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Progress and Prospects of Transition away from Fossil Fuels to Reach Net-Zero Climate Goals in China and Germany

Working Paper of Sino-German Track II Dialogue on Climate Change and Sustainable Development

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Executive Summary

Germany and China, as two of the world's largest economies and energy consumers, play pivotal roles in the global fight against climate change. The energy transition in China, the country with the highest GHG emissions globally, as well as Germany as the biggest emitter in the EU are essential to meeting international climate goals. This paper examines how Germany and China are addressing the urgent need to transition away from or phasing out of fossil fuels. By analysing their experiences, strategies, challenges, and solutions this study aims to provide insights into the opportunities of transitioning to sustainable energy systems, offering lessons that extend far beyond their borders.

Both China and Germany demonstrate their commitment to transitioning away from or phasing out fossil fuels through various actions and policies. However, they start from different points, especially regarding the role of coal in their energy systems. Germany has established a coal exit pathway, leading to a phase-out by 2038. In 2023, coal accounted for 17 percent of the total primary energy consumption in Germany. In contrast, China faces a more complex transition given coal's dominant role in its energy system, still accounting for 56 percent of total primary energy consumption in 2023.

While both Germany and China motivate the transition away from fossil fuels and in particular coal referring to their GHG reduction efforts, but also reducing particulate matter air pollution has been an important driver for the strictest controls on the combustion of coal in China.

These different outsets are also reflected in the countries' strategic approaches: While Germany has demonstrated strong coal reduction incentives, retiring 6 gigawatts of coal capacity in 2024 alone, China pursues a more measured approach by prioritising energy security during its transition, particularly given its rapidly growing energy demands and the need to maintain economic growth while pursuing environmental goals. That said, China will strictly limit the increase in coal consumption over the 14th Five-Year Plan period and phase it down in the 15th Five-Year Plan period.

In order to reach its climate targets, Germany must intensify its efforts to reduce the consumption of natural gas and oil. Combined, these two fuels accounted for 61 percent of total primary energy consumption in Germany in 2023. The German building and transport sectors,

where these fuels are primarily used, have been lagging behind expectations when it comes to reducing GHG emissions from these sectors. The fact that millions of individuals have to be mobilised to achieve the necessary reductions poses a challenge in these sectors.

The two countries differ also in the way they evaluate the role of natural gas. While China sees it as a cleaner alternative to coal, Germany will also need to phase out natural gas, in order to reach greenhouse gas neutrality by 2045.

Common lessons learnt

A range of common lessons learnt can be drawn from both countries' experiences. A recurring theme is the need for substantial investment and robust **infrastructure** development, particularly in the power and transport sectors, the needed support for expansion of renewables and electric mobility. Moreover, the transition necessitates active engagement and buy-in from all regions and groups in society, highlighting the importance of clear regulatory frameworks, monitoring mechanisms, as well as public support and enthusiasm for participating in advancing the energy transition. The industrial sector's transformation is heavily reliant on **technological advancements**, the availability of affordable clean energy and materials, and a stable policy environment, as well as robust implementation and enforcement that encourages long-term investments.

These **challenges are interconnected across sectors**. For instance, the successful expansion of renewable energy is directly dependent on overcoming challenges related to grid infrastructure, energy storage, public support and local enforcement. Similarly, the decarbonisation of the industrial sector hinges on the power sector's ability to provide competitively priced renewable electricity and hydrogen.

The development and deployment of a whole range of innovative technologies both on the supply and demand side is necessary to achieve the transition away from fossil fuels.

Ensuring a **fair and just transition** is key to success. Advancing the ideas of 'leaving no one behind' and supporting vulnerable regions, industries and individuals ensures broad support and participation in the transition. Related to the phase-out of coal in Germany, the German 'Coal Commission' developed strategies and measures aimed at the affected coal-mining regions. These measures are set to support the transformation of these regions by providing economic opportunities while providing support to those most affected. In the context of the incoming EU-wide carbon price in buildings and road transport, the European Union has set up a 'Social Climate Fund' aimed at financially supporting vulnerable groups through climate-friendly investments and other measures in order to avoid hardship and make sure everyone can participate in the transition.

Finally, **international cooperation**, such as the bilateral dialogue between China and Germany fosters common understanding and enables cross-border learning from good practices.

Country-specific recommendations: China

- Improve **legal and regulatory systems**, accelerate the formulation of the Law on Climate Change Response and other relevant laws and regulations, define the target and phased implementation path for total fossil energy consumption control, and strengthen the binding force of legal instruments
- Improve the **coal consumption control policy framework** and the monitoring of progress
- Establish a **renewable energy consumption guarantee mechanism** to ensure that clean power is given priority in connecting to the grid
- Deepen the **reform and innovation of market systems and mechanisms**, e.g. expansion of the carbon market and establishment of green electricity trading
- Support **innovation**, e.g. related to storage, hydrogen and CCUS
- Ensure a **fair transition** by e.g. supporting vulnerable regions and groups
- Strengthen **international cooperation** and exchange

Country-specific recommendations: Germany

- Keep up the **reliability of the energy sector transition** in order to guarantee planning security for companies and investors. Invest in innovations and foster the deployment of innovative technologies and reduce administrative red tape.
- Invest in **energy infrastructure** and **scale up storage capacities** for power and green hydrogen. Focus on climate neutral alternatives in electricity generation, by using generation based on natural gas only to guarantee grid stability.

- Establish a **coherent policy mix** of efficient market instruments like carbon pricing and complementary policies across sectors that recognises the synergies and trade-offs to achieve an efficient and effective phase-out of fossil fuels.
- Keep working towards a **just transition** by addressing social implications, e. g. through training and education for new green skills, and incentives for job transitions, as well as support for low-income households and other vulnerable groups. Decarbonise industry while avoiding carbon leakage and safeguarding competitiveness.

I Introduction

Transitioning away from fossil fuels is inevitable for countries to achieve their net-zero climate goal and promote the green and low-carbon sustainable development of their economy and society. The United Nations 28th Conference of the Parties held in Dubai in 2023 reached for the first time ever the important consensus of gradually transitioning away from fossil fuels in the energy system and increasing renewable energy as well as energy efficiency. This further consolidated an irreversible, in-depth and low-carbon energy transformation trend and pointed out the direction for future development. This transformation is not merely about replacing traditional fossil-based energy sources with renewables but requires a fundamental shift in how energy is produced and consumed.

China and Germany, as two of the world's largest economies and energy consumers, play pivotal roles in the global fight against climate change. Both countries are key players globally and are making their energy transitions essential to meeting international climate goals. This paper examines how China and Germany are addressing the urgent need to transition away from fossil fuels. By analysing their experiences, strategies, challenges and solutions this study aims to provide insights into the opportunities and challenges of transitioning away from and of phasing out fossil fuels and offers common lessons learnt that provide insights for other countries.

We address the following key questions:

- How do China and Germany address the urgent need to transition away from and phase out fossil fuels?
- Which experiences, strategies, and solutions do both countries apply to address the challenges?
- Which opportunities can be identified for transitioning away from and phasing out fossil fuels?
- What are common lessons learnt that also provide insights for other countries?

II Central Policies and Actions

2.1 Central Policies and Actions for Transitioning Away from Fossil Fuels in China

Since 2010, China has adopted a series of policies and actions to control the consumption of fossil energy, especially coal, and promote a clean energy mix. Since the proposal of the carbon peaking and carbon neutrality goals in 2020, China has further strengthened the control of fossil energy consumption, clarified and elaborated the policies and measures concerned. Relevant policy documents clearly put forward that the consumption of fossil energy shall be strictly controlled, and the pace of coal phase-down shall be accelerated. The increase of coal consumption shall be strictly controlled during the 14th Five-Year Plan period (2021-2025), and gradually decreased during the 15th Five-Year Plan period (2026-2030), while oil consumption shall peak and enter the plateau period during the 15th Five-Year Plan period. In addition, the coal consumption control targets of key areas for pollution reduction and carbon reduction are clearly stated as follows: During the 14th Five-Year Plan period, the coal consumption in the Beijing, Tianjin and Hebei region and its surrounding areas as well as in the Yangtze River Delta region shall be reduced by 10% and 5%, respectively. Furthermore, the coal consumption across Fenwei Plain shall achieve negative growth.

Fossil energy control is framed at the highest level of China's climate governance. The **Working Guidance for Carbon Dioxide Peaking and Carbon Neutrality in Full and Faithful Implementation of the New Development Philosophy (2021)** emphasizes the need to strictly control fossil fuel consumption, with coal consumption to be capped during the 14th Five-Year Plan and phased down in the 15th. It calls for tighter control over new coal-fired power projects, accelerated retrofits of existing coal plants to improve efficiency and flexibility, and a gradual phase-out of bulk coal.

These principles are further detailed in the **Action Plan for Carbon Dioxide Peaking before 2030(2021).** The plan specifies that coal consumption should be reduced more rapidly, that new coal power projects will be severely restricted, and that existing capacity will be modernized through energy-saving upgrades. In long-distance power transmission, it requires at least half of the electricity delivered by newly built lines to come from renewable sources, thereby limiting the role of supplementary coal power.

Complementing these overarching strategies, the **Renewable Energy Law of the People's Republic of China (2005, amended 2009)** provides the legal foundation for prioritizing renewable energy in the national energy system. It mandates grid companies to purchase the full amount of renewable electricity generated, establishes financial support mechanisms, and promotes independent renewable systems in remote areas. This law underpins the gradual substitution of fossil fuels with renewable energy in China's energy mix.

To implement the target of fossil energy consumption control, China has also issued special policies such as the following:

- *Guiding Opinions on Controlling the Total Coal Output and Optimizing the Industrial Layout,*
- *The Interim Measures for the Management of Coal Consumption Reduction and Substitution in Key Areas,*
- *Opinions on Strengthening the Clean and Efficient Utilization of Coal,*
- *Opinions on Promoting High Quality Development of Inland Waterway Transportation,*
- *Notice on Further Accelerating the Intelligent Construction of Coal Mines and Promoting High Quality Development of Coal,*
- *Notice on Promoting the Healthy Development of Modern Coal Chemical Industry, etc.*

So far, China has formed the consensus within the whole society on the need to gradually reduce fossil energy consumption and actively develop green and low-carbon energy, with its energy structure continuously optimized as a result.

