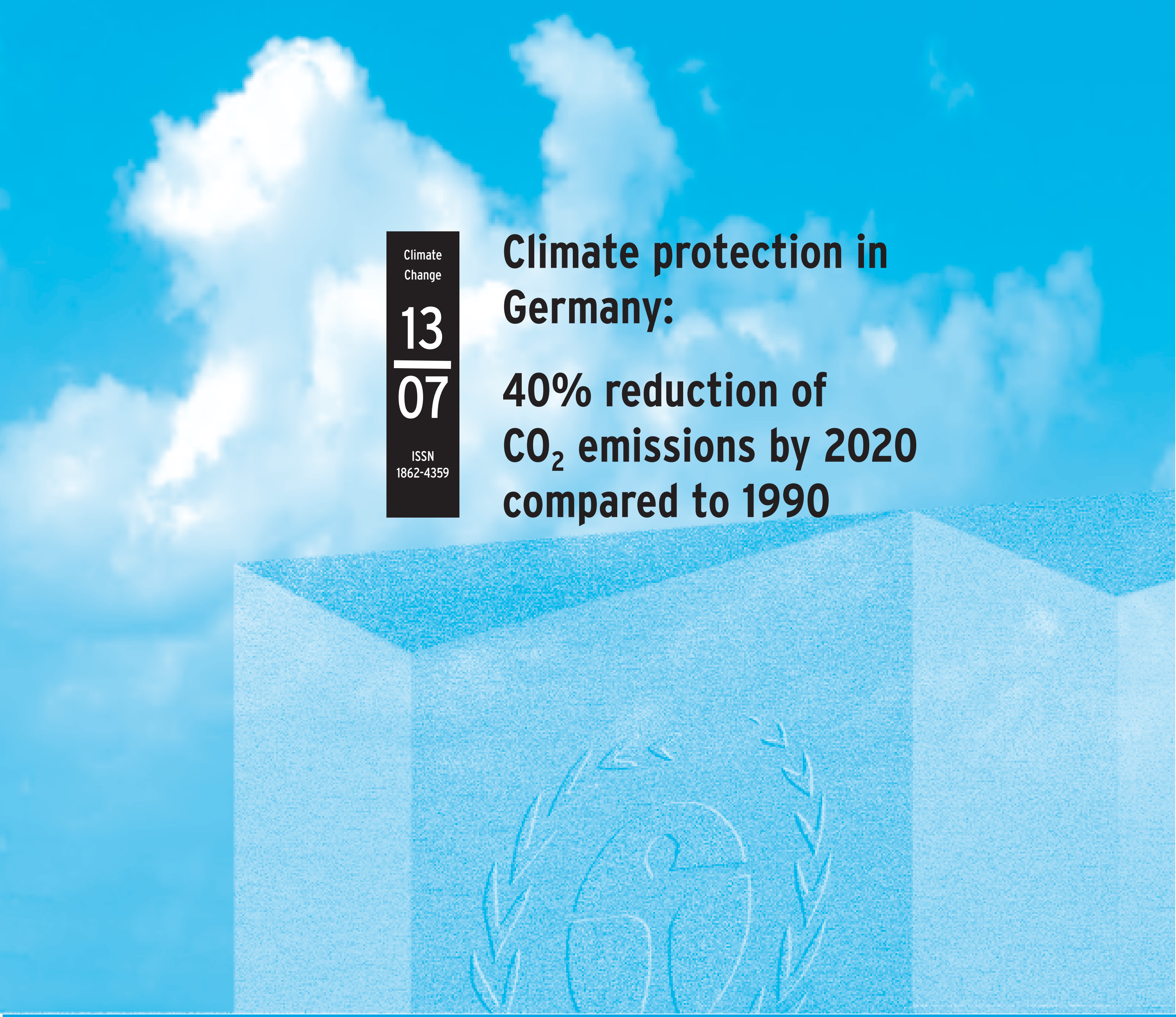
Climate Change



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Climate protection in Germany:

40% reduction of CO_2 emissions by 2020 compared to 1990

Umwelt Bundes Amt

Für Mensch und Umwelt

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1. Executive Summary

There is an urgent need for more determined and far-reaching action because climate change has already begun.

Recent forecasts indicate serious hazards for our economies, the stability of ecosystems and sustainable development. A global temperature rise of 2°C compared to pre-industrial levels appears to be the very most that can be tolerated. In order to achieve this 2°C target, the current industrial nations with their very large per-capita emission levels will even have to cut their greenhouse gas emissions by as much as 80% by the middle of this century compared to 1990. As an intermediate target, the European Union should reduce by the year 2020 its emissions by 30% against the 1990 level.

Germany as a pioneer: the 40% target

Germany should pioneer climate protection efforts and support a 30% reduction on EU level by committing itself to reducing its own emissions by 40% by the year 2020 compared to 1990 (40% target). Germany is already benefiting from its market leadership in the field of CO_2-saving technologies and is capable of developing this position further.

We must do more because the later we start the more expensive the consequences of climate change will be. Although the targets laid down in the Kyoto Protocol up to the year 2012 are within reach for Germany and the EU, they are only a first step. Within the scope of the distribution of burdens in the EU-15 under the Kyoto Protocol, Germany has undertaken to reduce greenhouse gas emissions by 21% over the period from 1990 and the 2008-2012 period. According to calculations by the Federal Environment Agency, more than 18% was already achieved in 2005. The measures discussed below will enable Germany to achieve the remaining 22% by the year 2020.

Energy is the key

The generation and use of energy are the key to successful climate protection. When it comes to energy-related CO_2 emissions, the 40% target corresponds to maximum annual emissions of 571 million tonnes of CO_2 in 2020. The Federal Environment Agency has identified eight measures in the electricity, heat and transport sectors in order to achieve this target by the year 2020. This is possible if we optimise the utilisation of energy, save energy and expand renewable energies – these should be the pillars for an emission reduction drive. Which technical and systemic measures will be selected from the overall CO_2 emission reduction scenario and how these measures will be weighted will depend on criteria of economic efficiency (minimum cost of avoidance per cost of CO_2 avoided), overcoming legal and administrative obstacles to emission reduction, as well as the likelihood of implementing the necessary changes in behaviour.

Fig. 1 shows the development of energy-related CO_2 emissions in Germany so far and the result of the Federal Environment Agency's scenario.

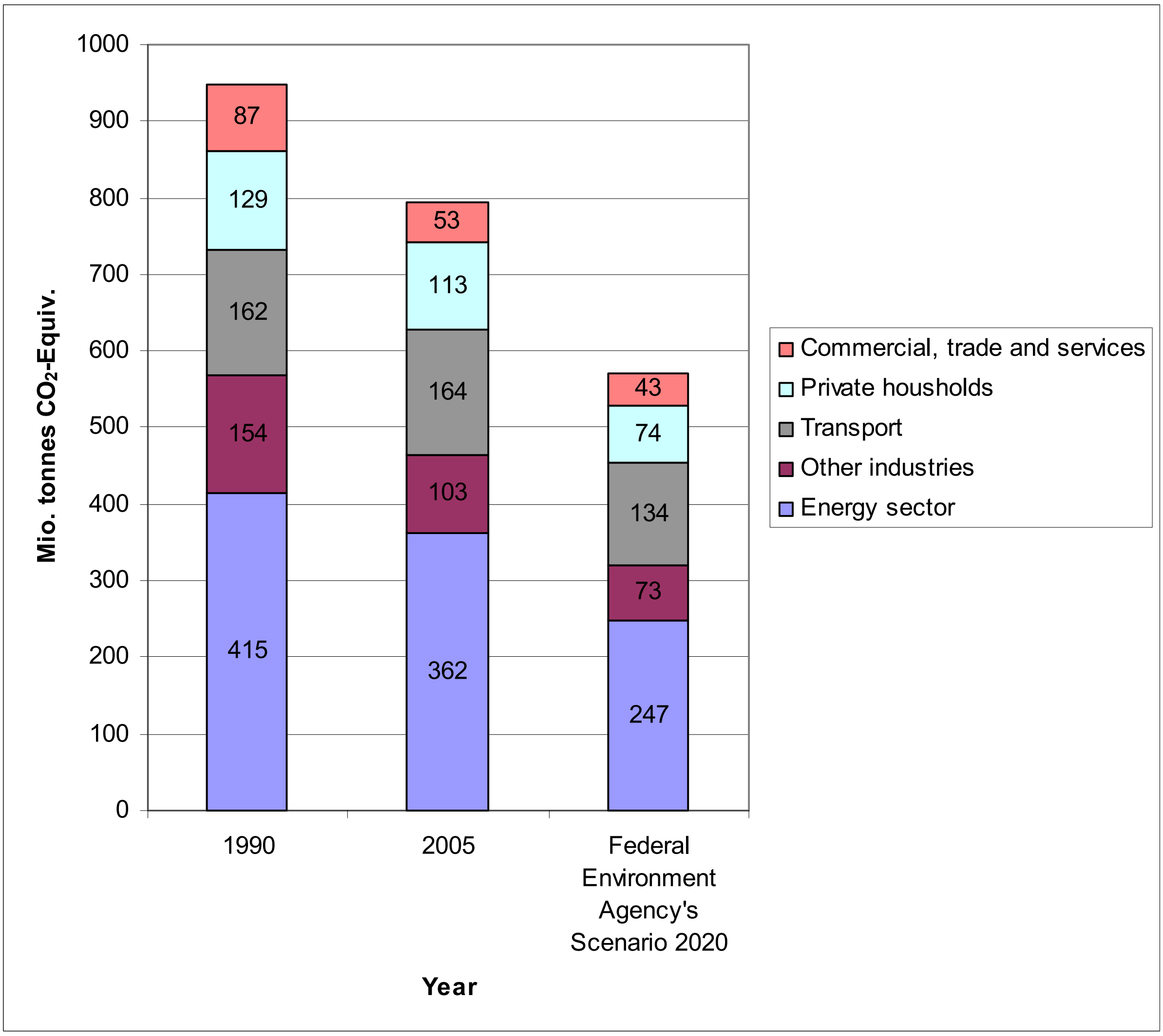

Fig. 1: Energy-related CO_2 emissions in Germany's economic sectors: actual values for 1990 and 2005, a scenario developed by the Federal Environment Agency for 2020. Source: calculations by the Federal Environment Agency, 2007.

What will have to happen in Germany?

Technical progress has led to cost reductions which are likely to continue also in future, especially with regard to renewable energies. The intensive use of these technologies for power generation will hence become possible at reasonable additional cost. The Federal Environment Agency expects that no new technologies not yet available on the market will emerge by 2020. This holds especially true for the separation and storage of CO_2 from power plants where we do not expect commercial uses to an extent worth mentioning until the year 2020.

Until the year 2020, this scenario would entail additional costs of no more than 11 billion euro per annum compared to a reference development without further climate protection measures. This corresponds to less than 25 euro per household per month.

The cost of climate protection measures is opposed not just by the long-term benefits of climate stabilisation and avoidable climate-related consequences, climate protection also generates short-term benefits for the environment and health. Energy saving, avoidance of unnecessary traffic and more widespread use of renewable energies contribute towards significant reductions of greenhouse gas emissions, air pollutants, such as sulphur dioxide, dust emissions, nitrogen oxides and volatile organic compounds. Lower air pollutant levels have positive effects not just for health – for example, due to reduced exposure to particulate matter – but also mean reduced exposure of ecosystems and less damage to building facades. Reduced damage can, in part, also be quantified in economic terms. According to a report commissioned by the Federal Environment Agency, every kilogramme of particulate matter (PM10) which is not emitted reduces health costs in Europe (EU-25) by 12 euro on average.

Taking the lead in climate protection can offer tremendous opportunities for the German economy as a whole because billions of euros need to be invested in climate-compatible energy supply world-wide over the next decades.

The eight most important measures for climate protection

1. **Saving electricity:**
   Annual reduction of 40 million tonnes in carbon dioxide emissions

   Saving is often not very popular – but nevertheless very effective: annual carbon dioxide emissions can be cut by 40 million tonnes by reducing electricity consumption by 11% by using more efficient devices and appliances, by significantly reducing standby electricity consumption and by doing away with electric heaters. The latter consume 8% of electrical energy in Germany!

   This will require efficient tools in order to implement the policy launched, but by no means fully developed by the German parliament in the last legislative period. Efficient incentives include, for example, a statutory requirement for efficiency races for electric appliances and devices (using the top-runner principle). Money saved by eliminating exemptions from energy taxation could be channelled into an energy efficiency fund which, for its part, could be used to finance advisory and consulting programmes and jump-start costs for innovative technologies.

2. **New power plants to replace old ones:**
   Annual reductions of 30 million tonnes in carbon dioxide emissions

Modules to this end are a 7% higher efficiency of new coal-fired power stations and replacement of coal with natural gas. An increase in the share of natural gas to 30% in electricity generation (i.e. from 70 terawatt hours today to 165 TWh in 2020) can be set off almost completely by saving natural gas for heating residential buildings (which currently accounts for up to 90%), so that total natural gas consumption in Germany would rise by a mere 3% by the year 2020.

Important incentives for increasing the share of natural gas in electricity generation include a significant reduction in the supply of CO_2 allowances in emissions trading and auctioning of these allowances as well as uniform benchmarks for coal and gas in future commitment periods. Furthermore, natural gas can be saved in heating applications if the federal government expands public financing subsidies and support for modernising the energy status of residential buildings and if the legislator amends rent law in order to create additional incentives for energy efficiency measures.

3. Increasing the share of renewable energies to 26% of electricity generation: Annual reduction of 44 million tonnes in carbon dioxide emissions

The target level for renewable energies in the Federal Environment Agency's scenario amounts to 140 terawatt hours. The – equally conservative – estimate of the new lead scenario developed by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, on the other hand, assumes a level of 156 TWh for the year 2020. There is hence still leeway for electricity consumption to develop in another direction. Focal issues are the further development of wind energy use (especially offshore) and the use of biomass for electricity generation.

The Renewable Energy Sources Act (EEG) is the most successful instrument for promoting renewable energies. The underlying principle - i.e. guaranteed payment for the electricity fed into the grid (fixed-price remuneration) – has proven to be cheaper, more efficient and more effective than other instruments used in this area throughout Europe.

With these three measures, electricity generation in the year 2020 would be made up of the following sources: coal 32%, natural gas 30%, renewable energies 26%, uranium 6%, other fuels 6% (mine gas, oil and non-biogenic refuse components). The changes in electricity generation described here not only lead to emission reductions in the energy sector, but can also influence power generation in industry. This will result in another 12 million tonnes of CO_2 savings.

4. Doubling the cogeneration share: Annual reduction of 15 million tonnes in carbon dioxide emissions

In order to achieve the goal of doubling cogeneration output from 70 TWh_{el} to 140 TWh_{el} by the year 2020, subsidies and support mechanisms offered by cogeneration law must be significantly stepped up and the priority of cogeneration must be laid down in construction planning law: In areas where district heating or long-distance heating networks are available or economically possible, the prioritary connection of heat producers (such as waste incineration plants) and heat customers to such networks should be laid down in the relevant laws and regulations. For these grids to be economically efficient, a sufficiently high population density must be maintained and rising land consumption must be stopped. The existing cogeneration law should be amended in order to promote and subsidise new or modernised, highly efficient cogeneration plants in the future. Special attention must be paid in this context to retrofitting existing waste incineration plants. Furthermore, subsidies must be available irrespective of whether electricity is fed into the grid or not.

