



## Climate policy claims encounter energy sector hurdles

**Climate policy instruments must be directed towards greater efficiency and effectiveness. International, comprehensive sectoral and uniform carbon pricing is essential.** Subsidies for fossil fuels must be cut back to zero. An openness to different technological solutions is also advisable. Research expenditure must be significantly increased, because we do not believe that carbon neutrality can be achieved in less than 30 years using the currently available, politically accepted technologies. There are a number of hurdles to overcome: economic, technological and, last but not least, political. Increased adaptation to climate change is already possible and expedient.

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**To tackle the issue of climate change, the world must significantly reduce its dependence on fossil fuels and end this in the long term. However, oil, coal and natural gas covered just under 81% of global primary energy demand in 2019. This value has remained fairly constant for decades.** At the same time, the world population energy consumption is growing, and fossil fuels will continue to supply most of the world's energy for the time being. Renewable energies, however, are recording the biggest increase. Financing these will require considerable effort, especially by poorer economies.

**Worldwide energy-related carbon emissions were 127% higher in 2020 than in 1971. However, the 2020s could become the first decade in which global energy-related carbon emissions fall rather than rise, even if only slightly.**

**In Germany, electricity from renewable sources is supposed to supply a large proportion of the energy requirements in the transport sector and the heat market. This will significantly increase absolute electricity consumption and peak demand.** In 2019, electricity accounted for only 20% of final energy consumption in Germany. Mobility and space heating each represented above 30%. Both sectors are changing very slowly because of the high importance of the stock of vehicles and buildings. Rapid reductions in energy consumption and carbon emissions are difficult to achieve in this case – not least for political reasons.

**Despite increased installed capacity from renewable sources, reliability of supply is likely to become a major issue if conventional power plant capacities are disconnected from the grid at the same time.** Alongside low carbon intensity, weather-dependent renewable energies offer the advantage of almost zero marginal costs. Electricity generation costs of renewables fall as well. This is offset by disadvantages in terms of overall system costs and performance.





## 1. Introduction: Climate change is an energy issue

Climate change represents one of the major global challenges of this century. Climate change and other global problems are closely linked: supplying the world's population with food and drinking water is made more difficult by climate change. Issues such as health, migration, biodiversity or even education are also more or less directly linked to climate change. Climate change and energy supply are clearly the most closely connected. Energy-related greenhouse gas emissions from people (e.g. electricity and heat generation, mobility), process-related emissions from industry (e.g. the production of building materials), and emissions from waste management and waste water treatment account for more than 80% of total global greenhouse gas emissions. Agriculture, forestry and land use change account for the remaining emissions. This means climate change is essentially an energy issue, as they are inextricably linked. The main culprit is the greenhouse gas carbon dioxide. One of the issues still to be resolved this century is developing powerful, low-carbon energy sources which are as cost-effective as possible. We will explain in greater detail what we mean by the term "powerful".

### Climate and energy policy requires a more realistic debate

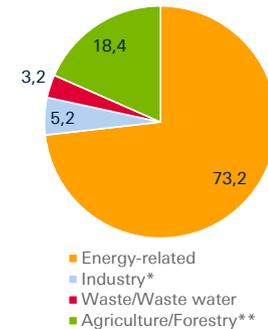
More and more countries and international communities are now drawing up increasingly ambitious climate change targets. A prominent example is the goal of carbon neutrality for the EU and the United States by 2050. The German Federal Government recently brought the deadline for its carbon neutrality goals forward to 2045. Some NGOs are even calling for this by 2035. In the "race" to set the most ambitious targets, however, one thing frequently overlooked is how these goals can be achieved and what this will mean in terms of energy sector figures. This report aims to indicate how climate change targets and the energy question are connected. Examining the various facts makes it possible to have a more reasoned, less emotional debate. We will take a detailed look at the current situation of the energy sector to demonstrate the challenges posed by the task of a carbon-neutral future.

In the public perception (at least among those who do not regularly deal with energy statistics), there is often a mismatch between perceptions about progress towards a climate-friendly – or even carbon-neutral – future and what has actually been achieved. One example is the debate on the German energy transition. The political and media focus on the share of renewable energies used in electricity generation (44% in 2020) means that some observers may be under the impression that we have already reached the half-way mark. This is far from being the case, because electricity accounts for only one fifth of final energy consumption in Germany. At the same time, the climate policy debate is too often dominated by emotionally charged symbols, which distract people from the overall issue and are actually of only limited relevance. Examples include coal-fired power generation, vehicles with a combustion engine in general and SUVs in particular, air transport, home ownership, meat consumption and, lastly, increased energy consumption due to IT usage. A serious look at the energy sector figures helps to shed light on the scale of the undertaking.

Finally, a realistic evaluation of the potential contribution of individual technologies to solving the energy and climate problem also needs to be made. There is no use emphasizing what is technologically feasible if there are no limitations. Instead, we must investigate the economic costs entailed, the time constraints and also realistically examine how powerful individual energy sources might be in the coming years, and what social consequences we may expect. We also need to

Figure 1: Energy-related greenhouse gas emissions dominate

Share in global anthropogenic greenhouse gas emissions, 2016, %



\* Only process-related emissions  
\*\* Including land-use change

Source: Our World in Data



discuss necessary changes in the behaviour of private households and companies, the consequences in terms of freedom of choice and property rights, and the political and social opposition that will certainly ensue. We should not overlook the fact that this is a politically contentious issue. We can expect that both ends of the political and social spectrum will try to make their extreme views and demands heard (e.g. “carbon neutrality in Germany in 10 to 15 years” versus “climate change isn’t a problem” or “limit climate protection because Germany can’t achieve anything on its own”). Recent political debates indicate that this is already happening. The term “climate lockdown” is just one example.

Climate and energy policy goals often come into conflict with other social and economic objectives as well as individual consumer demands. These conflicts cannot simply be brushed aside. There is thus a need for a democratic debate about which goals need to be set and how to prioritise them. One of the most important and most difficult political tasks in the coming years will be to find answers to the question of what instruments we should ideally employ for climate protection and the energy transition. There is clearly room for improvement. In this report, as well as examining facts about the energy sector, we will also formulate and explain theses about its future development. The aim is to revive the debate on energy and climate policy.

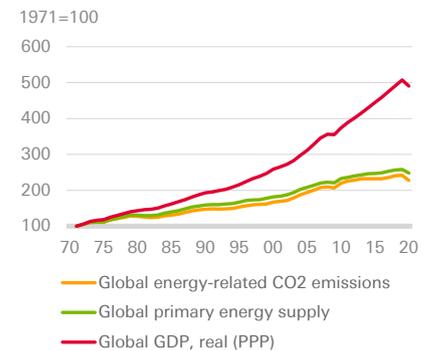
## 2. The global perspective

### Energy supply and energy consumption on the rise

**Fact: Energy consumption and energy supply have mostly risen steadily at a global level in recent years.** The International Energy Agency (IEA) has time series for global primary energy supply going back to 1971. Since then it has risen by just under 150%, or about 1.9% per annum. Energy supply and demand correlate closely, so primary energy demand is likely to have grown at a similar rate. According to the IEA’s estimates, energy demand and supply dropped by 4% in 2020 due to the coronavirus pandemic. If so, this will be by far the biggest annual decrease in the entire period under consideration. The only previous declines in global primary energy supply were in 2009 (global economic and financial crisis) and in 1980 and 1981 (oil crisis, thus high oil prices), each less than 1%.

**Thesis: The earth’s energy consumption will continue to rise. So the energy supply will rise too.** In its main scenario, the IEA expects global primary energy demand<sup>1</sup> to grow by 0.8% p.a. until 2040. The main drivers for rising energy consumption are obvious: The world’s population is currently growing by about 80 million people each year. Every relevant economy is striving for economic growth and most people want more (material) prosperity. This means consumption, mobility and industrialisation will continue to rise, leading ultimately to higher resource and energy consumption; per capita consumption will also increase, especially in developing and emerging countries. Advances in energy efficiency are likely to be overcompensated by higher consumption (rebound effect). Despite this, the IEA’s forecast growth in primary energy demand up to 2040 is significantly less than that of past decades.

Figure 2: GDP growth decouples relatively from energy consumption



Source: IEA, IMF, Global Carbon Project

<sup>1</sup> Primary energy demand is the primary energy (such as gas, oil, coal, and biomass) supplied to an economy. It is the beginning of what might be called the “energy value chain”. When primary energy is converted into final energy (i.e. fuels, electricity, and district heating), conversion losses occur.



### Energy mix: Fossil fuels dominant

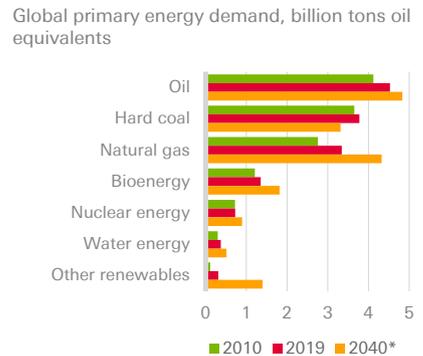
**Fact: Fossil fuels dominate the global energy sector. According to the IEA, oil, coal and natural gas covered just under 81% of global primary energy demand in 2019.** The most important non-fossil energy source in 2019 was bioenergy, at just over 9%. Fossil fuels also dominate the global electricity sector, accounting for 63% of generation. Hydropower is the most important non-fossil energy source at 16%, ahead of nuclear energy at 10%. Fossil fuels made up just over 80% of primary energy demand in 1990, 2000 and 2010 as well. This share has evidently been a global constant in recent decades. Despite all the efforts to protect the climate and increase energy efficiency, it has not changed significantly as yet.

**Thesis: Fossil fuels will continue to provide the bulk of the world's energy in the coming years.** The IEA formulates different scenarios in its annual World Energy Outlook. The aforementioned main scenario (Stated Policies Scenario, SPS) assumes that the international community will hold on to its commitments from the Paris Agreement and invest massively in renewable energies, energy efficiency, and other climate protection technologies. But even if they do, the share of fossil energy sources in primary energy consumption will only fall to 72% by 2040, according to the SPS. The IEA expects greater progress in the electricity sector. In the SPS, the share of fossil fuels in electricity generation declines to 44% by 2040; coal is pushed back more strongly, but remains the most important single energy source in the electricity sector until 2040, just ahead of natural gas. One could of course argue that the IEA has been overly pessimistic in its main scenario by underestimating how much fossil energies will decline. It is therefore worth taking a look at the IEA's Sustainable Development Scenario (SDS), which is much more ambitious from a climate policy perspective. For example, it assumes that many industrialised countries will have net zero emissions by 2050 and that global primary energy demand will fall. Both are bold propositions. And even if they prove true, fossil energy sources will still supply 56% of primary energy demand in 2040. Having said that, the SDS posits that the electricity sector will be largely decarbonised by 2040. Fossil fuels will then collectively account for only 17% of electricity generation, with coal shrinking to 5% (2019: 37%). In the SDS, renewable energies are the main pillar of the electricity sector at 72%, followed by natural gas and nuclear energy in second and third place, with 12% and 11% respectively. Nuclear energy makes a greater contribution to energy supply than it does in the main scenario, as climate policy ambition increases. It is worth noting that according to the IEA, decarbonisation pathways also require increased use of CCUS (Carbon Capture Usage and Storage) technologies.

### Wind power and photovoltaics still globally insignificant, but growing fast

**Fact: Bioenergy and hydropower are far and away the dominant renewable energy sources globally. Their combined share in the world's primary energy demand was about 12% in 2019.** At 9%, bioenergy is ahead of hydropower (3%), because wood is the most important energy source in many developing and emerging countries due to a lack of alternatives. In Africa, for instance, bioenergy (wood, biogenic residues) accounts for about 45% of primary energy demand. This has a number of negative consequences (air pollution in households from cooking on open fires; deforestation). **What the IEA calls "other renewables" – mainly wind power and photovoltaics – accounted for around 2% of global primary energy demand in 2019.** In the electricity sector, hydropower (7%) is ahead of other renewable energies (5%) and bioenergy (4%). In the electricity sector, all three renewable sources put together exceed nuclear energy's 13% share.

