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The Regional Innovation System and Smart Specialisation in the "energy region" Lusatia

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Abstract Lusatia, a rural-peripheral region in Eastern Germany, currently faces structural change due to the planned phase-out of lignite mining. Against the backdrop of the EU Smart Specialisation (S2) strategy, structural change funds need to be invested where it can strengthen Lusatia's Regional Innovation System (RIS). With Lusatia's history, energy seems a promising topic S2. However, it is questionable if there is a critical mass of actors and research for energy topics in the region that could enable regional competitiveness. This paper addresses this issue by analysing the current state of Lusatia's RIS and the potentials for S2. I use empirical data from statistical offices and the "Förderkatalog" as well as data on new research projects and institutes for my analysis. The gathered data suggest that the region's RIS is rather thin. While the proclaimed image of an "energy region" is not reflected in the data yet, this may change due to the structural change program and the strategic orientation of the region. S2 may be successful if the new institutes and research projects enable the attraction of skilled workers and firms and at the same time manage to increase the absorption capacity of existing firms in the region. Building a critical mass for cooperation and innovation is achievable, at least in the larger cities such as Cottbus. Monitoring and evaluation of the impacts of the invested funds will be crucial.

Keywords Regional Innovation Systems · Smart Specialisation · Periphery · Energy

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Das Regionale Innovationssytem und Intelligente Spezialisierung in der „Energieregion“ Lausitz

Zusammenfassung Die Lausitz, eine ländlich-periphere Region in Ostdeutschland, ist durch den geplanten Ausstieg aus der Braunkohleförderung vom Strukturwandel betroffen. Vor dem Hintergrund der EU-Strategie „Smart Specialisation“ (S2) müssen die Strukturwandelmittel dort investiert werden, wo sie das Regionale Innovationssystem (RIS) der Lausitz stärken können. Aufgrund der Geschichte der Lausitz scheint Energie ein vielversprechendes Thema für S2 zu sein. Es ist jedoch fraglich, ob es in der Region eine kritische Masse an Akteuren und Forschung zu Energiethemen gibt, die regionale Wettbewerbsfähigkeit ermöglichen könnte. Dieser Beitrag befasst sich mit dieser Frage, indem er den aktuellen Stand des RIS der Lausitz und die Potenziale für S2 analysiert. Für meine Analyse verwende ich empirische Daten der statistischen Ämter und aus dem Förderkatalog sowie Daten über neue Forschungsprojekte und -institute. Die gesammelten Daten legen nahe, dass das RIS der Region eher dünn ist. Das proklamierte Bild einer „Energieregion“ spiegelt sich zwar noch nicht in den Daten wider, das kann sich durch das Strukturwandelprogramm und die strategische Ausrichtung der Region jedoch ändern. S2 könnte erfolgreich sein, wenn die neuen Institute und Forschungsprojekte die Anwerbung von Fachkräften und Unternehmen ermöglichen und gleichzeitig die Absorptionskapazität der bestehenden Unternehmen in der Region erhöhen. Der Aufbau einer kritischen Masse für Zusammenarbeit und Innovation ist zumindest in den größeren Städten wie Cottbus möglich. Das Monitoring und der Bewertung der Auswirkungen der investierten Mittel wird von entscheidender Bedeutung sein.

Schlüsselwörter Regionale Innovationssysteme · Intelligente Spezialisierung · Peripherie · Energie

1 Introduction

Lusatia is a traditional lignite mining region in Eastern Germany and has already seen a period of structural change after the German reunification. In the former GDR, Lusatia was the centre of energy production with more than 80,000 workers in the energy industry (Herberg et al. 2020, p. 5). Currently, there are about 8000 employees directly employed in the lignite sector and around 5000 that are indirectly employed (MWAE 2022). With the phase-out of lignite that is planned for 2038 due to Germany's pledges to decrease emissions and switch to carbon neutral energy generation, the region faces structural change again. This is a huge challenge, as Lusatia is a peripheral and rural region with a rather heterogenic regional economy and a thin Regional Innovation System (RIS).

According to the Investment Act for Coal regions (Investitionsgesetz Kohleregionen), about 14 billion euros will be used for boosting research and economic development in the four mining regions, with 43% dedicated for Lusatia (Bundestag 2020). Additional funds will be provided, adding up to 40 billion in total and 17 billion for Lusatia (Rausch 2022). These funds will be invested for municipal needs, but also in new research institutes, research infrastructure and programs that aim to attract companies and skilled workers. There is a double challenge for the state and local governments involved: active economic promotion is intended to cushion social hardship and at the same time generate a leap in development (Herberg et al. 2020, p. 10).

Against this backdrop, the EU research and innovation strategies for smart specialisation (RIS3) is a promising approach for place-based economic transformation in Lusatia. Smart Specialisation (S2) is supposed to contribute to inclusive growth between and within European regions by strengthening territorial cohesion and by managing structural change, creating economic opportunity and investing in skills development, better jobs and social innovation (Foray et al. 2012, p. 8). Fittingly, one of the proposed goals of policy makers is to strengthen the region as an “energy region” by focusing on new trends and building on the region’s tradition and capacities. However, the self-perception as an energy region is only partly true. On the one hand, the rather large region had more industry branches than just lignite mining, on the other hand, the mining and generation industry in the region was not very innovative, therefore it is questionable if the region really is a “hotspot” of energy-related innovation.

In order to analyse if a S2 strategy in the field of energy in Lusatia is viable, this paper aims to shed a light on the status quo and future developments from the perspective of innovation economics. The following topics shall be addressed: How can we describe the RIS of Lusatia by comparing the innovation outputs with the German average and other regions? Can we observe a critical mass of enterprises and research for energy topics? Is the share of research projects in energy-related topics above average? Which actors play an important role in the region? Which projects and institutes that focus on energy are currently planned and is that enough to boost Smart Specialisation in that field?

The paper is structured as follows: In chapter two, I will give an overview of the region as well as the RIS and the S2 concept. In chapter three, I will first present data on the RIS and compare it with Germany and other regions in order to give some general policy recommendations for innovation strategies. Afterwards, I will focus on the region’s potentials for S2. For this, empirical data regarding the industry structure and research in the region will be analysed. I will use research projects funded by federal ministries as a proxy for research, as there is a good database available that is called the “Förderkatalog”. Here, I will apply a comparison to Germany and the federal state Baden-Württemberg, a well-known strong RIS. Furthermore, I will give an overview of research projects as well as institutes and networks that will focus on energy. Finally, I will assess the S2 potentials in the region against the backdrop of S2 strategies in Germany and Brandenburg. In chapter four, the results and implications for Lusatia’s innovation policies and Smart Specialisation in the region will be discussed.

