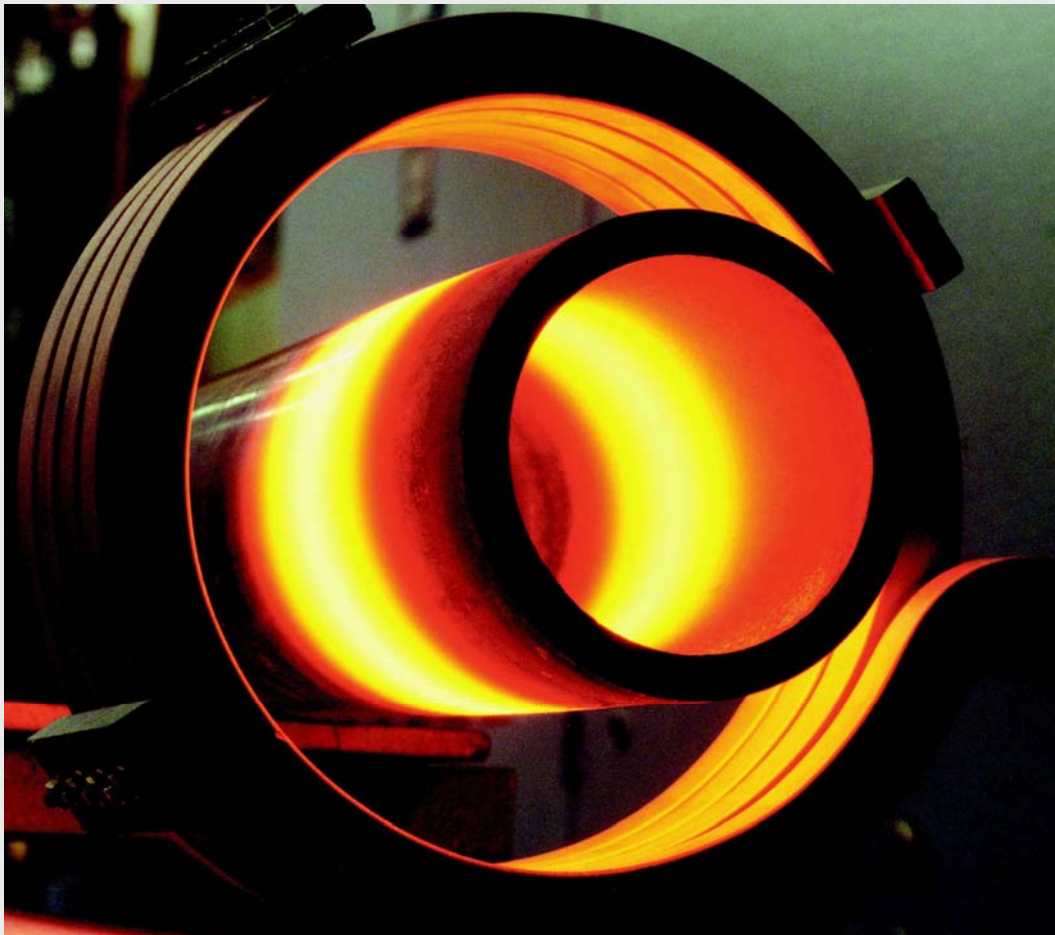

Steel's CO₂ Balance

A Contribution to Climate Protection



The present study was prepared independently by The Boston Consulting Group on behalf of the German Steel Federation (*Wirtschaftsvereinigung Stahl*).

Special thanks to the efforts of the participants from the member companies of the German Steel Federation, as well as the numerous experts for their constructive contributions and support in the validation of the analyses.

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Executive summary

The objective of the present study is to analyze the impact of the steel industry on the CO₂ emissions in Germany from an overall perspective by means of an extensive CO₂ balance, in which selected case studies in the sectors energy generation, traffic, households, and small consumers are examined, for which innovations in the material steel and the use of steel in innovative, climate-friendly applications can have a CO₂-reducing effect. For the year 2020, a total annual reduction potential of approx. 74 million tonnes of CO₂ results from the examined examples of steel applications alone.

Compared with the total emissions of the steel industry in the year 2007 of approx. 67 million tonnes, the result is a positive CO₂ balance.

Introduction

Since the 1992 UN Framework Convention on Climate Change, climate protection has been given increasing importance around the world. Especially Germany and the EU have increased their efforts in this area in the past years and have taken an international leadership role in many topics. The focus was and is particularly on energy-intensive industries as the main emitters of CO₂. The goal of limiting and reducing industrial greenhouse gas emissions has led to numerous regulation initiatives, such as, notably, the European CO₂ emissions trading introduced in 2005. However, in light of the great importance of fossil fuels for the production processes of energy-intensive industries, unilateral or asymmetric regulations in the EU and Germany give rise to the question of the international competitiveness towards regions outside Europe that have no similar regulations for the industry operating there, up to and including the threat of production and emission shifts ("carbon leakage").

For the selected case studies, an average ratio of savings compared with the emissions during production of the required steel of six to one is determined. The largest levers are found in an efficiency increase in fossil fuel power plants and an expansion of renewable energy sources, but also in the reduction of emissions in traffic through lighter vehicles. Approximately one-third of the federal government's climate target (a 40% reduction of greenhouse gas emissions by 2020 compared with 1990) can be achieved with steel alone. A strong steel industry is therefore—also from a climate-policy perspective—an important link in the value chain to provide the required material innovation and conduct the necessary research and development.

This applies also to the steel industry, which—as a result of its high process-related emissions from the reduction of iron ore to pig iron and the processing thereof to steel—is responsible for a significant share of the industrial CO₂ emissions in Germany. However, a focus on the emissions in connection with the production processes is too short-sighted. A holistic examination must include not only the emissions caused, but also the contribution that an industry and its products—and especially product innovations—make to the required emissions savings in other sectors. Only on this basis can it be assessed, also from a climate-policy perspective, how important a competitive and strong steel industry is for Germany and the EU. Against this background, the present study calculates a CO₂ balance for steel, in which the CO₂ reductions enabled through steel applications are compared against the CO₂ emissions caused by the production of these steel applications.

I. Initial situation worldwide and in Germany

In the context of this purpose, it is helpful to first take a look at the initial situation of CO₂ emissions worldwide and in Germany: Since the beginning of industrialization, the CO₂ concentration in the atmosphere has increased by 35%.¹ Between 1990 and 2007, the global CO₂ emissions increased by 38%.² Asia in particular played a major role in this development. In China, CO₂ emissions nearly tripled between 1990 and 2007, giving it the highest growth rate worldwide. In a per-capita analysis of CO₂ emissions, the United States remains at the head of the list among the major developed countries, with approx. 22 tonnes of CO₂ per capita in 2007.³

At the 1997 UN Framework Convention on Climate Change in Kyoto, the Kyoto Protocol was agreed, which came into force in 2005 and in which the EU, amongst others, committed to reducing greenhouse gas emissions by 8% by 2012 compared with 1990 levels. Although the December 2009 UN Framework Convention on Climate Change in Copenhagen did not specify mandatory targets, a further increase in the global effort to reduce greenhouse gas emissions can be expected.

Germany, one of the world's leading developed countries with an approx. 6% share of the global economic performance⁴, causes 2.3% of the global CO₂ emissions. Between 1990 and 2007, Germany reduced its CO₂ emissions by approx. 19%, from 1,036 million tonnes (Mt) to 841 Mt, thereby taking an international leadership role in climate policy (see exhibit 1). The various efforts

of individual economic branches have demonstrably yielded results: for example, the automotive industry was able to reduce the average fuel consumption of new passenger cars by 18% since 1990⁵, and since 1990, the energy consumption for space heating declined by 33%. The CO₂ output per kilowatt hour (specific CO₂ emission of the electricity generation mix) was reduced by almost 20% between 1990 and 2006.⁶ In addition to the efforts of the industry itself, subsidy programs of the federal government also contributed to the positive developments. If one examines the CO₂ emissions in Germany—which in 2007 amounted to approx. 840 Mt of CO₂—by the sectors causing them, the following picture emerges:

¹ IPCC (2007)

² BMU (2009), BMWi (2008)

³ BMU (2009), BMWi (2008), US Census Bureau (2009)

⁴ UNCTAD (2008)

⁵ BMU (2009), BMWi (2008), VDA (2009), KBA (2009)

⁶ BMU (2009), BMWi (2008)