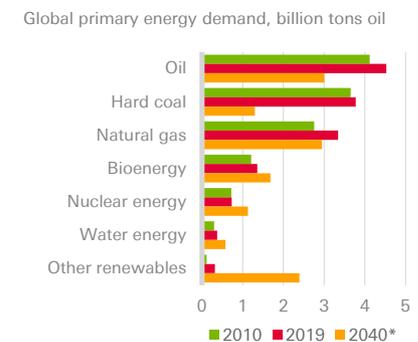
Figure 3: Oil fuels the global economy



\* Main scenario incl. implementation of commitments of the Paris Climate Protection Agreement

Source: IEA

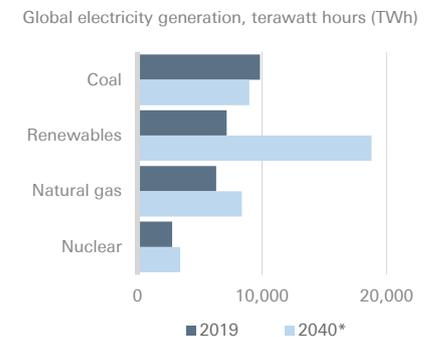
Figure 4: Hard coal strongly pushed back in SDS, but fossils remain important



\* Sustainable development scenario

Source: IEA

Figure 5: Power generation becomes more renewable



\* Main scenario

Source: IEA



**Thesis: Other renewable energies (wind power and photovoltaics) will grow fastest by far in the coming years.** In its SPS, the IEA expects the absolute primary energy demand accounted for by those energy sources to grow by over 7% p.a. until 2040. In the electricity sector, their growth will be even faster. This means a greater than fourfold increase from 2019's level by 2040. In its much more ambitious SDS, the IEA even attributes annual average growth rates of more than 10% to renewables (excluding bioenergy and hydropower) by 2040. The main reason for this growth, regardless of scenario, is political commitment in many countries to expand and provide state support for wind power and photovoltaics.

#### Investments in the electricity sector, especially in renewables

**Fact: By far the largest investments in the electricity sector are already in renewable energy generation capacities.** According to the IEA, an annual average of around USD 310 billion was invested globally in this area from 2015 to 2019, which is at least 64% of all investment in power generation capability. Investments in fossil fuel power stations over the same period amounted to 29% (an average of USD 139 billion p.a.). Total investment in the energy sector, including fossil fuel exploration, grid development and energy efficiency activities, amounted to USD 1.94 trillion per year from 2015 to 2019, according to the IEA.

**Thesis: Investments in renewable energies will increase significantly in the coming years, but financing them will become a major struggle.** In its SPS, the IEA forecasts investment in renewable electricity generating capacity at USD 366 billion per year between 2020 and 2040. Then there will be USD 452 billion p.a. for developing electricity grids and an annual USD 446 billion for energy efficiency measures (in total, 48% more than the average for the years 2015 to 2019). Taken together, this represents at least 1.3% of nominal global GDP in 2021. Up to now, most investments in renewable energies have been made in the context of state regulation and/or long-term contracts, such as in the form of guaranteed prices and feed-in tariffs, which reduce the risk for investors and lenders. Grid development enjoys regulatory incentives in many countries. As a rule, the energy sector has to compete for investments with other investment opportunities, regardless of whether they are primarily from the public or the private sector. Whatever money governments spend on climate-friendly energy supply is no longer available to spend on education, research and development, health, domestic and foreign security, the expansion of other infrastructure, pension increases, higher wages for public sector employees or tax cuts. In the private sector, investments are based on opportunity costs and achievable returns. Investing in areas other than the energy sector may be more lucrative for businesses. In this respect, the investments posited by the IEA are subject to financing and require considerable financial effort from national economies. This is especially true for poorer states. And the financial effort is even greater in the SDS, where the IEA forecasts annual investments of USD 615 billion per annum in renewable power generation capacity, USD 623 billion in electricity grids and USD 658 billion in energy efficiency. Collectively, these figures exceed the main scenario's investments in the three areas by more than 50% and are more than 120% higher than the average amount actually invested in the years 2015 to 2019.

#### Energy and carbon intensity decrease

**Fact: The global economy's energy and carbon intensity has steadily declined in recent decades. Economic growth has decoupled from energy consumption and carbon emissions in relative terms.** Global energy demand and carbon emissions per unit of GDP (in purchasing power parities) have more than halved since 1971. The reasons for this are higher energy efficiency across every economic area, the



service industry accounting for an increasing share of GDP compared with more energy-intensive manufacturing industries, and the growing importance of low-carbon energy sources. The 2010s saw particularly rapid progress in terms of energy and carbon intensity.

**Thesis: The trend of decreasing energy and carbon intensity will continue and even accelerate in the coming years.** This is supported by further advances in efficiency and growing efforts to switch to low-carbon energy forms. Furthermore, coal, which emits more carbon than oil or gas when burnt, is declining in the industrialised countries faster than in earlier years, and it is set to be used more efficiently in important consuming countries such as China, as older coal-fired power plants are replaced by more modern ones (efficiency). But many emerging countries will continue to rely on coal because it is available there, can often be used relatively cheaply and is a reliable source of energy. In the IEA's main scenario, for instance, coal-based power generation in India increases by more than 17% between 2019 and 2040.

### Global carbon emissions may have peaked

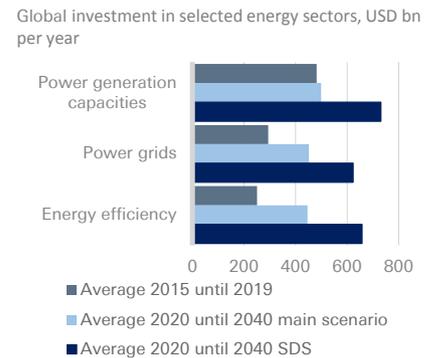
**Fact: Global energy-related carbon emissions have increased almost every year in recent decades. They were 127% higher in 2020 than in 1971. But their growth has slowed considerably in the last decade.** From 2000 to 2010, energy-related carbon emissions rose by almost 32% worldwide. An important reason for this was China's integration into the international value chain after joining the WTO at the end of 2001. In the last decade, from 2010 to 2020, growth in carbon emissions slowed to around 4%. This low growth is partly due to the coronavirus pandemic, which led to a reduction in emissions of around 6% from 2019. Nevertheless, even without the effects of the pandemic, energy-related carbon emissions would have risen more slowly than in any other decade since the IEA time series began in 1971.

**Thesis: The 2020s could become the first decade in which global energy-related carbon emissions fall rather than rise, even if only slightly.** There will be a rebound effect on emissions once the coronavirus pandemic has been overcome, but 2019 may yet turn out to be the year with the absolute highest global energy-related carbon emissions (peak carbon). For the time being, emissions will continue to rise in most developing and emerging countries, while beginning and continuing to decline in industrialised nations. Both effects may cancel each other out. The savings might even outweigh. In the IEA's main scenario, emissions in 2030 are roughly on a par with 2019. The IEA is likely to outline a somewhat more optimistic main scenario when it publishes its next World Energy Outlook in autumn 2021. In the SDS, energy-related carbon emissions decrease by 2.8% year on year until 2030, by which time they will be 27% below 2019's level. That would be a huge step forward viewed in terms of developments over the past 50 years, even though the path towards net zero emissions would still be a very long one, even in this rather unlikely scenario. And from a technological, economic and social point of view, it is certainly a path littered with unanswered questions.

### Wealthy countries record high CO<sub>2</sub> emissions

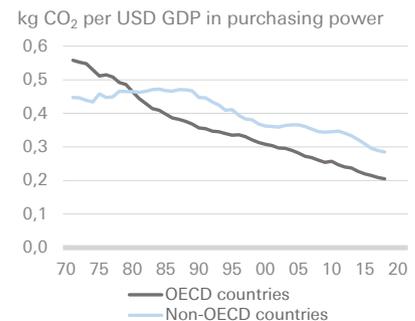
**Fact: There is a positive link between a country's level of prosperity and its energy-related CO<sub>2</sub> emissions. GDP per capita and CO<sub>2</sub> emissions are closely correlated.** Figure 9 shows this link in relation to the Group of Twenty (G20) states. Correlation does not necessarily indicate causality. However, in this case, it stands to reason that material prosperity goes hand in hand with a higher energy consumption, with over 80% of global energy demand based on fossil fuels. The fact that the CO<sub>2</sub> emissions deviate vertically from the trend line in the figure can be

Figure 6: Investments in the power sector increase



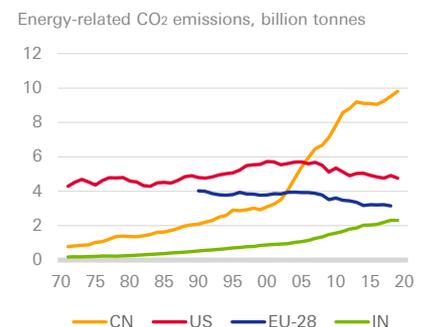
Source: IEA

Figure 7: CO<sub>2</sub> intensity is shrinking



Source: IEA

Figure 8: China largest CO<sub>2</sub> emitter

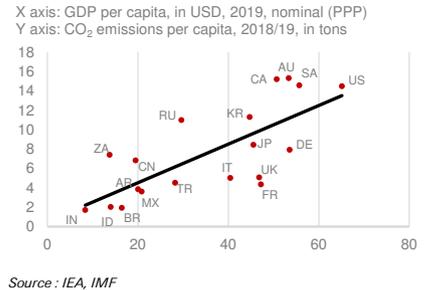


Source: IEA



explained by a variety of factors. These factors include differences in energy supply (including exploration of fossil fuels), energy prices, different consumption and production practices (e.g. mobility, settlement structure, share of manufacturing in total gross value added, energy efficiency), as well as climate-related factors that determine a country's heating requirements. The US, Australia, Canada and Saudi Arabia have very high CO<sub>2</sub> emissions per capita. All of these countries play an important role in producing fossil fuels. Furthermore, the energy prices paid by companies and private households are very low, meaning that the energy efficiency of buildings, cars, electronic consumer goods and other energy consumers is less important. Within the EU, Germany records significantly higher CO<sub>2</sub> emissions per capita than France, even though the two countries have a similar level of prosperity. A reason for this is that in Germany, the manufacturing sector accounts for approximately twice as much of the total gross value added as it does in France (2020: 19.7% compared to 10.4%). Moreover, cars in Germany have more powerful engines on average than cars in France. In addition, more heating is required in Germany. Unsurprisingly, a significant reason for the lower CO<sub>2</sub> emissions in France is that nuclear energy is the main energy source in its electricity sector, whereas lignite, which produces very high CO<sub>2</sub> emissions per kWh, plays a much bigger role in Germany. When compared with its level of prosperity, China has very high CO<sub>2</sub> emissions per capita. This economy produces high levels of CO<sub>2</sub> because coal accounts for approximately 60% of its primary energy demand. Moreover, it is the world's biggest exporter of industrial goods. Therefore, China also effectively exports CO<sub>2</sub> emissions to the buyer countries. Of all of the G20 states, France comes closest to achieving the goal of being relatively prosperous while causing as low a level of CO<sub>2</sub> emissions per capita as possible. However, even France is far from achieving the political objective of climate neutrality. Even the poorest states in Africa – where energy production is largely based on renewable energies (wood), motorised individual mobility is a minor factor and the GDP per capita amounts to just a fraction of the level in industrial countries – are not climate neutral.

Figure 9: Prosperous countries – high CO<sub>2</sub> emissions per capita



**Thesis: The positive link between the level of prosperity and CO<sub>2</sub> emissions per capita will persist for the time being. However, the trend line will flatten out.** In wealthy countries, CO<sub>2</sub> emissions will decline over the coming years. In poorer states, the GDP per capita probably increases more quickly than the CO<sub>2</sub> emissions per capita. The arguments for this thesis are listed above.

### Ambitious climate targets in many countries

**Fact: Many large economies have adopted tougher climate policy goals in recent years.** Following the example of the EU, the US, Canada and Japan have now also set themselves the goal of becoming climate neutral by 2050. China hopes to be CO<sub>2</sub> neutral by 2060. The German federal government has brought the deadline forward to 2045.

