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Towards an integrative, interdisciplinary perspective on governing regional lignite phase-out in Germany

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Abstract

This article takes a critical look at structural politics in the course of lignite phase-out in Germany. The authors compile analyses and research experiences from two different regions and interpret them against the background of the current regional policy mechanisms to compensate for the negative consequences in the affected regions. Based on many years of observation of the structural policy processes and related socioeconomic outcomes, different focal points are set. Calculations of innovation potentials are combined with policy and stakeholder participation analysis to sketch a framework for an interdisciplinary perspective of governing lignite phase-out in Germany. The authors conclude that together with the challenge of just transition resulting from the lignite phase-out region-specific transformation requirements are determining variables for regionally effective structural policy. From this, requirements for action can be derived for national funding policy as well as for the institutional settings and mechanisms of its implementation at regional level in the German federal states.

Keywords: Lignite phase-out, structural change, structural policy, socioeconomics

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1. Introduction and intention

Germany's decision to phase out lignite until 2038 is posing complex challenges for the affected regions. These are multi-dimensional, overlapping and conflicting, they involve economic issues, are based on demographic developments and peripheralization trends, and become apparent in social tensions and political problems. Accordingly, it is important for structural and regional developmental politics to identify and enhance regional innovation potentials in order to make regional structural change economically and thus socially and regionally viable. And if this were not already complicated enough, socio-historical or psychological issues must also be kept in mind given the medium-term goal of a systemic path change directed towards sustainability, so that such a structural policy intervention also gains the inevitable political acceptance for effective implementation. Academic disciplines such as economics, social and spatial science each contribute their part to ad-dress these challenges from a subject-specific perspective, but often they do so while not addressing or considering sufficient cross-disciplinary knowledge integration and cooperation. As a result, findings remain fragmentary and do not sufficiently combine subject-related components to draw a complex picture. Unfortunately, this is precisely what is needed in order to provide adequate scientific advice to political, economic as well as societal actors in structural politics (Lintz et al. 2012) and to make better use of academic analyses for a beneficial regional development.

Referring to the lignite phase-out in Germany and our academic cooperation in this field, we would therefore like to show the various facets and challenges that the structural change processes resulting from lignite phase-out in Rhineland and Lusatia involves. We show the difficulties that arise when assessing regional innovation potentials and drawing conclusions for regional economic development. We will also identify socio-political acceptance barriers for future transformation pro-cesses resulting from decades of structural change and accompanying disappointment experiences. And we want to point out the extent to which all of this is interwoven and must be considered together in an integrative manner if the governance of such challenging process constellations is not only to manage regional structural change from a purely economic side, but if it is to transform regional value chains systemically and make them more sustainable (Grillitsch et al. 2018). This combi-nation of sustainability-oriented transformation policy and socio-economic structural policy in regional development requires an integrative, interdisciplinary perspective on processes of structural change.

The greenhouse gas reduction targets set out in the German government's "Climate Protection Plan" require a gradual withdrawal from fossil fuels and the end of lignite-fired power generation. To meet this challenge by means of a just transition, the federal government established a "Com-mission for Growth, Structural Change and Employment" in 2018, representing perspectives from politics, business, environmental associations, unions and all regions affected. The commission's task was to establish a broad social consensus on the way to lignite phase-out and how to handle the resulting structural change in Germany. The Commission recommended ending lignite-fired power generation in Germany by 2038 at the latest. To facilitate the needed adjustment processes in the affected regions, the federal government has decided to provide structural aid amounting to around €40 billion (Bundesministerium für Wirtschaft und Energie (BMWi) 2019).

The lignite phase-out decided by the federal government and the structural aid face the respective regions with different opportunities and challenges. Lignite mining areas in particular are confront-ed with the challenge of developing forward-looking regional strategies to promote change and prepare for the

foreseeable end of their often dominant mining sector (Veldhuizen/Coenen 2022). These highly specialised regions are now faced with devaluing past investments and developing new green pathways (Breul 2022).

As the lignite phase-out is seen as a concurrent process in each region, this article takes a critical look at structural policy in these regions, reflecting measures and governing structures as well. While the Rhineland has a vision of creating an 'Innovation Valley' in order to present the region as particularly innovative, it is social contextual conditions that pose major challenges to structural change in Lusatia. Addressing these two different aspects, which are only briefly touched upon in both cases, facilitates understanding of the different challenges that structural politics has to cope with. In this respect, our contribution is not intended to serve as a conventional, classically structured research paper; rather it reflects and sets a focus on the multi-layered characteristics of complex transformation processes that are taking place in Germany's lignite phase-out. Thus, the text is to be understood as a plea for an overarching, integrative assessment of structural change in order to identify case-specific problem dimensions from interdisciplinary perspectives. For this reason, illustrating empirical insights from different academic disciplines covering the mining areas of Rhine-land and Lusatia are presented - not with a comparative focus, but with the intention to emphasize benefits and necessity of an interdisciplinary approach.

Adopting this perspective, this article calls for a small-scale and evidence-based regional policy with decentralized governance structures that corresponds to the particular regional transition requirements. The foundation for this claim are integrated analyses of socioeconomic, societal, partly also historical starting conditions and resulting development paths in the regions concerned. We argue that this tailor-made approach for policy and governance options requires a regional specific and interdisciplinary research perspective as well as a broad spectrum of quantitative and qualitative considerations.

With this end in view, the article first outlines the process of lignite phase-out in the course of the energy transition in Germany as well as the regional policies established to cope with it. Then two of the three affected regions in Germany – the Rhineland in North Rhine-Westphalia and Lusatia in Brandenburg and Saxony – are introduced regarding their socioeconomic starting situation and their previous development paths in structural change. The basis for the conclusions of this article are not own theoretical considerations, but insights into in-depth empirical analyses in the two regions. Thus, the focus of this analysis is based on many years of observation of the regional structural change processes. The article ends with a summary and conclusion.

2. Energy transition, lignite phase-out and regional structural policy in Germany

2.1 Anthropogenic climate change and energy transition in Germany

The German scenario of a nation-wide stop of lignite mining and power generation by 2038 directly derives from the fact of anthropogenic climate change. In the light of an increasing urgency to reduce global warming and CO_2 emissions contributing to this warming, coal and lignite phase-out have become key issues on the political agenda. Thus, effective climate protection policy is the background from related political decision of an "energy transition" arose. These political decisions' implications

are economically challenging, financially expansive, and politically also linked with considerable transaction costs. Thus, the process is guided by the socio-economic/-political needs for a just transition and to be embedded in a broader context of the related academic debate (Snell 2018; Weller 2019).

