as a tool to improve future policies or strengthen their implementation. Such evaluations still appear to have a smaller role in the policy cycle than ex-ante evaluations. For that reason, the EU's 6th Environmental Programme (2002-2012) expressed the need to undertake 'ex-post evaluation of the effectiveness of existing measures in meeting their environmental objectives' (EC, 2001). In response to this call, the European Environmental Agency has started a series of ex-post policy evaluations (EEA, 2005b, c).

The ex-post quantification of environmental policy impacts is not a straightforward task (see *textbox: structural decomposition*). Of course, time series of monitored air and water quality reflect the impact of environmental policy, but observed trends in the environment cannot always be easily traced back to individual environmental policies. By definition, abated emissions – which are in fact non-emissions – cannot be measured, but have to be estimated from an assumed reference development. This requires assumptions about what the world would have looked like in the absence of certain policies. To establish such a reference, different methods can be used that lead to different results (Gijsen and Oude Lohuis, 2005). Because the results depend on the method chosen, quantitative ex-post policy evaluations should at least be transparent in their methodology and should reflect on the extent to which methodological choices affect the main conclusions of the study.

Despite these difficulties, in this paper we have made quantitative estimates of the impact of environmental policies in the EU on greenhouse gas emissions. We have made such estimates for the period 1990-2005 for the nine most relevant policy areas. This addresses the first research question of our study: *what has been the impact of environmental policies on the emissions of the six Kyoto greenhouse gases in the EU between 1990 en 2005?* Next, we compared the overall estimated policy impact during 1990-2005 with the overall policy impact that will be required during 2006-2020 to attain the EU's 2020 climate goal: a 20% reduction in greenhouse gas emissions in 2020 compared to 1990 (European Council, 2007). We estimated that impact by using results from available ex-ante scenario analyses. Note that we used two time periods of identical length, 1990-2005 and 2006-2020, which allowed us to compare ex-post and ex-ante policy impacts. This addresses the second research question of our study: *how much should policy impact increase, halfway through the 1990-2020 period, to reach the new 2020 targets?* Finally, we briefly analysed the main uncertainties in the overall estimate of environmental policy impact on greenhouse gas emissions in the EU.

Structural decomposition of emissions time trends

One well described technique to analyze the impact of economic and technological developments on trends of environmental pollutants is the method of structural decomposition, abbreviated as SDA (Haan, 2001). This method uses national accounting matrices, including Environmental Accounts, to decompose temporal trends, such as CO_2 emissions, into various determinants. These determinants include i) changes in economic demand (consumption, exports, investments), ii) changes in the structure of production and consumption and iii) changes in the environmental intensity of production. The latter is the environmental pressure per financial unit of production. The CO_2 intensity is typically an aggregated determinant that includes changes such as fuel shift, autonomous improvements in clean technology and environmental policy induced improvements. Environmental policies are not a separate determinant in SDA, and the quantified effects of SDA are generally much larger than those of environmental polices alone. This is illustrated by Wilting et al. (2007), who give typical SDA results for CO_2 emissions of Dutch industries. Overall CO_2 emissions of Dutch industry increased by 17% between 1990 and 2004. Dominant drivers for this increase were volume growth (+39%), partly compensated by a decrease in CO_2 intensity of production (-19%).

Estimating policy impacts

We included the following nine most relevant policy areas in our study: renewable energy, land filling, N_2O from chemical industries, energy savings in the build environment, the Common Agricultural Policies (CAP), road transport, fluoride gases (F-gases), combined heat-power generation (CHP) and other efficiency improvements in industry.