5. **Heat savings through building rehabilitation, efficient heating systems and in production processes:**
   Annual reduction of 41 million tonnes in carbon dioxide emissions

   The most important elements for heat savings are building rehabilitation (increasing the rehabilitation rate!), efficient heating systems and cogeneration. In a parallel effort, the trend towards ever more heated living space per-capita must be stopped. The most important tools to this end include a more demanding Energy Saving Ordinance (EnEV) and its uncompromising implementation, financial support from an efficiency fund, amended rent law that eliminates the obstacles to energy-centred rehabilitation, as well as a significantly boosted CO_2 building rehabilitation programme.

6. **Heat supply from renewable energies:**
   Annual reduction of 10 million tonnes in carbon dioxide emissions

   Increasing the share of renewable energies (biomass, solar thermal energy, geothermal energy) in heat generation from today's 6% to 12% would reduce CO_2 emissions by households, commerce, trade and the services sector by 6 million and by industry by almost 4 million tonnes of CO_2. This should be laid down in legislation analogous to the Renewable Energy Sources Act (EEG).

7. **Reducing specific consumption in traffic and the transport sector: Annual reduction of 15 million tonnes in carbon dioxide emissions**

   Technical measures (such as motors with lower fuel consumption, reduced motor power, lightweight construction) and fuel-saving driving behaviour can reduce specific CO_2 emissions by passenger cars by up to 40% by the year 2020. In the case of HGVs, this can be around 20%, for example, with low-resistance tyres and low-friction oils. The most important instruments are fuel taxation, CO_2-dependent motor vehicle tax, the introduction of an HGV toll on all national roads and binding consumption limits for new vehicles through carbon dioxide emission limits.

8. **Avoiding unnecessary traffic and a shift to rail and waterways: Annual reduction of 15 million tonnes in carbon dioxide emissions**

   Expanding the rail infrastructure rather than building new roads will contribute towards shifting traffic – in particular, large parts of goods traffic - from roads to rail and to inland waterways. If, for example, the goals of the sustainability indicators for Germany developed in 2006 were achieved and the share of rail in goods traffic increased from 16.5% in 1999 to 25% in 2020, CO_2 emissions would fall by around 3 million tonnes against the trend. If 5% of all private car trips in urban traffic were replaced by public passenger transport and 30% of all private car trips of less than 5km were replaced by bicycle trips, CO_2 emissions would fall by around 3 to 4 million tonnes per year. The increase in air transport must be stopped – one flight to the Caribbean alone generates more than 6 tonnes of CO_2 emissions per capita. A binding, ambitious limitation of greenhouse gas emissions caused by air traffic by trading with allowances to be bought in emissions trading is an effective instrument for limiting the greenhouse effect of air travel. It is also important that the other climate effects of air travel – such as ozone build-up due to nitrogen oxide emissions and the development of condensation trails and cirrus clouds – also be considered within the scope of emissions trading. Furthermore, the mineral fuel tax exemption for kerosene and the VAT exemption for tickets for international flights must be lifted if all transport modes are to be treated equally. The resultant price increase would lead to a reduction of emissions.

Action is urgently needed and the positive message is: We can do something – policymakers, industry and every citizen. A great deal can be achieved through innovative technology as well as new and intelligent procedures and processes. Table 1 provides an overview of what is available. **We have enough options and tools – but we must also apply them with determination and we must do so quickly.**

Table 1: Overview of the effect of the proposed CO_2 emission reduction scenarios for Germany with the Federal Environment Agency's scenario in million tonnes of CO_2, source: the Federal Environment Agency's own calculations, 2007.

In million tonnes of CO_2	**Energy sector**	**Industry**	**Private households and the commercial, trade and services sector**	**Transport**	**All sectors**
Changing fuel use towards more natural gas and increasing efficiency in fossil-fuel fired power stations	-27	-3			**-30**
Doubling the share of renewable energies in electricity generation	-39	-5			**-44**
11 percentage points of electricity savings through more efficient consumption	-36	-4	Effect in energy sector and industry		**-40**
Doubling cogeneration	Effect in industry, private households and the commercial, trade and services sector	-5	-10		**-15**
Increasing the share of renewable energies in heat generation by 6 percentage points		-4	-6		**-10**
More building rehabilitation and higher efficiency of heating systems		-1	-31		**-32**
Savings of heat in production processes		-8	-1		**-9**
Reducing specific fuel consumption				-15	**-15**
Shift to public passenger transport, rail and ship as well as avoidance of traffic				-15	**-15**
Other measures and effects (public heat supply, refineries, coking plants)	-13				**-13**
Total	**-115**	**-30**	**-49**	**-30**	**-224**

2. Introduction: Why should Germany reduce its greenhouse gas emissions by 40% by the year 2020?

Climate change is not something in the distant future. It is already happening – world-wide, in Europe and also in Germany. Interpolations of future climate trends clearly show the enormous challenge facing mankind with today.[1] The knowledge of causes and effects has increased over the course of time as has knowledge of potential options for acting – but global greenhouse gas emissions still continue to rise.

But there is no doubt that the goal of the UN Framework Convention on Climate Change – i.e. stabilising greenhouse gas concentration[2] in the atmosphere in order to prevent dangerous anthropogenic interference with the climate system[3] – can only be achieved if global greenhouse gas emissions start falling from 2020 on and drop to less than half the current level by the year 2050. With a view to their higher emissions and stronger economic power, the industrialised nations will have to reduce their emissions by the middle of the century to an overproportionate extent compared to less developed countries – i.e. by up to 8% compared to 1990[4].

Experts agree: The community of nations has only around 10 to 15 years in order to reverse the trend in all areas of society in favour of climate protection. Nations must act immediately and on a global scale if they are to achieve the long-term stabilisation level of 400 parts per million (ppm) of greenhouse gases in the atmosphere. This will be the only way to prevent global warming of more than 2°C with sufficient probability by the end of the century because average global warming over the past 100 years alone already totalled 0.74°C.[5] The economic effects of failure to protect the climate at once or at all would surpass the cost of investing in a more energy-efficient and greenhouse-gas saving economy by several orders of

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[1] IPCC 2007, p. 21

[2] The Kyoto Protocol covers the following greenhouse gases: carbon dioxide, methane, laughing gas, partially halogenated fluorohydrocarbons, perfluorinated hydrocarbons and sulphur hexafluoride.

[3] UNFCCC 1992, Art. 2

[4] Enquete Commission 2002, p. 45 and following; WBGU 2003,p. 2

[5] IPCC 2007

magnitude - as Sir Nicholas Stern impressively showed in his recent report to the British government[6].

Intermediate goals are necessary on the road towards long-term stabilisation of global greenhouse gas levels. With the Kyoto Protocol (KP)[7] , the community of nations has agreed to first, binding emission reduction targets for industrialised countries in the 2008 – 2012 commitment period. During the following period until around 2020, the industrialised countries, including the Member States of the Union, would then have to reduce their emissions by the year 2020 on average by around one third to below the 1990 level[8] in order to achieve the planned 80% emission reduction target[9] by the middle of the century. Starting 2020 at the latest, developing and newly industrialised countries must clearly decouple their greenhouse gas emissions more strongly from economic growth. This does, however, require that the powerful economies fulfil – and beyond 2012 increase – their binding emission reduction targets in order to clearly signal towards developing and newly industrialised countries that they should take part in a complex of international treaties for cutting global greenhouse gas emissions by half by the middle of this century.

In order to convince the so-called newly industrialised and developing countries of a tenable link between the development of further wealth and climate protection, the EU or individual Member States should within one decade finance a programme with the working title "More wealth through climate protection" in a less developed country, check the success thereof and communicate the results world-wide.

Germany has so far influenced the international climate protection process to a decisive extent and, within the scope of the EU burden-sharing agreement on the KP, has committed itself to reduce greenhouse gas emissions by 21% during the first commitment period from 2008 - 2012 compared to 1990. Within the framework of a

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[6] Stern 2006, Summary of conclusion; UBA 2005a, p. 54 and following

[7] KP 1998, which came into effect on 16 February 2005, Art. 2 and Annex B

[8] EU 2005, p. 16

[9] Refer to UBA 2005a, p. 17

30% emission reduction in the EU and other industrialised nations by the year 2020, an ambitious target of 40% would be appropriate for Germany with a view to its emission reduction potential. Furthermore, this would also be in keeping with its pioneering role, especially with a view to the efforts required of industrial countries, including the European partners, by 2020 and beyond.

Of the envisaged 21% greenhouse gas reduction against 1990, around 18% was already achieved in 2005. The modernisation of the east German economy supported this positive trend. This means that Germany would reduce its greenhouse gas emissions by another 22% in the years until 2020.

Framework conditions and options for reducing greenhouse gas emissions differ strongly among the different sectors of the German economy. Following an explanation of boundary conditions and assumptions in chapter 3, the Federal Environment Agency will present ways for distributing the total emission reductions necessary to the different sectors in chapter 4. We will restrict ourselves to energy-related CO_2 emissions which account for more than 80% of German greenhouse gas emissions (refer to chapter 3). Chapter five subsequently discusses the measures to be taken by different players in order to achieve these CO_2 emission reductions. The sixth chapter describes the instruments which can motivate the respective players to actually take these measures. This is based on the current state of knowledge, whilst ongoing optimisation and further development of climate policy tools will, of course, remain the focus of work by the Federal Environment Agency and many other institutions and organisations in Germany. Chapter seven summarises the results.

3. Which boundary conditions and assumptions does the Federal Environment Agency use?

This analysis is based on a German target of reducing greenhouse gas emissions in Germany by 40% by the year 2020 against the 1990 level. This target refers to all six greenhouse gases considered in the Kyoto Protocol.[10]

In this report, we will restrict ourselves to energy-related CO_2 emissions because these account for more than 80% of German greenhouse gas emissions. This is based on the assumption that the reduction of total greenhouse gas emissions would be possible if the greatest part of these emissions were to decline significantly. The emission reduction potential of other greenhouse gases (methane, fluorinated greenhouse gases (F gases), N_2O) which can be opened up at a relatively low cost for many applications of F gases is not addressed in this report.[11]

According to the Kyoto Protocol, the participating countries have generally two options to reduce the greenhouse gas emissions attributed to them: Reductions can be achieved through measures which have an emission reducing effect in Germany or in part through the transfer of emission reduction credits from other countries via the so-called project-based Joint Implementation (JI) and Clean Development Mechanism (CDM)[12] . Furthermore, governments could also directly buy Assigned Amount Units (AAU) from other Annex-B countries[13] within the framework of the third flexible mechanism of the KP, i.e. international emissions trading on government

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[10] I.e. carbon dioxide (CO_2), laughing gas (N_2O), methane (CH_4), sulphur hexafluoride (SF_6) as well as perchlorinated and partially fluorinated hydrocarbons (PFC, HFC)

[11] In the case of non-CO_2 greenhouse gases, a 40% reduction compared to 1990 is to be achieved as early as during the 2008 - 2012 period (refer to Federal Government, 2006). The Federal Environment Agency expects that methane emissions from the waste sector will decrease further by the year 2020. In contrast to this, a study by the Federal Environment Agency expects a further increase in fluorinated greenhouse gas emissions which can, however, be countered by effective and relatively affordable reduction measures (refer to UBA 2004c, UBA 2005a, p. 74 and following*)*. Process-related CO_2 emissions (for example, in metal production) are strongly dependent upon the output of the respective underlying processes. Furthermore, substantial additional CO_2 emission reduction potential exists in the waste sector which can be achieved, for example, through improved energy utilisation in thermal waste treatment processes.

[12] Refer to UBA-DEHSt 2005, p. 3 and following

[13] Annex-B countries after the coming into effect of the Kyoto Protocol 2005 correspond to the Annex-1 countries of the UN Framework Convention on Climate Change.

level (International Emissions Trading). However, a substantial part of the reduction should be achieved in the country itself according to the Kyoto Protocol implementation decisions. Germany is determined to achieve its emission reduction targets for the current commitment period (2008 – 2012) largely through measures in Germany.[14] This report shows that it will also be possible to achieve the 40% target through measures in Germany.[15]

The pro-rata assignment burden will be assigned to the energy and industry sectors by determining the total budget for the individual trading periods in the EU emissions trade (cap). Notwithstanding this, the question remains as to how operators of facilities obliged to engage in emissions trading will respond to the curtailing of emission rights. EU emissions trading on a company level will continue to offer its participants the possibility to buy emission allowances from abroad or to sell such allowances abroad. The extent to which this will materialise will depend on the ratio between the prices of emission allowances in Germany and prices in other countries. The specific cost of concrete emission reduction measures by the parties involved in emissions trading determine the upper limit of the allowance price at a given cap. Statements on this price development are dependent upon many variables and would go beyond the scope of this analysis.

Especially in the case of renewable energies, technical progress reduces costs and thereby enables the use of these technologies for power generation at a moderate additional cost.[16] The Federal Environment Agency's scenario takes this into consideration. Furthermore, the Federal Environment Agency assumes that no new technologies not yet available on the market will be employed, but that all measures will be based on established technologies, such as more efficient power conversion in power stations and engines. Doing without new technologies is, in particular,

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[14] Federal Government 2005, p. 36

[15] The potential for greenhouse gas emission reduction resulting from the flexible mechanisms of the Kyoto Protocol should be used as a strategic reserve for subsequent commitment periods.

[16] Refer to Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) 2005a, p. 24

applicable to CO_2 separation and storage where the Federal Environment Agency does not expect commercial uses to an extent worth mentioning until the year 2020.[17]

The model calculations used in chapter 4 are based on the boundary conditions assumed by EWI/Prognos 2005. This concerns both energy prices and assumptions concerning demographic and economic trends (refer to Appendix 1). In the transport sector, this study is based on the data of the TREMOD model.[18] With regard to the definition of sectors, this report is based on the definition in the national greenhouse gas inventory.[19]

[17] Refer to UBA 2006, p. 90

[18] TREMOD version 4.17; December 2006

[19] This definition is advantageous as it enables a comparison of the data shown here with data of historical emissions. Furthermore, the energy models follow this definition. However, the downside of this is that certain measures are difficult to define, for example, because part of the electricity generated is generated by the industry sector. Moreover, it is not possible to compare this data directly to the data from the national allocation plan.

4. How should the required CO_2 emission reduction be distributed to the sectors?

With regard to the energy-related CO_2 emissions[20] discussed in this report, the 40% reduction target of annual emissions compared to 1990 by the year 2020 corresponds to maximum annual emissions of 571 million tonnes of CO_2 in 2020. This means reducing emissions by 224 million tonnes of CO_2 compared to the year 2005.

Framework conditions and options for reducing greenhouse gas emissions differ strongly among the different sectors of the German economy. Due to the strong increase in traffic volume in recent years, emission reductions are particularly difficult in the transport sector. A proportional distribution of the necessary CO_2 emission reductions to the different sectors of the economy (energy, industry, transport, commerce/trade/services, private households) is hence pointless. Instead, the Federal Environment Agency orientates the distribution of reduction targets towards the following criteria:

- Economic efficiency of existing reduction potentials, i.e. the lowest possible avoidance costs per tonne of CO_2 saved
- Overcoming the obstacles to emission reduction
- Possibility to implement the necessary changes in behaviour

For the purpose of allocating emission reduction burdens according to these criteria, the Federal Environment Agency uses two model calculations for future energy supply.[21]

First of all, the Federal Environment Agency includes the energy consumption forecast prepared by EWI/Prognos on behalf of the Federal Ministry of Economics

[20] Concerning the restriction to this part of total greenhouse gas emissions, refer to chapter 2

[21] The model calculations are based on partly different input data. It is hence not possible to compare their results directly. However, the results appear to be sufficient for the purposes of this study as they provide a coarse orientation on the basis of CO_2 emission reductions in different sectors.

and Technology (Table 2).[22] It shows the development of CO_2 emissions with the current boundary conditions of energy left unchanged (so-called reference development).