The term energy transition thereby addresses the development of the German energy system from a fossil-based one into a system relying on renewable energies at large scale. While the roots of this process date back to the 1970s, first indications for a societal awareness concerning renewable energy date to the mid-1980s and gained further momentum by both the nuclear accident of Fukushima and immediate effects of the climate crisis. As a result, Germany has not only decided to stop using nuclear power, but also decided to phase-out coal and lignite mining.

Whereas hard coal extraction in Germany has been stopped mainly for economic reasons, lignite phase-out is a primarily political decision taken for ecological reasons, which requires much more justification efforts and acceptance to be implemented. Although both decisions had or will cause substantial shifts in the economic bases of the lignite mining regions concerned, hard coal phase-out has had tremendous economic and job-related impacts. In contrast, lignite phase-out occurs comparatively smooth in terms of employment loss. Yet, this impression might be deceptive, especially against the background of Lusatia's mono-structural economic situation, which has focused on lignite industry for decades. Besides, problems transcend job losses as socioeconomic and spatial structures will undergo changes. Lignite-rooted regional identities are thus challenged, too. Obviously, this forthcoming transition has substantial impacts on the regions affected: (1) the economic structures it is to alter, (2) the energy supply that needs to be reorganized and (3) the inherited social aspects related to coal and lignite mining. Considering future economic and societal impacts it seems that the politically fostered lignite phase-out needs a stronger political legitimation and civic commitment than the hard coal phase-out did. This also explains the extent of political intervention and financial compensation for the consequences at all levels, provided by structural policy and its investment strategy.

2.2 Structural Policy and Energy Transition's Funding System

Therefore, an economically effective and societal responsive structural policy is expected to play a key role in successfully phasing-out from lignite. Consequently, federal politics not only provided the impetus of decarbonisation of economy and society, but also contributed two federal laws serving as central governing instruments for the structural change to be managed. The (1) "Renewable Energies Act" (EEG) envisions a fundamental restructuring of the energy supply and aims to increase the share of renewable energies in the German energy market to at least 80% by 2050. De facto, this entails a gradual phase-out of lignite mining and affiliated industries, which was scheduled in negotiations of the federal Commission for Growth, Structural Change and Employment for 2038. As such a phase-out decision will have significant consequences in many regards for the mining regions concerned, these consequences are to be mitigated for economic, social and – not least – political reasons. To this end, the German Bundestag passed the (2) "Structural Strengthening Act" (StStG) which established a package of compensatory measures. As one part of the Structural Strengthening Act, the "Coal Regions Investment Act" (InvKG) provides for aid measures and investment sums of considerable dimensions: €17 billion will be made available in the Lusatian mining area just to enable the structural transformation.

Essentially, the financial instruments to manage lignite phase-out in Germany result from the Structural Strengthening Act, defining two independent subsidy spheres with separate responsibilities for the expenditure of financial aids. The first subsidy sphere refers to financial assistance from the federal government and it is about investment funding to cope with the structural change caused by the lignite

phase-out. As such, these funds aim to investments in economic infrastructure, public welfare or environmental protection and fall under responsibility of the federal states. In addition, the second subsidy sphere provides measures in responsibility of the federal government that are administered by the federal government and to be spent on investments in transport infrastructure and the settlement of federal institutions, research institutes etc.

Because of this financing structure for the lignite phase-out, the affected federal states of NRW, Brandenburg, Saxony and Saxony-Anhalt are each individually accountable to the federal government for the funds spending. This responsibility also includes the establishment of appropriate governance structures to allocate grants, which has several implications. Therefore, the German lignite phase-out scenario is divided into four different assisted area settings with a fragmented structure of actors in which several veto players, each with diverging interests, meet at eye level. Additionally, states handle the subsidies whereas municipalities are typically applicants. All this does not make German structural policy any simpler and turns lignite phase-out into a phenomenon of complex federal multi-level governance: The federal government provides the money; federal states implement the structural change measures territorially, programmatically and procedurally on their own; and local municipalities adopt a role of more or less subordinate recipients of funds.

3. Context and regional essence of structural change processes in lignite phase-out: Insights from Rhineland and Lusatia

At first glance, the two lignite mining areas examined here, Rhineland and Lusatia, seem to be affected in a similar way by lignite phase-out. Both regions are facing future struggles like the disappearance of an entire branch of industry, job loss and shifts in regional identity to be managed, and nothing less than a partial reorganization of the social and economic environment's structure. Yet, a closer look reveals a more differentiated picture regarding the region-specific challenges and contextual conditions of both empirical cases. The two lignite mining areas differ not only in terms of their geographical location, governance and history, but also in terms of the challenges posed by structural change. While the Rhineland is located in an economically strong region and has to find new ways to be an attractive place to work and live, Lusatia is located in an economically much weaker region that is threatened to be cut off by the lignite phase-out. The aim of this article is to show that a uniformly prescribed political measure, such as the lignite phase-out and the associated structural change, leads to different challenges and thus to different approaches to solutions in the respective regions.

3.1 Region-specific contexts

3.1.1 Rhineland

The Rhenish lignite mining area is located in the south-west of NRW and stretches in east-west direction from the river Rhine between Düsseldorf and Cologne to the Belgian and Dutch borders. In 2020 that region covers about 4,800 km², is home to about 2.5 million people and provides 0.83 million jobs subject to social insurance[1] (Strukturwandel Rheinisches Revier n.d.a). Measured both in terms of the gross value added generated by lignite mining and the number of people employed, Rhineland currently

[1] If not marked differently, jobs and employees will henceforth be used for jobs/employees subject to social insurance.

is Germany's largest lignite mining area. While the mining of hard coal has shaped the regional identity of the 'Ruhrgebiet', located in NRW following the rivers Ruhr and Emscher, the Rhineland neither did nor does see itself primarily as a lignite mining region. Both the economic growth of the region and the composition of the industry are probably due to the cheap and readily available energy from lignite mining. As a result, particularly energy-intensive industries have settled in the region (Breul 2022).

