



German energy supply at a historical turning point

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Despite many years of expansion of renewable energies, Germany is – as most other industrialised countries in the world are – still dependent on fossil fuels. Germany imports close to 70% of its energy resources, with Russia currently the most important supplier of fossil fuels. Russia's war against Ukraine has led to a historical turning point in German energy supply. Germany aims to reduce its dependency on energy imports from Russia as rapidly as possible. The energy links between Germany and Russia that have endured for decades, even during the hottest times of the Cold War, are to be loosened in the years to come. From today's perspective, a renaissance of these energy links is hard to imagine given the current political regime in Russia.

Germany plans to massively expand renewable energies but will also invest in LNG infrastructure to diversify gas supply; new gas-fired power plants; power grids; energy efficiency of buildings, industrial processes, and mobility services; low-carbon heating technologies such as electric heat pumps; charging infrastructure for electric vehicles; power storage technologies, and infrastructure to produce, transport and use (green) hydrogen in energy-intensive industries. All these goals face many limitations, such as capacity and skilled labour constraints in the craft, construction, and capital goods producer industries; limited financial resources at the consumer, corporate and state level; time required for planning and approval procedures or local resistance against wind parks; and new power plants and/or grid expansion.

The short-term risk of being cut off from Russian gas and oil supply is more pronounced in the heating market and less severe in the electricity sector. While it seems very likely that gas supply is secured until autumn 2022, bottlenecks cannot be ruled out for winter 2022/23. The major (political) tasks in the short term are increasing LNG imports on a European level, filling up gas storage capacities over the summer months and securing hard coal supply. When it comes to the crunch in the next winter, demand-side measures could come into play. This could include scheduled and orderly shutdowns of industrial plants with high gas consumption. Private heating purposes would likely be treated with priority compared to industrial applications. A faster expansion of renewables is a consequence of the current energy crisis, but no short-term solution given limitations on the supply side.



German energy supply at a historical turning point

German energy statistics in a nutshell

Corona crisis causes decline of primary energy demand

1

Primary energy demand in DE, petajoules



Source: BMWi

To understand the historic dimension of the intended changes in German energy policy, it is important to understand German energy supply and demand. Thus, we discuss the key facts & figures of Germany's energy market.

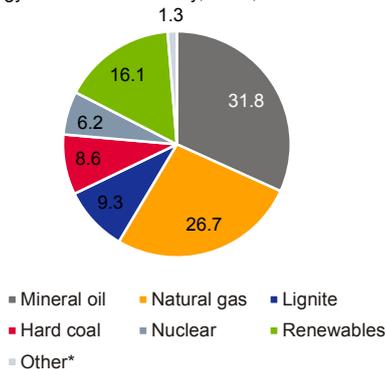
Primary energy demand still dominated by fossil fuels

Germany's primary energy demand reached close to 12,200 petajoule in 2021. This number was 7.7% below the average of the previous 10 years. The consequences of the COVID-19 pandemic (reduced mobility and overall economic activity) still had a dampening impact in 2021 even though primary energy consumption increased by 2.5% from its low in 2020. Last year, 76.4% of total primary energy demand in Germany was based on fossil fuels. Mineral oil is still the most important source of energy (share in 2021: 31.8%), followed by natural gas (26.7%), lignite (9.3%) and hard coal (8.6%). All renewables combined had a share of 16.1% in total primary energy demand with bioenergies (e.g., wood for heating and biofuels for mobility purposes) accounting for more than 50% of renewables' total contribution, followed by wind energy. Nuclear energy had a share of 6.2% in total primary demand in 2021. Clearly, fossil fuels still provide the lion's share of German energy supply.

Oil remains most important source energy

2

Share of energy sources in total primary energy demand in Germany, 2021, %



* Less electricity exchange balance

Source: AG Energiebilanzen

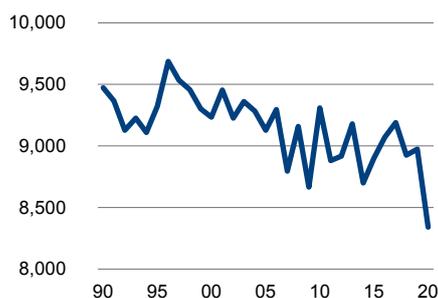
Structural decline in primary energy demand expected