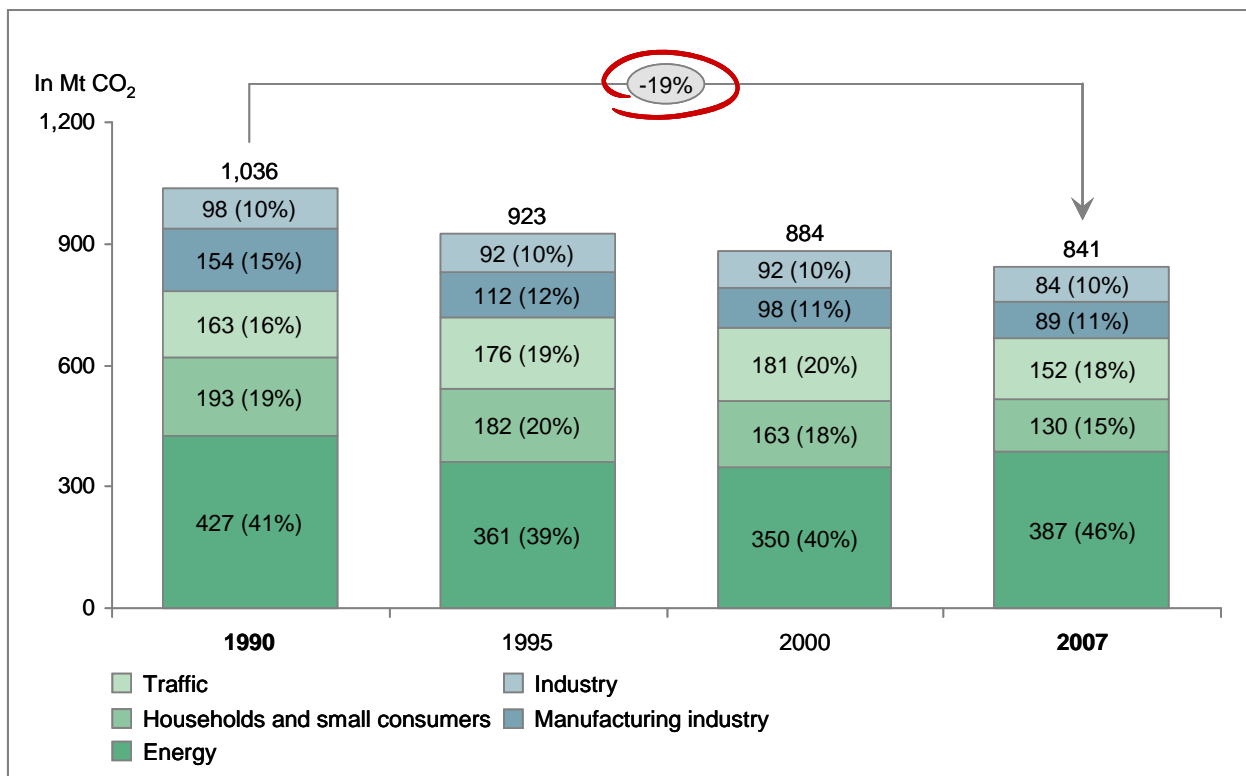


Exhibit 1: Development of CO₂ emissions in Germany by sector (1990–2007)

The energy industry is responsible for almost half of all emissions. The CO₂ shares of the traffic (20%) and industrial sector (10%) have remained more or less stable since 1995. The CO₂ emissions caused by the household and commercial sector, on the other hand, are declining strongly and in 2007 amounted to only 15%.

In 2007, the federal government met at Meseberg palace and decided on the "Integrated Energy and Climate Program" (IEKP). The central point of this program is the goal of achieving a 40% reduction in CO₂ emissions by 2020, compared with 1990 levels. In absolute figures, this would correspond to a reduction by approx. 400 million tonnes to approx. 620 million tonnes of CO₂. Until 2050, the Meseberg Program even aims for a CO₂ reduction of 80% compared with 1990 levels. To achieve this ambitious goal, the federal government

formulated a number of targets and measures. These include an increased use of gas-fired power plants, an overhaul of existing power plants to increase efficiency by 7%, the expansion of renewable energy sources to approx. 25% of electricity generation, a doubling of the share of combined heat and power (CHP), an increase in energy efficiency in electricity consumption, and emissions reduction in private and freight traffic.⁷

How can the material steel contribute to the achievement of these ambitious targets of the German energy and climate program? Or rather: Can they be achieved at all without steel? To answer this question in an objective and fact-based manner, the study presents a CO₂ balance in which the CO₂ reductions enabled through

⁷ BMU (2008), et al.

steel applications are balanced against the CO₂ emissions arising from the production of these steel applications.

Excursus 1: Historical development of CO₂ emissions in steel production

CO₂ emissions in steel production—in Germany, approx. 67 million tonnes in 2007—arise primarily in the production of pig iron and crude steel. Approx. 65% to 70% of the total emissions per tonne of produced steel arise at this level. In the period from 1960 to 2008, the German steel industry continuously reduced the energy expenditure per tonne of produced crude steel by over 40%. Milestones in the achievement of this result were an improvement of energy efficiency in the production process, a better utilization of the by-products of steel production, a reduction of output losses, and an improved recycling of products containing steel.

Between 1990 and 2007, the German steel industry was able to reduce its CO₂ emissions per produced tonne of finished steel products by 23%. This was made possible primarily through measures for increasing energy efficiency and reducing the consumption of reducing agents, e.g., an improved quality of coke. The examinations of the specific CO₂ emissions of the German steel industry were made on the basis of the distribution ratio of 68% via blast furnaces and 32% via electric furnaces prevalent in Germany (2008).

II. Purpose of the study

As emphasized earlier, the present study intends to convey a holistic perspective on the climate policy impact and contribution of the steel industry and its products. For this purpose, a CO₂ balance will be presented, in which the CO₂ reductions made possible through innovative steel applications on the one hand, and the production of these steel applications—or rather, the CO₂ emissions caused by the steel production industry as a whole—on the other, are balanced against each other, whereby the focus of the study is on Germany. Only steel applications that have an impact on CO₂ emissions arising in

Germany will be taken into account. The study examines only CO₂ emissions and no other greenhouse gases.

The calculations and analyses of the study use the actual values of 2007 as reference figures, while the possible reduction potential is always calculated with regard to the year 2020. The final result of the examinations is the CO₂ balance of the steel industry.

In this way, the steel industry's contribution to the achievement of the political climate targets can be assessed.

III. Methodology of the study

The methodology of this study—regarding both the underlying original data and the imputed forecasts—is based on external data of renowned research institutions and selected case studies. As regards the current CO₂ figures for Germany, the year 2007 was chosen as reference year, for which the data of independent research institutions serves as a basis. The study thus examines the period from 2007 to 2020 and concentrates exclusively on the development in Germany. A transfer of the analysis to the European Union would, however, be possible. The general projections for the development of CO₂ emissions as a whole until 2020, on which this study is based, originate from scenarios modeled in scientific examinations.⁸

The study is based on two important fundamental principles: On the one hand, the focus of the determination of CO₂ savings potential is on innovation, i.e. either the use of newly developed

steels for efficiency improvements in existing applications is examined (e.g., efficiency increases in fossil fuel power plants) or the use of steel in innovative applications (e.g., wind power), or both. The steel innovations required for this already exist in Germany today or are at least in development, and will therefore be available before 2020. The field of material substitution, however, is consciously excluded.

On the other hand, a highly conservative approach is applied, e.g., through the filtering logic explained below, the comprehensive inclusion of the emissions from production, including the extraction of raw materials, while the climate contributions from exported steel applications are excluded. The selected approach has the advantage that the determined CO₂ savings potential from steel applications may be regarded as highly reliable.

⁸ Energy scenarios based on studies of EWI Cologne (2005) and studies on behalf of the German Federal Environmental Agency

On this basis of current and future CO₂ emissions, the study concentrates on quantifying the CO₂ reduction contributions of the steel applications. The study thus does not formulate a comprehensive assessment of the development of CO₂ emissions as a whole or the overall degrees of reduction in the steel industry. Instead, the influence of innovative steel applications on the future development of CO₂ emissions is estimated on the basis of eight selected case studies and projected without overlap for the determination of the total effect.

In the selected case studies, a differentiation can be made between applications whose realization is possible only with the use of steel on the one hand, and applications in which other materials play an important role on the other. Furthermore, a differentiation can be made between the perspective "optimization of existing products" and "use of new applications" (see exhibit 2).

	Application only possible with steel	Alternative materials also possible
Optimization of existing applications	Efficiency increase through improved steel properties	Optimization effects potentially also achievable with other materials
New applications	Use of steel under conditions that allow no other materials	Replacement of previous materials in new steel application areas

Exhibit 2: Segmentation of the case studies by impact of steel on CO₂ reduction

Exhibit 3 illustrates the approach by the example of the CO₂ emissions arising in passenger car traffic: The delta at the center of the examination results from the comparison of the emissions development under assumption of the use of the

examined steel application against the emissions development since the reference year 2007 without the consideration of these steel applications.