**Thesis: In the future, announcing challenging long-term goals for the reduction of CO<sub>2</sub> emissions will continue to be easier than actually achieving these goals.** The setting of tougher goals in recent years has received a somewhat euphoric response from the media. References to the failure to meet climate policy goals in the past are frequently nothing more than a side note. If market observers and analysts remain sceptical regarding the ambitious goals because of reasons related to energy efficiency, the laws of physics, economic and social costs, political and social opposition or timing, technological and other limitations, or criticise measures relating to climate policy on the basis of inefficiency and ineffectiveness, it is sometimes assumed that they do not consider climate protection to be a worthwhile goal. However, the history of climate policy shows that there is often a



large discrepancy between promises and reality when it comes to climate protection because the aforementioned factors have an impact in real life. Therefore, there are certainly reasons to be sceptical. Indeed, scepticism is also an important driver for gaining research-based knowledge. We, too, regard the ambitious goals with scepticism. They refer not to reducing CO<sub>2</sub> emissions by the next 20, 40, 60 or even more percentage points but rather to achieving climate neutrality in its most literal sense in less than 30 years.<sup>2</sup> The 2020 analysis by the German Energy Agency (dena) on the topic of carbon neutrality states that: “In theory, neutrality could also be achieved by completely stopping all greenhouse gas emissions (a gross value of zero or – in terms of CO<sub>2</sub> – a full decarbonisation). However, this is unrealistic because in a number of sectors, completely eliminating emissions would be either impossible or associated with prohibitive costs. It is likely that a low residual level of emissions will prove to be unavoidable.”<sup>3</sup>

### Adaptation measures are becoming more important

**Fact: Already, adaptation measures to climate change can reduce the severity of the negative effects of climate change.** Examples of this include physical infrastructures in developing and emerging countries, which are more resistant to weather extremes, for better water management and more coastal protection, and changes in agriculture and forestry. However, it is also worth mentioning very simple measures such as warning systems for heatwaves that remind older people to drink enough (the heatwave in August 2020 led to an above-average mortality rate in Germany).

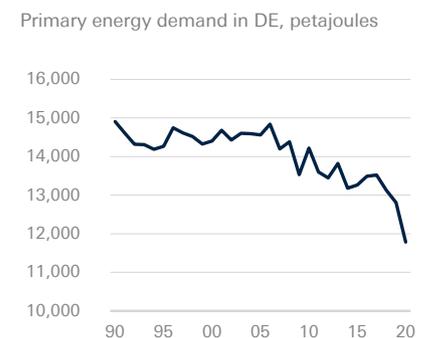
**Thesis: In the coming years, public debate will focus more heavily on adaptation measures. There may be greater demand to invest more financial resources in this area.** As the state’s financial resources are limited, the competition between state-financed climate protection measures to avoid CO<sub>2</sub> emissions (mitigation) on the one hand and adaptation measures on the other will increase.

## 3. A closer look at Germany

### A decrease in primary energy demand – even prior to COVID-19

**Fact: In 2020, primary energy demand in Germany was approximately 21% lower than in 1990.** The COVID-19 crisis caused the biggest decrease in the last 30 years: In 2020 alone, primary energy demand dropped by 8%. However, it was already falling prior to this. There are various reasons for this long-term decrease in primary energy demand. Directly following Germany’s reunification, the closure of industrial companies and outdated power plants in East Germany led to a drop in energy consumption. Over the entire period, advances in efficiency, e.g. in the generation of electricity or in its various applications (e.g. mobility, industry, buildings) meant that less energy was required. Moreover, in recent years, there has been a decline in the use of coal, which is a less efficient means of generating electricity than gas or steam power plants, for example; this has resulted in a lower usage of primary energy. It is also worth mentioning the fact that for years now,

Figure 10: Corona crisis causes decline of primary energy demand



Source: BMWi

2 Cf. Heymann, Eric (2020). Climate neutrality: Are we ready for an honest discussion? Deutsche Bank Research. Talking Point. Frankfurt am Main. Incidentally, the failure to achieve long-term political goals is not unique to climate policy. For example, in 2012, the European Commission set itself the goal of increasing the share of industry (the manufacturing sector) from 16% (the share at the time) to 20% by 2020. It is debatable whether this was a sensible goal. However, it is a fact that the industrial share has since remained roughly constant. Failing to achieve this goal has had zero consequences.

3 German Energy Agency (2020). dena analysis. Climate neutrality. A concept with far-reaching implications. (Klimaneutralität. Ein Konzept mit weitreichenden Implikationen.) Berlin.



there has been a decrease in capital stock in energy-intensive industries that are responsible for a high share of Germany's total electricity consumption. Finally, the fact that temperatures have been milder on average has had a considerable effect as less heating has been required during the cold seasons. For example, milder winters played a crucial role in the significant decrease in primary energy demand in 2014 and 2018.

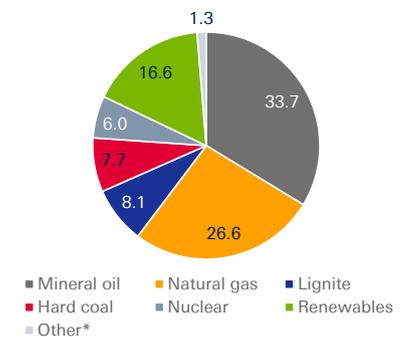
**Thesis: Aside from a short-term rebound effect following the COVID-19 crisis, primary energy demand in Germany will continue its downward trend in the coming years.** This is indicated by further advances in energy efficiency and the fact that industries with large energy requirements (e.g. metals production, the chemicals industry, building materials) are expected to continue to decrease in importance in Germany. The shift away from coal in the energy mix is also worth mentioning. If winters continue to become milder on average due to climate change, this would also help to curb primary energy demand. It is true that more energy would be required for cooling (more air-conditioning systems). However, there may be savings overall. The German federal government has set itself the goal of halving primary energy demand compared with 2008 by 2050. This would correspond to a reduction of at least 1.6% per year between now and then, in contrast with the extraordinarily low consumption in 2020 during the COVID-19 crisis. By way of comparison: From 1990 to 2020, primary energy demand decreased by "only" 0.8% per year, despite the impact of Germany's reunification and the massive drop due to COVID-19. Therefore, the annual savings in primary energy demand for the next 30 years would have to more than double compared with the last three decades. The comparison shows just how ambitious the German federal government has been in setting this goal.

#### Energy mix: Fossil fuels dominate in Germany as well

**Fact: As at the global level, primary energy demand in Germany is also clearly dominated by fossil fuels. In 2020, their share was 76.1%. Historically, this is the lowest value.** Compared to 2010 (78.2%), this corresponds to a decline of just over 2 percentage points and compared to 2000, a decline of 7.6 percentage points. Crude oil accounted for the largest share of primary energy demand last year (33.7%), followed by natural gas (26.6%). Lignite and hard coal combined came to 15.8% in 2020 and were thus below the figure for renewable energies (16.6%) for the first time. The latter reached a new record level in 2020. This was due in part to the good weather conditions for wind power and photovoltaics and in part to the significant decline in total primary energy demand, which in total led to a share gain of 1.7 percentage points for renewables. Within renewables, biomass accounts for the largest share of renewable energies with about 52% (mainly the use of wood for space heating, conversion of biomass into electricity and biofuels). **In contrast, all wind power plants in Germany and solar energy accounted for only just under 6% of total primary energy demand in 2020.** It should be taken into account that for energy sources without natural calorific value (nuclear energy, hydropower, wind power, photovoltaics) the contribution to primary energy demand is calculated according to what is known as the efficiency method. According to the Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen), renewable energy sources such as wind power and photovoltaics tend to account for a lower and nuclear energy for a higher portion of primary energy demand. However, this does not fundamentally change the overall picture.<sup>4</sup>

Figure 11: Oil remains most important source of energy

Share of energy sources in total primary energy demand in Germany, 2020, %



\* Less electricity exchange balance

Source: AG Energiebilanzen

<sup>4</sup> For the methodology of the calculation, see the Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen) (2020). Energy consumption in Germany in 2019. Page 38. Berlin, Berghem.



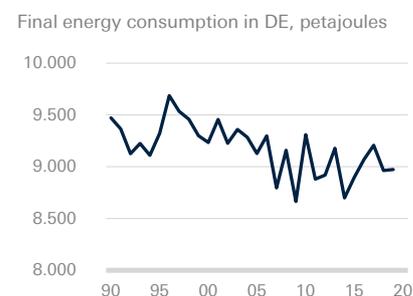
**Thesis: Fossil fuels will continue to account for the largest share of primary energy demand in Germany in the coming years. Nevertheless, their percentage will continue to decrease.** The declining importance of coal and nuclear energy (percentage of nuclear energy in 2020: 6%) is likely to be offset by an increasing percentage of natural gas and renewable energies. Nevertheless, a complete shift away from fossil fuels in the coming decades seems unrealistic. Their share has “only” fallen by 11 percentage points in the last 30 years. It can be debated whether primary energy demand is the right indicator when analysing the importance of renewable energies. After all, primary energy demand could be lowered by reducing conversion losses, which are quite high in thermal power plants (coal), for example, if the waste heat cannot be used for district heating. Nevertheless, there are also conversion losses when using renewable energies. These will tend to increase in the future if electricity from renewables is increasingly used for the production of liquid or gaseous energy carriers such as hydrogen or synthetic fuels (power-to-X, P2X) as part of the desired sector coupling. It should be noted that after 20 years of the EEG (German Renewable Energy Sources Act), the percentage of primary energy demand in Germany accounted for by wind power and photovoltaics is well below 10%. At the same time, the share of bioenergy (due to the limited availability of biomass) and hydropower (such as topographical restrictions) cannot be expanded at will. Given that coal accounts for less than 16% of total primary energy demand, it is also clear that the phase-out of coal-fired power generation, while significant, is not a game changer for overall energy use, especially as it is only partially replaced by renewables.

#### Final energy consumption only slightly lower in long-term comparison

**Fact: In 2019, total final energy consumption in Germany was just over 5% lower than in 1990.** Official figures for 2020 are not yet available, but last year alone final energy consumption is likely to have fallen by at least 5% due to the crisis. When it comes to the question of what energy is ultimately consumed for in Germany, a distorted perception sometimes prevails. The most important energy sources in final energy consumption are fuels (such as diesel, petrol) with 29.9% (2019), which are mainly used in the transportation sector. Gases follow in second place (25.5%). They are used in private households and in commerce for the generation of space heat as well as for industrial processes. Electricity is in third place, accounting for only one fifth of Germany’s total final energy consumption. From a sectoral perspective, the most important consumer of final energy is the transportation sector, followed by industry, private households and the trade, commerce and services sector. Industry, for example, is the most important consumer of electricity in Germany. When electricity generation plants based on renewable energies are newly connected to the grid, their performance is often measured in terms of how many households can (theoretically) be supplied with electricity by these plants. Such figures appear quite impressive at first glance. To classify these comparisons, however, it is helpful to know that the electricity consumption of all private households in Germany accounts for only 5% of total final energy consumption or 25% of total electricity consumption and is thus less relevant.

**Thesis: Final energy consumption in Germany will continue to decline. Increasing energy efficiency is a permanent driver in this regard. How quickly final energy consumption will fall in the future depends not least on climate policy measures (such as CO<sub>2</sub> pricing, regulation) and thus on the price development for final energies (such as fuels, electricity) including state taxes and fees.** Of course, the level of energy prices remains politically contentious. The loss of importance of energy-intensive industries in Germany is likely to continue and thus also contribute to the decline in final energy consumption. In the sectors concerned, this is likely to

Figure 12: Final energy consumption decreases only slightly\*



\* Official data for 2020 not yet available

Source: BMWi



be accompanied by a loss of domestic added value. The share of electricity in final energy consumption will increase because more sectors (mobility, space heating, industrial processes) are supposed to be supplied with electricity in the future.