2.2 Central Policies and Actions for Transitioning Away from Fossil Fuels in Germany

Germany employs a range of policies and instruments, often influenced by EU regulations and directives to achieve its **legally binding greenhouse gas neutralit target by 2045** and phase out fossil fuels.

A central policy instrument for the **power sector's** transformation is the **Coal-Phase-Out Act**, which mandates the gradual shutdown of coal power plants by 2038 at the latest. Some regions are even pursuing more ambitious timelines. To support affected coal mining regions, the federal government provides financial assistance through the Structural Aid Act. With a total amount of 40 billion euros, it provides structural-policy support and guarantees financial assistance for various targeted measures, such as compensation for former workers affected by job losses or investments in regional mobility and digital infrastructure.

The **Renewables Energy Sources Act (EEG)** is a highly relevant instrument, aiming for at least 80 percent renewable electricity consumption by 2030. It incentivizes investment in renewables through financing models and initially established a feed-in tariff scheme. Larger plants now participate in tenders and receive a market premium. The **EU Renewable Energy Directive (RED)** also sets a binding target for renewables in overall EU energy consumption. Furthermore, Germany is implementing spatial planning processes, influenced by the Directive, to ensure suitable land availability for renewable energy expansion.

The European **Emissions Trading System (EU ETS)** contributes to emission reductions in both the power and industry sectors by capping and pricing emissions. In the power sector, the system plays a crucial role in short-term fuel switching and provides a long-term signal through a declining cap on emissions.

Besides the declining cap and price signal, further important elements of the EU ETS in relation to **industry** include the **Innovation Fund**, which supports innovative reduction projects, and the Carbon Border Adjustment Mechanism (CBAM), which will replace free allocation of allowances. Since January 2023, the **Energy Financing Act** removed the EEG surcharge on electricity consumption for industries, with financing now provided by the Climate and Transformation Fund (KTF), which also compensates energy-intensive industries for additional electricity costs from the EU ETS carbon price. The German government has also introduced the **Carbon Contracts for Difference (CCfD)** program to support the decarbonization of energy-intensive industries by providing long-term funding and subsidies. The **National Hydrogen Strategy** promotes the ramp-up of domestic hydrogen production and international cooperation on hydrogen.

A central instrument in the **buildings sector** is the **EU Buildings Directive**, which aims for a zero-emission building stock by 2050. Emissions from fossil fuels used in buildings are covered by a **national CO_2 price (BEHG)** since 2021. This will transition to an EU-wide emissions trading system for buildings and road transport (ETS 2) from 2027 onwards, accompanied by a **Social Climate Fund** to support vulnerable groups. The amended **Buildings Energy Act (GEG)** requires new heating systems to use at least 65 percent renewable energy from mid-2026/2028 and prohibits fossil fuel heating from 2045. The law on municipal heat planning sets standards for heating system transformation at local levels. Additionally, **the Federal Subsidy for More**

Efficient Buildings (BEG) provides financial support for energy-efficient construction and refurbishment.

For the **transport sector**, key regulatory instruments include the **EU-wide CO_2 emission standards** for various vehicles. Germany also implements the renewable energy share target in transport from the Renewable Energy Directive through a **GHG mitigation quota**. The national implementation of the Eurovignette Directive adds a specific CO_2 emission price to the heavy goods vehicle (HGV) toll. Besides covering fossil fuels in the buildings sector, the national CO_2 price (BEHG) introduced in 2021 also covers petrol and diesel, which will later be included in the EU-wide ETS 2.

Increasing energy efficiency is relevant across all sectors to limit the use of fossil fuels and reduce the cost of the transition. The **EU Ecodesign Directive** and the **EU energy label** also ensure energy efficiency of new appliances and equipment. The **EU Energy Efficiency Directive** sets annual energy savings obligations for EU Member States.

Achieving a **fair transition** involves implementing comprehensive and coordinated policy measures across various sectors. Key elements include supporting workers through access to quality employment, training and education for new green skills, and incentives for job transitions. It also requires ensuring fairness in taxation and social protection systems, preventing and alleviating energy and transport poverty, and guaranteeing access to affordable essential services like energy and transport. Accordingly, the coal phase-out in Germany is accompanied by the **Structural Aid Act**. The EU's **Social Climate Fund** that is implemented along with the ETS 2 is another example of an instrument aimed at enabling a just transition.

III Progress in Transitioning Away from Fossil Fuels

3.1 Progress in China

The general structure of energy consumption in China

The structure of energy consumption in China, dominated by fossil energy, has changed during the past ten years. Firstly, the proportion of fossil energy consumption continues to decline. As displayed in Figure 1, in 2023, of China's primary energy consumption, coal consumption accounted for 55.5 percent, a decrease of 12.1 percentage points compared with 67.4 percent in 2013. Oil accounted for 18.3 percent, an increase of 1.2 percentage points over 2013, albeit at a slower pace. Natural gas accounted for 8.5 percent, an increase of 3.2 percentage points over 2013.

Secondly, non-fossil energy develops rapidly. In 2023, non-fossil energy consumption accounted for 17.9 percent of China's total energy consumption, 7.7 percentage points higher compared with 10.2 percent in 2013. In 2023, the installed capacity of power generation from renewable energy exceeded 1.2 terawatts, accounting for about 48 percent of the total installed power generation capacity in China. Notably, the installed capacity of power generation from such new energy as wind and photovoltaic, has ranked first in the world for many years in a row.

Thirdly, the energy efficiency keeps improving. In 2023, the energy consumption per unit of GDP was lowered by more than 23.2 percent on a cumulative basis over 2013, and the average coal consumption of the power supply for coal-fired power generation units was reduced to about 300g coal equivalent per kWh.

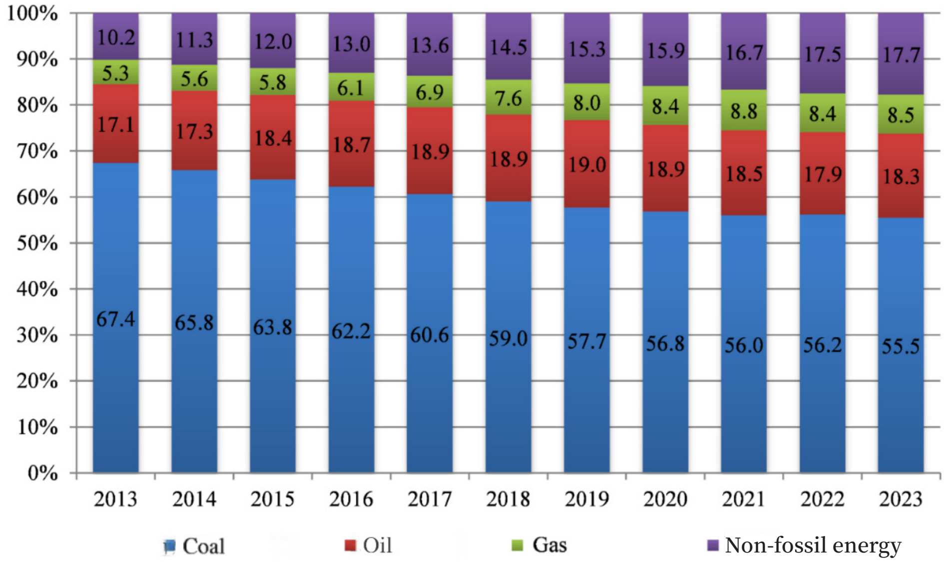

Figure 1 Primary Energy Consumption Structure of China in 2013-2023

Source: National Bureau of Statistics of China

Coal

The sustained rebound of the demand for coal consumption has been largely brought under control before 2020, but rebounded after the COVID-19. 2013-2023 was a key decade for the transformation of China's energy structure. During that period, the evolution of coal consumption in China was first characterized by a rapid decline(2012-2016), and finally a continuous rebound(2020-2023). According to the data of the National Bureau of Statistics and the National Energy Administration, the coal consumption of China fluctuated during that period, ranging from 4.24 billion tons in 2013 to about 4.73 billion tons in 2023, running at a high but stable level on the whole, while the proportion of coal consumption in the energy mix dropped significantly from 67.4 percent to 55.5 percent at the same time. The continuous rebound of coal consumption demand was mainly attributed to factors such as energy supply security and the Russia-Ukraine conflict, among other things.[1]

However, recent developments indicate that the trend has been basically reversed. In conclusion, China's coal consumption has entered a plateau period and is expected to reach its

1 See also https://climatecooperation.cn/wp-content/uploads/2024/11/T2D-WG1-Woring-Paper_Energy-security-in-Germany-and-China_EN.pdf

peak by the end of the 14th Five-Year Plan period (2021-2025). Nevertheless, given the bottom line of ensuring energy security, coal will still act as a ballast for energy consumption in China.

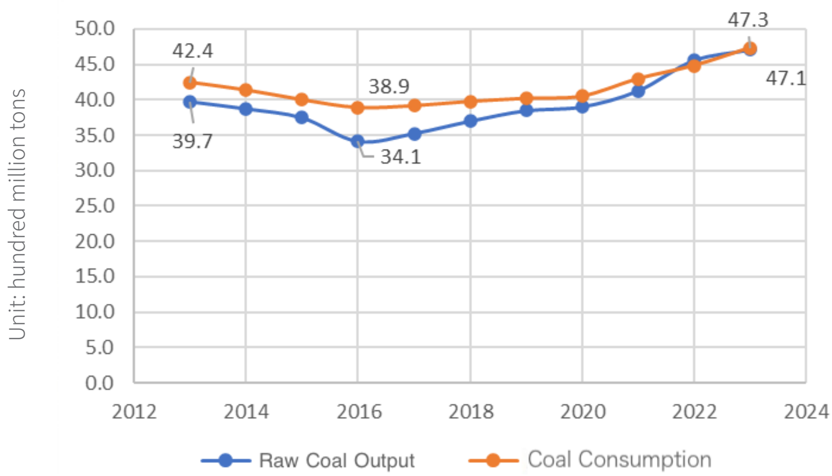

Figure 2 Raw Coal Output and Coal Consumption in China

Source: National Bureau of Statistics of China

Oil

The growth of crude oil consumption has gradually slowed down. From 2013 to 2023, China's crude oil consumption increased steadily, but at a slower pace in general. According to official data of the National Bureau of Statistics and the General Administration of Customs, the crude oil consumption of China grew from 498 million tons to 740 million tons during the period of 2013-2023, with an average annual growth rate of about 4.1 percent.

