

Lignite planning, structural change and coal phase-out in Germany

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Positionspapier aus der ARL 140

LIGNITE PLANNING, STRUCTURAL CHANGE AND COAL PHASE-OUT IN GERMANY

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LIGNITE PLANNING, STRUCTURAL CHANGE AND COAL PHASE-OUT IN GERMANY

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Abstract

Lignite planning in the Rhineland, central German and Lusatian coalfields is a core spatial development planning task at the federal state and regional levels. The Lignite Planning Information Group and Initiative (*Informations- und Initiativkreis Braunkohlenplanung*) was founded in 1994 at the ARL – Academy for Territorial Development in the Leibniz Association to provide a platform for expert discussion. Starting from experiences with the Rhineland and the structural upheavals in the new federal states in the early 1990s, it has since continuously addressed new technical and legal requirements involving resettlement, water balance issues, environmental assessments, the energy transition and the common good. Against the backdrop of rapid change and geopolitical events, the combination of structural change and the politically initiated phase-out of lignite-based power generation in a time frame between ‘ideally 2030’ and no later than the end of 2038 constitutes a challenge that will have to be met by the active players from the perspective of both federal state and regional planning and of regional development. This position paper takes stock of the situation across federal states and across coalfields and describes the required actions for lignite planning as a basis for reaching conclusions about a process with far-reaching national consequences. The various aspects of this process are subject to constant change and call for proactive strategies to exploit opportunities, tap potential, and effectively identify and avoid negative developments.

1 Ending power generation with lignite – political and legal context

Against the backdrop of the CO₂ emission reductions agreed at the 2015 UN Climate Change Conference in Paris, the German government’s creation of the **Commission on Growth, Structural Change and Employment** (*Kommission ‘Wachstum, Strukturwandel und Beschäftigung’*) in July 2018 led to a broad public discussion among local authorities, social partners, scientists and environmental organisations about ending coal-fired power generation in Germany. The discussions were reflected in the commission’s final report in January 2019 (*BMWi [Federal Ministry for Economic Affairs and Energy] 2019*), which recommended to policymakers at the federal and state level that lignite-fired power generation be ended in Germany by no later than the end of 2038. After lengthy and complicated debates that also included compensation and social plan aspects, this recommendation was incorporated into the **Act on the Phase-out of Coal-fired**

Power Plants (Kohleverstromungsbeendigungsgesetz, KVBG)¹, which came into force in August 2020 after its adoption by the German Federal Parliament and Federal Council, and confirmed the target date of the end of 2038. The legal provisions included the stipulation of dates (2026, 2029, 2032) for assessing whether the phase-out could be brought forward by three years for a target date of the end of 2035. In its second annex, the law includes block-specific dates for the final decommissioning of all lignite-fired power plants. The reduction path specified therein leads from an installed electric output at an initial level of 17.2 GW (2020) to 14.4 GW (2023), 9.3 GW (2030), 6.1 GW (2036) to the final level of 0.0 GW in 2039 (see footnote 1). This plan directly affects trends in opencast mining since most of the lignite mined in 2020 was burned to generate electricity: 88.6% (Rhineland 83.9%, central Germany 91.4%, Lusatia 93.3%) (Frenz/Preuße 2021).

From the reserves approved at the end of 2020 (3.35 billion tonnes, of which 2.1 are in the Rhineland [Garzweiler II 0.65, Hambach 1.23, Inden 0.21], 0.3 in central Germany and 0.95 in Lusatia [including 0.2 in subfield II in Welzow and 0.15 in the Mühlrose subfield of the Nochten opencast mine]), the **maximum amount of lignite still to be mined** in Germany will decrease to no more than approx. 1.7 billion tonnes (Rhineland 0.9 after the 2021 North Rhine-Westphalia policy decision [Garzweiler II 0.63, Hambach 0.13, Inden 0.11], 0.2 in central Germany [Vereinigtes Schleenhain 0.12, Profen 0.08], Lusatia 0.6 according to coalfield planning) (coal industry statistics²; Maaßen/Schiffer 2021; research by the authors). The total amount of lignite mined in Germany to date is approximately 26.5 billion tonnes (Rhineland 8.4, central Germany 8.7, Lusatia 8.5) (see footnote 1; Frenz/Preuße 2021); the remainder is accounted for by smaller coalfields that have been closed for some time (in particular Helmstedt [Lower Saxony, through 2016], Northern Hesse [through 2003] and Upper Palatinate [Bavaria, through 2006]).

After falling to a level of 107.4 Mt in 2020 (Rhineland 51.4, central Germany 12.8, Lusatia 43.3), lignite production increased significantly in 2021 to 126.0 Mt (Rhineland 62.6, central Germany 16.9, Lusatia 46.8) (see footnote 2). The increase was mainly attributable to lower yields from renewable energy due to low winds, the ongoing phase-out of nuclear power, the incipient increase in natural gas prices, and the recovery from the preceding pandemic-induced economic slump.