Notwithstanding the rebound effect following the COVID-19 crisis, we expect primary energy demand in Germany to 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, chemicals, building materials) are likely to lose importance in Germany. Milder winters on average due to climate change might also help to curb primary energy demand. Furthermore, primary energy demand should be lowered by reducing conversion losses (waste heat) that occur when fossil fuels are used in thermal power plants, the mobility sector or older heating systems in private households, and when the heat cannot be used for other purposes (such as district heating). With a higher share of renewables and more electrification in the power, mobility and heating sectors, these thermal losses will be reduced. Nevertheless, there are also conversion losses when using renewable energies. One example is the production of green hydrogen and other synthetic fuels based on renewable energies (power-to-X, P2X).

Final energy consumption is down only slightly (before COVID-19)*

3

Final energy consumption in DE, petajoules



Source: BMWi

Final energy consumption: Liquid fossil fuels and natural gas carry the burden

Total final energy consumption amounted to 8,340 petajoule in 2020 (no data available for 2021 yet). This was the lowest number since German reunification. The low energy consumption of the mobility sector due to the pandemic was the most relevant factor for the decline in final energy consumption. In terms of energy sources, liquid fossil fuels (gasoline and diesel for mobility, heating oil) had the highest share in total final energy consumption (34%), followed by natural gas (heating, industrial processes) with a share of 26.4%. Electricity, which is a form of final energy too, accounted for another 20.9%; coal, gas and other energy sources that are used for power generation are included in this number.

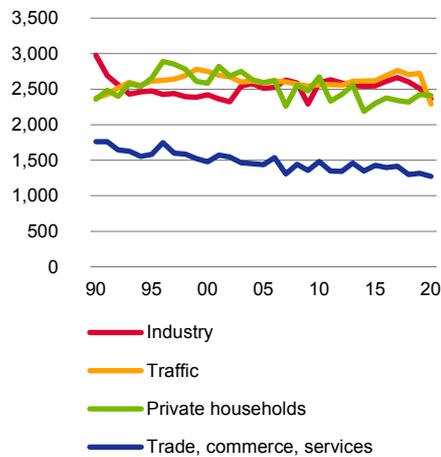


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Energy consumption of transport sector declines most due to COVID-19

4

Final energy consumption in DE, petajoules

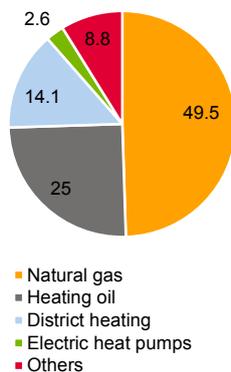


Source: BMWi

Natural gas dominates heating market

5

Share of heating systems and energy sources in existing residential units in Germany, 2020, %

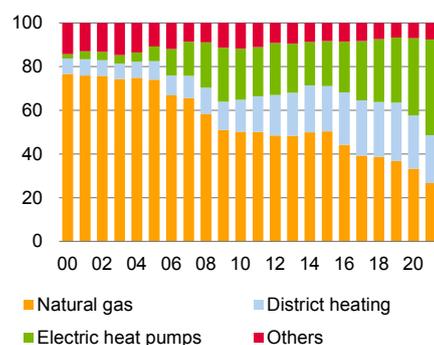


Source: BMWi

Heat pumps taking the lead in heating market for new buildings

6

Share of heating systems and energy sources in new residential units in Germany, %



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

Source: BDEW

Regarding energy consumption by sector or usage, private households had the largest share in total final energy consumption in 2020 (28.9%), followed by industry (28.3%) and mobility (27.5%). Trade and services accounted for the remaining 15.3%. Before the coronavirus pandemic, the shares of the mobility sector and industry had been higher. It's an important message that space and water heating (share of 33%, dominated by private households) as well as mobility each consume more final energy than total electricity consumption.

