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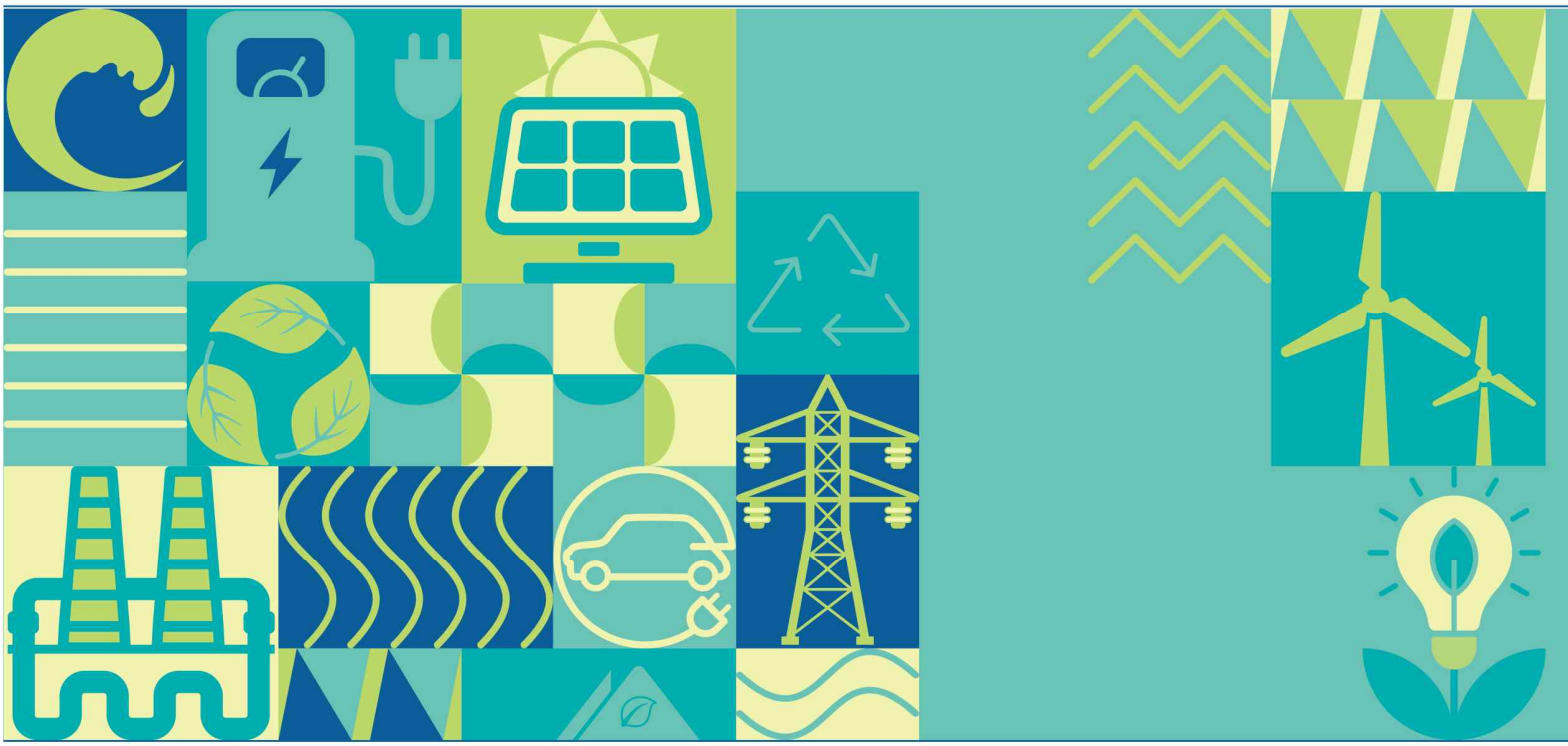
The German Coal Phase-Out : Policy Lessons for Green Transition and Job Preservation in South Korea

Author Misook Park | Kwanghee Yeom | Nga Ngo Thuy | Dimitri Pescia | Jaeryoung Song



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Authors

Misook Park and Jaeryoung Song (National Institute of Green Technology), Kwanghee Yeom, Nga Ngo Thuy, Dimitri Pescia (Agora Energiewende)

Design

Dongjin Corporation
T +82-2-2269-4783
M dj@djdnp.co.kr

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Misook Park / National Institute of Green Technology
Kwanghee Yeom / Agora Energiewende
Nga Ngo Thuy / Agora Energiewende
Dimitri Pescia / Agora Energiewende
Jaeryoung Song / National Institute of Green Technology

Abstract

• The global push to achieve carbon neutrality and the necessity of coal phase-out

The closure of coal-fired power plants is a crucial component of the global agenda to achieve carbon neutrality. However, coal-fired power plants continue to be the world's largest source of power generation. In South Korea, they play a significant role, constituting 41.9% of the country's total electricity production.

South Korea is actively seeking to reduce its reliance on coal-based power generation. In line with domestic and international decarbonization policies.

• German coal phase-out: policies and its implementation

Unlike Germany, which has been transitioning away from coal for over several decades, South Korea is confronted with task of achieving a rapid transition from coal to green alternatives. In this connection, the strategic assessment of the policy experience gathered by the panoply of countries pursuing green transition plays an important role. The first step towards a coal phase-out in Germany was taken in 2016 with the adoption of the Climate Action Plan 2050, which pledged to establish a commission that would develop a roadmap for phasing out coal power.

This chapter outlines the trends and challenges in Germany's coal-based power generation and explores the legal, economic, social, and structural recommendations put forth by the Coal Commission for a successful coal phase-out.

The Coal Commission issued recommendations focused on five points ((A) Phase-out coal, (B) Support the transition, (C) Modernize the power system, (D) Alleviate hardship, (E) Monitor and adjustment measures) to the government, which served as the basis for the regulations adopted to enable coal phase-out.

Germany's coal phase-out strategy has various implications for Korea. Governance mechanisms should be established to adjust the pace of phase-out with step-by-step coal phase-out implementation mechanisms.

• Domestic application of the German Coal phase-out strategy

A platform to build a consensus on the phase-out of coal, such as the Coal Commission, and structural financial support for coal phase-out are enshrined in law to ensure an orderly transition.

Acceptance towards the region can be enhanced through comprehensive consideration, involvement and compensation measures for stakeholders involved in coal power generation, including workers, communities, utilities, and consumers.

To preserve jobs, governance is in place to ensure active job transition, not just passively preventing layoffs, but promoting reemployment through retraining and capacity building.

- Domestic job preservation strategy

The strategy for domestic job preservation is to build sorts of social safety net for all stakeholders, including workers, utilities, local communities, and energy consumers, through a national coal transition rationale and structural financial support.

The second point is to foster the generation of high-quality jobs at local level.

Third, it is the establishment of regional transitions and the corresponding establishment of education and employment linkage systems.

KEYWORD

• Coal phase-out, Germany, Korean, Chungnam, the Coal Commission, Job preservation

1. Introduction

1.1 Background

- The global push to achieve carbon neutrality has reduced reliance on fossil energy in many jurisdictions. However, coal-fired power plants continue to supply most of the world's electricity, and South Korea is no exception in this regard, as coal makes up 41.9% of the country's power generation mix as of 2023 (KIER, 2023). South Korea is actively seeking to reduce its reliance on coal-based power generation, in line with domestic and international decarbonization policies. Industries, workers, and communities are in need of targeted policy support to make this energy transition a success (Lee et al, 2022).
- South Chungcheong Province, also known as Chungnam, is home to a significant share of coal-fired generation capacity in South Korea, accounting for 21.6% of the country's greenhouse gas (GHG) emissions at the provincial level in 2020 (GHG Information Center, 2022). When categorizing emissions by source, power plants make up 61.7% of total emissions, while industrial sectors such as steel and chemicals account for 29.7% (Chungnam Research Institute, 2023). Among municipalities in Chungnam, Boryeong-si, a pivotal hub of South Korea's energy industry and power supply, is responsible for 32% of Chungnam's GHG emissions.
- Given the regional concentration of coal power generation in South Korea, targeted socioeconomic transition measures that support local workers and communities will be particularly important as the country moves to phase out its coal-fired power plants. Various countries at the vanguard of climate action have already made significant progress in their coal phase-out initiatives – including in particular Germany, which has a similar industrial structure to South Korea, making it a valuable touchstone for the development of policy to promote a clean transition away from coal-fired generation (Lee et al, 2022).
- On 8 December 2021, a significant political transition took place in Germany as Angela Merkel concluded her 16-year tenure, and a new cabinet led by Olaf Scholz came into power. Despite this change in leadership, the new German cabinet is committed to pursuing robust coal phase-out policies. Notably, Germany has made a public commitment to cease the construction of coal-fired power plants and to gradually close all existing power plants by latest 2038.
- Given Korea's high dependence on coal-fired generation and insufficient time for coal phase-out, Germany's coal phase-out process, which shares similarities with South Korea's industrial structure and coal-based energy supply, promises to provide valuable insight for the development of South Korean environmental and industrial policy.