The **coalition agreement between SPD, Greens and FDP to form the new German Federal Government** for the period from 2021 to 2025³ calls for bringing forward the termination of lignite-based power generation, 'ideally to 2030'. This proposal has since seen positive responses from North Rhine-Westphalia and more reserved responses from Brandenburg, Saxony and Saxony-Anhalt; key conditions include maintaining security of supply and avoiding social hardship. It remains to be seen whether, when and in what form any revisions to the Act on the Phase-out of Coal-fired Power Plants will take place to effect binding new energy policy provisions at the national level. In view of Russia's war of aggression against Ukraine, increasing attention is being given to issues such as security of supply, the elimination of dependencies resulting from energy policy, extended schedules for decommissioning, and prolonged standby periods for lignite-fired power plants to be used in the event of shortages from other sources. At this time, the new federal states with active lignite mines (Brandenburg, Saxony and Saxony-Anhalt) insist on retaining the coal compromise from the Act on the Phase-out of Coal-fired Power Plants, while there is a broad multi-party consensus in North Rhine-Westphalia favouring a phase-out by 2030.

1 Act on the Phase-out of Coal-fired Power Plants (*Kohleausstiegsgesetz*) of 8 August 2020 (*BGBI*. [Federal Law Gazette] I p. 1818), revised by article 3b of the act of 3 December 2020 (*BGBI*. I p. 2682).

2 <https://kohlenstatistik.de> (accessed 26 April 2022).

3 *Mehr Fortschritt wagen. Bündnis für Freiheit, Gerechtigkeit und Nachhaltigkeit*. ['Dare for more progress. Alliance for freedom, justice and sustainability'] 2021–2025 coalition agreement between the Social Democratic Party of Germany (SPD), BÜNDNIS90/DIE GRÜNEN (Greens) and the Free Democratic Party (FDP). Berlin, 2021.

2 Structural Reinforcement Act to provide financial support for coal phase-out

Financial support for the coal phase-out has been comprehensively regulated with the August 2020 **Structural Reinforcement Act**⁴ (Strukturstärkungsgesetz Kohleregionen). This law stipulates the funding's objectives, volumes and guiding principles, its spatial distribution based on local authorities and associations of local authorities, the distribution of funds by federal state and by coalfield (Rhineland 37% [North Rhine-Westphalia]; central Germany 20% [of which 60% to Saxony-Anhalt and 40% to Saxony]; Lusatia 43% [of which 60% to Brandenburg and 40% to Saxony]), and the funding regulations. The percentages by federal state are 25.8% for Brandenburg, 37.0% for North Rhine-Westphalia, 25.2% for Saxony and 12.0% for Saxony-Anhalt. Lower Saxony (Helmstedt coalfield) and Thuringia (central Germany) are not included. The total volume of funds to be distributed by no later than 2041 over several funding periods (2020–2026, 2027–2032, 2033–2038) amounts to EUR40billion. For legal reasons relating to state aid, direct economic development aid provided to businesses that exceeds marginal amounts is ruled out. This makes it much more difficult to fulfil the basic objective of creating replacement jobs in industry, which cannot really be done at the municipal level. In the event of an earlier coal phase-out than called for in current legislation, earlier payment of structural strengthening funding may become necessary, and possibly in higher amounts.

Of the total amount, EUR 26 billion is allocated to **federal measures** focusing on research, infrastructure and the relocation of federal agencies to the coalfield areas; EUR14billion is intended for **measures at the federal state and regional levels**. Funding regulations and implementation structures have since been established in all affected federal states. The coalfield-related guidelines for structural change in central Germany and Lusatia stipulated in annexes 1 to 3 of the Structural Reinforcement Act, some of which apply across federal state boundaries, were only taken up in a very limited and unspecific form at the federal state level, contrary to the 2021 recommendations by the Advisory Board for Spatial Development⁵. This does not apply to North Rhine-Westphalia, a state with only one large coalfield. Annex 4 of the Act includes specific plans for new and expanded road and rail infrastructure under the responsibility of the federal government. Particular importance is attached to plans to establish large research centres, one each in central Germany and in Lusatia. **Additional funding** is available through a federal programme called Unternehmen Revier that assists coal mining areas with economic restructuring as part of the Joint Task for the Improvement of Regional Economic Structures (Gemeinschaftsaufgabe Verbesserung der regionalen Wirtschaftsstruktur, GRW). To ensure that funds are used continuously and appropriately, a regular evaluation of both the regulations and the implementation of the measures is recommended every three years to monitor the success of the programmes.

