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Greenhouse gas reductions in Germany and the UK - Coincidence or policy induced?

An analysis for international climate policy

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0 Executive Summary

Between 1990 and 2000 greenhouse gas emissions in Germany and the UK decreased by more than 18 % and about 12 %, respectively. Thus, Germany and the UK appear to be among the few industrialised countries which are on track to meet the emission reduction targets they have committed themselves to under the Kyoto Protocol and the subsequent European Union's Burden Sharing Agreement. Accordingly, Germany has to reduce greenhouse gas emissions by 21 % from 1990 to 2008-12, and the UK by 12.5 %. In terms of CO_2 emissions both countries have pledged to meet even stricter domestic policy targets: in Germany, the government has set the goal to reduce CO_2 emissions by 25 % between 1990 and 2005, and in the UK the objective is to reduce CO_2 emissions by 20 % between 1990 and 2010. These achieved emission reductions may appear less remarkable if one takes into account that Germany benefited from so-called "wall-fall profits", i.e. the breakdown and restructuring of the East German economy after reunification in 1990. Similarly, in the UK liberalisation of the energy markets in the early 1990s resulted in a fuel switch from carbon-intensive coal to natural gas, combined with higher nuclear output. At the same time, however, various policies at national, regional, and local levels were introduced in the 1990s in both counties, which also resulted in a reduction of CO_2 and other greenhouse gases.

In this report the underlying factors for greenhouse gas emission trends in Germany and the UK in the 1990s are examined. In particular, it is assessed whether the observed emission reductions are coincidental and could be attributed to rather special circumstances, or whether they are the result of specific policy measures.

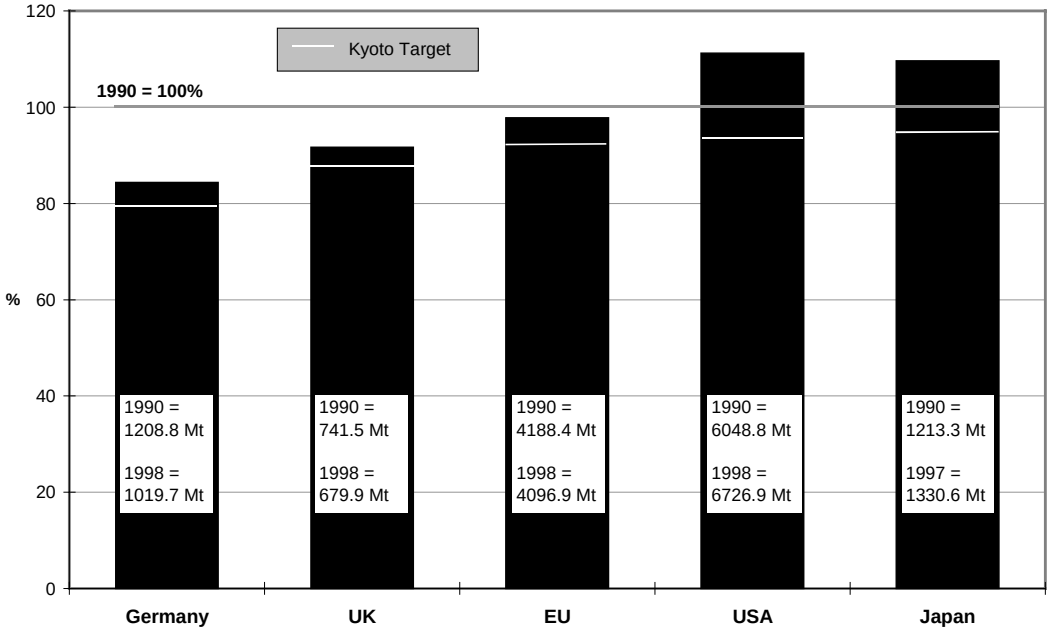
The findings indicate that for both countries, special circumstances accounted for about 50 % of the reduction of all six greenhouse gases. This share increases to 60 % if only energy-related CO_2 emissions are considered. At the same time, a diverse set of policies affecting energy-related CO_2 emissions accounted for about 40 % of the reduction of these emissions. Likewise, environmental policies directed towards non-CO_2 gases (in particular waste management and the reduction of N_2O from adipic acid production) had almost as strong an impact as policies addressing CO_2 emissions. Considering all six greenhouse gases, the policy-contribution was slightly higher than the impact of unification in Germany or liberalisation in the UK, respectively.

Although Germany and the UK are on a reduction path to meet their Kyoto targets, both countries, and perhaps the UK even more than Germany, might miss their national targets unless additional policies are implemented in the near future.

1 Background and Objectives

Comparing greenhouse gas emissions trends by industrialised countries suggests that Germany and the UK are among the few countries which are on track to meet the emission reduction targets they have committed to under the terms of the Kyoto Protocol in 1997 and the subsequent European Union's burden-sharing agreement in 1998 (see Figure 1-1). Between 1990 and 1998 emissions of the specified basket of six greenhouse gases in Germany and the United Kingdom decreased by 15.6 % and by 8.3 % respectively (see Figure 1-1).

Figure 1-1: Total greenhouse gas emissions of selected Annex I parties in million tons (Mt) of CO_2 equivalents for 1990 and 1998



Source: UNFCCC (2000)

By contrast, in most other industrialised countries, greenhouse gas emissions have increased since 1990. While the European Union is required to reduce its greenhouse gas emissions by 8 % from 1990 to 2008-12, Germany and the UK are required to reduce these emissions by 21 % and by 12.5 %, respectively. In terms of CO_2 emissions both countries have pledged to meet even stricter domestic policy targets: in Germany, the government has set the goal to reduce CO_2 emissions by 25 % between 1990 and 2005, and in the UK the objective is to reduce CO_2 emissions by 20 % between 1990 and 2010. Reduction targets may appear less ambitious taking into account that both countries have benefited from special

circumstances providing extraordinary opportunities for emission reductions: the breakdown and restructuring of the East German economy after reunification in 1990, and the liberalisation of the electricity and gas markets in the UK in the early 1990s resulting in a fuel switch from carbon-intensive coal to natural gas, combined with higher nuclear output.

Furthermore, both countries have implemented various climate-specific and more general environmental policy measures at the national, regional, and local levels, which have also resulted in considerable emission reductions.

The objective of this report is to examine the underlying factors for greenhouse gas emission trends in Germany and the UK in the 1990s. In particular, the study examines whether the observed emission reductions are coincidental and could be attributed to rather special circumstances, or whether they are the result of specific policy measures.[1]

[1] A shorter and more technical version of the analyses for Germany appears in Schleich et al. (2001).

2 Reduction of Greenhouse Gases in Germany

Between 1990 and 2000, actual greenhouse gas emissions in Germany decreased by over 18 %. In particular, CO_2 emissions, which account for more than 80 % of all greenhouse gas emissions fell by 15.3 % from 1014.3 million tons (Mt) to 859.3 Mt. CO_2 emissions are mostly energy related, and only about 3 % stem from industrial processes. While non-energy-related CO_2 emissions stayed fairly constant, energy-related CO_2 emissions decreased from 986.6 Mt in 1990 to 834.3 Mt in 2000, i.e. by 15.4 % (Ziesing, 2001). The greater part of the emission reduction was achieved up to 1994 (-11.2 %). Afterwards, the reduction slowed down.

Since the development of energy-related CO_2 emissions is a function of annual variations in temperature, it is useful to adjust CO_2 emissions for temperature for further analyses. Between 1990 and 2000, the temperature-adjusted CO_2 emissions were above actual emissions in all years except 1996, i.e. all years apart from 1996 were warmer than the long-term average (in terms of degree days) in Germany. For some years, the CO_2 emission changes based on actual and temperature-corrected values differ widely. For the whole period 1990 - 2000, the difference is less pronounced: the temperature-adjusted change amounts to 14.9 % compared to an actual change of 15.3 %.

2.1 Analysis of components of CO_2 emission reduction

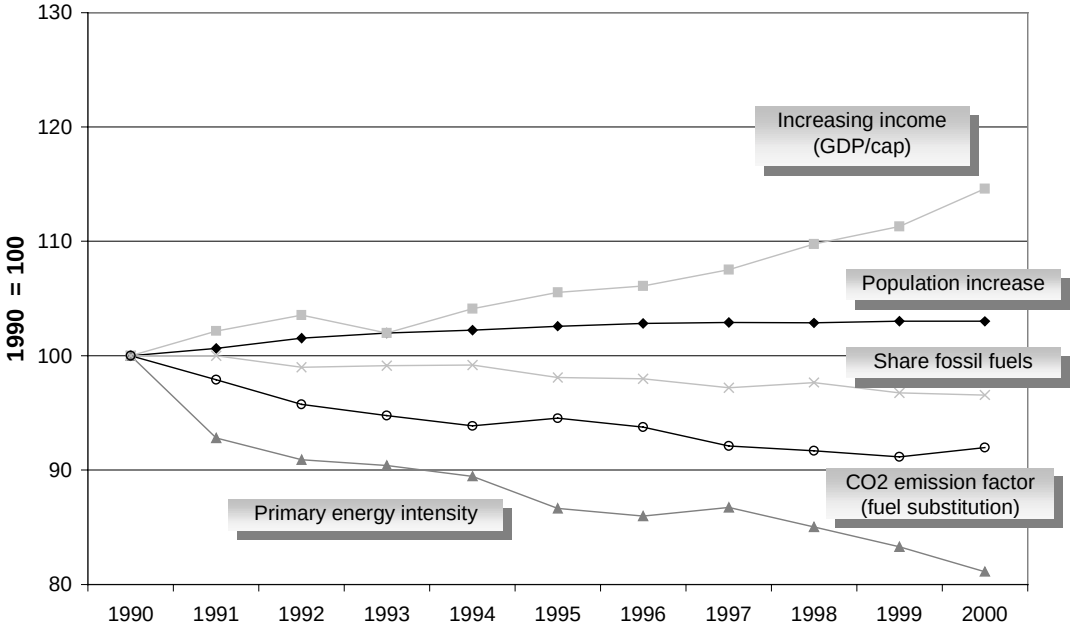
Apart from temperature variations, the development of total CO_2 emissions of an economy can be separated into various other factors. To obtain a picture of the influence of these different factors, a decomposition method was used to examine the extent to which the changes in (energy-related and temperature-corrected) CO_2 emissions are attributable to changes in:[2]

- population (population component),
- GDP per capita (per-capita income component),
- primary energy consumption in relation to GDP (energy intensity component),
- the share of fossil fuels in primary energy consumption (share of fossil fuels component), and
- the CO_2 emission factor of fossil primary energy (CO_2 factor of primary energy).

[2] Similar calculations were carried out in Ziesing et al. (1997) and Diekmann et al. (1999). The method which is used here is a Laspeyres derived index but dividing the residual among the main factors as proposed by Sun (1998).

The development of these factors between 1990 and 2000 is shown in Figure 2-1.

Figure 2-1: Trends of various factors of influence on changes in energy-related CO_2 emissions in Germany from 1990 to 2000



Sources: Federal Statistical Office 2001; Ziesing 2001.