Table 2: Reference forecast of EWI/Prognos 2005[23]

<table>
<tr><th>In million tonnes of CO₂ equivalents</th><th>Actual 2002</th><th>Forecast 2010</th><th>Forecast 2020</th><th>Reduction 2002-2020</th><th>Reduction 2002-2020 in%</th></tr>
<tr><td>Energy sector</td><td>357</td><td>342</td><td>335</td><td>-22</td><td>-6%</td></tr>
<tr><td>Industry</td><td>132</td><td>126</td><td>118</td><td>-14</td><td>-11%</td></tr>
<tr><td>Transport</td><td>176</td><td>171</td><td>155</td><td>-21</td><td>-12%</td></tr>
<tr><td>Private households</td><td rowspan="2">176</td><td rowspan="2">178</td><td rowspan="2">158</td><td rowspan="2">-18</td><td rowspan="2">-10%</td></tr>
<tr><td>Commercial, trade and services sector</td></tr>
<tr><td>Energy-related CO₂</td><td>841</td><td>817</td><td>766</td><td>-75</td><td>-9%</td></tr>
</table>

One of the fundamental assumptions underlying the reference development is that energy prices will remain low. Higher energy prices in the reference model would mean that the additional cost of energy saving would be relatively lower.

The Federal Environment Agency confronts the EWI/Prognos forecast with the IKARUS[24] energy system model. Its results are compiled in Table 2. The model compares a large number of technical CO_2 emission reduction options, such as the use of renewable energies or building insulation. In the calculation which leads to a 40% CO_2 reduction by the year 2020, the model lists the emission reduction options according to their cost for the economy. For these measures, the model identifies average costs of 50 euro per tonne of CO_2.[25] Some measures involve lower costs or

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[22] Refer to EWI/Prognos 2005, p. 398

[23] Loc. cit.

[24] The IKARUS-LP model was used here. For reasons of convenience, it will be simply referred to as IKARUS in the following.

[25] It is not possible to compare these costs directly with certificate prices in emissions trading. This is, firstly, because prices depend on the emission reduction targets which other countries have set for themselves. Secondly, emissions trading represents the transaction costs of trading partners rather than the costs for the economy as a whole. The transaction costs, however, depend not just on the costs of the measures but also on national boundary conditions. Measures with relatively high CO_2 avoidance costs for the economy as a whole, for example, can become rather cheap in the presence

pay off directly, for example, in the case of efficiency increases in terms of electricity consumption or building heating.
The annual costs compared to the reference development total between 1.7 billion (bn) euro in 2010 and 11.2 bn euro in 2020.[26]

The model calculation data shown gives an indication of existing trends as well as areas where emission reduction potentials can be achieved at a low – technology-dependent – avoidance cost. This data, however, does not consider any other obstacles, such as a lack of information or transaction costs. The IKARUS model is limited to technical CO_2 reduction options and does not reflect behavioural changes among the population.[27] Especially when it comes to considering behavioural changes in traffic, the costs to be expected are lower than those calculated in IKARUS.

On the basis of these aspects, the Federal Environment Agency therefore modifies the IKARUS numbers in the next step in order to present a more realistic scenario as to how the 40% emission reduction of energy-related CO_2 emissions in Germany can be achieved with high probability.

In the IKARUS model calculation, the **energy**[28] sector with 142 million tonnes of CO_2 accounts for a substantial part of emission reductions whilst the trend according to EWI/Prognos expects a reduction by just 22 million tonnes of CO_2 for this sector. The Federal Environment Agency expects that it will not be possible to implement the entire potential of the technical measures calculated in IKARUS because some investment decisions which are made today or in the next years do not fully consider

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of other support and subsidy mechanisms for the individual emissions trader. The Renewable Energy Sources Act, for example, has this effect.

[26] IKARUS calculates the results shown with regard to emission reductions and cost as an overall result of an optimisation process only. A detailed evaluation of the individual measures in different sectors and the related costs is not available to the Federal Environment Agency.

[27] The report titled "Klimaschutz in Deutschland bis 2030“ [Climate protection in Germany until 2030] presents the calculations in more detail (refer to UBA 2005, p. 285 and following). However, the calculations in this report are based on data from 2002. STE has updated the calculations made there for the Federal Environment Agency to reflect the situation in 2005.

[28] In the definition of the national greenhouse gas inventory used here, the energy sector comprises public power generation, central heat generation, for example, in cogeneration plants, as well as refineries and coking plants.

the climate protection targets which are discussed here, so that the related emission reduction contributions will be either non-existent or insufficient. The Federal Environment Agency has developed a scenario for electricity supply which will lead to an emission reduction of 116 million tonnes of CO_2 for the entire energy sector (refer to the following chapter).

In the **industry and private households sectors**, on the other hand, half of the emission reductions calculated in IKARUS of close to 27 million tonnes of CO_2 and 39 million tonnes of CO_2 is already achieved in the reference scenario. The Federal Environment Agency expects that it will be possible to fully achieve this potential.

In the **transport** sector, the trend forecast by EWI/Prognos already almost completely achieves the emission reduction potential of 22 million tonnes of CO_2 as determined in the IKARUS model. Taking behavioural change into consideration – such as substituting private car use by bus and rail transport – the Federal Environment Agency believes that values are possible which exceed the potential determined in IKARUS for technical measures, and therefore expects an emission reduction potential of 30 million tonnes of CO_2.

In the **commerce/trade/services sector**, there is a strong discrepancy between potential and trend. Since the obstacles - such as a lack of information concerning energy saving possibilities – are particularly high in this area, the Federal Environment Agency expects that of the total emission reduction potential of 18 million tonnes of CO_2 as determined by the IKARUS model, only 10 million tonnes of CO_2 will be achieved.

Table 3 summarises the result of these observations.

Table 3: The Federal Environment Agency's scenario for reducing energy-related CO_2 emissions in the different sectors in Germany and a comparison with the IKARUS model calculation.

	Actual values		**IKARUS**	**Federal Environment Agency scenario**		
In million tonnes of CO_2 equivalents	1990	2005	Absolute reduction 2004-2020	CO_2 emissions 2020	Change in percent 1990-2020	**Absolute reduction 2005-2020**
Energy sector	415	362	-142	247	-41%	**-115**
Industry	154	103	-27	73	-53%	**-30**
Transport	162	164	-22	134	-17%	**-30**
Private households	129	113	-39	74	-43%	**-39**
Commercial, trade and services sector	87	53	-18	43	-50%	**-10**
Energy-related CO_2	948	795	-248	571	-40%	**-224**

The actual values and the Federal Environment Agency's scenario are based on the Federal Environment Agency's own calculations. The calculation using the IKARUS model was performed on the assumption of a 40% CO_2 emission reduction by the year 2020 compared to 1990. The commercial, trade and services sector includes military facilities. [29]

[29] Appendix 2 gives a detailed overview of the underlying figures and their sources.

5. With which measures can Germany achieve this reduction at an affordable cost?

In this chapter, the Federal Environment Agency describes the technical and organisational measures with which the sectoral reduction targets mentioned in the previous chapter can be achieved. After chapter four showed how the CO_2 emission reduction can be distributed to the different sectors with optimum effects for the economy, the following chapter describes affordable measures by means of which the CO_2 emission reduction targets identified in this way can be achieved.

Energy sector

In the definition of the national greenhouse gas inventory, the energy sector comprises public power generation, central heat generation, for example, in cogeneration plants, as well as refineries and coking plants. By the year 2020, the energy sector is to reduce its CO_2 emissions by 115 million tonnes compared to 2005. This section focuses on the necessary measures in electricity generation because this application accounts for around 80% of CO_2 emissions in the energy sector.

In the following, the Federal Environment Agency outlines a scenario as to how electricity generation might have to look in order to achieve a total CO_2 emission reduction of 114 million tonnes against the year 2005.[30] This CO_2 emission reduction is distributed with 102 million tonnes of CO_2 to the energy sector and with 12 million tonnes of CO_2 to the industry sector because both sectors generate electricity.[31]

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[30] This figure should not be mistaken for the figure of 115 million tonnes for the entire energy sector. Refer to the table in Appendix 3.

[31] This calculation is based on the assumption that industry-run power stations can contribute towards CO_2 emission reductions in the same manner as power stations operated by the energy sector. This is a simplified assumption because industry power stations differ in their characteristics from public power stations. Industry power stations, for instance, are typically fossil-fuelled and hence offer a higher emission reduction potential. On the other hand, however, industry-run power stations are often smaller and feature a higher share of cogeneration and can hence contribute less towards emission reduction. Even if these two opposing aspects did not offset each other, total emission reductions from power generation in both sectors remains the same as a whole.

In this scenario, annual electricity production[32] must decline by as much as 11% (71 TWh) to 548 terawatt hours (TWh). Although other sectors must achieve this reduction in electricity consumption, this reduction relates to the power generation sector rather than these other sectors (refer to the sections on "Industry" and " the commercial, trade and services sector"). With regard to nuclear energy, the scenario considers the legal situation – i.e. the decision to discontinue the use of nuclear energy as of 2021 – and assumes that in 2020 electricity from nuclear energy will account for just 33 TWh compared to 163 TWh in 2005.
In the Federal Environment Agency's scenario, power generation in 2020 will be made up as follows: coal 32%, natural gas 30%, renewable energies 26%, uranium 6%, other fuels[33] 6% (refer to Fig. 2).

The construction of new gas-fired power stations will supply an additional 133 TWh of electricity which, together with plants still in operation at that time, will result in 49 million tonnes of CO_2 emissions, with the further expansion of renewable energies accounting for another 77 TWh without direct CO_2 emissions.

If the shares of these electricity volumes and savings are used to replace 258 TWh from old power stations[34], CO_2 emissions avoided can be quantified as follows:[35] The further development of gas-fired power stations and efficiency increases during energy conversion in fossil-fuelled power stations[36] lead to total emission reductions of 30 million tonnes of CO_2, the expansion of renewable energies will lead to

[32] This refers to gross electricity generation, i.e. the total electrical energy generated directly after conversion from other forms of energy. Subsequent losses are, for example, due to the internal electricity consumption of the power stations themselves.

[33] Other fuels include, for example, different oil fractions, fossil waste components as well as mine gas.

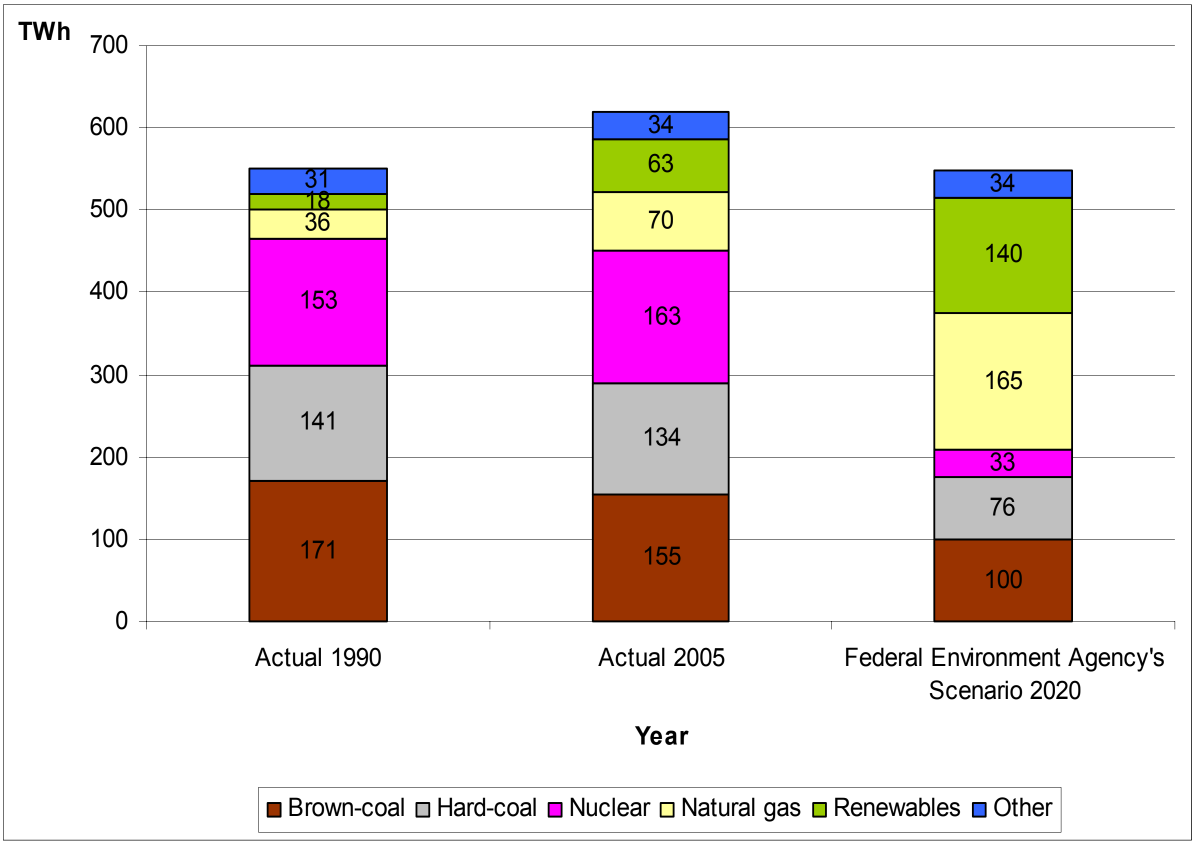
[34] Compared to 2005, the Federal Environment Agency's scenario replaces 130 TWh from power stations which will be shut down, 55 TWh from brown-coal fired power stations and 58 TWh from hard-coal fired power stations either by way of replacement by other fuels or by reduced generation due to savings. The CO_2 emission reduction of 108 million tonnes of CO_2 resulting from the shutting down of old coal-fired power stations are allocated on a pro-rata basis to replacing energy sources and savings in our calculations.

[35] The calculation for natural gas considers 49 million tonnes of CO_2 emitted by the gas-fired power stations themselves.

[36] The average degree of utilisation of fossil-fuelled power stations increases by around 7% in the case of coal-fired power stations, 11% for other fuels and – due to the high share of cogeneration plants and the high efficiency of natural-gas fired gas and steam turbine power stations – 13% in the case of natural-gas fired power stations.

reductions of 44 million tonnes of CO_2 and reducing electricity consumption by 71 TWh will save 40 million tonnes of CO_2.

Figure 2: Electricity generation according to energy sources in existing German power stations: actual situation for 1990 and 2005, as well as a scenario developed by the Federal Environment Agency for 2020. Source: AG-Energiebilanzen 2006, the Federal Environment Agency's own calculations, 2007



In this scenario, the energy sector would build only a few new coal-fired power stations as of now. The forthcoming process of revamping and replacing existing power stations offers the opportunity to implement the changes in the power generation sector – towards natural gas and renewable energies – which are proposed by the Federal Environment Agency at a particularly affordable cost for the economy as a whole.