As part of the structural change programme, the federal government and the power plant operators negotiated **compensation for additional expenses** amounting to EUR 4.35 billion (EUR 2.6 for RWE Power AG, EUR 1.75 for LEAG, and an unspecified amount for MIBRAG mbH) (Maaßen/Schiffer 2021). Potential additional expenses to fund reclamation activities in the areas where opencast mines are still operating but could be closed ahead of the currently scheduled dates have not been addressed by the financial arrangements thus far. This also shortens the time frame available for building up reserves from which pending mining obligations could be settled according to the 'polluter pays' principle.

4 Structural Reinforcement Act of 8 August 2020 (BGBl. I p. 1795).

5 Sustainable transformation in the coal-mining regions. Recommendations by the Advisory Board for Spatial Development. Berlin, April 2021.

3 Status quo and current situation of lignite planning

As a result of the regulations governing the coal phase-out, the existing spatial planning stipulations for the active opencast mining areas in the Rhineland (lignite plans for Garzweiler II, Hambach and Inden in North Rhine-Westphalia),⁶ in central Germany (lignite plan for Vereinigtes Schleenhain in Saxony, lignite plan/regional development programme for Profen in Saxony and Saxony-Anhalt, and the regional development programme for Amsdorf in Saxony-Anhalt) (Berkner 2019) and in Lusatia (lignite plans for Jänschwalde in Brandenburg, Welzow-Süd in Brandenburg and Saxony, and Nochten and Reichwalde in Saxony) no longer accurately reflect reality, at least in some areas. These plans will, in nearly all cases, need to be **amended and updated** to adapt them to developments. Corresponding review, consultation and decision-making processes are in progress in all affected federal states and coalfield areas.

Companies subject to mining law (RWE Power AG in the Rhineland, MIBRAG mbH in central Germany, LEAG in Lusatia) have also taken these considerations into account in their own planning or are obligated to adapt their planning to the amended lignite plans. Now the fundamental need is to establish the **basis in terms of planning law, mining law and other regulatory frameworks for phasing out** and closing opencast mines, including their conversion into post-mining landscapes that are multifunctional, capable of development and largely free of follow-up maintenance. This is severely complicated by the currently indeterminate political (phase-out dates and paths in the time frame from 2030 to 2038) and economic frameworks (especially due to the pricing of climate-relevant emissions and the future position of lignite in the energy market as the use of renewable energy continues to grow), which affect schedules, production volumes, mass balances and local conditions. Given these uncertainties, forecasts, scenarios and assumptions must be used to a much greater extent than in general regional planning.

Moreover, the time available for the pending plan adjustments is shortening considerably. Repeated **calls for accelerated planning** coming from policymaking and scientific circles in the course of the structural change debate are only of limited practicability within the existing legal framework at the European, federal and state levels; in particular, environmental assessment, transparency requirements and participation rights allow no trade-offs. In addition, spatial planning processes and planning processes related to mining and water law for opencast lignite mines are subject to considerable scrutiny during judicial reviews. In this regard, the activities of the Conference of Ministers for Spatial Planning (*Ministerkonferenz für Raumordnung, MKRO*) aiming for ‘more robust planning’, i.e. a change in the Federal Spatial Planning Act (*Raumordnungsgesetz, ROG*) to put planning on a more stable legal footing, are very welcome.

Under the prevailing conditions, aspiring to actually control developments through spatial planning instead of merely seeing them through or having to react to situations that can no longer be changed is the challenge of the day.

⁶ Federal state of North Rhine-Westphalia: *Leitentscheidung 2021. Neue Perspektiven für das Rheinische Braunkohlerevier. Kohleausstieg entschlossen vorantreiben, Tagebaue verkleinern, CO2 noch stärker reduzieren*. Resolution by the federal state government on 23 March 2021.

4 Support for formal planning and regional development through informal instruments

In the Rhineland (e.g. Indeland), in central Germany (e.g. regional conferences, architecture competitions, EXPO2000) and in Lusatia (e.g. Fürst-Pückler-Land international building exhibition, regional conferences), formal planning has already been accompanied by informal activities for some time. Of particular relevance is problem-related support for intercommunity cooperation, for example through master plans, regional development and action strategies, and special-purpose agreements and associations.

