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Transition from Lignite in Lusatia – Smart Specialisation and Regional Innovations[†]

By Julia Rettig, Maximilian Zoll and Stefan Zundel

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Introduction

Policy advances towards carbon neutrality and the impending coal phase-out have the potential to heavily impact peripheral, coal-reliant regions, which face distinctive challenges in the upcoming EU-wide energy transition. This policy brief, centred around the German economic region of Lusatia, is one in a series of three, discussing lignite-dependent regions (the other two examining Gorj, Romania and Eastern Wielkopolska, Poland). The aim of each policy brief in this series is to shed light on barriers to an effective transition by critically assessing the regional innovation system (RIS) and potential avenues for smart specialization of the regional economy to boost innovation. Smart specialization is especially important for peripheral or less developed regions with little endogenous innovation potential, as it creates a focused path with clear research priorities accounting for existing regional strengths and potential for innovation[1]. The RIS views innovational activity as learning created by interactions between many actors within the economy in research and development (R&D), such as firms interacting with universities[2].

Lusatia has a comparative advantage over the two other regions since structural change *(Strukturwandel)* and coal phase-out has been discussed within the region for a relatively long time. Resultingly, Lusatia has become a sort of test laboratory for a plethora of different approaches towards the transition, driving the region to become a model region in the transition. As such, after a regional overview of Lusatia, this policy brief will show some lessons learned from Lusatia's transition regarding smart specialization and the RIS.

Regional Overview of Lusatia

Lusatia (*Lausitz*) is a region in eastern Germany spanning several administrative districts within the states of Brandenburg and Saxony (*Sachsen*), as pictured in Figure 1. Historically, Lusatia served as the core domestic energy-producing region for the German Democratic Republic (GDR) post-World War II and as such, the regional economy became heavily dependent on lignite mining and coal power. Though the economic landscape of Lusatia has diversified since the German reunification in the 1990s and the associated economic transition, the region maintains a cultural identity as an

[1] Petra Szávics and József Benedek, "Smart Specialization Priorities of Less Developed Regions. A Critical Evaluation," in *NMP 2020: New Metropolitan Perspectives*, vol. 177, Smart Innovation, Systems and Technologies (Springer, Cham, 2020), 22–36, https://doi.org/10.1007/978-3-030-52869-0_3.
[2] Bjørn T. Asheim, Arne Isaksen, and Michaela Trippl, *Advanced Introduction to Regional Innovation Systems* (Cheltenham, UK: Edward Elgar Publishing, 2019).

Energieregion[3] (energy region) and has the second largest workforce within the lignite industry nationally[4].