In terms of structural policy and governance, the region started institution building about a decade ago: the "Innovation Region Rhineland" (IRR) was founded in 2011 and is the predecessor of today's "Future Agency Rhineland" (ZRR). Initiated by the state of NRW, the ZRR has the task of supporting structural change in the Rhineland by initiating and implementing projects and developing guiding principles, innovation strategies and action concepts. Until the planned phase-out of lignite mining in 2038, the ZRR wants to transform the Rhineland into a liveable, high-performance, innovative, climate-neutral and interconnected region. Following the delineation of the ZRR, the Rhineland includes the counties and cities that are characterised by the extraction, conversion to electricity and refinement of lignite and for which it can be expected that they will be particularly affected by structural change. These are the counties of Düren, Euskirchen, Heinsberg, the Rhein-Erft-Kreis and the Rhein-Kreis Neuss as well as the city of Aachen and Mönchengladbach (Strukturwandel Rheinisches Revier n.d.b).

3.1.2 Lusatia

Lusatia's lignite mining is located in the very east of Germany and it covers areas in the northeastern part of Saxony and the southern part of Brandenburg. Placed in a triangle of Berlin, Dresden and Gorlitz, Lusatia has a population of about 1.1 million people living in an area of 11,727 km², making it one of Germany's sparsely populated regions. Lusatia can be divided into two parts: The relatively mountainous Upper Lusatia in the south, an area without significant mining activity today; and Lower Lusatia in the northern parts, which is currently the center of regional lignite mining and extends up to the outskirts of Berlin. While the lignite area itself is the second largest lignite mining area in terms of employees and production volume, it is the smallest in terms of residential population. At present, around 8,000 people are directly employed in the lignite mining industry in four opencast mines and three power plants, producing around 40% of Germany's lignite (Deutscher Braunkohlen-Industrie-Verein e.V. (DEBRIV) 2018; Statistik der Kohlenwirtschaft 2022).

Lignite mining has a long tradition dating back to the 19th century and continues to shape the Lusatian economy, landscape and society. For many decades, lignite has been mined in Lusatia at an industrial level to be used both for power generation and for the production of briquettes, gas, and coke as well as for chemical products. East Germany's lack of significant deposits of oil and hard coal contributed to the expansion of lignite mining, so that at times more than 80% of the electricity supply in the German Democratic Republic (GDR) was realized by lignite-fired power generation. Thus, Lusatia became the country's most important 'energy region', which deeply shaped its socio-economic and ecological structure. At the same time, lignite's importance for the GDR economy not only led to a high dependency of the regional industry on coal as found today in Queensland (Molyneaux/Foster 2020), but also resulted in its correspondingly high social significance. This has given rise to a special regional identity of Lusatia, one that is still today closely interwoven with lignite mining, even though economic importance of lignite mining significantly decreased in the 1990s.

With regard to the gradual exit from lignite mining, the strategic development of Lusatia was initially based on the conceptual considerations and a framework that originates from "Commission for Growth, Structural Change and Employment" and the mission statement process of the "Zukunftswerkstatt Lausitz" ("Future Workshop Lusatia"). As Saxony and Brandenburg in 2020 decided against continuing a

joint, cross-state structural policy to promote Lusatia's regional development, each developed own action strategies and institutions. Consequently, by establishing the "Saxon Agency for Structural Development" (SAS) as well as Brandenburg's "Economic Region Lusatia" (WRL), institutional actors were created in each federal state. These actors are responsible for the allocation of project funds provided as financial assistance from the federal government. The resulting institutional funding structures in both states differ in procedure and approach, but what they have in common is a de-facto superior role of the federal states in managing and shaping structural change in Lusatia.

Summing up, the two major lignite-mining areas in Germany are subject to fairly different starting points and contextual conditions. The challenges related to energy transition should be similar however. To understand how structural change unfolds in those regions due to the lignite phase-out, we cast some light on different facets that need to be considered. Therefore, the next two subsections apply an inductive, phenomenological approach to collect relevant pieces of structural change, its spatial and economic characteristics and its societal embeddedness to eventually suggest the research framework mentioned above.

3.2 A tentative closer look at Rhineland in comparison with Lusatia in terms of its potential for "creative" people

In Germany's largest lignite mining area, the challenges of the lignite phase-out and the associated structural change are seen as an opportunity. Following this notion, an innovation process is to be initiated on the former open-cast mining area, currently a large-scale hole. The underlying expectation is that the hole and its surroundings will turn into an attractive place for working, living and innovating. Referring to regional development literature (Karlsson 2015) and knowledge-based regional development strategies (Cooke/Leydesdorff 2006), developing the region into an innovation region sounds as a promising strategy towards the region's future viability.

A closer look at the socio-economic data in the German lignite industry shows that both the impact of the lignite phase-out on the current labour market is comparatively small and that employment rates in the lignite industry have been declining for years. After reunification in 1989, 157,000 workers (approx. 15,500 in the Rhineland, 59,800 in Central Germany, 79,000 in Lusatia) were directly employed in the lignite industry. By the end of 2020, only about 19,500 workers (approx. 9,400 in the Rhineland, 2,200 in Central Germany and 7,800 in Lusatia) are still directly employed in the lignite industry (Akademie für Raumentwicklung in der Leibniz-Gemeinschaft (ARL) 2022: 9). The share of mining-related workplaces in Lusatia is thus 3.3% and in Rhineland 1.8%, whereas the share of gross value added in Lusatia is 4.3% and in Rhineland 2.4% (Gerwin/Raab/Birkhofer et al. 2023: 14). These numbers lead to the conclusion that a big part of the shrinking of the lignite sector has already occurred. This is a fact but it does not mean that the associated structural change process and its outcomes have been fully mitigated.

Still, the numbers illustrate the different economic importance of lignite in the two regions. Structural policy thus seems less relevant with respect to mitigating direct job losses in the Rhineland. However, targeted structural policy means will likely be necessary when it comes to getting the 'Innovation Valley' idea started. In order to both support those structural change and adaptation processes and to promote innovation-based socioeconomic viability in the medium and long run, the state government aims to market the region as particularly innovative.