To estimate the policy impact for each of the nine sectoral policy packages below, we determined reference emissions for each sector, starting in 1990 and ending in 2005. The impact of policies was estimated from the difference between the reference emissions and the actual monitored emissions, as available from public statistics sources for 2006 (EEA, 2006, 2007). In the reference situation, all the conditions except for sectoral environmental performance are assumed to be the same as in the actual situation. This includes sectoral volumes of electricity production, chemical production or amounts of land-filled waste. In the reference situation the sectoral environmental performance is poorer than in the actual situation due to the presumed absence of the environmental policies being studied. In some cases it was assumed that the reference sectoral environmental performance remained constant at the 1990 level, in other cases an autonomous improvement was assumed (see below). Uncertainties in the quantification of policy impacts are briefly discussed in the *textbox uncertainties.*

Renewable energy policies
Due to the influence of renewable energy policies in the EU and the Member States, renewable electricity production in the EU-25, excluding large-scale hydropower, increased four-fold between 1990 and 2005. Production of renewable heat and liquid biofuels for transport both increased by 20% (BRAC, 2006; EC, 2002; IEA, 2003). All these policies saved around 96 Mt of CO_2-eq in 2005. We calculated this number by assuming that in the

absence of renewable energy policies (the reference situation) electricity would have been produced with a natural gas fired power plant of EU-average efficiency, that heat would have been produced with a natural gas fired boiler with an efficiency of 90% and in the transport sector petroleum products such as petrol and diesel would have been used rather than biofuels.

Landfill gas policies
As a result of waste policies, emissions of methane from landfill sites in the EU-25 decreased by 40% between 1990 and 2005 (EEA, 2007). At the EU level, the Landfill Directive was introduced. This requires among other things increased use of landfill gas collection and energy recovery from the produced methane. We calculated the impact of landfill policies based on the assumption that in its absence CH_4 emissions per unit of waste would have stayed at the same level as in 1990. In that case, total EU-25 greenhouse emissions would have been 51 Mt higher in 2005.

N_2O from industry
N_2O emissions from industry in the EU-25 decreased by more than 50% between 1990 and 2005 (EEA, 2006). Most N_2O emissions from chemical industries occur in adipic acid and nitric acid production. The N_2O emissions from adipic acid production in the EU-25 decreased by 80% between 1990 and 2005. Most of the reductions were achieved between 1997 and 1999 due to the implementation of reduction measures in German, French and UK adipic acid production (Öko-Institut, 2006; EEA, 2004) and in 2004 due to an additional reduction in France (EEA, 2006). In Germany, the policy is based on a voluntary agreement between industry and the federal government. France has a tax on N_2O emissions of approximately 1.1 €/tonne CO_2-eq (Öko-Institut, 2006). The impact of these N_2O policies was calculated at around 75 Mt CO_2-eq based on the assumption that in its absence N_2O emissions per unit of adipic acid production would have remained at the 1990 level.

Combined Heat-Power generation (CHP)
There has been a major increase in the amount of installed cogeneration capacity (mainly fired by natural gas) in the EU; the amount of electricity produced by cogeneration plants in the EU-25 doubled between 1990 and 2004, while the amount of heat produced by cogeneration increased by 40% during the same period (IEA, 2005; IEA, 2006). Cogeneration, also known as CHP, was promoted with various types of national policies such as subsidies, fiscal measures, feed-in tariffs and obligations. We estimated that CHP policies resulted in a reduction of about 57 Mt of CO_2 emissions in the EU-25 in 2004. This estimation was based on the assumption that in the reference situation, electricity would have been produced with a natural gas fired power plant with an EU-average efficiency and heat would have been produced with a natural gas fired boiler with an efficiency of 90%.

Efficiency improvements in the built environment
The temperature corrected energy consumption for space heating per household in the EU-15 (in the cold and moderate central climatic zone, i.e. excluding Italy, Greece, Portugal and Spain) decreased between 1990 and 2005 by approximately 23%, which is about 1.8% per year (Eurostat, 2006b; Eurostat, 2003). We assumed that a 1% per year decrease can be considered as an autonomous development (Blok, 2006; see also *textbox: uncertainties*). We consequently estimated that the remaining 0.8% per year improvement in energy consumption was the result of national policies that have promoted thermal insulation and energy efficient heating systems through building standards and financial incentives. These policies saved approximately 34 Mt of CO_2 emissions in the EU-15 in 2005. No data were available to estimate the policy effect on energy efficiency of residential space heating in the 10 new Member States. The policy effect for the EU-25 therefore only includes reductions in the EU-15.