The energy mix of final energy consumption differs from sector to sector:

- In the heating market, 69.6% of final energy consumption is based on natural gas and oil. Other important energy sources in the heating market are renewables (mainly wood and other solid bioenergies) and district heating. Close to 50% of current housing stock in Germany is heated with natural gas, another 25% with heating oil. Given the longevity of buildings, the lack of skilled labour (craft sectors), technological hurdles with older houses and financial constraints among homeowners, a fast transition from natural gas and oil to alternative heating sources (electric heat pumps) is unlikely for the building stock. Gas will remain important in the heating market for many years to come. For new buildings, electric heat pumps are now the most important heating technology (share of 43.9% in the first eight months of 2021). The federal government aims to accelerate the switch from fossil fuels to renewable energies in the housing market (65% share for new heating systems from 2025, no heating systems based on fossil fuels in new buildings) and to increase the rate of energy refurbishments. All measures in the housing market are politically highly sensitive. Subsidies are necessary.
- The mobility sector is still dependent on mineral oil. Close to 92% of final energy consumption is based on liquid fossil fuels (gasoline and diesel). Biofuels (6%) and electricity mainly used in the railway sector (1.8%) cover the rest. As in the heating market, a quick changeover to alternative energy sources is not possible. The average age of the existing car fleet in Germany is 10 years. A complete replacement of the current fleet will take more than 15 years. However, market shares are changing. Stricter CO₂ limits for new cars in the EU, direct subsidies for the purchase of electric cars and financial support for the expansion of charging infrastructure are driving up the market share of electric vehicles. In 2021, almost 14% of new passenger car registrations were battery-electric vehicles. Plug-in hybrid electric vehicles had a share of 12.4% but this technology is losing political support. It remains to be seen to what extent car buyers are willing and able to switch to electric cars once subsidies run out. The political goal is to have at least 14 m electric cars on the road by 2030 (more than 1 m in 2021). Public and private charging infrastructure needs to be expanded: again, some public support is necessary. At the end of the day, electric cars will not be zero-emission vehicles for many years to come. In other parts of the mobility sector (such as heavy load traffic or aviation), electrification is not possible or very expensive. Thus, the shift away from oil in the mobility sector is a task that requires effort and patience.
- In power generation, renewable energies again were the most important source of energy in 2021 (share of 40.5% in gross electricity generation). Wind power (onshore and offshore combined) ranked 1st place with a 20% share. Natural gas (share in 2021: 15.2%) and hard coal (9.3%) – with a high import share of Russia (see below) – are still important energy sources. Natural gas is supposed to bridge the gap until renewable energies can provide the lion's share of German energy supply. With further electrification of the economy, annual electricity and gas demand will increase in Germany. What's more, peak load in the winter months is likely to increase when more houses are equipped with electric heat pumps, more industrial

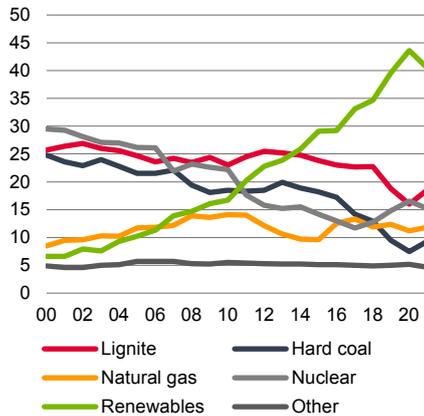


German energy supply at a historical turning point

First setback for renewables

7

Share of different energy sources in gross electricity production in Germany, %



Source: AG Energiebilanzen

processes are electrified, and more electric cars are on the road. The traffic light coalition acknowledges that new gas-fired power plants that are H2-ready are necessary. Our colleagues in equity research estimate that at least 25 GW (2020: roughly 30 GW) of new gas power capacity and 20 GW of battery storage capacity (2021: less than 1 GW) are necessary by 2030.¹ This is required to address the challenges related to renewable intermittency and demand seasonality. The estimate assumes that peak load could reach 70 GW in Germany by 2030 in winter months, below the current peak load of roughly 80 GW. If peak load rises significantly due to higher usage of electric heat pumps, electrified industrial processes, e-mobility and other applications, additional capacity requirements would increase even further. The federal government aims for the share of renewables to reach 100% in 2035 (80% in 2030). As a reminder: all renewables together had a share in gross electricity generation of 40.5% in 2020. A massive expansion of installed capacity will be necessary to reach this target: more than 100 GW onshore wind by 2030 (2020: 54 GW), 30 GW offshore wind by 2030 (2020: roughly 8 GW) and more than 200 GW solar PV (2020: 54 GW). The message is clear that renewables will be expanded massively. However, this goal faces many limitations such as capacity and skilled labour constraints in the craft, construction, and capital goods producer industries, financial resources, time required for planning and approval procedures as well as local resistance against wind parks.