As a brief excursus and to root these ideas in the scientific literature, we briefly summarize two relevant strands in the following paragraph. The idea is to highlight the necessity of innovation for future growth

and viability and – following this paper's goal – to eventually carve out why looking at "innovation in numbers" is a necessary but not sufficient guideline for regional structural policy.[2]

Following Capello (2013), innovation intensity and success vary between regions. In the study, the author assumes that the availability of creative people can be seen as a proxy for innovation capabilities. Florida (2004) sees the cause for the uneven regional distribution of innovations in the different availability of creative people. He defines these creative people as a creative class whose members are innovative, drive economic and technological development and prefer a tolerant and diverse climate in which a wide variety of cultural impulses enrich each other. In order for places to attract these creative people, Florida defines 3 T's, *talent*, *technology*, *tolerance*, that every place should have.

Having said this to facilitate shaping structural change, two things are required: (1) political framework conditions and leadership that take into account the different transformation experiences as well as the historical circumstances. (2) But also regions that have indicators that represent a possible potential for "creative" people.

Following this overview and its main implications, the aim of this part of our study was to develop a system of indicators that takes into account the main ideas from the innovation literature, especially the role of innovative "creative" people. Based on that, we establish a highlight-like comparison between the different lignite mining areas. In this way, the possible innovation potentials of the regions can be compared with those of the respective federal state[3].

Studies that aim to empirically determine or estimate regional innovation potentials and subsequently compare them often choose the path of translating a theoretical concept into operational metrics via suitable indicators or indicator systems. Most of these studies create an index consisting of three indicators, which are roughly following Florida's 3 T's (see, e.g., DIW econ 2008; Bobirca/Draghici 2011; Báez/Bergua/Pac 2014). Those studies differ in terms of which variables are used to form the sub-indicators which suggests that an agreed-upon set of variables for the sub-indicators exists in the literature.

We formulate in this study an innovation index based on the three indicators, following Florida's categorisation: qualified labour force, technology and openness. In view of the objective of this paper, the actual selection of the variables is rather illustrative than conceptual. For this reason, more weight was given to data accessibility than to conceptual depth and methodological stringency as would have been the case if we had wanted to make a statistically sound regional comparison and derive concrete policy recommendations. The two criteria of data availability and meaningfulness were ultimately decisive in making a selection for these individual indicators from a large number of possible variables.

The comparison of the two lignite mining areas, though based on the "Innovation indicator", mainly focuses on the "qualified labour force" as a proxy for innovation and innovation capability. One the one hand, this focus on human, creative and innovative capital is intended to show whether the regions have the potential to generate "creative" people themselves. This analysis is based on the number of students and school leavers with a university degree. On the other hand, the number of employees with an academic professional qualification at the place of residence, self-employed persons and new business start-ups show whether the regions also succeed in retaining "creative" people.

[2] The following paragraphs are, however, not intended to provide a full-fledged analysis of the debate concerning innovation and regional development. This analysis is neither necessary for the line of reasoning here nor suitable to be held in the context of discussion a certain economic sector. Debates around sub-topics such as knowledge-intensive business services (KIBS) and higher-order producer services (HOPS), respectively, regional innovation systems and related value chains fall into the same line of reasoning and good summaries have been provided elsewhere (see Asheim/Gertler 2005; Shearmur/Doloreux 2008; Strambach 2008).

[3] Saxony and Brandenburg were aggregated into one artificial federal state.

The other two indicators that the innovation index is compiled from are "Technology" and "Openness". The "Technology" indicator uses the number of companies in the I&C sector, the number of de-domains per company, the number of households with a broadband connection of at least 50 mbit/s and the travel time in minutes to the nearest highway or railway station to illustrate the general conditions for "creative" people to work there. Finally, the last indicator shows the "Openness" of the region based on the share of marriages with German and foreign partners, foreign employees with academic degrees, guest arrivals from abroad, overnight stays by guests from abroad and female employees at the place of residence. A full list of all variables, their sources and reference year can be found in Table 1 in the appendix. The indicators were calculated using the most recent data available at the time.

To ensure comparability between the variables entering the indicators, they were scaled from 0 to 100 in relation to the regions of the respective federal state and with 100 being the 'best' and 0 being the 'worst' value. Báez/Bergua/Pac (2014) use a similar ranking for their indicators. The indicators "Qualified labour force", "Technology" and "Openness" are calculated from the mean value of the respective five variables (see Table 1). Furthermore, the "Innovation index" is calculated from the mean value of the indicators. All variables used were weighted equally, as the innovation potential was not investigated for specific industries or sectors. After calculating the indicator values and the "Innovation index", the lignite mining areas can be compared with those of the respective federal state. This allows a regional comparison of the Rhineland and Lusatia in terms of strengths and weaknesses in various facets.

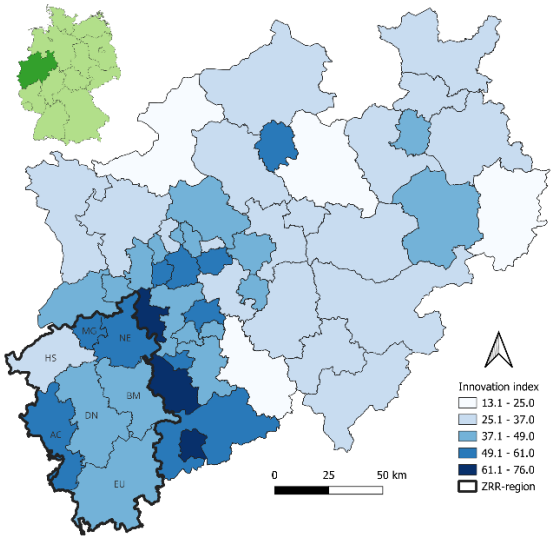
The calculations allow variables with different characteristics to be offset against each other in order to create indicators that compare the lignite mining areas with the regions of the respective federal state. The calculation on which the ranking is based determines values for the variables from 0 to 100 on the basis of the highest and lowest values of the respective federal state. Depending on the dispersion of the variables, this can have a high influence on the values of the ranking. When interpreting the results it should be noted that the bases of the ranking values are the respective federal states. A comparison of the lignite mining areas with each other should therefore always be seen in relation to the respective federal state and the regions also located there. Nevertheless, the authors' aim was to compare the lignite mining areas in terms of their value and potential in terms of "creative" people within the respective federal state.