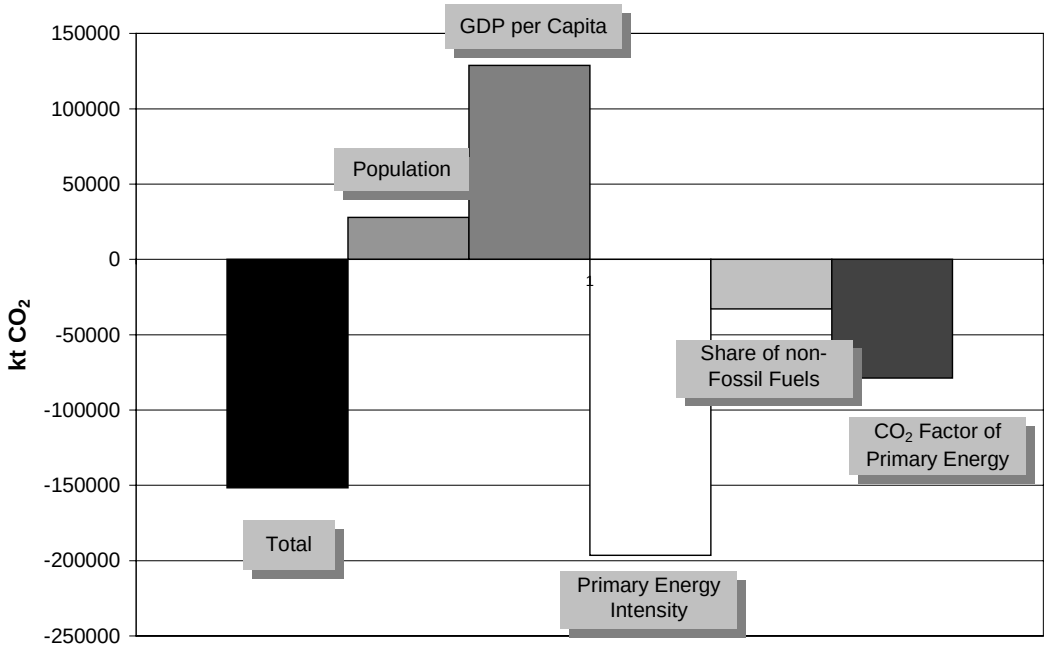
The population grew by 3 % from 79.8 million to 82.1 million between 1990 and 2000. The real increase of gross domestic product (GDP) amounted to 18 % or 1.7 % per annum. As a result, per-capita income rose by just under 15 % from 40,800 to 46,750 DM (in 1995 prices).[3] The other determinants, however, showed trends which resulted in decreased CO_2 emissions. First of all, Germany experienced a considerable decrease in primary energy intensity (temperature-corrected primary energy consumption related to real GDP) which fell on average by 2.1 % p/a during this period. The share of non-fossil fuels in total primary energy consumption increased from 11.9 % in 1990 to 14.7 % in 2000 which was the result of increasing availability of nuclear energy, but also of a rise in output from renewable energy sources in the second part of the decade. Finally, the CO_2 intensity of fossil primary energy decreased by 8 %, mainly due to the extensive substitution of lignite by oil and gas.

To quantify the relevance of these different factors for changes in (energy-related and temperature-corrected) CO_2 emissions between 1990 and 2000, decomposition

[3] 1 DM ≈ 0.51 €.

methods are applied. The result of this analysis is presented in Figure 2-2. For example, the increase in population of 2.3 million on its own would result in an increase of CO_2 emissions by almost 28 Mt CO_2, provided that all other components remained constant. Effects which led to an increase in emissions, such as population and GDP growth, were more than offset by effects which led to a decrease in emissions such as a higher share of CO_2–free fuels, a lower CO_2 emission factor of primary energy and a lower energy intensity. Looking at the orders of magnitude of the various effects considered, the decisive factor for the observed emission reductions was the decrease in energy intensity, which accounted for a reduction of 200 Mt of CO_2, ceteris paribus.

Figure 2-2: Contribution of various factors to changes in energy-related CO_2 emissions in Germany 2000/1990 (temperature corrected)



Source: Calculations by Fraunhofer-ISI.

2.2 The impact of reunification on CO_2 emissions

As pointed out above, between 1990, the year of German unification, and 2000, temperature-corrected CO_2 emissions in Germany declined by almost 15 %. The most dramatic drop in this decade occurred in the new federal states (Laender) between 1990 and 1995, where energy-related (temperature-corrected) CO_2 emissions fell by about 43 %, while emissions in the old Laender remained almost

constant (see Table 2-1). For the unified Germany, CO_2 emissions decreased by almost 13 % in the first half of the 1990s but fell by only 2.3 % in the second half. Since CO_2 emissions in 1999 accounted for nearly 85 % of the Kyoto-gas basket in Germany, more than half the Kyoto target had already been reached in only a quarter of the period under consideration.

The most dramatic emission reductions in the new Laender occurred in the manufacturing and energy sectors, i.e., sectors which had been hit the most by the economic downturn following the fall of the Berlin Wall in late 1989 (Ziesing/Jochem et al., 1997). In the first two years thereafter, GDP in the new Laender decreased by about one third and, in the manufacturing sector, gross value added decreased by over 60 % (Ziesing/Jochem et al., 1997, Ziesing/Diekmann et al., 1999). Thus, at least at first glance, these figures support the view that the observed emission reductions are mainly the result of the economic downturn in Eastern Germany, rather than the result of conscious climate and other environmental policy measures.

However, there is evidence that economic growth in Germany was higher than it would have been without the fall of the Wall, i.e., if both parts had remained independent. In 1993, the economy in the new Laender started to pick up again, spurred by strong growth primarily in the construction, manufacturing and services sectors, so that, as early as 1994, GDP in the new Laender overtook its 1990 level. Also, the old Laender benefited economically, supplying the vast majority of consumption goods for the new Laender, and exhibiting annual GDP growth rates of over 5 % in 1990 and 1991. Thereafter, economic growth slowed down considerably and even became negative in 1993. Nevertheless, economic growth between 1990 and 1995 in the unified Germany exceeded the average growth experienced in the other EU15 countries by more than 2 %.

A key factor in the reduction in CO_2 emissions was a significant decrease in the CO_2-intensity of the economy (measured as the ratio of total CO_2 emissions to real GDP), which decreased by about 28 % between 1990 and 2000 in the unified Germany. In particular, in the new Laender, where CO_2-intensity was more than four times as high as in the old Laender in 1990, CO_2-intensity dropped by more than 46 % up to 1995. This decline was primarily the result of the economic transformation, which was characterised by greater efficiency in the use of all production factors, and significant structural changes towards less carbon-intensive economic development. The latter include, for example, a decrease in the share of energy-intensive industrial sectors, and the decline of carbon-intensive lignite as an input for electricity and heat production. More specifically, the share of lignite in total primary energy consumption in the new Laender decreased from about 69 % in 1990 to 38 % in 1995 (Ziesing/Jochem et al., 1997). In addition, several policy measures had been implemented to further improve energy efficiency, such as support for district heating from CHP generation, or for the modernisation of

existing buildings and heating systems, and ordinances pursuant to the Federal Emission Control Act. So CO_2-intensity reduction continued to decrease in Germany after 1995, but at a much lower rate.

The question then arises as to what extent the observed reductions in GHG emissions over the last decade can be attributed to so-called "wall-fall profits", and to what extent they are the result of specific policy measures. Here, 'wall-fall profits' are defined as the reduction in emissions that are due to the special circumstances in Germany in the early 1990s, and not due to policy measures, efficiency gains, or structural change etc., which would have taken place in any case. Thus, to quantify the wall-fall profits for the year 2000, one has to estimate the quantity of CO_2 that would have been emitted in the year 2000 in the old and new federal states in the absence of the wall-fall effect. Wall-fall profits can then be calculated as the difference between the actual CO_2 emissions and the hypothetical emissions estimated for the year 2000. Estimating hypothetical values for CO_2 emissions involves assumptions about hypothetical growth rates for GDP and CO_2-intensity. Starting with the actual values for GDP and CO_2-intensities for both the old and the new federal states in 1990, the following assumptions are made to calculate hypothetical emissions of CO_2 in the year 2000:

- for old and new federal states, the annual growth rate of GDP between 1990 and 1995 is equal to the average annual GDP-growth rate of the EU15 during that period;
- for old and new federal states, the annual growth rate of GDP between 1995 and 2000 is equal to the actual average annual growth rate of unified Germany during that period (i.e. wall-fall effects on GDP are assumed to have levelled out by 1995);
- for the old federal states, the annual growth rates of CO_2-intensity between 1990 and 1995 are equal to the actual annual growth rates in the old Laender during that period;
- for the new Laender, the annual growth rates of CO_2-intensity between 1990 and 1995 are equal to the average annual growth rate in former East Germany between 1985 and 1989;
- for the old and the new federal states, the growth rates of CO_2-intensity between 1995 and 2000 are equal to the actual growth rates of unified Germany during that period (i.e. wall-fall effects on CO_2-intensity are assumed to have levelled out by 1995).

Under these assumptions, the hypothetical temperature-corrected CO_2 emissions in the year 2000 are 992.5 million tons (Mt), compared to the actual quantity of 887.6 Mt. Thus, the wall-fall profits are estimated to be about 105 Mt of reduced CO_2 emissions.

To analyse the effects of GDP growth and CO_2 intensity separately, the overall effect can be decomposed into an activity effect and an intensity effect. The growth effect which indicates the change in CO_2 emissions that occurs because actual GDP in 2000 is higher than it would have been in the hypothetical case, is estimated to be about 10 Mt of CO_2 (which is actually a "wall-fall deficit"). More importantly, the intensity effect which indicates the change in CO_2 emissions that occurs because CO_2-intensity of GDP is actually lower than it would have been without unification, is estimated to be about 115 Mt of CO_2.

Table 2-1: CO_2-emissions, GDP, and CO_2-intensity in Germany from 1990-2000

					percentage change			annual average growth rates		
		1990	1995	2000	90/95	95/00	90/00	90/95	95/00	90/00
Germany	Units									
CO_2[1]	[in 10^6 t]	1041.9	908.7	887.6	-12.8%	-2.3%	-14.8%	-2.7%	-0.5%	-1.6%
GDP[2]	[in 10^9 DM]	3253.6	3523.0	3840.8	8.3%	9.0%	18.0%	1.6%	1.7%	1.7%
CO_2/GDP	[in t / 10^6 DM]	320.2	257.9	231.1	-19.5%	-10.4%	-27.8%	-4.2%	-2.2%	-3.2%
New Laender										
CO_2[1]	[in 10^6 t]	315.6	180.3	-	-42.9%	-	-	-10.6%	-	-
GDP[2]	[in 10^9 DM]	298.3	317.8	-	6.5%	-	-	1.3%	-	-
CO_2/GDP	[in t / 10^6 DM]	1057.9	567.1	-	-46.4%	-	-	-11.7%	-	-
Old Laender										
CO_2[1]	[in 10^6 t]	726.3	728.4	-	0.3%	-	-	0.1%	-	-
GDP[2]	[in 10^9 DM]	2955.3	3205.2	-	8.5%	-	-	1.6%	-	-
CO_2/GDP	[in t / 10^6 DM]	245.8	227.3	-	-7.5%	-	-	-1.6%	-	-

[1] total CO_2-emissions, energy-related emissions are temperature corrected.

[2] in 1995 DM.

Source: Ziesing (2000, 2001), calculations by Fraunhofer-ISI.

2.3 The policy contribution to CO_2 reduction

2.3.1 Policy measures at the federal level and their contribution to CO_2 reduction

In this section the contribution of primarily Federal policies to the reduction of greenhouse gases in Germany in the 1990s is assessed. These policies were implemented by the governments formed by the conservative-liberal coalition before 1998, and by the government formed by the coalition of the Social Democratic party and the Green party thereafter. The set of policies considered covers federal policies that were primarily implemented to reduce CO_2 emissions (e.g. standards for thermal insulation), and policies introduced for purposes other than climate change mitigation but which had a direct impact on CO_2 emissions (e.g., fuel taxes). All sectors are covered by these policies which typically contain a mix of instruments.

Industrial and services sectors

The most prominent policy measure in the industrial and services sectors are the voluntary agreements between the majority of German industrial associations, organised under the Federation of German Industries (BDI), and the Federal government in 1995/1996 and in 2000, which include commitments by industry to specific energy reduction. Like most other sectors, the industrial and services sectors are also covered by building regulations – which address installations of heating equipment as well as thermal insulation - and by programmes offering low-interest credits for energy-saving investments. The entire manufacturing sector (as well as the agricultural and forestry sectors) is virtually exempt from the financial burdens of the Ecological Tax Reform, which came into force in April 1999, paying only 20 % of the general tax increases for fuel inputs and the new electricity tax. In addition, companies whose additional tax payments exceed the reduction in the social security payment (funded by the tax revenues) by a ratio of more than 1.2 will be reimbursed.