Table 1 Data on Lusatia 2019 (BBSR 2021)

	Population	Population density	GDP per inhabitant	Average age
Germany	83,166,712	232.6	41,472	44.1
Lusatia	1,147,870	97.9	29,844	48.4
Cottbus, Stadt	99,678	601.9	35,930	46.6
Dahme-Spreewald	170,791	75.1	33,407	46.5
Elbe-Elster	101,827	53.6	25,640	49.4
Oberspreewald-Lausitz	109,371	89.4	28,468	49.3
Spree-Neiße	113,720	68.6	34,432	49.6
Bautzen	299,758	125.1	27,372	48.1
Görlitz	252,725	119.7	28,194	49.2

2 The "energy region" Lusatia and innovation policy approaches

Lusatia is a rural-peripheral region, located between the metropolitan regions Berlin, Dresden and Leipzig and currently has around 1,150,000 inhabitants with a population density of 98 inhabitants per square kilometre (BBSR 2021). As for administrative borders, it includes seven districts or "Landkreise": Cottbus, Dahme-Spreewald, Elbe-Elster, Oberspreewald-Lausitz and Spree-Neiße in Brandenburg, Bautzen and Görlitz in Saxonia. Some general data for the region are shown in Table 1. Here, we can see that population density is much less than German average, the region is peripheral-rural. In addition, GDP is also below German average while the average age is slightly higher.

After the collapse of the GDR the industry was restructured and factories were shrunk, over 90% of jobs were lost (MWAE 2022). In addition, the exodus of many young people after the reunification led to a brain drain and demographic challenges in an already sparsely populated region. The identity of the region as an energy region remained after 1989 though. However, the focus on lignite was not the best choice from an innovation policy perspective. Structural policy was primarily aimed at preserving existing structures. Especially at the local and state level, there was a very strong focus on preserving industries from the GDR era, therefore there is a certain path dependency between previous structural policy and the neglect of the development of alternative diversified economic structures (Ragnitz et al. 2022, p. 20). Even with new trends in technology and the rising awareness for decarbonisation, the future of Lusatia was still seen primarily as a region that was based on the continued existence of the lignite industry.

In contrast to the 1990s, the current structural change is the implication of political decisions. Due to the aim of carbon neutrality, the carbon intensive energy production from lignite will be phased out. Therefore, there are many funds provided that try to compensate for the loss of the lignite sector and the jobs and even boost the region's economy by promoting innovation activities. Currently, two concepts that are important for Lusatia's innovation policies are in the European context: Regional Innovation Systems (RIS) and Smart Specialisation (S2).

The RIS framework is an approach that conceptualises regional development processes. It is closely linked to the National Systems of Innovation (NSI) approach. The term innovation system was first used in 1982 but is rooted in the work of List, Marx and Schumpeter who try to explain the competiveness of "systems of production". The difference to for example international trade theory is that the innovation systems approach is based on the idea that innovation rather than cost-efficient production is the main reason for a region's competiveness (Asheim et al. 2019, pp. 6–7) and it is linked to the evolutionary economics. Both NSI and RIS focus on innovation as an interactive learning process with long-term relationships between different stakeholders. Neither companies nor universities alone are the key actors who promote innovation, rather innovation is the result of research collaboration (Asheim et al. 2019, pp. 7–8). The narrow definition of RIS describes an RIS as the sum of the actors generating and exchanging knowledge within a region. Such interactions must be of a systemic character and in the end lead to innovation: private firms, research institutes and knowledge and technology transfer intermediaries, state organisations, consumers (see Asheim 2019, p. 11; Fritsch et al. 2008, pp. 7–8; Fritsch 2013, p. 16). It is assumed that these RIS are "planned top-down with governmental and public agencies playing an active role" (Asheim 2019, p. 11). There are different typologies to characterise and compare RIS. One is of particular interest here. According to this typology, there are (a) organizationally thick and diversified RIS, (b) organizationally thick and specialized RIS and (c) organizationally thin RIS (Asheim et al. 2019, p. 44). It can be assumed that peripheral-rural regions are organizationally rather thin RIS. Another point of the RIS approach that should be noted is that the original use of the approach was to promote innovation, economic growth and competitiveness (Asheim 2019, p. 11). This use has re-gained more attention recently, with the Smart Specialisation approach taken by the EU to promote regional economic growth.

Smart Specialisation (S2) is a policy framework developed by Foray et al. (2012) and is being used by the EU in order to design innovation policies. In contrast to the RIS approach, it is newer. The Smart Specialisation as a policy-prioritization logic builds on the existing regional innovation systems literature (McCann and Ortega-Argilés 2015, p. 1300; see McCann and Ortega-Argilés 2013). It is one of the new "industrial policy approaches" (Vezzani et al. 2017, p. 9). In the context of Europe 2020, Smart Specialisation emerged as a key element for place-based innovation policies. (Foray et al. 2012, p. 8). The Smart Sepcialisation approach is the basis for the current EU "Research and Innovation Strategies for Smart Specialisations (RIS 3)". It is "probably the single largest attempt ever of an orchestrated, supranational innovation strategy to boost economic growth through economic diversification and new path development [...] for the first time in the EU's history, provides a policy framework for promoting and implementing a broad based innovation policy" (Asheim 2019, p. 9).

One key element of Smart Specialisation is that governments should focus "in activities—not in sectors in per se—that reflect areas where a region or country has some comparative advantage (specialisation) or emerging areas where entrepreneurs could develop new activities (diversification)" (OECD 2013, p. 17). As a policy strategy, it is not a simple top-down approach. On the contrary, the approach focuses on the strengths of regional stakeholders and accordingly develops bottom-up regional measures for fostering innovative activities (Ruhrmann et al. 2021, p. 1). The selection of relevant activities or areas for specialisation and competitive advantage is an interactive process. Policy makers should build on the existing strengths of the region, this process is also called the "entrepreneurial discovery process" (Asheim 2019, p. 10). Accordingly, in the Europe 2020 strategy, the European Commission "highlighted that each RIS should be based on the specific knowledge located in a region" (Höglund and Linton 2018, p. 60). In addition, an important aspect of Smart Specialisation strategy is the "continuous search for new opportunities for structural change within regions" (Vezzani et al. 2017, p. 29). Taking the starting point of existing strengths, the regions will diversify their economies and capabilities to related and unrelated sectors, which leads to path upgrading, path diversification und path emergence (Asheim 2019, pp. 10–13).