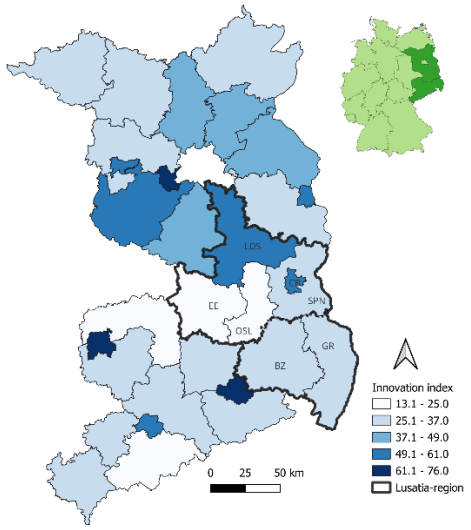
The following figure show an overall impression represented by the "Innovation index" of NRW and of Saxony and Brandenburg. Counties belonging to the respective lignite region are circled with a bold black line and marked with the respective number plates. The bluish choropleth maps use the same five intervals, identically shaded, to highlight similarities and differences between the regions. Following this overall impression, the figure focuses on the "Qualified labour force"-indicator and its underlying variables for the Rhineland and Lusatia regions.

Figure 1 shows in its upper part on the left-hand side the federal state of NRW and within it the counties that form the ZRR-region. The ZRR-region consists of two large cities, Aachen and Mönchengladbach, as well as five counties. The lignite mining area of Lusatia, which is located in eastern Germany is shown on the right-hand side. It extends across the federal states of Brandenburg and Saxony and comprises six counties and one city – Cottbus. In contrast with ZRR, where all the regions are located in one federal state, two Lusatian counties are located in Saxony and the remainder in Brandenburg.

Within the ZRR-region, the city of Aachen achieves the highest "Innovation index" with 58.6 and is the first group following the leaders. So are the Rhein-Kreis Neuss and the city of Mönchengladbach, all of which belong to the ZRR-region. Three counties in the ZRR-region (Rhein-Erft-Kreis, Düren and Euskirchen) are in the middle interval. The lowest "Innovation index" within the ZRR-region is achieved by the county of Heinsberg with 35.6, which places it in the fourth-highest interval and no county within the ZRR is in the last interval. Thus, all but one county within ZRR-region score comparatively high innovation potential values. It is furthermore notable that most counties in the highest three intervals are

located in the south-west of NRW – and this is where the ZRR-region is also located. Although spatial concurrence does not imply causal relationships, it can be concluded that the ZRR-region is surrounded by the largest cities in NRW and that these cities are not least due to their renowned universities fairly innovative. Likewise, spatial economic spillovers, agglomeration shadows and potentials of borrowing size are possible.

<table>
<tr><th colspan="2">Rhineland</th><th colspan="2">Lusatia</th></tr>
<tr><td colspan="4">An overall impression: “Innovation index”</td></tr>
<tr><td colspan="2"> 

Source: Authors based on desk research and shapefile data from OpenGeodata.NRW, 2022.</td><td colspan="2"> 

Source: Authors based on desk research and shapefile data from Staatsbetrieb Geobasisinformation und Vermessung Sachsen [GeoSN], 2022, & Landesvermessung und Geobasisinformation Brandenburg (LGB), 2022.</td></tr>
<tr><td colspan="2">Cities: Aachen (AC) and Mönchengladbach (MG)
Counties: Düren (DN), Heinsberg (HS), Euskirchen (EU), Rhein-Kreis Neuss (NE), Rhein-Erft-Kreis (BM)</td><td colspan="2">City: Cottbus (CB)
Counties: Bautzen (BZ), Görlitz (GR), Dahme-Spreewald (LDS), Elbe-Elster (EE), Oberspreewald-Lausitz (OSL), Spree-Neiße (SPN)</td></tr>
<tr><td colspan="4">A closer look at “Qualified labour forces”</td></tr>
<tr><td>Variable</td><td>Scaled average value</td><td>Variable</td><td>Scaled average value</td></tr>
<tr><td>Students</td><td>5.96</td><td>Students[4]</td><td>15.59</td></tr>
<tr><td>Academics</td><td>22.03</td><td>Academics</td><td>22.24</td></tr>
<tr><td>Self-employed</td><td>53.36</td><td>Self-employed</td><td>49.11</td></tr>
<tr><td>Highly qualified school graduates</td><td>55.45</td><td>Highly qualified school graduates</td><td>30.14</td></tr>
<tr><td>Start-ups</td><td>34.38</td><td>Start-ups</td><td>31.43</td></tr>
<tr><td>Total</td><td>34.20</td><td>Total</td><td>30.50</td></tr>
</table>

Figure 1: Comparison of the ZRR and Lusatia for the “Innovation index” and the indicator “Qualified labour force” (Source: own)

The highest “Innovation index” within Lusatia is achieved by the city of Cottbus with 57.2, which lies in the second-highest group, as is the county Dahme-Spreewald. An explanation for this is that Cottbus

[4] Not available for Brandenburg: Elbe-Elster, Spree-Neiße.

hosts a medium-sized technical university and the county of Dahme-Spreewald probably benefits from its neighbourhood to the city of Berlin. Looking at Lusatia reveals that the counties of Görlitz and Bautzen in Saxony and Spree-Neiße in Brandenburg score best though fairly weak "Innovation indices" as these belong to the fourth out of five intervals. As opposed to the Rhineland, there are two counties located in Lusatia whose "Innovation index" values fall within the lowest interval: Oberspreewald-Lausitz and Elbe-Elster in Brandenburg. Additionally, Elbe-Elster scores 18.8 and it thus has the lowest "Innovation index" of all counties.

Since this study also aims to compare the lignite mining areas in terms of the "creative" people there as a proxy for innovation, the lower part of Figure 1 shows the summarised "Qualified labour force"- indicator for the ZRR on the left and Lusatia on the right. While the two lignite mining areas have similar values in relation to their comparison regions for "Academics at the place of residence", "Self-employed persons" and "Start-ups", they show larger differences for "Students" and "School leavers with a qualified degree".