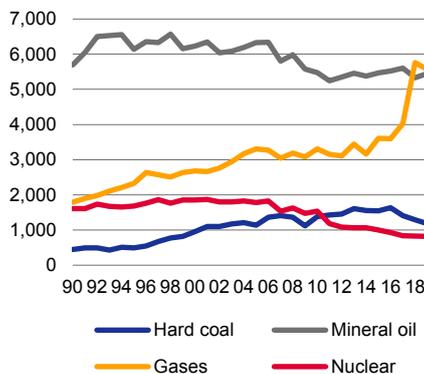
- Final energy consumption in the German industry is mainly based on gas (2020: 35%), electricity (31%) and hard coal (13%). Industrial consumption of natural gas is dominated by the chemical industry, metal industry, building materials, pulp and paper and the food industry. The share of industrial gas consumption in total final energy consumption is roughly 10%. The large German capital goods producers (automotive, mechanical, and electrical engineering) are less energy-intensive and are more reliant on a stable electricity supply. The overall dependency on oil has been reduced in German industry. Natural gas has replaced oil in some industrial sectors. For instance, the oil consumption of the chemical industry fell by more than 90% during the last 20 years. During the same time, natural gas consumption increased by more than 10%.

Germany dependent on energy imports

Massive increase in gas imports

8

German imports of energy sources, petajoule



Source: AG Energiebilanzen

Germany is heavily dependent on energy imports. Some 70% of all energy sources are imported. This share has been quite stable during the last 25 years. Germany imports more than 90% of its mineral oil and natural gas and 100% of its nuclear fuel rods. Hard coal is not produced in Germany anymore. By contrast, lignite is a fully domestic energy source that is used mainly for (baseload) electricity generation (with the disadvantage of high CO₂ emissions per kWh). Renewable energies can be regarded as a domestic source of energy as soon as the plants are in operation. However, Germany will likely remain dependent on imports for the expansion of solar PV capacity since China is the largest supplier of solar PV installations and equipment.

Russia is by far the most important source for German energy imports. Germany imports more than 50% of its natural gas, roughly one-third of its mineral oil (2021) and 57% of its hard coal (2021) from Russia. Russia's war against Ukraine has led to a historical turning point in German energy supply. Germany aims to reduce its dependency on energy imports from Russia as fast as possible. The energy links between Germany and Russia that have endured for

¹ See Brand, James, and Olly Jeffery (2022). Decarbonising power & gas: The intermittency & seasonality challenges. Deutsche Bank Research. London.



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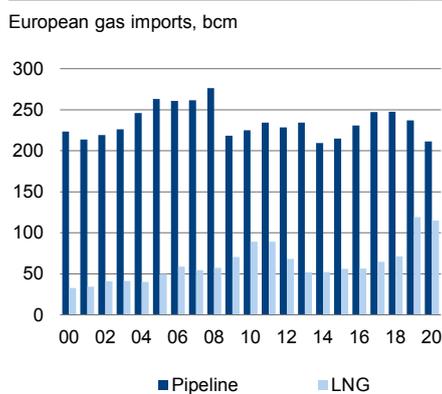
decades -- even during the hottest times of the Cold War -- are to be loosened in the years to come. From today's perspective, a renaissance of these energy links is hard to imagine given the current political regime in Russia.

LNG to become more important – capacity markets on the rise?

Germany will try to accelerate the expansion of renewable energies (numbers described above). It will also invest in power grids; the energy efficiency of buildings, industrial processes, and mobility services; low-carbon heating technologies such as electric heat pumps; charging infrastructure for electric vehicles; power storage technologies; and infrastructure to produce, transport and use (green) hydrogen in energy-intensive industries.