No clear policy effect could be observed in the energy use for space heating in the service sector in the EU-15 for the period 1990-2005. Therefore, no policy effect in the service sector was included in the final results.

Common Agricultural Policies (CAP)
European Common Agricultural Policies were not specifically aimed at the reduction of greenhouse gases. One side effect of CAP policies has been a reduction in the numbers of livestock, leading to a reduction of CH_4 emissions. We assumed that the CH_4 emission reduction is completely caused by livestock reduction, without improvement of the CH_4 emission per animal (EEA, 2006). Thus we estimated that in 2005, CAP policies saved some 17 Mt of CO_2-equivalent emissions in the EU-15. The 10 new Member States joined the CAP in October 2004 and therefore no policy effect has been attributed to CAP for the new Member States for the period 1990-2005.

Note, that as a side effect of the Nitrates Directive, the emissions of N_2O from soils decreased slightly (EEA, 2007). Because it is uncertain whether this small decrease can be attributed to nitrates policies, we did not take it into account in our calculations.

F-gases
The EU-15 emissions of HFC (hydrofluorocarbons) from the production of halocarbons decreased by 86% in the period 1997-2005 (EEA, 2007). This decrease was mainly a result of policies stimulating end-of-pipe measures in the production of HCFC-22. In 2005, these policies reduced approximately 41 Mt of CO_2-equivalent emissions in the EU-15. We made this calculation based on the assumption that in the reference situation emissions would have grown by 3% from 1997 on. This growth rate was estimated by Velders et al. (2007) from the growing market volume of refrigerants for large-scale refrigeration facilities and other uses. The 3% rate also compares well with the still unabated growth of HCFC-22 emissions between 1997 and 2004.

PFC emissions from aluminium production decreased by 14 Mt in the EU-15 between 1990 and 2005 (EEA, 2007). This was the result of a strongly decreasing emission per unit of aluminium. This improvement is a side-effect of process optimization, which we considered to be an autonomous development and not an effect of environmental policies. Our estimates also excluded the climate protection achieved by phasing out ozone-depleting substances such as CFCs, as these gases are not included in the Kyoto Protocol (see also *textbox uncertainties*).

Passenger cars
Between 1990 and 2005, CO_2 emissions from road transport increased by 30% in the EU-15. Between 1995 and 2005, however, the specific CO_2 emissions of new passenger cars fell by 13%, from 185 gCO_2/km to 161 gCO_2/km (EC, 2006a). This improvement has been attributed to two developments: the agreement between the European Commission and the auto industry (referred to as the ACEA Agreement) and the increasing share of diesel cars, which are on average more efficient than petrol-fuelled cars. The latter trend, called 'dieselization', is mainly caused by the price difference between diesel and petrol and was not considered to be a policy effect. Dieselization explains about 20% of the improved CO_2 performance of cars. The remaining improvement has been attributed to the ACEA Agreement, assuming that the autonomous efficiency improvement was 0% (see also the uncertainty section). Consequently, we estimated that without the ACEA Agreement, the total EU-15 emissions of greenhouse gases would have been 21 Mt higher.

Efficiency improvements and fuel switch in industry and the energy sector
In the period 1990-2005, substantial reductions in CO_2 emissions from the energy sector were observed in the United Kingdom and Germany. The most important reason for German CO_2 reductions in electricity and heat production were efficiency improvements in coal-fired power plants. This is regarded as an autonomous effect due to replacement of old plants by new plants with higher efficiency. In the United Kingdom, the most important factor in the above emission reductions was the fuel switch from coal to natural gas in electricity production. The 'dash to gas' was mainly driven by the privatization of the UK electricity industry and the low natural gas prices in the 1990s. This was not considered to be a policy

effect within the scope of this study. The same applies to the energy sector in other EU countries; changes in CO_2 emissions were mainly driven by the liberalization of the energy market and the prices of various fuels. We have therefore limited our estimates of the policy effect on CO_2 emissions from the energy sector to the effects of renewable energy and CHP.