With a nominal 102 million tonnes, electricity generation hence accounts for the largest reduction share in the energy sector.[37] Although emissions from heat generation will increase – due to the expansion of central heat generation in cogeneration plants – at a nominal 7 million tonnes in this sector, emissions nevertheless decline when calculated over all sectors because de-centralised heating boilers will be replaced (refer to the section titled "Private households and the commercial, trade and services sector"). Declining production in coking plants and refineries to be expected in the Federal Environment Agency's scenario will lead to emission reductions of 20 million tonnes of CO_2.[38]

This translates into net emission reductions of 115 million tonnes of CO_2 in 2020 for the energy sector.
The Federal Environment Agency expects that CO_2 separation and storage will not contribute significantly towards reducing CO_2 emissions by the year 2020.[39]

Excursus: expansion of renewable energies in electricity generation
A study for the Federal Ministry for the Environment (BMU) shows that an increase in the range of 139 to 177 TWh is possible for electricity generation by the year 2020 if the current subsidy policy in the electricity sector will be continued.[40] Despite considerable uncertainty with regard to the further development in the offshore area, wind energy with around 85 TWh and biomass with around 30 TWh will be the key sectors for this growth in the year 2020[41]. In this scenario, the Federal Environment Agency assumes an expansion to 140 TWh by the year 2020. The – equally conservative – estimate of the new lead scenario developed by the Federal Ministry

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[37] Reductions in the electricity generation area resulting from declining consumption (refer to the "Private households" and "Industry" chapters), increased efficiency and changes in energy sources total 114 million tonnes of which, however, the industry sector's internal electricity generation accounts for 12 million tonnes.

[38] The Federal Environment Agency estimates that declining fuel consumption will lead to savings of around 25%, corresponding to 5 million tonnes of CO_2, in refineries. The assumption of declining emissions by coking plants by 15 million tonnes is based on the expectation that existing coking plant capacity for further processing will be reduced in line with declining hard coal mining in Germany.

[39] UBA 2006, p. 4, p. 28 and following

[40] BMU 2005, p. 5

[41] BMU 2005, p. 17 and following

for the Environment, Nature Conservation and Nuclear Safety[42], on the other hand, assumes a level of 156 TWh for the year 2020. There is hence still leeway in electricity supply to develop in another direction.

In order to facilitate this expansion, the technical potential for electricity generation must be developed at a reasonable cost for all sectors of renewable energies, taking environmental interests into consideration in these efforts. Hydropower as a whole has only little development potential to offer, with the Renewable Energy Sources Act foreseeing subsidies and support only for small hydropower stations below 5 MW and efficiency increasing measures in large hydropower stations of up to 150 MW. In contrast to this, geothermal energy and photovoltaic applications are just at the beginning of their development and have significant potential to offer; in this respect, the further development of technical concepts and cost savings will require special support. Onshore wind power offers further potential; obstacles to repowering – i.e. replacing large numbers of old installations with technically advanced systems with a significantly higher power – must be eliminated in order to enable possible power increases and to reduce environmental burdens due to old installations.
Several improvements should be implemented in the biomass sector. These include not only further technological development and improvement, but also the physical separation of biomass production and use by producing biogas and feeding this into the natural-gas grid and hence consumption-near cogeneration in local heat networks.
At present, the basic power generation necessary for energy supply is generated primarily by hydropower stations, hard-coal fired power stations, natural-gas fired power stations as well as peak-load or topping gas turbines. Better integration of distributed electricity generation – especially from fluctuating sources – into the grid is an important intermediate goal of sustainable development in the energy sector. This integration is supported by the increasingly precise forecast of the hourly wind energy supply in Germany which is currently possible with an average error rate of 6% for a period of 24 to 48 hours.[43] This error rate also determines the basic energy supply. Base energy supply no longer available from hard-coal fired power stations

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[42] BMU 2007a, S 30
[43] ISET 2006, p. 6

which are shut down can be compensated for by the natural-gas fired power stations to be newly built which will be fitted with comparable base supply facilities. Some of these plants should be designed and operated as cogeneration plants the base supply of which will be limited. Further options for better integration of power from regenerative sources must hence be examined in the medium and long term. This can include, for instance, the use of large geographic areas through more far-reaching interlinking of the German power grid to the grids of Germany's neighbouring countries, further developments in the field of storage technologies for electricity, heat and cold as well as comprehensive generation and load management.

Excursus: Expanding electricity generation from natural gas and supply reliability

Around 90% of natural gas consumed in Germany today is used for heating. In order to keep the uncertainties and dependencies at bay connected to natural gas imports if this raw material were to be increasingly used for electricity generation, the share of natural gas used for heating should be reduced. In this respect, renewable energies (biomass, solar thermal energy), cogeneration and the rehabilitation of buildings for improving the efficiency of heating and thermal insulation systems offer the relevant potential (refer to the section titled "Private households and the commercial, trade and services sector"). Calculations performed by the Federal Environment Agency show that total natural gas consumption – in order to achieve the necessary carbon dioxide emission reduction in the energy sector by the year 2020 – would increase by only 3% with increased use of natural gas for electricity generation because savings of natural gas in the heat generation sector would make up most of the additional consumption of natural gas in the energy sector.[44] However, in order to increase supply reliability in spite of this, the use of liquefied natural gas (LNG) could open up new sources of supplies.[45]

The total emission reductions in the energy sector are shown below.

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[44] Own calculation of natural gas savings with the measures proposed here. According to these calculations, the natural gas demand by industry, private households and the commercial, trade and services sector would decline by 183 TWH from natural gas, whilst the demand for natural gas for electricity generation and public heat supply would increase by 210 TWh. Energy consumption in 2005 totalled an equivalent of 899 TWh.

[45] DIW 2006, p. 553-559

Table 4: CO_2 emission reductions according to the Federal Environment Agency's scenario in the 2005 - 2020 period in the energy sector. Source: the Federal Environment Agency's own calculations.

In million tonnes of CO_2	**Energy sector**
Changing fuel use towards more natural gas and increasing efficiency in fossil-fuel fired power stations	-27
Doubling the share of renewable energies in electricity generation	-39
11 percentage points of electricity savings through more efficient consumption	-36
Doubling cogeneration	-- Effect in industry, private households and the commercial, trade and services sector --
Other measures and effects (central heat generation, refineries, coking plants)	-13
Total	**-115**

Industry

In the Federal Environment Agency's scenario, industry is to save a total of 30 million tonnes of CO_2 by the year 2020.[46] This must be accomplished on the level of direct, energy-related CO_2 emissions for thermal uses, in industrial power stations (including cogeneration) and in electricity consumption. The changes necessary in electricity generation were already described in the "energy sector". The resultant emission reductions which – due to internal electricity generation in industrial operations – are to be allocated to the "industry" sector total 12 million tonnes of CO_2.[47]

Electricity savings

The German Energy Agency (dena) estimates that by the year 2020 German will be able to reduce its total electricity consumption by around 10% compared to 2005.[48] The Federal Environment Agency assumes a good 11% (71 TWh) of gross electricity generation.[49] Cross-sector technologies, in particular, offer an enormous electricity

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[46] Process-related emissions for the purposes of the definition used in the national greenhouse gas inventory are not considered in this report.

[47] Refer to the "Energy sector" section in this chapter.

[48] BMU, BMBF 2006 p.1

[49] CO_2 emission reductions from electricity saving measures are statistically not attributed to the electricity consuming sectors. Refer to the "Energy sector“ section, p. 11 and following.

saving potential which also pay off in commercial terms: compressed air 33% [50], pumps and fans 15%[51], lighting[52] 24%. Since industrial and commercial cross-sector technologies with electric drives account for one third of Germany's total electricity consumption, it is particularly important to open up this largest electricity saving potential.[53]

Heat savings and supply with renewable energies

The economic energy saving potential in the field of thermal energy use (excluding industry-run power stations) in the industry sector amounts to 8 to 12 million tonnes of CO_2.[54] Thermal cross-sector technologies have the largest potential to offer. Compared to this, it is much more difficult to open up energy saving possibilities in process-specific applications, above all, in the energy-intensive basic industries which account for the largest part of energy consumption and it is often not possible to make use of these potentials until plants and equipment are replaced and processes substituted within the framework of long investment cycles.

In order to be able to identify the economic energy saving potential, energy use concepts must be developed for companies and industrial plants – an effort for which especially small and medium-sized enterprises require external energy consultancy services.

Heat generation from renewable energies (biomass, solar thermal energy, geothermal energies) offers a further significant CO_2 saving potential. Increasing the share of renewable energies in heat generation from 6% to 12% will reduce CO_2 emissions by close to 4 million tonnes of CO_2.[55]

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[50] Fraunhofer ISI et al. 2003, p. 183

[51] Enquete Commission 2002, p. 185

[52] Fraunhofer ISI et al. 2003, p. 236

[53] Refer to UBA 2005a, p. 96

[54] UBA 2005b, p. 342

[55] Assumption: CO_2 emissions by industry in heat generation plants decline to 60 million tonnes of CO_2 by the year 2020 through saving measures, with 6% of this figure totalling 3.6 million tonnes of CO_2.

Expanding cogeneration

Expanding cogeneration and ensuring optimum heat distribution through heating grids offer a particularly good opportunity. With this technology, the fuel used in power stations is used not just to produce electricity but at the same time also to generate heat or cold that can be used to heat or cool buildings or industrial production processes. Cogeneration is today possible in most fossil-fuelled power stations.

Electricity from cogeneration plants can be doubled from around 70 TWh in 2005 to around 140 TWh by the year 2020. Assuming an electricity to heat ratio[56] of 1, this increase in heat production from cogeneration by 70 TWh means that around 15 million tonnes of CO_2 could be avoided.[57] This emission reduction is distributed with 5 million tonnes of CO_2 to the industry sector and with 10 million tonnes of CO_2 to private households and the commercial, trade and services sector because cogeneration heat is produced primarily by the energy sector whilst emission avoidance takes place in industry, private households and in the commercial, trade and services sector.

Maintaining a sufficiently high population density is a precondition for the use of cogeneration heat in order to achieve the best possible cost-to-benefit ratio for investment in district heating and long-distance heating grids. CO_2 emissions could be reduced even further through the use of renewable energy sources (biomass and geothermal energy) in cogeneration plants.

Other measures, such as thermal insulation for industrial production plants, could contribute another 1 million tonnes of CO_2 to emission reductions.

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[56] The electricity to heat ratio describes the ratio between electricity and heat generation. An electricity to heat ratio of 0.5 hence means that 2 kWh of heat is produced per 1 kWh of electricity.

[57] Assuming an emission factor of 250g of CO_2 per kWh_{th} for a mix of natural gas and oil heatings and an electricity to heat ratio of 1. The emission reduction by cogeneration-specific efficiency increases in the energy sector must be added to this emission reduction due to the substitution of fossil heat. Although the emission reduction by cogeneration-specific efficiency increases in the energy sector totals around 5 million tonnes of CO_2 in the Federal Environment Agency's scenario, this figure is included in the "Energy sector" chapter in the figures related to general efficiency increase.

Table 5: CO_2 emission reductions according to the Federal Environment Agency's scenario in the 2005 - 2020 period in the industry sector. Source: the Federal Environment Agency's own calculations.

In million tonnes of CO_2	**Industry**
Changing fuel use towards more natural gas and increasing efficiency in fossil-fuel fired power stations	-3
Doubling the share of renewable energies in electricity generation	-5
11 percentage points of electricity savings through more efficient consumption	-4
Doubling cogeneration	-5
Increasing the share of renewable energies in heat generation by 6 percentage points	-4
More building rehabilitation and higher efficiency of heating systems	-1
Savings of heat in production processes	-8
Total	**-30**

Private households and the commercial, trade and services sector

The Federal Environment Agency proposes the following measures in order to achieve the contribution described in chapter 4 towards emission reductions by private households at a level of 39 million tonnes of CO_2 and 10 million tonnes of CO_2 in the commercial, trade and services sector.

Building rehabilitation and improving the efficiency of heating systems

Energy-related rehabilitation of existing buildings used by private households and in the commercial, trade and services sector[58] could reduce CO_2 emissions by 20 million tonnes of CO_2 if the annual, energy-related rehabilitation rate were to increase from the present figure of 0.6%[59] to 2% and if CO_2 emissions were to decline by an average of 60% as a result of rehabilitation measures.[60] Replacing and modernising

[58] In calculating the CO_2 emissions in the commercial, trade and services sector, we have made the flat assumption that room heating accounts for 50% of CO_2 emissions in order to consider process heat and a lower rehabilitation potential compared to the private households sector. This was considered by the calculation of the CO_2 emission reduction in the commercial, trade and services sector.

[59] Refer to UBA 2005b, p. 96

inefficient heating systems in existing buildings would improve the energy efficiency of such systems by around 10%[61]. Modernisation of heating systems can help save around 11 million tonnes of CO_2.

Renewable energies and cogeneration

Expanding cogeneration can save 10 million tonnes of CO_2 emissions in the area of private households too by replacing decentralised oil and gas fired heating systems with district and long-distance heating. Increasing the share of renewable energies from the current figure of 6% to 12% of heat supply in 2020 can reduce CO_2 emissions by 6 million tonnes of CO_2.

Saving electricity

Electricity consumption by private households can decline by around 15%. Savings of between 25% and 50% will be possible by the year 2020 in the field of domestic appliances, hot-water preparation and consumer electronics.[62]

Similar savings are also conceivable in the commercial, trade and services sector. As already explained in more detail in the "Industry" section, the Federal Environment Agency assumes that Germany will be able to save a good 11% of gross electricity production by the year 2020 compared to 2005.

Other measures, such as improving efficient use of heat for commercial applications, will contribute another 2 million tonnes of CO_2 to emission savings.

Excursus: energy-efficient settlement development / maintaining compact settlement structures

New calculations by the Federal Statistical Office[63] confirm that all efforts so far aimed at saving heating energy in private households were more than over-compensated by the increase in heated living space. Heating energy consumption by

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[60] This reduction target is applicable to the average inventory of existing buildings. Since this target cannot be achieved for all buildings, a higher rate of energy-related rehabilitation will be required for other buildings, if possible, up to the standard of a passive house. The calculation considers the fact that a one-year lead time is required for these measures.

[61] UBA 2005b, p. 95. Bandwidth of 10-25%; lower value

[62] UBA 2005a p. 97

[63] Federal Statistical Office 2006, p. 23; Radermacher 2006, p. 8

private households rose by 2.8% between 1995 and 2004 even though the heating energy needed per square metre of living space declined by around 9%.[64] The reason for this is the fact that heated living space rose by 13% during this period.

The increasing demand for living space is not only due to the growing number of smaller households. Since the number of households – and hence of apartments used – increased during the same period by around 5% (with the population growing by just around one percent), the increase in heated living space by a total of 13% is largely due to greater consumption of living space per household (and, above all, per capita of the population).[65]

A more detailed analysis of the data by the Federal Office for Building and Regional Planning (BBR) shows that the consumption of living space by elderly people in one-person and two-person households remaining alone in single-family homes or large family apartments after the family phase (remanence) accounts for the largest part of the per-capita increase in living space consumption[66]. Especially in the years since 1995, a particularly large number of single-family homes were built even though existing living space - from a purely mathematical point of view – would have offered ample space in many regions in order to provide families with children with sufficiently[67] large apartments. However, this would have meant that older people would have to be motivated to move to smaller apartments after the family phase. In the course of demographic change in Germany, there is a risk that the construction of one-family homes will continue in regions which are already stagnant, whilst many apartments and one-family homes which are today still used by older people are likely to become vacant in a few years from now.

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[64] Heating energy input in 1994: 0.95 GJ per sqm per annum; 2004: 0.86 GJ per sqm per annum. Calculation by the Federal Environment Agency on the basis of figures from: Federal Statistical Office 2006, p. 23

[65] Increase in living space per household by 7% from 78 sqm to 83 sqm and increase in living space per capita by 11.6% from 35 sqm to 39 sqm during the period from 1995 to 2004; source: loc.cit.

[66] BBR 2006, p. 78

[67] What is considered to be "sufficient", i.e. as socially acceptable, with a view to living space supply for families differs strongly in Germany from region to region depending on building property prices or short supply of affordable living space. "Sufficient" is here equivalent to "customary in this region".