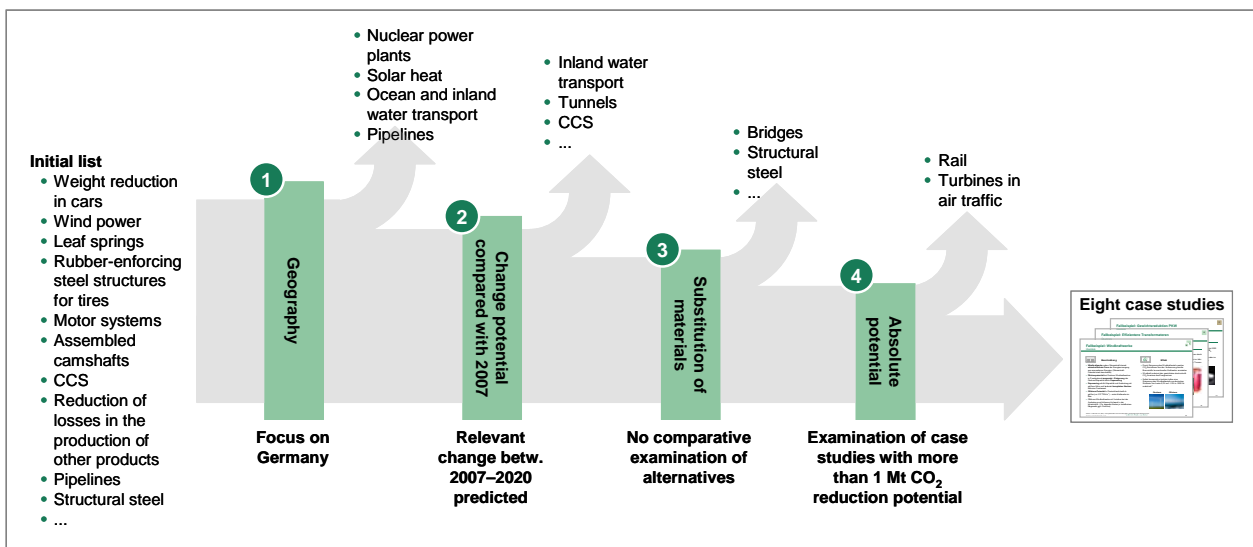


Exhibit 4: Four-step filtering logic leads to a short-list of eight case studies

One effect of the filtering logic is that—in order to ensure an unambiguous crediting to steel—a wide range of steel applications with substantial CO₂ reduction potential is not taken into account in this study. The geographical filter, for example, results in the exclusion of pipelines for gas transport or the export of German cars and the reduction of CO₂ emissions resulting from these. The filter that specifies the need for substantial reduction potential results in the exclusion of the shipping segment or the technology of carbon capture and storage (CCS), as shipping has already realized its potential, and CCS is not expected to yield significant potential before 2020. Material substitution is left completely unconsidered on principle, in order to ensure that the focus remains on innovations in the steel industry alone. The material substitution filter, for example, excludes the avoidance of emissions in other industries, e.g., the reduced use of cement as a result of improved structural steel. Finally, the filter that calls for an absolute reduction potential of at least one million tonnes of CO₂ leads to the exclusion of, e.g., turbines in air traffic, trains, or rolling resistance in tires. If all possible steel ap-

plications were to be fully included in the examination, the expected CO₂ reduction effects would be quantified much higher than in the present study. To assess the eight case studies selected on the basis of the four-step filtering logic, the selected steel applications are examined in their life cycle. The initial CO₂ emissions will therefore be apportioned to the entire life cycle of the steel applications.

The CO₂ balance calculation is made by comparing the CO₂ reduction potential from steel applications with the CO₂ emissions arising from the production and provision of these applications. First, the gross CO₂ reduction potential from the steel applications is calculated, in which the contributions of other materials are also included. In the next step, the contribution of steel to the realization of this gross CO₂ reduction potential is taken into account, so that the respective reduction potential that can be credited to the contribution of steel can be better determined. The resulting net CO₂ reduction potential is then compared with the CO₂ emissions caused by the application and production of steel. The result is the CO₂ balance of the steel industry. (see exhibit 5).

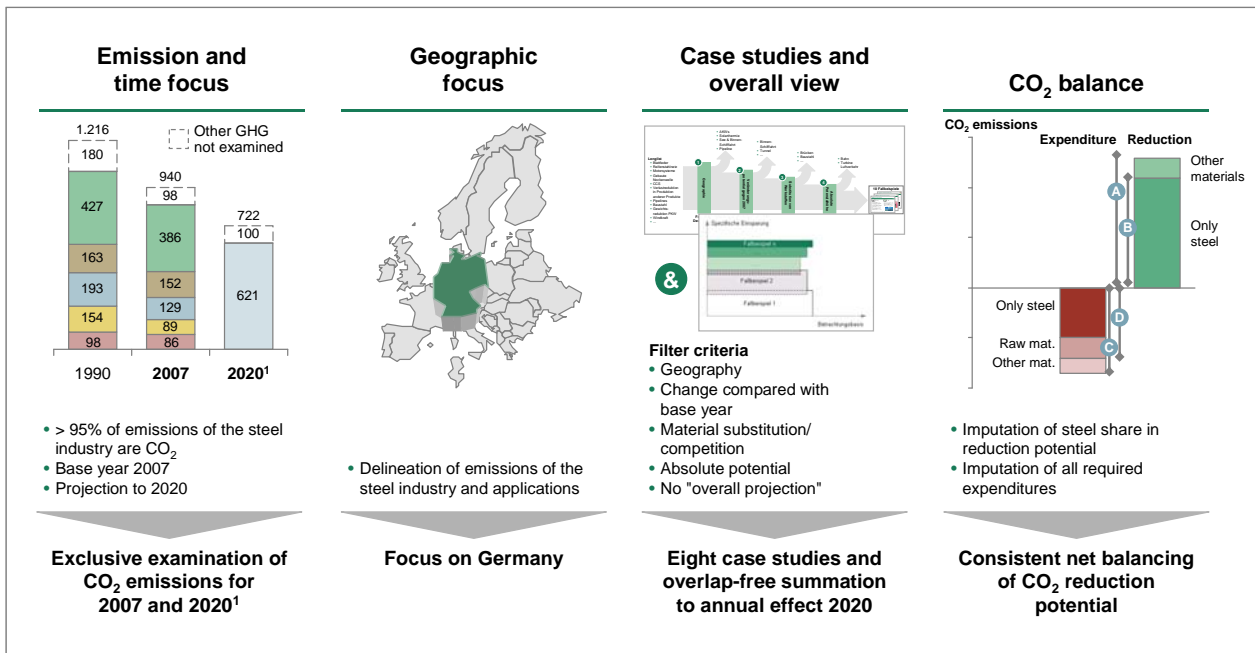


Exhibit 5: Overview of the focus and methodology of the study

Excursus 2: Steel-induced CO₂ emissions along the production process

The CO₂ emissions in the steel industry can be segmented into three examination areas. In scope I, the CO₂ emissions arising directly in steel production are taken into account. In scope II, the CO₂ emissions connected with the externally purchased electricity used in steel production are examined. In scope III, mainly the CO₂ emissions connected with the extraction of raw materials (primarily iron ore and metallurgical coal) are taken into account.

There are two basic methods of steel production: basic oxygen furnace (BOF) for the primary production of crude steel, and electric arc furnace (EAF) for the production of steel from scrap. The CO₂ emissions of the two methods vary at all steps of the steel production process—from the extraction of raw materials to coking, steel production, hot-rolling, cold-rolling, and hardening and tempering, to the final product. For the purposes of this study, the distribution determined for Germany—68% for BOF and 32% for EAF—is used as a basis.

IV. The CO₂ balance of the steel industry

On the basis of the outlined purpose of the study and the described methodology, the following result emerges for the eight examined case studies (see exhibit 6): The gross CO₂ reduction potential connected with innovative steel applications is calculated at 87 million tonnes per year. A consideration of the specific steel contributions of the individual case studies results in a net effect of approx. 74 million tonnes of CO₂ per year.

The five greatest reduction opportunities lie in the overhaul of fossil fuel power plants (29.5 Mt), a further expansion of wind power (14.2 Mt), a weight reduction in passenger cars (11.2 Mt), an expansion of CHP (9.2 Mt), and further renewable energy sources (5 Mt).

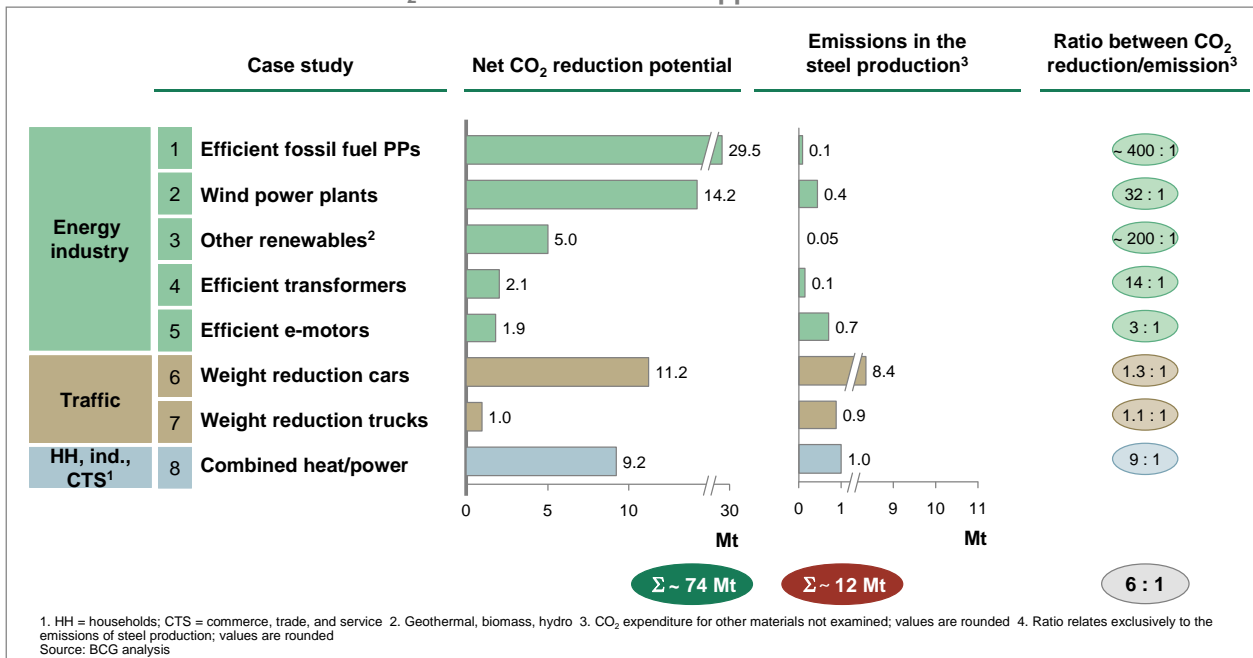
If, by way of illustration, one compares the annual net reduction potential of 74 million tonnes of CO₂ from the eight selected case studies with the total annual CO₂ emissions of 67 million tonnes caused by the steel production in Germany, the result would in mathematical terms be a positive CO₂ balance from these examples alone. The emissions caused by steel production in Germany are more than compensated by the examined case studies.

