40% reduction of CO2 emissions by 2020 – Germany's path towards a sustainable energy system

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In order to stabilize the GHG concentration in the atmosphere at 400 ppm, developed countries have to reduce their greenhouse gas (GHG) emissions by considerable amounts in the next decades. 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. The results presented in this contribution shows that Germany can reduce its GHG emissions by 40% by 2020 compared to 1990. According to calculations by the Federal Environment Agency (UBA), more than 18% was already achieved in 2005. The measures discussed in the study will enable Germany to achieve the remaining 22% by the year 2020. Since generation and use of energy are the key to successful climate protection in Germany, the German Federal Environment Agency has identified eight measures in the electricity, heat and transport sectors in order to achieve the 40% target by 2020. This corresponds to an emission reduction of around 224 million tonnes (Mt) of CO2 until 2020 (376 Mt over the total time period from1990). An important result of the study is that this emission reduction could be achieved with reasonable economic costs.

Introduction

In order to ensure that the impacts of global climate change do not result in irreversible ecological and economic damages, the global temperature rise must be limited to 2°C above preindustrial levels. This restriction presupposes a long-term stabilisation of the concentration of greenhouse gases at a level of 400 ppm. To achieve this aim, global GHG emissions have to fall by 50% by the middle of this century; because of their responsibility for the present concentration of greenhouse gases in the atmosphere the industrialized countries should reduce their greenhouse gas emissions by 80% by that time compared to 1990.

The UBA believes that Germany - as a pioneer in climate protection - should support the European Union's target of a 30%[1] reduction of greenhouse gas emissions by reducing its own emissions by 40% by 2020. Within the scope of the Kyoto Protocol Germany is obligedto reduce its emissions by 21% by 2008-2012. This goal is within close reach; in 2007 about20% were already achieved (in 2005: 18%). To reach 40% by 2020 there are 22% left between 2005 and 2020. An UBA study shows that a 40% reduction of GHG emissions in Germany by 2020 compared to 1990 is feasible. The measures discussed in this study will enable Germany to achieve the remaining 22% by the year 2020. Since generation and use of energy are the key to successful climate protection in Germany, UBA has identified eight measures in the electricity, heat and transport sectors in order to achieve the 40% target by 2020. This corresponds to an emission reduction of around 224 million tonnes (Mt) of CO2 by2020 (376 Mt over the total time period from 1990).

1 The EU member-states in principle support the proposal for the unilateral reduction on the part of the EU of CO2 emissions by 20% until 2020 and by 30% if other industrialized countries as well proceed in corresponding reductions.

The suggestions made by UBA were taken up by the German Federal Government, although not fully. In a policy statement in April 2007, the German Minister of Environment announced a plan including the eight measures for a 40 % reduction of greenhouse gases in Germany by 2020. To achieve this goal, in August 2007 the German Federal Government adopted an integrated energy and climate programme (IEKP) which contains 29 measures for emission reduction. In December 2007 and in June 2008 the majority of the measures and instruments were adopted by the Federal Cabinet (for further details see Tab. 2).

Assumptions

Germany aims to reduce its GHG emissions mainly through measures implemented within Germany. This contribution illustrates that this is possible. The scenario considers only technologies which are already commercially available. This rules out carbon capture andstorage as an option within the scenario, because UBA does not expect a commercial use of CCS before 2020 (UBA, 2006). Regarding the use of nuclear energy the study assumes that the nuclear phase-out will be completed by 2021 as planned.

The scenario calculations are based on the assumptions concerning energy prices, economic and demographic development made in the study of EWI-Prognos (EWI, 2005). In the transport sector, the study is based on the TREMOD model (version 4.17).

The classification of sectors follows the definitions of the National Greenhouse Gas Inventory. The allocation of the total emission target to the different sectors of the economy is based on the following criteria: (1) economic feasibility of the measures, i.e. lowest possible CO2 abatement costs, (2) capability to overcome legal and administrative barriers to emission reduction and (3) possibility to implement the necessary changes in behaviour.

The 40% emission reduction scenario

The reduction of energy-related CO2 emissions is the key to successful climate protection in Germany. More than 80% of Germany's GHG emissions and about 95% of its CO2-emissions are energy-related. Concerning the latter, the 40% target translates into maximum annual emissions of 571 million tonnes of CO2 in 2020 (Tab. 1).