Structural change in the context of the coal phase-out has been a catalyst for **informal instruments** since 2019 or 2020 at the latest. In the Rhineland, Neuland Hambach GmbH, Zweckverband LandFOLGE Garzweiler and Entwicklungsgesellschaft indeland GmbH have established themselves as strong local initiatives. In addition, Zukunftsagentur Rheinisches Revier GmbH – with shareholders from various public and social sectors – is an institution commissioned by the federal and state governments to organise structural change and relevant projects in the coalfield area there. In central Germany, a comprehensive cross-state regional development strategy was established for the Profen opencast mining area in 2020 and 2021 with broad involvement of the key stakeholders. A similar alliance was established between the district, local authorities, regional planners and mine operator for the Vereinigtes Schleenhain opencast mining area. Examples for Lusatia are the regional development strategy for the area around the Cottbus-Nord and Jänschwalde opencast mines with the Cottbus higher-order centre and the Guben and Forst middle-order areas (Lusatia) with ten local authorities and agencies and the Spree-Neiße district (*Strategie 2030 für regionale Entwicklung und Zusammenarbeit*) in Brandenburg as well as the development strategy for the Schleife administrative association in Saxony. Activities such as national or regional garden shows, an international building exhibition (currently debated in central Germany), or an international building and technology exhibition (under consideration in the Rhineland) also appear conceivable as suitable vehicles for stimulating long-term development.

Examples of **cooperation between scientists and planners** include *Planungslabor Raumbilder Lausitz 2050*, the results of *Zukunftswerkstatt Lausitz*, and coalfield-related water conferences (on mining, water and climate in 2021). Planned research projects lend themselves well to supporting lignite planning and structural change (e.g. *RegioNetWasserBoden* from the agencies for environment, agriculture and geology and for reservoir administration in Saxony, or in central Germany *Energiekonzept IRMD* and *Sozioökonomische Perspektive 2040* under the aegis of the Central German Metropolitan Region).

5 Regional water balance, outflow and rising groundwater, flooding of mining cavities

In recent decades, all of Germany's major lignite fields have had severe **impacts on their adjacent river basins** involving river diversions with associated encroachments in floodplain ecosystems and their natural flood retention areas, flow rates and water quality levels. As a consequence, the stipulations of the EU Water Framework Directive are currently not fulfilled over wide areas for rivers and streams affected by mining. There are significant problems with flow increases due to continuous discharges of mine water from opencast mines (the Erft in the Rhineland, the White Elster and Pleiße in central Germany, the Spree in Lusatia); these will decline and cease earlier than planned as a result of the coal phase-out. Furthermore, there will be much shorter time frames for the necessary adaptations to watercourse cross-sections and uses, and for dealing with impaired water quality largely caused by old mining areas (iron and sulphate pollution: the 'brown Spree' in Lusatia and the 'brown Pleiße' in central Germany). The disconnection of catchment areas previously important for runoff has caused streams to dry out for long periods after longer intervals of low precipitation (Black Elster in Lusatia).

Because of climate change and some remaining mining-related reductions in the groundwater level, such situations can be expected to worsen in the future, with an **impact on protected assets downstream** (Schwalm-Nette nature park in the Rhineland, Leipzig Riverside Forest in central Germany, Spree Forest and drinking water supply in Berlin). Given this expectation, methods of water management that are proactive with respect to both quantity and quality will have to be implemented and refined. Facilities and initiatives like the *Erftverband* in the Rhineland, the control centre for the southern Leipzig area in central Germany, and the flood control centre in Lusatia are a good starting point. In some cases, watercourses are at risk of running dry as a result of the coal phase-out (raft canal in central Germany). At the same time, in some areas lakes resulting from opencast mining offer opportunities for **improving flood protection**. However, these opportunities can only be realised in cooperation between the federal states and the companies subject to mining law (Indener See in the Rhineland, Schwerzauer See and Groitzscher See in central Germany, and Cottbuser Ostsee in Lusatia, with detailed debates still in the early stages). This has already been done as a result of lignite planning in the Zwenkauer See area in central Germany, which showed enormous retention capacity during the June 2013 flooding.

As **groundwater rises**, changes in the volume, position and height will require dedicated monitoring so that, in combination with construction warnings, saturation effects can be avoided, especially in built-up areas. In central Germany and Lusatia, these problems will be exacerbated by the existing impacts of mine remediation. Impacts are already apparent in some areas, with delayed flooding processes and usage restrictions due to excessively low or fluctuating water levels; this has effects on the start of planned secondary uses and on the usual seasonal patterns.

After the termination of mining activities, several large opencast mine lakes with as yet indeterminate contours will form in all of Germany's major lignite fields (in Rhineland approx. 70 km² in area and 7 km³ in volume, in central Germany 35 km² and 1 km³, and approx. 90 km² and 2 km³ in Lusatia); their overall dimensions will scarcely change as a result of the early coal phase-out. It is foreseeable that the required **flood water volumes**, which must take into account the geotechnically required minimum rise rates, will need to be provided much earlier and on a continuous rather than phased basis. This means a considerable strain on the regional water supplies affected, which must be taken into account ahead of time by both researchers and planners. Spatial development planners, even if they are not responsible for the final decisions under water law, will be responsible for making early-stage strategic decisions and for considering variants and alternative courses of action, thus assuming an 'early warning' role for downstream administrative processes.