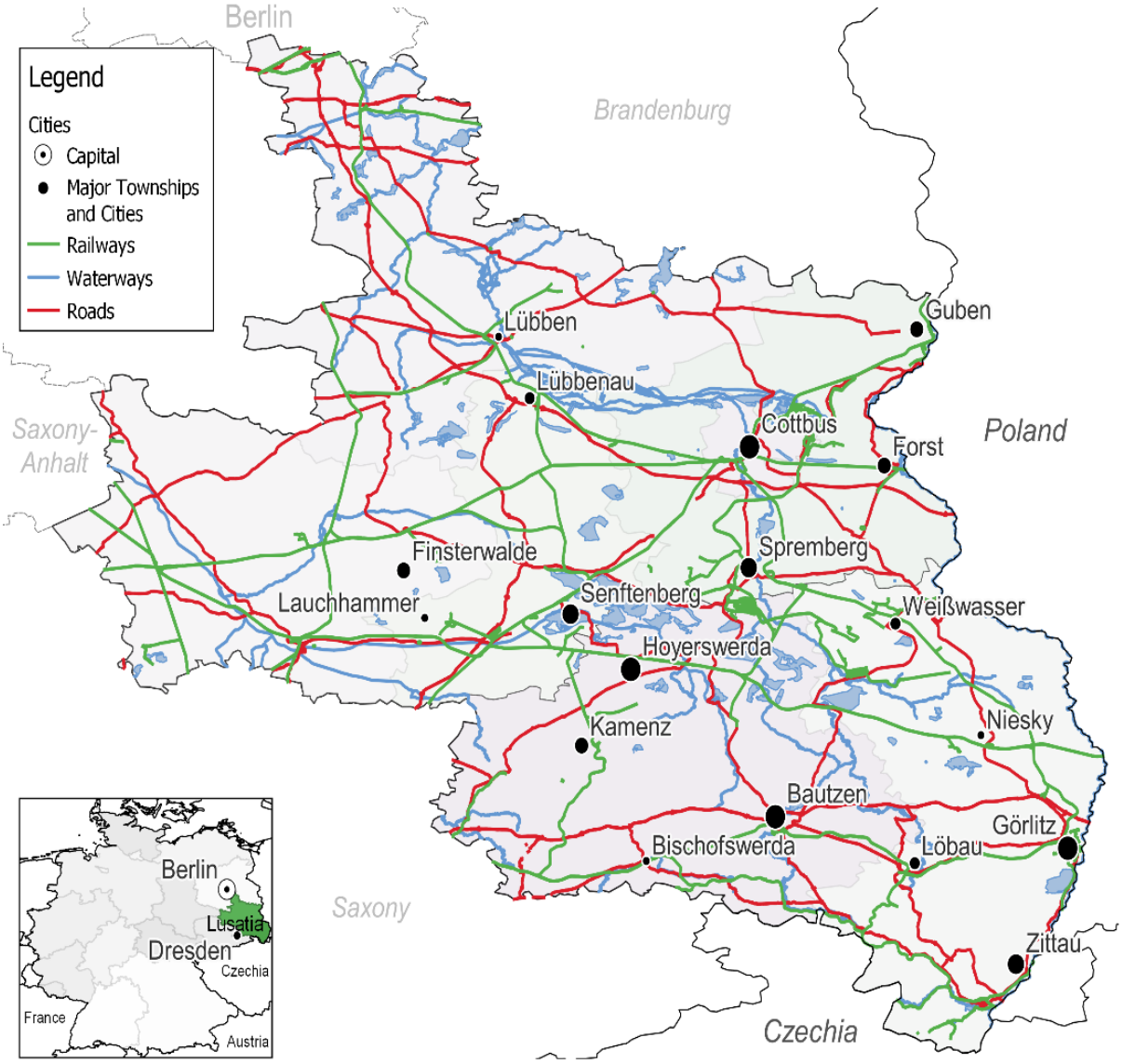

Figure 1: Map of Lusatia. Own creation using data from online databases5,6.

Today, with reference to national averages (see Table 1), the area is characterized by a low population density, a high unemployment rate, low levels of tertiary education, and substantial

[3] Marius Nagel and Stefan Zundel, "Legenden oder Leitbilder? Ausgewählte Narrative der Lausitz," Schriftenreihe Fachgebiet Allgemeine VWL mit dem Schwerpunk Energie- und Umweltökonomik (Cottbus: BTU Cottbus-Senftenberg, 2021), 12–13, https://www-docs.b-tu.de/fg-energie-umweltoekonomik/public/Schriftenreihe-pdf/sr03.pdf.

[4] Statistik der Kohlenwirtschaft e.V., "Beschäftigte der Braunkohleindustrie in Deutschland," 2021, https://kohlenstatistik.de/wp-content/uploads/2020/11/B-12-20.pdf.

[5] Eurostat, "The Geographic Information System of the COmmission (GISCO)," Online Database, 2021, https://ec.europa.eu/eurostat/web/gisco.

[6] Geofabrik GmbH Karlsruhe, "OpenStreetMap Shapefiles," Online Database, Geofabrik, 2021, https://www.geofabrik.de/data/shapefiles.html.

depopulation trends[7,8]. The region also has some unique inherent advantages. For one, the region receives substantial amounts of national funding[9], totalling 10.6 billion Euros. This is equivalent to 2.2 million Euros per person currently employed in the lignite sector or 1.3 million Euros per person indirectly employed in the lignite sector within Lusatia. The region is also the largest of the three considered under this series of policy briefs in terms of area. Finally, Lusatia has the innate locational advantage of bordering on the capital, Berlin, which lies just to its North (see Figure 1).