Several methods can be used to support the identification of potential niches for smart specialisation. One method is the analysis of scientific and technological specialisation and comparative advantage: analyses of specialisation of r&d (research and development) investment, publications and citations, and patent applications and citations by 'field'. A region has a comparative advantage in a certain field if it shows an above-average concentration of these indicators compared to the value taken in the country or a group of countries. Another way to identify potential niches is the analysis of regional economic specialisation, for example by location quotients that measure whether some sectors are over-represented in a regional economy compared to other regions or countries. In addition, qualitative studies can be carried out on activity domains where a region shows relative specialisation. The last method is foresight. It captures existing expert intelligence sources on future trends and makes them accessible for present decision-making. (Foray et al. 2012, pp. 29–32).

For a peripheral region facing structural change, strengthening the RIS and encouraging Smart Specialisation could be an opportunity for economic growth and the necessary leap in development. Many actors in the region are already focusing on a post-lignite energy region Lusatia and see the structural change as an opportunity:

> "In addition to the challenges of structural change, there are also opportunities for the Region, because it is Lusatia's declared goal to remain an energy region in the future. The region can benefit from many years of expertise and the existing energy infrastructure and specialists benefit locally. This locational advantage that Lusatia offers compared to other regions in Germany should be actively used to accelerate the energy transition across sectors and successfully lead Lusatia into the age of renewable energy sources. So that it will also be said in the future: The energy comes from Lusatia" (Hölzinger et al. 2021, p. 11; translated by the author).

However, the question arises as to whether the topic of energy carries enough weight in the region for a S2 strategy and is more than a self-image based on the past. For this, a certain potential must already exist through funding from outside, but also within the region.

3 Potentials for Smart Specialisation in energy related fields

3.1 Collection of data and sources

In order to gain an overview of the current status of Lusatia's RIS and for analysing if there are observable potentials for Smart Specialisation, the following set of data was collected. For the RIS, full-time equivalent of staff in r&d as well as internal spending on research and development, start-up intensity, national patent applications via the DPMA and projects within the ZIM funding program were used. The data was collected for 2013–2017 due to data availability.

For data on research, the funding portal (Förderkatalog) of German ministries was used as a data source, here the focus was on funded projects starting in 2018. Furthermore, a collection of patent data regarding energy-related patent applications are presented.

For the economic and business potential regarding energy, number of employees with social insurance, number and size of firms according to statistical data of different sources were used. In addition, future projections on renewable energy production and employees plus a collection of data from LEAG (Lusatia Energie Kraftwerke) is presented.

For recent energy innovation trends, some well-known projects and institutes are collected by researching news of Fraunhofer, IHK and Universities websites. With the exception of the recent trends, all data are presented in tables.

3.2 Lusatia's Regional Innovation System

The RIS is the sum of actors in the region, their cooperation relationships and innovation produced. Accordingly, indicators must represent the amount of actors and cooperation plus if there is significant output of innovation. Therefore, for a short overview of the region's RIS following data are quite relevant.

First, we look at the employees in r&d and private internal r&d spending. Especially employees in r&d are a representative indicator for regional cooperation and knowledge spill overs, as we can assume that the greater the number of r&d employees, the greater the opportunity to find a suitable partner for cooperation and knowledge exchange (Fritsch and Slavtchev 2011, p. 910) (Tables 2 and 3).

The r&d employees as well as internal r&d spending are below German average. A study analysing German mining regions concludes that private r&d is too low in Lusatia to assume significant spill over effects (Frondel et al. 2018, p. 68). Public r&d spending however is above average. This can be seen as an attempt to compensate for the low private r&d (Frondel et al. 2018, p. 68). Between 2015 and 2017, the internal private spending fell, which indicates a loss of innovation potential. At the same time, the share of r&d employees also decreased slightly, while the total number was stable. With overall low numbers in the region, such changes can be related to a single firm or few firms, therefore we must be careful with interpreting these numbers.

A second indicator for regional spill over effects and also innovation output is the company start-up intensity. The start-up intensity indicator represents the number

Table 2 r&d staff in full-time equivalents

r&d staff in full-time equivalents						
	2015	2017	2015–2017	2015	2017	2015–2017
	Total		Change in %	Share of all employees with social insurance in %		Change in %
Germany	404,767	436,571	7.86	1.32	1.36	3.18
Lusatia	1369	1374	0.37	0.34	0.33	–2.63
Bautzen	588	611	3.94	0.54	0.55	1.21
Cottbus	59	88	49.41	0.13	0.19	47.04
Dahme-Spreewald	105	113	7.39	0.18	0.18	0.73
Elbe-Elster	47	45	–4.49	0.14	0.14	–6.47
Görlitz	427	351	–17.79	0.52	0.42	–19.64
Oberspreewald-Lausitz	127	148	17.22	0.33	0.36	11.30
Spree-Neiße	17	18	8.53	0.05	0.05	7.70

Source: Stifterverband Wissenschaftsstatistik (2019)

Table 3 Internal r&d spending per employee in €

Internal r&d spending per employee in €			
	2015	2017	2015–2017 Change in %
Germany	1415.15	1553.85	9.80
Lusatia	293.51	235.77	–19.67
Bautzen	359.58	359.02	–0.16
Cottbus	47.98	75.81	57.99
Dahme-Spreewald	84.19	78.63	–6.61
Elbe-Elster	77.98	64.26	–17.60
Görlitz	749.04	476.64	–36.37
Oberspreewald-Lausitz	101.34	99.53	–1.78
Spree-Neiße	34.87	32.86	–5.76

Source: Stifterverband Wissenschaftsstatistik (2019)

of new firms per 10,000 inhabitants in working age, so inhabitants between 15 and 65 years. The overall start-up intensity as well as the start-up intensity for energy and mining is shown in the Table 4.

In total, the company start-ups in relation to inhabitants is significant lower than German average. This is also true for the energy and mining sector, where we can observe very few new company start-ups in general. That may be due to the fact that there are often very few, but large companies in these sectors. For a Smart Specialisation in Lusatia, these numbers should eventually rise in the near future, in particular since there is the goal to tap new value chains.

Another relevant indicator reflecting the RIS is patent applications. They represent innovation output in the region. The Table 5 shows patent applications in the years 2013–2017.