Municipal, regional and federal-state administrations will, if at all, have to classify construction areas for new homes within the scope of regional planning as well as home-owner and urban development subsidy and support programmes only in those regions and municipalities where living space is particularly scarce due to a continued - actual rather than expected or forecast - inflow of citizens. In areas with an inflow of new citizens or in stagnant regions with increasing inventories of large apartments and few inhabitants, living space management[68] measures should be introduced in order to make the living space in existing apartments and homes available especially to families with children. This could be one way to prevent an ever-increasing heat demand for living space – despite subsidies for energy saving measures for buildings, cogeneration and renewable energies.

Furthermore, settlement structures must be sufficiently dense in order to support environmentally compatible forms of transport (walking, cycling, public transport) and enable affordable public transport services, i.e. to satisfy mobility demand with less traffic. Furthermore, compact settlement structures have a favourable effect on the ratio of cable and pipe length (for example, for electricity and heat supply) and the number of households to be supplied with energy.

Table 6: CO_2 emission reductions according to the Federal Environment Agency's scenario in the 2005 - 2020 period in private households and the commercial, trade and services sector. Source: the Federal Environment Agency's own calculations.

In million tonnes of CO_2	**Private households and the commercial, trade and services sector**
11 percentage points of electricity savings through more efficient consumption	-- Effect in the energy sector and industry --
Doubling cogeneration	-10
Increasing the share of renewable energies in heat generation by 6 percentage points	-6
More building rehabilitation and higher efficiency of heating systems	-31
Savings of heat in production processes	-1
Total	**-49**

[68] Several research and model projects by the federal government and federal-state governments are currently underway concerning forms of living for the elderly (such as shared living, assisted living for the elderly, several generations living together, "living in the centre", etc.) in order to identify attractive forms of living which might be capable of replacing the trend towards staying in excessively large family apartments.

Transport

CO_2 emissions in the transport sector are to be reduced by 30 million tonnes of CO_2 by the year 2020. If, however, the current trends were to continue, this reduction would be as low as 8 million tonnes of CO_2.[69]

Strategies for reducing CO_2 emissions further in this sector include technical improvements for increasing efficiency[70], better utilisation of existing vehicle capacity, shifting traffic towards more energy-efficient modes (for example, goods transport from HGVs to the rail) and avoidance of traffic (for example, through compact settlement structures which enable short distances).

Reducing specific consumption

With technical measures and fuel-saving driving, up to 40% of specific CO_2 emissions from passenger cars can be saved by 2020 compared to 2005. Specific CO_2 emissions from HGVs can be reduced by up to 20%, for example, by using low-resistance tyres and low-friction oils.

The most effective way of reducing specific consumption of buses in urban transit is driver training in order to promote more energy-efficient driving, accompanied by technical measures[71]. These measures led to an energy saving potential of 25% during the period surveyed. The reduction potential of other bus types is comparable with that of HGVs.

In view of the very long service life of locomotives, specific CO_2 emissions can be reduced by a maximum of 5% only[72].

In the case of inland waterway ships, the saving potential is even as low as around 3% due to the even longer service life and the resultant inventory of old vessels.

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[69] The trend calculation is based on the results of the TREMOD model and refers to the years from 2005 to 2020. This is why the values differ from the EWI/Prognos values reported in Table 1.

[70] Example: use of energy-saving engines or lightweight construction for passenger cars, in the case of ships: hull modifications

[71] Hybrid engines, low-resistance tyres, low-friction oils as well as SCR (selective catalytic reduction)

[72] One important measure is to increase engine efficiency, in particular, using the SCR technology for reducing nitrogen oxide emissions.

In the case of aircraft engines, the Federal Environment Agency considers a fuel consumption reduction potential of 15%[73] to be achievable.
This translates into a total CO_2 emission reduction potential of 15 million tonnes of CO_2.

Avoiding traffic

A high degree of mobility and goods traffic can be achieved with very different transport volumes measured in terms of mileage per capita and mileage per tonne. In order to avoid traffic, compact, low-traffic settlement structures must be maintained and regional economic cycles promoted according to the "city of short distances" concept. The basis for this is greater integration of traffic and settlement planning within and between municipal administrations. In this way, the number of transports and average transport distances can be reduced through greater manufacturing depth at production sites, low-traffic logistics (including stock-keeping) and an increasingly decentralised organisation of distribution operations on the part of retailers and wholesalers.

Determined action is necessary in order to counter the increase in air travel, in particular, so-called low-cost carriers. Attractive regional holiday and recreation offers and their marketing can contribute towards this end.

New road construction projects should be generally abandoned because the road network is satisfactory to a very large extent. 15% - 20% of the increase in traffic is due to the construction of new roads[74] in as far as citizens use the time saved for additional and longer errands. Instead, bottlenecks should more be addressed through improved transport management, more continuous traffic flows in order to enable better use of transport infrastructures, as well as by shifting transport to rail or waterway transport.

A reduction of goods traffic by 5% compared to the expected trend is definitely realistic if all these measures are implemented with the result of a CO_2 emission

[73] The specific consumption of aircraft declined by around 1% per annum in recent years. This trend is very likely to continue until after 2020, so that a reduction in the order of 15% can be expected.

[74] UBA, 2005: Determinanten der Verkehrsentstehung. UBA-Texte 26/05, Dessau 2005

reduction by 2.5 million tonnes of CO_2. A reduction of this order in passenger transport would even reduce emissions by as much as 5.5 million tonnes of CO_2.

A shift to more environmentally compatible transport modes

Compact settlement structures enable a significant improvement in the supply of and demand for environmentally compatible forms of transport, i.e. rail, bus, bicycle and walking. Compact settlements are a precondition for the environmentally compatible and cost-effective operation of these means of transport. Abandoning new road construction projects and developing the rail infrastructure contribute towards shifting traffic growth – in particular, goods traffic – to rail and waterway transport.

Due to the large number of factors influencing the choice of a particular means of transport, the potential of this measure can only be calculated on an exemplary basis. If 5% of all private car trips in urban traffic were replaced by bus and rail and 30% of all private car trips of less than 5km were made by bicycle, CO_2 emissions would drop by around 3 to 4 million tonnes.

The measures aimed at avoiding traffic and the shift in the modal split together represent a CO_2 emission reduction contribution of 15 million tonnes of CO_2.

Together with the 15 million tonnes resulting from a reduction of specific consumption, the transport sector offers a savings potential of 30 million tonnes.

Table 7: CO_2 emission reductions according to the Federal Environment Agency's scenario in the 2005 - 2020 period in the transport sector. Source: the Federal Environment Agency's own calculations.

In million tonnes of CO_2	**Transport**
Reducing specific fuel consumption	-15
Shift to public passenger transport, rail and ship as well as avoidance of traffic	-15
Total	**-30**

Summary of the measures

Table 8 summarises the measures described for the individual sectors and shows that the quantities by sector identified in chapter 4 can be achieved under the conditions stated herein.

Table 8: Overview of the effect of the proposed CO_2 emission reduction scenarios with the Federal Environment Agency's scenario in million tonnes of CO_2, source: the Federal Environment Agency's own calculations, 2007.

In million tonnes of CO_2	**Energy sector**	**Industry**	**Private households and the commercial, trade and services sector**	**Transport**	**All sectors**
Changing fuel use towards more natural gas and increasing efficiency in fossil-fuel fired power stations	-27	-3			**-30**
Doubling the share of renewable energies in electricity generation	-39	-5			**-44**
11 percentage points of electricity savings through more efficient consumption	-36	-4	Effect in energy sector and industry		**-40**
Doubling cogeneration	Effect in industry, private households and the commercial, trade and services sector	-5	-10		**-15**
Increasing the share of renewable energies in heat generation by 6 percentage points		-4	-6		**-10**
More building rehabilitation and higher efficiency of heating systems		-1	-31		**-32**
Savings of heat in production processes		-8	-1		**-9**
Reducing specific fuel consumption				-15	**-15**
Shift to public passenger transport, rail and ship as well as avoidance of traffic				-15	**-15**
Other measures and effects (central heat generation, refineries, coking plants)	-13				**-13**
Total	**-115**	**-30**	**-49**	**-30**	**-224**

6. Which instruments should Germany use?

The previous chapter shows the measures which different players should take in order to achieve the necessary CO_2 emission reductions at the lowest possible cost.

This chapter now describes the most important instruments which the federal government – if necessary, in cooperation with other national levels, such as the EU - can use in order to motivate the players to implement the corresponding measures. The Federal Environment Agency suggests the instruments which will be described below in more detail because these instruments feature a relatively high effectiveness and are hence particularly important for climate protection with a view to the emission reductions that can be achieved in this way ("effectiveness" criterion). Furthermore, the instruments are very efficient, i.e. the costs incurred by the economy as a whole (emission avoidance costs and transaction costs for the government and the players involved) in order to achieve the emission reduction target are relatively low (efficiency criterion).[75] Thirdly, the instruments proposed are also usually particularly advantageous for other reasons, for example, due to relatively simple implementability, relatively high social acceptance or a strong incentive effect for climate protection innovation (the "further advantages" criterion). The instruments are selected according to the latest state of research and scientific discussion and also consider historical backgrounds and political boundary conditions.

Achieving the 40% target will require regulatory and planning law as well as economic and information instruments. Against this background, the Federal Environment Agency proposes a mix of both cross-sector instruments – such as energy taxation - and sector-specific tools. In this report, we describe only the most important instruments which the Federal Environment Agency considers to be necessary for climate protection in Germany and which are to be specifically adapted for climate protection in Germany. Besides, there are further instruments which can also make an important contribution towards climate protection by avoiding or

[75] The Federal Environment Agency also considers the criterion of low avoidance costs per reduced tonne of CO_2 in the selection of measures.

reducing large-scale mistakes in climate policy. These include, for example, the abolition of climate-damaging subsidies or a climate-orientated purchasing policy for the public sector.

Some of the instruments supplement each other and overlap in their effects on individual sectors. This is why the resultant CO_2 emission reductions in the individual sectors are often difficult to assign to a singular instrument or even instrument type. For other reasons too, it is often methodologically difficult to quantify the absolute CO_2 emission reduction contribution of a single climate protection instrument, for example, because its effect depends on singular, future economic boundary conditions, such as price developments for the different primary energies. With regard to the necessary instruments, which we are proposing for climate protection, we therefore refer to the CO_2 emission reductions that can be achieved by the measures to be taken (refer to chapter 5).

Energy sector

According to the Federal Environment Agency's scenario, the energy sector with a volume of 115 million tonnes of CO_2 is to make the biggest contribution towards emission reduction. The most important measures in this sector are the change in fuel and increasing efficiency with a total contribution of 27 million tonnes of CO_2, the use of renewable energies with 39 million tonnes of CO_2 and electricity savings with 36 million tonnes of CO_2. Emissions trading is the instrument designed to achieve the change in fuel and efficiency increases. The expansion of renewable energies in electricity generation should continue to be pursued within the scope of the successful Renewable Energy Sources Act (EEG). Since private households and the industry sector are to contribute most towards electricity savings, possible instruments are described in the corresponding chapters.

Emissions trading

EU emissions trading will be an important instrument for the energy and industry sectors in order to implement the necessary emission reductions by the year 2020 and beyond. As a result of emissions trading, CO_2 emissions are avoided at the place where avoidance costs are lowest. This market logic induces players to spot these avoidance potentials without governments having to impose any requirements for the respective measure itself. The fixed cap for emission rights ensures that the emission reduction target will be achieved in any case. The fact that the certificates can be traded means that emission reductions will occur in places where they cause the lowest avoidance costs.[76]

In order to achieve the largest part of the emission reductions in the energy and industry sectors – as suggested in the Federal Environment Agency's scenario - Germany should significantly reduce the emission rights budget (cap) by the year 2020. The sectoral distribution of emission reductions in the Federal Environment Agency's scenario means that the cap for the fourth trading period from 2018 to 2022 will have to be reduced to 330 to 350 million tonnes of emission rights a year[77]. A constant reduction over the 2008-2012, 2013-2017 and 2018-2022 would require steps of 48-55 million tonnes of CO_2 depending on the concrete cap which is aimed at. The cap in the national allocation plan for the second trading period 2008-2012 (NAP II) means a reduction by 32 million tonnes of CO_2 compared to the actual values of the year 2005.[78] The foreseen reduction of the budget during the second trading period is hence smaller than a constant reduction requires. This means that at the transition from the second trading period 2008-2012 to the third trading period 2013-2017 the cap must be reduced much more than at the transition from the first trading period 2005-2007 to the second trading period 2008-2012.

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[76] However, a "spot landing“ will require complete and accurate recording of all emissions within the scope of emissions reporting. Risks currently exist in this respect especially because of the leeway which the EU requirements afford to plant operators with regard to the determination and reporting of their emissions, the pursuit of responsibilities on the part of federal-state governments, and with regard to the examination of the reports by licensed private experts who are commissioned by the operator. These uncertainties must be eliminated in order to improve the precision of emissions trading even further.

[77] This budget is based on the target proposed for the energy and industry sectors (319 million emission rights per annum for energy-related CO_2 emissions). Another 80 million or so tonnes of emission rights for process-related emissions, which are likely to remain largely unchanged compared to the year 2005, must be added to this figure. The energy and industry sectors also include plants which are not subject to emissions trading requirements. In 2005, these plants emitted 54 million tonnes of CO_2 (considering that plants with emissions of around 11 million tonnes of CO_2 will be included in emissions trading). The bandwidth stated for the budget of the emissions trading sector results from emission reductions which are expected by the non-emissions-trading segment of the energy and industry sectors.

[78] Without the 11 million tonnes of CO_2 from plants additionally subject to emissions trading requirements

The Federal Environment Agency's scenario expects a significant expansion of gas-fuelled electricity generation.[79] The assignment of emission rights is an important incentive for the decision by plant operators in favour of or against a particular fuel.[80] The allocation rules which are currently foreseen in the NAP II foresee the free allocation of emission rights for modern gas and hard-coal fired power stations on the basis of a benchmark that is orientated towards the best available technology and differentiated according to fuels. This change in the allocation method for plants in the energy sector from the free allocation of emission rights on the basis of historical emissions of a reference period (grandfathering) towards allocation according to a benchmark system can be regarded as an improvement in the emissions trading mechanism because it creates incentives for increasing energy efficiency. However, the incentive effects of the proposed benchmark system with fuel differentiation are clearly weaker than those of a purely product-related benchmark system. Investor decisions for new coal-fired power stations are strongly dependent upon expectations which will probably be coined by the debate on the future design of emissions trading, such as the possible share in the budget that could be auctioned in future. If a separate benchmark for coal-fired power stations were to be retained, this could, however, favour investment in coal-fired power stations – also with a view to the continued, relatively high natural gas price level. If the proposed budget reductions were successfully implemented, this would then lead to the need to purchase additional emission rights. This would subsequently trigger an inflow of emission allowances to Germany[81].

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[79] However, this does not mean that Germany's demand for natural gas will increase on condition that the energy measures described in chapter 4 are implemented by households and the commercial, trade and services sector. Refer to the excursus: Expanding electricity generation from natural gas and supply reliability

[80] Emissions trading does not specify the fuel which plant operators have to use in their new plants. Rather than investing in gas-fired power stations, plant operators are free to use a more emission-intensive fuel and to purchase emission rights which may be lacking from the market for emission certificates.