Energy transformation sector

The above mentioned voluntary agreements by German industry also include all major utilities. So far, significant emission reductions on the supply side have been achieved primarily through efficiency improvements and fuel switches.

The medium-term objective of the German government is to double the share of renewable energy sources in power production by the year 2010. The seminal instrument to achieve this goal is the Act on the Sale of Electricity to the Grid, which was enforced in 1991 and prescribed feed-in tariffs for electricity from renewable energy sources not owned by utilities. These feed-in tariffs were linked to the average sales price for electricity and had to be paid for by the preceding grid operator. Because the liberalisation of the electricity market in 1998 resulted in lower electricity prices for end users (approx. –30 % for industrial customers and –10 % for private customers between 1998 and 2000), feed-in tariffs for electricity from renewable energy sources would have fallen without further intervention. To avoid stranded investments and to increase planning security for new investors, German lawmakers passed the new Renewable Energy Act in February 2000. Under the new law, feed-in tariffs are no longer linked to electricity sales prices, but fixed for 20 years and the costs are evenly distributed among grid operators. Furthermore, utilities are now allowed to participate as producers.

The feed-in tariffs have for a long time been complemented by public funding programs, in which both the federal government and the “Laender” (federal states) played an important role (see Section 2.3.2). The technology that has benefited the most from the feed-in tariffs is wind energy: with more than 6100 MW of installed capacity, Germany now hosts the largest wind energy capacity in the world.

In the new federal states, an extensive programme of modernisation of District Heating and Combined Heat and Power (CHP) was implemented in the early 1990s in collaboration with the Federal government.

Low electricity prices in the wake of liberalisation had already led to the closure of several CHP plants and are now seriously threatening the existence of this low-cost technology for climate change mitigation. To provide temporary support for cogeneration in the public electricity supply sector, and to avoid stranded investments, lawmakers passed a CHP protection law ("KWK-Vorschaltgesetz”) in Spring 2000. Similar to the Renewable Energy Act, municipal power producers can now receive a minimum compensation from the grid operator for electricity generated from cogeneration.

Transport sector

Tax increases on emitting activities occurred especially in the transport sector. The two increases of mineral oil taxes in 1991 (12.5 Euro cents) and 1994 (8 Euro cents), almost doubled the mineral oil taxes in force prior to 1991. The revenues of the 1994 increase were used to support the railway system (BMU 1996, p. 33). The Ecological Tax Reform, which is scheduled to increase fuel taxes by a total of about

15 Euro cents in five steps from 1999 to 2003, was implemented on environmental grounds, but also to finance the reduction in social security payments.

Two important measures in the German transport sector were initiated at EU level. First, under the terms of the agreement between the European Commission and the European, Japanese and Korean car producers, specific CO_2 emissions of cars in 2008/2009 will be approx. 25 % lower than in 1995. As a conservative estimate, considering only the effects of those technical measures identified in the European Commission (2001) - which are slightly lower than the agreement's goals - an interpolation for the year 2000 results in a reduction of 2.4 Mt. Second, the Regionalisation Act for public transport assigns the responsibility for regional public transport to the federal states. This act is expected to boost the efficiency and customer orientation of transport services, which are supposed to favour the modal shift from private cars to public transport systems.

Residential sector

For residential thermal energy consumption, the most important policies are the ordinances on heating installations and on thermal insulation. Both regulations prescribe standards, in particular for new buildings, but also for refurbishment. Furthermore, especially in the new Laender, funding programmes for the renovation of older houses have been implemented. In recent years, labelling as well as standardisation measures for electrical equipment such as refrigerators, washing-machines etc. have been introduced. Finally, the Ecological Tax Reform has increased prices for heating fuels (oil and gas) as well as for electricity.

Reduction of CO_2 emissions

Figure 2-3 illustrates the timing and estimated effects of the most relevant policies and measures on CO_2 emissions. The figure also shows that several measures that had an important impact up to 2000 are now being followed up or substituted by new and often more stringent measures (see BMU, 2000). More specifically, standards have been tightened, such as the new Energy Savings Ordinance for buildings, or procedures have been modified, such as subsidies for programmes for the renovation of residential buildings, or in the Renewable Energy Act. Quantitative figures for the effects of all policies and measures (P&Ms) which started before 1997 are based on Ziesing et al. (1997), where emission reduction of these policies and measures was estimated to be 66.4 Mt CO_2 against a "without-measures" scenario. This value has been adjusted in a conservative manner to account for more recent information which suggests that: (i) the voluntary commitment by the German industry sector turned out to be largely in line with autonomous technical progress and unification effects; (ii) building regulation do not appear to be fully implemented yet; (iii) the Act on the Sale of Electricity to the

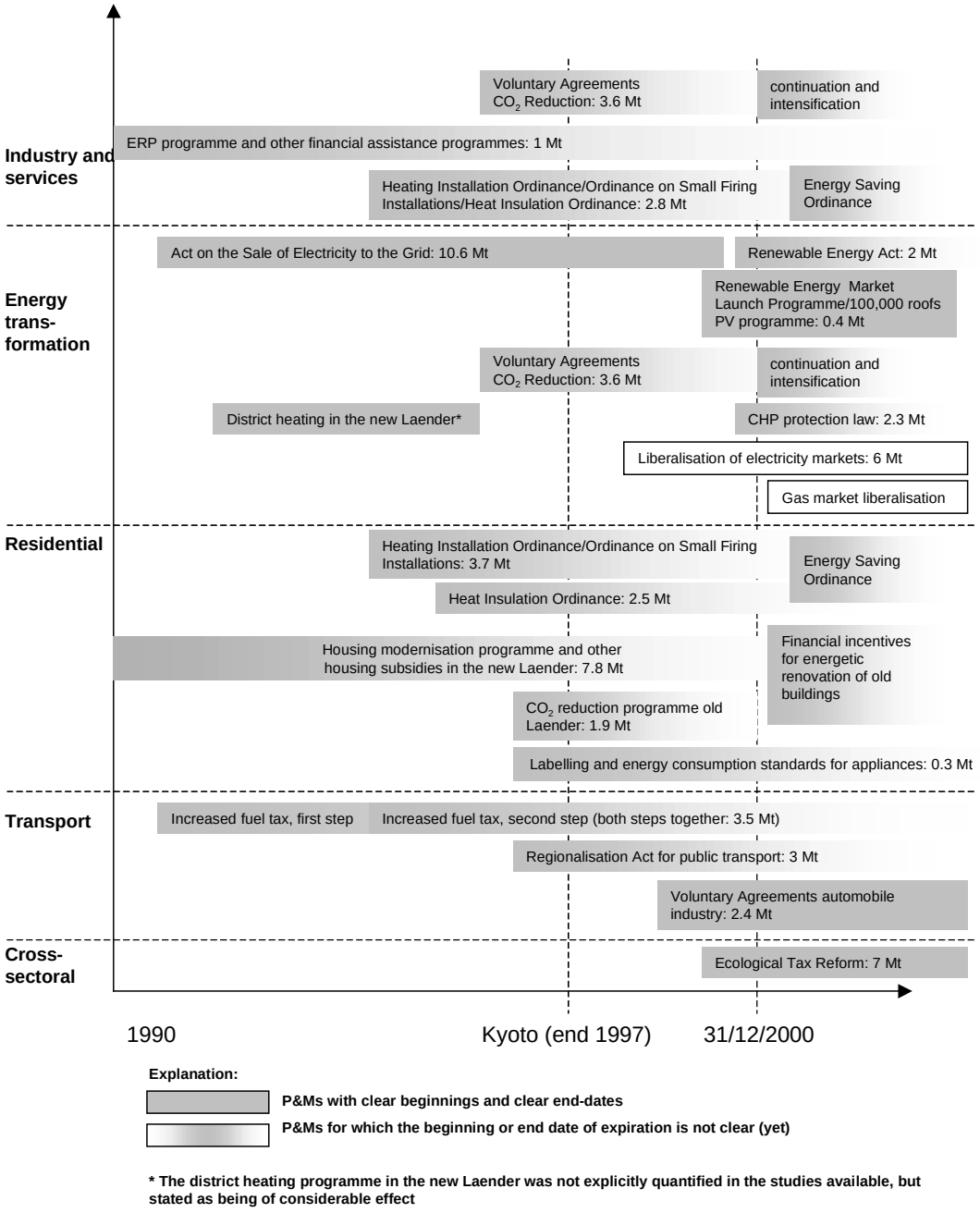
Grid has induced a far higher wind energy capacity than predicted; and (iv) the liberalisation has resulted in an increase (instead of the predicted decrease) in emissions since the effects of lower electricity prices more than outweigh the effects of additional combined-cycle gas-turbines plants (CCGT).[4]

Under these assumptions, the total effect of policies implemented prior to 1997, including those at the regional and local levels (see Section 2.3.2), but excluding liberalisation of the electricity market, is estimated to be a reduction of about 56 Mt CO_2.

Estimates for policies introduced since 1997 are based on a recent analysis of the effects of the Ecological Tax Reform (DIW 2001) (a reduction of 7 Mt), and for other more recent policies on Ziesing/Diekmann et al. (1999) (a reduction of 7.4 Mt CO_2). Thus, all policies implemented in the 1990s at the federal, regional and local levels are estimated to have resulted in a reduction of energy-related CO_2 emissions of 70.7 Mt CO_2. These findings are illustrated in Figure 2-4, which also shows the effects of German reunification as estimated in Section 2.2.

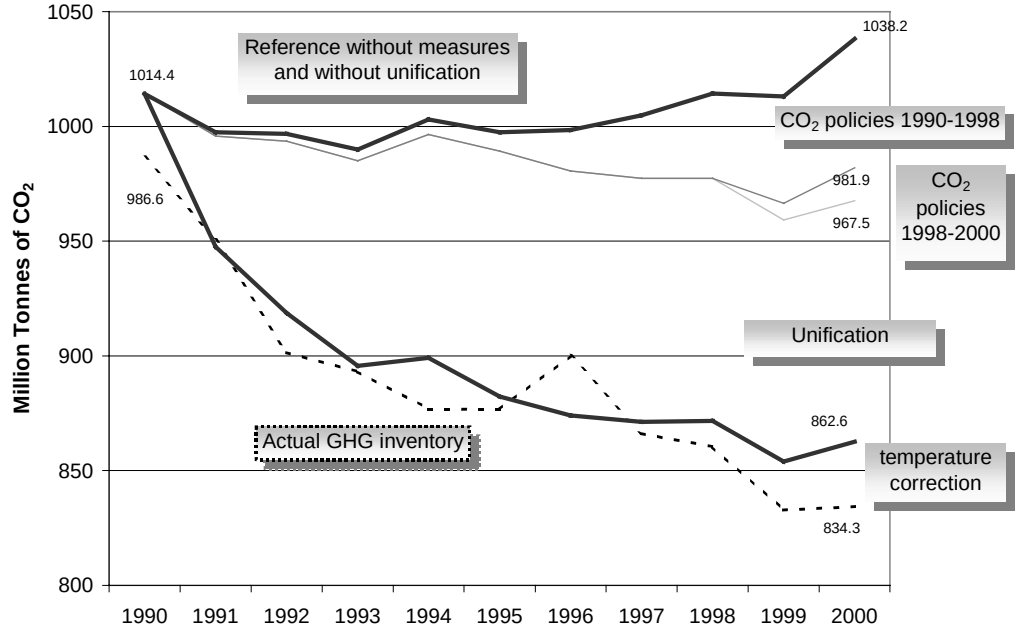
4 For further details see Schleich et al. (2001).