With a less conservative filtering logic, e.g., without the focus on Germany or on the period 2007–2020, the result would be even more positive. In

this case, the total reduction can be estimated at two- or five-fold the sum of the analyzed case studies.

If one considers that the over 4 million exported German vehicles will at their destinations have at least a similar CO₂ reduction effect of approx. 10 million tonnes as in Germany, that exported power plant technology will reduce the specific CO₂ emissions of fossil fuel power plants across the whole world, that the inland waterway transport in Germany contributes another approx. 20% of the road freight transport volume (approx. 40 million tonnes of CO₂ emissions arise from freight transport), one can imagine the extent of the CO₂ potential not examined.

Relating to the selected case studies with their approx. 12 million tonnes of CO₂ emissions from steel production and a reduction potential of approx. 74 million tonnes, the material steel can potentially achieve a CO₂ reduction for these applications that is about six times as high as the emissions caused by the steel production for these applications. The most effective success lever is in the area of fossil fuel power plants; here, the addressed ratio is as high as 400 to 1. For renewable energy sources, the corresponding ratio is 200 to 1; for wind power plants, it is 32 to 1; for more efficient transformers, 14 to 1; and for CHP, 9 to 1.

Exhibit 6: Results overview: CO₂ reductions from steel applications

V. Conclusion: The political climate targets in Germany cannot be achieved without innovative steel applications

The CO₂ reduction potentials of the examined case studies alone result in a positive CO₂ balance for steel. The use of innovative steel products can therefore balance the associated CO₂ emissions for the provision of the applications through increased efficiency in energy generation, reduced consumption, and emissions avoidance, and even achieve a multiple positive effect in the selected examples. A further important result of the study is that the ambitious climate targets of the federal government cannot be achieved without the steel industry (see **exhibit 7**). By 2020, the federal government aims to reduce CO₂ emissions by 40% compared with the reference year 1990. This means a reduction from approx. 840 million tonnes of CO₂ in 2007 to approx. 620 million tonnes in 2020. With a gross CO₂ reduction potential of approx. 87 million tonnes, the examined steel applications contribute approx. 40% to the planned 220 million tonne

reduction. Approx. 80% of the reduction potential in the case studies examined in this study can only be achieved with the application of steel. The reduction potential that can be credited to the material steel alone, at 74 million tonnes, accounts for one-third of the federal government's reduction target. This contribution cannot be replaced with alternative materials, as—from a technical and economic perspective—there is virtually no alternative to steel in important applications, e.g., in power plants and wind parks. Due to its various applications, the material steel has a crucial importance for many segments of technical infrastructure, such as buildings, transport routes, or supply. According to the logic developed in this study, a strong steel industry is also an important link in the value chain, in order to provide material innovations important from a climate policy perspective, and to conduct the required research and development.

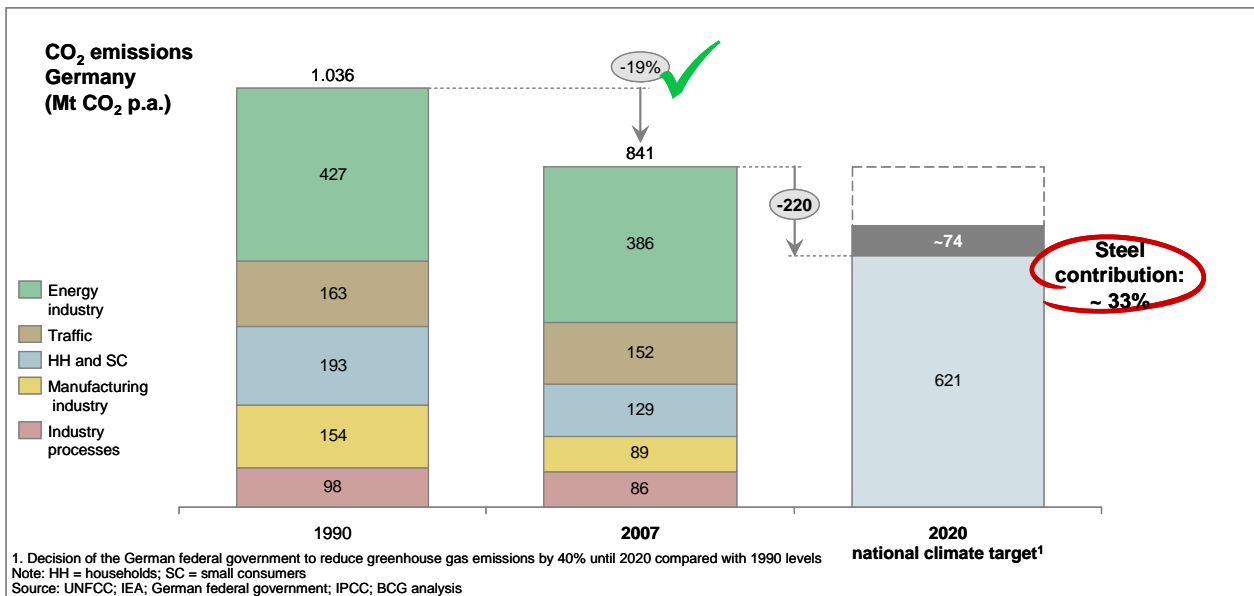


Exhibit 7: Contribution of steel to the federal government's political CO₂ reduction plans accounts for up to 33%.

Appendix: Steel applications for CO₂ reduction: Six case studies

In the following, the calculations and results for the main examined case studies will be explained in detail.

Example: Increased efficiency of fossil fuel power plants

The efficiency improvement in steam power plants in recent years was achieved through a consistent optimization of the entire process. The most important individual measures were the increased steam temperatures and steam pressures, the reduction of internal losses in the steam turbine and in own consumption, and the improved recooling and degree of effectiveness in steam generators. The increase in steam conditions will require the development and use of new, specially developed, high temperature-resistant steel types to withstand the extremely high pressure and temperature strains in boilers and steam pipes. While power plants from the 1960s, with efficiencies of just over 30%, are currently still in use, efficiencies of 51% for bituminous coal and 47% for lignite (without CHP) should be possible by 2020.⁹ In combined-cycle plants, approx. two-thirds of the electricity is generated through the gas turbine, and one-third through the steam turbine. With an appropriate research and development effort, efficiencies of 63% should be achievable in combined-cycle plants by 2020. The first combined-cycle plants, which were installed in 1980, had efficiencies of approx. 50%. The world's largest and most efficient gas turbine, with a performance of 340 MW, is currently in testing in Irsching. It weighs 400 tonnes and is 95% steel. Modern bituminous coal, lignite, and combined-cycle plants have a

steel share of 80% to 90% in the most important part, the structural and electrical engineering.¹⁰

The calculation of the CO₂ reduction potentials through more efficient fossil fuel power plants is based on the following premises: In 2007, electricity was generated with average specific emissions of 1.16 t CO₂/MWh in lignite power plants, 0.87 t CO₂/MWh in bituminous coal power plants, and 0.37 t CO₂/MWh in natural gas power plants.¹¹

For 2020, a reduction of specific emissions to 0.95 t CO₂/MWh in lignite power plants, 0.74 t CO₂/MWh in bituminous coal power plants, and 0.30–0.37 t CO₂/MWh in natural gas power plants is predicted. Should these improvements fail to be realized, the emissions of the electricity production volume forecast for 2020 at the expected electricity mix would be higher by about 37 Mt CO₂/year. For 2020, forecast values of the electricity generation mix were used in order to separate the effect of the efficiency improvement and to exclude the mix effect from the examination. An increasing importance of gas would lead to an additional reduction of emissions, which could be enabled only through steel pipelines.

⁹ EWI (2005), Siemens (2009), et al.

¹⁰ EWI (2005), Platts (2009), et al.