As shown in the table, there were relatively few patent applications in Lusatia between 2013 and 2017. Admittedly, this is also the case for Brandenburg and Saxonia in general, where only 13 and 18 patent applications per 100,000 inhabitants

Table 4 Start-up intensity 2014–2017

Start-up intensity 2014–2017 (new firms per 10,000 inhabitants in working age)		
	All sectors	Mining and energy generation
Germany	31.37	0.40
Lusatia	20.66	0.27
Bautzen	19.45	0.14
Cottbus	23.74	0.36
Dahme-Spreewald	32.89	0.44
Elbe-Elster	17.07	0.79
Görlitz	19.85	0.03
Oberspreewald-Lausitz	17.48	0.30
Spree-Neiße	20.26	0.10

Source: ZEW (2017), Inkar, own calculations

Table 5 National patent applications

National patent applications per 100,000 inhabitants					
	2013	2014	2015	2016	2017
Germany	58.61	59.29	57.65	58.74	57.71
Lusatia	11.71	9.36	9.87	8.69	9.50
Bautzen	20.11	13.37	10.77	11.16	7.93
Cottbus	11.04	8.04	14.04	6.97	19.79
Dahme-Spreewald	17.41	24.70	13.98	10.84	13.75
Elbe-Elster	7.54	5.71	5.73	7.66	9.67
Görlitz	3.81	2.69	6.15	6.58	5.07
Oberspreewald-Lausitz	13.18	6.20	14.23	14.29	17.10
Spree-Neiße	2.52	0.00	5.95	0.86	0.87

Source: DPMA (2022), Statistisches Bundesamt (2022)

were filed, respectively (DPMA 2018, p. 7). In comparison, in Baden-Württemberg around 132 patent applications per 100,000 inhabitants were filed (DPMA 2018, p. 7). It is remarkable that between 2015–2019, 37 patent applications in Lusatia were filed by the BTU Cottbus-Senftenberg with 8 Co-Patents (DPMA 2022). The university is therefore the organisation with most patent applications in the region. At a total of 437 applications in these years (DPMA 2022), 8.47% of all applications were filed by the BTU. Similar to the r&d spending, we can assume that public research is comparably strong in Lusatia and partly compensates the lack of innovation among firms. Nevertheless, a strong RIS needs different kinds of actors and especially cooperation between public and private research.

In this regard, we can observe some positive trends in state-funded cooperative research projects in the ZIM (Zentrales Innovationsproramm Mittelstand) program. This initiative is aimed at SME and encourages projects where regional SME and research institutes or HEI (higher education institutions) conduct joint applied research. Data on ZIM funded projects are shown in the Table 6.

Table 6 ZIM projects 2015–2017

ZIM projects 2015–2017	Granted funds in million €	Non-cooperative projects	Cooperative projects	Network projects	Total projects
Lusatia	35.9	19	210	10	239
Cottbus	6.7	3	35	0	38
Dahme-Spreewald	7.2	5	39	3	47
Elbe-Elster	1.4	2	9	0	11
Oberspreewald-Lausitz	6.2	2	35	0	37
Spree-Neiße	0.6	0	5	0	5
Bautzen	9.4	6	54	7	67
Görlitz	4.4	1	33	0	34

Source: Berger et al. (2019, p. 209)

Annual average of funding between 2015 and 2017 was around 12 million Euro, which is about 1.03 € per 100,000 inhabitants. In comparison, German average in the years 2015–2018 was around 0.65 € per 100,000 inhabitants (Berger et al. 2019, p. 209). In addition, a study evaluating the ZIM program concludes that on average, more projects were approved in Western Germany than in Eastern Germany (Kaufmann et al. 2019, p. 68). This study also finds that the BTU Cottbus-Senftenberg applied for 324 projects in the evaluation period and was therefore ranked 7th place among German HEI (Kaufmann et al. 2019, p. 55). For ZIM network project funding, TH Wildau was ranked 8th place with 28 applications and BTU Cottbus-Senftenberg was ranked 10th place with 25 applications (see Kaufmann et al. 2019, p. 56). This is an indication that the universities in Lusatia fulfil an important function in the application and implementation of joint innovative research projects (Pomp and Zundel 2021, p. 17) and contribute to cooperation and regional spill over effects. We also can assume that government funding for an innovation policy does trigger cooperative research and interaction in the region.

In conclusion, Lusatia's RIS can be described as thin, as there is a lack of critical mass of actors. In addition, the innovation inputs and outputs are below German average. The situation in this region is similar to the other German regions impacted by the phase out of coal and induced structural change. A study on these four coal mining regions reveals that all four regions suffer from lower innovation potential to a certain extent (Frondel et al. 2018). Among those four, the Rhineland region is the strongest:

> "The analysis of innovation indicators shows a mixed picture, with the eastern German regions showing significantly lower values in some cases, which speaks for a lower innovation potential. […] Although the Rhineland coal region is still below the research intensity of NRW, which is relatively weak in terms of research compared to the national average, it is more than twice and three times as high as in Lusatia" (Frondel et al. 2018, pp. 200–204, translated by the author).

In terms of the RIS literature, Lusatia is a typical region with a thin RIS. In many of these regions, traditional, resource-intensive industries with low innovation rates are predominant (Trippl and Frangenheim 2018, p. 61) and beyond that the firm landscape is rather heterogeneous and fragmented. Currently, in the east German mining regions and especially Lusatia low private investments in r&d and the generally lower proximity to universities and research institutions are compensated by public r&d (Frondel et al. 2018, pp. 200–202). But that won't be enough to trigger more innovation activities and economic growth.

Recent literature on RIS suggests that RIS reorientation, i.e. building on existing actors and institutions could enable the development of "innovative solutions to regional problems and needs that are related to grand societal challenges, such as the decarbonisation of industries" (Isaksen et al. 2022, p. 2126). In thin RIS, new RIS elements need to be created if endogenous potentials are too low. Possible policy approaches include path transplantation and path modernisation. The former includes policies aimed at attracting knowledge and resources from outside the region. Here, companies, research and educational institutions, public services or even highly qualified individuals are "lured" into the region. For path modernisation, access to knowledge, resources and other innovation impulses from outside the region also play a decisive role. Against this background, policy strategies aimed at proactively fostering relationships with partners and sources of knowledge external to the region appear particularly sensible. […] A strategy aimed at mobilising exogenous development impulses can only be successful if measures are taken that also force the anchoring and circulation of extra regional knowledge in the region and strengthen the absorption capacities of regional actors. (Trippl and Frangenheim 2018, p. 62). It would also be necessary to evaluate if the new elements have a positive regional impact in the long term and if the path transplantation and modernisation is successful. Optimally, they should contribute to an improvement of the innovative output in the region, create new jobs and generate economic growth that can be sustained after the funds have been spent.

Due to the region's unique situation of having the structural change program, the available funds can be allocated for such a creation of RIS elements. Currently, this is actually happening in Lusatia (see 3.5). There will be new research projects and institutes, especially those who are focused on energy research. Implementing S2 strategies seems useful, as it is much easier to generate critical mass in sectors where there are endogenous potentials than to generate critical mass in all industries. However, the question arises whether endogenous potentials are high enough or the new elements have the potential not only to attract external knowledge and actors but also to increase the absorption capacity in the region.