Figure 2-3: Policies and measures in Germany for the reduction of CO_2 emissions 1990-2005



Source: Fraunhofer-ISI

Figure 2-4: The role of environmental policies and special developments (unification) in the reduction of energy-related CO_2 emissions in Germany



2.3.2 The role of regional and local activities for the reduction of CO_2 emissions

Reductions of CO_2 emissions rank highly on the agenda of most German Laender and municipalities. Numerous initiatives aiming at climate protection have been launched in the recent decade: from local taskforces, citizen memberships in international climate organisations up to local energy agencies. An estimation of the impact (Ziesing et al. 1997) shows that these activities result in a reduction of around 7 Mt CO_2 for the year 2000, in particular in the commercial & service sector and in the private household sector. In the industrial sector regional and local activities achieved only a small additional reduction effect.

Estimation of the impact of decentralised CO_2-reduction activities[1)] in Germany for the year 2000

Level	Reduction in Mt CO_2
Industry	1.1
Commerce & Service	3.3
Private Household	2.4
Traffic	No special analysis of activities on local level
Total	**6.8**

[1)] among others: information on rational use of energy, advice by regional and local energy agencies, measures in commercial buildings, use of renewable energy sources, membership of climate alliances.

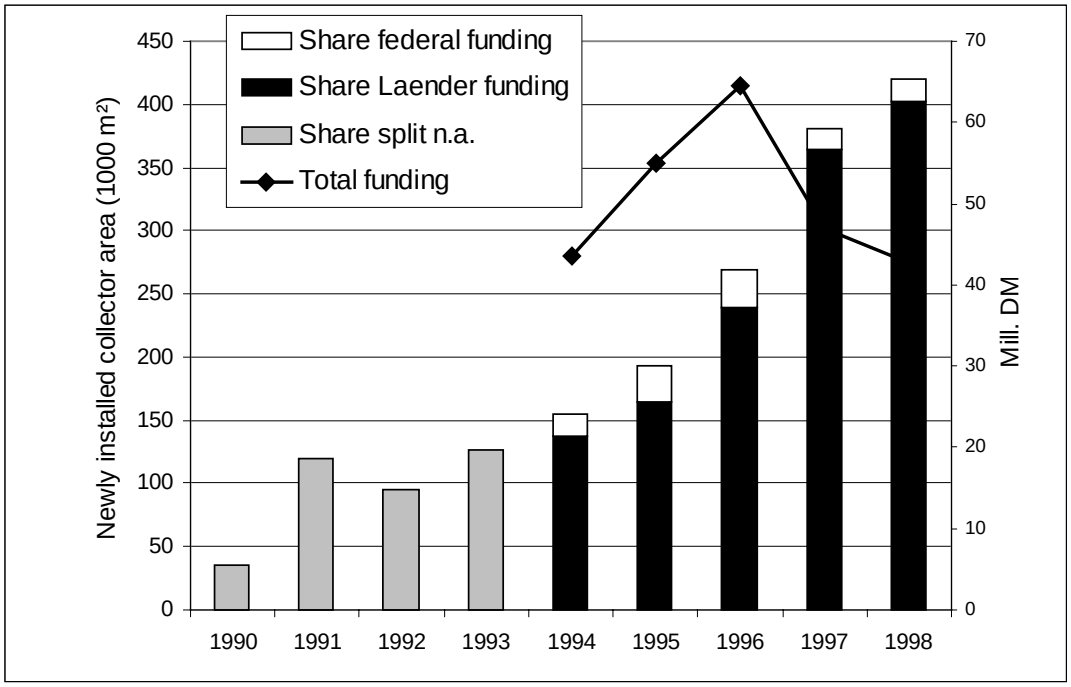
[2)] only direct (fuel based) emission reduction; emissions from electricity are considered to be part of the power plant sector.

Beyond that only a qualitative assessment of the influence of decentralised activities is possible, since evaluations of the measures in terms of their impact on CO_2 emission have not usually been carried out.

Public funding for renewable energy sources

In the 1990s the German Laender accounted for a much larger share than the Federal government in terms of providing financial support for renewable energy sources, in particular for thermal solar energy and wind power. The annual financial support for the installation of all renewable energy sources (wind, hydro, solar collector, photovoltaic, biogas, biomass, heat pumps and geothermal) in the second half of the 1990s was around 165 Million DM, more than 90 % of which was provided by the Laender. To illustrate this, Federal and Laender funding for thermal solar collector installations between 1990 and 1998 is shown in Figure 2-5.

Figure 2-5: Funding and newly installed capacity of solar collectors in Germany



Source: Reichert et al. (1999), Deutscher Fachverband Solarenergie; calculations by ISI.

For German wind energy, the highest installed wind capacity in the world (approx. 6100 MW), funding by the Laender is similar to funding for solar collectors, but the share is even a little higher.

At the end of the 1990s the relative contribution of Laender versus federal funding for renewable energy sources has started to shift significantly in favour of the latter. Of particular importance are the federal *Markteinführungsprogramm Erneuerbare Energien*"(market penetration program for renewable energy sources), which started 1999 and focuses on the use of solar thermal and biomass energy. The funds of 200 Mio. DM originate from the revenues of the eco-tax. Further, in February 1999, the *"100.000 roofs" photovoltaics programme* of the Reconstruction Loan Bank (KfW) started. The programme aims to support the installation of an additional 300 MW – on top of the existing 50 MW providing zero-interest loans for new photovoltaic systems,

Membership in local alliances for climate protection

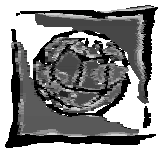
There is a symbiotic relationship between the membership of a community in an alliance for climate protection and local climate activities: membership is a consequence of engagement and at the same time a catalyst for further measures. As early as 1998, one third of all German communities with more than 10,000 citizens

(equivalent to 72 percent of the German population) participated in a local alliance for climate protection (Böde/Gruber 2000). Most communities joining a climate organisation are members of the Climate-Alliance/Alianza del Clima. This alliance was founded in 1990 to initiate climate protection activities at the local level, and to provide all members with an information network. Member communities have committed to cut their CO_2 emissions by the year 2010 by at least 50 %, and then reduce them even further, step by step. The lack of common standards in the communities, different starting positions, the "own history" of each community, and co-existence of other policies make it difficult to estimate the contribution from being a member of the Climate-Alliance. Currently, sets of indicators for success and guidelines for measuring and monitoring are being discussed at the Laender level and at the Climate-Alliance itself.

In Germany 416 communities, combining 34.5 million citizens, or 40 % of the population, have entered a Climate-Alliance and have committed themselves to protect the climate.

Date: March, 2001.

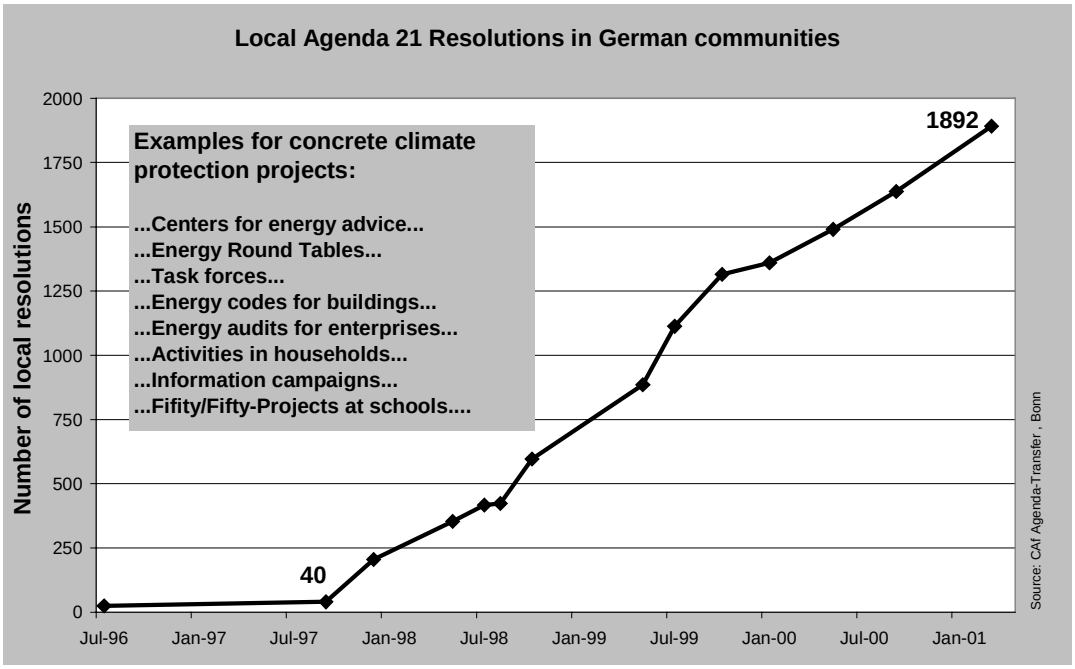
Source: Climate-Alliance/ Alianza del Clima.



Local Agenda 21

The Agenda 21 of Rio 1992, which was reinforced by the "Charter of Alborg", requires communities to initiate sustainable development at a local level. Besides many basic activities such as developing visions, analysing weaknesses, identifying necessary actions, and setting objectives, communities also launch practical projects once a "Local Agenda 21" (LA21) resolution has been formally passed.

Figure 2-6: Development of Local Agenda 21 resolutions in 1996-2001



It turns out that climate protection/energy savings measures play an important role for all communities engaged in LA21 processes. After a slow start, the number of LA21 resolutions in Germany has steadily increased since mid 1997 (see Figure 2-6). Today nearly 2000 communities have passed a LA21 resolution (13.5 % of all German territorial authorities).

2.4 Causes for the reduction of non-CO_2 greenhouse gases

There were substantial decreases in emissions of CH_4 (- 36 %) and N_2O (- 8 %) between 1990 and 1998. Two major political initiatives were responsible for the bulk of emission reductions of non-CO_2 GHG in the 1990s:

- The Technical Instructions on Waste from Human Settlements ("TA Siedlungsabfall") from 1993 which limit the amount of organic waste disposed to landfill sites and prescribe measures to recover landfill-gas. They account for methane emission reductions of approx. 26 Mt CO_2-equivalents (CO_2-eq.) (calculated from BMU 1997, and UBA 2000).
- The voluntary agreements between the government and the two German adipic acid producers to capture and transform N_2O emissions, which has also had an effect of approx. 26 Mt CO_2-eq.

Methane reductions in the waste sector have been helped by the Closed Substance Cycle and Waste Management Act ("Kreislaufwirtschafts- und Abfallgesetz"), which requires waste avoidance and recycling, and by the "TA Abfall, Part 1", which sets rules for such waste which requires special supervision.

Further, there have been considerable methane emission in hard coal mining reductions (approx. 10 Mt CO_2–eq. of CH_4), where both a reduction in production (accounting for approx. 7 Mt; partly policy-induced, partly "business-as-usual") and an intensification of coal pit gas recovery (policy driven, approx. 3 Mt) have lowered emissions.

In agriculture, the greater share of emission reductions (CH_4 and N_2O together roughly 10 Mt CO_2–eq.) was due to the reduction of livestock, especially in the new Laender. This effect is mainly regarded to be a unification effect. Further reductions were brought about by compensation payments for abandoning agricultural area, by the Fertiliser Ordinance ("Düngemittelverordnung") and by a general reduction in fertiliser use.

For halogenated gases („F-gases", i.e., HFCs, PFCs and SF_6), there have been two voluntary commitments by industry ("Declaration of the German primary aluminium industry" for PFCs and "Declaration on the use of SF_6 in electrical switching equipment and systems in Germany"), each estimated to have an effect of approx. 0.5 Mt. Especially regarding HFCs, major steps still have to be undertaken to combat a considerable rise in emissions. Unification did not appear to have had a large effect.