In the Rhineland, the planned **transfer of Rhine water** to the Garzweiler II opencast mine, which is already included in established planning, offers sufficient supply options in principle if there is an adjustment to the new situations for the active Hambach opencast mining area. This applies equally to the Inden opencast mine with the neighbouring river Rur. The flooding of pit lakes in central Germany can only be ensured by transferring water from neighbouring river basins (the Vereinigte Mulde and optionally the Saale rivers). The situation in Lusatia is particularly precarious because the Spree cannot provide enough water by any means. In addition to assuring minimum flow, there are restrictions on the use of the Lusatian Neisse since it flows along the Polish border and of the Elbe because any water transfer would have to take place over a considerable distance.

Existing **water management infrastructure** (dams on the Rur in the Rhineland, the Mulde diversion canal in central Germany, and the dams and reservoirs in Lusatia) has the potential to support the flooding processes. Given flooding times lasting up to several decades until geologically stable end states are reached in some regions, the focus will return to possible interim or temporary uses, though it can be expected that the designs of slope systems and outflows will need to be adapted for fluctuating water levels and climatic changes. In view of previous geotechnical experiences (in particular the 2009 Nachterstedt landslide), any early use of opencast mine lakes must be considered with due caution. In all coalfields, the opencast lakes created in the excavation

cavities of active mines offer significant water retention capabilities via lake retention and storage levels. However, they also act as dissipation areas that are or can become relevant to the hydrological balance due to increased evaporation during the summer months, especially in central Germany and Lusatia.

6 Geotechnical requirements and public safety

Ensuring public safety in active opencast mining areas and in post-mining landscapes is a non-negotiable requirement to be addressed in terms of both mining law (certification of stability) and planning law (safety lines). Repeated landslides during opencast mine remediation (Nachterstedt in 2009) and in post-mining landscapes (most recently Knappensee in east Saxony and Helenesee near Frankfurt an der Oder in 2021) and also in active opencast mining areas (Vereinigtes Schleenhain in 2012 and 2013, Amsdorf in 2014) with property damage, personal injury, and long-term restrictions on use in some cases, make this very clear. ‘Geotechnical events’ such as flood-related breakthroughs into neighbouring opencast mining areas by rivers whose courses have been redirected for mining reasons, for example the Mulde into the Goitzsche (central Germany) in 2002 and 2013 and the Inde into the Inden opencast mine (Rhineland) in 2021, are also examples of this kind of problem. The experience that rivers have ‘memories’ should always be kept in mind.

The developments that have to be modified with respect to the initial plans when opencast mines are worked into their end states often result in **mining cavities** and slope systems in less favourable geotechnical and hydraulic positions, which then have to be addressed through the appropriate remediation measures. There is an increasing trend in the number of steep and toppled slope systems that can no longer be proactively influenced through practical mining measures and require substantial extra remediation costs. For example, in the area of the slope system at the northern edge of the Hambach opencast mine, which has an elevation difference of around 400 m, an estimated 470,000,000 m³ of material will be needed to provide support in the vicinity of the town of Elsdorf alone. Overall, there is a need for up to 770,000,000 m³ in the opencast mine area, which will have to be supplied at least in part by special operations in unworked areas at the margins of the mine without lignite extraction. In the Vereinigtes Schleenhain opencast mine area, the Pereser See, a lake to be formed when the mine closes in 2035, would be broken up into three pit lakes in the event of a closure five years earlier; one of those pit lakes would be completely surrounded by spoil heaps. In the Lusatian opencast mines that will remain active in the longer term (Welzow-Süd, Nochten and Reichwalde), the challenge will be to reshape the distinctive ridged landscapes, which result from the use of conveyor bridges, for planned future uses.

In the **Jänschwalde opencast mine area**, the positions of the pit lakes will change while retaining their overall proportions. As a result, three smaller pit lakes are to form here instead of a single lake; the land balance in the planning area should remain unchanged. It is assumed that the fundamentals of the planning will remain unaffected by the requested change to the water/land allocation. Nevertheless, a derogation procedure will be needed to adjust the arrangements for reshaping the post-mining landscape, with adequate consideration given to the geotechnical specifics of the changed opencast lake configurations.

With the ruling by the Cottbus Administrative Court on 16 March 2022 approving the mine’s main operation plan for 2020 to 2023, mining operations are likely to end on 15 May 2022. The consequences for mining and for the post-mining landscape are currently being examined by the mine operator and the responsible administrative authorities. An accelerated closure of the mine would affect the coal supply for the Jänschwalde power plant, which is slated to continue operating through the end of 2028; the plant would then have to secure its supplies from other opencast mines in Lusatia. There would probably also be further changes to the post-mining landscape.