### Electricity consumption in Germany on the rise

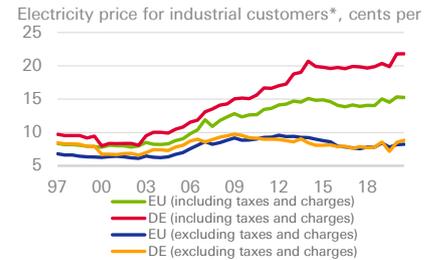
**Fact: Gross electricity consumption in Germany in 2000 was roughly at the same level as in 1990 (552 terawatt hours, TWh). Without the coronavirus crisis effect, electricity consumption would have exceeded the value of that time.** However, it had already fallen slightly in 2018 and 2019, due to the weak economy in energy-intensive sectors (such as chemicals) in those two years.

**Thesis: Electricity consumption in Germany will increase in the coming years. The main reason for this is that larger parts of the transportation sector (for instance, electromobility) and the heating market (heat pumps) are to be supplied with electricity (sector coupling).** In addition, electricity is to be used increasingly in the future for the production of hydrogen and (other) synthetic fuels. Further efficiency gains or a shrinking capital stock in energy-intensive industries are likely to be more than offset by the additional demand. In a recent analysis, the Cologne Institute of Energy Economics (EWI) expects electricity consumption to reach 685 TWh by 2030.<sup>5</sup> That would be 24% more than in 2020. **It is one of the major political inconsistencies of the energy transition that the German government has so far assumed that electricity consumption will remain more or less stagnant until 2030, although it is pursuing the goal of supplying larger parts of the national economy with electricity in the future.** Here, too, a look at the energy industry dimensions helps: In 2019, final energy consumption for space heating and water heating in Germany was just under 793 terawatt hours (TWh). This exceeds the total gross electricity generation of the same year by more than 30%. Added to this is the final energy consumption of the transport sector, which amounted to around 756 TWh in 2019, exceeding total gross electricity generation in Germany by 24%. Even if only small parts of the heat market and transport sector are to be electrified, this will lead to a noticeable increase in electricity demand. A theoretical calculation example helps to illustrate the dimensions: If the entire final energy consumption of the transport sector were to be covered by electricity, it would require, for example, the amount of electricity generated by 86 nuclear power plant units, each with 1 GW of installed capacity, running at full load all day, 365 days a year (86 times 1 GW times 8,760 hours = 753 TWh). Alternatively, the amount of electricity required would be equivalent to 108,000 wind turbines, each with 3.5 megawatts of installed capacity and 2,000 full-load hours per year (108,000 times 3.5 MW times 2,000 = 756 TWh). Conversion losses are excluded in both calculation examples. This is, of course, a consideration of the status quo. Thus, the absolute final energy consumption of the transport sector could decrease through efficiency gains or traffic avoidance. However, this had not been achieved in the last 30 years (before the coronavirus crisis). Ultimately, however, this is primarily a presentation of the rough dimensions. By way of comparison: At the end of 2020, there were 29,608 onshore wind turbines in Germany.

### Power consumption: Renewables now most important source of electricity

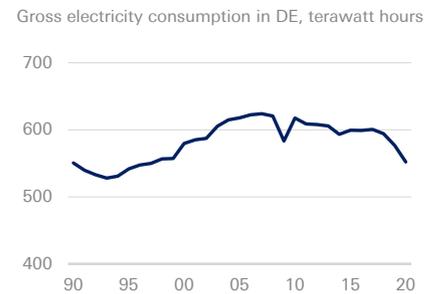
**Fact: The share of all renewable energies in gross electricity generation in Germany rose to a new record high of just under 44% in 2020.** The favourable

Figure 13: Transport most important sector for final energy consumption



Source: Eurostat

Figure 14: Gross electricity consumption before corona fairly stable



Source: AG Energiebilanzen

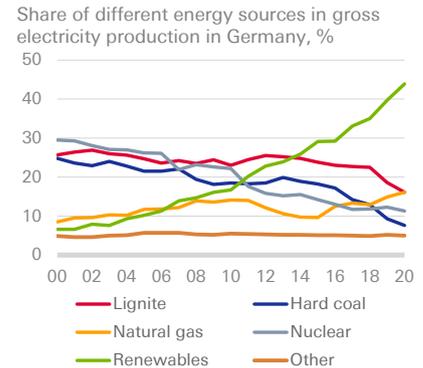
<sup>5</sup> Cf. EWI (2021). Impact of the EEG (German Renewable Energy Sources Act) 2021 on the proportion of renewable energies in electricity demand in 2030. Cologne.



weather conditions and the overall lower demand for electricity were the main reasons for this increase in proportion. Natural gas and lignite each accounted for around 16% of gross electricity consumption, while nuclear energy accounted for 11% and was thus ahead of hard coal (2020: 7.6%). Other sources (such as pumped-storage hydroelectricity and waste incineration plants) accounted for just under 5%.

**Thesis: The percentage of renewables in gross electricity generation will continue to rise because this is where the greatest expansion will take place and at the same time conventional power plant capacities are to be taken off the grid (nuclear energy, coal-fired power plants). The expansion will mainly take place in the wind power and photovoltaics sectors. The necessary investment costs until 2030 are (significantly) more than EUR 100 billion.** The German government has set itself the goal of increasing the share of renewables to 65% by 2030. Assuming a gross electricity consumption of 685 TWh in 2030 and neglecting electricity imports and exports for the sake of simplicity, the annual gross electricity generation of renewables would have to increase by 77% by then compared to 2020 (from 251 billion kWh in 2020 to about 445 billion kWh in 2030). Since mainly photovoltaics and wind power are to be added, the new generation capacity to be installed by 2030 would have to increase even more strongly compared to 2000. This is due to the fact that these two forms of generation have a very low annual average capacity utilisation compared to biomass-based power plants.<sup>6</sup> The necessary minimum of additional capacity to be installed is already more than 100 gigawatts (GW). This means that the additional nominal capacity alone would be above the current peak load in Germany, which exceeds 80 GW. The higher the share of photovoltaics, the more capacity would have to be added, because photovoltaics has by far the worst annual average capacity utilisation of all renewable energy sources (2020: a little over 11%). With a higher share of offshore wind power plants, the necessary capacity addition would be lower because these plants have a higher capacity utilisation (2020: approx. 40%). The addition of more than 100 GW of installed renewable energy capacity by 2030 is an ambitious undertaking. By way of comparison: As of mid-June 2020, a total of 123.5 GW of renewable generation capacity was installed. The biggest hurdle to expansion is not likely to be the fundamental political will, as politicians are sometimes accused of. Rather, it should be noted that planning and approval processes take some time, local citizen protests, such as against wind turbines, are likely to increase, the implementing companies cannot expand their capacities at will, many good locations for renewable energies are already occupied and some older plants will be taken off the grid in the next decade. Of course, the necessary investment funds must also be raised. The amount depends on the additional capacities that are created. For example, offshore wind turbines are significantly more expensive per megawatt of installed capacity than onshore wind turbines or photovoltaic systems. The higher investment costs for offshore wind power are offset on the plus side by more full-load hours. If we assume average investment costs of EUR 1 million per megawatt of nominal capacity for a mix of onshore and offshore wind power and photovoltaics, we would arrive at investment costs of EUR 100 billion for an expansion of 100 GW by 2030. This is likely to be the lower limit of the investment

Figure 15: Renewables gain ground, nuclear energy and coal lose



Source: AG Energiebilanzen

<sup>6</sup> To calculate the annual average capacity utilisation, the full-load hours is needed first. This number can be determined from the ratio of electricity generation (in watt hours) in a specific year to the installed capacity or rated power (in watts). These full-load hours are then set in relation to the total number of hours in a year. Calculation example: 10 gigawatts of nominal capacity are installed from one energy source. If these generation capacities produce 65,000 GWh of electricity in one year, then 6,500 full-load hours are calculated. In relation to the annual number of hours of 8,760, this results in a capacity utilisation of just over 74%.



volume required. In addition, there are investments for grid expansion. According to the second draft of the grid development plan for electricity from the end of April, these are over EUR 70 billion for onshore grids until 2035. This adds up to investments for offshore connections of EUR 33 to 55 billion (also until 2035).

### Distinction between power generation and installed capacity, important

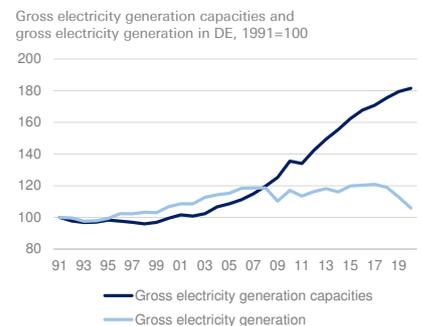
**Fact: The average share of renewable energies in gross electricity consumption or in gross electricity generation within a year does not indicate much about their contribution to the assured capacity.** It is the power that is most likely to be constantly available. Since wind power and photovoltaics are dependent on the weather and solar irradiation, respectively, their contribution to the guaranteed capacity is significantly smaller than the installed capacity. The German Energy Agency's (dena) "Integrated Energy Transition" pilot study from 2018 states the following: "Non-controllable offshore wind can contribute 5% and onshore wind 1% of the installed capacity to the secured capacity, while photovoltaic makes no contribution [to covering the annual peak load]."<sup>7</sup> Although online sources indicate that approx. 6% of the installed capacity of onshore wind power plants can be attributed to the secured capacity, the discrepancy would still be enormous even with this value. Regardless of their contribution to covering the peak load, the total installed capacity of the photovoltaic systems accounts for only a marginal part of the electricity supply for many weeks in the winter months. The idea that wind power and photovoltaics can only supply electricity when the wind is blowing or the sun is shining is actually banal. However, it is often only a marginal note in political discussions. It is true that at least wind power always accounts for a certain amount of electricity supply, because the wind is always blowing "somewhere" in Germany. However, extended periods of widespread "dark doldrums" are not uncommon (nights with little wind, stable high-pressure weather conditions in winter with heavy fog).

**Thesis: For the time being, the discrepancy between installed capacity and secured capacity in weather-dependent renewable energy remains one of the fundamental technological problems of the energy transition, for which a comprehensive, feasible and cost-effective solution that can be realised in the medium term has yet to be found.** We will come back to this. First, however, we will discuss other facts and present propositions that pertain to this topic area.

### Massive expansion of power generation capacities

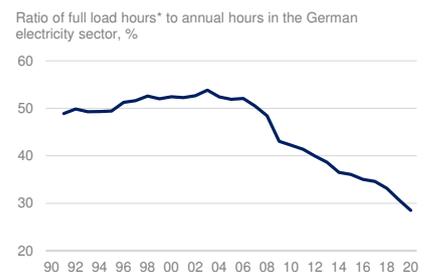
**Fact: The installed electricity generation capacity in Germany has increased significantly in recent years. Most of the expansion is related to wind power and photovoltaics. As a result, capacity utilisation in the entire power sector has decreased significantly.** In 2000, total capacity was at about the same level as in 1991 (125.5 GW). So there was a buffer above the peak load (even then already a little over 80 GW) of more than 50%. This surplus capacity was held in reserve for maintenance and repair work on the power plant network, etc. In 2000, more than 90% of the installed power plant capacity was still generated by fossil fuels and nuclear energy. From 2000, the year the EEG (German Renewable Energy Sources Act) entered into force, until 2020, the installed capacity in the German power plant network increased by more than 82%, reaching 229 GW in mid-2020. This means that the installed capacity exceeds the peak load by more than 180%. As of the middle of last year, wind power (onshore and offshore) and photovoltaics together accounted for 113 GW, almost 49% of the total nominal capacity. By contrast, in the

Figure 16: Power generation capacities grow rapidly



Source: BMWi, Deutsche Bank Research

Figure 17: Capacity utilisation in the German power sector declines



\* Ratio of gross electricity generation in a year to installed capacity at the end of the year; for 2020, installed capacity at the middle of the year

Source: BMWi, Deutsche Bank Research

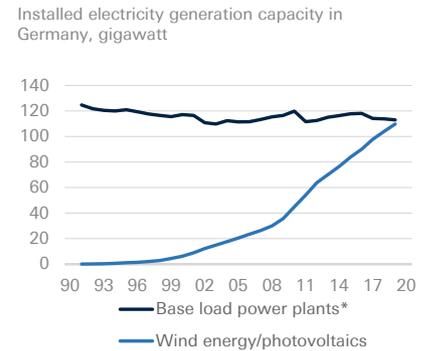
7 German Energy Agency (2018). Dena Integrated Energy Transition Pilot Study. Berlin.



last 20 years, capacities at hard coal and nuclear power plants have been reduced or shut down quite significantly. Lignite-fired power plants are experiencing only slight losses. However, the installed capacity of gas-fired power plants has increased by about one third since 2000. The installed capacity of conventional power plants is still large enough to fully cover the peak load in Germany. In mid-2020, this amounted to just under 92 GW, covered mainly by coal-fired, gas-fired and, to a lesser extent, nuclear power plants. Biomass and hydropower plants contribute to the assured capacity as well. In addition, there are fossil power plant capacities that are currently (still) assigned to the grid reserve or emergency standby or have been temporarily shut down, but can be ramped up in the winter months if there is not enough capacity available (about 10 GW). **The bottom line is that it has not yet been feasible to reduce the capacities of conventional power plants to a greater extent because of the low level of secured capacity for weather-dependent renewable energies.** The expansion of renewable power generation capacities (with only a slight reduction in conventional capacities at the same time) has led to a dramatic drop in average capacity utilisation in recent years. Weather-dependent renewables inherently have low full-load hours. Because of their low marginal costs in electricity production (see below) and feed-in priority, they are also displacing conventional power plants, where capacity utilisation is falling. In 2000, the ratio of full-load hours to the total number of hours in the year was about 52% for the entire power plant network. In 2020, it was only 28%.