¹¹ EWI (2005)

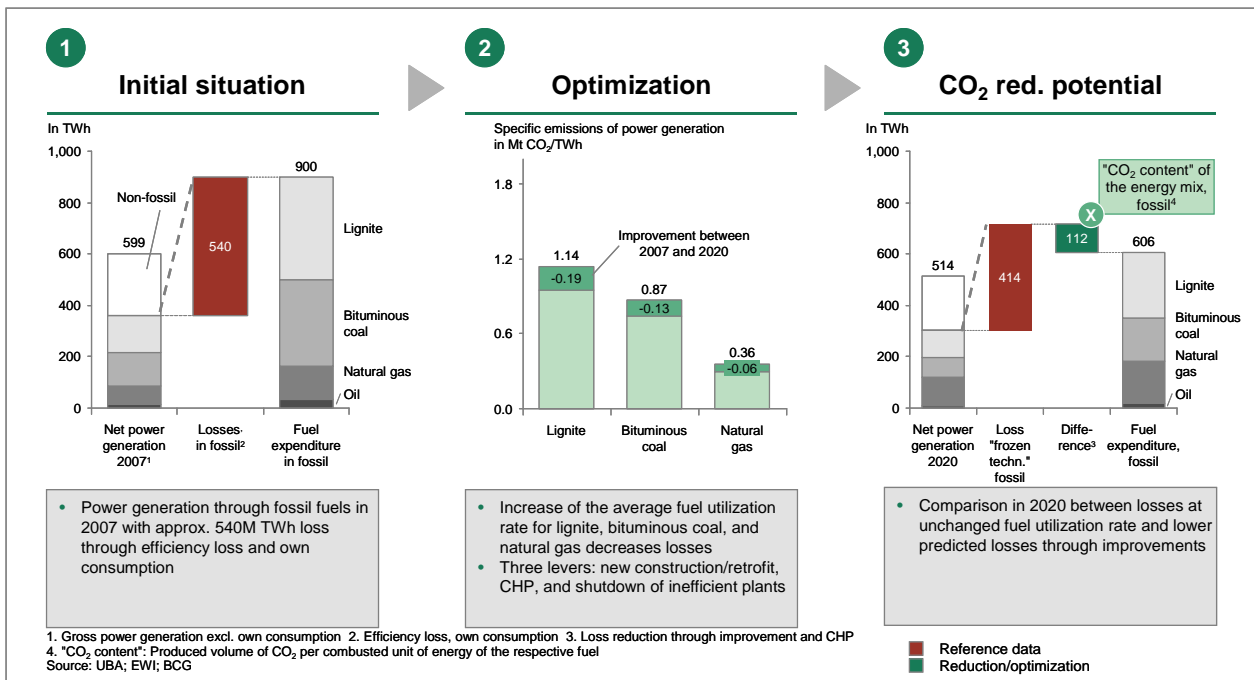


Exhibit 8: CO₂ reduction in fossil fuel power plants through efficiency improvements

In the mathematical model, a new construction of 13 GW gas power plants, 6.5 GW bituminous coal power plants, and 4.6 GW lignite power plants was assumed. The material expenditure for the installation of the power plants and the corresponding CO₂ emissions for material generation and product provision were quantified and apportioned to a typical 35-year life cycle of fossil fuel power plants. The resulting CO₂ emissions reduction through steel innovations and components until 2020 is 37 Mt CO₂. For the efficiency increase in fossil fuel power plants, this means a ratio of 400 to 1 between emissions in 2020 and the apportioned expenditure for steel alone.

The specific CO₂ emissions of a power plant result from the carbon content of the fuel and the electrical efficiency of the power plant. The higher the average electrical efficiency, the less fossil fuel is required to generate the electricity.

The average efficiency in turn is calculated by the respective efficiency of the existing power plants. In recent years, the efficiency of new power plants has increased continuously and will further improve in the future. A greater share of new power plants will therefore lead to a reduction of the average specific emissions. Between 2007 and 2020, 26 GW of capacity in fossil fuel power plants will be shut down after expiry of their planned life cycle. The intended withdrawal from nuclear energy in Germany will also lead to a capacity reduction. If existing power plants are replaced with new ones after expiry of their life cycle, this will lead to a jump in efficiency of approx. 11–12% in fossil fuel power plants and approx. 10% in gas and steam power plants. A further expansion in CHP units will lead to additional emissions reductions (for details, see the CHP description).

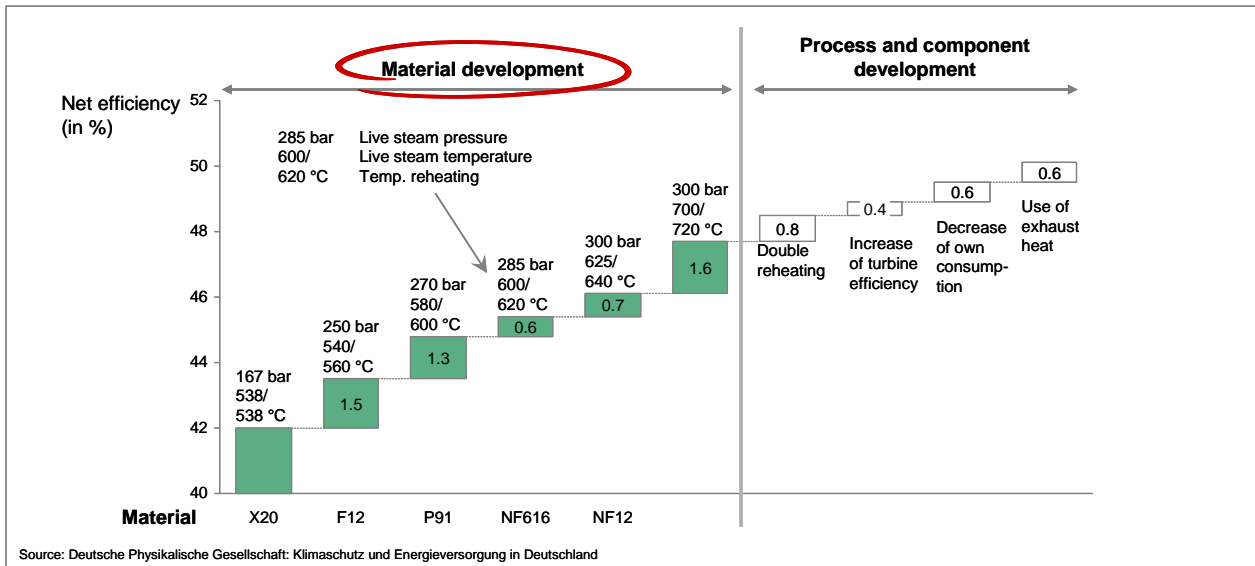


Exhibit 9: Materials development with a positive impact on efficiency improvement

In case of a stronger expansion of fossil fuel power plants until 2020, the absolute emissions in the power generation industry would most likely decline less strongly. However, the contribution of new fossil fuel power plants and, ac-

ordingly, of steel would be significantly higher, as fossil fuel power plants would achieve a much stronger reduction due to the higher specific emissions compared with natural gas.

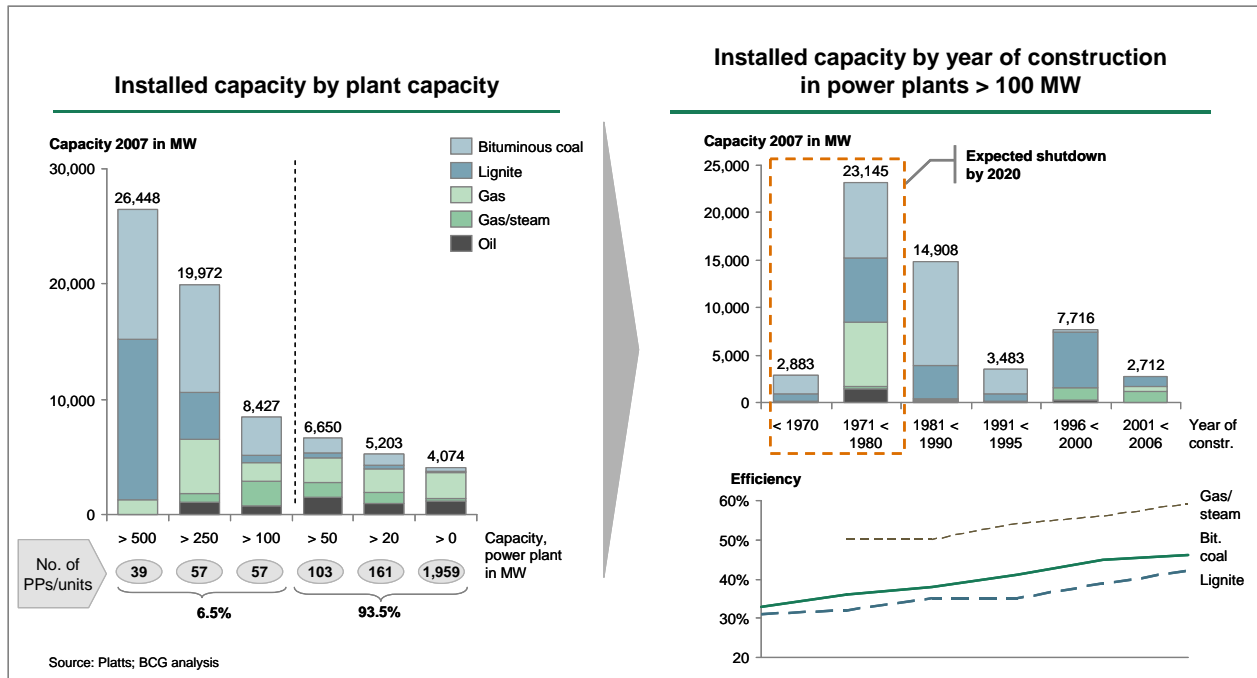


Exhibit 10: Improved efficiency in fossil fuel power plants

Example: Expansion of wind power

The calculation of CO₂ reduction potentials from wind power plants is based on the following premises: Since the beginning of the 1990s, the share of wind power in the German energy mix has increased to a feed-in of approx. 40 TWh in 2007. This corresponds to almost 7% of the net power production. According to political targets, a feed-in of 76 TWh—translating to an approx. 15% wind power share—by 2020 is assumed. For 2020, the climate targets specify a 25% share of renewable energy sources in total power generation.