[81] The success of this commercially sensible strategy is, however, dependent upon the availability of emission rights on the European market at favourable prices – compared to the options for action which the respective power station operator has. A determined reduction of the budget of all European Member States in the interest of the European climate protection target (20% - 30% greenhouse gas emission reduction by the year 2020) is likely to lead to rising prices for emission rights, all other circumstances remaining unchanged. As a result, investment in new brown-coal fired plants is particularly likely to become economically unreasonable already in the medium term. Deviating from the expansion path underlying the Federal Environment Agency's scenario might then turn out to be a misinvestment both in commercial terms and for the economy as a whole.

Reducing the emissions trading budget to 453 million tonnes of CO_2 per annum is one step towards the 40% reduction target. The reduction target does, however, imply even higher reductions at the transition from the second to the third and from the third to the fourth trading period. This means that the efforts required in emissions trading resulting from the 40% target will hence have to be at least as demanding as today.

The Renewable Energy Sources Act

The Renewable Energy Sources Act (EEG) is based on the principle of guaranteed payment for the electricity fed into the grid without a quantity limitation (fixed-price remuneration). The fixed-price remuneration is a tried-and-tested and – compared to other instruments, such as a quota system with allowance trading – largely prevailing system throughout Europe as an instrument for promoting renewable energies in the electricity market.[82] The Renewable Energy Sources Act foresees the promotion and support of all areas of renewable energies and determines remuneration levels even for technical variants (size, location and other parameters). Remuneration height and duration (mostly 20 years) are selected in such a manner that electricity generation costs are covered and the operator of the plant can achieve a sufficient return on investment. The remuneration rates for newly installed plants are subject to annual degression, so that economic incentives are created to implement cost-saving technical progress. This degression rate totals, for instance, 2% per annum for wind energy and 5% per annum for photovoltaic energy.[83]

This instrument achieves a high level of effectiveness and efficiency through meticulous technical differentiation, the amount and duration of remuneration payments as well as the degression rate. Subsidy-taking effects are thereby avoided to a large extent. Regular revisions of the Renewable Energy Sources Act by the German parliament (section 20 of the Renewable Energy Sources Act – experience report) ensure this on a lasting basis. The guaranteed fixed-price electricity purchase ensures high investment security, so that investors tend to use only low risk mark-

[82] UBA 2006b, p. 8

[83] BMU 2007b, no page stated

ups on the capital invested. Furthermore, the Renewable Energy Sources Act provides a very cost-effective process which generates hardly any transaction costs. Utility companies only incur additional costs for the allocation payment under the Renewable Energy Sources Act. Finally, the simple design of the scheme as a relation between plant and grid operators under private-law without government intervention also means simple implementation.

The Renewable Energy Sources Act has contributed significantly towards the growth of wind energy, photovoltaics energy and modern biomass uses – often termed "new" renewable energies – by a factor of six in the electricity sector since 1998. This gave a boost not just to the industries involved and their suppliers – in 2006, Germany recorded around 214,000 jobs in the renewable energies industry[84] – but also enabled Germany to take the lead world-wide as an exporter of wind energy use and photovoltaic systems.[85]

Compared to the Renewable Energy Sources Act, a quota model has numerous downsides[86]:

- Without guaranteed minimum remuneration, the investment risk for investors would be higher. With the quota model, this would mean that they could demand a higher risk mark-up on the interest on their investment which would make the expansion of renewable energies more costly. As a result, some projects, especially small generating plants, would not materialise.
- Operators of plants already written down or situated in favourable locations would reap considerable windfall profits which is not desirable.
- Due to the uniform target quota, the quota model would open up the innovation potential of renewable energies only insufficiently, with new technologies receiving insufficient support. The dynamic efficiency of support and promotion would be low and this would then mean a trend towards rising costs in order to achieve the long-term climate protection target.

[84] BMU 2007d, p. 6

[85] BMU 2006c, p. 35

[86] UBA 2005c, p. 2

Against this background, there is no reason to change the system, for example, to replace the Renewable Energy Sources Act with a quote model. This would probably significantly slow down the expansion of renewable energies.[87]

Besides regular revisions of the Renewable Energy Sources Act within the scope of the experience report, general energy law must also be developed further. Wind energy installations, for example, already now often break even in the peak-load range. Starting in the middle of the next decade, the production costs in the field of wind energy use will more and more often remain below the market prices for electricity. However, this does not mean that the Renewable Energy Sources Act could be immediately abandoned and the transition to the market performed because the technical conditions of the power grid and the market conditions for alternative suppliers are not conducive especially for users of distributed or fluctuating sources. The electricity system in its present form is orientated towards large power stations in the very high voltage transmission grid and hence foresees the electricity flowing in one direction only, i.e. to the lower level distribution grid and to the consumer. Through the further development of energy law, billing systems and communication structures, it must be transformed to a system which is orientated towards distributed generation, which enables flexible electricity flow control and which integrates not just electricity generating plants, but also storage and load management[88] functionalities (virtual power plant). The German and European electricity sector would be faced with far-reaching re-orientation which would have to be supported both by the legislator and by industry.

Industry

One important measure in the industry sector is the reduction of CO_2 emissions in industrial electricity generation by a total of 12 million tonnes of CO_2. This emission

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[87] Experience with the quota systems introduced in the UK, Italy or Sweden also suggests this in a comparison with the fixed-price remuneration systems in Germany, Austria or Spain. Refer to UBA 2006b, p. 36.

[88] Storage facilities which are available today are mostly pumped-storage power stations. Future technologies which are discussed today include, for example, capacitors and flywheel storage solutions. Load management systems are already in use. With this approach, high loads, in particular, are disconnected from the grid in order to compensate for temporarily high demand or low generation levels and vice versa. The possibilities for flexible management and a corresponding pricing system are limited under today's boundary conditions of technical management and electricity trading.

reduction is achieved by the two instruments described in the "Energy sector" section, i.e. the Renewable Energy Sources Act and emissions trading, and, to some extent, the instruments for electricity savings which are described in the "Private households" section, such as the energy efficiency fund. Saving heat and the supply of emission-free heat from renewable energy sources are to contribute 13 million tonnes towards CO_2 emission reductions. Cogeneration is to yield savings of 5 million tonnes of CO_2.

Emissions trading

Industry is involved in EU emissions trading with a host of facilities and - like the energy sector - will be affected by a lowering of the cap. The conditions and incentive effects for emission reduction in the industry sector are similar to those described in the "Energy sector" chapter. However, the NAP II foresees the continuation of the allocation method based on historical emissions for industrial plants. This means that the incentives are much weaker for these facilities.

The Federal Environment Agency's scenario does not consider process-related emissions from industrial processes, for example, in cement production or steelmaking[89]. The Federal Environment Agency expects that it will not be possible to reduce these process-related emissions through technical efficiency measures to the same extent as energy-related emissions.

However, one way to reduce CO_2 emissions is to reduce production, for example, through improved resource efficiency, for instance, by using less metal in building construction. As a result, the reduction of process-related emissions can make an additional contribution towards climate protection – however, without quantifying the contribution at this point.

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[89] However, emissions trading also generates incentives for lowering process-related emissions. Emissions trading does not discriminate between energy-related and process-related emissions with regard to the treatment of these emissions. In both cases, operators must give away emission rights corresponding to their actual annual emissions. However, if emission rights are allocated largely for free, there is a possibility for sectoral differentiation in the allocation of rights (use of different fulfilment factors) which is pursued in the NAP II. In the case of process-related emissions too, reducing emissions pays off for plant operators if the costs of reduction are lower than the price for the emission rights which are not needed.

Energy taxation

In view of the many and diverse industrial production plants and energy consumers which are not subject to emissions trading, CO_2 reductions in the industry sector still need broad-based taxation of primary energy sources and electricity.[90]

The standard energy tax rates should be equally applicable to all sectors. The lowering of energy tax rates for the producing sector to 60% and the peak compensation system have so far prevented far-reaching incentives for efficient energy use[91]. The Federal Environment Agency is of the opinion that the federal government should generally grant energy tax breaks (for facilities not subject to emissions trading) only to those companies which, in direct consideration thereof, introduce a certified energy management system and implement at least those energy saving measures which pay off and break even within a reasonable period of time from an economic point of view. Further energy and electricity tax breaks should only be available to those energy-intensive facilities which due to intensive international competitive pressure are unable to pass on to their customers the additional costs resulting from energy taxation. Flat-rate tax breaks for mineralogical, chemical and metallurgical production processes must be abandoned. The tax on coal used for heating which was introduced in 2006 must be gradually increased to 1.98 euro (€) per gigajoule (GJ) (0.715 cent per kWh) so that coal reaches a level comparable to fuel oil[92] .

Promoting heat from renewable energies

With the present instruments for promoting renewable energies on the heat market, it is unlikely that renewable energies will reach a share of 12% (i.e. doubling) in heat supply in the year 2020.[93] The federal government should hence introduce further instruments to promote the use of renewable energy sources for heat generation.

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[90] Concerning the energy taxation issue, refer also to the "Private households and the commercial, trade and services sector" as well as "Transport"

[91] In 2005, electricity tax shortfall (reduction to 60% for the producing sector) totalled an estimated 1.85bn euro. Tax shortfall related to fuels totalled 0.342bn euro in 2005. Tax shortfall due to the peak compensation system totalled 1.9bn euro in 2005. Source: Federal government 2006a, p. 1-2

[92] Measured by energy content and CO_2 emission relevance which are considered at a rate of 50% each in the conversion of the tax rates.

[93] Refer to BMU 2006a, p. 27

The Federal Environment Agency considers the following instruments to be generally worth discussing:

- Use model[94] with a compensation rule
- Quota allowance system for fuels from renewable energies
- Bonus models (purchase/remuneration systems) on the basis of private exchange relations
- Financial support (investment grants)

From the Federal Environment Agency's point of view, there are good reasons to support smaller plants with direct financial assistance and larger plants via a bonus model. However, the Federal Environment Agency has not yet completed its opinion-forming process on this issue. With regard to new instruments, one should generally ensure that these supplement the instruments already in place on the heat market, above all, the Energy Saving Ordinance (EnEV), the Cogeneration Law and various subsidy and support programmes.

The Cogeneration law (KWK-G)

The Cogeneration Law turned out to be a successful instrument for promoting cogeneration. Between 2002 and 2006 it contributed towards the revamping of cogeneration plants with a capacity after revamping of 3,000 megawatt (MW_{el}) and thereby contributed towards additional cogeneration electricity production of 10 TWh per annum (effectiveness).[95] The Federal Environment Agency considers the administrative requirements related to this instrument to be low.[96] Due to the possibility of graduated bonus payments depending on plant type, this instrument also enables the promotion of innovative energy conversion technologies.
Today's instruments are not enough to double cogeneration. The Cogeneration Law no longer provides subsidies for new plants with an electrical power of more than 2 MW, for example. The law must hence be amended. A central issue in this respect is the inclusion of new cogeneration plants within the scope of the Cogeneration Law – in order to support both plants feeding the public grid as well as station-service

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[94] This model is also called "target quota model".

[95] Refer to BMWi, BMU 2006, p. 7

[96] Despite intensive public debate on the continuation of the instruments, the Federal Environment Agency has not received any comments which criticise the administrative requirements as high.

plants. Furthermore, the period for revamping existing plants should be extended to 2012.[97] Without revamping, existing plants should not receive any additional support in order to avoid subsidy-taking effects to the largest extent possible.

Energy efficiency fund

The energy efficiency fund would finance a host of measures for fuel and electricity savings in the industry sector as well as energy use concepts at company level. The Federal Environment Agency presents the features of the energy efficiency fund in the following section dealing with private households and the commercial, trade and services sector.

Private households and the commercial, trade and services sector

The most important measures in these sectors are building rehabilitation and the installation of more efficient heating systems with emission reductions totalling 31 million tonnes of CO_2. In view of the large number of players in the building sector, a combination of different, complementary instruments must be used. Higher energy taxation means that more building rehabilitation measures will pay off and thereby reinforces the effect of the Energy Saving Ordinance (EnEV) through financial incentives. Government subsidies, for example, in the form of a building rehabilitation programme, offer additional incentives. This section describes the instruments of energy taxation and the building rehabilitation programme as well as two instruments for electricity savings. The instruments for promoting cogeneration and regenerative heat generation described in the "Industry" section lead to CO_2 emission reductions in private households and the commercial, trade and services sector. These instruments are hence not described again here. Increased use of cogeneration and regenerative heat generation in conjunction with further measures, for example, for saving heat in the commercial, trade and services sector, can lead to a total CO_2 emission reduction by 18 million tonnes of CO_2.

Energy taxation

Private households and the commercial, trade and services sector pay energy taxes primarily on heat generation and electricity consumption.

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[97] After 2012, a modified emissions trading system could generate the necessary incentives (refer to the "Energy sector" section).

Energy taxation is an easy-to-apply tool which influences millions of decisions by consumers and businesses and generates financial incentives for reducing CO_2 emissions from "diffuse" CO_2 sources in small businesses, service providers and private households and therefore constitutes a tried-and-tested, effective and indispensable instrument for climate protection. It systematically generates incentives for cost-effective emission reduction measures because energy consumers consider it to be economically advantageous to reduce only those CO_2 emissions where the limit cost of avoidance is lower than the tax rate. Furthermore, the administrative costs[98] of energy taxation are lower compared with other instruments and thereby also contribute towards the high efficiency of this instrument.

Taxation of the individual energy sources should be orientated towards their relative environmental harm and also consider the aspect of resource saving in order to increase the steering efficiency of energy taxation and its acceptance by the population. Against this background, all energy sources should be taxed to 50% according to their energy content and to 50% according to their greenhouse gas emission relevance.

In the long term, the level of energy tax rates should be gradually adjusted in such a manner that, together with the other climate protection instruments, they fully internalise the external costs related to carbon dioxide emissions. On the basis of evaluations in recent publications[99] , the Federal Environment Agency recommends using a value of 70 euro per tonne of CO_2 as the best estimate of external costs.[100] Referring to this value, the Federal Environment Agency has calculated average external costs of electricity generation of close to 6 cents per kWh (nuclear power disregarded).[101]

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[98] Administration costs for the ecotax in 2002 accounted for only 0.13% of revenue from this tax which is very low compared to other tax types, such as corporation tax (5%) or income tax (2.2%). Refer to Deutscher Bundestag 2002, 14th legislative period, publication 14/9993, p. 31.

[99] Krewitt et al. 2006, p. 1

[100] This value for the external cost of damage can change in future in response to new results concerning consequential damage to climate and its evaluation.

[101] In this respect, costs vary strongly between less than 1 cent per kWh in the case of renewable energy sources and close to 9 cents per kWh in the case of power generation from brown coal.

Furthermore, energy tax breaks must be abandoned if they reduce the economic incentives to reduce CO_2 emissions. The moratorium for the coal tax, which was introduced in 2006 for heating in private households, should not be extended up to the end of 2010; instead, it should be introduced in this area as quickly as possible and it should then be gradually raised to a level of €1.98 per GJ (0.715 cent per kWh) comparable to fuel oil taxation.[102]

Energy Saving Ordinance and CO_2 building rehabilitation programme

The Energy Saving Ordinance (EnEV) lays down maximum energy demand values for new buildings. As a precondition for opening up the CO_2 reduction potential of existing homes and apartments, the Energy Saving Ordinance and its basis, the Energy Saving Act (EnEG), will have to be amended. To this effect, stricter energy consumption standards must be laid down than those currently foreseen under the Energy Saving Ordinance and these more restrictive standards must be increasingly made applicable to existing buildings too. As a precondition for introducing effective retrofitting obligations for existing buildings, the criterion of "reasonable periods and deadlines" for implementing savings in existing buildings would have to be especially expanded in the Energy Saving Act. Increasing energy taxation on fuels would also help here because this would mean that the above-mentioned economic efficiency requirement would be fulfilled earlier.