Across the time series, however, the growth rate gradually flattened: 2013-2017 was a fast growth period, with the crude oil consumption growing at an annual rate of 5.2 percent on average and breaking the threshold of 600 million tons in 2015. This dynamic was mainly driven by high-speed economic growth (with the average annual GDP growth rate standing at 7 percent), rapid increase in car ownership, and petrochemical capacity expansion. 2018-2020 was a growth shift period, with the annual average growth slowed to 3.5 percent, mainly due to the impact of economic structure adjustment and the development of new energy vehicles.

The period from 2021-2023 was a period of fluctuation, with an average annual growth rate of about 3.6 percent (actually 2.8 percent if the effect of low base in 2020 is accounted for), mainly due to the lowered share of demand for chemical raw materials, and the significantly slowed growth of the demand for transportation.

In 2024, crude oil consumption rose further to 740 million tonnes, while domestic production remained stable at around 210 million tonnes, highlighting China's continued heavy reliance on imports. According to the International Energy Agency, fuel-related oil demand such as gasoline, diesel and jet fuel declined to about 8.1 million barrels per day, whereas petrochemical feedstock demand still increased by nearly 5 percent, reflecting diverging structural trends in oil use.

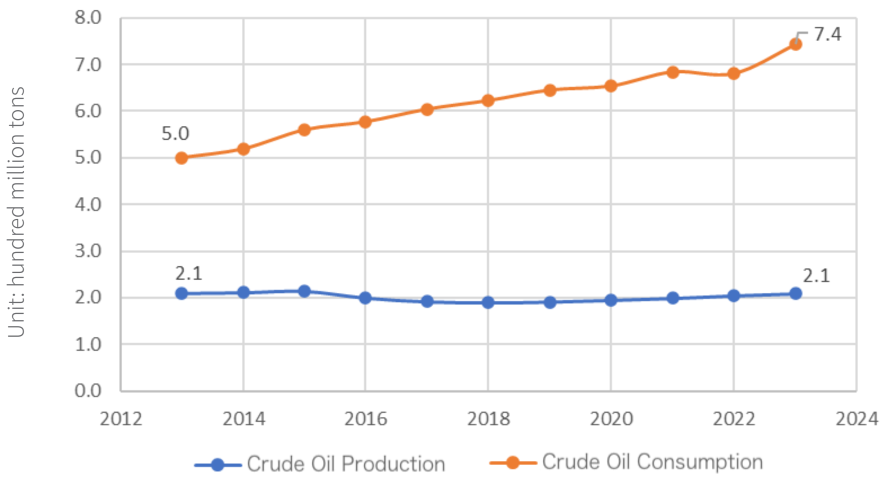

Figure 3 Crude Oil Production and Consumption in China

Source: National Bureau of Statistics of China

Natural gas

Both the supply and demand of natural gas are high and have played an important role in coal substitution. Natural gas is an energy carrier with lower GHG emissions than coal. From 2013 to 2023, China saw the development of natural gas as an important solution to the replacement of coal, and completed the largest coal to gas initiative in the world. China's natural gas consumption increased rapidly from 170.5 billion cubic meters in 2013 to 401.7 billion cubic meters in 2023, with an increase of 136 percent in 10 years and an average annual increase of 23.1 billion cubic meters. At the same time, China's natural gas production has continued to increase, reaching 232.4 billion cubic meters in 2023. This equals to a production volume 1.9 times that of 2013 and almost a doubling in a decade. In particular, the output of unconventional gas[2] reached 96 billion cubic meters in 2023, accounting for 43 percent of the total natural gas output and becoming an important driver for the increased gas reserve and production in China.

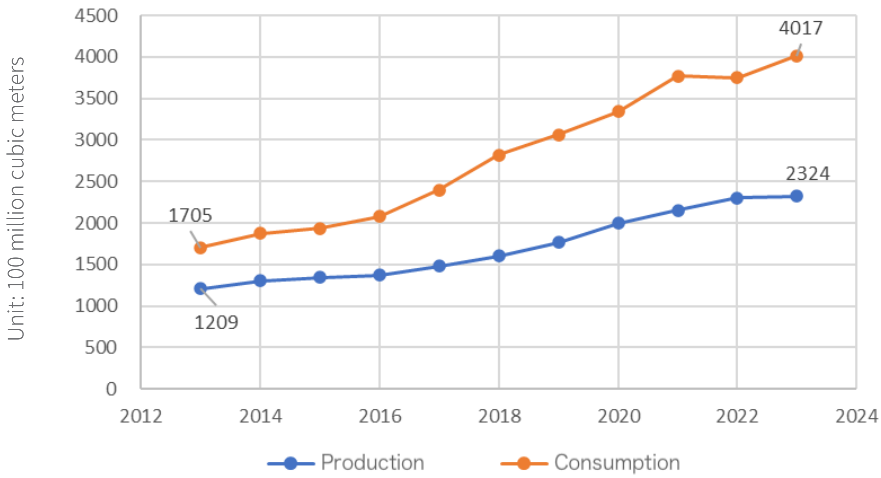

Figure 4 Natural Gas Production and Consumption in China

Source: National Bureau of Statistics of China

The interaction between fossil fuels and China's economic development

The dependence of economic development on fossil energy consumption has steadily declined. From 2013 to 2023, on average, the annual energy consumption growth rate of 4.0 percent supported the annual economic growth rate of 7.5 percent in China. Also, the energy consumption per unit of GDP decreased by 23.2 percent (as shown in Figure 5), resulting in an accumulated energy saving of 1.22 billion tons of coal equivalent. From 2014 to 2023, in particular, China's GDP grew by 78.5 percent, but fossil energy consumption only increased by 37.2 percent. This means fossil fuel consumption per unit of GDP decreased by 33.7 percent from 0.53tce per ten thousand Yuan in 2013 to 0.35tce per ten thousand Yuan in 2023. Therefore, the dependence of economic development on fossil fuel consumption continued to decrease.

2 Unconventional natural gas mainly includes types such as coalbed methane, shale gas, tight sandstone gas, natural gas hydrates, etc. Its occurrence and extraction methods are significantly different from conventional natural gas.

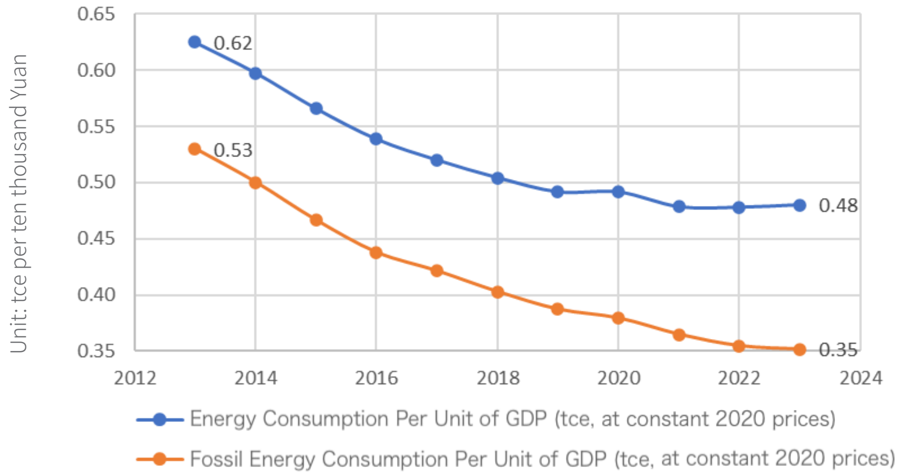

Figure 5 Changes in the Energy Consumption Per Unit of GDP in China during the Last 10 Years

Source: National Bureau of Statistics of China

From 2014 to 2023, China led the world in terms of the reduction in carbon emission intensity. During that period, the global carbon emission intensity decreased by 2.1 percent on average, with 3.0 percent in the United States, 5.5 percent in the United Kingdom, 3.7 percent in Germany and 4.3 percent in China. Therefore, China was one of the countries with the highest decline in the energy-related carbon dioxide emission intensity. From 2013 to 2023, China's decline in the carbon emission intensity was equivalent to having cut 3.84 billion tons of carbon dioxide emissions, making the country an important and even irreplaceable contributor to the global response to climate change.

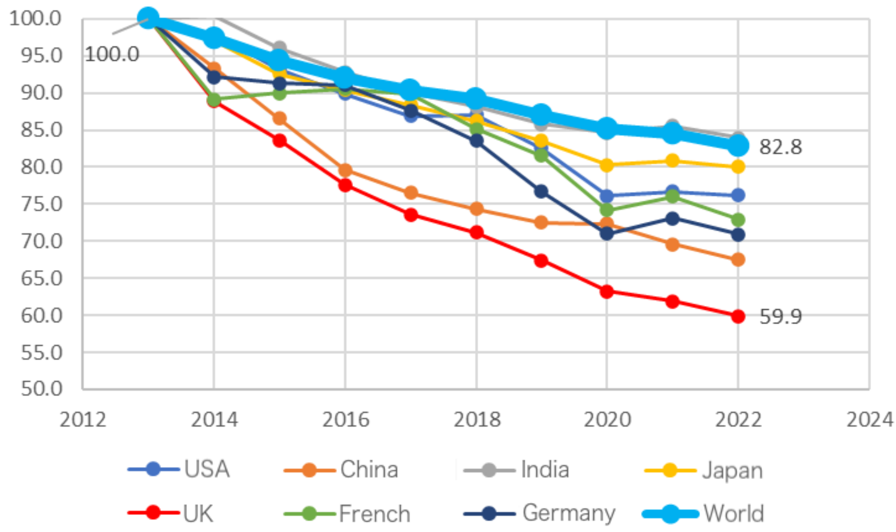

Figure 6 Changes in Carbon Emission Intensity of the World and Typical Countries in Recent 10 Years (100 in 2013)

Source: National Bureau of Statistics of China

Energy-related environmental pollution

Energy-related environmental pollution and carbon emission intensity continue to decline. Fossil energy consumption is one of the main causes of air pollution in China. In 2013, the emission of sulfur dioxide was 24 million tons, the emission of nitrogen oxides was 22.3 million tons, and the emission of particulates was 15 million tons in China. In 2023, China's sulfur dioxide emissions were 2.4 million tons, 90 percent less than in 2013; the emissions of nitrogen oxides were 900,000 tons, a decrease of 96 percent over 2013; and the particulate emissions were 4.9 million tons, down 67 percent over 2013.