**Thesis: The installed capacity in power generation plants will continue to grow. Due to the political course that has been established (EEG 2021), the expansion will continue to take place primarily in wind power and photovoltaics. Although electricity consumption and, in the medium term, the peak load in Germany will increase, capacity utilisation in the electricity sector is likely to trend downwards. This is also related to the planned closure of conventional power plant capacities. The focus is increasingly on the reliability of the electricity supply which may be in jeopardy.** According to the EEG 2021, the nominal capacity of onshore wind power plants is to increase from just under 54 GW (mid-2020) to 71 GW by 2030. An expansion from 51.5 GW to 110 GW is planned for photovoltaics. Germany's Wind Energy at Sea Act envisages a nominal capacity of 20 GW for offshore wind energy in 2030 (compared to 7.7 GW in mid-2020). Following the stricter German Climate Change Act, it is likely that the expansion targets will be raised after the Bundestag elections in September 2021 even further. Even without more stringent measures, these three energy sources alone would account for more than 200 GW of installed capacity in 2030 if these plans were implemented. However, their contribution to assured capacity would be considerably lower because of their dependence on the weather. Even assuming an optimistic share of secured capacity of 5% of the average installed capacity of the three energy forms (onshore and offshore wind power as well as photovoltaics), their secured capacity would only be just over 10 GW. At the same time, the peak load in Germany is likely to increase if significant parts of the transport sector as well as the heating market are to be supplied with electricity by 2030 or even 2050. The cited dena pilot study from 2018 states the following in this regard: "The average peak power during the two-week cold "dark doldrums" in 2050 will correspond to about 90 GW in the technology mix scenarios and 150 GW in the electrification scenarios. The majority of the demand for power consumption comes from the building and industrial sectors."<sup>8</sup> The peak load will therefore continue to occur mainly on working days (industrial production) in the cold season (space heating

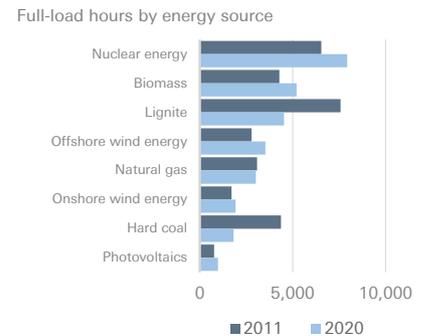
Figure 18: Little change in base-load capable power plants



\* Fossil fuels, nuclear energy, biomass and hydropower

Source: BMWi

Figure 19: Full-load hours decline, especially for coal-fired power plants



\* Due to the shutdown of several nuclear power plants in 2011, we have used the data for 2010 instead of 2011 for nuclear energy.

Source: BMWi, Federal Network Agency, Federal Wind Energy Association, Deutsche Bank Research

8 German Energy Agency (2018). Dena Integrated Energy Transition Pilot Study. Berlin.



consumption). However, electricity generation from photovoltaics will continue to be very low in the winter months and completely absent at night. The gap between the secured capacity of renewables and the future peak load is therefore vast.

At the same time, conventional power plant capacities will be taken off the market within the next few years. According to the Federal Network Agency (Bundesnetzagentur), more than 12 GW net of supply-independent (in other words, weather-independent) power plant capacity will be eliminated by 2023 alone (nuclear phase-out, start of coal phase-out). **The question therefore arises as to how electricity demand (extended “dark doldrums” and peak load) is to be met in the future when electricity consumption increases, secured capacity is taken off the grid, when there is no new construction of conventional power plants due to the low expected capacity utilisation and newly created generation capacities are predominantly weather-dependent.** The German Federal Audit Office already warned of short-term gaps in the electricity supply in a recent report. It states: “Given the deviation of the adopted coal phase-out path from the previous planning, a gap of up to 4.5 GW of secured capacity can be expected from 2022 onwards due to the coal phase-out.”<sup>9</sup> In order to recognise the relevance of the reliability of supply issue, it is therefore not necessary to look into the year 2030 or 2050. Apparently, (1) imports of electricity, (2) load management and (3) electricity storage are to secure any gaps in the electricity supply.

Regarding (1): The above mentioned dena pilot study states the following with regard to power imports: “For instance, the electricity output imported in the long-term and climate scenarios commissioned by the Federal Ministry for Economic Affairs and Energy (BMWi) peaks at about 50 GW, even during the “dark doldrums”. The dena study defines a rather restrictive assumption that a maximum of 5 GW of power can be imported to cover the output requirement.”<sup>10</sup> The BMWi’s 2019 monitoring report on supply reliability states that Germany will be dependent on electricity imports of up to 20 GW in 2030 at peak times.<sup>11</sup> To recap: This corresponds to about a quarter of the current peak load. It is a fact that electricity imports and exports already serve to balance the load within Europe. In 2020, Germany’s peak net exports of electricity were over 12 GW, while the maximum net imports on individual days were just under 8 GW. And of course making the European electricity grids more integrated, for instance, through grid expansion, is a good idea so that peaks in supply and demand can be better balanced in the future. The crucial question, however, is whether Germany wants to rely on foreign countries always stepping into the breach and reliably supplying electricity in the event of a prolonged coverage gap. It is also interesting from an ecological point of view from which sources the imported electricity should come. Stable high-pressure weather conditions in the winter months often do not stop at the country’s borders. Photovoltaic capacities cannot produce electricity all over Europe at night. Therefore, it is to be expected that at least part of the imported electricity will continue to come from conventional power plants (including nuclear energy from France or the Czech Republic).

Side note: From an economic point of view, it should be noted that Germany’s

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9 Bundesrechnungshof (German Federal Audit Office) (2021). Report pursuant to Section 99 BHO (German Federal Budget Code) on the implementation of the energy transition with regard to reliability of supply and affordability in electricity. Bonn.

10 German Energy Agency (2018). loc. cit.

11 BMWi (2019). Monitoring report of the German Federal Ministry for Economic Affairs and Energy pursuant to § 63 in conjunction with § 51 of Germany’s law on the energy industry (EnWG) on the reliability of grid-based electricity supply. Berlin.



foreign trade in electricity is negatively correlated with the price of electricity. This means that Germany usually exports a particularly large amount of electricity when the exchange price is low. This is the case, for example, when a lot of renewable electricity is available and the electricity price falls because of the low marginal costs of renewables. A lot of electricity is then exported to Austria or Switzerland, where the electricity is used to pump water from the lower to the upper storage basin in pumped storage power plants, for example. In contrast, Germany usually imports electricity at high prices, specifically when it is in short supply. In terms of volume, Germany was again a net exporter of electricity in 2020 (67.1 TWh exports versus 47.1 TWh imports; balance: 20 TWh). The net exports are partly due to the fact that conventional power plants (especially lignite and nuclear) cannot be shut down fast enough when conditions are good for wind power and photovoltaics. Net exports decreased by 39% compared to 2019 (32.7 TWh). From a monetary perspective, the net export surplus actually fell by 69% (from EUR 1.096 billion in 2019 to EUR 0.337 billion last year) as a result of low wholesale electricity prices. On average, 1 kilowatt hour of net electricity export was thus remunerated at only 1.685 cents, while the average wholesale electricity price in 2020 was 3.047 cents per kWh.

Concerning (2): With regard to **load management**, hopes rest on the fact that in the future large consumers can be taken off the grid for a short time in the event of temporary power shortages. Such demand side management is already happening today. Henrik Paulitz from Akademie Bergstraße (Bergstrasse Academy) gives some examples of this in his book with the descriptive title “StromMangelWirtschaft” (“Power Shortage Economy”) and also explains the problems that result from interruptions in production.<sup>12</sup> It is true that the large industrial consumers (such as from the metal production industry) are financially compensated for their “load shedding”. Such unreliability in the electricity supply is however certainly not a good indicator for Germany as an industrial location. The capital stock of the energy-intensive industries (chemicals, metal production, building materials, paper) in Germany has been shrinking quite steadily for years. In our view, the absolute electricity price is not the main reason for this. This is because of exemptions in the EEG and the EU Emissions Trading System (EU ETS) for energy-intensive sectors. As a result, electricity prices for these customers are quite low and internationally competitive. What is more important is the uncertainty among companies as to whether these special regulations will still apply in five, ten or more years. Temporary power cuts or grid instabilities are an additional adverse factor for the location. The “Die Familienunternehmer” (“The Family Business Owners”) association published a position paper on the EU’s Green Deal in 2020: “Reliability of supply is probably the last great advantage of Europe and Germany as a business location over its global competitors. Unfortunately, this asset is also coming under increasing threat.”<sup>13</sup> It also represents a huge paradigm shift for a rich industrialised country like Germany that electricity should no longer always be available around the clock. When it comes to load management, what dimensions are we talking about? The second draft of the grid development plan for electricity from the end of April 2021 expects 4 to 8 GW of demand-side flexibility through load shedding by 2035, depending on the scenario. The dena Integrated Energy Transition pilot study predicted a value of just under 7 GW by 2050. On its homepage, dena puts the industrial DSM (demand side

Figure 20: Real net fixed assets have declined in energy-intensive sectors



Source: Federal Statistical Office

12 Cf. Paulitz, Henrik (2020). StromMangelWirtschaft. Warum eine Korrektur der Energiewende nötig ist. (“Why we need to adjust the energy transition”) Seeheim-Jugenheim.  
13 Die Familienunternehmer (2020). European Green Deal. A critical assessment by Die Familienunternehmer. Berlin.



management) potential at 5 to 15 GW. Each of these are significant capacities. It is also clear, however, that these can only be used to bridge bottlenecks that last a few hours at the most. The capacities are not suitable and not large enough to compensate for coverage gaps over several days due to unfavourable weather conditions. The fact that load management involves costs is also undisputed. These can, of course, be lower than maintaining reserve power plants that only run for a few hours or days a year.