Table 1: Selected socioeconomic data for the Lusatia

	Lusatia	National
Geographic area [km^2][10]	11,727	357,580
Population density [inhabitants / km^2][11]	98	233
Population [millions] (2020)[12]	1.14	83.1
Employed population with tertiary education [%][13]	12.6	16.8
Unemployment rate [%][14]	5.8	5.4
Population directly employed in lignite sector[15] (percent of total employed population)[16]	7,822 (1.7%)	19,483 (0.05%)
Population directly and indirectly employed in lignite sector (percent of total employed population) in 2016[17]	13,245 (3.3%)	-

The region directly affected by the national mandate for coal phase-out is much smaller, concentrated the cities of Cottbus, Spremberg, and Weißwasser. Within this area, four coal-fired

[7] Manuel Frondel et al., "Erarbeitung aktueller vergleichender Strukturdaten für die deutschen Braunkohleregionen. Projektbericht für das Bundesministerium für Wirtschaft und Energie.," Endbericht (Essen, Germany: RWI, 2018), https://www.bmwi.de/Redaktion/DE/Publikationen/Wirtschaft/endbericht-rwi-erarbeitung-aktueller-vergleichender-strukturdaten-deutsche-braunkohleregionen.html.
[8] Wolfram Berger et al., "Standortpotentiale Lausitz" (Zukunftswerkstatt Lausitz, 2019), https://zw-lausitz.de/fileadmin/user_upload/01-content/03-zukunftswerkstatt/02-downloads/studie-standortpotenziale-lausitz.pdf.
[9] Deutscher Bundestag, "Strukturstärkungsgesetz Kohleregionen," Part I No. 37 § (2020), http://www.bgbl.de/xaver/bgbl/start.xav?startbk=Bundesanzeiger_BGBl&jumpTo=bgbl120s1795.pdf.
[10] Statistisches Bundesamt, "Kreisfreie Städte und Landkreise nach Fläche, Bevölkerung und Bevölkerungsdichte am 31.12.2020," 2020, https://www.destatis.de/DE/Themen/Laender-Regionen/Regionales/Gemeindeverzeichnis/Administrativ/04-kreise.html.
[11] Statistisches Bundesamt.
[12] Statistisches Bundesamt.
[13] InnoHub13, "Lausitzdatenbank," Online Database, Standortfaktoren der Projektregion, 2020, https://indikatoren.innohub13.de/.
[14] Bundesagentur für Arbeit, "Bund, Länder und Kreise - Arbeitsmarkt im Überblick," 2021, https://statistik.arbeitsagentur.de/DE/Navigation/Statistiken/Statistiken-nach-Regionen/Politische-Gebietsstruktur-Nav.html.
[15] Statistik der Kohlenwirtschaft e.V., "Beschäftigte der Braunkohleindustrie in Deutschland."
[16] Bundesagentur für Arbeit, "Beschäftigungsquoten - Deutschland, Länder, Kreise und Agenturen für Arbeit (Jahreszahlen und Zeitreihen) Juni 2020," 2020, https://statistik.arbeitsagentur.de/SiteGlobals/Forms/Suche/Einzelheftsuche_Formular.html?nn=1523064&topic_f=beschaeftigung-sozbe-bq-heft.
[17] Frondel et al., "Erarbeitung aktueller vergleichender Strukturdaten für die deutschen Braunkohleregionen. Projektbericht für das Bundesministerium für Wirtschaft und Energie."

power plants remain in operation—Boxberg, Cottbus, Jänschwalde, and Schwarze Pumpe (see Table 2). Considering international commitments for the reduction of greenhouse gas emissions, the German federal government has mandated a national coal phase-out by 2038[18], implying an ultimate deadline for the retirement of each power plant. Thus, political support exists on both the national[19] and regional level for the transition to a post-coal economy in Lusatia.

Table 2: Summary of lignite-fired power plants in Lusatia[20]

Power plant	Cottbus	Boxberg	Jänschwalde	Schwarze Pumpe
Owner	Stadtwerke Cottbus GmbH	EPH operated by Lausitzer Energie AG (LEAG)		
Commission year	1999	1979	1981	1997
Planned retirement	2022	2038	2028	2038
Coal units operational	1	4	6	2
Power capacity operational [MW]	82	2,582	3,210	1,600
CO_2 emissions [Mt / year] (2020)	0.01	15.4	13.7	10.3

Though only 3.3% of the actively employed population of Lusatia are directly or indirectly involved in the lignite industry (Table 1), the energy industry remains a clearly identifiable specialization cluster within the region[21] (see Figure 2). Figure 2 shows the Balassa-Hoover Index, which represents the degree of specialization within a region, measured by a ratio of the population actively employed in each industry compared with the national baseline (HBI = 1.0). A value greater than one indicates that the sector is proportionately overrepresented while a value less than one indicates an underrepresentation of that sector[22]. Between Figure 2 and Figure 3, it is clear that Lusatia overperforms in agriculture and industry, while underperforming in tourism when compared to the national baseline.