In the calculation, the emissions of the forecast energy mix in 2020 were first taken into account. Then, it was assumed that, with a stable feed-in as of 2007 of power generated from renewable energy sources, the "missing" power volume would have to be "compensated" by the remain-

ing energy mix. In this case, the absolute emissions of power generation would be substantially higher, resulting in a wind power potential of approx. 16 million tonnes per year to reduce CO₂ emissions by 2020.¹²

¹² EWI (2005), BMU (2008), DENA (2005), et al.

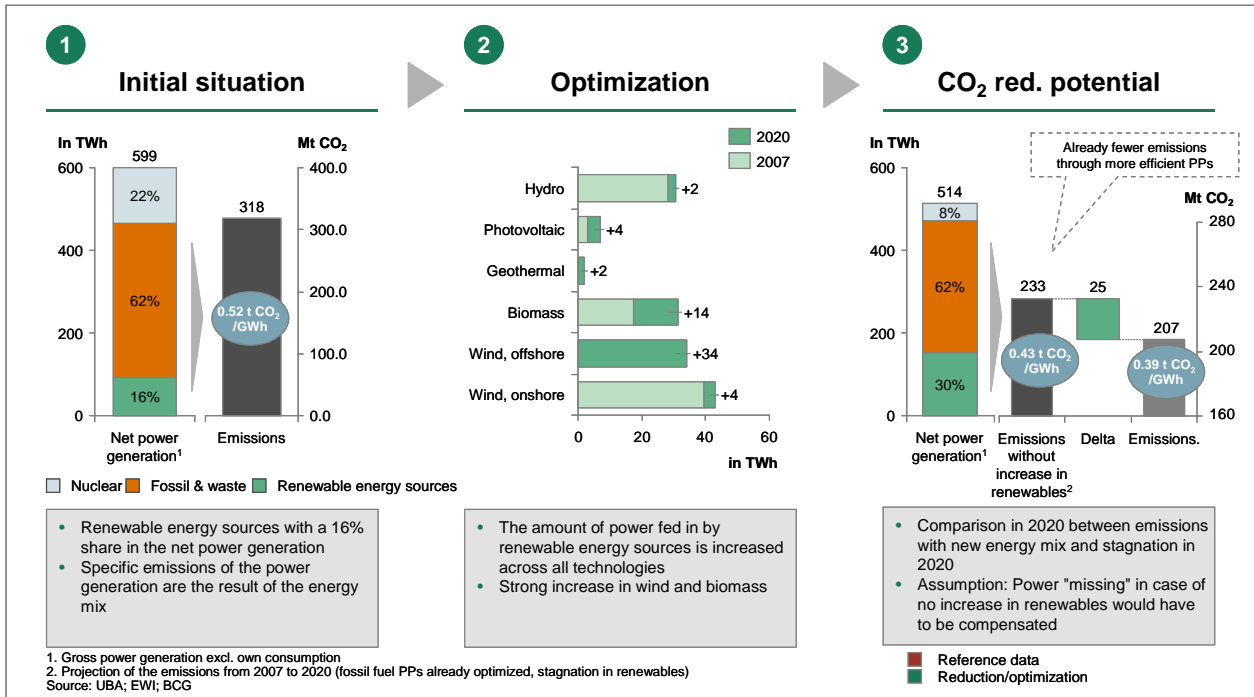


Exhibit 11: Reduction of CO₂ emissions in power generation through renewable energy sources

So, wind power plants are replacing conventional power plants, leading to a reduction of CO₂ emissions from the combustion of fossil fuels and a reduction of the specific CO₂ emission of the German energy mix. For the planned expansion of wind power, an additional construction of 1.8 GW onshore wind power and 10 GW offshore wind power is assumed¹³. The steel production for the provision of the wind power plants would cause emissions in the amount of approx. 9 million tonnes of CO₂. This amount was apportioned to a 20-year life cycle. The resulting ratio for wind power plants between CO₂ reduction in 2020 and the apportioned CO₂ emissions for steel alone is 32 to 1.

Due to the previous development in the area of wind power plants, the onshore area potential has been nearly exhausted. This potential is limited in any case due to landscape conserva-

tion reasons. As modern wind turbines have become continuously larger and more powerful, limited additional onshore potential can be tapped through replacement of older, smaller wind turbines (repowering). The study therefore assumes that the increase in the wind power share in the German energy mix from currently approx. 7% to 15% in 2020 will for the major part occur through an expansion of offshore wind power, the development of which is still in the early stages. With *alpha ventus*, the first German wind park is currently in construction. Compared with onshore wind turbines, offshore wind parks have the advantage, amongst others, that the average number of full-load hours at sea is almost twice as high as on land. To achieve the political targets, a similar development is expected for offshore wind power by 2020 as was observed for onshore wind power in the last years.

¹³ EWI (2008)

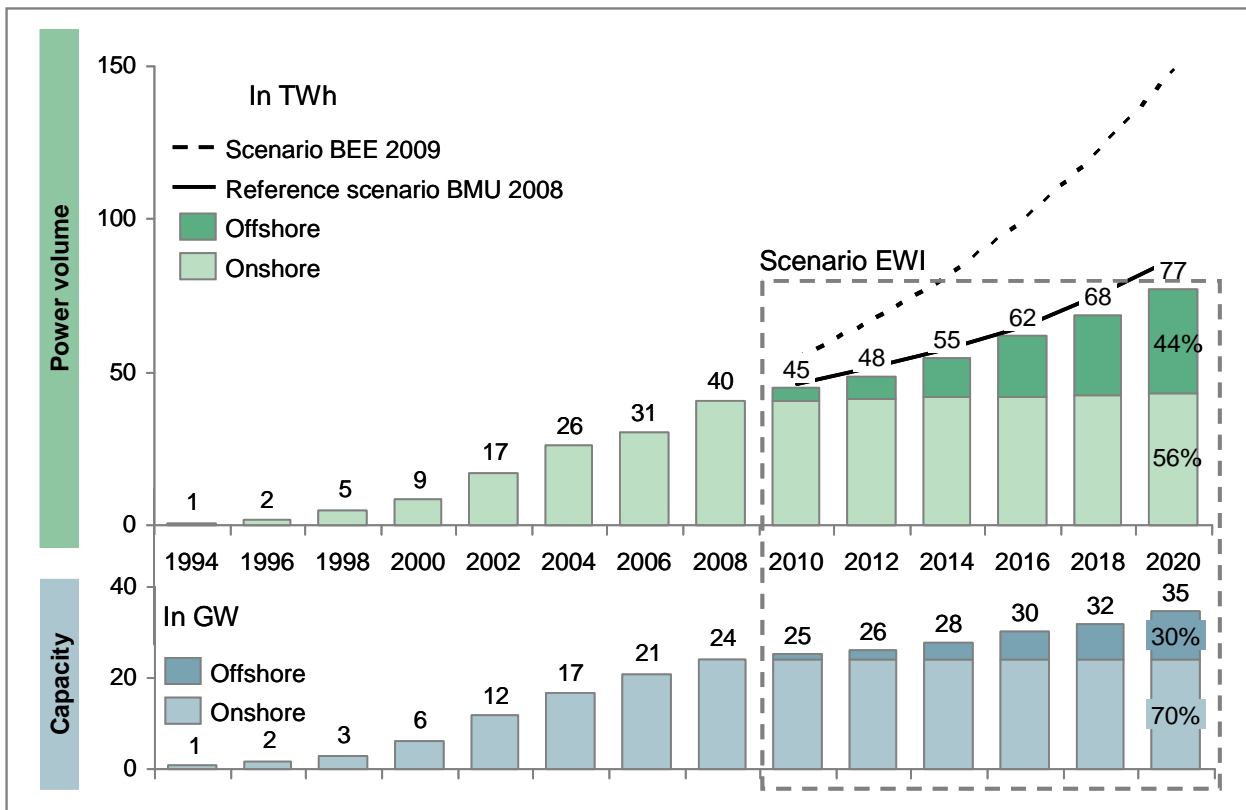


Exhibit 12: Power volume and capacity of wind power plants in Germany 1994–2020

In onshore wind turbines, tower, nacelle, and gearbox of the rotor are largely constructed of steel. The results in an almost 90% share of the material steel (excluding the concrete foundation). The steel share of offshore wind turbines is even higher than that of onshore wind turbines, as the foundation is additionally constructed of steel (e.g., tripods at *alpha ventus*). A 200 MW tripod offshore wind park consists of approx. 100,000 tonnes of steel. The infrastructure, e.g., the electrical substation or the supply vessels, also have a substantial steel share.