7 Mining-related resettlement

There have been more than 400 resettlements related to lignite mining in Germany since 1920; approximately 131,000 people (43,000 in the Rhineland, 54,000 in central Germany, 29,000 in Lusatia, 4,000 in Helmstedt and 1,000 in Upper Palatinate) were affected (Berkner/Kulturstiftung Hohenmölsen 2022). Although there has been steady improvement, especially since 1990, in the urban development standards of resettlement sites (community resettlement) and the social impact in terms of compensation ('new-for-old' principle), the issue remains a major **stress factor** in public perception and for those affected.

As mining operations draw to a close, a few locations are still up for resettlement in the Rhineland (approximately 600 people in the Garzweiler II opencast mine area) and in Lusatia (approximately 200 people in the Nochten-Mühlrose opencast mine area in Saxony); however, resettlement is no longer a current issue in central Germany. With the phase-out and decommissioning dates for opencast mines and power plants still not settled in political and economic terms, there are **uncertainties** as to whether and when the ongoing resettlements will be completed. Those affected remain in a stressful state of limbo in terms of being able to plan their lives; this can only be resolved by quick decisions that establish the framework for what will happen.

In addition, **revitalisation measures** now need to be managed for localities in the advanced stages of mining-related resettlement in the Rhineland (Morschenich on the margin of the Hambach opencast mine area) and in central Germany (Pödelwitz on the margin of the Vereinigtes Schleenhain opencast mine area in Saxony); it is now certain that these localities will be preserved as a result of the coal phase-out and will need public assistance to provide prospects for a viable future. Action is also required for Proschim in the Welzow opencast mine area in Brandenburg, for which a political decision in favour of preservation was made in 2019. The successful revitalisation of such localities must include planning, financial and civic aspects in equal measure, for which structural strengthening instruments offer specific possibilities. **Experiences in the new federal states after 1990** (Dreiskau-Muckern and Sausedlitz in central Germany [Saxony], Pritzen in Lusatia [Brandenburg]) provide some background in this regard even if every case is unique and many open questions remain, especially about organisational and financial support (e.g. the specifics of Morschenich's designation as a 'village of the future').

The issue of the **required distance between active opencast mines and inhabited areas** still needs to be clarified depending on the specific local situation (ideally 500m in the Rhineland, other arrangements in the other coalfields).

8 Value creation and impact on employment

The lignite industry in Germany directly **employed** approximately 19,500 people at the end of 2020 (9,400 in the Rhineland, 2,200 in central Germany and 7,800 in Lusatia). In 1989, the industry directly employed approximately 157,000 people (15,500 in the Rhineland, 59,800 in central Germany, and 79,000 in Lusatia). For the new federal states, the experiences of massive structural break-up in the early 1990s must be taken into particular account. Between 1989 and 1995, the number of people directly employed in the mining sector decreased by 89% in central Germany and 76% in Lusatia. As a result, the real unemployment rate in the affected areas, accounting for early retirement arrangements and job creation and training measures, was as high as 50% at times. To this day, many of those affected have not mentally come to terms with this experience, which lives on in the 'social memory' of these regions. With regard to the current situation, the Commission on Growth, Structural Change and Employment noted in its final report that 'because of connections to the intermediate goods, consumer goods and capital goods industries and because of other purchasing power effects [...] for every job in the lignite sector, there is another indirect or secondary job in the coalfield area and another outside the immediate geographical

boundary that depends on that job. It can thus be assumed that there are around 60,000 jobs that have a connection with the lignite industry' (*BMWi* 2019, p. 52; *Öko-Institut* 2022, translation of the original German quote).

The **initial structural situations of the coalfield areas** still show significant differences today. While the Rhineland should be in a very good position to deal with the employment impact of the coal phase-out because of its economic strength in the area around Aachen, Mönchengladbach, Cologne and Düsseldorf, and central Germany is in a much better situation compared with its earlier monostructures, Lusatia faces a much more urgent need for action due to its structural weaknesses and demographic trends. From the perspective of workers in the mining and energy sectors, who are well organised and trained and receive compensation according to collective bargaining agreements, the announcement of the 2038 date for the coal phase-out constituted a challenge that has been met with remarkable discipline. However, bringing the phase-out date forward by a substantial time frame is increasingly regarded by employees as a clear breach of trust on the part of policymakers. Moreover, there is a **'countdown effect'** that has older workers questioning their prospects for the future and younger workers seeing fewer and fewer incentives to stay in their jobs or to seek employment in the sector. As a result, the sector is now seeing attrition that was unthinkable in the period between 1995 and 2019 because of the good income and working conditions. This attrition does not yet constitute a mass phenomenon, although targeted and in some cases supra-regional efforts to lure away workers, especially those with special skills, are on the rise as a symptom of the shortage of skilled workers. This situation is compounded in Lusatia by the contraction in the potential workforce due to demographic change.