To sum up, for the policy and unification effects on non-CO_2 gas emissions, the following figures are obtained (relative to a "without measures" scenario:

- aggregate effect of climate and other environmental policies: -56.7 Mt CO_2–eq.;
- aggregate effect of other policies: -5.9 Mt CO_2–eq.
- aggregate unification effect: -8.0 Mt CO_2–eq.

Table 2-2 lists the figures in a more detailed form. It shows the projected year 2000 emissions (as estimated in UBA 2000) - first for the trend scenario, i.e., without policy measures or unification effects, then including both these effects. It then identifies specific policies and measures undertaken, and states their estimated individual and aggregate effects. The last column shows the estimated effect of unification. Thus, unlike for CO_2 emissions, *wall-fall profits for other greenhouse gases have been rather small and account for less than 10 % of the observed reductions in those gases*.

Table 2-2: Reductions of non-CO_2 gases

											non-env. policy with...		
Mt			1990	1995	2000 without measures and without unification	2000 with measures and with unification	Measures	2000 policy impact vs. trend	Climate Policy	Other env. Policy	positive climate impact	negative climate impact	unification effect
CH4	**GWP=21**		**117,0**	**81,7**	**110,6**	**70,1**		**-33,8**					**-6,7**
	Energy related		**37,3**	**27,4**	**30,9**	**23,4**		**-7,5**					
		Fuel combustion	**4,5**	**2,3**	**2,7**	**1,8**							
		>of which transport					> catalytic converters in cars	-0,9		X			
		Fugitive Fuel Emissions	**32,8**	**25,1**	**28,2**	**21,6**		**-6,6**					
		>of which from solid fuels	25,8	17,6	22,1	15,5	> reduction of coal production	-3,7			X		
							> voluntary agreements to increase capture of pit gas	-2,9	X				
		>of which from oil and natural gas	7,0	7,5	6,1	6,1	> increased gas use in the new Laender	net effect roughly zero				X	
							> reduction of distribution losses		X		X		
	Agriculture		**39,9**	**32,7**	**39,9**	**33,0**		**-0,2**					**-6,7**
		>of which enteric fermentation	26,2	21,4	26,2	22,0	> reduced livestock mainly in the new Laender						-4,2
							> better digestion due to food improvement program	small	X				
		>of which manure mangement	13,2	10,8	13,2	10,5	> reduced livestock mainly in the new Laender						-2,5
							> reduction of emissions from anaerobic processes, and increased biogas use	-0,2		X			
	Waste sector		**39,8**	**21,6**	**39,8**	**13,7**		**-26,1**					**0,0**
		>of which disposal on land	38,7	21,6	39,8	13,7	> Technical Instructions on Waste from Human Settlements	main impact		X			
							> Closed Substance Cycle and Waste Management Act	additional		X			
Total enviromental policy effect										**-30,1**			
N_20	**GWP=310**		**69,6**	**67,3**	**74,0**	**44,9**		**-27,8**					**-1,3**
	Industrial processes	>chemical industry (mainly adipic acid production)	**25,7**	**25,4**	**32,8**	**6,5**	> voluntary commitments by adipic acid producers to capture N_2O	**-26,3**	X				
	Agriculture		**29,8**	**26,4**	**29,8**	**26,0**		**-3,0**					**-0,8**
		emissions from soils and manure management					> compensation payments for farmers who reduce their cultivated area	-2,2			X		
							> Fertiliser Ordinance	-0,2		X			
							> reduced livestock; autonomous reduction of fertilising	-0,6					-0,8
	Energy related		**11,4**	**12,3**	**11,4**	**12,4**		**1,5**					**-0,5**
		>of which transport	3,2	5,4	3,6	5,6	> catalytic converters in cars	2,0		X			
		>of which other sectors	8,2	6,9	7,8	6,8	> reduction of energy consumption in the old Laender	-0,5	X				
							> reduction of energy consumption in the new Laender						-0,5
Total enviromental policy effect										**-25,6**			
F-Gases	(base value for 1995)		**8,9**	**11,1**	**11,0**	**10,0**		**-1,0**					**0,0**
	industrial processes and other sources		8,9	11,1	11,0	10,0		ca. - 1,0					
	PFCs						>voluntary commitment by aluminium industry	ca. -0,5	X				
	SF6						>voluntary commitment by switching equipment industry	ca. -0,5	X				
Total enviromental policy effect										**-1,0**			
Total Non-CO_2 effects			**195,5**	**160,1**	**195,6**	**125,0**				**-56,7**		**-5,9**	**-8,0**

Source: BMU (1997), UBA (2000), and own calculations.

3 Reduction of Greenhouse Gases in the UK

Between 1990 and 2000, actual greenhouse gas emissions in the UK decreased by about 12 %. In particular, CO_2 emissions, which account for some 80 % of all UK greenhouse gas emissions fell by 8 %. In the UK, which is responsible for about 2.5 % of global CO_2 emissions from energy and industrial processes in 1998 about 92 % of the UK's CO_2 emissions arose directly from energy consumption: some 34 % from petroleum products; 22 % from coal and smokeless fuel; and 37 % from natural gas. Of the remaining 8 % of UK CO_2 emissions, 3 % arose from non-energy products and 5 % from land use change and forestry. A more detailed picture of the underlying factors for the observed reduction in CO_2 emissions is provided in the subsequent sections.

3.1. Analysis of components of CO_2 emission reductions

Overall UK Primary Energy and CO_2 Emission Trends

Between 1990 and 1999, total UK inland consumption of primary fuels rose from 221.6 to 235.9 mtoe (see Table 3-1).

Table 3-1: UK Primary Energy Consumption (mtoe)

Year	Coal	Oil	Gas	N/H/Imp	Total	Temp. Corrected Total
1990	66.9	78.3	51.2	17.7	214.9	221.6
1991	67.1	77.8	55.3	19.2	220.0	221.4
1992	63.0	78.3	55.1	20.4	217.7	220.6
1993	55.0	78.5	63.0	23.4	221.0	222.5
1994	51.3	77.6	64.8	23.2	218.5	221.5
1995	48.9	75.7	69.2	23.1	218.7	223.7
1996	46.2	77.9	80.9	23.8	230.3	229.2
1997	41.1	75.4	82.7	24.8	226.2	231.7
1998	41.4	74.9	85.8	25.2	229.4	235.2
1999	36.7	73.4	90.9	24.4	227.8	235.9

Notes:
(i) Data is rounded. The total also includes renewable sources such as waste, wind, wood, landfill gas and sewage gas.
(ii) N/H/Imp is nuclear, hydro and net imports of electricity (from France).

Source: *Digest of UK Energy Statistics*, DTI, London, 2000, p. 35 and p. 39.

The final column reflects temperature correction, based on deviations from mean UK air temperatures between 1961 and 1990. For the years 1995, 1997, 1998 and 1999 the average temperature was 1 degree Celsius or more above this long-term mean.

The UK's GDP, at constant 1995 market prices, rose by 19.7 % over the period 1990-99. Based upon the temperature-corrected data for primary energy consumption, the UK's energy intensity - as measured by the energy ratio (toe per £1m of GDP) - declined by 11.3 %.

The UK Government's most recent analysis of CO_2 emissions by source is summarised in Table 3-2. Including land use changes, UK CO_2 emissions fell from 616.0 Mt CO_2 in 1990 to an estimated 565.8 Mt CO_2 in 2000, a fall of some 8.2 %.

Table 3-2: Trends in UK CO_2 Emissions, Mt CO_2 (rounded)

Sector	1990	1995	2000	2005	2010	2020
Power stations	198.4	161.7	147.4	131.3	130.5	137.1
Refineries	18.7	21.3	18.7	22.0	23.1	23.8
Residential	78.8	79.6	81.4	81.8	82.9	86.9
Services	30.8	32.3	35.2	34.8	35.6	37.0
Industry	129.1	125.8	123.9	121.0	118.1	117.0
Road transport	109.3	110.7	117.3	127.2	136.8	154.7
Off-road	5.9	5.5	4.8	4.8	4.8	4.8
Other transport	13.2	11.7	11.4	11.4	11.4	11.4
Total without land use change	584.1	548.5	540.1	534.2	543.0	573.1
Land use change	31.9	26.0	25.7	22.0	20.9	16.1
Total with land use change	616.0	574.6	565.8	556.2	563.9	589.2

Notes:
(i) Data for 2000-2020 are estimated, using the average of six alternative projection cases developed for the Programme.
(ii) Off-road transport includes agriculture and construction.

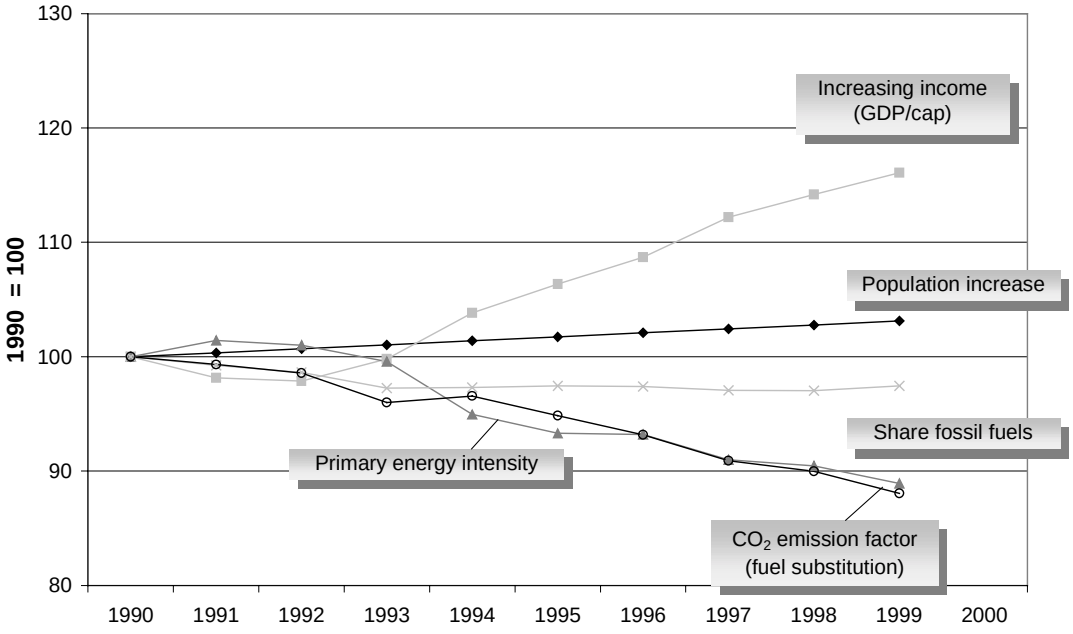
Source: Data derived from *Climate Change: The UK Programme,* Cm. 4913, DETR, The Stationery Office, London, 2000, p. 181; and *Digest of Environmental Statistics*, DETR, London, 2001.