In terms of "Students", both lignite mining areas do not have a high value in relation to their comparative regions. However, the value in Lusatia is slightly higher than in the ZRR. This finding could be due to the fact that both lignite mining areas contain locations of renowned universities – the RWTH is located in Aachen and the BTU is located in Cottbus-Senftenberg. However, these cities have a different weight in the ranking in relation to other university locations in both regions.[5] While the NRW contains many other renowned universities with higher registration numbers spread across the entire federal state, Brandenburg and Saxony do not have as many and they are rather concentrated in the largest (capital) cities.

The ZRR achieved a higher value than Lusatia for "School leavers with a qualified qualification". The reason for this could be that the southwest of NRW is a popular place to live and work. Three important chemical parks and the German headquarters of several international companies are located there. Especially highly qualified people are attracted to live and work in the region, and thus their children go to school there. The regions of Lusatia are less attractive in comparison, as they are still suffering from the economic collapse after reunification and its lasting effects on industries and companies (Stognief/Walk/Schöttker et al. 2019: 9 f.). Furthermore, the counties of Bautzen in Saxony and Oberspreewald-Lausitz in Brandenburg, which belong to Lusatia, achieve the two lowest values of all regions for the "Qualified labour force" indicator. Thus, the ZRR receives a slightly higher value than Lusatia in the indicator for "Qualified labour force".

The preceding analysis facilitates a regional comparison of the two lignite mining areas. Although they face the content-wise same challenges of structural change due to the lignite phase-out, the challenges are of differing severity and the regions also seem to have different potentials. This leads to the assumption that the same problems in the same country require different approaches for their solution.

Having said this, a solely quantitative comparison of the lignite mining areas Rhineland and Lusatia is only meaningful to a limited extent. While it does provide a solid basis of the status quo, its deeper implications require more information than numbers only. A technical reason for this is the way, the indicators have been calculated, which permit within-comparisons. Cross-case comparisons, however, are to be handled with care and desire a qualitative interpretation and back-up with additional regional and local knowledge.

Additionally, the spatial structure of ZRR-region in particular and its location in the south-western part of North Rhine-Westphalia give rise to certain socioeconomic interdependence between ZRR and its neighbours. The lignite mining area is close to the cities of Bonn, Cologne and Düsseldorf – all of these

[5] We find other higher education institutions such as Universities of Applied Sciences in many counties but these do not have an as high reputation as RWTH and BTU.

are large cities are endowed with several universities and further higher education institutions, public and private research institutions as well as research-intensive firms. The resulting locational advantages of the region indicate a high potential for future innovations of the regions (see Stognief/Walk/Schöttker et al. 2019).

In contrast, Lusatia's geographical location, its regional neighbours and internal structure do not permit these economic effects to be effective. Larger cities such as Dresden, Berlin or Leipzig, are relatively far away and rather poorly connected. Here, Stognief/Walk/Schöttker et al. (2019: 8) suspect a below-average innovation capacity in the region compared to the German average due to the low research and research personnel intensity as well as the below-average share of company start-ups and high-tech start-ups.

While the ZRR is surrounded by large and economically strong (university) cities, Lusatia is rather surrounded by structurally weak regions with sparser population. This has led to a massive migration and brain drain from Lusatia, which has significantly changed the population structure (Gerwin/Raab/Birkhofer et al. 2023: 14). A closer look at the "Qualified labour force" indicator also suggests that this is the case, especially for "Highly qualified school graduates". However, a closer look into more fine-grained data and underlying processes is necessary to confirm this assumption. Moreover, further non-quantifiable aspects of innovation potentials could be incorporated, such as social innovation potentials. We might assume that "creative" people also contribute to social innovation potentials, but digging deeper is necessary for a more sophisticated understanding. In summary, this study indicates that the ZRR-region seems to have a higher innovation potential than the Lusatia-region.

According to Iammarino/Rodriguez-Pose/Storper et al. (2019), the changing economic structure could interact with the regional characteristics to generate new and innovative development patterns. For this structural change to succeed, it needs to be seen in the context of the policy-making process to fully understand why a region faces implementation problems or wants to develop certain economic sectors rather than others (Breul 2022). Our analyses have shown that the challenge of compensating for the structural change caused by the lignite phase-out is bigger in Lusatia than in the Rhineland. The regions of the ZRR are located in the immediate vicinity of large university cities and business locations, which positively influences the potential for innovation and "creative" people in the region. By contrast, in Lusatia (more or less) comparable cities such as Dresden, Leipzig, Berlin or Potsdam are much further away. This spatial pattern illustrates one facet of the different challenges arising from structural change and lignite phase-out in the two lignite regions considered here.

Yet, our figures only provide an indication of the challenges ahead due to structural change. When developing a regional structural policy, this should be taken into account, along with the political framework conditions and a governance that takes into account the different transformation experiences as well as the historical circumstances.

3.3 'Mortgage of the past' – Structural change in Lusatia struggling with acceptance and regional identity issues, and some implicit thoughts why this is different in Rhineland

Structural change processes are subject to different regional-specific characteristics and influences. As the analysis of the ZRR-region has proven, the possibilities of transition processes strongly depend on economic preconditions and strategies. However, this fact all too often results in a prevalent focus on economic aspects in structural politics governance, not least because the consequences of regional energy transition processes are mainly reflected in economic indicators that are easily accessible to the

public. Political actors, usually in charge in such processes, therefore often regard structural change as a primarily economic phenomenon, and strategies for solving the problem are also tailored to this dimension.

This approach is certainly not inappropriate, but it falls short in multifaceted cases like Lusatia where economic and social vulnerability go side by side and are interdependent, which is not unusual for decarbonisation scenarios (Snyder 2018). In addition to economic features, energy transition is of course embedded in social, political, historical and psychological context conditions and cultural scripts, some of which develop spill over effects on the outcome of a structural change process. Therefore, the key to an effective policy approach for managing structural change on a case-by-case basis is an integrative analysis of the essential challenges of the regional process itself. These aspects then require substantial consideration in the governance of structural change.