1.2 Purpose and Need

- The closure of coal-fired power plants is a crucial component of the global agenda to achieve carbon neutrality. However, regions heavily reliant on power plants as a significant part of their local industry are rightfully concerned about negative social and economic impacts, including rising unemployment and population flight. Unlike Germany, which has been transitioning away from coal for over several decades, South Korea is confronted with the task of achieving a rapid transition from coal to green alternatives. As a result, it is imperative to assess the current situation in South Korea and develop a policy strategy tailored to its domestic context. In this connection, the strategic assessment of the policy experience gathered by the panoply of countries pursuing green transition plays an important role.

1.3 Research Focus

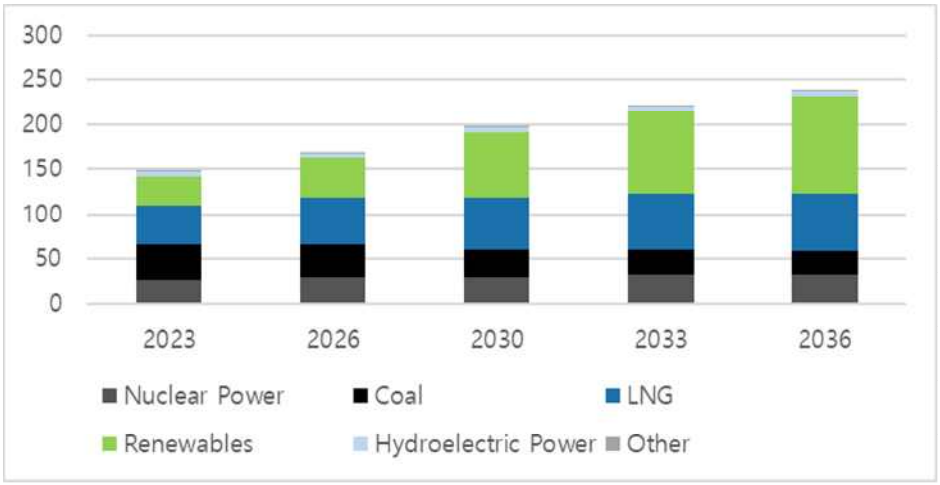
- This study investigates the current state of coal power generation in South Korea with a view to identifying important factors and policy elements that could inform structural innovation strategy for green transition and job preservation in Chungnam Province. On the basis of international collaborative research between South Korea and Germany, the goal is to present strategies for preserving jobs as a foundation for transitioning from coal to green energy and facilitating green industrial transformation.
- To this end, this study analyzes the current issues surrounding coal power generation in South Korea and Germany, as well as Germany's green transition strategy in the coal power sector. A multi-stakeholder commission – known as Coal Commission – was formed to develop a roadmap for phasing out coal-fired power generation. Following extensive deliberations with relevant stakeholders, the Coal Commission issued recommendations to the government, which served as the basis for the regulations adopted to enable coal phase-out. One important instrument has been "reverse auctions" to compensate energy providers for early shutdown. This study takes a closer look at current conditions in South Korea in light of the recommendations presented by the German Coal Commission, in order to assess current South Korean efforts to transition away from coal and provide orientation for future action.

2. Coal Power Challenges in South Korea

2.1 Energy Industry Trends

- South Korea is heavily reliant on energy imports, with an import dependence exceeding 90% (EG-TIPS, 2023). In terms of domestic power generation, coal is by far the dominant energy carrier, accounting for 41.9% of the power mix (KIER, 2023).
- South Korea's coal-fired generation is a primary contributor to national GHG emissions (MOTIE, 2021). In 2020, the Korean government announced a plan to retire 30 coal-fired power plants (15.3 GW) and convert 24 of them (12.7 GW) to liquid natural gas (LNG) power generation by 2034 as part of the 9th Basic Plan for Electricity Supply and Demand (2020-2034), which strives to make progress toward carbon neutrality.
- In 2023, the 10th Basic Plan for Electricity Supply and Demand (2022-2036) includes the retirement of Donghae Units 1 and 2, as well as Dangjin Units 5 and 6. These actions are part of a broader strategy aimed at transitioning a total of 28 old coal power plants to LNG-based generation by 2036. Consequently, coal-fired generation is anticipated to witness a decline both in terms of absolute capacity and as a share of total power generation. Standing at 27.1% (40.2 GW) in 2023, it is expected to decline to 16.0% (31.7 GW) by 2030 and to 11.3% (27.1 GW) by 2036 (Fig. 1).

Figure 1. Annual Power generation forecast (GW) (Source: Adapted from MOTIE, 2023)



• Conversely, renewable energy is poised to experience significant and rapid growth, both in terms of absolute capacity and its share of the power mix. While renewables account for 22.1% of generation (32.8 GW) in 2023, this is anticipated to surge to 36.7% (72.7 GW) by 2030 and to 45.3% (108.3 GW) by 2036. By contrast, nuclear energy is expected to witness an increase in capacity from 26.1 GW in 2023 to 31.7 GW in 2036. However, nuclear will see a decline as a share of the power mix, from 17.5% to 13.2%). Consequently, the power industry is undergoing a significant structural transformation. (Kwon, 2023).

2.2 Efforts to Reduce Coal Power in South Korea

• In September 2021, the government enacted the "Basic Act on Carbon Neutrality and Green Growth in Response to the Climate Crisis," which aims to encourage transition to a carbon-neutral society. This included the establishment of a phase-out plan for the closure of coal-fired power plants. As of 2023, there are 58 coal power plants in South Korea: 29 in Chungnam, 14 in Gyeongnam, 7 in Gangwon, 6 in Incheon, and 2 in Jeonnam. These figures reveal the strong regional concentration of these plants.

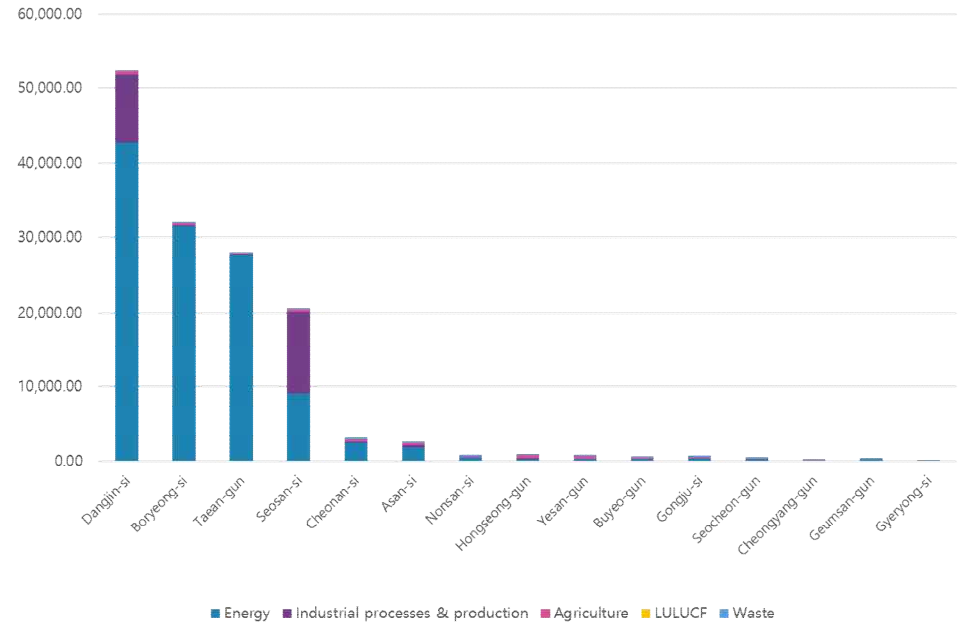
• South Korea's energy industry and power supply is largely concentrated in Chungnam. Accordingly, Chungnam is the province with the highest GHG emissions and is also the second-largest consumer of energy. Moreover, 57.5% of the industrial facilities in the province belong to high-emission sectors. In light of the national ambition to reduce coal power generation, there is a clear need for targeted transition policies to assist Chungnam and other coal-dependent regions. Ultimately, the strategies that are adopted in Chungnam to transition away from coal power generation to green alternatives while also avoiding negative socioeconomic effects such as increased unemployment are sure to provide important orientation for structural transformation in other regions of South Korea.

2.3 Emission and Industry Trends in Chungnam

• In 2020, among the cities and counties of Chungnam, Dangjin-si emitted the most GHG, accounting for 52.5 Mt CO_2-eq (36.5%), followed by Boryeong-si at 32.1 Mt CO_2-eq (22.3%), Taean-gun at 27.9 Mt CO_2-eq (19.4%), and Seosan-si at 20.5 Mt CO_2-eq (14.3%) (Fig. 2) (EEI, 2023). The GHG emissions in these four municipalities above represent 92.5% of total emissions in Chungnam Province, which in turn account for 20% of the total regional GHG emissions in South Korea.

