Footnotes

I Within the framework of the Kyoto Protocol, Germany committed itself internationally to reduce greenhouse gas emissions by 21% compared to 1990 between 2008 and 2012. In addition, the German government published an energy concept in the autumn of 2010, which was updated in June 2011. It stipulates that the proportion of renewable energies in German energy generation should increase, while nuclear energy is abandoned. Furthermore, there are more detailed targets for the reduction of energy consumption in various sectors. More concrete reduction targets for GHG emissions were set compared to 1990 levels: 40 % by 2020, 55 % by 2030, 70 % by 2040 and 80 - 95 % by 2050.

II Land use, change of land use and forestry

III We calculated a reduction of 51 %. Please note that for 2050, international marine transport and aviation were included in the calculations, which is not done in current calculations.

IV According to recommendations by the German Nutrition Society (DGE)

Imprint

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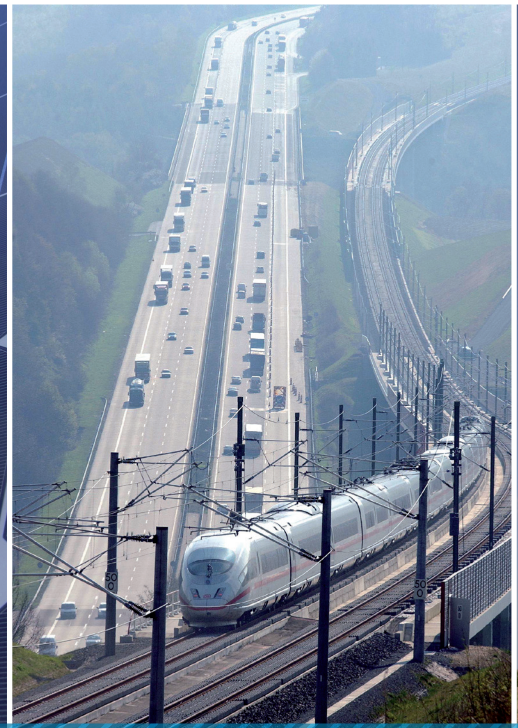


BACKGROUND PAPER // OKTOBER 2013

A greenhouse gas-neutral Germany in 2050

Abstract

For our Environment

Umwelt Bundesamt

In order to prevent serious disruption to the climate system and its uncontrollable consequences, industrial countries must reduce their emissions by approximately 80–95% compared to 1990[I]. *Our study shows that a virtually greenhouse gas-neutral Germany with annual per capita emissions of around one tonne of* CO_{2eq} *by 2050 is technically achievable (reduction of approximately 95 % compared to 1990).*

In our scenario analysis, we assume that Germany in 2050 is still an exporting industrial nation with an average annual growth rate of 0.7 % of GDP and a population of 72 million, whose consumption and behaviour patterns are similar to today's.

Our study looks at all greenhouse gas (GHG) emission sources in Germany, including the following sectors: energy (including transport), agriculture, industrial processes and LULUCF[II]. For sustainability reasons, it is based on the following premises:

- No use of fossil or nuclear energy carriers
- No cultivation of biomass crops for energy purposes
- No CCS (Carbon Capture and Storage)