LNG is catching up

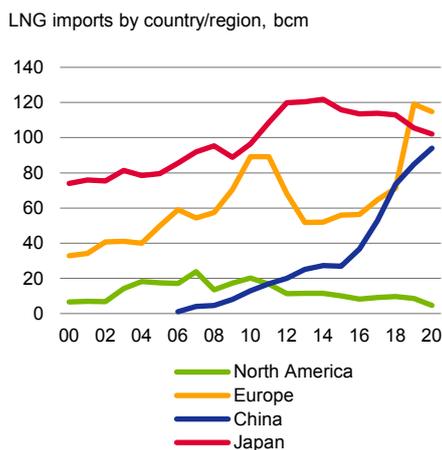
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Source: BP

LNG imports rise in China and Europe

10



Source: BP

All these measures were already on Germany's energy and climate policy agenda before Russia's invasion of Ukraine. A new emphasis is now on the expansion of infrastructure for liquified natural gas (LNG). The federal government plans to build two LNG terminals on German shores that can be connected to the gas network; this will take at least three years. Germany has also agreed with Qatar to purchase LNG in the years to come. Germany currently receives most of its natural gas via pipeline (from Russia, the Netherlands and Norway). Thus, LNG is not yet important for Germany. However, LNG has gained in importance in Europe as well as globally and could develop into the fastest-growing energy source behind renewables. According to BP, LNG accounted for 35% of total European gas imports in 2020. An expansion of LNG infrastructure in Germany and other EU countries will also lead to a diversification of the supply and would strengthen gas imports from countries other than Russia. This process will take time, of course, but LNG will become more relevant. Countries with rich gas reserves will invest in LNG export infrastructure since gas can substitute for coal in the power sector; reducing coal consumption is a political goal in many countries. Australia, Qatar, and the US are currently the largest producers and exporters of LNG. On a global scale, demand for LNG is likely to grow faster than supply. Thus, LNG will probably remain more expensive than pipeline gas. If Europe is able to reduce its gas imports from Russia in the coming years, Russia might increase its LNG exports, too. China could become an important client. China's LNG imports increased by more than 600% between 2010 and 2020 and will continue to rise.

Back to Germany: The political goal to build new gas-fired power plants probably needs some form of public support. With further expansion of renewables, their market share in power generation will continue to increase. Given the marginal costs of wind power and solar PV being close to zero, these weather-dependent renewables will be fed into the grid on a preferential basis. Therefore, average annual capacity utilisation of the back-up power plants (in future Germany, mostly natural gas) will continue to decline. German gas power plants had an average utilisation rate of only 32% in 2021. On the other hand, Germany needs this back-up capacity to secure power supply in times of need, such as when demand in cold winters cannot be satisfied with renewables alone. Insufficient capacity utilisation will make it difficult for investors to create a business case for new gas-fired power plants when revenues can only be generated by electricity sales. Thus, the government could support the necessary investment by creating a capacity mechanism where operators of power plants are rewarded for the provision of secured capacity. Without any incentives to invest in gas power plants, the envisaged phase-out of coal in the power sector by (ideally) 2030 would probably be out of reach. Given the current supply chain disruptions, we believe that building new capacities in the power market in the short to medium term is already quite ambitious.



German energy supply at a historical turning point

How to compensate for interruptions of Russian energy supply

The war in Ukraine is fuelling the discussion about whether Germany should ban or suspend its energy imports from Russia. There is also a risk that Russia stops exports to Germany even though the country needs the revenues from energy sales to finance public expenses. There have been several assessments of how and to what extent a stoppage of energy imports from Russia could be compensated for.² Since the markets for oil and coal are quite diversified on the supply side, possible physical shortages in gas supply are the major reason for concern.

In the electricity sector, one temporary measure being discussed is some substitution of coal for gas. Power plants based on hard coal had capacity utilisation of roughly 31% in 2021. Assuming that supply could be secured, power generation based on hard coal could be increased to help offset the loss of gas; CO₂ prices in the EU Emissions Trading System would rise (everything else being equal) since hard coal has a higher CO₂ intensity than gas. Higher solar power generation during summer months could also contribute to electricity supply and discharge gas. Spring and summer should be used to increase LNG imports via third EU countries and to fill gas storage capacities in Germany as much as possible. While utilisation of LNG import infrastructure in the EU should currently not be a limiting factor, export and transport capacity could hamper a fast increase in European LNG imports. There is also public and media discussion about whether the three remaining nuclear power plants in Germany should remain in operation for longer. One key point in the debate is that it would be another source of (baseload) electricity generation and could help to reduce gas input in the power sector in winter 2022/23.