However, an amendment to the Energy Saving Ordinance will not become fully effective until 2020 because the implementation of the Energy Saving Ordinance in its current form is already difficult as can be seen by the fact that only part of the rehabilitation projects carried out also includes rehabilitation of energy systems. Determined enforcement of an amended Energy Saving Ordinance would require substantial manpower and hence lead to financial burdens on the federal states which are responsible for enforcement. Even given optimum implementation of an amended Energy Saving Ordinance, it is unlikely that the target will be achieved because the legislator will probably have to allow extended transition periods for the

[102] Referring to the current fuel oil tax rate of 6.135 cents per litre and converted according to energy content and CO_2 emission relevance which are included in the conversion of the tax rates at 50% each.

introduction of binding rehabilitation obligations. The finance basis of the CO_2 building rehabilitation programme which has been successfully operating since 1999 must hence be significantly enlarged in order to generate effects in the short to medium term. Furthermore, this support instrument is also a suitable way of reducing the necessary transition periods for obligations under the Energy Saving Ordinance.

In addition to imposing more restrictive requirements within the scope of the Energy Saving Ordinance, the federal government should hence continue and amend the CO_2 building rehabilitation programme[103] in such a manner that the annual rehabilitation rate rises to 2.0% as soon as possible[104]. An instrument of the type described in the "Industry" section must be introduced to support and promote renewable heat generation.

Attempts to save energy in residential buildings in Germany have so far been set off by the increased consumption of living space. In order not to favour this trend further, the federal government should support the above-mentioned instruments by removing subsidies in the housing sector. The housing bonus and the employee savings allowance for building society savings schemes must be abandoned; subsidies for promoting economic and regional structures must be put to the test. Furthermore, new and undifferentiated subsidies for new homes should be avoided, for example, in the form of a flat-rate subsidy and support programme for owner-used residential property within the framework of the "Riester pension" scheme.[105]

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[103] The amendment of the programme effective as of 1 January 2007 points in the right direction: If the requirements for new buildings pursuant to the Energy Saving Ordinance are outperformed by more than 30% in building rehabilitation projects, the owner receives a once-off redemption grant of 12.5% of the loan volume.

[104] The current subsidy budget totals €1.5bn per annum and will probably have to increase further. Quantification is not possible at this stage because the effect of the recent increase must first be allowed to materialise since it is at present not possible to finally evaluate the effect of the increase in the subsidy budget to €1.5bn in 2006 against less than €400m in 2005.

[105] Experience shows that especially residential property motivates elderly people to stay in their family home even after the children have moved out. This leads to high per-capita consumption of living space by elderly one-person or two-person households whilst at the same time young families may be forced to build additional homes. This results in new living space which must be heated in winter and possibly cooled in summer. A more appropriate approach would be to induce elderly people to move into smaller apartments in locations with a good infrastructure.

A redesign of property acquisition tax by relieving transactions with existing buildings and burdening transactions with new settlement space (such as a tax on new settlements, on newly sealed land, development charges) is necessary for two reasons. Firstly, in order to relieve transactions with existing buildings from transfer costs, so that it would be easier to efficiently use existing buildings. If, for example, people sell their one-family home before retirement in order to move to a smaller apartment in the city centre, they should be able to sell their home at fair market value and without losses, if possible. Secondly, in order to decelerate the expansion of settlements – including the necessary infrastructure – and instead to promote the re-use of fallow settlement areas and existing buildings.[106]

Financial assistance for home owners in order to support the rehabilitation of energy systems in existing buildings (and, if necessary, also a particularly high energy standard for new buildings in remaining growth regions with an urgent demand for new buildings) and, in particular, the above-mentioned CO_2 building rehabilitation programme, should be granted irrespective of a change in the ownership of buildings or land.

Efficiency race and efficiency fund

Low power consumption values of devices and appliances and consumer information campaigns have an important role to play in the debate on increasing electricity efficiency. Influences on the electricity consumption of devices and appliances vary strongly.[107]

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[106] More research is still needed with regard to further instruments for the targeted promotion and support of resource-efficient and socially compatible use of fallow settlement areas and existing living space. To this effect, the Federal Environment Agency has proposed the R&D project titled "Chancen der Nutzungspotenziale auf Stadtbrachen und künftige Wohnungsnachfrage, FKZ 3707 14 102“ [Prospects of use potentials on fallow urban areas and future demand for living space] within the scope of the 2007 environmental research plan [UFO-Plan 2007].

[107] Firstly, it is hence not sufficient aiming at lower power consumption ("watt values") only. These are momentary values which are determined under laboratory conditions. In practical use, there are many other influences, such as user behaviour. In order to keep the resultant power consumption at a low level, it is therefore necessary to influence not only power consumption in the different operating modes, but also other properties of the equipment. Secondly, it is not only user motivation which determines his or her behaviour; characteristics of the appliance and other factors also have an influence. Furthermore, campaigns always reach only a small part of the population and are capable of motivating even fewer citizens. But even if the situation were different: Consumers cannot compensate for technical shortcomings which, by the way, is not their job anyway.

Just like electricity consumption is influenced by a combination of many factors, it is also necessary to combine different instruments. The Federal Environment Agency proposes an energy race[108] and an efficiency fund[109] as key instruments for this purpose:

The **efficiency race** is a combination of the setting of efficiency standards and mandatory labelling requirements which must be adapted to technical progress at regular intervals. It is a further development of the "consumption target value" instruments from Switzerland and the Japanese "top-runner" programme.

The efficiency race must be implemented using regulatory instruments.[110] Compared to consumer campaigns, the efficiency race can be implemented much easier by setting regulatory efficiency standards because it addresses, for example, only "38 TV set manufacturers" rather than 38 million households throughout Germany. Consistent product labelling systems must also be effectively introduced on a regulatory level.

On EU level[111] , the legislator can generally impose the efficiency race in the form of implementation measures for the Eco-design Directive. Germany should hence try to exert its influence on EU level in order to have demanding requirements for electricity efficiency standards and mandatory labelling requirements introduced by the Commission or Council. In contrast to this, regulation powers are very limited on Member State level.[112]

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[108] Refer to report I 4.4 – 72256-2/0 dated August 2005

[109] Refer to report I 4.4 – 72256-3/0 dated May 2005

[110] In this context, efficiency standards must be identified and laid down in binding legislation for the individual device and appliance groups with an economical electricity saving potential. The efficiency standards should be based on the average power consumption of the best quarter of the corresponding devices which are available on the market. Furthermore, certain other characteristics, such as the existence of a power switch, should also be specified. Each manufacturer and importer is obliged to comply with the standards for their products after a defined period of time. Violations must be effectively sanctioned – concrete sanctions to this effect have yet to be developed.

[111] We have chosen the term of "EU level" because the EU law foundations thereof are to be found on the EU Treaty (Art. 95, Art. 249 of the Treaty of Rome) rather than in the EU Treaty.

[112] Refer to report I 2.1 – 90 106-1/23 dated March 2006

Germany needs an **energy efficiency fund** to promote a portfolio of various energy efficiency activities[113] because the transaction costs of many saving measures are relatively high from the point of view of the parties involved. An energy efficiency fund reduces the transaction costs for the parties involved because the measures under this fund are centrally co-ordinated whilst technical and advisory services are rendered de-centrally. One proposal by Wuppertal Institut for establishing an energy efficiency fund foresees bestowing the fund with €5.8bn over a period of five years (mainly from 2006-2010)[114]. This finance volume will lead to annual savings of 31.5 TWh of electricity and more than 35 TWh of gas, oil, district heating and coal. The Federal Environment Agency recommends financing the energy efficiency fund via the proposed reduction of climate-damaging energy tax breaks.[115]

Transport

One important measure in the transport sector is the reduction of specific consumption with an emission reduction contribution of 15 million tonnes of CO_2. Reducing CO_2 emissions in the transport sector calls for a bundling of instruments, from the abolition of subsidies to an HGV toll. The most important instruments are motor vehicle tax, energy taxation and binding consumption limits. Avoidance of traffic and shifting the modal split will also enable emission reduction contributions of up to 15 million tonnes of CO_2.

Mineral oil tax and an HGV toll

Instruments designed to avoid traffic and to shift traffic to less environment-burdening transport modes have already been introduced and are also generally tried and tested, such as the ecological tax reform and the HGV toll on motorways. In their current form, however, these instruments are not enough in order to reduce the high CO_2 emissions from traffic to such an extent that the transport sector too will be able to contribute its share towards the national climate protection obligations. Germany needs a fundamental change in the transport sector.

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[113] For example, rehabilitation of energy systems of buildings or installation of high-efficiency recirculation pumps, Wuppertal Institut 2005, p. 14-22

[114] Wuppertal Institut 2005, p.40

[115] The general, 40% energy tax break for the producing sector, agriculture and forestry as well as the so-called peak compensation system for energy-intensive businesses in the producing sector alone totals around €4bn per annum. Refer to Bundesregierung 2006, p. 1-2

The HGV toll in its current form has not led to a major shift from road to rail or inland waterway traffic. Various studies show that this was not to be expected.[116] In order to achieve a shift in transport modes and additionally create an incentive for better utilisation of vehicles, the HGV toll must be expanded to cover all federal roads – rather than selected roads as is currently the case – and must be additionally increased further.

Model calculations within the framework of environmental-economic accounts show that by the year 2020 the expansion of the HGV toll to all federal roads in conjunction with a doubling of the HGV toll to 25 cents per kilometre driven would reduce goods traffic by around 2.7% against the trend and shift traffic from the road to rail. This will mean CO_2 emission reductions of around 3 million tonnes. The level of such a toll is justified because this would mean that HGVs would have to bear the infrastructure costs of the road network. Even higher toll rates could be justified if the external costs of traffic were additionally allocated.[117]

The calculations show that this instrument, with a better design, can be very effective. The HGV toll is a simple way of creating incentives for cost-effective carbon dioxide emission reductions through better HGV utilisation as well transport mode shifts and traffic avoidance. Furthermore, the federal government generates revenue which it can once again use in order to shift goods traffic to rail and waterway traffic.

Tax incentives for increasing energy efficiency and for saving energy in traffic must be left in place and gradually re-adjusted. In order to increase the steering efficiency and acceptance by the population even further, the ecotax should be orientated more towards clearly understandable, environment-related criteria, such as the energy content of fuels and the climate relevance of the resultant emissions. The federal government should hence at least gradually adjust the tax rates on diesel and petrol, all the more so since diesel has higher specific CO_2 emissions than petrol.

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[116] Rothengatter, Doll 2001, p. 117-120

[117] UBA 2004a, p. 7

The development of motor vehicle mileage since the ecological tax reform in 1999-2003 shows a relatively high sensitivity to high prices[118]. Besides the effect of stabilising and reducing motor vehicle mileage, the mineral oil tax also supports the demand for low-consumption vehicles. Furthermore, the instrument requires very little administrative effort.

CO_2 dependent motor vehicle tax and binding emission reduction

The coalition agreement for the 16th legislative period of the German parliament foresees the introduction of a CO_2-dependent motor vehicle tax. This tax is an effective instrument in order to increase demand for fuel-saving vehicles. Several European countries have already gone this way. The UK, for example, taxes company cars at a higher rate than private cars. As a result, average CO_2 emissions from company cars are now below those from private cars.

Although the collection of motor vehicle tax in Germany requires considerable administrative effort, the instrument develops a very effective steering effect. This has become apparent since the pollutant component is included in the tax and experience from other European countries confirms this experience with regard to the inclusion of carbon dioxide. Merging the motor vehicle tax into the mineral oil tax would not only mean that a steering instrument for air pollutants would be lost; the resultant increase in mineral oil tax would also be too unspecific with regard to air pollutants.

Parallel to the introduction of a CO_2-dependent motor vehicle tax, the federal government should demand on EU level that the EU Commission present a proposal for a directive for legislation to limit CO_2 emissions by the middle of 2008 at the latest. The voluntary promise by the European automotive industry to achieve average CO_2 emissions of 140 g/km from new vehicles (passenger cars) in 2008 will not be kept. This means that binding limit values for specific CO_2 emissions are required. This will be the only way to achieve by the year 2012 the target for the average of new cars which has already been increased from 120 to 130 g/km. Although CO_2 limit values are an effective instrument for limiting CO_2 emissions from passenger cars, this will

118 UBA 2005d, p. 3-4

be strongly dependent on the design of such a system. Meaningful consumer information concerning the fuel consumption[119] of vehicles in show-rooms and in ads will enable people buying new cars to clearly identify energy-efficient models. Maximum benefits can be achieved at a relatively low cost.

Emissions trading and kerosene tax for air traffic

In order to create fair competition conditions between the transport modes, the federal government – together with the neighbouring countries important for air traffic – should cancel the exemption of kerosene from mineral oil tax and advocate an EU-wide kerosene tax. The kerosene tax should be generally integrated into the existing mineral oil tax system. This means that a tax rate of 654.50 euros per 1,000 litres of kerosene should be aimed at, i.e. the same rate which is also payable on petrol. This was also demanded by the "Innovative Financing Instruments" work group of the Federal Ministry of Finance. Furthermore, the VAT break on international flights must be abandoned.

In order to limit the climate damaging effect of air travel, the Federal Environment Agency supports the inclusion of air transport and air travel in the European emissions trading system as of 2011 as intended by the Commission[120] . The special climate damaging effect of air travel must be considered in this respect.[121] Especially kerosene tax and emissions trading generally offer a high potential to effectively reduce climate-damaging emissions from air travel.

Further instruments in the transport sector

Furthermore, the federal government should implement the National Bicycle Transport Plan from 2002 to 2012 and call upon federal-state governments to grant

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[119] The current German implementation of Directive 1999/94/EC relating to the availability of consumer information on fuel economy and CO_2 emissions in respect of the marketing of new passenger cars is not helpful because the information provided is difficult to understand for consumers and presented in a visually unattractive form. A comparative label for new cars with energy efficiency classes A-G (similar to domestic appliances) is required.

[120] Commission proposal dated 21 December 2006 to include air travel in the EU emissions trading system.

[121] Air travel has an effect on climate not just because of carbon dioxide emissions. At cruising altitude, the emission of nitrogen oxides leads to the build-up of ozone which acts as a strong greenhouse gas at these altitudes. Steam emissions from aircraft engines lead to the formation of condensation trails and subsequently of cirrus clouds. According to recent scientific results, cirrus clouds may have a particularly strong effect on climate.

better subsidies and more funds for public local passenger transport[122] .[123] The federal state of Brandenburg, for example, has introduced, besides other criteria, the number of passengers in public local passenger transport as a success component relevant for the distribution of public local passenger transport money to municipal level via a distribution key. As a result, successful operators can over the course of time increase their share from the federal state's overall budget.[124] By introducing urban development promotion schemes aimed at compact settlement structures, replacing property acquisition tax with tax on new settlements, tax on newly sealed land or development charges[125] as well as a further reduction of the distance-related tax allowance for commuters designed as a social compensation system for long-distance commuters rather than for commuters in the immediate vicinity of cities, settlement forms are to be promoted which are characterised by lower traffic and a pedestrian, bicycle and public transport-friendly infrastructure. These instruments have a long-term effect because they can change existing settlement structures only slowly. They are, however, a precondition for a high effectiveness of the other measures and instruments and must hence be introduced without delay. The costs are often very low because new investment is usually not required. The federal government and municipal administrations may even increase their revenue or reduce their expenditure, so that these instruments not only effectively reduce carbon dioxide emissions, but can also improve the public budget situation in the long run.