Within the scope of the present study, it was not possible to estimate the policy effects on CO_2 emissions in industry because that would require an analysis of specific energy use at the subsector level (e.g. GJ/tonne of steel). Based on evaluations of voluntary agreements in the period 1990-2004 in different countries, Eichhammer (2006) concluded that the policy effects were 'rather weak' compared to autonomous developments.

Overview of policy effects 1990-2005

Table 1 provides an overview of the policy effects for the period 1990-2005. The largest reduction effect was obtained with policies aimed at renewable energy, CHP, reduction of N_2O from industrial processes and policies to reduce methane emission from landfills. Overall, the impact of environmental policies between 1990 and 2005 was estimated at 6.9 % for the EU-27. This means that without environmental policies greenhouse gas emissions in the EU-27 would have be 6.9% higher than they actually were in 2004. For purposes of comparison, this reduction – the explicit result of environmental policies in Europe – amounts to approximately 380 Mt CO_2, which is comparable to the current CO_2 equivalent emissions of Belgium and the Netherlands together.

Table 1 Abated greenhouse gas emissions in the EU in 2005 (Mt), compared to the reference situation without sectoral environmental policies in the EU between 1990 and 2005.

Policy	EU-15	EU-25 (EU27) [d]
Renewable energy	77	96
N_2O industry	73	75
Combined Heat-Power generation (CHP) [c]	42	57
Landfill gas	41	51
Energy efficiency residential space heating[a]	34	34
F-gases[a]	41	41
Passenger cars[a]	21	21
Agricultural policies[b]	17	17
Total (Mt)	347	382
% reduction compared to realised emissions in 2005	8.3%	7.9% (7.6%)
% reduction compared to reference emissions in 2005	7.6%	7.2% (6.9%)

a. No data were available to estimate this policy effect in the 10 new Member States. The EU-25 figure includes the policy effect only for the EU-15.

b. The 10 new Member States joined the Common Agricultural Policies in October 2004, therefore no policy effect has been attributed to CAP for the new Member States.

c. based on 2004 data, no 2005 data available.

d. *Figure 1* illustrates the impact of environmental policies on the trend of greenhouse gas emissions. To make our analyses as up-to-date as possible, we converted our results to the level of the EU-27. This is of interest because the new EU climate target applies to the entire group of 27 Member States. To recalculate the EU-25 data to the level of the EU-27, we assumed no impact of environmental policies in the 1990-2005 period in the two new EU Member States of Romania and Bulgaria. Thus, the policy impact over the 1990-2005 period for the EU-25 was also applied to the overall EU-27.

Figure 1 (left side) provides another overview of the policy effects for the period 1990-2005. *Figure 1* (left side, upper dotted line) shows that even when corrected for the impact of environmental policies, emissions in the EU-27 decreased in the 1990s. This was due to the restructuring of economies in the new EU Member States and Germany (including the former East Germany). *Figure 1* also shows that half of the policy impact between 1990 and 2005 originated from reductions of non-CO_2 greenhouse gases and the other half from CO_2. In the next section, we will show that between 2006 and 2020, CO_2 emissions will have to be reduced at a much higher rate than emissions of non-CO_2 gases. This emphasizes the need for increased CO_2 policies in the years ahead.

Looking forward to 2020

In this section we compare the past (1990-2005) impact of environmental policy on greenhouse gases in Europe with the policy effort required to reach the EU's 2020 target. For that purpose we again need a reference development, also called a baseline development. We used the baseline development between 2000 and 2020 as published in the EEA Environment State and Outlook 2005 (EEA, 2005a). Their scenario effort was based on PRIMES results (EC, 2003) extended to include non-CO_2 greenhouse gases. A similar baseline scenario was used for the Clean Air for Europe (CAFE) programme. This baseline scenario is a modestly optimistic economic growth scenario with diversified development of the European energy system (See *Table 2* for some characteristics). The scenario assumes a nearly linear increase in the inland energy consumption and electricity generation between 1990 and 2030. Most of the fuel mix changes occur in electricity generation, where the shares of natural gas and renewable sources increase at the same rate as the cost of coal, lignite (solids) and nuclear energy (*Table 2*). The baseline scenario essentially assumes a continuation of current environmental policies in the EU and does not take into account additional climate policies related to implementation of the Kyoto Protocol (situation 2005). Scenario data were available for the EU-15, EU-25 and EU-27, as well as for the intermediate scenario year of 2020 (EEA, 2005a).