3.3 Empirical data on energy-related research

After presenting data on the RIS in general and the status of the energy industry in Lusatia, empirical data for energy-related research and detailed patent data is presented in this chapter. Needless to say, not only the numbers of firms and employees are relevant for a supposed Smart Specialisation on energy in Lusatia, but also research and innovation. The question is whether energy is only produced in Lusatia or if we can expect innovation potential for a decarbonized energy industry.

Previous studies on the field of energy research in the region concluded that between 2005 and 2014, 2.2% of all federal funds in Brandenburg and 6.2% of all federal funds in Saxonia were spent on energy research (Diekmann 2015, p. 25) while in 2018, Brandenburg issued 0.5% and Saxony issued 10% of the state funding for the field of renewable energies (Jessen 2018, p. 4). Therefore, the overall impression is that the Energy research in Lusatia has so far not been particularly noticeable statistically (Nagel and Zundel 2021, p. 11).

In order to carry out an analysis of funded research in Lusatia, I now present my collection of data. Projects of the federal ministries were used for the evaluation as data is freely accessible. State funding of projects can be used as a proxy for research in general, especially in a region with few internal private r&d and in the field of energy with cost-intensive research. For the first part of the analysis, the number of energy-related research projects in Lusatia was compared to the total number of research projects. All projects under the numbers EA1110—EF6000 are considered energy-related, these are for example crystalline silicon module technology, fuel cells, energy-optimized building technology, advanced power plant systems, basic energy research, hydrogen production (electrolysis) and more. As a benchmark, the numbers for Lusatia are compared to Germany and Baden-Württemberg.

The numbers for total projects and amount of funding are shown in the Table 7.

The share of energy related projects in Lusatia was 8.10%, slightly smaller than the average for Germany and for Baden-Württemberg. Overall, among all funded projects in Germany, 1.09% of them were carried out in Lusatia, while 22.72% were carried out in Baden-Württemberg. This is no surprise, as the federal state is a much larger entity. Regarding energy-related projects in Germany, 0.78% were carried out in Lusatia and 22.86% were carried out in Baden-Württemberg (Table 7).

For the share of funding, the numbers are slightly different (Table 8). In Lusatia, there was less funding for energy-related research projects in comparison to the share of number of research projects. The German average was also slightly smaller, whereas in Baden-Württemberg the share of funding was much larger than the

Table 7 Number of projects (Förderkatalog)

Number of projects in the Förderkatalog (EA1110—EF6000) starting 2018 including projects in progress					
Germany total	56,394	Germany Energy	6440	Share in %	11.42%
Baden-Württemberg total	12,814	Baden-Württemberg Energy	1472	Share in %	11.49%
Lusatia total	617	Lusatia Energy	50	Share in %	8.10%

Source: Förderkatalog des Bundes

Table 8 Funds for projects (Förderkatalog)

Total funds for projects in the Förderkatalog (EA1110—EF6000) starting 2018 including projects in progress					
Germany total	42,760,352,924	Germany Energy	4,670,003,318	Share in %	10.92%
Baden-Württemberg total	7,468,931,892	Baden-Württemberg Energy	1,341,220,694	Share in %	17.96%
Lusatia total	426,531,359	Lusatia Energy	31,159,212	Share in %	7.31%

Source: Förderkatalog des Bundes

share of projects. Similarly, 1% of all funds for research projects were provided for Lusatia and 17.47% for Baden-Württemberg, while 0.67% of funds for energy-related research projects were provided for Lusatia and 28.72% were provided for Baden-Württemberg.

In order to gain more insight into the relevant actors for energy research in Lusatia, it is useful to find out which organisations carried out the most projects in recent years. For organisations with at least three projects since 2010 including projects in progress, there are: BTU Cottbus-Senftenberg (36 projects or project participations), Hochschule Zittau/Görlitz (19 projects or project participations), Skeleton Technologies (6 projects or project participations), Lusatia Energie Kraftwerke (3 projects or project participations), Sachsenmilch Leppersdorf (3 projects or project participations). If we look only at projects since 2018 including projects in progress, there are: BTU Cottbus-Senftenberg (13 projects or project participations), Hochschule Zittau/Görlitz (8 projects or project participations), Skeleton Technologies (6 projects or project participations).

Two of the most active organisations are HEI in the region. The BTU Cottbus-Senftenberg alone carried 26% of all energy-related funded research projects. Furthermore, LEAG as a representative of the lignite industry has not done any projects in recent years. Sachsenmilch Leppersdorf is a dairy producing firm and did projects that try to improve energy efficiency in dairy processing, which is not really contributing to the energy region image of Lusatia. Skeleton Technologies, however, is a firm that is located in Großröhrsdorf and registered in Estonia that focuses on energy storage and is “Europe’s leading manufacturer of ultra-capacitors” (Energy Saxony e. V. 2022). They did all of their projects after 2018 and these are all projects in progress. This indicates that we can possibly expect more research and innovation from this new firm in the near future.

Another interesting set of data presented is a time-sensitive comparison. Project themes according to different programs (Leistungsplansystematik) starting between 2010–2017 and projects starting in 2018 are compared. This comparison allows to estimate if there is an observable shift from conventional energy research and nuclear energy research to renewable energy and energy efficiency research. For research projects starting between 1st January 2010 and 31st December 2017, there were 72 projects or project participations in total, 11 of them focusing on conventional energy (EA1110—EA1999) and 9 focusing on nuclear energy (EC1100—EF6000). Therefore, 72.2% of the projects were focusing on renewable energy or energy efficiency. For projects starting 1st January 2018, there were 50 projects or project participations in total. Here, 4 of them were focusing on conventional energy and another 4 focusing on nuclear energy. Therefore, 84% of the projects were focusing on renewable energy or energy efficiency. Hence, the data show a slight trend towards future trends in sustainable energy production and away from conventional energy.

In addition to funded research projects, an analysis of patent data shows a specialisation in energy that is above German average. The patent application data are based on total patent applications in the years 2013–2017 and patents in the field of “Electrical machinery and apparatus, electrical energy” according to the WIPO classification (Schmoch 2008, p. 5) (Tables 9 and 10).