Factor analysis of UK CO_2 emission trends

In broad terms the driving forces for energy related CO_2 emissions have evolved in a similar manner to those in Germany (see Figure 3-1):

- Both population growth and the rise in per capita incomes are associated with an increase in CO_2 emissions;
- Both Fuel substitution and lowering of the primary energy intensity are associated with a decrease in CO_2 emissions;

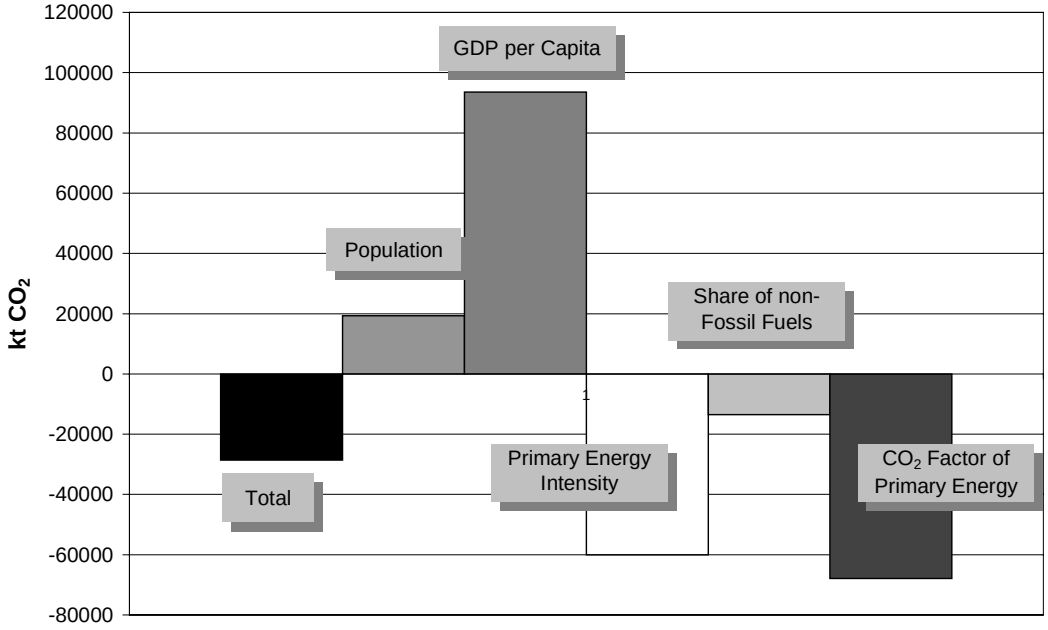
Figure 3-1: Trends of various factors of influence on changes in energy-related CO_2 emissions in the UK from 1990 to 1999



Nevertheless, some notable differences are the comparatively small overall reduction of energy related CO_2 emissions and the smaller role which the reduction of primary energy intensity played compared to fuel switching.

The resulting impact of these changes on the total change in UK energy-related CO_2 emissions is shown in Figure 3-2.

Figure 3-2: Contribution of various factors to changes in energy-related CO_2 emissions in the UK 2000/1990 (temperature corrected)



3.2. The impact of non-climate policy on CO_2 emissions

Some of the key factors underlying the decline in UK CO_2 emissions are now examined under three main categories: (i) the primary energy mix; (ii) the energy supply sector, especially electricity generation; and (iii) in final energy demand sectors.

Trends in the primary energy mix

Between 1990 and 1999, gas use rose by 78 %; and the share of gas in UK primary energy consumption rose from 24 % in 1990 to 40 % in 1999 (see Table 3-1). In the same period, primary electricity consumption (nuclear, hydro, other renewables and imports from France) rose by 38 %. French electricity imports were stable over most of this period, but declined a little after 1998. The major factor behind the rise in primary electricity consumption was higher nuclear output which increased by 49 % between 1990 and 1999 - its share of total UK electricity output rising over the same period from 19.5 % to 25.1 %. The commissioning of the Sizewell B PWR in 1995, and much higher output from the older Advanced Gas-Cooled Reactors (AGRs), explains this. Electricity generation from renewables has grown rapidly (doubling between 1995 and 1999), but this was from a very low base. Renewables of all forms provided only 2.8 % of electricity generated in 1999. However, policy

measures adopted earlier in the 1990s are now having a strong cumulative effect on investment in renewables (see below).

Trends in the energy supply sectors

CO_2 emissions from all UK energy supply sectors fell by about 17 %, from 238.3 Mt CO_2 in 1990 to about 198 Mt in 1998. Emissions from the electricity sector alone fell by some 25 % over this period. Some explanatory factors were discussed above. Since 1990 some 66 % of the growth in total UK gas demand occurred in the electricity sector (see Table 3-1 and Table 3-3). The main explanation was the 'dash for gas' associated with the commissioning of some 17 GW of CCGTs over this period.

Table 3-3: Fuel Inputs to UK Power Generation (mtoe)

Year	Coal	Oil	Gas	N/H/O	Total
1990	49.8	8.4	0.6	17.5	76.3
1991	45.0	7.6	0.6	23.7	76.9
1992	46.9	8.1	1.5	20.1	76.6
1993	39.6	5.8	7.0	23.0	75.4
1994	37.1	4.1	10.1	22.7	74.0
1995	36.3	4.2	13.3	23.4	77.2
1996	33.6	4.0	17.2	24.4	79.2
1997	29.0	2.3	21.5	25.5	78.3
1998	30.3	1.8	22.9	26.3	81.3
1999	25.1	1.8	27.0	25.6	79.5

Note: N/H/O is nuclear, hydro and other fuels (incl. coke, refuse and other renewables such as wind).

Source: *Digest of UK Energy Statistics*, DTI, London, 2000, p. 142.

The key policy and market drivers included factors such as:

- Privatisation of the gas and electricity sectors;
- Energy market liberalisation;
- Reduced political and financial support for the UK coal industry, which was privatised in late 1994;
- The electricity generators' desire to secure greater fuel diversity;
- The opportunities provided by technological change (e.g. CCGT);
- The impact of the EU Large Combustion Plant Directive on permitted power station SO_2 emissions (and thus on utility fuel choice);
- The abolition in 1990 of the EU-wide limitations on gas use in power generation, first imposed in 1975.

- Whether nuclear power had been in the hands of the public or the private sectors, it is unlikely that further nuclear plant ordering would have proceeded in this period. However, commercial disciplines of the private sector may well explain the significant increase in nuclear output from the AGRs.

The importance of the electricity sector in reducing total UK CO_2 emissions over the last decade must be stressed, but also placed in context. Whilst total CO_2 emissions fell by some 50.2 Mt from 1990-2000, the decline in CO_2 emissions from the electricity sector was 51.0 Mt. Privatisation and liberalisation of the electricity industry certainly played a role in this process but these two factors should not be over-emphasised. Rather, a complex combination of factors explains the radical changes in the UK power station fuel mix in the 1990s.

It might also be argued that CO_2 emission reductions in the electricity sector - and for the UK as a whole over this period - were related in only a minor way to explicit climate change policy. But this would be a mistake. It would underestimate the importance of measures increasingly being applied in other sectors to curb UK CO_2 emissions.

It is certainly true that, at this relatively early stage of climate change policy implementation, the actions and measures taken to reduce emissions are often offset by countervailing factors such as higher GDP and household incomes; more households; smaller household size; continued expansion in appliance ownership and use; growth in IT applications in all sectors; and reduced market-based incentives for energy efficiency given lower gas and electricity prices in particular.

Trends in final energy demand sectors:

Residential: Total energy demand rose from 40.8 mtoe in 1990 to 46.1 mtoe in 1999. Key trends over this period included: population growth (from 57.6m to some 59.4m); a 10 % increase in the number of households; continued displacement of coal and oil by natural gas (use of which rose 18.5 % in the 1990s) in space heating markets; steady replacement of older, less efficient boilers - though penetration of condensing boilers is still low in the UK; purchase of more efficient electrical appliances and lighting; installation of insulation and double-glazing; and two revisions of building regulations.

Unlike transport (see below) a major feature was the reluctance to use market mechanisms, such as taxes, in the domestic sector. Parliament had earlier rejected a proposed increase in VAT on residential energy from 8 % to 17.5 %; and the Labour Government reduced the VAT rate to 5 % in 1997. This was because of the regressive effect of such taxation on the poor and mounting policy concern about

fuel poverty (the difficulty obtaining adequate warmth given poor insulation standards in the older UK housing stock).

Services: Energy use in commercial and public services and in agriculture rose by 11.6 % between 1990-99 to 21.5 mtoe. Much of the growth was for electricity, especially in commercial services, whilst higher gas use displaced that of coal and oil. Major growth has occurred in floor area, together with IT equipment, improved heating and ventilation, and some growth in air conditioning. Development of out-of-town shopping and leisure facilities, and warehouses, has also influenced travel patterns and thus transport energy demand.

Industry: A major decline in UK industrial energy use occurred between 1973 and 1990. Between 1990 and 1999 this decline slowed, particularly after 1995, partly as a result of lower real energy prices. Use of electricity, and especially of gas, has expanded at the expense of coal and oil. Detailed analysis of longer-term energy trends in industry has highlighted that structural change away from energy-intensive sectors was much less important than the overall improvement in efficiency of energy use. Manufacturing industry's share of GDP has continued to decline in the 1990s.

Transport: Some 94 % of sectoral energy use was accounted for by road transport in 1998. Despite much higher taxation, both energy use and CO_2 emissions increased in the last decade. However combined petrol and diesel consumption for road transport grew by only 5 % between 1990-1999; and fell between 1997-1999. Some analysts interpret this as reflecting the cumulative effect of higher road fuel taxes. But growth in transport CO_2 emissions is again projected to increase in the present decade (see Table 3-2).

3.3. The impact of climate policy on CO_2 emissions

Use of a reference scenario in this brief UK case has proved difficult, for several reasons. First, for many years, no detailed official projections of energy use or emissions were published in the UK. The most recent projections (both published in 2000) were required for preparation of the draft and final Climate Change Programme and they focus primarily upon 2010. Second, the choice of any reference scenario to evaluate policy impacts - with a specific start and end date - is inevitably somewhat arbitrary. This is because of the long lead times involved in initial policy formulation; subsequent consultation both inside Government and with numerous external stakeholders; the preparation and Parliamentary passage of any necessary legislation; and its subsequent implementation. In practice all these stages can take some 2-5 years.

Third, many policy measures are introduced for purposes other than climate change mitigation (e.g. tax raising, or to boost investment and raise productivity and international economic competitiveness). An example is higher road fuel taxation (see below) which was, at least in part, motivated by climate policy considerations. However, such higher taxation was also consistent with the then prevailing view of higher indirect (e.g. road fuel duties and VAT) and lower direct (e.g. income) taxation. As most climate-specific measures are only now being introduced in the UK, there is virtually no published official quantification of the impact of the earlier policy measures adopted in the 1990s.

Throughout the 1990s much policy attention was given to the progressive liberalisation of UK electricity and gas markets; to its second-round effects, such as the rapid reduction in UK coal mining capacity; and to the evolving regulatory regime. The coal industry and more of the nuclear industry were also privatised. Until recently, somewhat less attention was paid to climate change policy.

UK CO_2 emissions began to decline following the first oil shock in 1973, the rapid penetration of natural gas, and an acceleration in industrial restructuring. The UK's first Climate Change Programme was published in 1994 in response to the UNFCCC. Few analysts considered this an ambitious document. As already stated, the proposed introduction of higher VAT on residential energy use was defeated in Parliament. Government funding for energy efficiency schemes remained modest reflecting the public expenditure philosophy of that period. At this time, other than much higher taxation of road fuels, most measures sought to rely upon voluntary actions - stimulated by encouragement of best practice through information campaigns.

The transport sector witnessed perhaps the most decisive policy intervention in the mid 1990s. The Conservative Government introduced the fuel duty 'escalator' in 1994, whereby the annual increase in road fuel taxation rose by 5 % above inflation. The Labour Government initially increased this to 6 % p/a but, since 1999, the increase has been determined annually. The cumulative effect was that, by 1999, the total share of tax and duty on UK road fuels reached 82.2 % for unleaded petrol and 83.5 % for diesel.

Unlike in some other EU countries, in the UK there is no tax relief on travel costs to work. In addition, during the 1990s, the tax position of company cars and of company-provided vehicle fuel was greatly tightened. In 1999 the UK had the highest tax component and the highest retail 'pump' prices for unleaded petrol and diesel in the EU. Vehicle taxation has also been increased for cars with larger engines but the tax rate is now graduated to reflect engine capacity (and thus, implicitly, efficiency and emissions).

Climate change concerns, coupled with other considerations, also assisted renewable energy sources. The Non Fossil Fuel Obligation (NFFO) and the Fossil Fuel Levy (FFL) were originally introduced, following the 1989 Electricity Act, to assist the nuclear industry after privatisation of most of the electricity sector. To avoid discrimination these measures were also applied to renewables. This form of support was withdrawn for nuclear power in 1998, but maintained for renewables. Longer-term targets for both renewables and CHP have been raised since 1997. The Government expects renewables to account for 10 % of UK electricity output in 2010; and the target is for 10,000 MW of CHP capacity, also in 2010. A selection of some important policy measures affecting CO_2 emissions in the UK is provided in Table 3-4.