Tab. 1: 40% emissions reduction scenario calculated by the Federal Environment Agency, by different sectors of the German economy

Mill. tonnes of CO_2	Figures according to the GHG Inventory		Federal Environment Agency Scenario		
	1990	2005	2020	Changes in % 1990-2020	Absolute reduction 2005-2020
Energy Sector	415	362	247	-41%	-115
Industry	154	103	73	-53%	-30
Transport	162	164	134	-17%	-30
Private Households	129	113	74	-43%	-39
Commercial, trade, services	87	53	43	-50%	-10
Energy-related CO_2 Emissions	948	795	571	-40%	**-224**

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 optimize the utilization and production of energy and expand renewable energies – these should be the pillars for emission reductions. In the following the eight most important measures are presented:

1. Saving electricity: Annual reduction of 40 million tonnes of CO2

Annual carbon dioxide emissions can be cut by 40 million tonnes by reducing electricity consumption by 11%. This can be achieved by using more efficient devices and appliances, reducing standby electricity consumption and banning electric heaters. At the same time, the industry has to use electricity more efficiently (pumps, electric motors, fans, etc.).

This will require effective instruments in order to implement the policy launched. Efficient incentives include, for example, a statutory requirement for efficiency races for electric appliances and devices (using the top-runner principle). At European level the EU provides specifications for energy using products within the scope of the EU Eco-design Directive aiming to reduce the environmental impact of these products.

Furthermore, an energy efficiency fund could be used to finance advisory and consulting programmes and jump-start costs for innovative technologies. The financial resources needed could be provided by eliminating exemptions from energy taxation.

2. Replacement of old power plants: Annual reduction of 30 million tonnes of CO2

Measures to this end are a 7% higher efficiency of new coal-fired power stations and replacement of coal with natural gas.

In the scenario a 30% increase is expected in the share of natural gas in electricity generation (i.e. from 70 terawatt hours today to 165 TWh in 2020). The additional gas consumption 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 CO2 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 of CO2

The target level for renewable energies in the UBA scenario amounts to 140 TWh. Focal issues are the further development of wind energy use (especially offshore) with 85 TWh and the use of biomass for electricity generation with 30 TWh.

The Renewable Energy Sources Act (EEG) is the most successful instrument for promoting renewable energies. The underlying principle - i.e. guaranteed payment for renewable 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 comprise the following sources: coal 32%, natural gas 30%, renewable energies 26%, uranium 6%, and 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 CO2 savings.

4. Doubling cogeneration's share: Annual reduction of 15 million tonnes of CO2

In order to achieve the goal of doubling cogeneration output from 70 TWhel to 140 TWhel 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 priority 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 of CO2

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 instruments 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 CO2 building rehabilitation programme.

6. Heat supply from renewable energies: Annual reduction of 10 million tonnes of CO2

Increasing the share of renewable energies (biomass, solar thermal energy, geothermal energy) in heat generation from today's 6% to 12% would reduce CO2 emissions by households, commerce, trade and the services sector by 6 million and by industry by almost 4 million tonnes of CO2. This is already laid down in legislation as Renewable Heat Sources Act (EEWG).

7. Reducing specific consumption in traffic and the transport sector: Annual reduction of 15 million tonnes of CO2

Technical measures (such as engines with lower fuel consumption, reduced engine power, lightweight construction) and fuel-saving driving behaviour can reduce specific CO2 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, CO2-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 of CO2

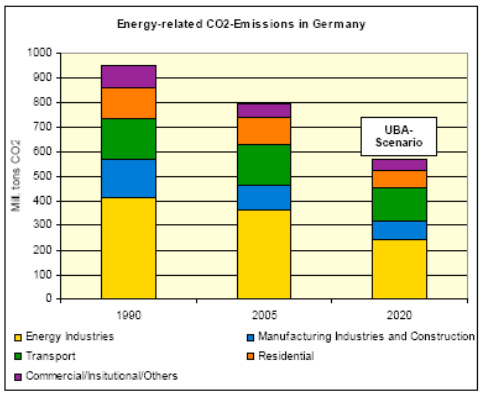
Expanding the rail infrastructure rather than building new roads will contribute towards shifting traffic – in particular, large parts of goods traffic - from roads to rail and to inland waterways. If the share of rail in goods traffic increased from 16.5% in 1999 to 25% in 2020, CO2 emissions would 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, CO2 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 CO2 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 – are 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.