Table 9 Patent data total and energy-related

	Patent applications total 2013–2017	Patent applications in electrical machinery and apparatus, electrical energy 2013–2017	Percentage (%)
Germany	239,416	24,844	10.38
Lusatia	535	114	21.31

Source: DPMA (2022), own calculations

Table 10 Patent data per 100,000 inhabitants total and energy-related

	Patent applications per 100,000 inhabitants 2013–2017	Patent applications in electrical machinery and apparatus, electrical energy per 100,000 inhabitants 2013–2017
Germany	58.47	6.07
Lusatia	9.19	1.96

Source: DPMA (2022), own calculations

While the share of energy-related patent applications from Lusatia is only 0.46%, the share of such patent applications within the region is as twice as high as the German average. This indicates that although the absolute innovation potential according to patent applications is not very high (see Chap. 3.2), at least it is relatively higher for energy.

3.4 The status quo of Lusatia's energy sector

In order to analyse the regional potential for Smart Specialisation in the energy production, storage and use, there are several aspects to consider. First, industry and workforce base (Fritsch et al. 2008, p. 8) within a region are an important factor for an RIS. Second, for Smart Specialisation aimed at a certain branch of industries, there must be specific knowledge in that industries. That implies that for energy-related specialisation, there have to be comparably more employees and firms in that sector. Finding adequate data sources is difficult, as there are many different industries connected to energy production. One starting point is the data of the federal agency for work (Bundesagentur für Arbeit). Current data for the share of employees in the energy sector in general are shown in the Table 11.

Overall, the share of employees in the energy sector is distributed unevenly across Lusatia. In Spree-Neiße the share is exceptionally high, in Görlitz and Cottbus the share is also around twice as high as the German average. In Cottbus, 1.31% of employees subjected to social insurance contributions work in the energy sector, this is almost twice as much as the German average. At the same time, the share of firms in the energy sector is only half as much as the German average, as shown in the Table 12.

Those two data sets imply that there are presumably few firms in the region that have a large number of employees. There are complementing data on size of firms in the energy sector, at least for Brandenburg. For Saxonia, no data were available (Table 13).

Here we can see that there are only very few firms with more than 50 employees and only three firms with over 250 employees. For example, in Cottbus there were

Table 11 Number of employees 2018

	Total employees with social insurance 2018	Energy sector employees with social insurance 2018	Share in %
Germany	32,870,230	229,940	0.70
Lusatia	420,550	4710	1.12
Bautzen	113,110	440	0.39
Cottbus	45,870	600	1.31
Dahme-Spreewald	62,540	220	0.35
Elbe-Elster	33,680	350	1.04
Görlitz	86,860	1260	1.45
Oberspreewald-Lausitz	41,440	260	0.63
Spree-Neiße	37,050	1580	4.26

Source: Bundesagentur für Arbeit

Table 12 Number of firms 2018

	Number of firms 2018 (WZ2008-sectors B-N and P-S)	Number of firms in the energy sector 2018 (D)	Share in %
Germany	3,764,671	77,101	2.05
Lusatia	48,811	555	1.14
Bautzen, Landkreis	12,645	112	0.89
Cottbus	4278	41	0.96
Dahme-Spreewald, Landkreis	8205	85	1.04
Elbe-Elster, Landkreis	4386	68	1.55
Görlitz, Landkreis	10,460	121	1.16
Oberspreewald-Lausitz, Landkreis	4164	68	1.63
Spree-Neiße, Landkreis	4673	60	1.28

Source: Statistisches Bundesamt (2022)

Table 13 Firm branches in the energy sector 2018

Firm branches in the energy sector 2018					
	Total	0–9 employees	10–49 employees	50–249 employees	Over 250 employees
Germany	77,101	–	–	–	–
Lusatia	555	–	–	–	–
Bautzen	121	–	–	–	–
Cottbus	41	34	3	3	1
Dahme-Spreewald	85	79	5	1	0
Elbe-Elster	68	66	0	2	0
Görlitz	112	–	–	–	–
Oberspreewald-Lausitz	68	63	3	2	0
Spree-Neiße	60	49	6	3	2

Source: Amt für Statistik Berlin-Brandenburg (2022)

600 employees in 2018. With 3 firms that have over 50 employees and one firm with over 250 employees, more than 500 of the employees worked in 4 firms.

In addition to data provided by the federal and statistical offices, there are databases offered by private firms that cover information about companies. One of them is the "Markus" database, it contains information on companies with entry into the national trade register (Bureau van Dijk 2018). A database excerpt for Lusatia that was provided in 2018 lists 256 companies that are operating in the energy industry in total. The Table 14 summarises the number of companies according to the different WZ 2008 codes.

These data have to be taken with a grain of salt, as they differ from the data given by the statistical offices. Not all firms are listed in the database and the criteria were not transparent when the dataset was acquired. While the Markus database has registered half as much firms in the energy sector as the records of the statistical offices, the numbers of employees are similar to those given by the federal agency for work. If lignite mining is not considered, there are 4882 employees in the energy sector according to the database. More than half of these are employed in

Table 14 Number of employees per WZ code

WZ 2008 Code	WZ 2008 Code description	Number of firms	Number of employees (if recorded)
B05200	Mining of lignite	1	4837
D35110	Production of electricity	28	23
D35111	Production of electricity without distribution	17	33
D35140	Trade of electricity	5	198
D35120	Transmission of electricity	5	90
D35100	Electric power generation, transmission and distribution	3	109
D35130	Distribution of electricity	13	618
B09900	Support activities for other mining and quarrying	2	96
D35112	Production of electricity incl. purchases from other suppliers for distribution	54	2733
D35113	Production of electricity excl. purchases from other suppliers for distribution	93	165
D35210	Manufacture of gas	3	4
D35212	Manufacture of gas incl. purchases from other suppliers for distribution	3	111
D35213	Manufacture of gas excl. purchases from other suppliers for distribution	11	6
D35200	Manufacture of gas; distribution of gaseous fuels through mains	2	21
D35220	Distribution of gaseous fuels through mains	1	2
D35300	Steam and air conditioning supply	15	273
–	*Total*	*256*	*9319*

Source: Bureau van Dijk (2018)

54 firms that operate in electricity generation subcontracted for distribution. The data presented in the Markus database thus confirm the assumption that there is a small number of firms in the region that are dominant in terms of size.

Sectoral and industry focus are often seen as the potential of a region, as they include a specialized labour pool, an industry-specific infrastructure, the proximity to upstream and downstream value-added stages and intra-industrial knowledge spill overs (Farhauer and Kröll 2014, 126). Such focal points are usually determined empirically using localization coefficients. These are defined as an industry’s share of the added value or the number of employees subjected to social security contributions in the sub-region to be examined in relation to the corresponding ratio of a reference region. If these localization coefficients are significantly greater than 1, this is taken as an indication of a corresponding specialisation and potential (Nagel and Zundel 2020, p. 4).