Table 3-4: Selection of key UK policy measures

Sector	Broadly climate policy related	Not specifically related
Energy supply	• Non Fossil Fuel Obligation (stimulated renewable investment) • Fossil Fuel Levy (ditto) • Replaced by Renewables Obligation from 2001-2026	• Relaxation of EU limits on gas use in 1990 • Reduced public funding for coal. Coal industry privatised in 1994. • Large Combustion Plant Directive (all encouraged the 'dash for gas')
CHP	• Target setting for installed capacity, facilitation & removal of barriers	• Liberalisation of electricity and gas markets
Domestic	• Current revision of building Regulations • Market Transformation Programme (for appliance efficiency standards) • Energy Efficiency Standards of Performance (EESoP) – charge on electricity, now also gas, consumers • Home Energy Conservation Act (indicative targets only, but no extra funding for local government) • Local Energy Efficiency Advice Centres • Higher funding for Energy Saving Trust	• 1995 revision of building Regulations • Release of capital receipts from sales of public housing – partly used by local government for energy efficiency and refurbishment • Energy efficiency scheme (HEES and the much-expanded New HEES) to increase comfort levels mainly • General housing improvement grants • Urban renewal grants
Services	• Current revision of building Regulations • Market Transformation Programme (for appliances & IT equipment)	• 1995 revision of building Regulations • Capital allowances for investment against Corporation Tax
Industry	• Energy Efficiency Best Practice Programme (EEBPP) • Making a Corporate Commitment • Increased use of voluntary agreements • Funding for carbon trading trials • Preparation of Climate Change Levy (in force from April 2001) & Carbon Trust	• Capital allowances for investment against Corporation Tax
Transport	• Big increase in road fuel taxation • Higher taxation of company cars and company-provided fuel • Tougher vehicle emissions testing • Higher public investment in rail • Stronger land use planning • Facilitation of local transport plans	Reduction in spending on road programmes (initially to reduce public expenditure)
General	• Publication of the Climate Change Programmes, and associated literature, projections etc, to raise awareness • Stimulating more media interest to raise awareness and public debate	

Notes: Allocation across the last two columns is somewhat arbitrary on occasions, especially for multi-objective measures such as higher road fuel taxes (for tax revenue, and to reduce congestion & emissions).

Even though some measures listed may formally take effect from 2000 onwards, policy assessment, planning and drafting of any necessary legislation often commenced from 1997/98.

Some official estimates of the CO_2 reductions arising from individual policy measures are available from the UK's second national Communication for the 1990s, and are reported - with some modifications due to a smaller than expected impact – in the text.

Without any doubt, climate-related policy making has accelerated since the Kyoto Conference in 1997. Following a period of consultation on a draft, the UK Government published its definitive response strategy in November 2000 (*Climate Change – The UK Programme*, Cm. 4913). This was immediately before the sixth Conference of the Parties to the Climate Change Convention (COP6) held in The Hague. The document set out the Government's overall strategic approach to climate change and has been associated with the reinforcement of many existing measures and the introduction of new ones. The Programme also identified numerous policy decisions and practical steps needed to reduce emissions further over the period to 2010 and beyond. In addition, the Government has also re-examined taxation principles and prepared a Climate Change Levy on most industrial and service sector energy use to be applied from April 2001.The Government estimated that the policy proposals and market developments in the Programme, if fully implemented, could reduce UK greenhouse gas emissions by about 23 % - and CO_2 emissions by about 19 % - over the period 1990-2010.

Regional Activities

Although a quantitative assessment of regional efforts in the UK to reduce greenhouse gas emissions is not available, the literature provides a vast collection of individual case studies. For example, a small, but increasing, number of local authorities (e.g. town or county councils) are securing ISO14001 certification for environmental management as a result of their efforts to reduce the impact of their activities on both the local and global environment. In addition the Local Authority Energy Advisory Service is funded by the Energy Saving Trust and is operated in partnership with the Local Government Association (in England and Wales), the Convention of Scottish Local Authorities, and the Association of Local Authorities of Northern Ireland. It offers a free source of advice to all UK local authorities on matters relating to sustainable energy use, including a web site, briefing notes and case studies and a quarterly newsletter. Other local initiatives include increased tenders for electricity from renewable energy sources by local authorities and district councils, public-private partnerships to upgrade community heating systems, or local authorities requesting building developers and new house builders to exceed the standards specified in the UK Building Regulations.

3.4. The policy contribution to the reduction of non-CO_2 greenhouse gases

The UK baseline year for the basket of six greenhouse gases is 1990 for CO_2, methane and nitrous oxide but 1995 for HFCs, PFCs and SF_6. For the latter group the Government has stated that the 1995 data were more reliable and that the difference between 1990 and 1995 figures is very small (see Table 3-5).

Table 3-5: Trends in Overall UK Greenhouse Gas Emissions, Mt CO_2–eq. (rounded)

Greenhouse Gas	1990	1995	2000
Methane	77.2	61.3	52.4
Nitrous oxide	65.7	55.1	41.1
Hydrofluorocarbons (HFCs)	11.4	15.2	9.2
Perfluorocarbons (PFCs)	2.3	1.1	0.7
Sulphur hexafluoride (SF_6)	0.7	1.1	1.5
Carbon dioxide including land use	616.0	574.7	565.8
Total greenhouse gas emissions	776.2	708.4	670.6

Sources: *Climate Change: The UK Programme,* Cm. 4913, DETR, The Stationery Office, London, 2000, p. 53; and *Digest of Environmental Statistics*, DETR, The Stationery Office, London, 2001.

Methane: The main sources for methane emissions are landfill waste, agriculture, coal mining, natural gas distribution and offshore oil and gas production. Overall these emissions fell by 28 % between 1990 and 1998; and those from coal mining by 68 % given the steep reduction in coal production. Measures include collection and combustion of landfill gas; proposed lower volumes of dumped municipal waste; and reduced leakage from gas pipes and offshore platforms.

Nitrous oxide: Major sources are agriculture, chemical processes and fuel combustion. Measures include lower fertiliser use and, especially, the combustion of off-gas from nylon production.

HFCs, PFCs & SF_6: The major sources for HFCs and PFCs are leaks from refrigeration and air conditioning equipment, foam blowing, aerosols, aluminium smelters and chemical use in electronics manufacturing. Measures include voluntary agreements aimed at tighter process control and use of alternative fluids. SF_6 is used for electrical insulation, magnesium smelting and some other industrial processes but, at present, few measures to reduce emissions exist other than tighter process control.

3.5 Quantitative assessment of policy and liberalisation effects on greenhouse gases

The quantitative assessment of the impacts of climate and other environmental policies, and of the liberalisation of the energy markets (including privatisation) on the reduction of greenhouse gases in the UK during the 1990s relies on the figures given in the UK 2nd National Communication to the UNFCCC (see Table 3-6). Since the targets set out in the Communication for renewables and CHP are unlikely to be met, estimates for renewables and CHP have been adjusted downward. The profitability of CHP has recently been negatively affected by a decrease in electricity prices and an increase in gas prices, and renewable energy schemes have been hampered by problems in securing local planning permission. Under these assumptions, liberalisation (including privatisation) resulted in a reduction of almost 73 Mt of CO_2-eq., while climate and other environmental policies decreased greenhouse gas emissions by almost 83.5 Mt of CO_2-eq. relative to the assumed "business as usual scenario".

Table 3-6: Quantitative estimate of the impact of greenhouse gas reduction measures in the UK in the 1990s (in Mt of CO_2-eq.)

CO_2	CO_2 - equ.	**Policy**
Fuel Switch (Market liberalisation)	62.3	other
Nuclear productivity (fostered by market liberalisation/privatisation)	10.6	other
Renewables	3.0	climate
Fuel duty escalator	11.0	climate
CHP development	9.2	climate
Public sector savings target	2.9	climate
Energy savings trust	1.8	climate
Energy Eff. Best Practice Programme	12.8	climate
Others (Regulation, advice, grants, labelling)	5.9	climate
Total climate + environment	**46.6**	
CH_4		
Waste management strategy	17.6	environment
Leakage control strategy for gas distribution	1.8	climate
Total climate + environment	**19.4**	
N_2O		
Limiting emissions from adipic acid	17.4	climate

Source: UK 2nd National Communication to the UNFCCC, SPRU/ISI own estimates.

4 Summary and Conclusions

This report gives an overview of the underlying factors for greenhouse gas emission trends in Germany and the UK in the 1990s. The main focus of the study was to assess to which extent the observed reductions in emissions of the specified basket of six greenhouse gases are the result of special circumstances, i.e. the reunification of Germany and the liberalisation (including privatisation) of the energy markets in the UK, and to which extent these emission reductions are the result of specific policy measures.

The main findings of the report are displayed for Germany in Figure 4-1 and Table 4-1, and for the UK in Figure 4-2 and Table 4-2.

In the year 2000 greenhouse gas emissions in Germany were more than 18 % lower than in 1990, and in the UK they were about 12 % lower. In terms of quantity, these greenhouse gas reductions in Germany correspond to 225 Mt CO_2 –eq., i.e., they are 2.5 times higher than in the UK. In both countries, special circumstances had an important impact on the observed reduction of greenhouse gases in the 1990s. Unification in Germany and the fuel switch resulting from liberalisation (and privatisation) of the energy markets in the UK accounted for about 50% of the emission reductions of all greenhouse gases, and for 60% of the reduction of energy-related CO_2 emissions.

In either country a diverse set of policies affecting energy-related CO_2 emissions accounted for about 40 % of the emission reductions. In Germany, many of these policies were introduced and continuously improved over the past decade. In the UK, an increase in policy efforts can be observed after 1997.

Likewise, environmental policies directed towards non-CO_2 gases (in particular waste management and the reduction of N_2O from adipic acid production) had almost as strong an impact as policies addressing CO_2 emissions. Considering all greenhouse gases, the contribution of all policies was slightly higher than the impact of unification in Germany or liberalisation in the UK, respectively.

In Germany, and to a lesser extent in the UK, local and regional activities contributed increasingly to the reduction of greenhouse gas emissions. For example, the German Federal States “Laender” contributed significantly to the successful expansion of wind energy and solar thermal energy. The impact of these activities is difficult to quantify since they are not systematically monitored.

Emission reductions resulting from unification were the main argument behind Germany’s stringent emission reduction target of –21% under the terms of the EU Burden Sharing Agreement. The analyses for Germany in this study suggest that even without these wall-fall profits, the reductions of greenhouse gases observed are quite significant. Thus, at this point in time, Germany is clearly on a reduction path

to meet the Kyoto target. However, chances to reach the more ambitious national target of –25% CO_2 emissions by 2005, appear rather slim. To meet this target, further and immediate policy efforts are very likely to be necessary. Areas where such policies are likely to be effective include the transport sector, the existing building stock, combined heat and power generation, and extending the Ecological Tax Reform and modifying the tax schemes to provide stronger incentives to save energy, in particular in the manufacturing sector.

The analyses for the UK suggest that even without liberalisation and privatisation in the energy sector, greenhouse gas emissions in the UK in 2000 would have been well below the 1990-levels. And, in contrast to most other Annex-B countries, the UK – like Germany - appears roughly in line with „mean efforts“ to achieve the Kyoto-target. Benefiting from the emission-reducing effects arising from liberalisation, the UK is likely to achieve its 12.5% reduction target under the EU Burden Sharing Agreement . However, in order to reach the more ambitious national UK target of –20 % in CO_2 emissions by 2010, the past efforts appear not sufficient. It appears from Table 3-2 and Figure 4-2 that, despite the policy efforts to date, emission reductions are slowing down or may even increase between 2000 and 2010. In particular, the relatively easy reduction of N_2O from the production of adipic acid is now largely achieved and the switch away from coal in power generation has already been substantial. The rather strong economic growth in the past five years might have contributed to this development, but further efforts with respect to renewables in particular but also energy efficiency in households, services and industry are necessary.