Table 2 Baseline scenario characteristics (EEA, 2005a).

EU-25	1990[a]	2000	2020	2030
GDP (Billion Euro)	7315	8939	14462	18020
Gross inland energy consumption (Mtoe[b])	1554	1651	1889	1960
Solids (%)	27.7	18.4	13.4	15.3
Oil (%)	38.4	38.5	35.6	34.4
Gas (%)	16.7	22.8	31.6	32.1
Nuclear (%)	12.7	14.4	11.3	9.5
Renewables (%)	4.5	5.8	8.0	8.6
CO_2 (Mt), energy related	3770	3665	4041	4304
CO_2-eq (Mt)	4945	4680	5136	5360

a) 1990 and 2000 data are monitored data, 2020 and 2030 area scenario output

b) Million tonnes of oil equivalents

The baseline greenhouse gas emission development is shown in *Figure 1* (right side, upper dotted line). The gap between the baseline and the 2020 greenhouse gas emission target (-20% compared to 1990 emissions) is approximately 1100 Mt CO_2-eq. When this number is compared with the ex-post policy impact estimate of 380 Mt CO_2-eq (see *Table 1*), it can be concluded that realizing a 20% reduction within the EU-27 in 2020 (compared to 1990) will require the overall policy effect between 2006-2020 to increase by a factor of three, compared to the 1990-2005 period.

Several scenario exercises have shown that there are sufficient emission reduction measures available from the baseline development to reduce greenhouse gas emissions in 2020 to 20% below the level in 1990 (EEA, 2005a; Den Elzen et al., 2007; EC, 2006b). Further reductions of non-CO_2 greenhouse gases could deliver 160-170 Mton CO_2-eq in 2020; see *Figure 1* (EEA, 2005; Den Elzen et al., 2007). A growing share of renewables in energy consumption to a level of 20% in 2020 could deliver CO_2-reductions of approximately 500 Mt CO_2-eq in 2020 (EC, 2006b; EEA, 2005, Ragwitz et al., 2005 and 2007). Increased energy savings, including CHP, could provide between 525 and 630 Mt CO_2-eq (EC, 2006b; Den Elzen et al, 2007). The overall additional direct costs of these measures range between 0.2% and 0.3% of GDP (den Elzen et al., 2007; Ragwitz et al., 2005).

These aggregated estimates of emission reduction potentials illustrate that by far the largest part of the reduction can be realized in CO_2 rather than non-CO_2 greenhouse gases (see *Figure 1*). For CO_2 alone, the impact of future policy will have to increase by as much as a factor of 4.5, compared to the 1990-2005 period (*Figure 1*: a policy effect of 935 Mt in 2020 compared to a policy effect of 208 Mt CO_2-eq in 2004). To realize this reduction potential, new or renewed EU policies are crucial; these policies are currently being prepared by the European Commission and are expected to be presented early 2008. These policies include legislation for CO_2-efficient passenger cars, a Directive on Carbon Capture and Storage, a comprehensive Directive for renewable energy, including biofuels targets, the regulation of greenhouse gas emission reduction targets, including a 'burden sharing' agreement with individual targets for Member States and a proposal for the improvement of the post-2012 Emissions Trading Scheme.