Dangjin-si has the highest share of GHG emissions, primarily attributable to the manufacturing industry, which accounts for nearly 50% of regional GDP, or 5.3 trillion Korean won (approx. 3.7 billion euros). This suggests that Dangjin-si is less likely to incur direct impacts from coal phase-out in Chungnam Province. By contrast, Boryeong-si's economy heavily relies on the energy supply sector, which represents 27.5% of Boryeong-si's total GDP, or 3.8 trillion won (approx. 2.7 billion euros).

Figure 2. Direct GHG emissions in Chungnam by municipalities
(Unit: Kt CO_2-eq.) (Source: Adapted from GHG Information Center, 2022)

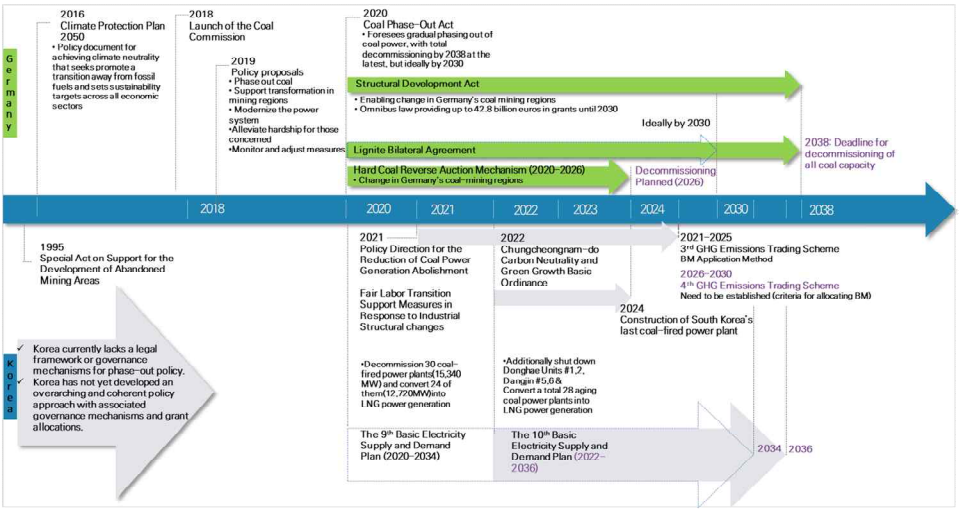


- Within Chungnam, coal phase-out is anticipated to hit Boryeong-si the hardest, as this city accounts for 32% of the province's power generation. The premature closure of Boryeong Thermal Power Units 1 and 2 in 2020 plunged the local economy and industry into a crisis to exacerbate negative trends, including ongoing declines in employment, GDP, and tax receipts that persists to this day. Boryeong-si has plans to shutter Units 5 and 6 by 2025, and this is expected to expand the negative trends caused by the closure of Boryeong Thermal Power Units 1 and 2.

3. The German Coal Phase-out: Policies and Implementation

- The details of the German coal phase-out plan were elaborated in 2018 based on the overarching roadmap and recommendations provided by the Coal Commission. The Coal Commission together with the Ministry of Economy and Environment who provided the secretariat had support from the ruling government. In South Korea, by contrast, as shown in Fig. 3, responsibility for domestic coal phase-out is fragmented among various government departments, due to the absence of an overarching legal foundation or steering structure.

Figure 3. Comparing Coal Phase-out: Germany (above) and South Korea (below)



• This section examines Germany's coal phase-out, including the adopted regulatory mechanisms, progress achieved thus far, and associated challenges. It devotes specific attention to the Coal Phase-Out Act and Structural Development Act, as well as the mechanisms for achieving gradual phase-out, including bilateral agreements with energy suppliers and reverse auctions.

3.1 The Role of Coal in Germany

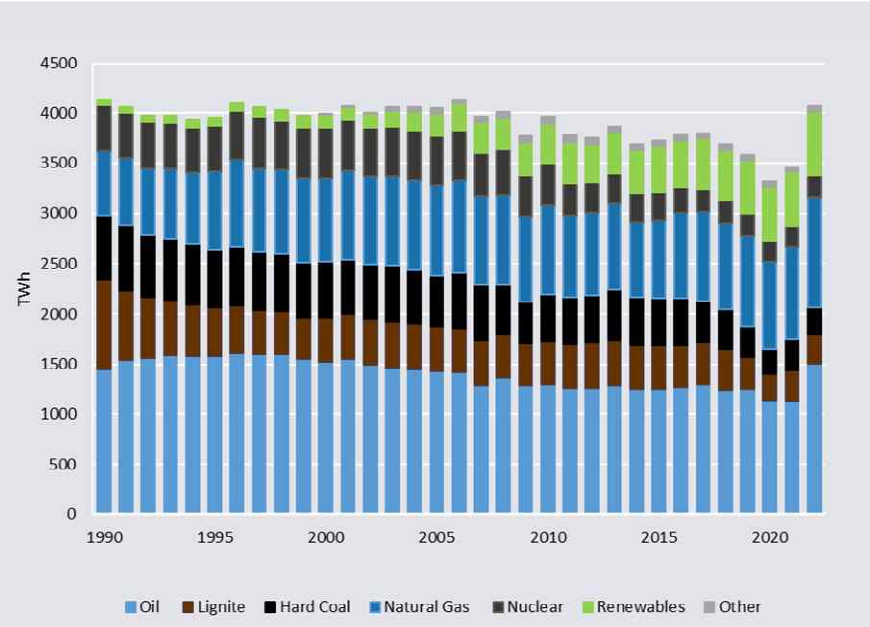
• Coal played a major role in the rise of Germany as an industrial power and has been used for electricity generation since the late 1800s. Germany has significant brown coal (lignite) and hard coal (anthracite) reserves. Domestic hard coal mining initially started to decline in the 1960s due to unfavorable geological conditions and an associated lack of international competitiveness. In 2018, national hard coal mining activities were completely stopped, and since then, hard coal demand has been fully covered by imports from various countries, including the US, Australia, Colombia, and South Africa (Destatis, 2023). While Russia was formerly Germany's largest supplier of coal, imports from Russia were suspended in August 2022, because of the Russian invasion of Ukraine. In Germany, hard coal is used for power generation and in industry, particularly in steel and chemicals.

• Lignite continues to be mined in Germany, and it is consumed exclusively by the energy sector. German lignite-fired power plants and lignite open-cast mines are concentrated in the Rhineland, Lusatian, and Central German coal regions. By contrast, hard coal-fired power plants are widespread throughout Germany, but most are situated in West German states.

3.1.1 Energy Consumption in Germany, 1990-2022

• The share of coal in Germany's total energy consumption has continuously decreased over the last three decades, mainly due to the replacement of coal by natural gas in the heating sector and by renewable energy in the power sector. The rate of decline was particularly sharp after German reunification, with coal consumption decreasing from 1,530 TWh in 1990 (representing 37% of total primary energy consumption) to 956 TWh in 1999 (24% of total primary energy consumption). A second sharp decrease occurred between 2018 and 2022, as the share of coal dropped from 22% of total primary energy consumption to 14%. Today, coal accounts for power production of 561 TWh (lignite: 290 TWh; hard coal: 271 TWh).

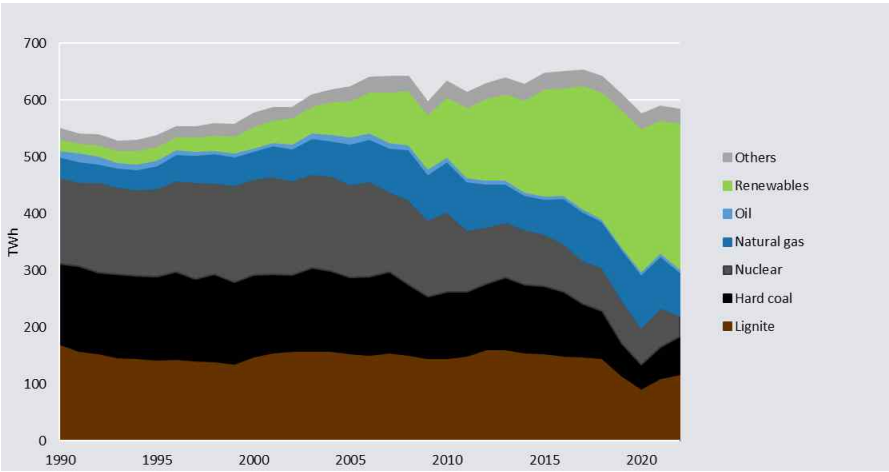
Figure 4. Energy Consumption in Germany, 1990–2022 (Source: AGEB, 2022)



3.1.2 Power Generation in Germany, 1990–2022

- The share of coal in power generation has declined by half over the last three decades. Coal accounted for 31% of total power generation in 2022, down from 57% in 1990 (Fig. 5). Today, Germany's lignite-fired power plants (48 units) have a total capacity of 19.7 GW, while hard coal plants (88 units) have a capacity of 20.3 GW[1)] (Umweltbundesamt, 2021).