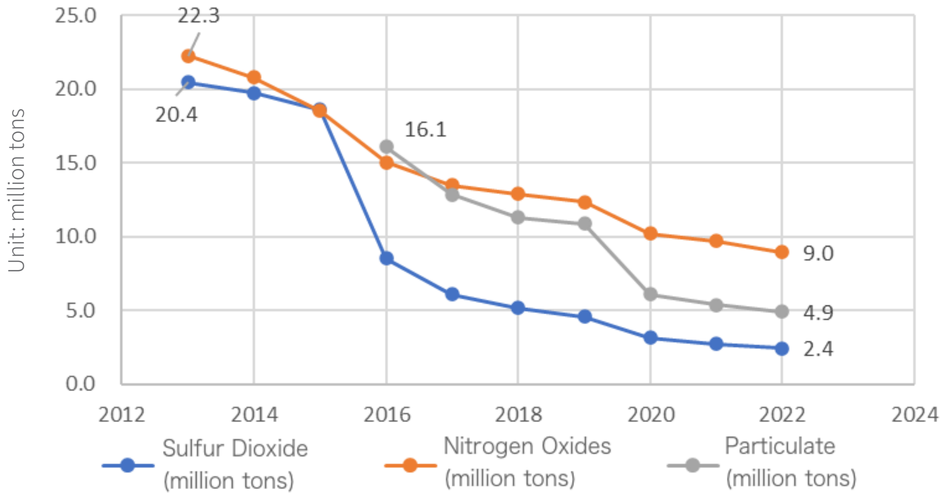

Figure 7 Air Pollutant Emissions across China in Recent 10 Years

Source: National Bureau of Statistics of China

3.2 Progress in Germany

The general structure of energy consumption in Germany

The German total primary energy consumption, as well as the consumption of coal and oil have been steadily declining over the past ten years (Figure 8). The total primary energy consumption fell by about 23 percent from 3860 terawatt hours (TWh) in 2013 to 2959 TWh in 2023.

In 2023, the consumption of fossil fuels – coal 487 TWh, fossil gas 730 TWh, oil 1077 TWh - has also decreased compared to the previous year (see also Figure 8). The decline in total primary energy consumption and the consumption of fossil fuels can be attributed to advances in energy efficiency, the rise of renewable energy and the phase-out of fossil fuels, stimulated by energy and climate policies. In the short-term, measures as a reaction to the 2021-2023 energy crisis also played a role.[3] Year on year fluctuations are also explained by factors such as climatic, as well as economic conditions.

3 https://climatecooperation.cn/wp-content/uploads/2024/11/T2D-WG1-Woring-Paper_Energy-security-in-Germany-and-China_EN.pdf

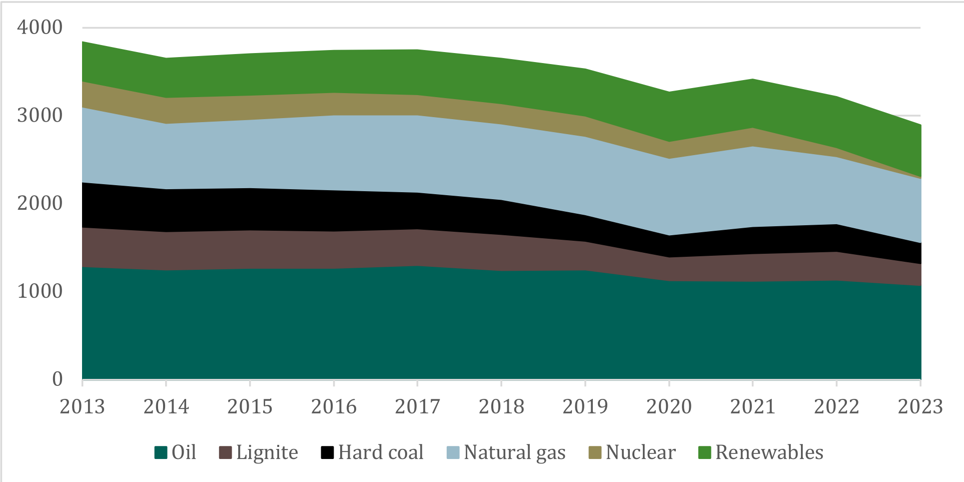

Figure 8 Primary energy consumption in Germany 2013-2023

Source: AGEB (2024a).

Coal

The share of coal in Germany's total energy consumption has continuously decreased over the last decade (Figure 8), mainly due to the replacement of coal by fossil gas in the heating sector and by renewable energy in the power sector. In 2023, coal accounted for around 17 percent (hard coal 9 percent and lignite 8 percent) of primary energy consumption in Germany.

The decline of coal in the last couple of years, except of 2021 and 2022 due to the energy crisis, was driven by several key factors. First, the country's strong environmental commitments and climate goals have led to policies favoring the reduction of greenhouse gas emissions, including the planned phase-out of coal by latest 2038[4]. Second, the increase in renewable energy sources, such as wind and solar power, has reduced the dependency on coal for electricity generation. Third, advancements in energy efficiency have decreased overall energy consumption.

In Germany, coal is mainly used in the power and industry (steel and chemistry) sectors. Lignite is primarily used for power generation[5]. It continues to be mined in Germany and is

4 At regional level, the state of North Rhine-Westphalia plans to phase out coal already by 2030.

5 To a small extent, lignite is still used for the production of briquettes and further processing.

concentrated in the Rhineland, Lusatia, and Central Germany. Domestic hard coal mining started to decline in the 1960s due to unfavorable geological conditions and an associated lack of international competitiveness. In 2018, domestic hard coal mining activities were completely stopped, since then, hard coal demand has been fully covered by imports from various countries, including Australia, the United States, and Colombia (Statistisches Bundesamt, 2023).

In 2023, a total of 512 TWh of electricity was generated from which lignite accounted for around 17 percent (876 TWh) and hard coal for 8 percent (3941 TWh). In 2023, a total of 214 TWh of conventional electricity (lignite, hard coal, fossil gas, oil, and nuclear) was produced, corresponding to a decrease of 53 percent compared to 2013 with 460 TWh (Figure 9). Lignite-fired power generation falling by 46 percent in the period 2013-2023 and hard coal-fired power generation even falling by 65 percent. A decline in electricity demand and increased generation and imports from predominantly renewable energies led to a significant reduction in electricity generation from conventional power plants.

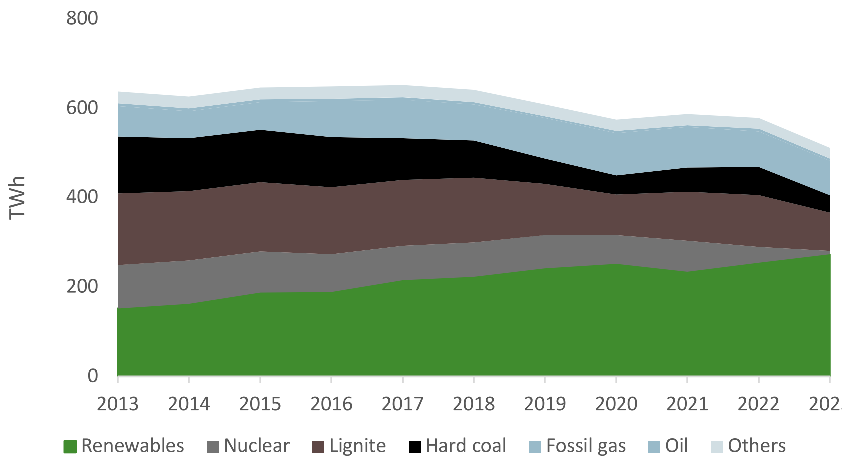

Figure 9 Electricity generation in Germany 2013-2023

Source: AGEB (2025).

As in many other countries, the regional and local economy of the coal regions is often heavily dependent on coal, this includes all direct and indirect branches. While the number of direct coal employees has continued to decline in recent years, various processes have already been implemented to diversify the former coal regions to maintain job opportunities.[6]

6 More information on structural change in the two main coal regions: https://lausitz-brandenburg.de/; https://www.wirtschaft.nrw/strukturwandel-im-rheinischen-revier

Oil

In Germany, oil is used for road transport, air and maritime transport, building heat and industrial production. The final energy consumption in the transport sector has the highest share of oil at around 77 percent, followed by households and commercial services at about 20 percent, and the industry at 4 percent.

In 2023, Germany's oil consumption stood at 90 million tonnes. The three dominant mineral oil products in Germany, accounting for 69 percent of the total, are petrol (17.4 million tonnes), diesel (33.2 million tonnes), and heating oil (11.3 million tonnes). Due to limited domestic oil resources, Germany relies heavily on oil imports, which totaled 72.6 million tonnes in 2023. Domestic production stood at around 1.8 million tonnes in the same year, covering about 2 percent of Germany's demand (AGEB, 2023).