The German federal government wants to introduce legislation that determines higher filling levels of national gas storage capacities at the beginning of the winter. Germany has gas storage capacities of roughly 24 bn cbm that are operated by private companies. This translates into roughly 950 petajoule of gas storage capacity, or 25-30% of total annual natural gas consumption. Thus, Germany would be able to secure gas supply with its storage capacities for several months if they were fully filled. Actual filling levels were unusually low at the beginning of the heating period of 2021/22 and remain low (roughly 25% at the latest reading). Moreover, private operators shy away from refilling at current prices, which might result in heavy losses if prices come down again. Higher gas prices might motivate private households to save energy by reducing room temperatures. This is a factor that should not be neglected since a reduction of room temperature by 1°C translates into energy savings of roughly 6%.

While it seems likely that gas supply is secured until autumn 2022, bottlenecks cannot be ruled out for winter 2022/23. These bottlenecks would likely affect the (industrial) heating market more than the power market. The major (political) tasks in the short term are increasing LNG imports on a European level, filling up gas storage capacities over the summer months, and securing hard coal supply. State influence in the energy sector will probably increase (once again). When it comes to the crunch next winter, further demand-side measures (beyond voluntary gas savings in private households) could come into play. That could include scheduled and orderly shutdowns of industrial plants with high gas consumption. Private heating would likely be deemed a priority compared to industrial applications. A rationing of gas supply for energy-intensive industries would lead to a decline in industrial production. The relevant sectors would probably (partly) be compensated. There is also a risk that the structural decrease in capital stock in energy-intensive industries (chemicals, metals, building materials, paper) that has been registered for 20 years now could

² See Leopoldina (2022). How Russian natural gas can be replaced in the German and European energy supply. Ad-hoc statement. Halle.

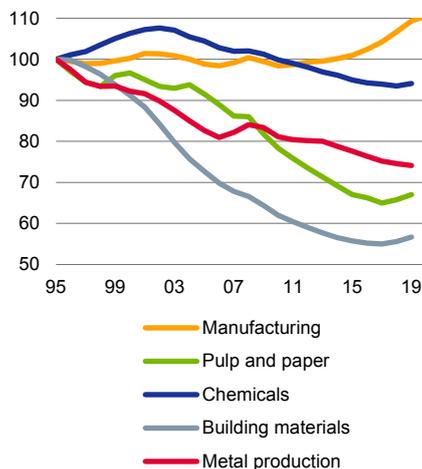


German energy supply at a historical turning point

Real net fixed assets have declined in energy-intensive sectors

11

Real net fixed assets in individual German industrial sectors*; 1995=100



Source: Federal Statistical Office

accelerate if physical energy shortages came on top of high energy prices and the uncertainties regarding German climate and energy policy.

Further acceleration of the renewable build-up – a consequence but no solution in the short run

Political support for the massive expansion of renewables has increased in the face of the current energy crisis. FDP's Minister of Finance called renewables "freedom energies". Indeed, the war in Ukraine will be an additional political driver for faster expansion of renewables. The above-mentioned goals show the high ambition. However, the contribution of "more and faster renewables" to the current problem will be limited in the short term since major bottlenecks in gas supply are likely to affect industrial processes and heating markets where renewable power is not yet a substitute. The power sector, where additional wind and solar PV capacities will broaden the supply side, is less fraught with problems caused by possible interruptions in Russian gas supply. But the considerable obstacles on the supply side (intermediate goods and skilled labour) will hinder a fast expansion in the short term and might even become a permanent bottleneck in the years to come.

Final remarks

Natural gas is supposed to bridge the gap until renewable energies can bear the brunt of supplying German energy. This bridge might be longer than many observers currently expect. This holds for the heating market, industrial processes, and the power sector. It will take decades until renewables and synthetic fuels based on renewables will have taken over completely in all these areas. If Germany wants to reduce gas imports from Russia, building up a powerful LNG infrastructure together with European partners and reliable global suppliers is a major task that needs political support. Ideally, this infrastructure would be designed so that it can be used for hydrogen in the future.

The current crisis shows that sufficient energy supply should not be taken for granted. A long-lasting era of physical energy scarcity would be dire both economically and socially. LNG infrastructure is part of the energy transition, but it will not replace the expansion of renewables, of technological progress in energy efficiency, storage technologies, low-carbon mobility systems and other fields of action. The state influence in the energy sector is likely to increase as well as public support for the planned transition. Given that weather-dependent renewable energies will not be able to secure the energy supply of a growing world population (+80 m every year), more R&D spending on low-carbon technologies but also on adaptation to climate change is necessary.

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