Concerning (3): **Electricity storage systems** have so far also failed to provide a satisfactory solution to the problem of possible supply bottlenecks lasting longer than just a few hours. Pumped storage power plants cover about 99% of electricity storage capacity worldwide. The basic principle has already been briefly outlined above: In such power plants, there is a difference in elevation between two storage reservoirs. When there is a surplus of electricity or when electricity prices are low, water is pumped from the lower basin to the upper basin. When there is a power shortage or high electricity prices, water flows from the upper basin through a turbine into the lower basin, generating electricity. Such power plants dominate the storage market in Germany as well. The German Energy Agency values the net nominal capacity of pumped storage power plants in Germany at 9.6 GW. Lower figures of less than 7 GW can also be found in the literature. There has been no significant increase in capacity in recent years, nor is there any prospect of one. Plans for new developments have failed in recent years, not least due to the resistance of the local population. The grid development plan does not include a significant increase in nominal capacity until 2035. According to AG Energiebilanzen, pumping work of 8 TWh was offset by 6.1 TWh of output from the power plants in 2020 across all load cycles. Thus, the export accounted for a little over 1% of the total gross electricity generation. A more relevant question than this annual average analysis is how long all pumped storage hydroelectric power plants in Germany would be able to compensate for a prolonged supply shortfall if the upper storage reservoirs were completely filled. An article from 2017 estimates the maximum storage energy content of all pumped storage plants in Germany at just over 37 gigawatt hours (GWh) per load cycle.<sup>14</sup> Let's round the figure up to 40 GWh. Again, a calculation example will illustrate the dimensions: If a 14-day winter supply gap of only 20 GW were to be bridged with electricity storage, a storage energy content of 6,720 GWh would be required. This means that the current capacity of all pumped storage hydroelectric power plants in Germany would have to be increased by a factor of 168. It is true that there are pumped storage hydroelectric power plants in the neighbouring Alpine region (Austria, Switzerland) or in Norway from which Germany can draw electricity. But even these capacities are far from sufficient to bridge prolonged supply bottlenecks. Moreover, Germany has no right to use these capacities (exclusively) for itself. Battery storage systems linked to photovoltaic systems in private households or small businesses (PV battery storage systems) cannot compensate for prolonged (in other words, several days) supply bottlenecks either, although an increase in this area is likely in the coming years. The draft grid development plan lists between 11 and just under 17 GW by 2025, depending on the scenario. However, these are actually intended to supply electricity to the respective households. We will come back to the role of hydrogen as a potential battery storage system later.

**Summary:** It is obvious that the issue of supply reliability will become more

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<sup>14</sup> Cf. Heimerl, Stephan and Beate Kohler (2017). Aktueller Stand der Pumpspeicherkraftwerke in Deutschland. ("Current status of pumped storage hydroelectric power plants in Germany") In: WasserWirtschaft (Water resource management) 10/2017.



important in the coming years (this does not refer to the short-term, isolated power outages at households, which averaged a record low of just over 12 minutes in 2019). The issue of supply reliability is also not about the symbolic question of how fast coal-fired power generation can be phased out. Of course, this could succeed before 2038 if enough other secured power (gas-fired power plants) were available. Perhaps the rising price of CO<sub>2</sub> will drive coal out of the German electricity sector well before 2038 without politics having to do anything about it. Nevertheless, the laws of physics and economic restrictions outlined above could persuade policymakers to leave conventional power plants in some form of capacity reserve for longer than planned and to remunerate the plant operators accordingly. No government will have an interest in jeopardising the reliability of supply.

### Renewables can already cover the entire electricity load in phases

**Fact: There are already times of day when Germany's whole electricity consumption is covered entirely arithmetically by renewable energies.** For example, the share of renewables in the grid load was 112% on 17 May 2020 between 2:00 p.m. and 3:00 p.m., according to the German Federal Network Agency. Admittedly, this was a Sunday in times of the coronavirus pandemic, so industry had little demand for electricity. Nevertheless, this is substantial. That day also saw net exports of electricity as well as negative electricity prices at times.

**Thesis: With the further expansion of renewable energies, the periods when renewable electricity covers the entire power consumption or when the electricity supply exceeds the current demand will increase. In the event of supply surpluses, the stock exchange electricity prices come under pressure.** The stock exchange electricity prices are likely to slip more frequently into negative figures. According to the German Federal Network Agency, there were a total of 298 hours with negative (day-ahead) wholesale electricity prices in 2020; this represents an increase of 41% compared to 2019. Unless there are state or privately negotiated price guarantees for the operators of renewable electricity generation plants, this lowers the potential income from electricity sales and makes it more difficult to amortise the investments.

### Surplus electricity production to (also) be stored in the future

**Fact: The political objective is to store the surplus production of electricity from renewable energies in the future or to convert it into synthetic fuels. The production of "green hydrogen" or P2X technologies based on renewable electricity are expected to play a major role.** According to the German government's National Hydrogen Strategy of 2020, hydrogen is to play "a central role in the further development and completion of the energy transition".

**Thesis: In order for green hydrogen to make a significant contribution to a climate-friendly energy supply of the future, it must be produced in large quantities, at low cost and with as little CO<sub>2</sub> as possible.** Major economic and technological hurdles will need to be faced. Moreover, there are challenges with the transport and storage of hydrogen. Pure green hydrogen, i.e., produced exclusively on the basis of renewables, will remain scarce and thus expensive in the coming years. As always, a look at the orders of magnitude can be helpful: The German government expects domestic green hydrogen production of up to 14 TWh by 2030. This corresponds to just under 0.6% of total final energy consumption in Germany in 2019. Even if ten times the amount of domestically produced hydrogen



could be imported in addition, the total contribution would be modest.<sup>15</sup> Large-scale hydrogen imports would also require production capacities abroad that do not yet exist, as well as the corresponding transport and distribution infrastructure. Another example: The Linde company is building the world's largest production plant for the generation and liquefaction of green hydrogen in Leuna/Germany. The plant is scheduled to go into operation in 2022. According to a company press release, the plant can supply 600 fuel cell buses with green hydrogen, for example, which travel a total of 40 million kilometres per year. That is quite an impressive figure. However, it should be taken into account that Berlin's transport companies alone operate 1,500 buses. We expect that green hydrogen will initially be used primarily in large-scale, location-based applications, such as in energy-intensive industries. For the time being, government subsidies will be required. Hydrogen is theoretically an energy multi-talent. Not least because of the high costs (initial investment in the necessary generation infrastructure, running operations including conversion losses, storage, transport, distribution), however, its contribution to the energy transition is likely to be limited in the next one to two decades.

### CO<sub>2</sub> intensity of German electricity supply drops

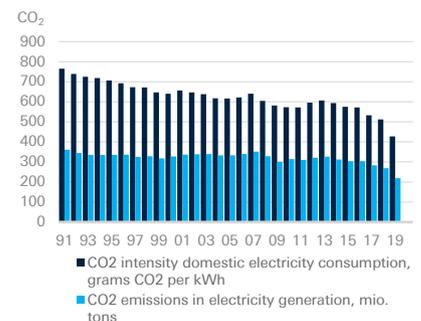
**Fact: The CO<sub>2</sub> intensity of German electricity generation has fallen steadily in recent years. At 427 grams per kilowatt hour of domestic electricity consumption, CO<sub>2</sub> emissions in 2019 were just under 40% below the 1995 level.** The expansion of renewable energy sources has contributed significantly to this, even though their specific CO<sub>2</sub> emissions per kWh are not zero. In addition, the loss of importance of coal-fired power generation has contributed to the declining CO<sub>2</sub> intensity.

**Thesis: The CO<sub>2</sub> intensity in the German electricity mix will continue to fall. A marked decline is likely to have already occurred in 2020 due to the coronavirus crisis and favourable weather conditions. The phase-out of nuclear energy will lead to an increase in the CO<sub>2</sub> intensity ceteris paribus. However, this could be overcompensated after a short time by a further increase in renewables and the commencement of the coal phase-out.** How quickly the CO<sub>2</sub> intensity will fall depends on the speed of the coal phase-out and the expansion of renewable energies, but also on the development of the demand for electricity. The more this figure rises, the longer gas-fired power plants are likely to play a role. In a study from 2020, the Fraunhofer Institute for Solar Energy Systems (ISE) calculates a CO<sub>2</sub> emission factor of just under 150 g/kWh for electricity supply in 2030 in the reference scenario. That would be more than 50% of what it is today.

### Electricity prices in Germany are among the highest in the world

**Fact: Electricity prices for private households and most businesses in Germany have risen in recent years. Taxes and fees are the main driving factors for this. For commercial customers, for example, electricity prices in the second half of 2020 were 45% higher than in the first half of 2015 and more than 170% higher than in 2000.** Electricity prices in Germany, including all taxes and charges, currently exceed the EU average by 43% for commercial customers and by 41% for private households. Excluding taxes and fees, the difference to the EU average is only just under 8% and 9%. According to BDEW (Bundesverband der Energie- und Wasserwirtschaft e.V. – the German business organisation for the energy and water industry) just over 51% of the electricity price for household customers in 2021 are

Figure 21: CO<sub>2</sub> intensity in the German power sector declines



Source: Federal Environmental Agency

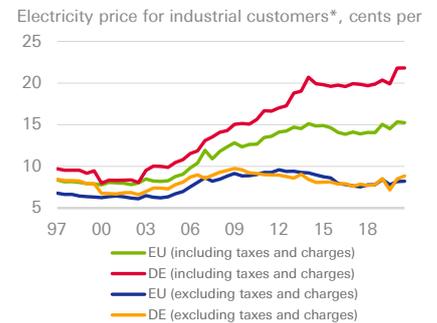
15 For more details, see Heymann, Eric (2021). Green hydrogen as a source of energy: The trillion-euro question. Deutsche Bank Research. Talking Point. Frankfurt am Main.



made up of taxes, levies and surcharges. Regulated grid fees account for a further 23.5%. According to BDEW, the EEG surcharge alone accounts for almost 40% of all government price components (taxes, levies and surcharges) for private households in 2021, and this despite the fact that the EEG surcharge has been reduced and the financing of renewables is now partly paid from general budget funds. **Without this federal subsidy, the EEG surcharge would not be 6.5 cents per kWh in 2021, but around 9.6 cents per kWh.** In absolute terms, the so-called EEG differential costs (in other words, the remuneration and premium payments to the operators of renewable energy plants minus the marketing revenues of the grid operators from the sale of electricity from these plants) amounted to EUR 25.5 billion in 2019. The electricity prices for large consumers are significantly lower than for normal commercial customers due to various special regulations in the EEG or EU emissions trading. These benefits are granted so that Germany can remain competitive as a location for energy-intensive industries. We have already explained above that for the energy-intensive large consumers the main problem is not so much the current electricity price, but rather the uncertainty as to how long the special regulations can still be granted. But it is also a fact that, according to BDEW, 96% of all industrial companies in Germany pay the full EEG surcharge.

**Thesis: The development of the price for electricity in the coming years depends above all on how policymakers want to finance the further expansion of renewable energies and the expansion of the grid.** For example, the EEG surcharge is to be reduced to 6 cents per kWh in 2022. The federal subsidy for financing renewables will be increased accordingly. Grid fees have risen steadily in recent years (for private households in 2021: 7.8 cent per kWh). The further expansion of the electricity grids would result in a continuation of this trend. Nevertheless, it is also conceivable that part of the grid costs will be financed through the budget in the future. At least it seems that a large number of politicians have recognised the competitive disadvantages for Germany as a business location if the energy transition continues to be financed through the price of electricity. Admittedly, the EEG surcharge could fall for all electricity customers if the large consumers paid the same surcharge as the other electricity customers. However, this would be an immense competitive disadvantage for the location in international comparison, which would result in an accelerated shrinking of the capital stock in the relevant sectors. In addition, the price of electricity is also likely to become an increasingly important location factor for non-energy-intensive sectors in the future if production is to be further automated and digital technologies increasingly used. Further financing of the energy transition through the electricity price also causes social distortions, because low-income households suffer more from high electricity prices than wealthy ones. A figure in this regard: According to the German Federal Network Agency, 6.6 million disconnection threats were issued to private electricity customers in 2019. The discussion about electricity prices often includes arguments about whether renewable forms of electricity generation are cheap or expensive. **The answer: Renewable energies are cheap and expensive at the same time.** It depends on how you look at it. A distinction should be made here between the marginal costs of electricity generation, the electricity production costs and the total costs of the expansion of renewables (system costs). In terms of **marginal costs**, in other words, the cost of an additional kilowatt hour of electricity, wind power and photovoltaics are unbeatably cheap. The saying that the sun and wind do not send a bill applies here. Once the system is up and running, the additional kilowatt hour costs (almost) nothing. The **levelised cost of producing electricity** includes the initial investment costs, the fixed and variable operating costs and the capital costs. These are compared to the amount of electricity generated. These are more or less the costs that an investor pays attention to from

Figure 22: Taxes and charges are the main drivers of electricity prices in Germany



Source: Eurostat



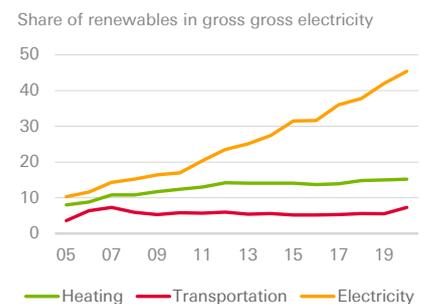
a business perspective. In terms of the **levelised cost of electricity**, renewable energies have made enormous progress in the last 20 years. According to a 2018 study by Fraunhofer ISE, they range from 4 to just over 10 cents per kWh for onshore wind power or photovoltaics, for example, depending on the location and type of system.<sup>16</sup> These are competitive costs compared to new conventional power plants to be built and an enormously positive side effect of the German energy transition. As a rule, the levelised cost of electricity is meant when stating that renewables are now cheaper than conventional power plants.