A further factor is an increase in the **social pressure on workers in the sector to justify themselves**, especially in urban settings; those affected find this stressful. In the process of preserving value chains or establishing new ones, success will depend on whether and to what extent the remaining active mining companies are able to use their core expertise in energy, landscape design and logistics to develop post-mining jobs. Even so, at best it will be possible to preserve only a fraction of the jobs and value creation (in central Germany, around one-quarter of the original level) in this way. The lack of opportunities for direct economic development is particularly damaging in this regard. Prospects for a future economically and ecologically viable use of lignite (whether and in what volume) on a fundamentally different technological basis are completely open at this time and are the subject of intensive basic research. However, their actual relevance is difficult to assess given the geopolitics, price trends and security of supply issues.

Domino effects that are often not apparent at first glance need to be accounted for in the strategies. For example, gypsum from natural deposits will be needed by no later than 2038 to compensate for the loss of gypsum from the desulphurisation of power plant flue gas (currently 6 million tonnes per year), almost all of which has been used by the construction materials industry. This will pose new spatial planning challenges. District heating networks based on combined heat and power generation in lignite-fired power plants will need new energy sources and major restructuring. The use of sewage sludge as a complementary fuel at many power plants must be replaced. Losses of purchasing power and tax revenue must be compensated or at least alleviated, especially in the core mining areas.

9 Industrial heritage

With their range of structures, heavy equipment and industrial sites, Germany's lignite mining areas – even if they do not correspond to the aesthetic values associated with natural landscapes – are still impressive cultural landscapes that are rightly referred to as the **'largest landscape construction sites'**, at least at the continental level. If the traces and artefacts of industrial heritage are not preserved, the mining areas would quickly lose their identity and their history would no longer be recognisable to future generations.

In central Germany, **experiences with the loss of industrial heritage** in the 1990s led to the establishment of the Mitteldeutsche Straße der Braunkohle e.V. (Central German Lignite Road); the rescue of mining heritage like FERROPOLIS, the ‘City of Iron’ in Saxony-Anhalt as part of the ‘Industrial Garden Realm’ for EXPO 2000, the Bergbau-Technik-Park (Mining and Technology Park) near Leipzig in Saxony; der Pfännerhall machine hall in the Geisel Valley of Saxony-Anhalt; the coal railway in Thuringia and Saxony; and the Herrmannschacht briquette factory in Zeitz in Saxony-Anhalt. Today these sites constitute a nearly unbroken sequence of stepping stones along the European Route of Industrial Heritage (ERIH). An analogous development took place in Lusatia, with the Fürst-Pückler-Land international building exhibition assuming the role of catalyst between 2000 and 2010. Other visible objects of industrial heritage include the Knappenrode briquette factory as part of the Saxon Museum of Industry and in Brandenburg the F60 overburden conveyor bridge near Lichterfeld, the Biotürme in Lauchhammer, the power plant in Plessa, and the Domsdorf briquette factory.

Since several generations of technology have been lost completely (cable railways, chain railways, low-temperature carbonisation furnaces) or to a significant degree (extraction shafts for underground mining, briquette presses), there is now an urgent **need to inventory and preserve** what remains. There are limits to what is possible: not everything can be preserved in museums, and the work involved calls for professional qualifications beyond those of volunteers. Corresponding projects (a cultural heritage project in the Rhineland, an inventorisation and listing initiative by Saxony’s heritage management body in central Germany, in Lusatia an analogous project for the districts of Bautzen and Görlitz [Saxony] and a project to record mining landscapes as well as *Kulturplan Lausitz* [Brandenburg]) have been initiated in all coalfield areas and are to be carried on and funded beyond the documentation phase.

‘Hidden treasures’ that are looked after by dedicated but often old-age people require special attention. In this respect, initiatives like DOKMitt in central Germany with its aim of building a documentation centre or establishing a Neuseenland House near Markkleeberg in Saxony, and ensuring viable use and further development (e.g. Schloss Paffendorf, :terranova and the Indemann in North Rhine-Westphalia; and in Lusatia the IBA Terraces in Großräschen, the Slav fortress in Raddusch and the archive of lost towns in Forst [Brandenburg], and bucket-wheel excavator 1452 at Berzdorfer See [Saxony]) are particularly important. Given the importance of this economic sector for the industrialisation of these coalfield regions with the most advanced technologies of their time, initiatives with aims including designation as World Heritage sites like the Erzgebirge/Krušnohoří Mining Region (2019), which are currently being discussed for Lusatia, are plausible and worthy of support. In many cases, the instruments and funding opportunities provided by structural strengthening programmes offer the last substantive chances for promoting such causes.

10 Reflections on funding instruments and their implementation

With a **three-tiered strategy involving the federal, state and regional/local authority levels**, an outline, viable arrangement for structural strengthening related to the coal phase-out was developed to give adequate consideration to all concerns and ensure the meaningful involvement of the key stakeholders at all levels. From the outset, one shortcoming was that the final report from the Commission on Growth, Structural Change and Employment included an inadequately prioritised ‘wish list’ of projects; that list raised expectations in some quarters that were heightened by measures designated as immediate or ‘turbo’. However, it should be noted here that considerable political pressure demanding action posed a major challenge to efforts to take a strategic approach to regional development.