A pilot study of the German Federal Ministry for Environment, Nature Conservation, and Nuclear Safety, as well as forecasts of other institutions, predict an even stronger increase in wind power until 2020.¹³ In case of a possible stronger expansion of fossil fuel power plants compared with the planned gas power plants until 2020, the reductions would be significantly higher, as the mix of the fossil fuel power plants replaced by renewable energy sources would have higher specific emissions (t CO₂/TWh) than forecast.

¹³ EWI (2008), UBA (2007), DEWI (2009), et al.

Example: Weight reduction in passenger cars and trucks

The calculation of CO₂ reduction potential from weight reduction in passenger cars and trucks is based on the following premises: In 2007, the passenger car traffic in Germany emitted approx. 110 million tonnes of CO₂. Truck traffic (vehicles over 3.5 tonnes) were responsible for CO₂ emissions of approx. 30 Mt. CO₂ emissions in road traffic are caused by the fuel consumption of the vehicles, which in return is influenced by the factors motor efficiency, rolling resistance, air resistance, and vehicle weight. A weight reduction in passenger cars can be achieved through the application of high-performance steel for chassis and body—for example, through the use of tailored blanks. A comparison of different series shows a deceleration—in the newest vehicle generations, even a partial reversing—of the historical trend towards increasing vehicle weight. New vehicles consume approx. 10% less fuel than the existing passenger car fleet in Germany. The weight of a vehicle is an important influencing factor for fuel consumption and, accordingly, for CO₂ emissions (for passenger cars, reduction by approx. 0.35 l/100 kg/100 km).¹⁴

The innovations in the steel industry in the form of high-strength steel types now allow the production of substantially lighter vehicles. Depending on the part (body shell, doors, flaps), weight reductions of 10% to 40% are possible. The calculation in this study isolates the steel contribution by analyzing the reduction potential of the steel share in vehicles and excluding additional efficiency improvement effects from engine efficiency, c_w value, or tire rolling resistance. These effects are only implicitly taken into account in the forecast CO₂ emissions per vehicle. For the life cycle view, the possible CO₂ reduction of a

vehicle was calculated based on the average annual driving distance of approx. 13,000 km. The emissions from the steel generation required for the production of the passenger cars were apportioned to the life cycle of eight years typical in Germany. The forecast total driving distance of the German passenger car fleet in 2020 of approx. 600 billion km therefore results in a potential CO₂ reduction of approx. 11 million tonnes for passenger car traffic. Due to the isolation of the steel weight reduction, the contribution of steel is estimated at 100%. The steel-induced CO₂ emissions for the production of the vehicles amount to approx. 8 million tonnes of CO₂. Approx. 45 million passenger cars are expected in Germany for 2020. The resulting ratio for weight reduction in passenger cars between CO₂ reduction in 2020 and the apportioned CO₂ emissions for the steel production alone is 1.3 to 1.¹⁵

The weight reduction in trucks has only a partial impact on the truck diesel consumption. On many trips, the reduced weight will be compensated as additional payload. However, the higher average load of vehicles will reduce the number of required trips. This trip reduction applies only to fully loaded trips and a load of continuously increasable goods. On trips with volume restrictions (large goods with low density, e.g., empty containers or furniture), trips with heavy piece goods (machines, etc.), or partially loaded or empty trips, only the reduced fuel consumption will apply. This will lead to approx. 1.4% CO₂ reduction per 10% weight reduction and is calculated via the pro-rata reduction (approx. 0.06 l/100 kg/100 km) of the average fuel consumption of the current truck fleet. In comparison, the reduction of required trips even leads to

¹⁴ IFEU (2003), IFEU (2006), et al.

¹⁵ KBA (2009), et al.

a relative effect of an approx. 5.7% CO₂ reduction per 10% weight reduction. A reduction of approx. 1 million tonnes of CO₂ is therefore possible in truck traffic by means of the abovementioned levers.

As with passenger cars, for trucks, the contribu-

tion of steel is estimated at 100% due to the isolation of the steel weight reduction. For weight reduction in trucks, the resulting ratio between CO₂ reductions in 2020 and apportioned CO₂ emissions for the steel production alone is 1.1 to 1.

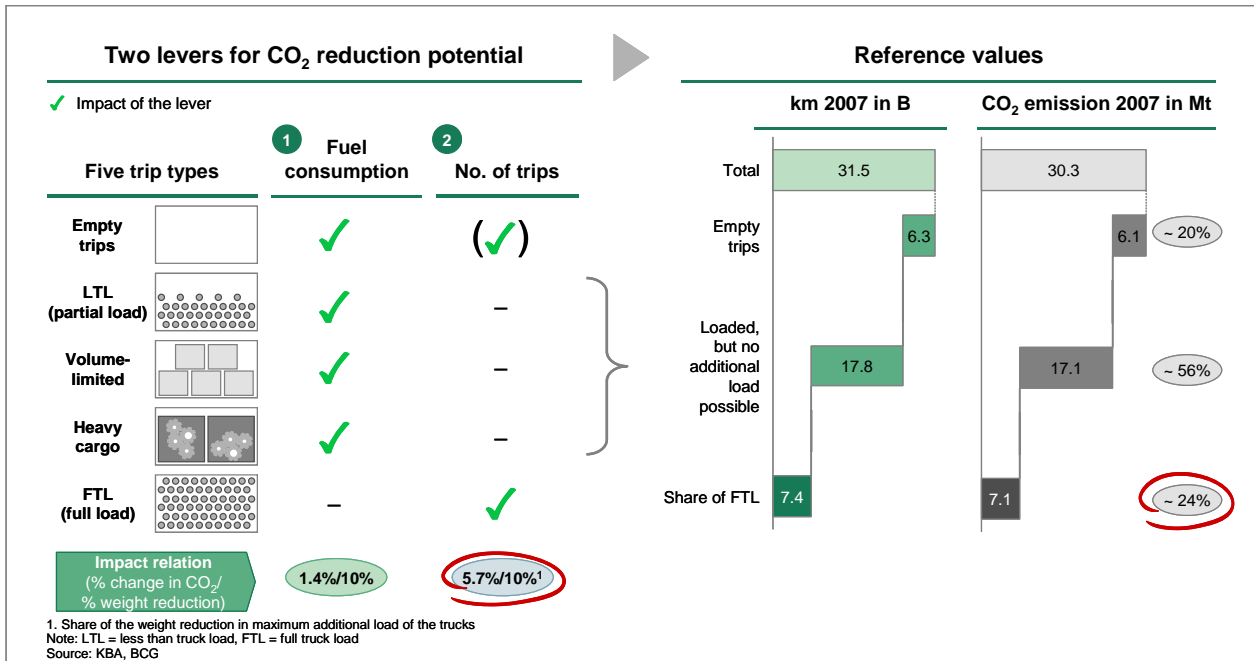


Exhibit 13: CO₂ reduction potential from weight reduction in trucks

Example: Efficiency increase in transformers

The calculation of the CO₂ reduction potential through more efficient transformers is based on the following premises: In the energy transmission and distribution, losses of approx. 4–4.5% of the gross energy generation (energy generation of the power plants after own consumption) arise in the energy grid and in the distribution to transformers. In 2007, approx. 25 TWh were lost in the transmission and distribution of energy, which corresponds approximately to the energy generated by three conventional fossil fuel power plants and causes approx. 13 million tonnes of CO₂ based on the estimated specific CO₂ emis-

sions for 2020.¹⁶ The majority of the losses arise in the low-voltage network at the level of the distribution transformers through reactive power. Due to very high efficiencies and capacity utilization, the losses at the first transformer are relatively low. Relevant losses arise at transmission, but these are not or only minimally influenceable through steel applications.

¹⁶ AGEB (2008), VDE (2008)