[18] Deutscher Bundestag, Strukturstärkungsgesetz Kohleregionen.
[19] Deutscher Bundestag.
[20] "Coal Exit Tracker" (Europe Beyond Coal, 2021), https://beyond-coal.eu/coal-exit-tracker/.
[21] Marius Nagel and Stefan Zundel, "'Wat den Eenen sin Uhl', is den Annern sin Nachtigall' - Ausgewählte Aspekte der Standortqualität der Lausitz," Schriftenreihe des Fachgebiets Allgemeine VWL mit dem Schwerpunkt Energie- und Umweltökonomik (Cottbus: BTU Cottbus-Senftenberg, 2020), https://www-docs.b-tu.de/fg-energie-umweltoekonomik/public/Schriftenreihe-pdf/sr01.pdf.
[22] Nagel and Zundel, 8.

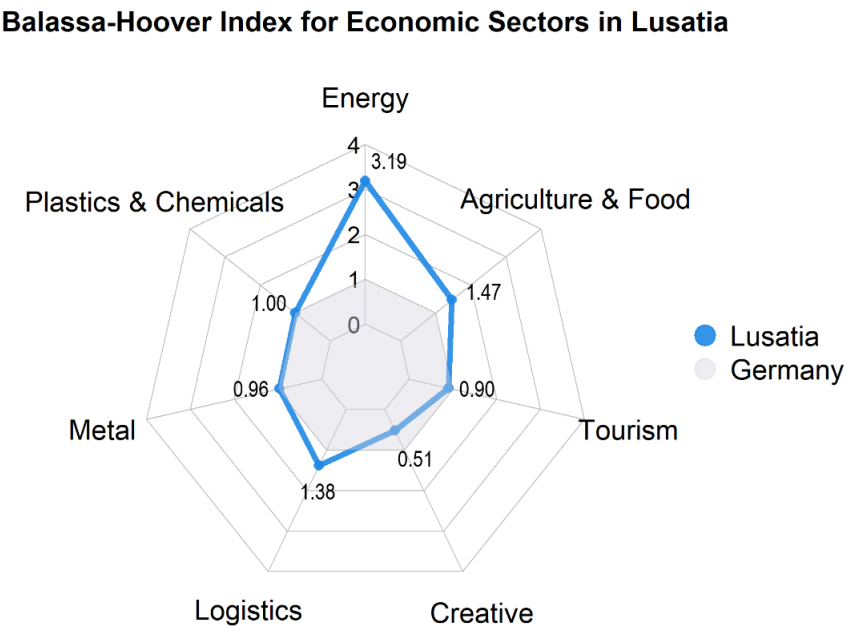

Figure 2: The Balassa-Hoover Index (BHI) for select industries within Lusatia, in comparison with the national reference level (BHI = 1). Adapted from Nagel and Zundel (2020, p. 8).