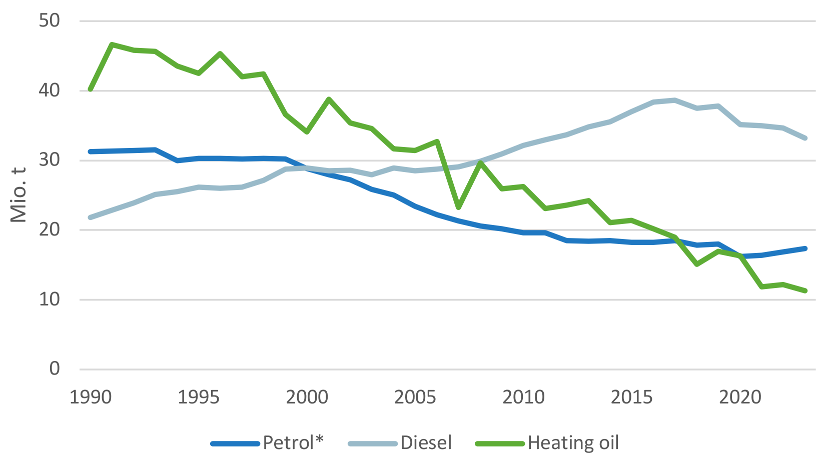

Figure 10 Domestic supply of petrol, diesel and heating oil 1990-2023

*without raw petrol

Source: BAFA (2023), AGEB (2023), BAFA (2022), BMWK (2022).

Petrol and heating oil experienced a steady decline from 1990 onwards (Figure 10), dropping from around 43 million tonnes in 2013 to 29 million tonnes by 2023. Diesel consumption increased steadily until around 2015, after which it plateaued and started to decline slightly. The drop in diesel use, largely tied to freight transport, may reflect reduced truck mileage—corroborated by a continuing decline in the truck toll mileage index since November 2022 and fewer diesel vehicles since 2018.

Natural Gas

The year 2023 was characterized by historically low natural gas consumption. Germany's primary energy consumption of natural gas was at 738 TWh of which 547 TWh was final energy consumption. Around 42 percent of natural gas was consumed by households, 40 percent by industry, and 18 percent by commercial customers. Compared to the previous year, natural gas consumption fell by 2 percent (756 TWh primary energy consumption).

Germany imported a total of 898 TWh (1,316 TWh in 2022) of natural gas in 2023. The largest quantities came from Norway (39 percent) and the Netherlands (27 percent). A share of 7 percent was imported via its German LNG terminals. To ensure supply security during peak demand periods, such as cold winters, Germany maintains significant fossil gas storage facilities spread across strategically located underground sites. In Germany natural gas is primarily used for space heating, hot water and industrial process heat. Germany's decline in gas consumption can be attributed to a combination of structural and situational factors. Warmer winter temperatures reduced heating demand, while the energy crisis and resulting price surge incentivized households and small businesses to curb usage. In the last years, a growing shift toward alternative energy sources—such as renewables, heat pumps, and district heating—has further accelerated the move away from natural gas. Figure 11 illustrates the share of energy sources used for heating supply.

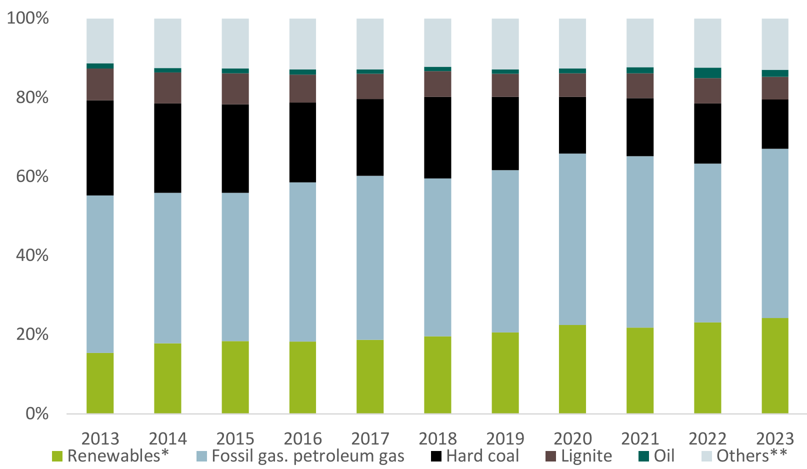

Figure 11 Heat supply in Germany 2013 - 2023

*Biomass and renewable waste, water, wind and PV systems, other renewables

** Non-renewable waste, waste heat, other gases, nuclear energy (until 2003)

Source: AGEB (2024b) as of September 2024; 2023: preliminary data.

In 2023, 91 percent of the energy sources used in industry were for generating electricity and heat, while the remaining 9 percent, mainly oil products and natural gas, were used as raw materials in sectors such as chemicals, food, metals, and construction materials. Despite a 6.4 percent decline from the previous year, fossil gas remained the most used energy source in industry (28 percent), followed by electricity (21 percent), mineral oils and products (16 percent), and coal (15 percent) (Statistisches Bundesamt, 2024).

Ⅳ Key Drivers and Technologies

4.1 Key Drivers and Technological Paths for Transitioning Away from Fossil Fuels in China

Coal and petroleum are the main targets for China to control its fossil energy consumption. Particularly coal is the first and foremost target, as it takes a relatively larger share in the country's fossil energy consumption. China attaches importance to rationally distinguishing between the control targets, focusing on controlling the total amount of coal consumption and the incremental amount of oil consumption, and implements differentiated total amount management over coal consumption in different regions.

In key air pollution prevention and control areas, China strictly controls the total amount of coal consumption, implements coal consumption reduction and substitution, and expands the scale of natural gas substitution. The targets for the Beijing Tianjin Hebei region and surrounding areas are the most stringent, requiring a 10% decrease in coal consumption by 2025 compared to 2020; The target for the Yangtze River Delta region is to reduce by about 5%; The Fen Wei Ping principle requires negative growth in coal consumption,. At present, China's technological paths to control fossil energy consumption mainly include the following: energy structure adjustment; industrial structure optimization; energy-saving technology transformation; resource recycling; product output reduction; energy efficiency improvement, etc. Examples include vigorously promoting the use of clean energy, strengthening industrial capacity regulation and structure adjustment, promoting energy efficiency improvement technology, and accelerating the construction of recycling systems.

Coal

The measures to control coal consumption mainly include: eliminating backward capacity in key industries such as power, steel, cement and coking; carrying out energy conservation-oriented renovation projects, such as waste heat and pressure utilization, coal-fired power plant upgrading and transformation, energy system optimization, etc.; renovating coal-fired boilers and eliminating scattered and backward boilers; implementing “coal to gas” and “coal to electricity” projects; and renovating coking and coal chemical processes and industrial kilns so that coal can be used in a clean and efficient way.

The coal-fired power industry focuses on the “Three Synchronized Renovations (i.e., energy conversation and carbon reduction-oriented renovation, flexible renovation, and heating renovation)” to promote its systematic transformation. In terms of the energy conversation and carbon reduction-oriented renovation, it relies on technologies such as ultra-supercritical secondary reheating to improve coal power efficiency, eliminate older, less efficient small and medium thermal power units, reduce energy consumption, and push the power supply coal consumption to the international advanced level; in terms of the flexible renovation, it improves the system’s adaptation capability through deep peak shaving, fast start-stop and other technologies; in terms of heating renovation, it promotes combined heat and power generation through high back pressure and multi-energy complementary models to realize integrated energy use. To control demand, the industry tightens the demand-side management, and optimizes load distribution through intelligent dispatching and virtual power plant, so as to improve the unit load rate and tap the potential of power saving. Additionally, surplus renewable electricity is used to produce green hydrogen, which is then synthesized into green ammonia. This green ammonia is employed as a partial fuel in coal-fired power units. Through these measures, a new coal-power system has been established, characterized by clean and efficient operation, flexible adjustment, and low-carbon fuel. In this way, the industry has built a new coal-power system featuring “clean and efficient operations, flexible adjustment, and low-carbon fuel”.

The steel industry promotes coal consumption control and carbon emission reduction through systematic reform, with a view to forming a three-dimensional path of transformation toward “structural optimization, technology upgrading, process reconstruction, and digital empowerment”. To optimize the capacity structure, the industry strictly implemented the capacity replacement policy, with the capacity in key regions “reduced rather than increased”, eliminates the backward capacity, and controls the export of high energy-consuming products. To promote process innovation, it creates a technology matrix consisting of “hydrogen energy metallurgy and whole-process residual energy utilization”, demonstrates the non-blast furnace ironmaking technologies such as hydrogen-based direct reduction and hydrogen-rich carbon cycle oxygen blast furnace, and rolls out innovative technologies such as gas-steam combined cycle power generation. To build an energy conservation system, it implements the transformation to large-sized equipment, promotes the interface connection technology between processes, and constructs a full-process residual energy recycling system. To enable the digitally intelligent transformation, it develops an Industrial Internet energy efficiency management platform which dynamically optimizes process parameters through online energy consumption monitoring and intelligent management technologies, and creates a microgrid integrating “generation, grid, load, and storage” with the development of distributed photovoltaic, green hydrogen energy storage and other new energy systems.

The cement industry carries out low-carbon transformation focused on “capacity reduction, fuel innovation, and energy efficiency improvement”. To optimize production capacity, the industry resolutely eliminates backward capacity, actively carries out capacity replacement, promotes the implementation of merger and acquisitions, and continuously optimizes the industrial layout. To promote energy structure transformation, biomass fuels and hydrogen energy are used for fuel substitution, the construction of new self-contained coal-fired units is restricted, and clean energy substitution is promoted. To improve energy efficiency, the advanced sintering, high-efficiency grinding, and waste heat recovery technologies are integrated to build a whole-process energy conservation system.

The coal chemical industry focuses on raw material transformation, process innovation, and industrial coordination to promote clean upgrading. At the raw material end, it implements diversified substitution to gradually replace coal-based raw materials with natural gas, coke oven gas, and green hydrogen; also, it promotes the use of coal as both “raw material and fuel”, and extends the refined product chain. At the process end, it creates an “energy conservation and consumption reduction plus clean production” technical system that integrates high-efficiency gasification, waste heat power generation, and intelligent control technologies to accelerate the elimination of outdated equipment and improve the efficiency of energy conversion. At the industrial coordination level, it deepens the coupling with metallurgy, building materials and other industries, builds a regional energy cascade utilization network, promotes centralized heating instead of decentralized coal-fired facilities, and advances the integrated utilization of coal, electricity, chemistry and heat.