To sum up, the analyses provided in this report suggest that emission reductions arising from special circumstances account for about 50 % of the reductions for all Kyoto gases, and for about 60 % for energy-related CO_2 emissions. However, environmental policies in both countries also had a major impact on the reduction of greenhouse gases. Thus, the observed reductions are a mix of both, coincidence and real policy efforts. Nevertheless, both countries, and perhaps the UK even more than Germany, might miss their national targets unless additional policies are implemented in the near future. Realising the policies announced in both countries in the Fall of 2000 in their respective climate change programmes would be an important step.

Table 4-1: Comparison of environmental policy and unification effects on greenhouse gas emission between 1990 and 2000 in Germany

	Energy-related CO_2		All Kyoto gases	
	Policy effect	Unification effect	Policy effect	Unification effect
Reduction compared to "BAU" for 2000 (% of 1990 emissions[1])	175.6 Mt (17.3%)		240.3 Mt (19.4%)	
Single effects, compared to "BAU" (% of total reduction[1])	70.7 Mt (40.3%)	104.9 Mt (59.7%)	127.4 Mt (53.0%)	112.9 Mt (47.0%)
Actual reduction compared to 1990 emissions (% of 1990 emissions[1])	151.6 Mt (14.9%)		224.8 Mt (18.2%)	
Single effects[2] (% of 1990 emissions[1])	61.0 Mt (6.0%)	90.6 Mt (8.9%)	119.2 Mt (9.6%)	105.6 Mt (8.5%)

[1] temperature corrected emissions

[2] The actual emission reduction was distributed in proportion to the shares of the single effects versus Business-as-usual development.

Table 4-2: Comparison of environmental policy and liberalisation effects on greenhouse gas emissions between 1990 and 2000 in the UK

	Energy-related CO_2		All Kyoto gases	
	Policy effect	Unification effect	Policy effect	Unification effect
Reduction compared to "BAU" for 2000 (% of 1990 emissions[1])	119.6 Mt (20.4%)		156.4 Mt (20.9%)	
Single effects, compared to "BAU" (% of total reduction[1])	46.7 Mt (39.0%)	72.9 Mt (61.0%)	83.5 Mt (53.4%)	72.9 Mt (46.6%)
Actual reduction compared to 1990 emissions (% of 1990 emissions[1])	47.5 Mt (8.1%)		89.0 Mt (11.9%)	
Single effects[2] (% of 1990 emissions[1])	18.5 Mt (3.2%)	29.0 Mt (4.9%)	47.5 Mt (6.3%)	41.5 Mt (5.5%)

[1] temperature corrected emissions

[2] The actual emission reduction was distributed in proportion to the shares of the single effects versus Business-as-usual development.

Figure 4-1: The role of policies and special developments (unification) in the reduction of greenhouse gas emissions in Germany

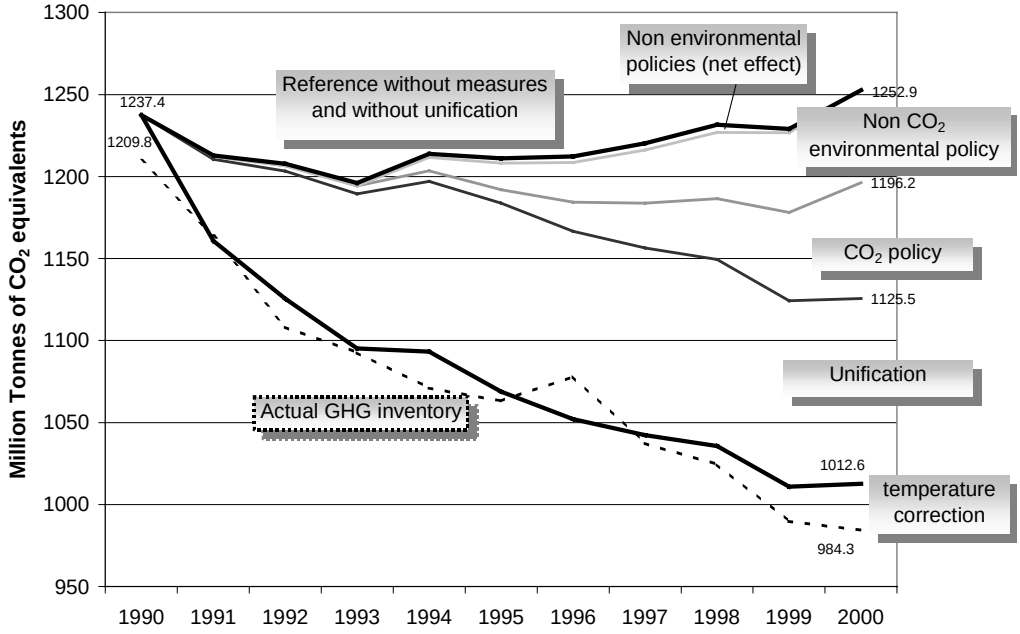
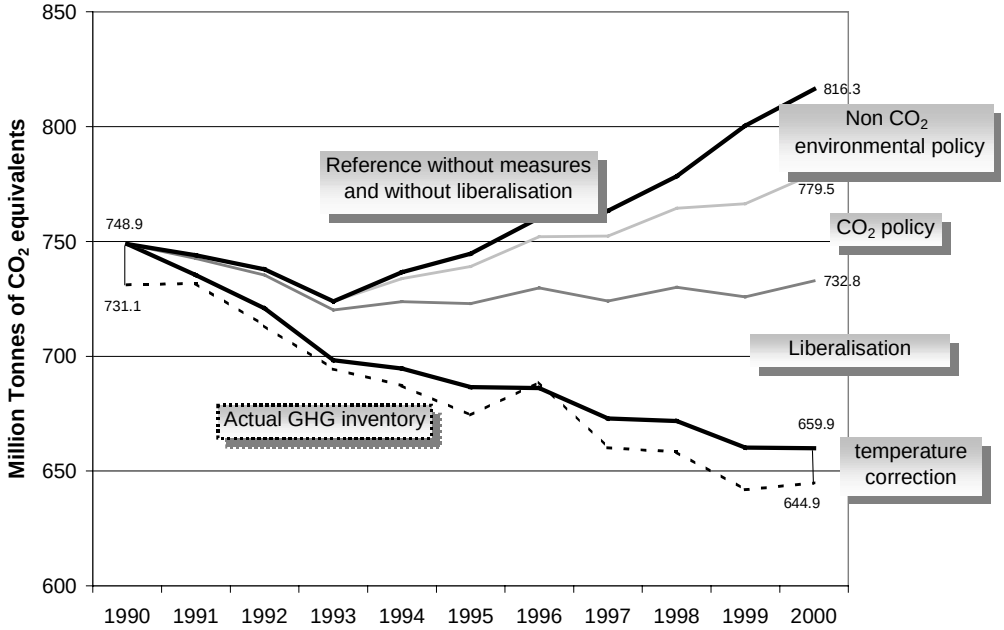


Figure 4-2: The role of policies and special developments (liberalisation) in the reduction of greenhouse gas emissions in the UK



References

BMU (Federal Ministry for the Environment, Nature Conservation and Nuclear Safety): Sechster Immissionsschutzbericht der Bundesregierung. Bonn, Deutscher Bundestag, Legislation period 13, Drucksache 13/4825. Bonn: BMU 1996.

BMU (Federal Ministry for the Environment, Nature Conservation and Nuclear Safety): Climate Protection in Germany. Second Report of the Federal Republic of Germany Pursuant to the UNFCCC. Bonn: BMU 1997.

BMU (Federal Ministry for the Environment, Nature Conservation and Nuclear Safety): Germany's National Climate Change Programme. Summary. Berlin: BMU 2000.

Böde, U.; Gruber, E.: Klimaschutz als sozialer Prozess: Erfolgsfaktoren für die Umsetzung auf kommunaler Ebene. Physica-Verlag, Reihe „Technik, Wirtschaft und Politik" des Fraunhofer Instituts für Systemtechnik und Innovationsforschung. Heidelberg 2000

Diekmann, J.; Eichhammer, W.; Rieke, H.; Schlomann, B.; Ziesing, H.-J.: Energie-Effizienz-Indikatoren. Statistische Grundlagen, theoretische Fundierung und Orientierungsbasis für die politische Praxis. Heidelberg: Physica-Verlag, 1999. Executive Summary (40 p.) also available in English (published as: Energy Efficiency Indicators: Statistical Basis, Theoretical Foundations, and Guide for Political Practice. BMWi-Dokumentation No. 456. Bonn/Berlin, March 1999).

DIW (German Institute for Economic Research): Die gesamtwirtschaftlichen Auswirkungen der ökologischen Steuerreform, Study prepared for the German Ministry of Finance, Berlin, March 2001.

European Commission: Economic Evaluation of Emissions Reductions in the Transport Sector of the EU. Study prepared by Ecofys Energy and Environment, AEA Technology Environment and National Technical University of Athens. Brussels: March 2001.

Federal Statistical Office: National Accounts. Wiesbaden 2001

Reichert, J.; Gruber, E.; Mannsbart, W.: Evaluierung der Förderung von Maßnahmen zur Nutzung erneuerbarer Energien durch das Bundesministerium für Wirtschaft (1994 – 1998). Karlsruhe, 1999.

Schleich J., et al. : Greenhouse gas reductions in Germany – Lucky strike or hard work. In: Climate Policy (2001), forthcoming.

Sun, J.W.: Changes in Energy Consumption and Energy Intensity: A Complete Decomposition Model. In: Energy Economics 20 (2) 1998, S. 85-100.

UBA 2000: umwelt deutschland. Study on behalf of the Federal Environmental Agency UBA, conducted by Fraunhofer-Institut fuer Systemtechnik und Innovationsforschung (ISI), Deutsches Institut fuer Wirtschaftsforschung (DIW) und ifeu - Institut fuer Energie- und Umweltforschung ; unpublished. Karlsruhe/Berlin/Heidelberg: 2000.

UK: The Stationery Office: Digest of UK Energy Statistics, DTI, London, 2000.

UK: The Stationery Office: Climate Change: The UK Programme, Cm. 4913, DETR, London, 2000.

UK: The Stationery Office: Digest of Environmental Statistics, DETR, London, 2001.

UK: 2nd National Communication to the UNFCCC.

United Nations Framework Convention on climate Change (UNFCCC) (2000) *National communications from parties included in Annex I to the Convention: Greenhouse gas inventory data from 1990-1998*. FCCC/SBI/2000/INF. 13.

Ziesing, H.J. et al.: Politikszenarien für den Klimaschutz. Band 1: Szenarien und Maßnahmen zur Minderung von CO_2-Emissionen in Deutschland bis zum Jahre 2005. Untersuchungen im Auftrag des Umweltbundesamtes. Juelich: Forschungszentrum Juelich 1997.

Ziesing, H.J. et al.: Politikszenarien für den Klimaschutz. Band 5: Szenarien und Maßnahmen zur Minderung von CO_2-Emissionen in Deutschland bis 2020. Untersuchungen im Auftrag des Umweltbundesamtes. Juelich: Forschungszentrum Juelich 1999.

Ziesing, H.J., Jochem, E., Mannsbart, W., Schlomann, B.: Causes of the Trend in CO_2 Emissions in Germany between 1990 to 1995. Executive Summary. Bonn: BMU 1997

Ziesing, H.-J.: CO_2 –Emissionen im Jahre 1999: Rückgang nicht überschätzen. In: DIW-Wochenbericht 6/2000 pp. 77-85

Ziesing, H.-J.: Höhere CO_2-Emissionen im Jahre 2000. In: DIW-Wochenbericht 6/2001 pp. 91-99