In practice, aspects of the cooperation between the levels could still be significantly expanded. The federal government shows a conspicuous tendency to designate infrastructure measures that were going to take place anyway as ‘structural strengthening’. At the federal state level, individual measures were pushed forward with insufficient preparation and inadequate consultation with the regional or local authority level. At the municipal level, there is a tendency for local authorities to accept structural change funds as a welcome addition to their discretionary spending without a link to an actual purpose; this leads to problematic precedents in terms of equal treatment. Equally problematic is how questions of the time frame for using such funds are addressed, as sometimes the impression is that the available funds must be spent or at least committed as quickly as possible without doing sufficient justice to the **long-term nature of structural change processes**. In some places there are initial indications at the municipal level in particular that implementation processes are becoming increasingly bureaucratised, with too little mutual feedback between the levels. In addition, in central Germany and Lusatia there are conflicts between structural change and the administrative agreement between the federal government and the states on lignite remediation measures that must be considered in order to avoid undermining remediation obligations. The agreement has been in force since 1992, with multiple extensions through the end of 2022, and assigns responsibility for the remediation measures to the Lausitzer und Mitteldeutschen Bergbau-Verwaltungsgesellschaft mbH (LMBV). The follow-on agreement for 2023–2027 has been negotiated but not yet signed.

In some areas, the **funding frameworks** were far too broadly defined with their stipulations based on districts and urban districts. These would have been better targeted if they were defined on the basis of municipality or at least if they differentiated between ‘core’ and ‘additional’ areas in order to shape structural change regionally while giving special emphasis to the core areas. In addition, the lack of possibilities for direct economic development should also be pointed out. Although innovative structural policy should not be too narrowly targeted in spatial terms, its success ultimately depends on how the main concern of generating growth and employment can be successfully implemented in the areas most strongly affected. The involvement of spatial development planners in coordination and decision-making processes relating to structural change ranges from intensive (advisory input of regional planning associations in regional supervisory committees in Saxony) to limited (the regional planning level in Saxony-Anhalt).

Conclusions

On the whole, the impending structural change is a multifaceted process that calls for a complex, holistic approach. Accordingly, focusing on sectoral components is not sufficient. From the perspective of spatial development planning, which also has to assume responsibility for regional development, the actions required are summarised below.

- > With respect to energy and environmental policy requirements at the federal and state levels, lignite planning needs a dependable framework if it is to accomplish its mission.
- > To provide a basis for planning, forecasts and scenarios for coal demand, production volumes, production time frames and mass balances must be kept up to date at all times.
- > For the pending planning changes, only limited acceleration is possible due to requirements for environmental assessments, participation, transparency and legal certainty.
- > Cooperation between scientists and planners and the creation of incentives for ideas and innovations through new strategies and informal instruments are helpful and should be supported.

- > Establishing a regional water balance largely free of follow-up maintenance in terms of volume and quality calls for active water management with adaptations to changing conditions (climate change!).
- > Safety-relevant geotechnical deficiencies can have long-term consequences and thus must not be tolerated simply because of the ongoing coal phase-out.
- > The remaining cases of mining-related resettlement and the revitalisation measures resulting from the coal phase-out must be clarified as soon as possible.
- > The allocation of available and spent structural strengthening funds, and the monitoring of how successfully they are used, require regular evaluation and adjustment.
- > Direct, indirect and secondary value creation must be safeguarded and ‘social peace’ protected in the core regions of the lignite industry.
- > Knowledge transfer according to the best practice principle should be assured among all parties involved and supported by suitable platforms and forums, including the ARL.
- > Documentation of the lignite industry’s material heritage needs to be professionalised, placed on a stable footing and funded appropriately, and needs to be carried on beyond mere recording and inventorisation activities.
- > Constructive cooperation among the different levels of government (federal, state and local authority) and transparent decision-making processes are of key importance in shaping structural change.

Despite understandable desires to end lignite-based power generation as soon as possible, it is still necessary to shape the required process, in all its complexity, so that it can be successful. Innovative combinations of formal and informal spatial development planning instruments, a sound and broadly understood communication of technical issues and contexts, and the participation of a wide range of stakeholders can assist in this regard, whereby motivated and creative young people can be particularly tapped.

The combination of regionally available expertise from mining activities and existing location factors in the coalfield areas provides basic conditions for the development of new economic clusters. Germany’s coal phase-out and structural change are being observed attentively by the neighbouring countries of Poland and the Czech Republic, so it can be expected that developments will send a signal beyond the national level.

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