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[122] UBA 2003, p. 17, DIFU 2006, p. 35

[123] Around half of all passenger car trips is shorter than 5km. If a significant part of this can be shifted to the bicycle, it will be possible to open up a relatively large emission reduction potential. Costs are relatively low compared to those of other transport modes. Municipal administrations and the federal government can pay these costs by giving priority to promoting non-motorised traffic against road traffic.

[124] DER NAHVERKEHR, Vol. 5/2005, p. 48.

[125] UBA 2004b, p. 140-144

7. Conclusion: The 40% target can be achieved – but only with a determined climate and energy policy

The report shows that the target of a 40% reduction of energy-related greenhouse gas emissions in Germany by the year 2020 against 1990 can be achieved with measures in Germany.[126]

Using the IKARUS energy system model, the Federal Environment Agency calculates average costs for emission reduction measures in the different sectors of €50 per tonne and a total of €11bn in the year 2020.[127] This would correspond to an additional monthly expenditure per household of less than €5 in 2010 and less than €25 in 2020.

The potential of cost-effective emission reductions is particularly high in the energy sector. These potentials can be achieved with three types of measures:

a) Increasing the share of renewable energy in electricity supply by continuing the Renewable Energy Sources Act

b) Changing electricity generation to gas-fired power stations by offering stronger incentive effects in emissions trading

c) Reducing electricity consumption by bundling instruments, such as an efficiency race for electrical devices and appliances.

Although emissions trading can generate economic incentives in order to implement the change in electricity generation in favour of gas-fired power stations, it is ultimately always the operator's decision which fuel is to be used in a new or replacement plant. Should utility companies build a larger number of new coal-fired power stations than anticipated in the Federal Environment Agency's scenario, the decline of emissions in the emissions trading sector would be less pronounced. This would then require higher CO_2 emission reductions in other sectors at relatively high costs in order to achieve the 40% reduction target for CO_2 emissions by the year

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[126] This is summarised in Table 8 in chapter 5.

[127] Since the emissions trading sector is only one of the sectors discussed, it is not possible to extrapolate the future certificate price from this figure. Furthermore, the price for emission rights is not set by German climate protection policy; instead, it is a function of the all-European interaction of supply and demand. Price forecasts are hence not possible.

2020 against 1990. It is hence important that the budgets of the following trading periods be orientated towards the target value of 330 to 350 million emission rights for the 4th trading period from 2018 - 2022 as calculated in the Federal Environment Agency's scenario.[128]

The current trend suggests that emissions in the traffic sector will decline only slightly by the year 2020. Additional emission reductions of 22 million tonnes of CO_2 are necessary. In order to achieve this, necessary measures include, for example, emission limits for car manufacturers, additional financial incentives from the HGV toll and an adjustment of mineral oil tax which complies with the interests of climate protection.

In the industry sector, further emission reductions of 30 million tonnes of CO_2 can be achieved by 2020 compared to 2005 by energy savings in the field of process heat, by cogeneration and by more widespread use of renewable energies for heat generation. This requires, amongst other elements, an energy efficiency fund and an amendment to the Cogeneration Law.

Measures and instruments similar to those in the industry sector are also effective in private households and the commercial, trade and services sector where a total of around 50 million tonnes of CO_2 can be saved. Besides the measures mentioned in the "Industry" sub-chapter, improved building energy efficiency is a crucial parameter in this respect with a potential to achieve CO_2 emission reductions of more than 30 million tonnes in this area alone. In order to achieve the necessary rehabilitation of existing buildings, the Federal Environment Agency proposes a combination of subsidies, minimum energy standards for buildings and energy taxes which can be adjusted in line with climate protection requirements.

Both in the transport sector and for private households, compact settlement development is a necessary precondition for the measures proposed in chapter 5 to become effective.

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[128] The underlying rationale being that utility companies should buy any additional emission rights needed abroad rather than the government. If this involves high costs due to the increasing scarcity of emission rights observed in all Member States, this could mean that some new plants may no longer be profitable.

Germany, together with its EU partners, should implement effective measures in order to set a successful example for all the other industrialised nations so that they too introduce demanding emission reduction targets. This is all the more important in view of Germany's per-capita emissions which are relatively high compared to the EU as a whole[129].

Such a pioneering role by Germany will offer great opportunities for the German economy. Although many climate-protecting technologies still require widespread market penetration in order to be able to compete against conventional technologies, Germany will be able to profit from their forthcoming global implementation because billions of euros will have to be invested in the next decades, especially in the energy supply sector. Furthermore, Germany will be able to confirm the trust of its international partners and to intensify co-operation through ambitious climate protection. The reputation of Germany and the EU in the field of climate policy and their credibility will have a fundamental role to play with a view to the involvement of developing and newly industrialised countries in emissions limits to be aimed at in international climate protection after 2012. A determined and stringent course in climate policy will give a clear signal to those countries in and outside the EU which, for different reasons, have not yet sufficiently striven for climate protection. In this respect, the climate protection initiatives underway in the United States at federal-state and regional level can also develop momentum which will be of global importance for the next steps in climate protection.

The CO_2 emission reductions mentioned in this report are technically feasible and economically practicable. They can only be achieved with determined and quick action. Every year lost on the way towards rehabilitation of energy systems in buildings in Germany can, for example, mean an additional 1.5 million tonnes of CO_2. These buildings will then not be rehabilitated again for another 40 years. The same is also applicable, for example, to CO_2 emissions from power stations and the installation of inefficient heating systems.
It is hence urgently necessary to act with determination. The future is in our hands.

[129] WRI 2005: EU-25: 10.5 t $CO_{2(equiv.)}$ per capita; Germany: 12.3 t $CO_{2(equiv.)}$ per capita (data for 2000)

8. Abbreviations and chemical formulae

AAU – Assigned Amount Units

Federal Ministry for the Environment, Nature Conservation and Reactor Safety and Radiation Protection

BMWi - German Federal Ministry of Economics and Technology

CDM – Clean Development Mechanism

CO_2 – Carbon dioxide

CH_4 – Methane

EEG – Renewable Energy Sources Act

EnEG – Energy Conservation Act

EnEV – Energy Saving Ordinance

EU – European Union

GJ – Gigajoule

IPCC - Intergovernmental Panel on Climate Change

JI – Joint Implementation

KP – Kyoto Protocol

KWK-G – Cogeneration Law

kWh – kilowatt hour

NIR – National Emissions Inventory Report

N_2O – Dinitrogen oxide (laughing gas)

SF_6 – Sulphur hexafluoride

TWh – terawatt hour

UBA – Federal Environment Agency

UNFCCC - United Nations Framework Convention on Climate Change

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Appendix 1: Framework data of the reference forecast by EWI/Prognos 2005

Table 5: Population and households, 2000-2030

	2000	2010	2020	2030
	in Thousands			
Population, mid-year	82,212	82,411	81,393	79,421
Private households, mid-year	38,151	39,665	40,021	39,716
Of which:				
1-person households	13,777	15,044	15,329	15,675
2-person households	12,736	13,857	14,677	14,608
3-person households	5,588	5,235	4,981	4,711
4-person households	4,387	3,975	3,627	3,411
5-person households	1,663	1,555	1,407	1,312

Source: Own presentation according to EWI/Prognos 2005, p. 191

Table 6: Added value according to industries (real prices; price basis: 1995), 2002-2030

	2002	2010	2020	2030
	in Mrd. EUR (1995)			
Agriculture and forestry; fisheries	24	24	24	23
Mining, winning of stones and earths	4	3	2	2
Processing sector	400	452	524	592
Energy and water supply	40	46	50	53
Construction industry	90	91	102	112
Trade sector; repair of motor vehicles and consumer goods	189	206	222	232
Hotel and catering industry	20	20	23	25
Transport and communications	162	206	268	330
Banking and insurance industry	111	126	149	176
Real property sector; rental; services for companies	485	565	681	781
Public administration; defense; social insurance	109	111	114	120
Education	72	75	79	83
Health, veterinarian and social sector	127	147	182	224
Other public and private service providers	86	98	120	142
Statistical adjustments	70	67	68	65
Gross Domestic Product	1,990	2,238	2,611	2,960

Source: Own presentation according to EWI/Prognos 2005, p. 149

Table 7: Prices for primary energy sources (real prices; price basis: 2000), 2000-2030

	2000	2010	2020	2030
Oil price, fob (USD/bbl)	28.40	28.00	32.00	37.00
Average import prices				
Crude oil (EUR/t)	227	200	235	270
Natural gas (EUR/kWh)	1.10	1.11	1.28	1.43
Power-station coal (EUR/t SKE)	42.1	46	48	50
Third-country coal (EUR/t)	37.7	40	43	44
Brown coal (EUR/GJ)		0.83	0.83	0.83

Source: own presentation according to EWI/Prognos 2005, p. 70

Table 8: Prices for mineral oil natural gas and coal (real prices; price basis: 2000), 2000-2030

	2000	2010	2020	2030
Industry (without VAT)				
Fuel oil, extra light	381.5	363.7	423.7	485.2
Fuel oil, heavy	188.9	179.1	211.7	242.7
Natural gas	1.7	1.9	2.1	2.3
Hard coal	42.7	57.0	71.4	84.2
Private households (including VAT)				
Fuel oil, extra light	40.8	38.6	45.2	51.7
Natural gas	3.7	4.1	4.7	5.4
Petrol	1.00	1.08	1.15	1.21
Diesel	0.81	0.90	0.97	1.04

Source: Own presentation according to EWI/Prognos 2005, p. 73

Appendix 2: Comparison of sectoral distribution of CO_2 emissions in terms of actual values, energy model calculations and the Federal Environment Agency's scenario in million tonnes of CO_2

		Actual values			**Reference Forecast**				**Federal Environment Agency's scenario**					**IKARUS-Calculation 2006**			
In million tonnes of CO2-equivalents	Reference year 1990/95	Actual 2003	Actual 2004	Actual 2005	Actual 2002	Forec. 2010	Forec. 2020	Reduction 2002-20	Target 2020	Red. 1990-20	Red. in % 1990-2020	Red. 2005-20	Red. in % 2005-20	Emissions 2004	Emissions 2020	Red. 2004-20	Red. in % 2004-20
Energy Sector	415	**374**	**370**	**362**	357	342	335	-22	247	-168	-41%	-115	-32%	328	186	-142	-43%
Industry	154	**96**	**102**	**103**	132	126	118	-14	73	-82	-53%	-30	-29%	129	102	-27	-21%
Transport	162	**171**	**171**	**164**	176	171	155	-21	134	-28	-17%	-30	-18%	196	174	-22	-11%
Private househoulds	129	**124**	**118**	**113**	176	178	158	-18	74	-55	-43%	-39	-35%	125	86	-39	-31%
Commercial, trade and services sector	87	**58**	**55**	**53**					43	-44	-50%	-10	-19%	60	42	-18	-30%
Energy-rel. CO2	**948**	**822**	**816**	**795**	**841**	**817**	**766**	**-75**	**571**	**-377**	**-40%**	**-224**	**-28%**	**838**	**590**	**-248**	**-30%**

Sources:

Values in 1990, 2003-2005, calculations by the Federal Environment Agency, all values preliminary

Reference forecast: EWI/Prognos 2005, Die Entwicklung der Energiemärkte bis zum Jahr 2030, Basel 2005

Federal Environment Agency's scenario: own calculations

IKARUS calculations 2006: model calculation of the Jülich research centre IKARUS assuming a CO_2 emission reduction by 50% by the year 2030 compared to 1990

Explanations:

- According to the Kyoto Protocol, the reference year for CO_2 is 1990.
- The reference forecast of EWI/Prognos and the IKARUS model calculations do not follow the current sector definition of the NIR, and, in particular, do not reflect the changed allocation of certain CO_2 emissions as process-related CO_2 emissions. The emission level is hence around 40 million tonnes of CO_2 higher than stated in the NIR. According to the territorial principle, IKARUS also includes the CO_2 emissions from international air traffic. In the interest of improved comparability, a flat amount of 16 million tonnes of CO_2 emissions from international air traffic was hence subtracted from the IKARUS figures in the transport sector.
- The commercial, trade and services sector includes military units.

Appendix 3: Electricity production and CO_2 emissions

	Actual 2005				Federal Environment Agency's 2020				Difference 2005-2020					
	E factor (fuel input)	Elec-tricity gener-ation	Fuel con-sump-tion	CO2 emis-sions	Electri-city genera-tion, actual kW	Federal Environment Agency's scen-ario	Fuel con-sump-tion	CO2 emis-sions	Elec-tricity gener-ation	CO2 emis-sions	New electricity genera-tion	Emission factor of the electricity substituted	Emission factor of the new electricity	Emission reduction balance
	gCO2/kWh	*TWh*	*TWh*	*million tonnes of CO2*	*TWh*	*TWh*	*TWh*	*million tonnes of CO2*	*TWh*	*million tonnes of CO2*	*TWh*	*kg CO2/kWh*	*kg CO2/kWh*	
Brown-coal fired power station	404	155	414	167	85	100	227	92	-55	-76	15	-0.567	0.918	5
Hard-coal fired power station	338	134	331	112	59	76	162	55	-58	-57	17	-0.567	0.719	3
Nuclear power station		163	494	0	33	33	100	0	-130	0	0	-0.567	0.000	0
Natural gas	202	70	127	26	32	165	243	49	95	23	133	-0.567	0.298	-36
Renewables		63	63	0	63	140	140	0	78	0	78	-0.567	0.000	-44
Other	190	34	101	19	19	34	76	14	0	-5	15	-0.567	0.422	-2
Total		**619**	**1530**	**324**	**291**	**548**	**948**	**210**	**-71**	**-114**	**258**	**-0.567**		**-74**
(Electricity savings)						*71*						-0.567		-40
													Total	**-114**

Sources:

E(mission) factors: Converted on the basis of mean values from the NIR 2004

Actual values 2005: AG Energiebilanzen 2006, Stromerzeugung aus erneuerbaren Energien nach BMU, Erneuerbare Energien in Zahlen: May 2006 update, average utilisation rates: the Federal Environment Agency's own calculations on the basis of the energy balance of AGEB [AG Energiebilanzen - Energy Balances Work Group], CO_2 emissions: the Federal Environment Agency's own calculations

Federal Environment Agency's scenario for 2020: Actual electricity generation in power stations (KW) on the basis of the Federal Environment Agency's power station database; all other values representing the Federal Environment Agency's own calculations.

Difference 2005-2020: the Federal Environment Agency's own calculations.

Explanations:

- Line: Electricity savings: 12% electricity savings compared to 2005. Assumptions from UBA 2005b, p. 431
- Line "Of which energy sector": The CO_2 emissions had to be distributed because electricity is generated not only by the energy sector, but also by private households and by industry. This calculation is based on the assumption of an equal CO_2 intensity of electricity generation in all sectors. Electricity generation by private households is included in the total sum. It is, however, not reported as a separate item because these quantities are small and additionally originate mostly from production from renewable energies – and hence from CO_2-neutral generation.
- Column "Fuel consumption": With regard to cogeneration, the Federal Environment Agency attributes fuel consumption to electricity and heat generation on a pro-rata basis. The expansion of cogeneration is, in particular, responsible for the high efficiency of natural-gas fired (cogeneration) stations in 2020. With this calculation approach, however, emissions increase for the pro-rata fuel consumption for heat supply.
- Column "Actual electricity generation in power stations": This represents the power stations which are today already in operation and which have a technical service life until 2020 or beyond.
- Column "Reduction contribution through replacement capacity": Share of the respective energy source in emission reduction by contributing towards replacing older coal-fired power stations with lower efficiency.