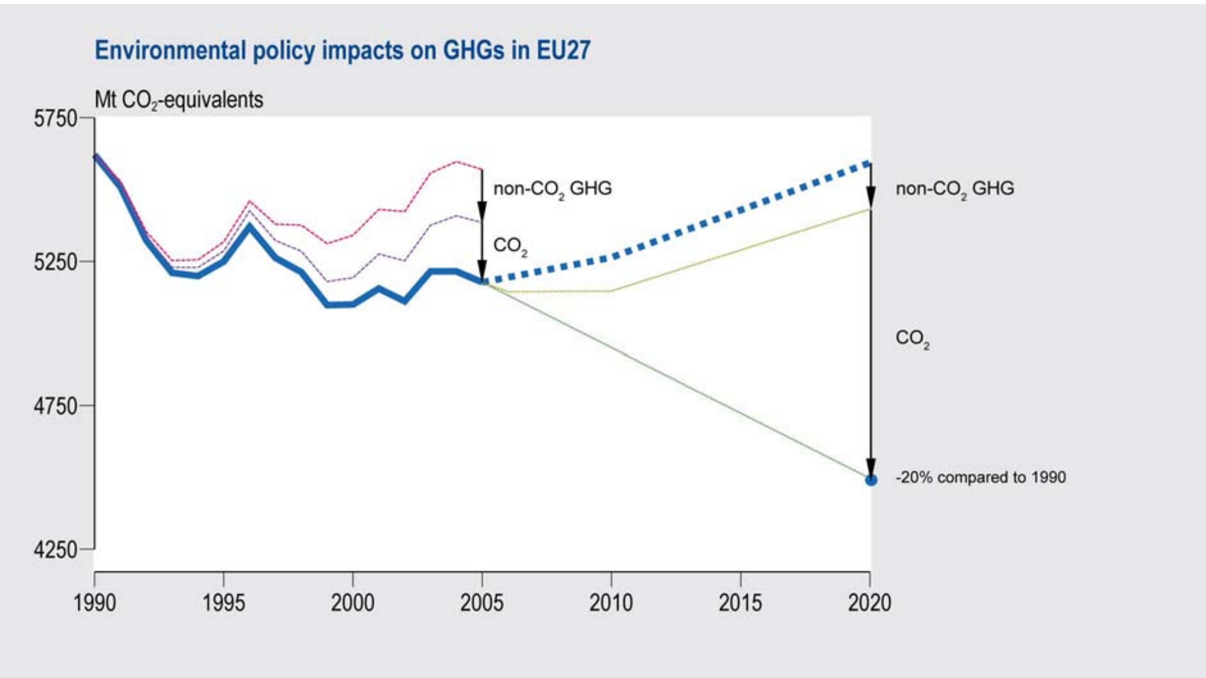

Figure 1 On the left, the ex-post estimated effects of environmental policies on GHGs (greenhouse gases:CO_2 and non-CO_2) in the EU-27 in the period 1990-2005. On the right, the ex-ante policy impact estimates (see main text).

Uncertainties

In this section we take a brief and semi-quantitative look at uncertainties in both the ex-post and ex-ante evaluations. This does not result in a quantified overall uncertainty estimate of the policy effects that we calculated. Instead, it illustrates the uncertainties in the reference emissions and the large impact of Montreal Protocol policies, which were not included in our overall policy impact estimate.

Ex-post analysis

The CO_2-eq effect that is attributed to different policies depends on assumptions about the reference case. This effect is especially influenced by assumptions about the reference case for electricity production. In our analysis, we assumed that electricity produced by CHP (cogeneration) or by using renewable energy sources would otherwise have been produced by a natural gas fired power plant with an EU-average efficiency. There are good arguments for this assumption. New electricity production capacity installed in the EU over the last ten years was mainly natural gas fired, so additional CHP and renewables may have reduced new gas fired production capacity. This assumption results in a comparatively low CO_2 effect; however we attributed the total effect to policies. For the Netherlands, Jeeninga et al (2002) used the average fossil fuel mix as a reference to calculate the CO_2 effect of renewables and CHP which results in a high CO_2-effect, but they also estimated that only part of this effect was attributable to policies (80% for renewables and 50% for CHP). In our case, such a calculation would increase the CO_2 effect of renewables by 30 Mt CO_2-eq and that of CHP by 25 Mt CO_2-eq. The total effect of policies on greenhouse gas emissions in the EU-27 in 2004 would then be 7.8% instead of 6.9%.