A study analysing the German coal and lignite regions calculated a localization coefficient of 2.34 for Lusatia in 2016 (Frondel et al. 2018, p. 78). The highest localization coefficients were found in the districts Oberspreewald-Lausitz (4.03) and Spree-Neiße (10.35) (Frondel et al. 2018, p. 78). A study by Nagel and Zundel analysed those localization coefficients for Lusatia’s cities in 2018 and found particular high coefficients for the cities of Spremberg (42.57), Senftenberg (15.69), Mittenwalde (4.25), Cottbus (2.47), Finsterwalde (2.22), Weißwasser (2.19), and Niesky (2.20). They conclude that the area between Senftenberg, Cottbus, Spremberg and Boxberg is the focus of the Lusatian energy industry. (Nagel and Zundel 2020, p. 23).

This is partly due to the locations of LEAG. The firm is currently responsible for lignite mining and generation in Lusatia. With over 7000 employees and over 3300 partner companies, it is the largest energy company in eastern Germany and one of the most important private-sector employers in Lusatia (LEAG 2022).

LEAG produces lignite energy in Jänschwalde, Schwarze Pumpe, Boxberg and Lippendorf with a total capacity of 8000 MW and they also own tow gas turbines in Thyrow und Ahrensfelde (LEAG 2022). In the 2000s, LEAG was researching and testing carbon capture and storage (CCS) technologies, mainly in Schwarze Pumpe (LEAG 2022). This can be seen as an attempt to continue with lignite generation against the backdrop of decarbonisation of energy production. Nowadays, the company is investing in renewable energy projects in Lusatia. There are solar pv parks in Welzow and Zschornewitz, plus solar pv rooftop panels in Lübbenau in Cottbus with a total of 209.5 MW. LEAG is breaking new ground and has built a battery storage facility with a usable capacity of 53 MWh at the Schwarze Pumpe power plant and industrial site.

However, LEAG is not the only company that is involved in renewable energy projects in the region. According to a recent study by the IÖW (Institute für Ökologische Wirtschaftsforschung) that analysed the potential for renewable energy in Lusatia, in 2018 there were currently 37 firms that either produce power plants and components (4 firms) or provide services (37 firms) for wind energy, solar energy or biomass (Hirschl et al. 2022, p. 149). A total of 940 jobs was estimated for the employees at the identified companies. In relation to the total number of employees in Lusatia in 2018, this corresponds to a share of around 0.2%. Around 75% are employed by manufacturers and just under 25% by service providers in connection with the planning, installation, operation and maintenance of plants. (Hirschl et al. 2022, pp. 150–151). For the year 2040, the study projects the regional value creation by renewable energy systems at 184.5 million euros for a current-policies-scenario and 433.3 million euros for a climate-neutrality-by-2045 scenario, which corresponds to a total of 1632 employees and 3556 employees respectively (Hirschl et al. 2022, p. 162).

3.5 Recent energy innovation trends in Lusatia

In order to gain more insight into future potentials of cooperation and innovation in energy-related fields, the establishment of research institutes, projects and networks in these fields are also important. They are a starting point for more interactions in the region, a stronger cooperation between public and private research and potentially attract more firms and professionals.

The state programs for structural change in Lusatia from both Brandenburg and Saxonia that are based on the "Structural Strengthening Act for Coal Regions" (StStG) address the continuity of Lusatia as an energy region. The "Lausitzprogramm 2038" names strategic goals and mission statement for the structural development, one of them is that Lusatia shall be a "modern and sustainable energy region" (Staatskanzlei 2020, p. 12). In addition, the "Handlungsprogramm zur Umsetzung des Strukturstärkungsgesetzes Kohleregionen des Bundes in den sächsischen Braunkohlerevieren" in Saxonia formulates its own goals for Lusatia. Goal 4 is that Lusatia shall be a "modern and sustainable energy region […], making Lusatia a central part of the sustainable energy industry in Germany through new and innovative concepts for energy production and supply" (Staatsministerium für Regionalentwicklung Freistaat Sachsen 2020, p. 17) which is in accordance to Brandenburg's goals. Saxonia's strategic paper also names recommendations for action: (1) promotion of approaches to innovative energy generation, supply and storage, (2) promotion of knowledge and know-how transfer in the field of energy management, (3) creation and use of application clusters for innovative energy concepts, (4) projects to reuse old power plant sites for innovative energy concepts, (5) creation of infrastructure for Power-To-X applications (Staatsministerium für Regionalentwicklung Freistaat Sachsen 2020, pp. 17–19).

As mentioned above, Lusatia's HEI are very active in energy research. The BTU Cottbus-Senftenberg alone has planned some cooperative research projects covering different aspects of the energy transition and decarbonisation. For example, there are CHESCO (Center for Hybrid Electric Systems Cottbus), EIZ (energy innovation center), Innovationscampus Elektronik und Mikrosensorik Cottbus, ismartC, SpreeTec next, T-CELL (Brandenburgische Technische Universität Cottbus-Senftenberg 2022). Moreover, there will also be new Fraunhofer institutes, for example the Fraunhofer Hydrogen Lab Görlitz, which focuses on hydrogen fuell cells and hydrogen value chains and is funded with over 42 million Euro (Fraunhofer-Gesellschaft 2021). "PtX-Lab Lusatia" is another institute focusing on hydrogen, it was opened in 2021 (Zukunft—Umwelt—Gesellschaft (ZUG) gGmbH 2021). Hydrogen is supposedly a field with great potentials in Lusatia. In addition to existing networks such as

Table 15 LEAG renewable energy projects

Name	Type	Capacity
Windpark Cottbus-Ost	On-shore wind	24 MW
Windenergieprojekt Forst-Briesnig II	On-shore wind	102 MW
Floating PV Cottbusser Ostsee	Solar pv	21 MW
Energiepark Bohrau	Solar pv	400 MW
Deponie Jänschwalde I	Solar pv	31 MW
Solarpark Kraftwerk Boxberg	Solar pv	24 MW
Solarpark IAA Böhlen	Solar pv	17 MW
Solarpark Hirschfelde	Solar pv	20 MW
Solarpark Dissen-Striesow	Solar pv	200 MW
Solarpark Hühnerwasser und Wolkenberg	Solar pv	300 MW
Total	–	*1139 MW*

Hypos, EnergySaxony and the HZwo cluster, the first local associations and networks for researching and establishing hydrogen technologies, for sector coupling and for structural change have been formed (Kratzsch et al. 2020, p. 11). The hydrogen network Lusatia “Durchatmen” was founded in 2019 and currently has more than 100 members and supporters from business, science and politics from East Saxony and southern Brandenburg (Han 2020). WALEMOBase, an initiative of Lusatian companies and research institutions, aims to establish a cluster for closely linked projects in the Zittau/Görlitz area focusing on hydrogen-based drives and autonomous driving (Sächsisches Staatsministerium für Regionalentwicklung 2021). At the Industriepark Schwarze Pumpe, there will be a new power plant called “Referenzkraftwerk Lusatia” (RefLau). The aim is to map energy supply based on renewable energy sources and hydrogen, including storage. The project partners plan to identify potential purchases for hydrogen in the region as a precautionary measure in order to be able to supply the first customers by the time the plant is commissioned in 2025 and to use synergies in the establishment of a hydrogen economy (Hydrogentle 2021).