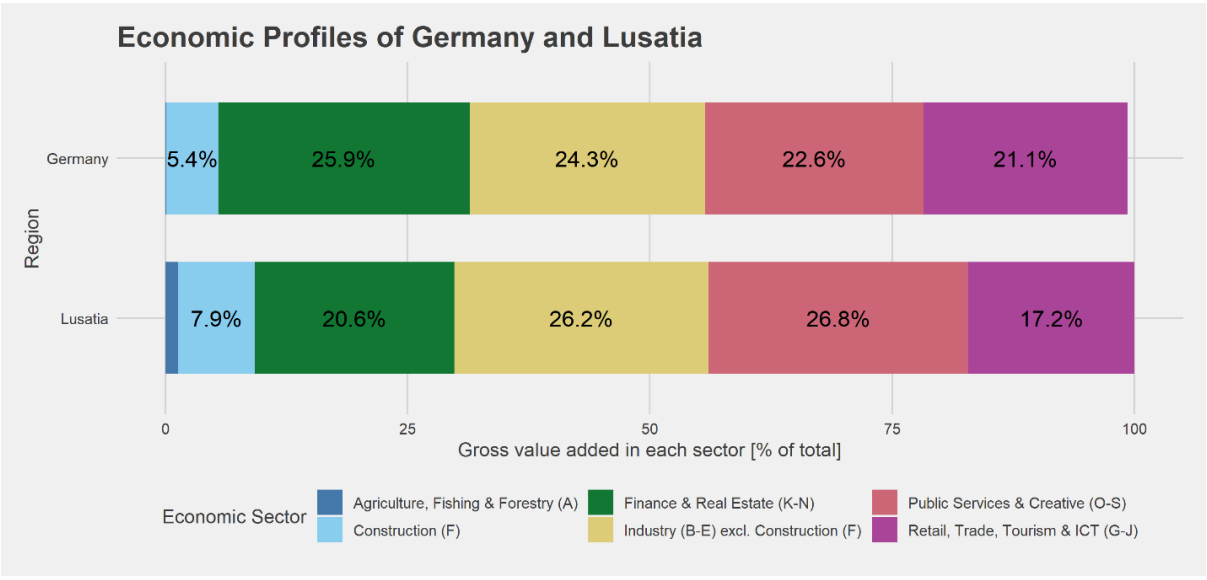

Figure 3: Economic profile of Lusatia based on gross value added (GVA) in economic sectors[23] from 2019 as a percent of total GVA.

In comparison with the national innovation indicators, Lusatia's regional innovation indicators are low (Table 3). Particularly R&D expenditures and patents granted lie significantly below national

[23] Eurostat, "Gross Value Added at Basic Prices by NUTS 3 Regions," Online Database, Data Browser, 2021, https://ec.europa.eu/eurostat/databrowser/view/nama_10r_3gva/default/table?lang=en.

levels. The regional dominance of small and medium enterprises (SMEs) can be seen as a hinderance for innovation activity.

Table 3: Summary of indicators for Lusatia's RIS[24]

Indicator		Lusatia	National
Intramural R&D expenditures in all sectors (2015)	in millions of Euros	156.06	60,952
	as % of GDP	0.50	2.01
Total R&D personnel and researchers (2015)	in full-time equivalent (FTE)	2,435.82	404,767
	as % of total employment in FTE	0.59	1.17
Patents granted (2017)	in number per 100,000 inhabitants	15.1	57.7
Enterprise birth (2019)[25]	in all sectors	7,603	672,609
Enterprise numbers by size class in 2019 (as % share of total)[26,27] Excluding micro businesses (0-9 employees)	Small (10-49 employees)	4271 (80.37%)	357,937 (79.80%)
	Medium (50-249 employees)	865 (16.28%)	73,823 (16.46%)
	Large (250+ employees)	178 (3.35%)	16,798 (3.74%)
Staff employed in enterprises by size class in 2018 (as % share of total)[28,29,30] Excluding micro businesses (0-9 employees)	Small (9-49 employees)	64,549 (29.74%)	7,247,881 (24.20%)
	Medium (50-249 employees)	79,124 (36.45%)	7,465,689 (24.93%)
	Large (250+ employees)	73,388 (33.81%)	15,231,283 (50.86%)

The organizational setting underlying the RIS appears strong, with the region boasting of a relatively large number of universities, colleges, technology parks, and transfer offices. In Table 4, the organizations present within the region and their area of research will be summarized.

[24] InnoHub13, "Lausitzdatenbank."
[25] Statistisches Bundesamt, "Regionaldatenbank Deutschland," Text, 2021, pts. 52311-01-04-4: Gewerbeanmeldungen, abmeldungen-Jahressumme-regionale Tiefe: Kreise und krfr. Städte, https://www.regionalstatistik.de/genesis/online.
[26] Statistisches Landesamt Sachsen, "Unternehmensregister-System (URS)," Online Database, Statistik Sachsen - GENESIS-Online, 2021, secs. 52111-104K, https://www.statistik.sachsen.de/genonline/online.
[27] Amt für Statistik Berlin-Brandenburg, "Unternehmen Brandenburg," Online Database, Statistik Berlin Brandenburg, 2021, https://www.statistik-berlin-brandenburg.de/unternehmen.
[28] Statistisches Bundesamt, "Regionaldatenbank Deutschland."
[29] Statistisches Landesamt Sachsen, "Unternehmensregister-System (URS)," secs. 52111-104K.
[30] Amt für Statistik Berlin-Brandenburg, "Unternehmen Brandenburg."