In the case of energy consumption for household space heating, we assumed a 1% per year autonomous improvement, which is a general estimate often used in policy studies (Blok, 2006). This assumption means that we attribute 44% (0.8% compared to 1.8%) of the overall improvement in energy consumption to environmental policies. This is roughly comparable the figure of 55% that was derived for the Netherlands by Jeeninga et al. (2002) in a bottom-up study.

The estimated policy impact of the ACEA Agreement on passenger car CO_2 emissions – 21 Mt CO_2-eq. – can be regarded as an upper limit. A recent study suggests that individual vehicle CO_2 emissions have not changed since the ACEA and that the reductions in passenger car CO_2 emissions achieved so far are due entirely to market changes, such as the shift to diesel cars (Gontara and Samaras, 2007).

Our estimates focus on the six Kyoto greenhouse gases and exclude the effect of climate protection measures achieved by the phase-out of ozone-depleting substances such as CFCs under the Montreal Protocol. Recently, Velders et al. (2007) showed that the strong decrease in global CFC emissions has had a major effect on reducing total global greenhouse gas emissions. According to the global picture presented by Velders et al (2007), it is clear that the phase-out of CFC has also resulted in a large net reduction of greenhouse gas emissions in the EU. Within the scope of the present study, it was not possible to calculate the net effect of replacement of CFCs by HFCs and other substances for the EU, since no CFC emission time series are available for the EU. However, the effect for the period 1990-2005 in the EU could have been on the order of 1000 to 2000 Mt CO_2-eq (Velders, personal communication), which is 3 to 6 times higher than the total policy impact of 380 Mt that we calculated in our study.

Ex-ante analysis

The 2005-2020 baseline (see *Figure 1*) entails various uncertainties that affect the baseline emissions. These uncertainties include the economic growth rate, the increase in energy consumption and the fuel mix. We believe that the CO_2 emissions associated with the baseline are a realistic towards a conservative estimate. Firstly, annual growth of gross and final energy consumption between 2000 and 2020 remains around 0.7%/yr, which is comparable to the period 1990-2000. Secondly, we assume that autonomous gasification will continue, mainly in power generation (see *Table 2*). To illustrate the sensitivity to latter aspect, if we assume that the share of gas in gross inland energy consumption remained at 22% after 2000 (see *Table 2*) and extra demand was supplied by coal rather than gas, the CO_2 emissions in 2020 would increase by about 150 Mt compared to the current baseline. This would increase the policy gap between baseline and target in 2020 from 1100 to 1250 Mt of CO_2-eq. An opposite assumption, where the extra demand for gas after 2000 is fully supplied by renewables or nuclear energy, is unlikely without new environmental policies. Such new policies fall outside the definition of the baseline scenario.

Conclusions

Our mid-term review of environmental policy impacts during the 1990-2020 period reveals two unique and policy-relevant indicators for the EU. Firstly, environmental policies had a 7% impact on emission trends between 1990 and 2005. Secondly, to meet the EU's 2020 climate target, this impact must increase by a factor between three (all greenhouse gases) and 4.5 (CO_2) in the 2005-2020 period.

This required increase in policy impact is by no means evident from the 1990-2005 monitoring data and the 2005-2020 linear-pathway-to-target line (see lower lines in *Figure 1*). By explicitly filtering out the effect of environmental policies, as we did in our study, better insight can be acquired into the true challenges for the EU's climate policies.

The uncertainty analysis illustrates that the ex-post quantitative policy evaluations, as applied here, may require additional in-depth research, documentation and methodological consensus before a stronger role for this type of analysis in the policy cycle can be achieved. This paper can be a starting point for such additional work. Despite the uncertainties, we believe that the main results from this study can serve as a strong signal to policy makers that the impacts of current environmental policies on greenhouse gases in the EU are significant but must increase strongly in order to achieve the EU's 2020 climate policy target.

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