Figure 5. Gross electricity generation by fuel in Germany, 1990–2022 (Source: AGEB, 2022)



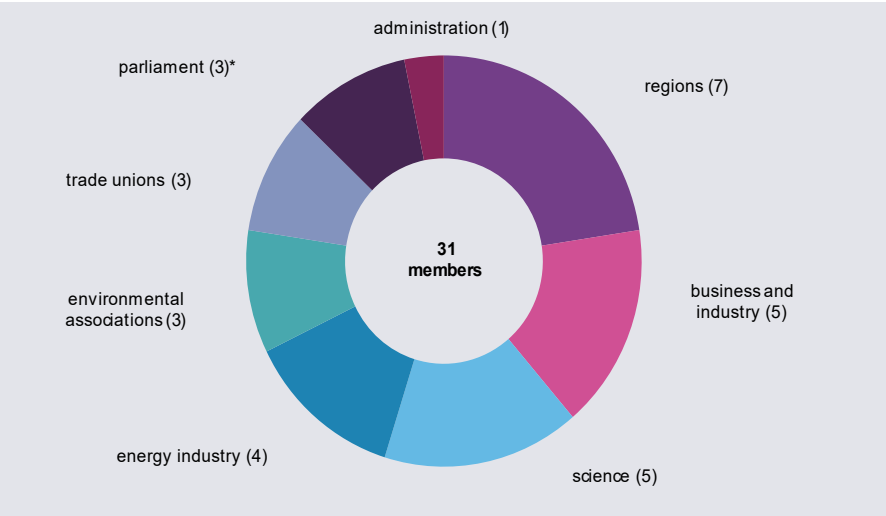
1) Some of these plants are located outside the electricity market (e.g. in the replacement reserve).

3.2 The German Coal Commission

3.2.1 Establishing the Coal Commission

- The first step towards a coal phase-out in Germany was taken in 2016 with the adoption of the Climate Action Plan 2050, which pledged to establish a commission that would develop a roadmap for phasing out coal power. In 2018, the coalition agreement that was signed between the CDU (Christian Democratic Union) and SPD (Social Democratic Party) confirmed the pledge to establish such a commission. At the end of 2018, the "Commission for Growth, Structural Change, and Regional Development," also known as "Coal Commission," came into being.
- The Coal Commission was tasked with: (1) proposing measures to ensure that the energy sector would meet the GHG emissions reduction target for 2030 (at that time, -55% by 2030 compared to 1990 levels); and (2) developing a long-term plan for the gradual phase-out of coal-fired electricity generation, including necessary measures to achieve this goal while helping coal-reliant regions to ensure a just transition for impacted employees and communities.
- To ensure broad support for the phase-out plan, the Coal Commission was established as an independent body with 31 representatives from various walks of society, including trade unions (3 representatives), environmental associations (3), the energy industry (4), academia (5), business organizations (5), public administration (1), and the affected regions (7). The meetings of the Coal Commission were also attended by three members of the German parliament (Bundestag). However, they had no voting rights on the Commission.

Figure 6. Composition of the Coal Commission



- The Coal Commission was led by four co-chairs: Ronald Pofalla (the former head of the German Chancellery), Barbara Praetorius[2] (an energy and environmental economist), and the former heads of the state governments of Brandenburg and Saxony, Matthias Platzeck and Stanislav Tillich. These co-chairs were supported in their work by a secretariat at the Federal Ministry of Economic Affairs and Energy. Coal Commission resolutions required a two-thirds majority, which meant that each of the major stakeholder groups had veto power.

2) Dr. Barbara Praetorius previously served as the Deputy Director of Agora Energiewende.
* without voting rights

• The representational breakdown and voting rules adopted for the Coal Commission were reflective of the German approach to political decision-making, which relies on consensus-building. Due to the distributed nature of political power in German federalism, support at the state level is particular important for national initiatives. In addition, the German constitution offers strong protection against expropriation. Accordingly, a solution that was opposed by the private sector could have resulted in lawsuits, as occurred when the German government decided to accelerate the phase-out of nuclear energy in 2011 (which ultimately resulting in legal settlements with the nuclear power industry worth more than 2.4 billion euros). The Coal Commission wanted to avoid a similar outcome by initiating a process that would generate a broad consensus on the best way forward.

3.2.2 Policy Proposals of the Coal Commission

• The Coal Commission's proposals were finally published in January of 2019 following eight months of meetings. The Commission recommended decommissioning 44 GW of coal-fired capacity, which would result in costs of 69-93 billion euros[3] (Agora Energiewende, 2019).

• The Coal Commission's proposal to the government aimed to address the concerns of all key stakeholders:

(1) Coal phase-out: It was agreed that no new coal power plants and mines were to be opened in Germany and that all existing coal-fired power plants were to be shut down in a stepwise manner by latest 2038[4]. Operating capacities were to decrease to 30 GW by 2022 (15 GW of lignite and 15 GW of hard coal) and to 17 GW by 2030 (9 GW of lignite and 8 GW of hard coal). In order to reasonably compensate the owners of these plants, the hard coal power plants were to be decommissioned through reverse auctions, and lignite power plants were to be decommissioned through bilateral negotiations. (see Section 3.4 for details on these phase-out instruments).

(2) Support for transformation: The Commission proposed using structural aid to boost investment in new energy systems, expand transport and digital infrastructure, promote innovation, and create alternative employment and economic opportunities in the coal-mining regions.

(3) Modernizing the power system: The Commission's proposal included measures to accelerate the deployment of renewables and cogeneration power plants to replace coal-fired power generation while also maintaining security of supply and increasing system flexibility. The Coal Commission also proposed a cancellation of ETS emission certificates granted for the plants, in line with the phase-out.

(4) Alleviate hardship: The Commission recommended extensive labor market measures to support those employed in the coal industry, including protections against dismissal, provisions for retraining, measures for transitioning to new jobs and early retirement of workers.

• In addition, consumers would be protected against an increase in electricity prices, with subsidized prices if necessary. Finally, power plant operators would be compensated for the early shutdown of the coal power plants.

(5) Monitoring and adjustment measures: The Commission called for monitoring reports to be published every three years. Given positive trends, it was envisioned that the coal exit timeline could be accelerated.

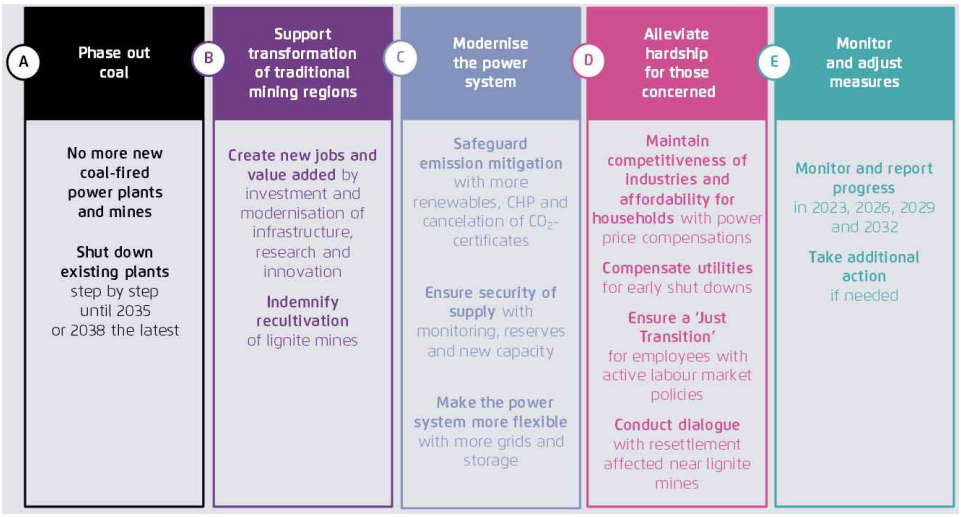
3) In comparison, the German nuclear exit targeted 12 GW of nuclear capacity and came at a cost of ~38 billion euros (Clean Energy Wire, 2015) for decommissioning and waste storage, before the additional 2.4 billion euros was paid to operators.

4) In 2021, the current government has vowed to end the fossil fuel era and phase out coal "ideally" by 2030, eight years earlier than agreed in German coal phase-out law. In 2022, this political commitment was turned into law in the state of North Rhine-Westphalia, which aimed to complete the phase-out of coal no later than 2030. However, two lignite plants in that state that were supposed to go off the grid in 2022 will remain in operation until 2024 to provide additional power capacity amid the energy crisis fueled by Russia's invasion of Ukraine.