Oil

The main technological paths for oil consumption control include demand control, energy efficiency improvement, fuel substitution, structure optimization, clean utilization, etc. Demand control, i.e. reducing demand, reduces unnecessary demand for oil by adjusting economic and industrial structures and improving planning, management and consumption patterns, Examples include: promoting remote work to reduce commuting-related fuel consumption, developing public transportation systems to shift travel from private cars to buses and metros, and optimizing urban planning to create walkable and bike-friendly cities.. Energy efficiency improvement mainly means to improve the efficiency of equipment and fuel consumption facilities through technical means and eliminate outdated fuel consumption equipment. Fuel substitution refers to measures such as replacing oil with other energy types and substances. Examples include: adopting fuel-efficient vehicle technologies such as turbocharging and hybrid engines, phasing out outdated and inefficient fuel-burning equipment like old industrial boilers, and using lightweight materials such as carbon fiber in automobiles and aircraft to reduce fuel use.

In the field of transportation, the oil consumption control system is built around "fuel substitution, structure optimization and energy efficiency revolution". More specifically, China uses "electricity, hydrogen and biofuel" to diversify fuel substitution, improves the layout of filling facilities, and promotes the electrification and hydrogenization of vehicles. Also, it strengthens energy efficiency management and implements differentiated tax incentives. In addition, it builds a new "road to railway + multimodal transport" pattern, improves the connection of transportation hubs in metropolitan areas, and develops an intensive logistics platform. Moreover, it optimizes the urban spatial layout and promotes the shift of mobility modes to public transport. Furthermore, it deepens the innovation of clean utilization technology and continuously upgrades the quality of oil products and the efficiency of internal combustion engines. Last but not least, it adjusts the industrial layout, reduces the ineffective transportation demand, and improves the efficiency of logistics organization by using information technology.

In the petrochemical field, the oil consumption reduction path across the industrial chain is built around "demand regulation, raw material revolution, and energy efficiency leap". On the demand side, China implements the "source reduction + recycling" dual-track strategy, and promotes the shift of plastic economy to a closed-loop mode by restricting the use of disposable plastic products, strictly controlling the export size of high-oil-consuming products, and building an eco-friendly design system and resource recovery network. On the supply side, China deepens structural reform, promotes the diversified substitution of raw materials, accelerates the industrial application of degradable materials, expands the processes that uses natural gas, biomass and other non-oil-based raw materials, and develops ethane cracking, coal-to-olefin and other new chemical technologies. With respect to energy efficiency improvement, China builds the "intelligent upgrading + capacity optimization" technological matrix, strengthens the whole-process digital management, eliminates the backward production capacity, and promotes the integration of refining and chemical industries and the manufacturing of high-end products. What's more, China implements a global resource allocation strategy, and supports advantaged enterprises to deploy non-petrochemical production capacity overseas to enhance the international competitiveness of the petrochemical industry.

Natural Gas

The natural gas consumption control focuses on "energy efficiency improvement, substitution and transformation, and system optimization" to build a full-chain regulation and control system. China promotes energy conservation-oriented renovation technologies for high-efficiency gas turbines, heat pumps and industrial furnaces/kilns, optimizes the management of process parameters and operations, strengthens intelligent monitoring and dynamic control, and reduces transmission and distribution losses. It accelerates the multi-energy complementary and integrated application of renewable energy, develops biomass heat supply, ground source heat pumps and green hydrogen-coupled energy supply systems, and creates alternative clean heat source solutions for high-temperature industrial scenarios. It also strictly manages and controls the access to high gas-consuming projects, promotes the coordinated dispatching of distributed energy stations and regional gas and power systems, and promotes the intelligent transformation of CHP systems. Moreover, it establishes smart gas management platforms, integrates dynamic monitoring and demand side response technologies, and explores innovative modes such as hydrogen mixing transportation in the transmission and distribution networks. Furthermore, it improves the peak-valley gas price adjustment mechanism, deepens the gas-power price linkage reform, guides the optimization of consumption structure by market-oriented means, and forms a dual regulation path featuring "technology drive and mechanism innovation", to systematically promote the clean and efficient transformation of natural gas consumption.

4.2 Key Drivers for Phasing out Fossil Fuels in Germany

In Germany, the transition away from fossil fuels is driven by the actions and policies outlined in Section 2.2. While there is a clear phase-out path for coal by 2038 at the latest, the transition away from natural gas and oil is determined by overall climate goals and a whole range of policy instruments and measures, the majority of which addresses sector specific drivers and technologies that are outlined in this section.

Power sector

In the power sector, a central driver for achieving the transition away from fossil fuels is the targeted expansion of renewable energy sources. To support this, significant efforts are required in strengthening and expanding transmission and distribution networks to accommodate the increased and geographically dispersed renewable generation. Furthermore, expanding energy storage capabilities, including batteries and other technologies, is essential to manage the inherent variability of solar and wind power. Enhancing the flexibility of electricity demand through demand-side management and smart grid technologies also plays a vital role in balancing supply and demand.

Industry

For the industrial sector, establishing a stable and predictable regulatory environment is identified as a fundamental condition to encourage long-term investments and the greater use of renewable energy sources. To achieve emission reductions despite potential production increases, it is necessary to significantly accelerate investments in climate-neutral production processes, which includes electrification, flexibilisation, and the development and deployment of innovative technologies and climate-neutral energy sources. Ensuring the availability of competitively priced, renewable-based electricity as well as green hydrogen, derivatives, and raw materials is critical to support the industrial transformation.

Buildings

For the buildings sector, the two primary drivers for phasing out fossil fuels are the switch to renewable heating systems and energy-efficient refurbishment of existing buildings, alongside efficient new construction. Renewable district heat and electricity-based heat generation, as well as other climate-neutral sources like geothermal energy and waste heat, are further alternatives to fossil-fuelled boilers.

Transport

In the transport sector, key drivers include the promotion of electric mobility while phasing out internal combustion engines, and the promotion of alternative fuels where electrification is not possible. Additionally, encouraging a shift to more environmentally friendly alternatives such as active mobility (walking and cycling) and public transport, particularly rail, is crucial for reducing emissions.

The phase out of fossil fuels is not only achieved by switching from “old” energy carriers to renewable ones, but the overall reduction of energy consumption and the improvement of energy efficiency should be considered as a starting point (“efficiency first principle”). Reducing the overall energy consumption, reduces the cost of the transformation by limiting the amount of renewables needed to replace fossil fuels and reducing the size of new infrastructure that needs to be built.

V Key Challenges

5.1 Key Challenges in Transitioning Away from Fossil Fuels in China

China's transition away from fossil fuels faces the following major challenges.

Technological bottlenecks and innovation needs

Firstly, there is inadequate investment in the R&D of high-efficiency fossil energy utilization technologies, resulting in insufficient motivation for technological innovation. Although the 14th Five-Year Plan of China explicitly proposes to strengthen the innovation of energy technologies, in the actual implementation process, the progress of many key technological R&D projects is slow due to the insufficient investment of funds and the constraint of scientific research systems and mechanisms. Secondly, the development of alternative energy technologies for oil and natural gas lags behind. Although the popularity of electric vehicles is increasing year by year, the charging infrastructure shortage and the battery technology bottleneck still restrict further development. As a clean energy source, green hydrogen has great potential in theory, but in reality, there are still many technological barriers to hydrogen preparation, storage and transportation. In addition, the level of intelligence and digitalization of the energy system needs improving as well.

Economic cost and social impact

The implementation of strict fossil energy consumption control will lead to the increase of direct investment by the energy industry, which will undoubtedly have a significant impact on the financial situation of relevant enterprises. With the restructuring of the energy mix, the number of jobs in the traditional energy sector, particularly in the coal and oil extraction sectors, is likely to be reduced, resulting in large numbers of workers at risk of unemployment. According to the Ministry of Human Resources and Social Security, in the coal sector alone, more than 500,000 workers are expected to be re-employed or retrained by 2025. This social problem is related not only to the livelihood of individuals, but also to the stability and harmony of the society at large. The environmental improvement brought by fossil energy consumption control will bring long-term health and economic benefits to the society, attract more tourists and investment, and therefore promote economic diversification. Therefore, fossil energy consumption control is a complex process requiring multi-party coordination and long-term efforts, and the best solution needs to be found between balancing economic development and addressing climate change and environmental protection. This requires not only the policy guidance of the government, but also the active participation of enterprises and the public, as well as the joint efforts of the whole society.

Policy implementation and monitoring

The effectiveness of fossil energy consumption control policy is often restricted by the lack of executive power on the part of local governments. With the rapid development of distributed energy and smart grid technologies, traditional supervision means have become difficult to cover these emerging energy consumption modes, resulting in the emergence of supervision blind areas, and therefore, digital governance tools need to be introduced. At the same time, there is a need to explore the establishment of a flexible and powerful policy enforcement mechanism that allows local governments to make appropriate adjustments according to actual conditions, so as to balance the relationship between economic development and environmental protection.

5.2 Key Challenges in Phasing-out Fossil Fuels in Germany

Technological Bottlenecks and Innovation Needs

In the power sector, lagging grid expansion and the slow transformation to a smarter grid present bottlenecks for the transition, including lagging behind on demand-side flexibility of residential consumers and using this flexibility for system services.

In the industrial sector, challenges include the delayed uptake of hydrogen projects, both domestically and globally, due to substantial investment costs. Germany's limited inland production potential also leads to a high dependence on imports, which is subject to geopolitical considerations.

The buildings sector faces the challenge of speeding up the rate of transformation to meet climate targets. Current trends, such as the collapse in the rate of new construction, a renovation rate that is half the desired level, and falling sales of new heating systems, especially renewable ones in 2024, illustrate the scale of this challenge. A lack of clear guidelines in

German regulation, for example, regarding the decommissioning of gas grid areas, also presents a challenge in prioritising efficient heating options and adapting infrastructure.

The transport sector faces similar technological and infrastructure challenges. The short-term availability of sufficient charging options, particularly for trucks, and the necessary adaptations to the power grid infrastructure are critical challenges. The adaptation and expansion of rail infrastructure and public transport also require significant effort.

Economic Cost and Social Impact

In the power sector, a major challenge is to ensure the long-term economic viability of renewable energy without relying on state subsidies. Furthermore, reconciling conflicting land-use demands of renewable projects with nature conservation targets and agricultural activities, and consequently, tackling issues of public support for renewables and grid expansion, are significant hurdles.