In addition, following renewable energy projects by LEAG are currently planned and will be completed within the next years (Table 15):

3.6 Energy as a focus in Lusatia in the wider Smart Specialisation context and policy implications

Besides the current and future developments in the energy sector, the S2 structure in Germany and in Lusatia is also relevant, as it is builds the strategical foundation. In Germany, S2 is implemented at the federal state level, in Berlin and Brandenburg there is a joint strategy based on innoBB (European Commission and Prognos 2020, p. 35). This also forms the overarching framework for Lusatia. The federal states pursue different strategies and also have different priorities (European Commission 2020). With regard to strategic orientation, there are some elementary differences between the federal states in terms of their overarching orientation. In addition to Berlin-Brandenburg, some federal states have a clear focus on excellence, such as Baden-Württemberg, Bavaria, North Rhine-Westphalia, while the other states tend to follow a capacity-building approach (European Commission and Prognos 2020, p. 107). The RIS3 strategies that contain regionalisation approaches are those of Baden-Württemberg, Berlin-Brandenburg and Lower Saxony (European Commission and Prognos 2020, p. 109). All federal states except Saarland have energy in the narrower or broader sense (e.g. renewables, energy technology, sustainable energy, etc.) in the portfolio of their S2 priorities (European Commission and Prognos 2020, pp. 134–136).

Lusatia as an energy region would be in accordance with the "innoBB", the joint innovation strategy of Berlin and Brandenburg, where five future trend areas were identified. These are health, energy, mobility/logistics, information technologies/media/creative industries and optics (European Commission and Prognos 2020, p. 35). Here, we can already identify an entrepreneurial discovery process. In addition, the regionalised approach of the Smart Specialisation strategy takes Brandenburg's heterogeneity into account. The stakeholders among the different clusters develop the main topics of each cluster in a cooperative advisory process (European Commission and Prognos 2020, p. 38). Accordingly, energy was identified as one of the "hot topics" in the "Entwicklungsstrategie Lausitz 2050", which also included the ideas and perspectives of regional stakeholders (WRL 2020). This is appealing, as it fits to Lusatia's history—the idea of Lusatia as an energy region would be retained, but the old path dependency on lignite would be replace with new, carbon-free energy production systems. For new technologies such as hydrogen, market opportunities and new value chains could be created.

4 Discussion and outlook

The aim of this paper was to give an overview of Lusatia RIS and reveal if energy-related industry and research actually play a major role in the region. Some key findings of the data presented in Chap. 3 are as follows. The RIS of Lusatia can be described as thin, there is not a lot of significant innovation input and output regarding standard indicators such as private r&d and patents. Nonetheless, funding programs aimed at SME such as ZIM are well received. In order to strengthen the RIS as a whole, an investment in viable industries, sectors or topics can be a promising approach and would be in accordance with the EU Smart Specialisation strategy. The question is if energy is such a viable industry and if there are enough endogenous potentials.

From a S2 perspective, the issue of energy is made bigger than it currently is in terms of innovativeness and research. The data on companies and employees in the region at least partially indicate a focus on energy. But they also show that there are in principle rather few large companies in the field of mining and generation, in particular LEAG, which is a result of the history of the region. Few large companies presumably are an indicator for mono structures, path dependency, the danger of technological lock-in and a lack of innovation potential. As there is no critical mass of actors yet, knowledge spill-overs are rather unlikely. Furthermore, the lignite mining and generation sector covers only a part of Lusatia.

Although there are above-average location coefficients in Lusatia, this is not reflected by an above-average amount of research in Lusatia. Research projects in the field of energy are not outstanding in comparison to the whole of Germany and also not in comparison to Baden-Württemberg. The activities of public research institutions partially compensate for private research, as it is the case for many east German regions. It is doubtful whether this is expedient in the long term, since strong RIS are characterized by excellent private-sector research. Also, it doesn't necessarily indicate potentials for smart specialisation when only regional HEI excel in energy research.

Having said that, the use of structural change funds suggests that the current situation could change. Promoting the "energy region Lusatia" is at least partially justified from an innovation policy perspective. Admittedly, the region is in competition with practically all other German regions as far as energy is concerned, also and especially in comparison with the three other coal regions. In the Rhineland region for example, energy was also identified as one of three topics for S2 as a study from 2013 concludes (Regionomica 2013, p. 51). But with the attraction of new firms and the formation of many research projects, critical mass for cooperation and innovation is achievable, at least in the larger cities such as Cottbus. There are already signs that a dynamic will develop in the energy sector. This is visible, for example, through the activities of Skeleton Technologies, the activities of the Lusatia hydrogen network and through other new settlements of institutes and projects. New technologies that are aimed at the decarbonisation of not only the energy sector but a whole string of sectors and industries seems promising and necessary in the context of carbon neutrality. Such new technologies can be a real market opportunity, despite the competition with other regions.

Three conditions are necessary for the success of a S2 in the field of energy. Firstly, the newly founded projects and institutes must manage to attract new knowledge, workforce and businesses to the region. This is due to the fact that endogenous potentials are still too low. Secondly, they must be self-sustaining enough to remain in the region even after the subsidies expire. Thirdly, the absorption capacity of the existing regional actors must be increased and an actual exchange between "old" and "new" actors must take place. Successful path creation in new industries is often based on the existence of assets, resources or competencies rooted in the area, such as an excellent scientific base (Martin and Sunley 2006, see Asheim 2019, p. 14). Furthermore, from a policy perspective it is important to monitor to what extent the innovative capacity and competitiveness of the region is developing.

Last but not least, from a research point of view, Lusatia is an exciting special case. The developments in the coming years should be researched from different perspectives of different disciplines. By doing so, emerging problems and undesirable developments can be identified at an early stage. Especially measuring the effects of recruitment and settlement of skilled workers, the participation of regional companies in new business fields and increase of innovation outputs will be a challenge for academics.

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