Short discussion of results and costs

As shown in Fig.1, in absolute numbers the largest reduction of energy-related CO2 emissions is achievable in the energy sector itself. Savings in electricity and heat as well as increasing the share of renewable energy supply make the largest contribution. On the other hand, the current trend in the transportation sector shows that emissions in this sector will decline only slightly by 2020. However, additional emission reductions are necessary and feasible as described above.

Fig. 1: Development of energy-related CO2 emissions in Germany in 1990 and 2005 (real values) and for 2020 (after the UBA 40% scenario)



According to our calculations the average costs for emission-reduction measures in the different sectors would amount to € 50 per tonne and a total of € 11 billion by 2020. This would correspond to an additional household expenditure of less than € 10 per month in 2010 and less than € 25 per month in 2020. On the other hand, the costs of climate protection measures contrast not just with the long-term benefits of climate stabilisation and avoidance of climate-related impacts, but also generate short-term benefits for the environment and health. Energy saving, avoidance of unnecessary traffic, and more widespread use of renewable energies generate significant reductions of air pollutants (e.g. SO2, dust, NOx and VOC). This has positive effects not only for health, but also means reduced exposure of ecosystems and less damage on building facades.

Conclusions

The results of the UBA scenario show that a 40% reduction of CO2 emissions in Germany is possible at reasonable costs.

Globally effective climate protection cannot be achieved by emission reduction by any one country alone. However, Germany's potential pioneering role could demonstrate that ambitious emission reductions are feasible, often at justifiable costs. Additionally, in and outside of the European Union further efforts must be made to reduce emissions in a sustainable manner.

In conclusion, Tab. 2 shows the eight measures presented above including their reduction potential, the related instruments and their statutory implementation within the integrated energy and climate programme.

	Measures	Reduction UBA scenario in million tonnes of CO_2	Detailed Measures	Instruments	Statutory obliga-tion
Electricity:					
1	Electricity savings through more efficient consumption: 11%	40	Households: more efficient devices and appliances, reducing standby electricity consumption, abolish electric heaters Higher efficiency in the industry: Cross-section technologies (pumps, electric motors, fans…)	Implementation of the EU Ecodesign Directive and the top-runner approach; Setting efficiency standards and mandatory labelling Implementing energy efficiency funds for counselling and financial support for innovative technologies	EU/IEKP II
2	Changing fuel use towards more natural gas and increasing efficiency of fossil-fuel fired power plants	30	Modernising and replacing coal-fired power plants; expansion of power generation based on natural gas	Reducing and auctioning CO_2 allowances in the emission trading scheme ("optimised allocation") with uniform benchmarks for gas and coal	IEKP I/EU
3	Doubling the share of renewable energies in electricity generation (to 26% of total electricity generation)	44	Expansion of power generation based on renewable energies, foremost wind energy - 85 TWh (repowering and offshore) and biomass - 30 TWh	Amendment of the Renewable Energy Act	IEKP I
Heat:					
4	Doubling cogeneration (from 12 to 25% of total electricity generation)	15	Amendment of the CHP Act, Maintenance of sufficiently high population density	Subsidies and support mechanisms for new and modernised, highly efficient cogeneration plants; retrofit of existing incineration plants	IEKP I
5	Savings of heat in buildings and production processes	41	Improvement of building insulation; exchange and adaptation of inefficient heating systems Replacement of inefficient plants and equipment of production processes	Amendment of Energy Saving Ordinance (EnEV) Implementation of an efficiency fund, amendment of the CO_2 building rehabilitation programme, increasing energy taxation	IEKP I, II
6	Increasing the share of renewable energies in heat generation (from 6 to 12%)	10	New legislation, Implementation of new support programmes	e.g. requiring the use of renewable energies in new buildings	IEKP I
Transportation:					
7	Reducing specific fuel consumption	15	Technical measures (more efficient motors, lightweight design), driver training for more efficient driving	CO_2-dependent motor vehicle tax; extension of HGV toll for trucks; binding consumption limits for new vehicles	IEKP II/EU
8	Avoidance of traffic, shift to public passenger transport, rail and ship	15	Development of infrastructure to support the shift in the modal split to rail and waterways, and to an increased use of public passenger transport (and for short trips replacement by bicycle)	Implementation of an emissions trading system for air traffic, abolishing the exemption of kerosene from the mineral oil tax; abolishing the VAT exemption for international flights; financial support for public passenger transport	IEKP II
	Other measures	13			
	Total reduction of energy-related CO_2 emissions	224			

[For more detailed information see (UBA, 2007).]

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