Despite efforts to reduce electricity prices, continued high costs hinder the production of and transformation towards electricity-intensive products. Overall, ensuring competitiveness of industries while decarbonizing is seen as the biggest challenge in this sector.

The transformation of the value chain in the automotive and supplier industry from combustion engines to electric ones presents an economic challenge. The sector's delayed transformation to zero and low emission technologies has resulted in it lagging behind in contributing its share to overall emission reduction targets.

Due to their limited progress in decarbonisation, the buildings and transport sectors will likely face high carbon prices in the EU emissions trading system covering buildings and road transport from 2027, which will increase the price of fossil fuels. Fossil fuel prices could reach the level of the energy crisis 2022-23, putting a significant burden on households and businesses.[7] This makes effective policy measures for the decarbonisation of these sectors even more important in order to prevent carbon price peaks.

Preventing excessive burdens for vulnerable groups during this transition is another critical

7 https://climatecooperation.cn/wp-content/uploads/2024/11/T2D-WG1-Woring-Paper_Energy-security-in-Germany-and-China_EN.pdf

challenge, necessitating a redesign of financial support programs with targeted elements for low-income households and other vulnerable groups. The fact that heating system replacement and home refurbishment decisions are made by many individuals underscores the importance of public enthusiasm for the energy transition.

Assuring a fair and just energy transition is a key policy focus both at the German national level and in strategies and policies at the level of the European Union. The transition should be inclusive and equitable, ensuring that no individual or region is disproportionately negatively affected. This requires careful consideration of the potential social and economic disruptions that may arise from the transition, particularly for those in vulnerable situations, such as low-income households, workers in carbon-intensive industries, and regions facing specific challenges. The overarching goal is to transform society in a way that is not only environmentally sound but also socially just, fostering a more prosperous and fairer future for all.

Policy Implementation and Monitoring

Slow approval processes, bureaucratic hurdles and shortages of skilled workers can hamper the efficient and swift implementation of relevant instruments and policies.

The effective supervision of ongoing processes relies on robust data and evidence to monitor progress and address emerging challenges. The German Climate Law forsees the modelling of emissions scenarios in order to ascertain whether Germany is on the right track to meet its climate goals in the mid- and in the long-term. These scenario projections are assessed by an independent expert council. In case the projections show that Germany is not on track to reach its climate goals, this has to be remedied with immediate programs.[8]

8 https://www.umweltbundesamt.de/themen/klima-energie/klimaschutz-energiepolitik-in-deutschland/szenarien-projektionen/treibhausgas-projektionen-in-deutschland#Projektionen

VI Prospect of China's and Germany's Fossil Energy Consumption

6.1 Prospect of China's Fossil Energy Consumption

From the comprehensive point of view, the 15th Five-Year Plan (2026-2030) will be a window period for China to peak its carbon emissions, and also a window period for its fossil energy consumption to peak. During this period, the development of new energy in China will move from "incremental substitution" to "stock substitution" of fossil energy. An analysis of the fossil energy consumption trend in China reveals the following characteristics:

Firstly, the consumption of refined oil has embarked on the downward path. In 2024, the production and sales volume of new energy vehicles in China exceeded 10 million for the first time, and the annual penetration rate exceeded 40%, which greatly exceeded the 20% target for new energy vehicle sales by 2025. Due to the continuous and rapid promotion and popularization of new energy vehicles, the consumption of refined oil products in China decreased by 2.4% year-on-year in 2024. Of them, gasoline consumption declined by 3.1%, diesel consumption decreased by 4.8%, and only kerosene consumption increased. Although petrochemical demand will somewhat increase in the future, it is preliminarily predicted that China's oil consumption will peak at the beginning of the 15th Five-Year Plan at the earliest.

Secondly, there will be room for growth of natural gas consumption. China has actively increased natural gas consumption, and started to promote the "coal to gas" project on a large scale since 2014. Except in 2022, China's natural gas consumption has maintained an annual growth rate of 20-40 billion cubic meters over recent years. It is predicted that the consumption of natural gas in the fields of power generation, industry, transportation and domestic life in China will continue to increase in the future, and natural gas will play an important role as a transitional energy in the process of steady carbon reduction in China after 2030. Considering the fact that natural gas is a relatively clean and low-carbon energy, and that natural gas accounts for less than 9% of China's energy consumption, the increase in natural gas consumption will not significantly hike the national carbon emissions of the country.

Thirdly, coal consumption will reach its peak during the 15th Five-Year Plan period. The "15th Five-Year Plan" period is the time window for new energy power generation to meet the new power demand and gradually replace the existing coal-fired power. To ensure carbon peaking, China has formulated a detailed package of measures to promote new energy power generation, such as advancing both centralized and distributed new energy development, promoting the flexible transformation of coal power, gradually transforming coal power into system-regulated power supply, accelerating the construction of various flexible regulating facilities such as electrochemical energy storage, compressed air energy storage, pumped storage and hydrogen energy, and encouraging the "generation-grid-load-storage integration" to promote the in-situ utilization and transformation of wind and photovoltaic power. It is predicted that with the sustained growth of wind and photovoltaic power generation and continuous increase of investment in non-fossil energy such as hydropower and nuclear power, China's coal power generation will reach its peak before 2030, and coal consumption will reach its peak accordingly. In the background that oil consumption has reached its peak in the first half of the "15th Five-Year Plan", China will certainly achieve the strategic goal of carbon peaking before 2030.

6.2 Prospect of Germany's Fossil Energy Consumption

In Germany the picture regarding the phase-out of fossil fuels is different depending on the type of energy source in question. While the phase-out of coal is clearly defined and timed, there is currently no explicit strategy for gas and oil. This is reflected in projected levels of primary energy consumption of fossil fuels in Germany until 2050, as shown in Figure 12. Consumption levels of lignite and hard coal are well below those of fossil gases and oil, with the phase-out date for coal set for 2038 at the latest.

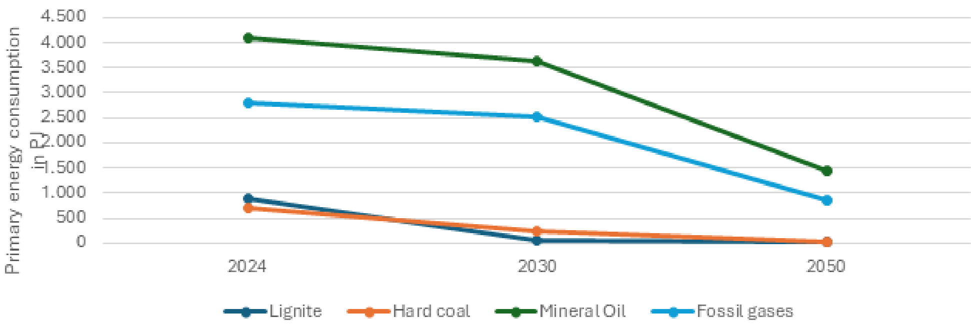

Figure 12 Projected primary energy consumption of fossil fuels based on current policies

Source: UBA (2024).

While there is no explicit gas and oil phase-out strategy formulated in Germany to date, climate targets and the associated policy instruments stimulate their phase-down via decarbonization.

The following figures show projections related to the phase-out of fossil fuels under different scenarios. The BMWK-T45-power scenario approaches the legal target path of greenhouse gas reduction very closely (Figure 13).

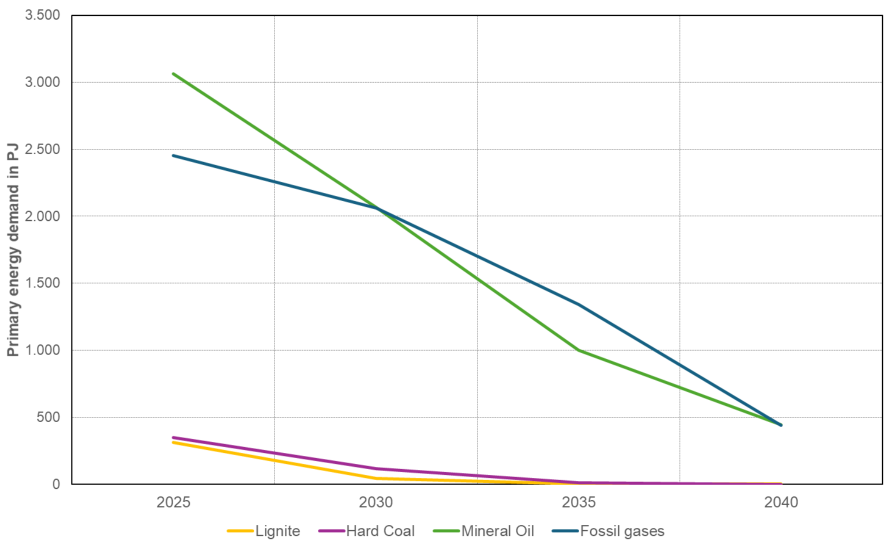

Figure 13 Projected primary energy demand of fossil fuels based on greenhouse gas neutrality scenario BMWK-T45-power

Source: Fraunhofer ISI (2025).

Figure 14 shows that the MMS scenario where existing instruments are implemented will lead to a total reduction in primary energy consumption of fossil gases and oil by 70 percent by 2050. Additionally, the CARESupreme scenario also depicted in the figure shows how a much faster reduction is possible.

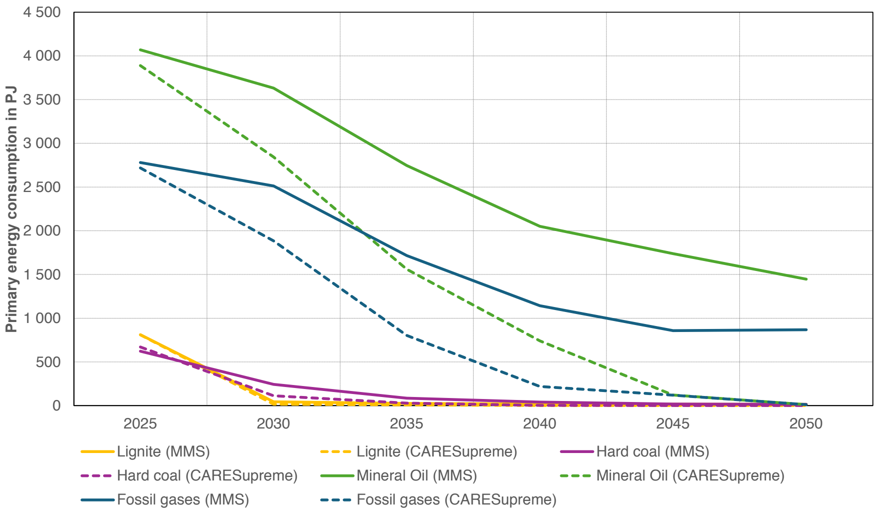

Figure 14 Projected primary energy consumption of fossil fuels based on the MMS current policy and CARESupreme scenarios

Source: UBA (2024), UBA (2025).