The total **system costs** of the expansion of renewables, on the other hand, play only a subordinate role in the public discussion. These include the fact that – as explained above – the capacity utilisation of the entire electricity sector decreases when more renewables are connected to the grid. This causes higher costs for the operators of the conventional plants. The start-up and shut-down of thermal power plants also involves costs, depending on the amount of wind or solar radiation. Many traditional power plants are only partially designed for this. In addition, there is the grid expansion, which is at least partly triggered by the expansion of renewables, or the provision of reserve capacities. In addition, the grid operators have to carry out grid and system safety measures more frequently; according to the Federal Network Agency, the costs incurred for this amounted to EUR 1.4 billion in 2019. This includes, for example, curtailing the feed-in of renewable energies for reasons of system safety (for example, when there is too much wind and the demand for electricity is low). System operators are compensated for this. In the future, investments in electricity storage will also be part of the system costs associated with the expansion of renewables. All in all, these system costs contribute to the fact that the electricity price in Germany is one of the highest in the world despite the lower electricity production costs for renewables. Renewable energies would be more competitive compared to fossil energy sources if their **external costs** were internalised to a greater extent. It is, of course, difficult to quantify the exact amount of these external costs. The CO<sub>2</sub> price in EU emissions trading has risen sharply in recent months. This results in a greater internalisation of external costs. As a result, coal is already being pushed back in favour of gas. This trend is likely to continue without any additional political decision to phase out coal. However, it is also true that external effects exist for all forms of energy that are not or only partially internalised. Fossil energy sources are dominated by climate damage. In the case of renewables, for example, interventions in natural and cultural landscapes are noteworthy. Citizen protests against the erection of wind turbines or against power lines can also be counted among the external effects.

### Transport sector: Reducing final energy consumption is difficult

**Fact: Final energy consumption in the transport sector makes up around 30% of Germany's total final energy consumption. In 2019 it was over 6% higher than it was in 2010, and more than 14% above the level of 1990. Energy consumption dropped slightly in 2018 and 2019.** It probably dropped significantly in 2020, because people travelled less during the coronavirus pandemic; but there are no official figures yet. However, setting aside the effect of the pandemic, energy efficiency gains in the transport sector have been more than offset by a greater total transport volume. The volume of freight transport has risen faster (+12% between 2010 and 2019) than passenger transport (+5% over the same period). The proportion of the transport sector's final energy consumption which came from renewable energies in 2020 rose to 7.3% in 2020. By far the dominant factor there

Figure 23: Progress of renewables still limited in the heating sector



Source: Federal Environment Agency

16 Cf. Fraunhofer ISE (2018). Levelized Cost of Electricity – Renewable Energy Technologies. Freiburg.

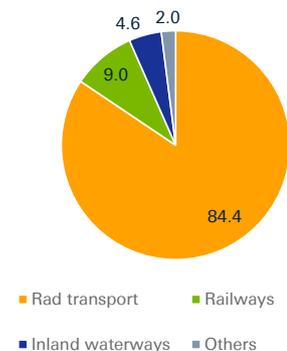


is bio fuel, which is added to petrol and diesel. A certain amount of the electricity used for rail transport and electric vehicles comes from renewable energy. But most of the final energy consumed by them is produced by fossil fuels, with a share of almost 93%. The transport sector's carbon emissions in 2019 were a little less than 7% above 2010's level.

**Thesis: Final energy consumption in the transport sector is likely to fall over the next few years. But a serious decline in energy consumption and associated carbon emissions can only happen if there is much less traffic. To achieve that, energy and climate policy regulation in the sector would have to be much tighter than it has been up to now. This would mean higher administrative prices for mobility and/or greater regulatory requirements, which are unlikely to come about without political and social resistance.** Aside from regulatory considerations, technical progress in propulsion and vehicle technologies is an important aspect of energy consumption. Therefore, the way governments price mobility and lay down regulatory law, and vehicle energy efficiency, are the dominant factors on the supply side. On the demand side, the development of industrial production, the industrial division of labour and the construction sector (transport of building materials and rubble) are major factors in future freight traffic development. The outlook for the coming decade is uncertain due to ambitious climate policies, especially relating to industrial production. Online retail continues to grow, which should accelerate demand for parcel services; the pandemic has been a catalyst in this. In passenger transport, personal mobility remains highly coveted and is part of the DNA of liberal societies, thereby making the enforcement of a significant reduction in transport volume, and therefore energy consumption, by state interventions fundamentally difficult, as exemplified by recent debates around banning short-haul flights or higher gasoline prices. It is true that more people now work from home, and will continue to do so at least some of the time after the pandemic. This reduces commuter traffic. More online conferences will also attenuate business travel. But private mobility remains a prized commodity, demand for which grows disproportionately as income grows. This is especially true when people go on holiday. **The share accounted for by renewable energies in the transport sector's final energy consumption will grow over the coming years.** This is the aim of the greenhouse gas reduction quota. It obliges businesses that put fuels into circulation to reduce the greenhouse gas emissions produced by their fuels. A draft law to develop this greenhouse gas reduction quota, which is currently in the midst of the legislative process, envisages this quota rising step by step to 25% by 2030; it was 6% in 2020. To achieve this aim, suppliers of fossil fuels (oil companies and petrol station operators) can credit their reduction quota whenever they place certain biofuels and electricity-based fuels on the market; the latter must be produced using renewables. Suppliers of fossil fuels can also purchase certificates from businesses that operate electric vehicle charging stations. They can then add the electricity used to charge vehicles to their own quota. This means a more profitable business model for businesses that operate the charging infrastructure. **Despite this regulatory control, many things stand in the way of a significant and genuine reduction in carbon emissions from the transport sector.** Consider vehicles, for instance, which are long-lasting consumer and capital goods (cars, heavy goods vehicles, ships, aircraft). Replacing vehicle fleets can take decades. The majority of vehicles on the road, therefore, will continue to be powered by fossil fuels for the next decade at least. Germany's roads, for example, are still likely to be populated by over 40 million passenger cars in 2030 that still will have a combustion engine. Heavy goods transport is based almost exclusively on diesel fuel. This industry may be working on greener solutions (overhead power lines for heavy goods vehicles on the motorways, hydrogen and

Figure 24: Road by far the most important mode of transport in freight traffic

Share of individual modes of transport in transport volume in Germany, 2019, %



Source: BMWi Verkehr in Zahlen



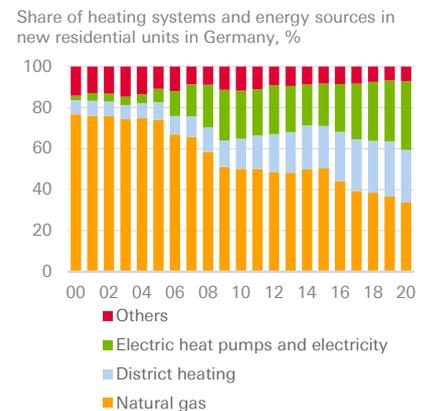
fuel cells, biofuels and synthetic fuels), but large-scale structural changes cannot be expected by 2030. The thing therefore most likely to significantly reduce carbon emissions is a significant reduction in transport volume. And there is yet another aspect: legislators may define electric vehicles as producing no emissions, but that is only the case on paper. Yes, the carbon footprint produced by electric cars will continue to improve compared with combustion engine vehicles over the next few years, as more renewable energy gets fed into the grid.<sup>17</sup> Furthermore, energy consumed and carbon emitted in the production of each battery should drop due to technical progress and the economies of scale. But all in all, growing numbers of newly registered electric vehicles will contribute little to the overall German carbon footprint in the years to come. This is without going into the fact that reducing carbon emissions through electric vehicles entails very high abatement costs, which studies estimate at over EUR 1,000 per tonne of CO<sub>2</sub> saved.<sup>18</sup>

Here is another thing to consider: policymakers have been trying for decades to shift freight transport from road to rail. But there are major capacity restraints. For one thing, shifting just 10% of what is carried on the roads today onto the railways would require a 90% increase in rail capacity. Because the German rail network tends to be fairly full in normal times (i.e. when there is no pandemic), its capacity to absorb additional traffic will remain small without major infrastructural expansion. This is unlikely to happen, because of limited financial resources, other political priorities, and, not least, resistance from those affected by new railway lines.<sup>19</sup> Were the government to divert freight traffic off the roads and onto the rails using regulatory policy, it would mean productivity losses in the sector and therefore higher costs. Heavy goods vehicles are by far the most important mode of carrying freight due to their flexibility and speed (productivity) and their share in total freight transport volume in 2019 was 84.5%. Cargo bikes are sometimes put forward as an alternative method of freight transport, which they may be for private shopping and inner-city couriers. But they are not a means of transport which can cause a tangible shift in the modal split in terms of transport quantity (tonnes carried) or transport volume (tonne-kilometres). That is why cargo bikes will not appear in any future goods transport statistics. Because cargo bikes cannot carry anything like as much as motor vehicles, it is obvious that they offer much less productivity per driver.

### Heating market: a persistent system

**Fact: The final energy consumed by heating interior spaces and hot water accounted for just under 32% of Germany's total final energy usage in 2019. Absolute final energy consumption had dropped by a little over 7% compared with the average over the years 2008 to 2012.** Energy-related greenhouse gas emissions attributable to buildings in Germany fell by 28% between 2000 and 2020, to 120 million CO<sub>2</sub> equivalents. Contributing factors included milder winters, more efficient buildings and better heating systems. Renewable energies do not yet play a major role in the heating market. According to the German Environment Agency (Umweltbundesamt), renewables accounted for just over 15% of the final energy used for heating and cooling in 2020 and were dominated by various forms of bioenergy (especially wood), with an 85% share. Around two thirds of all German

Figure 25: Natural gas holds a narrow lead



\* Share of wood and wood pellets in other heating systems was close to 59%. Oil heatings not relevant anymore.

Source: BDEW

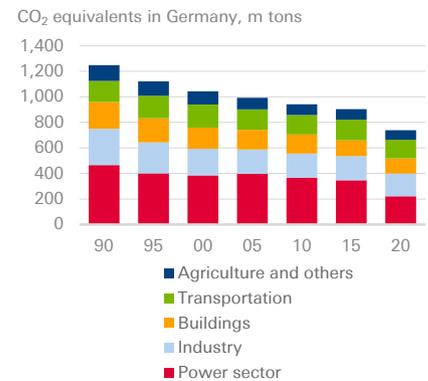
17 Our assumption is that electric vehicles are charged using the average electricity mix. One could equally argue that electric vehicles are charged using the marginal electricity supply (i.e. with the additional kilowatt hour of electricity). This is currently electricity from conventional power stations, because renewable energies are already in the grid on account of low marginal costs and their feed-in priority.  
18 Cf. Weimann, Joachim (2020). Elektroautos und das Klima: die große Verwirrung [Electric Cars and the Climate: the Big Confusion]. In: Wirtschaftsdienst 2020/11.  
19 See Heymann, Eric and Christoph Eschenfelder (2019). Myths around the transport turnaround: The promise of clean skies. Deutsche Bank Research. Talking Point. Frankfurt am Main.



dwellings were built before 1979. According to BDEW, almost 50% of these were heated by gas in 2020, 25% using heating oil and 14% by means of district heating from thermal power plants. Wood, electric heat pumps and electricity accounted for the remaining heating systems. Gas heating is still installed in more than a third of new residential buildings. Electric heat pumps account for just over 33%, ahead of district heating (25%) and wood (4.2%). The rate of upgrading energy systems in buildings has been around 1% of the stock for years.