• As noted above, the Commission proposed different mechanisms for buying out hard coal power plants (reverse auctions) and lignite power plants (negotiated phase-out). A differentiated approach was selected because the German lignite sector is dominated by just two big companies, RWE and EPH (the owners of LEAG and MIBRAG), making competitive auctions impossible. Furthermore, in the case of lignite, Germany's open-pit mines and power plants are predominantly located in close proximity, so there are complex relationships between generation and mining that are difficult to account for in auctions.

• While the consensus reached by the Commission was generally well received, several voices criticized that it would be insufficient for achieving the Paris agreement targets. Another point of complaint was the divergent treatment received by lignite and hard coal power plant operators.

Figure 7. Overview of the recommendations made by the Coal Commission (Source: BMWK, 2019)



3.3 Coal Phase-out Policies in Germany

3.3.1 The Coal Phase-out Act

• In July of 2020, the German government adopted the "Act to Reduce and End Coal-fired Power Generation" (also referred to as the Coal Phase-Out Act), 18 months after the Coal Commission issued its recommendations. The Coal Phase-Out Act foresees a gradual decline in coal power capacity, with total phase out by 2038 at the latest, yet ideally by 2030. The roadmap for phase-out includes specific pathways for lignite and hard coal (Fig. 8). While the reduction in lignite capacities is based on bilateral negotiations between lignite operators and government,[5] the reduction in hard coal plants is organized through auctions up to 2023 (decommissioning by 2026). Specifically, the plants bid against each other, indicating the minimum level of compensation they are willing to accept from the government to perform decommissioning. From 2027 onward, however, phase-out for hard coal plants is mandated, and no financial compensation is provided. This deadline for receiving compensation incentivizes coal plant operators to submit bids throughout the reverse auction process that ended 2023. (for more details on auctions, see Section 3.4.2).

5) A lignite phase-out has a greater effect on mining regions and workers than a hard coal phase-out due to the complex vertical integration of the lignite sector.

• The Coal Phase-Out Act sets forth coal capacity ceilings for 2022 and 2030, following the recommendation of the Coal Commission. Specifically, the Act foresees a maximum of 30 GW by the end of 2022 (hard coal and lignite: 15 GW each)[6] and 17 GW by the end of 2030 (9 GW lignite and 8 GW hard coal) (Fig. 8). Remaining coal capacity must be decommissioned by 2038 at the latest, yet ideally by 2030.[7]

Figure 8. Germany's Roadmap for Capacity Reductions

3.3.2 Structural Development Act

• The Structural Development Act supports structural change in Germany's coal-mining regions, with the aim to encouraging new sustainable economic activities. The Structural Development Act was an omnibus law that introduced the Investment Act for Mining Areas and amended various other regulations. Under the Investment Act for Mining Areas, coal regions will receive as much as 42.8 billion euros in financial aid up to 2038. Of this amount, 14 billion euros are to be managed directly by the impacted states, and used to make investment in business-related infrastructure, public transportation, high-speed internet, and transport infrastructure (see Fig. 9).

• A further 26 billion euros are to be managed by the federal government working in collaboration with the impacted states to fund environmental protection measures, research programs, transport infrastructure, or to relocate federal institutions to the coal mining regions, with the objective of creating up to 5,000 new jobs.

• In addition, up to 2.8 billion euros will be allocated to local jurisdictions that are economically weak and particularly dependent on hard coal plants.

6) In comparison, at the end of 2017, a total of 42.6 GW of coal-fired power plants were still in the market (22.7 GW of hard coal and 19.9 GW of lignite).
7) The government will evaluate whether the decommissioning can be moved up to 2030 by the end of 2023.

Figure 9. Financial assistance to coal regions (Source: BMWK, 2020)

Regional measures	Federal and regional measures	Additional measures
Up to 14 bn € For particularly important investments by the regions and municipalities Regions and municipalities decide on projects	Up to 26 bn € For new programs and existing programs Federal state and regions decide on projects through a coordinating body	Up to 1 bn € for hard coal power plant locations that are particularly affected by the coal phase-out Up to 1.8 bn € for former coal regions in central Germany

3.4 Coal Phase Out Instruments in Germany

3.4.1 Bilateral Agreements (Lignite)

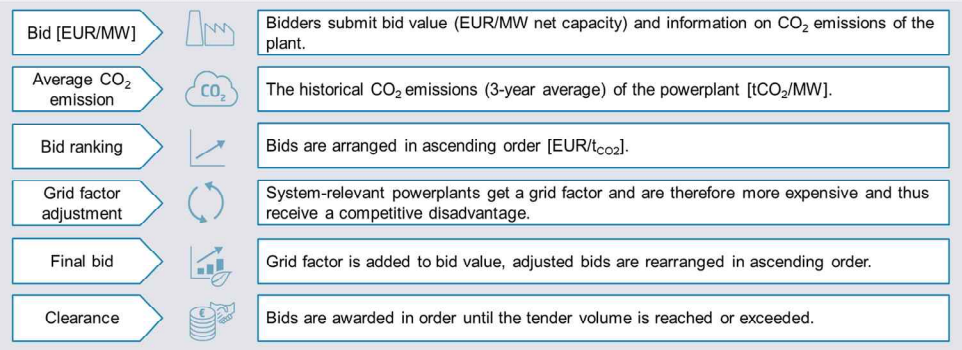
- In January 2020, after months of talks, the federal government reached an agreement with lignite operators and the government heads of the impacted federal states. The agreement foresees a timeline for the shutdown of lignite plants based on contracts signed with the lignite operators RWE and EPH. The agreement also foresees starting the phase out in West Germany (specifically, in the Rhineland) to dampen the effects on the economically weaker East German mining districts. In total, 4.35 billion euros will be paid to compensate the operators of lignite power plants (2.6 billion euros for RWE and 1.75 billion euros for LEAG). The contracts signed with the operators specifically preclude operators from pursuing lawsuits for damages at a later date.

3.4.2 Reverse Auction Mechanism (Hard Coal)

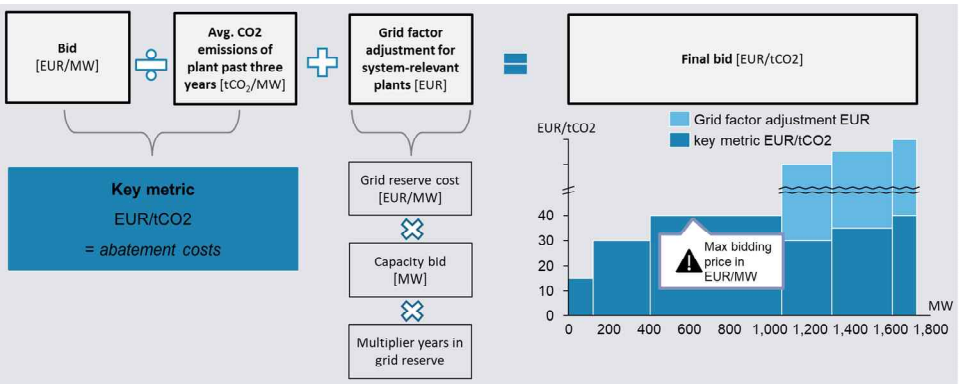
- Since September 2020, the reduction of hard coal capacity has been implemented through the mechanism of "reverse auctions," which will be organized by Germany's grid regulator, the Federal Network Agency, up to 2026. The auction is organized on a "pay-as-bid" basis, meaning that every successful bidder receives only the amount that was bid. The auctions took place around twice a year; the last auction was held in June 2023, for planned decommissioning in 2026. The auction mechanism (as illustrated in Fig. 10) foresees both incentives and penalties.
- Each auction includes a maximum bid price, which declines with each successive auction, as to incentivize early participation in the program. Bid prices are also adjusted by an emissions factor to encourage the retirement of higher-emitting plants. The Coal Phase-Out Act also includes provisions to force decommissioning without financial compensation in the event of insufficient participation in the auctions. In this way, the operators have a clear incentive to participate (i.e. compensation) and also risk penalties for non-participation (i.e. forced closure, with no compensation).
- The forced closure provisions will be activated in the event of insufficient participation in the auctions, and closures will proceed according to the age of power plants (with older plants decommissioned first). Before shutdown occurs, transmission grid operators are required to check whether the plant is required for grid stability.
- The reverse auction mechanism was chosen as it provides several benefits: it leverages competition and thus helps to reduce the cost of the coal phase-out; the associated publication of auction results provides coal plant owners with a market signal as to the value of "early retirement"; the government maintains control over the timing of plant retirements; and reduces financial risks.

Figure 10. Reverse auction mechanism for hard coal power plants
(Source: Agora Energiewende, 2022)

How does the auction process work?