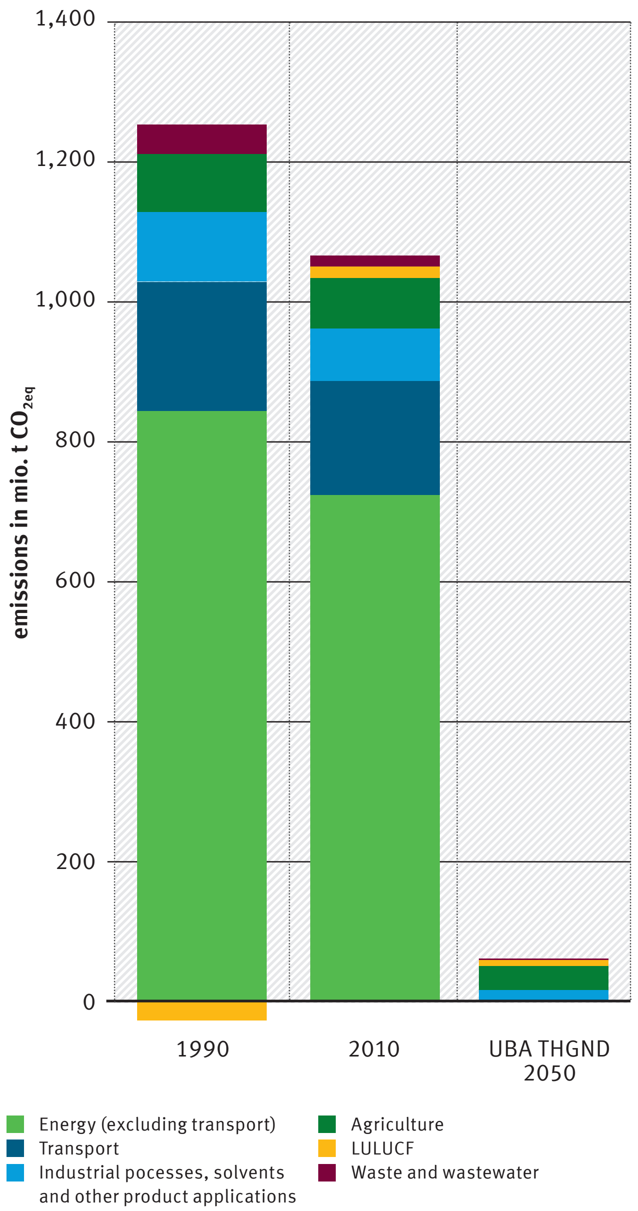
The study is not a prediction of future developments and does not outline transformation pathways, but describes one of many possibilities of achieving a GHG-neutral Germany. Essential steps towards GHG-neutrality in Germany are closely entwined with developments within the EU and depend on a European policy that, at the very least, sets ambitious GHG reduction targets for the entire union and supports national policies to achieve GHG-neutrality.

As shown in Figure 1, the sectors agriculture and industrial processes will still cause unavoidable residual emissions. It is therefore necessary to reduce emissions from the energy sector (power, heat and transport) to zero by switching to renewables and making extensive use of potential efficiency gains.

A major precondition for GHG-neutrality in Germany is the reduction of final energy consumption. We demonstrate that by 2050, final energy consumption in households, traffic, industry and in trade, commerce, services can be halved[III] compared to 2010.

At the heart of a completely renewable energy supply is the generation of hydrogen through the electrolysis

Figure 1:
Greenhouse gas emissions[1,2]



1 1990 and 2010 according to NIR.
2 Transport excluding the international share of marine transport and aviation.

Source: Umweltbundesamt

of water, using renewable power. Through further catalytic processes, hydrogen can be converted (by power to gas, PtG, or power to liquid, PtL) into methane and other hydrocarbons, which, in turn, provide renewably produced fuel for freight transport on our roads, aviation and marine transport.

Furthermore, heat for buildings and industrial processes can be supplied by renewable power or renewably generated methane. In the chemical industry, petroleum-based raw material can be replaced by renewably produced hydrocarbons. This would avoid emissions from industry, except for process-related emissions mainly from the cement and lime industries.

However, the technologies described above – power to gas and even more so power to liquid – still require considerable further development before they can be widely introduced to the market. In addition, they are associated with major conversion losses, as Figure 2 shows. They also require sufficient climate-neutral sources of carbon.

In our study, we assume that Germany can supply its own power, for which the necessary potential exists. However, we also assume that most of the power required for PtG and PtL in Germany will be generated in other countries where this can be done more economically. PtG and PtL technology could also be produced where the power is generated and the resulting fuel could be imported.