Modelling phase-out paths

In Germany, modelling is a key approach for estimating the impact of policies and instruments on greenhouse gas emissions and the associated role of fossil fuels in the coming years. For this purpose, current data (e.g. data on GHG emissions, the economy, technological development) and the political framework are used to model possible outcomes. The modelling results displayed in Figure 8 are based on two scenarios which differ fundamentally in their approaches. The MMS scenario was produced by the German government to project emission pathways and the impact of policies and measures until 2050 under different policy scenarios and is used to fulfil Germany's reporting requirements for progress in climate protection vis-à-vis the European Commission. In the modelling exercise, sectoral models for the energy supply, buildings, road transport and industry sectors are employed and their results integrated in the final analysis. The impact of the different pathways on the overall economy, on households and businesses is analysed in a next step via additional models. The CARESupreme and BMWK-T45-power scenario, on the other hand, are projected to reach a set emission reduction target under certain parameters and assumptions. For example, the CARESupreme scenario is an optimistic, yet feasible scenario with a high part of efficiency and sufficiency.

VII Conclusions

Both Germany and China are essential to global climate goals, and their energy transitions offer important lessons for other countries. Despite different starting points—especially regarding coal—both nations show strong commitment to transitioning away from or phasing out fossil fuels, though their strategies and timelines differ. Germany's clear coal phase-out path and China's gradual approach highlight that national context, such as energy security and economic growth, shapes transition strategies.

Reducing reliance on natural gas and oil remains a significant challenge, especially for Germany, and will require intensified efforts, particularly in the buildings and transport sectors. The role of natural gas varies: China treats it as a transitional fuel, while German greenhouse gas neutrality scenarios show it must be phased out to reach climate goals.

Successful energy transitions depend on substantial investment in infrastructure, technological innovation, improvements in energy efficiency and the expansion of renewables. Public engagement, clear regulatory frameworks, and monitoring mechanisms are crucial for societal buy-in and effective implementation. A just transition is key, requiring support for vulnerable regions, industries, and individuals to ensure no one is left behind. Sectoral interdependencies mean that progress in one area, like renewables, is closely linked to advances in others, such as grid infrastructure and industrial decarbonization.

International cooperation and sharing of best practices, as seen in the Germany-China dialogue, are vital for accelerating global progress toward climate goals.

China-specific conclusions and policy suggestions

In addition to the common conclusions shown above, there are a number of points that apply in particular to the Chinese context and policy making:

- Be active and prudent: On the premise of ensuring the security of energy supply, gradually reduce the consumption of fossil energy and avoid coal reduction campaigns.
- Build the new before discarding the old: On the condition of ensuring the secure and reliable substitution of new energy, maintain the smooth transition of traditional energy and avoid exerting adverse effect on economic and social stability.
- Enforce measures by category: control the total amount of coal, optimize the consumption structure of petroleum, allow natural gas to play a transitional role, and accelerate the development of non-fossil energy.
- Lead by the dual-carbon goal: Oriented to the carbon peaking and carbon neutrality goals, scientifically plan the exit of fossil energy and avoid one-size-fits-all practices.

Main policy suggestions for China to control fossil energy consumption are as follows:

- First, improve the legal and regulatory systems. With reference to Germany's legislative experience in making laws such as the Renewable Energy Act and the Climate Protection Act, China can accelerate the formulation of its own Law on Climate Change Response and other relevant laws and regulations, define the target and phased implementation path for total fossil energy consumption control, and strengthen the binding force of legal instruments. More, it can establish supporting supervision mechanism and punishment measures to ensure effective implementation of policies.
- Second, improve the coal consumption control policy framework. China can strictly control the growth of coal, electricity and coal consumption and of the new capacity in high-energy-consuming industries, and promote the reduction and replacement of coal consumption in key areas. Moreover, it can establish a nationally unified energy consumption monitoring platform to enable accurate management and control.
- Third, optimize the energy structure. China can greatly increase the proportion of non-fossil energy and accelerate the development of nuclear power and biomass energy. Additionally, it can establish a renewable energy consumption guarantee mechanism to ensure that clean power is given priority in connecting to the grid.
- Fourth, deepen the reform and innovation of market systems and mechanisms. China can expand the industrial coverage of the carbon market, implement gradient carbon prices, and improve the green electricity trading mechanism. In addition, it can promote the formation of long-term market-oriented emission reduction mechanisms.
- Fifth, enhance the drive of tech innovation. China can focus on breaking through key technologies for energy storage, hydrogen energy and CCUS, and establish national funds for energy transformation and innovation. At the same time, it can support the flexible transformation of coal power, and the substitution of low-carbon processes in the industrial sector to improve energy efficiency.

- Sixth, ensure just transition. China can set up a special transition fund to support industrial upgrading in resource-based areas, and strengthen reemployment training for employees of the fossil energy sector. In the meantime, it can establish a transformation impact assessment mechanism to ensure a stable social transition.
- Seventh, strengthen international exchanges and cooperation. China can deepen cooperation with Germany and other developed countries in the field of energy transformation, and jointly carry out tech R&D and demonstration projects, so as to lead the in-depth low-carbon energy transformation across the globe and contribute China's solutions for the global energy governance reform.

Germany-specific conclusions

Given the national specificities, the following conclusions can be derived for Germany:

Commit to move ahead ambitiously:

- Keep up the reliability of the energy sector transition in order to guarantee planning security for companies and investors. A firm commitment to renewables - as we observe in China - is key to making the energy transition a success and lowering energy prices.
- Stick to the parallel strategy of phasing out coal and increasing the share of renewables.
- Intensify efforts to reduce the consumption of natural gas and oil given Germany' s ambition to become greenhouse gas neutral by 2045. Strive for an earlier phasing out of coal-fired power generation, building on current market trends and scenarios that show a faster emission reduction is feasible.
- Guarantee both reliable grid connection and grid stability by investing in energy infrastructure and scaling up storage capacities for power and green hydrogen.
- Focus on climate neutral alternatives in electricity generation, by using generation based on natural gas only to guarantee grid stability and focussing on green hydrogen.
- Reduce administrative red tape by e. g. coordinating and reforming rules, addressing planning bottlenecks, streamlining and standardization of approval processes.
- Establish a coherent policy mix of efficient market instruments like carbon pricing and complementary policies across sectors that recognises the synergies and trade-offs to achieve an efficient and effective phase-out of fossil fuels.
- Keep working towards a just transition by addressing social implications, e. g. through training and education for new green skills, and incentives for job transitions, as well as support for low-income households and other vulnerable groups.
- Decarbonise industry while avoiding carbon leakage and safeguarding competitiveness. Recognise the economic opportunities of the energy transition and the path towards greenhouse gas neutrality. Invest in innovations and foster the deployment of innovative technologies.

Sources

AGEB (2023): Energieverbrauch in Deutschland im Jahr 2023. URL: https://ag-energiebilanzen.de/wp-content/uploads/2024/04/AGEB_Jahresbericht2023_20240403_dt.pdf

AGEB (2024 a): Auswertungstabellen zur Energiebilanz 1990 bis 2023. URL: https://ag-energiebilanzen.de/daten-und-fakten/auswertungstabellen/

AGEB (2024 b). Arbeitsgemeinschaft Energiebilanzen, Endenergieverbrauch nach Sektoren, Energieträgern und Anwendungszwecken, 2024.

Bundesamt für Wirtschaft und Ausfuhrkontrolle (BAFA) (2022): Amtliche Mineralöldaten Dezember 2022. URL:

Bundesamt für Wirtschaft und Ausfuhrkontrolle (BAFA) (2023): Amtliche Mineralöldaten August/September 2023. URL: https://www.bafa.de/SharedDocs/Downloads/DE/Energie/Mineraloel/moel_amtliche_daten_2023_08.html; URL: https://www.bafa.de/SharedDocs/Downloads/DE/Energie/Mineraloel/moel_amtliche_daten_2023_09.html

Bundesministerium für Wirtschaft und Klima (BMWK) (2022): Energiedaten: Gesamtausgabe. URL: https://www.bmwk.de/Redaktion/DE/Artikel/Energie/energiedatengesamtausgabe.html

Fraunhofer ISI (2025). Primärenergiebedarf [TWh] / Primary Energy Demand [TWh]. https://enertile-explorer.isi.fraunhofer.de:8443/open-view/57684/f4869314a4e83d8b3bec5e243120836a#.

UBA (2024). Datenanhang mit Kernindikatoren zum Projektionsbericht 2024 (Projektionsbericht 2024). Umweltbundesamt. https://www.umweltbundesamt.de/sites/default/files/medien/372/dokumente/projektionen-2024_kernindikatoren_20240624_uba_v2.xlsx

UBA (2025). Ambitionierte Pfade für Treibhausgasneutralität in Deutschland: CARESupreme und CARETech. Umweltbundesamt. Results from the research project FKZ 3720 41 506 0.

Statistisches Bundesamt (2023). Einfuhr von Steinkohle für die Jahre 2018 bis 2023. https://www.destatis.de/DE/Themen/Branchen-Unternehmen/Energie/Verwendung/Tabellen/einfuhr-steinkohle-zeitreihe.html

Statistisches Bundesamt (2024) Energieverbrauch der Industrie 2023 um 7,8 % geringer als im Vorjahr. https://www.destatis.de/DE/Presse/Pressemitteilungen/2024/11/PD24_413_435.htmlt