**Thesis: The final energy consumed by heating interior spaces and hot water, and the associated carbon emissions, will generally drop over the coming years. But we cannot expect quick progress, because the existing building stock is a very persistent system and there are other restrictions.** Because of this, the aim of achieving an almost climate-neutral building stock by 2050 is very distant indeed. Doubling the renovation rate from 1% to 2% is hampered by the unavailability of tradespeople capable of doing the work. In extreme cases, old buildings can be made to consume as much as 80% less energy through comprehensive energy upgrades, after which they emit less carbon than before. But such sweeping savings can generally only be achieved if the building had a very bad carbon footprint in the first place. Even after very comprehensive energy upgrades, most buildings are not carbon neutral; they are merely more energy efficient than before. Raising the necessary investments to convert every dwelling to low-carbon and carbon-free energy sources by 2050 is also a major challenge. Comprehensive upgrades to detached and semi-detached houses (façade, windows, roof, heating system) can easily run into six figures. The technological barriers to conversion can also be prohibitively high. A building heated by gas or district heating cannot always be converted to electric heating at a justifiable cost. The thermal power plants that supply district heating cannot be switched off until alternatives have been put in place for the dwellings. Another politically charged question is how to deal with the owner-occupiers of houses and apartments who, for financial or other reasons, will not or cannot upgrade their buildings. Stricter regulatory laws and much higher carbon prices will meet with resistance and will overburden some owners and tenants. This is already clear from debates about how carbon costs should be shared between tenants and landlords. Then again, greatly increased subsidies for building upgrades are bound to fall down on account of public sector financial restrictions. The state cannot subsidise everything that protects the climate. Furthermore, far-reaching subsidies for energy upgrades will put even more pressure on already scarce skills in the building trade and/or lead to higher construction costs. All in all, a climate-neutral building stock is still very far off, on account of technological, economic and social restrictions.<sup>20</sup>

Figure 26: GHG emissions have declined only slowly of late



Source: Federal Environment Agency

<sup>20</sup> See also Heymann, Eric and Jochen Möbert (2021). Climate-neutral building stock by 2050: A highly ambitious goal. Deutsche Bank Research. Talking Point. Frankfurt am Main.



### Energy policy: Insufficient quantitative economic targets

**Fact: German energy policy traditionally emerges from what is referred to as the “energy policy target triangle” made up of capability/powerfulness (reliability of supply), economic viability (affordability) and environmental and climate compatibility. Reliability of supply should by rights be a non-negotiable target. This present report uses examples to show that there are extensive, specifically quantified targets in ecology and climate protection. Economic goals are much more vaguely formulated than these ecological goals, and are certainly less clearly quantified.** Most policymakers articulate an aim of keeping energy prices “affordable” and not threatening the competitiveness of local industry. But it is not clear exactly what these things mean. There is no quantitative target to tell us which electricity prices, EEG surcharge, absolute EEG payments, grid fees and such like are considered “affordable”. Nor is there a target defining how much public money may be put aside each year to fund energy and climate policy activities. The risk is that decision-makers will ignore targets that are not specific or measurable. This accusation around the economic viability of the energy turnaround and climate protection measures has been levelled at politicians for years.

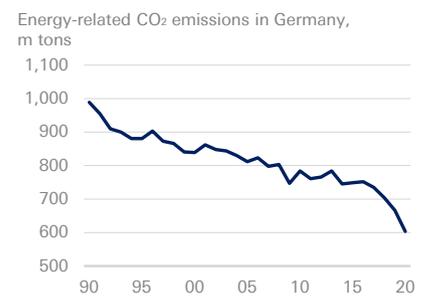
**Thesis: A fourth dimension should be added to Germany’s energy policy target triangle. This dimension is political and social acceptance. An energy source will not succeed in the long term if it is not accepted politically and socially.** This is currently the case with nuclear energy in Germany, even though it helps to supply low-carbon electricity and is a powerful source of energy. Political and social acceptance of coal-fired power is declining in almost every industrialised country, despite coal being a cheap (if external costs are not factored) and reliable way of generating power. It is also worth going into more detail on the dimension of powerfulness. Firstly, it constitutes the absolute amount of energy that an energy source can provide. It has to be able to make an appreciable contribution to the energy supply; geothermal and tidal power plants, for instance, are globally insignificant. Secondly, powerfulness entails reliability of supply, which means the maximum possible number of full-load hours, or the ratio of assured capacity to nominal capacity. Lastly, powerfulness also includes controllability, which means the ability to ramp power generation up and down as and when required. So this gives us a climate policy target “square”, which in turn allows us to formulate the proposition that there are currently no forms of energy that are powerful, cost-effective, low-carbon and politically acceptable. Every energy source has its strengths and weaknesses. There is, therefore, not yet a viable path to a climate-neutral future.

**Fact: Energy-related carbon emissions in Germany fell by just under 40% from 1990 to 2020. Those 30 years encompass the effects of Germany’s reunification and the pandemic; the latter alone is likely to have caused emissions to drop by more than 9%.**

Without the coronavirus crisis and its hundreds of billions of euros of economic impact and massive mobility restrictions, Germany would have fallen far short of its climate change target for 2020 (40% carbon reduction from 1990). Now that the Climate Change Act has been stiffened in Germany, its carbon emissions are supposed to sink by 65% by 2030, compared with the 1990 level. This means a reduction of just under 43% compared with the low level of the 2020 coronavirus pandemic year.

**Thesis: There will not be enough low-carbon energy forms by 2030. Furthermore, existing vehicles and buildings, industrial plants, agricultural machinery and**

Figure 27: Corona leads to a strong decrease in CO<sub>2</sub> emissions



Source: Federal Environmental Agency



**construction machinery cannot be converted to low-carbon technologies and fuels within a short space of time. So from that point of view, these kinds of far-reaching carbon savings will not be achievable in less than ten years without a significant reduction in energy consumption.** From today's viewpoint, it is impossible to see how that can be achieved without serious economic cost and political resistance. Nor have policymakers said how they intend to achieve the targets. The facts explained here show that even a massive expansion of renewable energies would not suffice. Our 2016 report on Germany's energy transition concluded that the country has taken on too much in too little time. Back then we pointed to four limiting factors: the cost to businesses and the economy, physical limits, the time available and political feasibility.<sup>21</sup> As this latest report shows, all four factors are still highly relevant today. The difference now is that Germany has upped its climate change targets dramatically.

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## 4. Conclusion and political placement

### Climate change is a negative external effect – climate protection is a public good

From an economic perspective, anthropogenic climate change is a global negative external effect. Human activity causes greenhouse gas emissions that accelerate climate change. The external effect is that negative climate consequences have so far not been factored into prices in consumption and investment decisions, or at least not sufficiently, and are therefore too widely ignored. As a result, emissions are too high. At the same time, climate protection is a prime example of a purely public good. It is subject to the principle of non-excludability, since individual consumers cannot be excluded from the "consumption" of a better climate. This consumption is also non-rivalrous: consumers consume climate protection without limiting its availability to others.

In economic theory, purely public goods are prone to market failure. Such goods are not produced in sufficient quantity by market forces alone (the private sector) because their properties mean that businesses cannot monetise their supply. Climate protection suffers from this kind of market failure. Whole economies, as well as businesses and private individuals, have little incentive to factor emissions heavily into prices, to invest in climate protection or to reduce their own emissions by doing things like consuming less, when everyone else profits from an improved climate without having to pay for it. This is known as "the tragedy of the commons". The fact that climate protection is a public good is the key reason why international climate protection negotiations have dragged on so much in recent decades. Things are further exacerbated by the problem of postponement, since most of the cost of climate damage comes later. Moreover, richer countries find it easier to adapt to the negative consequences of climate change, which is why short-term climate protection activities do not happen there if they are very expensive.

### What can policymakers do?

Financial resources for climate protection and restructuring the energy sector are limited. Energy and climate policy will have to become much more efficient and effective if ambitious climate protection goals are to be achieved. This in turn requires comprehensive, uniform carbon pricing. It matters less for now whether that happens via a carbon tax or EU emissions trading. Both instruments have the

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<sup>21</sup> Cf. Heymann, Eric (2016). German Energiewende: Many targets out of sight. Deutsche Bank Research. Current Issues. Frankfurt am Main.



advantage of higher economic efficiency (lower costs) and greater ecological accuracy than today's dominant mix of instruments consisting of regulatory law (orders, prohibitions, quotas, limits and so on) and technology-specific subsidies. An advantage emission trading has over carbon tax is that it includes an upper limit for carbon emissions, which is something science demands to attenuate climate change. That is why EU emissions trading should be extended to other sectors (transport and the heating market) and ideally to other countries. But this is easier said than done.<sup>22</sup>

Germany's climate protection package has begun to put a price on carbon emission from transportation and the heating market (in force since the beginning of 2021). This is an important step. If carbon begins to be factored into prices comprehensively and uniformly, it will be possible to reduce or even abolish technology-specific subsidies and regulatory measures (such as EEG and subsidies for the purchase of electric cars). This of course will be met with resistance from those sectors that benefit from such support and it is unlikely to happen in the short or medium term, especially as it would contradict policymakers' rationale of providing individual subsidies or betting on specific measures. That is why at least those aspects of the energy transition that are not economically viable should be financed via the general public budget and not electricity prices. This would place such measures in competition with other duties of the state (such as education, health, domestic and foreign security). The competitive and social disruptions of high electricity prices would also be reduced.

But the path to climate neutrality will clearly not be easy, even with the most efficient climate policy based on comprehensive and uniform carbon pricing, because such a path will initially mean high investments in new technologies combined with major write-offs for existing capital stock replaced before the end of its planned life cycle. This means high carbon prices will present significant economic challenges to some businesses and private individuals. It will not be possible to compensate for all the economic damage or expense by means of transfers. There will be many (relative) losers in such a policy.

### More research

The state must invest more in research if it wants to minimise the negative effects of this transformation. We said at the outset that the task of the century is to develop efficient, low-carbon energy sources that are as cost-effective as possible and that enable climate-compatible growth. Considering the potential risks of climate change, research should be as open to technology as possible. Furthermore, the risks of climate change should be weighed against the risks of each energy source. In the end, every political, business and private decision is implicitly subject to risk assessment. And when it comes to energy supply, there is no energy source that is entirely devoid of risk. The USA, for instance, is pursuing efforts in the field of next-generation nuclear energy (smaller, more controllable reactors designed to preclude nuclear meltdown and create less radioactive waste). If they achieve a breakthrough, this kind of nuclear power station could augment renewable energies in generating electricity, and also be used around the clock for things like producing synthetic fuels. The cost of all this is of course not insignificant. But advocates of the technology are expecting economies of scale, provided this kind

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<sup>22</sup> Air transport within the EU is already part of the EU emissions trading scheme. A ban on flights within the EU is therefore an example of Symbolpolitik, or tokenism, rather than ecologically or economically indicated. Air travel will in any case become less popular wherever there are attractive alternatives (fast rail connections such as, most recently, the Munich-Berlin route).



of power plant can be built in large numbers. American tech billionaires have set up private support initiatives in this regard. It of course presupposes social acceptance, which does not (yet) exist in Germany at the moment. In the end, fossil energy sources and their external effects will not be driven back globally until there are similarly cheap and effective alternatives that produce little or no carbon emissions.

#### Political communication needs to be improved

If more ambitious climate protection policies remain limited to Germany and the EU, then these locations will become less competitive internationally and the effect on the climate will remain limited. The carbon border adjustment system (e.g. climate tariffs) proposed by the EU is bound to elicit countermeasures from those countries affected (USA, China). There are no simple solutions to this, even if the new US administration has tightened its climate change targets.

Society will not accept self-denial as a road to climate neutrality. Overly strict climate protection policies whose high energy prices, commands and prohibitions impact heavily on people's lives, or gradually undermine the nation's industrial basis, entail a significant risk of strengthening political fringes. Conflicting goals exist. This risk is already evident in the political debate since Germany tightened up its Climate Change Act. Preventing these social tensions from getting out of hand will be a political challenge. Setting overly ambitious targets raises expectations that can easily be disappointed. That is why the communication of energy and climate policies has to improve. What is needed is a factual comparison between what we want and what we can probably achieve. Neither of these needs to be static. They can and will change over time.



# Appendix 1

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