In this respect, social factors are sometimes not immediately apparent and can hardly be quantified in figures. Rather, the example of Lusatia demonstrates that dimensions that need to be explored qualitatively, such as traditions, perceptions, emotional connotations, and even beliefs can play an influential role. From a social science perspective, this connection is theoretically covered by the sociological 'Thomas theorem' (Thomas/Thomas 1928), describing the dependence of human behaviour on 'definitions of the situation'. These shape both perception and assessment of social scenarios and thus decisively guide a person's subsequent behaviour in that social context (Merton 1995). To what extent these situational definitions actually correspond to facts is irrelevant for their effectiveness: However subjective, irrational or even incorrect these situational interpretations may be, the consequences of actions guided in this way are real.[6]

With regard to just transition scenarios and their influencing factors or constraints, the 'Thomas theorem' underlines the importance to know these regionally effective situational definitions of those affected in order to be able to respond to them at all, and for a successful process design. Assuming that a regional process of structural change will only succeed sustainably and make full use of existing endogenous innovation potential if it is sufficiently supported by the local population, a relevant question arises: What shapes today's guiding definitions of the situation in Lusatia's structural change?

Processes of structural change like the one in Lusatia or Rhineland represent far-reaching interventions in the regional socio-economic order over long periods of time. The extent to which these structural policy interventions can unfold desired effects is highly depending on the extent they are accepted by regional addressees and whether they consider the process design to be legitimate (Lenz/Viola 2017). The fact that such disruptive interventions regarding traditional economic realities and socio-psychological identity settings lead to controversial resistance is not peculiar to Lusatia and can also be observed in similar cases such as Wyoming in the U.S. (Cha 2020). It therefore seems all the more important that regional addressees are appropriately included in governance processes, as they bring different perspectives to the table and exclusion of addressees wastes acceptance and chances for future development. If trust and acceptance are lacking, this has the potential to significantly impede, delay and consequently increase the cost of establishing a de-carbonized economic structure in Lusatia.

This is all the more true since lignite phase-out is not a decision taken out of economic necessity, which would require less justification and acceptance, as it would be self-explanatory. Instead, Germany's lignite phased-out is a normatively driven process that is politically initiated and coordinated at the federal level. As a result, the course and outcome of this political process is very much shaped by principles and criteria of democratic decision making, which essential components are considered to be legitimacy and acceptance (Fraune/Knodt 2018). With regard to Lusatia, it should be emphasized that

[6] "*If men define situations as real, they are real in their consequences"* Thomas/Thomas (1928).

this process is taking place in a politically charged situation (Lorenz/Träger 2020) and is therefore particularly dependent on social acceptance and commitment. The reasons for this date back to the 1990s, when the region had to face a severe crisis resulting from an economic structural break with dramatic societal consequences that continues to have an effect today.

In order to assess the significance of the developments that followed the reunification of Germany in 1990, it is necessary to bear in mind the importance the Lusatia region and its lignite-mining industry had. Since the GDR could not draw on considerable deposits of hard coal, gas or oil after 1949, it decided to expand lignite mining in large scale over decades. Besides serious ecological problems, this resulted in a high degree of industrialization of the once agriculturally shaped Lusatia region over decades, in population growth and in comparatively well-paid jobs. As a result of several decades of industrialization related to the extraction and processing of lignite, a distinctive industrial culture (Harfst et al. 2018, Bole 2021) had developed and consolidated in the region. In the 1990s many of the former opencast lignite-mines and power plants in Lusatia were shut down, which led to a de facto de-industrialization of the region within a very short period of time. Subsequently, the foundations of Lusatia's industrial culture were gradually wiped out, but this element of a 'lignite-based' industrial heritage still seems to be significant for the region's identity today and shapes future options for regional development. Lost living and income perspectives, combined with unemployment, migration, over-aging and a deficit of skilled workers were the result (Kluge/Lehmann/Ragnitz et al. 2014; Markwardt/Mißler-Behr/Schuster et al. 2016; AGORA Energiewende 2017). Hence, this structural break of the 1990s marked a far-reaching and lasting disruption for the Lusatia region in two respects, as economic and societal characteristics of the region were severely destabilized. Combined with the economic structural break, centrifugal social dynamics that subsequently set in brought about societal uncertainties and socio-psychological impacts, which are still effective for the people's interpretation of the current structural change process.

Looking at Lusatia's self-perception, the once outstanding economic significance of lignite resulted in a regional identity that was also strongly interwoven with the lignite industry. Consequently, the cut which implied the closure of the opencast mines and power plants, was all the more severe (Marot/Harfst 2012). The end of the lignite industry, which had represented the energy basis of an entire country only five years earlier, was associated with deep disappointments, loss of identity as well as feelings of degradation and heteronomy (Willisch 2008). As a result, in the course of today's structural change in Lusatia, the problem of a societal identity and a self-image as industry and mining region has to be dealt with although it overemphasizes by far the actual importance of lignite, be it in terms of economic value or employment. This industrial culture – some might even regard it as a 'mortgage of the past' –, going hand in hand with a loss of faith in political processes therefore continues to have an effect and sets up barriers In contrast to phase-out scenarios due to a lack of profitability, normatively triggered scenarios are particularly dependent on acceptance, legitimacy and political support (Easton 1975) in order to generate local/regional effectiveness.

So, what can be derived from Lusatia's case, especially for similar processes in other regions? From a governance perspective, Lusatia illustrates how important it is to analytically reflect the societal, political and socio-psychological implications of the process in its historicity. This seems to be one the preconditions for knowing which obstacles arise from the past – and what aspects consequently have to be taken into account when designing a participatory governance process for effective structural policy. The Lusatian process is a decidedly political process whose difficulties relate to soft issues such as identity, disappointment, and distrust in politics. Therefore, the role of structural policy cannot be reduced to foster business enterprises economic structure or employment growth. Structural policy, as is obvious in Lusatia, inherently must have a socially stabilizing component making those affected part of the journey. However, integrative strategies and debates on future economic and societal visions and

developmental paths of a region are too often lacking. In this regard, Lusatia had experienced a promising integrative 'Leitbild'-process in 2018-2020, generating guiding principles and developmental visions for Lusatia in 2050 (Heer/Wirth/Knippschild et al. 2021). It would be beneficial for the region if more of this bottom-up generated ideas and visions are implemented in the developmental strategies of Brandenburg and Saxony. Lusatia's empirical case demonstrates that there are influential levels of problems that need to be identified and addressed by organizing the process in an inclusive and transparent way that increases acceptance. In this respect, the attempts implemented in particular in the Brandenburg part of Lusatia to include existing expectations by means of involvement of the affected population are promising (Heer 2022). After all, it seems that if politics and administration fail to substantially involve local population in regional transition processes, no matter how much structural aid is provided, it hardly will bring about the lasting positive effects sought after.