How are the bids calculated?



• As part of the auction process for hard coal plants, 41 plants with a total capacity of 10.7 GW have been committed to phase-out. The auction process came with cost of round 700 million euros (Tiedemann and Müller-Hansen, 2023).Fig. 11 shows the results of the last seven auctions. In the first round, the maximum bid was set at 165,000 euros per MW but actual bids ranged only from 6,047 euros per MW to 150,000 euros per MW. The capacity-weighted average bid reached 66,259 euros per MW, significantly below the permitted maximum bid. During that first round, 11 power plants, worth a total of 4.8 GW, submitted a bit, above the target volume of 4 GW. The largest power plant that was selected in the first auction had a size of 3,600 MW, while the smallest was only 875 MW. The compensation payments for this first auction round totaled 317 million euros.

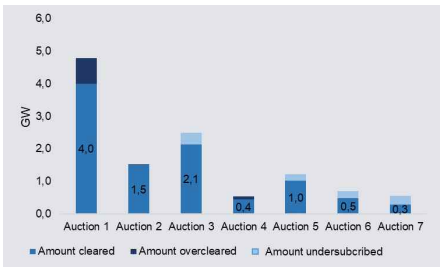
Figure 11. Reverse auction results (Source: Bundesnetzagentur, 2023)

a. Auction results

Auction round	Maximum bid (euros/MW)	Auctioned capacity (MW)	Year of decom.	Smallest and largest power plant (MW)
Round 1 (Sep.2020)	165,000	4,000	2021	875 – 3,600
Round 2 (Jan.2021)	155,000	1,500	2021	67 – 757
Round 3 (Apr.2021)	155,000	2,480	2022	8.4 – 717
Round 4 (Oct.2021)	116,000	433	2023	8.4 – 510
Round 5 (Mar.2022)	107,000	1,222	2024	1.5 – 517
Round 6 (Aug.2022)	98,000	699	2025	472
Round 7 (Jun.2023)	89,000	542	2026	〈 150

b. Bid range of auctions

c. Over-and undersubscription to auctions



• Interestingly, auctions 2, 3, and 5 saw some bids for 0 euros per MW. This can be explained by the fact that operators additionally benefit from financial support for early retirement when they are selected to decommission, beyond the compensation tied to the number of MW being shut down. This extra payment from the state government is not directly included in the auction-based compensation.

3.5 Ensuring a Just Transition for Affected Regions and Workers

3.5.1 Modernizing the Coal Sector in the Ruhr Area (Former hard coal mining region in West Germany)

• In 1968 around 80% of all hard coal mines in Germany, which were previously owned by independent companies, were merged into one company: Ruhrkohle AG (later renamed RAG). The German government covered the debts of companies joining the Ruhrkohle AG consortium. This consolidation of ownership enabled the government to manage mine closures more efficiently while also providing solutions for laid-off workers. The labor unions secured massive influence within RAG. Specific rights for workers in the coal and steel sector were enshrined in federal law (in the "Mining Codetermination Act"). Workers at mines undergoing closure had the opportunity to continue working in another mine or enter an early retirement scheme.

• RAG received extensive subsidies. For example, in 1968, most of Germany's steel mills signed a contract to buy coal only from RAG, with the government agreeing to cover the price gap between domestic coal and cheaper imports (Klute, 2015). Furthermore, beginning in 1965 a series of laws were implemented that enabled German electricity utilities that predominantly used German coal to levy a surplus charge on customers, in order to cover price difference to cheaper coal imports.

• In 2007, an agreement to discontinue government subsidies for coal mining in Germany was reached

between RAG, the German government, the governments of the coal-mining states (North Rhine-Westphalia and Saarland) and the trade union IG BCE (IG Bergbau, Chemie, Energie). This agreement ensured: (1) the discontinuation of coal mining by 2018 in a socially equitable manner by providing professional reorientation opportunities; (2) the financing of necessary environmental protection and safety measures following decommissioning; and (3) support for education, research, and cultural programs in the region (RAG, 2019).

3.5.2 Economic Diversification Measures in the Ruhr Area

- At the end of the 1950s, the government of North-Rhine Westphalia embarked on efforts to diversify the state's economy. North-Rhine Westphalia is home to the Ruhr Valley, a traditional center of German heavy industry. With the decline of the domestic coal mining industry accelerating, the state government launched its first structural support policy, the "Ruhr Development Program" of 1968, worth 17 billion German marks (approx. 37 billion euros today). Some years later, in 1979, the state government launched the "Ruhr Action Program," which sought to integrate various stakeholders in the policy development process. One point of emphasis was to improve the region's image and the "soft factors" that contribute to regional competitiveness (e.g. quality of life, leisure opportunities). The "International Building Exhibition Emscher Park," which sought to promote local ecological, economic, and social renewal, was one outcome of the state's regional development efforts.[8] Over 120 projects were implemented between 1989 and 1999, including projects to improve water quality, recultivate mining areas, and create more livable urban areas. The attractiveness of the region was increased through the transformation of former industrial complexes into cultural and touristic sites. This structural development program was accompanied by additional measures to generate positive synergies for regional development:

  (1) The government made significant investments in transport infrastructure to undergird and enable economic development.

  (2) Significant investments were also made in research and education. In the 1950s, the Ruhr (with more than 5 million inhabitants) did not have a single university. Ruhr University Bochum opened its doors in 1965. Today, 22 universities, colleges, and research institutes are located in the region (Prognos, et al., 2015). Some of the first technology parks in Europe were founded in the Ruhr, which provided a fertile environment for cooperation between research institutes and the private sector.

  (3) A regional development agency ("Zukunftsagentur Rheinisches Revier") was founded in cooperation with the region's municipalities, business associations, and the trade union IG BCE. The agency has been supporting regional development and structural change since 2014.

  (4) There have also been efforts to develop sustainable energy in the region. The onshore wind farm "Königshovener Höhe" (67 MW, 21 turbines) was installed in 2015 on the recultivated site of the Garzweiler open cast mine. Such projects build on the Ruhr's history as a major center for industry and energy.

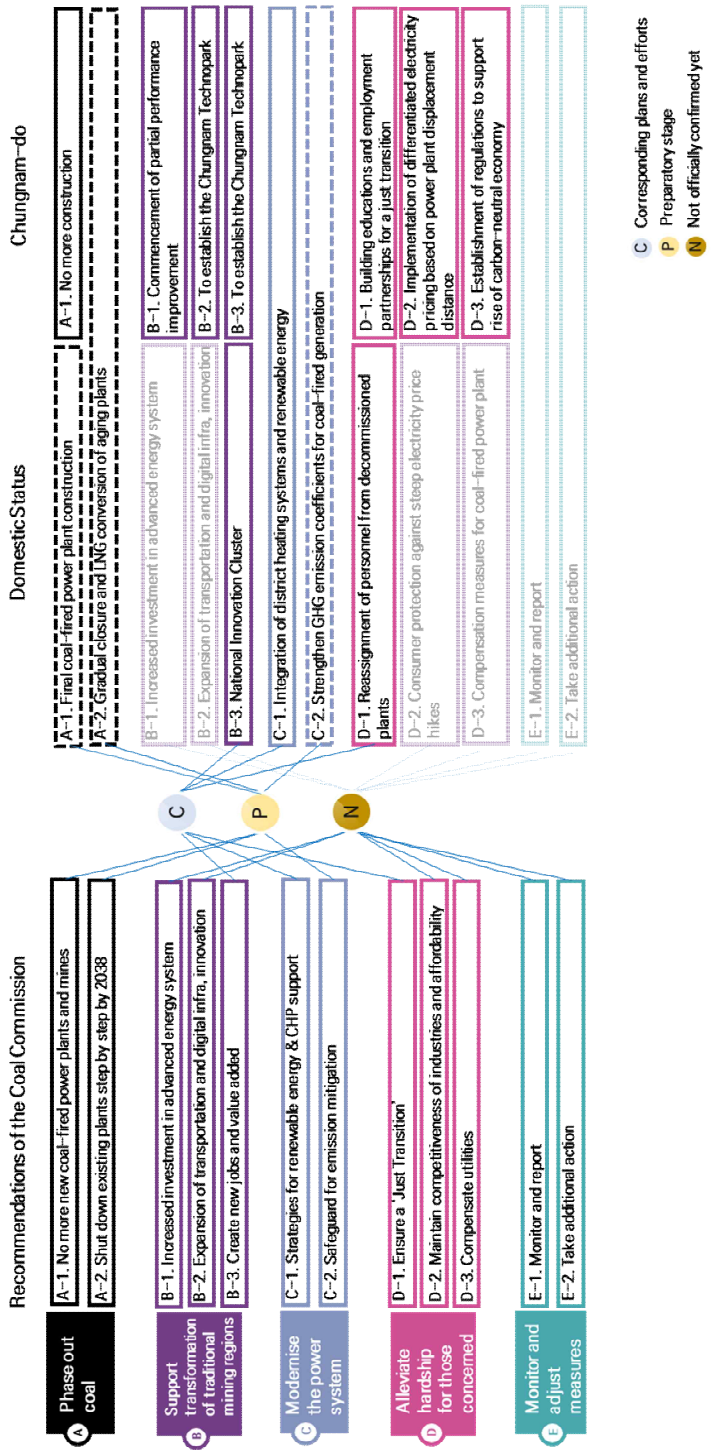
8) In the 1980s, the Emscher was one of the most polluted rivers in Europe. At that time, the epicenter of industrial activity in the Ruhr had already moved north (following the availability of coal), leaving the Emscher Region with high shares of very unattractive postindustrial sites.