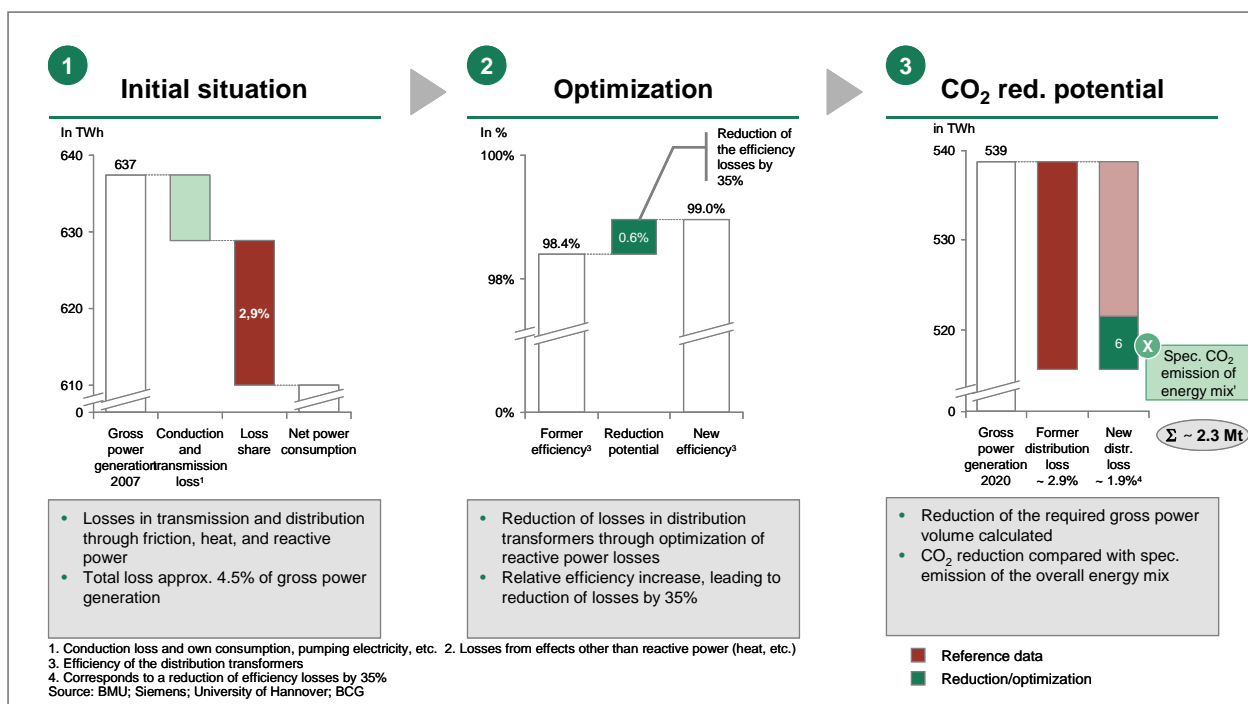


Exhibit 14: Case study transformers—CO₂ reduction through loss minimization

Losses in energy transmission and distribution result primarily from friction, heat, and reactive power. The efficiency of a conventional distribution transformer already lies at over 98% and is limited primarily by the physical properties of the steel core. Modern, grain-oriented steel cores, however, would allow a relative reduction of losses by approx. 35%. To achieve low hysteresis losses in applications with high capacity utilization like transformers, and to meet the high requirements regarding permeability, steel is produced with as uniform an orientation of the crystallites as possible, i.e., grain-oriented strips.¹⁷

Theoretically, a reduction of reactive power losses by up to two-thirds compared with conventional steel is possible.¹⁸ Steel innovations therefore increase the efficiency of the transformers

through special steel, thereby decreasing the resulting losses at distribution level.

Steel innovations in the field of transformer efficiency could result in an emissions reduction of 2.3 million tonnes of CO₂ in 2020 compared with 2007. For the calculations of the study, the steel contribution was estimated at 90% due to the great influence of the steel cores on the efficiency of the transformers and the exclusiveness of the use of steel as a material. The CO₂ reduction results from a reduction of the required gross energy volumes through lower losses. The optimized steel is more expensive but, due to the loss reduction, the investment will pay off within a short period of time. However, the current replacement rates of approx. 3% of the installed base per year would have to be increased substantially to achieve the full potential by 2020. The resulting ratio for transformer efficiency between CO₂ reduction in 2020 and apportioned CO₂ emissions for the steel production is 14 to 1.

¹⁷ SEEDT (2008), Dt. Kupferinstitut (2007), et al.

¹⁸ VDE (2008), SEEDT (2008)

Example: Combined heat and power (CHP)

Heat energy plays an important role especially in households (space and water heating) and industry (process heat). In households, space heating accounts for approx. 80% of total energy consumption. The demand for heat will decrease in future due to current developments in thermal insulation and low-energy houses, but will nevertheless continue to play an important role in energy generation. With combined heat and power (CHP), the waste heat in power plants can be used for power generation as heat energy. Hot water or steam from the power plants is transported to the end users via pipeline systems, where it is connected to the heat supply via heat exchangers. In the simultaneous generation of power and heat, the fuel utilization can be up to 90%. The federal government aims to double the share of CHP and is financially subsidizing the generation of power through CHP. For the use of CHP units, the simultaneous need for power and heat, as well as the proximity to the end user, are assumed.

The growth area for the use of CHP units are primarily local cogeneration units for the generation of local heat for residential areas, large buildings, swimming pools, or industrial parks. Mini- and micro-CHP units for individual buildings or households will also be used increasingly in the future, whereby power for the building supply will be generated as a by-product of the heat generation. These units were, however, not taken into account in the quantification of the study, as no supply network—and accordingly, no relevant volumes of steel—are required for the heat transmission.¹⁹

Through waste heat transport in steel pipes, CHP units increase the overall efficiency of fossil fuel power plants. For the heat generation with CHP units, low additional CO₂ emissions of the heat energy are added on (the add-on is calculated by the Finnish method²⁰). Through this steel application, approx. 10 million tonnes of CO₂ will be saved in 2020 compared with 2007. Due to the substantial contribution of the steel pipes to the feasibility of CHP units and the exclusiveness of the use of steel as a material, the steel contribution is estimated at 90%. The expansion of the network will require an additional pipeline length of approx. 50,000 km. The weight of the steel for the pipes is estimated at approx. 450 t/km. Steel-induced emissions from the production of these pipes are distributed across a life cycle of 40 years. The resulting ratio for combined heat and power between CO₂ reductions in 2020 and apportioned CO₂ emissions for the steel production alone is 9 to 1.²¹

The aspired additional construction of CHP units will, however, require intense political and economic efforts to significantly expand on-grid heat despite declining demand for heat in the households.

¹⁹ IEA (2009)

²⁰ Calculation of the add-on in comparison with separate generation of heat and power, see also TU Dresden (2008)

²¹ BMU (2008), AGFW (2008), UBA (2007), et al.

Excursus 3: Importance of steel recycling and material efficiency by the example of packaging cans

Environmental aspects and life cycle examinations play an increasingly important role in the selection of materials for various different applications. Due to their reusability and comparatively simple separability from other materials, steel product can to a large extent be recycled with practically no loss in nearly every application. The recycling of steel products saves up to two-thirds of the required energy. In addition, it leads to an optimization of the use of resources and, accordingly, to a conservation of natural resources.²²

A good example of steel recycling can be found in the packaging segment. Steel packaging is especially relevant for the recycling system, due to the comparably short life cycle of the products. By reducing the thickness of food and beverage cans, substantial material efficiency improvements were realized in recent years, whereby CO₂ emissions from steel production were avoided. In 2008, over 90% of all tinplate packaging was recycled. In contrast, plastics have the lowest recycling rate among common packaging materials. While the consumption of packaging in Germany increased by a total of 20% in the last ten years, the share of steel in overall consumption of packaging declined continuously.

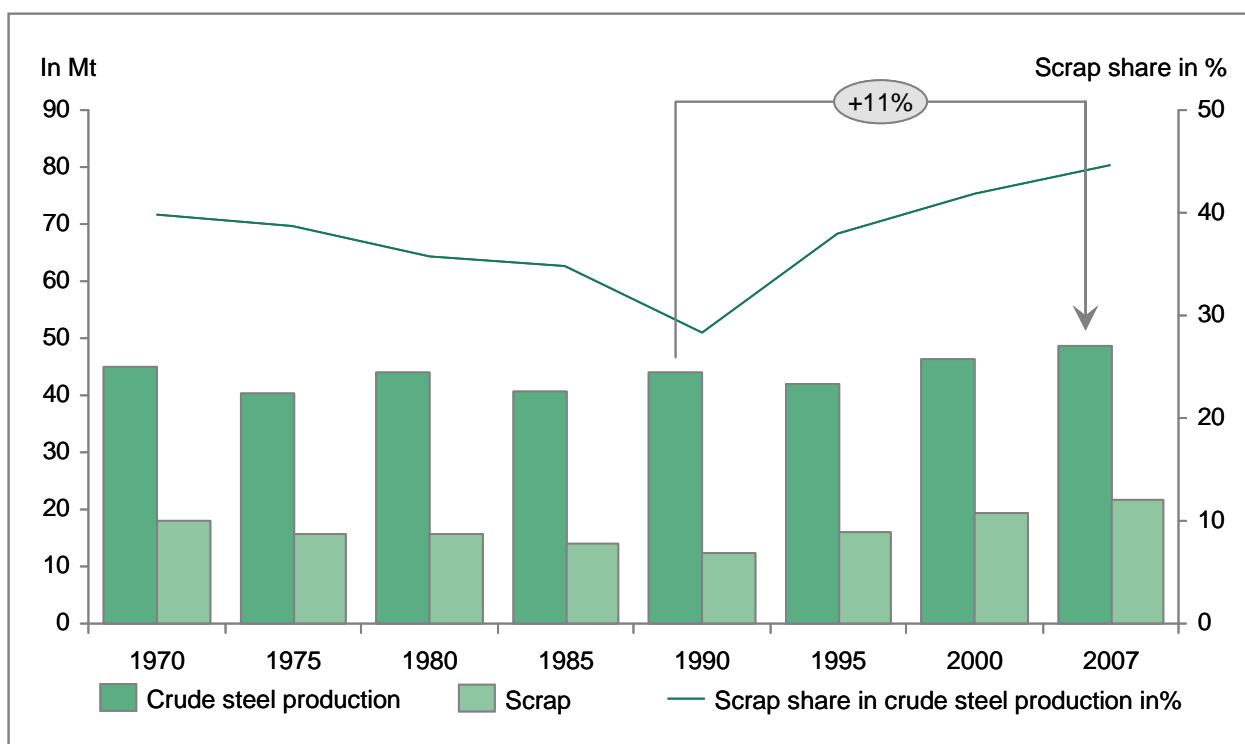


Exhibit 15: Development of crude steel production and scrap share in the German steel industry

²² Philipp, Still, Volkhausen (2003)

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