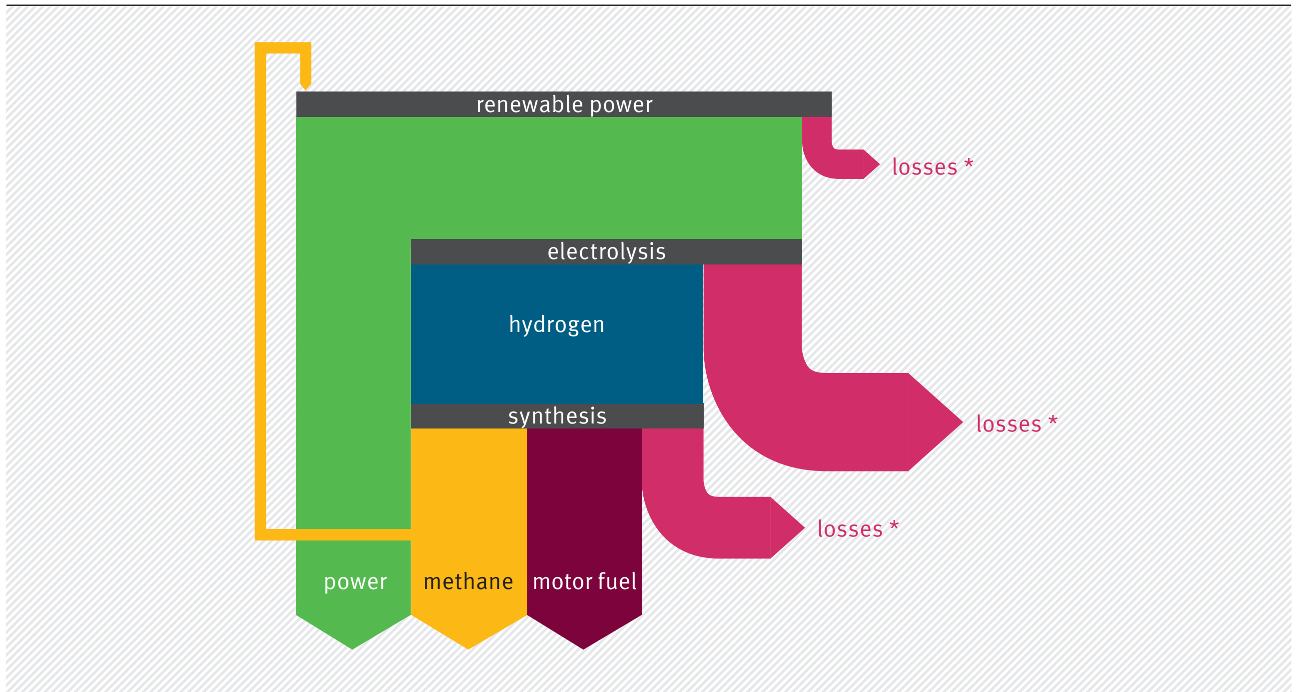
Emissions from agriculture could be more than halved. This cannot be achieved by technology alone, but livestock populations, especially ruminants, must also be reduced. We therefore assumed that meat consumption in Germany will have dropped to levels recommended for healthy eating[IV]. Nevertheless, with 35 million tonnes of CO_2, agriculture will remain the greatest contributor to GHG emissions in 2050.

Emissions from the LULUCF sector can be further reduced, mainly by returning agriculturally used wetlands to their natural state.

Emissions from the waste and wastewater sector have already dropped considerably and can be further reduced, largely by technical measures.

There are areas that have not been comprehensively dealt with and require further investigation. These include economic cost-benefit analysis, interrelations with resource productivity, possible relocation of emissions outside Germany (carbon leakage), emission reduction through behavioural changes, policy measures and instruments that are required to implement GHG neutrality in Germany.

Figure 2:
Qualitative representation of the energy flow in the UBA THGND 2050 Scenario,[1,2] own graphics.



1 Including demand for renewable inputs in the chemical industry.
2 Energy flows are shown in proportion to energies required.
* Including line losses, losses from reconverting methane into power and losses from converting biomass into power

Source: Umweltbundesamt