3.5.3 Structural Policy in Lusatia

- For over 20 years, the "Lusatian and Central German Mining Management Company" (LMBV) has been reclaiming and recultivating decommissioned lignite mines from the former East Germany in the Lusatian and Central German mining regions. LBMV projects have created various opportunities, not only for new economic development, but also for the restoration of intact natural environments. One example is the Lusatian Lake District, a chain of artificial lakes that resulted from the flooding of 20 open pit mines sites. It is now the largest collection of artificial lakes in Europe (with a surface area 70 km2) and a popular recreation area.
- The state of Brandenburg, which is situated next to lignite mining regions, is slowly becoming a center for electric vehicle (EV) technology and manufacturing. In November 2019, Tesla announced it would invest 6.8 billion dollars to construct a gigafactory that would create 12,000 jobs. In October 2021, Rock Tech Lithium, a Canadian–German lithium development company, announced that it would be building Europe's first lithium hydroxide converter in Guben. BASF, the world's largest chemicals producer, decided to site its new cathode active materials production plant in Schwarzheide. These investment decisions could unleash a "virtuous circle" and make the state a major center for EV technology.

4. Applying the German Coal Phase-out Strategy to Chungnam in South Korea

Figure 12. Framework for the application of the German coal phase-out strategy in Chungnam Province



• Germany's Coal Commission formulated a roadmap for the gradual phase-out of coal-fired power generation. The Coal Commission also developed a broader strategy for managing the transition, including the provisioning of new economic opportunities for impacted regions. Figure 12 compares German measures to the measures undertaken in South Korea thus far, and identifies policy gaps.

4.1 Coal Phase-out Efforts

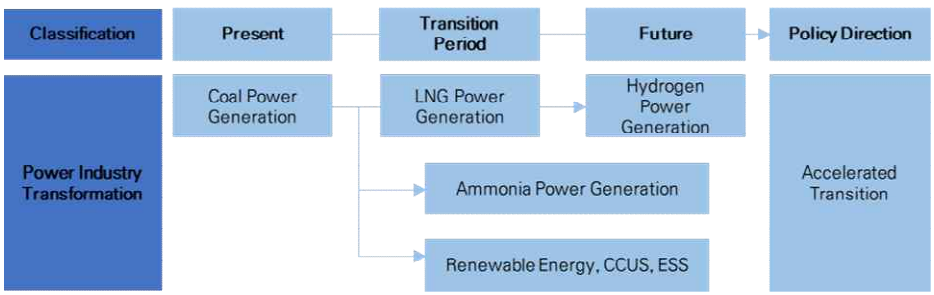
• With a view to measures for coal phase-out, Germany has implemented bilateral agreements and a reverse auction mechanism to compensate impacted power plant owners and manage the decommissioning (A). South Korea, by contrast, is still in a transitional phase, as new coal plants are scheduled for construction. The Samcheok Blue Power Plant (2.1 GW) is currently under construction and is set to be the last new coal-power plant in South Korea. However, in Chungnam, which is a concentrated area for coal-fired power plants, new coal-fired power plants are no longer being constructed.

• The government has plans to gradually close down aging power plants. However, it is worth noting that at present, South Korea lacks a legal basis to mandate or recommend coal phase-out, making such decisions dependent on the willingness of operators. In contrast to Germany, where many coal-fired power plants are operated by various entities, in South Korea, most of these plants (36.8 GW of total 32.6 GW) are owned and operated by state utilities (KEPCO, 2023). Accordingly, given the achievement of consensus among the government leadership, phase-out for most plants could proceed without a need to rely on mechanisms such as reverse auctions. However, separate discussions would be necessary with a view to privately owned coal power plants.

• There could be one responsible body that leads the whole process of coal phase-out. The RAG example could be used to distribute laid-off workers in the state-owned utilities to other plants or industries. The responsible body that leads the whole process needs to oversee the state-owned power plants to come up with a phase-out plan. And this body also needs to consider the stakeholder's concerns.

• While some domestic coal-fired power plants have been completely shut down, most are being transitioned to LNG-based generation. This transition aligns with the medium-to long-term policy direction for coal power phase-out and reduction presented by the Ministry of Trade, Industry, and Energy in 2021. The plan involves transitioning coal-fired power plants to LNG, ammonia-based generation, renewable energy, CCUS (Carbon Capture, Utilization, and Storage), and eventually transitioning LNG generation to hydrogen-based generation (illustrated in Fig. 13). Given Korea's strong dependence on coal-fired power generation, the need to consider affordability and security of supply is a particularly important aspect of decarbonization efforts.

Figure 13. Korea's medium to long-term policy direction for reducing/phasing out coal power generation (Source: MOTIE, 2023)



4.2 Transition support efforts

- With a view to transition support (B), Korea displays a notable lack of policies for investment in transport, infrastructure, or innovation. However, in relation to compensation for abandoned mine areas (B-2), Korea does have the "Special Act for the Development and Support of Abandoned Mine Areas," enacted in 1995. In relation to policies to support jobs and industry (B-3), the "Chungnam Carbon Neutrality and Green Growth Basic Ordinance" is currently being implemented. While the effectiveness of this policy remains to be seen, it is first of its kind in South Korea, as it establishes a foundation for a "just transition." That being said, compared to countries that are at the forefront of climate action, Korea lacks policy initiatives or legislation specifically designed to facilitate coal phase-out (Lim et al, 2022).
- Through the 2023 National Innovation Cluster Project, the government is in the process of conceptualizing national innovation hubs that are tailored to the unique characteristics of 14 different provinces. Specifically, for the Chungnam region, there are plans to establish the Chungnam Technopark (MOTIE, 2023). The Chungnam National Innovation Cluster is slated to take the form of an R&D hub and industrial complex with a focus on hydrogen technologies. It is set to receive support for the commercialization of hydrogen energy, both upstream and downstream. Consequently, this development is expected to generate significant economic opportunities.
- Yet even if national and local governments are successful in transforming Korean industry by means of technological innovation, ongoing advances in IT and automation may lead to "jobless growth" (MoS et al, 2016). Therefore, policy efforts should be dedicated to ensuring industrial transformation that also generates jobs.

4.3 Power system modernization efforts

- Regarding the modernization of the power system (C), the Korean government has announced the Fifth Basic Plan for Promoting the Development and Utilization of Renewable Energy. This legislation aims to reform market mechanisms and harness innovation to make renewables the primary energy source by 2034. Additionally, in May 2023, the National Assembly enacted the "Special Act on Activating Distributed Energy," which aims to decentralize the highly centralized power system and differentiate electricity rates by region. Furthermore the state utility in charge of district heating is making efforts to enhance the management of the heating grid and to maximize efficiency and cost-effectiveness by integrating renewables into district heating. In response to the emissions trading system (ETS) (C-2), there is a gradual enhancement of the benchmark (BM[9]) allocation method to strengthen the GHG emission factors for coal while relaxing the emission factors for liquefied natural gas (LNG)(MoE, 2020). The Korean ETS has been in place since 2015, and it follows the "fuel-specific BM method," in which the BM factor (signifying the amount of GHG emissions per unit of power generation) is pre-determined for each type of fuel. The aim is to provide incentives for reducing GHG emissions by favoring fuels with higher emission efficiency.
- On a practical level, these efforts face the challenge of encouraging mitigation in line with GHG reduction goals. Carbon pricing is one of the most important policies for transitioning to low-carbon power sources, and there are discussions underway on strengthening the role of K-ETS as part of preparations for the 4th phase of the ETS Basic Plan (2026-2030).