4. Conclusions

Drawing on interdisciplinary expertise and experiences gained in two different regions, this paper asked for the characteristic challenges of structural change processes and requirements resulting for the research of such processes. The insights presented from two German lignite mining areas exemplified the phenomenological variety that emerges in the continuum of lignite phase-out scenarios. The cases of Lusatia and Rhineland demonstrate how different the regional and thematic essence of each structural change process may appear and has to be governed even though it occurs in the shared context of energy transitions based on a joint political motivation. In Lusatia, with its specific socio-political constellation, it became apparent how much effective structural policy depends on acceptance, public support and involvement of regional stakeholders, population and local actors. Moreover, the Lusatia case illustrated the persistence of historical experiences and the need to consider such socio-psychological aspects embedded in the regional identity construction in order to define and implement effective regional policies. The Rhineland-case revealed that even if considerable regional innovation potentials are available, they must be sensibly embedded into the socioeconomic context of the region. Likewise, it became apparent that a closer look at each of the variables within the indicators is necessary to better understand the innovation potentials at hand. Moreover, extension in the direction of including social innovations might be considered in future research to organising and governing structural policy in a more target-specific way.

Given this heterogeneity, successful governance of structural change requires an interdisciplinary informed understanding of different contexts, identifying the essence of the process, and finally implementing an appropriate process design of participative governance. As different and diverse as the empirical characteristics of lignite phase-out scenarios are, as flexible and context-adapted the process design must be. It is evident that spatial/economic structural change has many case-specific facets that require sound measurement and context-sensitive interpretations, so our paper ties to debates of regional energy transitions and their specific, spatial implications and causalities (Coenen/Hansen/Glasmeier et al. 2021). We have shown that constructive governance of energy transitions cuts across several academic fields, which is why we argue for an interdisciplinary perspective using an integrative framework to appropriately investigate politically fostered energy transitions under the given socio-economic conditions and in socio-historical embeddedness.

This text intends to be read as a plea for a holistic, interdisciplinary approach to processes of structural change and for the knowledge acquired in this way not to be presented side by side in disciplinary terms,

but rather to be opened up for an integrating process of understanding. In pursuing this integrative approach, we suggest that 'Gestalt-perception'[7] could be helpful as hermeneutic pre-analysis of the economic, social and other contextual conditions before the empirical in-depth analysis is started. We consider this to be supportive when trying to understand the complexity of lignite phase-out and energy transition processes adequately and to examine the defining aspects of these processes more closely. This is why we refer to 'Gestalt-perception' as a morphological-analytical process that basically precedes the disciplinary process of detailed analysis and which – after considering interdisciplinary insights – allows conclusions to be drawn about the essence, specific configuration or "Gestalt" of the structural change process under investigation.

In this context, 'Gestalt-recognizing' process analysis is advantageous in several respects. Firstly, it allows an appropriate focusing of the research interest independent of disciplinary path dependencies. Secondly, it concentrates the empirical/analytical efforts on the essentials, thus using research resources and funds more effectively. And thirdly, it will increase the probability of regional policy interventions with impact applied at the appropriate leverage points.

Our plea towards integrative, interdisciplinary perspective on regional decarbonisation processes and governing the resulting structural change implies some consequences for regional research, research funding and regional politics as well. With regard to regional research, this means that complex regional structural change processes such as lignite phase-out scenarios should be explored preferably in an interdisciplinary way. Moreover, research should include an integral process of 'Gestalt-perception' compiling transdisciplinary knowledge from different professional perspectives, and should finally focus recommendations for politics, society and communities of practice according to the identified essence of the process examined.

Concerning regional structural politics, an opening for scientific accompanying research at an early stage is necessary, including transparency and the disclosure of political preferences. For research funding, it would be helpful to foster interdisciplinary collaborative research and to develop more openness to adjusting research steps and methods during the research process as flexibility and adaptability is essential to this research approach. It is such a holistic approach integrating economics, social and spatial sciences, that paves way to analyse multifaceted structural change and to derive evidence-based policy recommendations. In doing so, we want to emphasize the necessity to design, organize and govern regional transformation processes in an economically sensitive, politically integrative, future-oriented and socially accepted way.

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[7] On the basic concept of 'Gestalt-perception' and its epistemological benefits for science, see Lorenz (1959).

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6. Appendix

Table 1. Indicator selection

Indicator	Variable	Definition	Source	Year
Qualified labour force	Students[8]	Proportion of students in the winter term at a university or higher education institution per 1,000 inhabitants	INKAR	2017
	Academics	Proportion of employees with an academic vocational qualification at place of residence out of the total number of employees at place of residence	Destatis	2020
	Self-employed	Proportion of self-employed persons per 1,000 employed persons, including those subject to social insurance	INKAR	2017
	Highly qualified school graduates	Share of school graduates with higher education qualification in all school graduates	Destatis	2019
	Start-ups	Number of new commercial establishments per 1000 inhabitants	Destatis	2019
Technology	Companies Information and communication	Proportion of companies I&C in all companies	Destatis	2018
	Domain density	Number of de-domains per company	Destatis	2017
	Broadband connection	Number of households with a broadband connection of at least 50 mBit/s per number of all households	INKAR	2020
	Accessibility of highways[9]	Car travel time to the next highway access point in minutes	INKAR	2020
	Accessibility of train stations[6]	Car travel time to the nearest station with IC, EC or ICE stop in minutes	INKAR	2020
Openness	Mixed Marriage	Share of marriages with German and foreign partner in total marriages	Destatis	2019
	Foreign academics	Proportion of foreign employees with an academic degree in all employees with an academic degree	Destatis	2020
	Foreign guest arrivals	Share of all guest arrivals from abroad	Destatis	2018
	Overnight stays by foreign guests	Share of all overnight stays by guests from abroad	Destatis	2019
	Female employment rate	Share of female employees at place of residence in all employees at place of residence	Destatis	2020

Source: Authors (based on desk research).

[8] Not available for Saxony: Vogtlandkreis, Leipzig county, Nordsachsen and Brandenburg: Elbe-Elster, Märkisch-Oderland, Oder-Spree, Potsdam-Mittelmarkt, Prignitz, Spree-Neiße, Teltow-Fläming, Uckermark.

[9] Not available for Saxony: Leipzig county.

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