9) BM factor = GHG emissions of the application (tCO_2-eq) ÷ activity data of the application (MWh)

4.4 Grievance Mitigation and Review Efforts

- In relation to alleviating stakeholder grievances (D), some measures have been taken at the national level to ensure employment for workers in the power generation sector who have been affected by the shutdown of coal power plants. This includes the relocation of 95% of the workforce to other positions in industry as a labor market intervention (MOTIE, 2021). While this has helped prevent layoffs, reassignment within the same industry is considered a temporary solution, and there have been no visible efforts to provide retraining and re-employment opportunities.
- In light of this deficit, efforts are underway at the local government level in Chungnam to provide re-employment opportunities. Dedicated initiatives in Chungnam aim to foster a labor force attuned to industry demand, enhance employment safety nets, and support the resurgence of the automotive parts industry.
- However, there is a conspicuous lack of national measures to protect consumers or power plant operators. In response, the Chungnam Province has devised plans to establish a cooperative undertaking between companies and educational institutions that will help to facilitate a just transition. While there's a lack of a national-level compensation plan for electricity consumers, Chungnam Province is pursuing differentiated electricity rates based on the distance from power plants. There seems to be no dispute regarding facilities operated by the national government for coal-fired power plants. Still, compensation plans for private power plants have not been separately outlined.
- Thus, while Chungnam Province does not explicitly provide for the compensation for power plants, it has created a foundation to provide indirect support to companies pursuing carbon-neutral economic activities.

5. Implications

5.1 Domestic Application of the German Coal Phase-out Strategy

- South Korea has a plan in place for the gradual closure of older power plants (A-2) as a means of implementing coal phase-out (A). However, it currently faces a transitional situation with regard to the suspension of new coal-fired power plants and mine construction (A-1). The 10th Basic Plan for Electricity Supply and Demand primarily focuses on the conversion of aging coal plants to LNG fuel as part of the phase-out of existing power plants. In support of this transition (B), there is a strategy at the national level for fostering innovation clusters tailored to each region. This strategy foresees the expansion of investment in advanced energy systems (B-1), the expansion and promotion of transportation and digital infrastructure (B-2), and the stimulation of employment and economic opportunities in coal power generation and mining areas (B-3). Furthermore, in Chungnam, efforts are underway at the local level to bring about a carbon-neutral economy as part of a special initiative being undertaken in concert with national strategies.
- The issue of power system modernization (C) is addressed in part by Korea's renewable energy expansion plan, which calls for the development of a renewable energy strategy (C-1). In terms of emissions mitigation (C-2), Korea does not yet have provisions for cancelling excess certificates, as foreseen by the EU-ETS. Since 2015, South Korea has been running the K-ETS, which seeks to reduce emissions from coal-fired power plants by raising GHG emission coefficients. However, there are ongoing discussions regarding strengthening the role of this scheme, particularly in anticipation of the implementation of the 4th phase of the ETS Basic Plan (2026-2030). This discussion has revolved around criticism that the ETS design is not sufficiently stringent for meeting GHG reduction targets.

- Regarding grievance mitigation (D) strategies, Korean labor market measures (D-1) have primarily focused on preventing layoffs, as there have been limited efforts to provide retraining and re-employment opportunities. At the national level, policy action has been minimal in relation to job retraining, the provisioning of new employment opportunities, protections for electricity consumers, and compensation for power plants. However, in Chungnam, a separate strategy has been devised and is being pursued, as discussed above.
- It is premature to discuss Korean policy in relation to review and adjustment (E). Currently, some corresponding measures are being taken at each stage, but the domestic coal-fired power industry is focused more on industrial transition rather than job transition or community transition (Kwon, 2023).
- **In light of the foregoing discussion, Germany's coal phase-out strategy has various implications for Korea:**
  - ✔ **First, Korea should task a multi-stakeholder special working group, similar to that of the Coal Commission, with developing a roadmap for an orderly transition, including recommendations for structural adjustment and associated financing for areas that rely economically on coal power.**
  - ✔ **Second, support for phase-out in impacted regions can be enhanced through comprehensive consideration of stakeholders involved in coal power generation, including workers, communities, utility companies, and consumers. In this connection, targeted compensation to ease the burden of transition and enable stakeholder "buy-in" is important.**
  - ✔ **Third, provisions should be established that allow for a flexible response to employment shocks and other economic and social impacts of the transition.**
  - ✔ **Fourth, governance mechanisms should be established at the outset to slow, accelerate, or adjust the pace of phase-out. In this connection, the phase-out should proceed in a gradualistic and systematic fashion.**
  - ✔ **Fifth, to preserve jobs, measures should be enacted to enable retraining and re-employment, and not just layoff prevention.**

5.2 Elaborating a Job Preservation Strategy for Korea

- Based on the lessons learned from Germany's coal phase-out strategy, Korea would be advised to pursue a domestic job preservation policy that seeks to provide support to all stakeholders, including workers, utilities, local communities, and energy consumers. This support should emerge from an overarching national strategy and should contain provisions for allocating financial assistance, including that required to retrain and integrate workers into new jobs.
- The second key lesson from the German experience is that the generation of new employment opportunities requires collaboration with local stakeholders in the public and private sector as well as local residents. Even when industrial restructuring is planned and implemented at the national level, the support and active buy-in local governments and residents is essential to facilitate economic transformation and give rise to new job opportunities. The OECD's Local Employment and Economic Development Program (LEED) recommends the implementation of local employment policies as a part of a regional development strategy and highlights best practice examples of local initiatives and successful policy implementation (LEED, 2023). LEED acknowledges that the distribution of responsibility for labor market policies at various levels of government creates challenges; local actors must be provided with freedom of action, but also remain accountable. South Korea's current domestic policy arrangements raise a hurdle in this regard, as local governments enjoy limited autonomy, hampering their ability to execute projects tailored to local characteristics (Shin, 2020). Chungnam is seeking to overcome such limitations by actively preparing a carbon-neutrality roadmap that elaborates

detailed strategies and investment plans, with the aim of making the province a best-practice example for successful transformation.

- To facilitate job creation strategies that are attuned to local conditions and best harness local capacities and knowledge to affect change, there are needs for central governmental policy action that devolve specific powers to local government and that establish suitable local governance structures (Shin, 2020).
- Third, there is a crucial need to establish regional transition strategies as well as corresponding partnerships between educational institutions and employers for retraining and re-employment. In the German case, the overarching plan that was developed at the national level was ultimately translated into regional transition plans for coal-dependent regions. South Korea still lacks a nationwide overarching phase-out plan, but efforts are underway to facilitate a regional transition in line with the national innovation cluster development plan.

6. Conclusions

6.1 Conclusions and Implications

- Despite the various similarities between Germany and South Korea, both countries also display a range of legal, political, and socioeconomic differences. This includes differences pertaining to regulations, the ownership structures of coal utilities, the economic structures within and outside the coal sector, governance arrangements, and socio-cultural frameworks.
- While directly emulating the German experience may not be feasible for South Korea, given divergent local contexts, surveying the history of structural change within the German coal sector promises to yield valuable insights. Accordingly, this study seeks to highlight policy factors that merit consideration when formulating a strategy that aligns with Korea's unique circumstances.
- The EU has adopted a just transition mechanism that aims to support nations and regions experiencing adverse effects during the shift toward carbon neutrality. In Germany, the establishment of a Coal Commission provided a valuable service in terms of collecting input from stakeholders, devising a roadmap for phase-out, and facilitating a just transition.
- One lesson that emerges from the German context is that in addition to establishing a top-down vision, it is crucial to enable bottom-up collaboration between the federal government and local governments; ideally, this collaboration should work harmoniously, like a well-coordinated set of gears. Of course, various forms of policy action require decisions at the national level, including carbon pricing, compensation for power plant decommissioning, the monitoring of roadmap achievement, or altering the timeline for achieving carbon neutrality. Other aspects of a just transition, however, even if ratified at the national level, call for local government support.
- In Germany, both government agencies and NGOs have played a key role in advocating for and supporting coal phase-out policies. Additionally, green political forces at the national level, particularly the Green Party, have exerted an influence on decision-making, and have engaged with citizens both directly and indirectly. To ensure that the voices of local residents are heard, South Korea should create opportunities for climate-focused civil society and for grassroots participation in policy decisions, mirroring the German approach. This is an important approach for ensuring that policies are tailored to local conditions and have the active support of the populace. Indeed, the active "buy-in" of all stakeholders was crucial for reaching consensus and elaborating a politically viable phase-out strategy in the German context.

6.2 Research Limitations and Challenges

- The absence of a standardized concept or classification system for green industries and jobs has hindered the development of a systematic approach at the national level in South Korea. South Korea's strategy for phasing out coal-fired power generation centers primarily on the establishment of energy clusters, but at the current stage, it faces limitations in accommodating a diverse range of stakeholders, including coal power plant operators and local residents. This study focused on Chungnam Province, which is home to extensive coal-fired power generation capacity. In part due to the complex interlinkages between employment, energy production, and economic structures at the regional level, a one-size-fits-all approach is impractical. Accordingly, it is imperative to consider relevant local factors "on the ground," including local legal, political, socioeconomic conditions. Indeed, awareness for the need to elaborate tailored strategies for each region in question represents an essential starting point for a transformation policy that is actively embraced by local populations, not only because it promises to mitigate climate change, but also because it creates new opportunities for human flourishing.

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