Table 4: List of long-established organizations comprising the RIS of Lusatia and their locations

Type	Institution	Location
University or College	Brandenburg University of Technology Cottbus-Senftenberg[31]	Cottbus, Senftenberg
	University of Applied Sciences Zittau/Görlitz[32]	Zittau, Görlitz
	Technical University of Applied Sciences Wildau[33]	Wildau
Technology Parks	Technology and Industrial Park Cottbus[34]	Cottbus
	Technology and Research Center Cottbus[35]	Cottbus
	Aerospace Technology Center Schönefelder Kreuz[36]	Wildau
	Technology and Start-up Center Wildau[37] (TUAS Wildau)	Wildau
	Senftenberg Innovation Center[38]	Senftenberg
	Center for Future Technologies	Wildau
Research Institutions and Centers	Center for Energy Technology Brandenburg (CEBra)[39]	Cottbus
	Research Institute for Post-Mining Landscapes[40]	Finsterwalde
	Research Center for Lightweight Construction Materials Panta Rhei[41] (BTU Cottbus-Senftenberg)	Cottbus
	Institute for Floating Structures[42] (BTU Cottbus-Senftenberg)	Cottbus
	GridLab GmbH[43]	Schönefeld
	Joint Lab Dependable Sensor Networks[44] (BTU Cottbus-Senftenberg)	Cottbus
	Fraunhofer Institute for Applied Polymer Research[45]	Various

[31] BTU Cottbus-Senftenberg, "Brandenburgische Technische Universität Cottbus-Senftenberg," 2021, https://www.b-tu.de/.
[32] UAS Zittau-Görlitz, "Hochschule Zittau/Görlitz - Studieren und Forschen im Herzen Europas," 2021, https://www.hszg.de/.
[33] TUAS Wildau, "TH Wildau," 2021, https://www.th-wildau.de/.
[34] "Technologie- und Industriepark Cottbus (TIP)," Wirtschaftsförderung Cottbus, 2021, https://www.egc-cottbus.de/gewerbeflaechen-immobilien/technologie-und-industriepark.
[35] Heinze, "Technologie- und Forschungszentrum (TFZ) Cottbus," 2021, https://www.heinze.de/architekturobjekt/technologie-und-forschungszentrum-tfz-cottbus/12801286/.
[36] ZLUR, "Aerospace Technology Center - Schönefelder Kreuz - Where Innovations Fly," 2021, https://www.zlur.de/en/.
[37] Bianca Baumann, "Startup Center," TUAS Wildau, 2021, https://www.th-wildau.de/forschung-transfer/zentrum-fuer-forschung-und-transfer/startup-center/.
[38] "Innovationszentrum Senftenberg," 2021, http://www.innovationszentrum-senftenberg.de/Startseite/.
[39] CEBra e.V., "Centrum für Energytechnologie Brandenburg," 2021, https://www.cebra-cottbus.de/.
[40] Forschungsinstitut für Bergbaufolgelandschaften e.V., "Wir Heilen Landschaften - Forschungsinstitut Für Bergbaufolgelandschaften," 2021, https://fib-ev.de/en/start_en/.
[41] Panta Rhei, "Panta Rhei gGmbH - Forschungszentrum für Leichtbauwerkstoffe," Brandenburgische Technische Universität Cottbus-Senftenberg, 2021, https://www.b-tu.de/pantarhei-cottbus/wir-ueber-uns/profil.
[42] IfSB, "Institute for Floating Structures," Brandenburgische Technische Universität Cottbus-Senftenberg, 2021, https://www.b-tu.de/en/schwimmende-bauten/.
[43] DNV Energy Systems Germany GmbH, "DNV Energy Systems Germany and Gridlab Training Center," Gridlab - A DNV GL Service, 2021, https://gridlab.de/unternehmen-gridlab/?lang=en.
[44] Leibniz Institute for High Performance Microelectrics, "Dependable Sensor Networks," Joint Labs IHP - BTU Cottbus-Senftenberg, 2021, https://www.ihp-microelectronics.com/joint-labs/btu-cottbus-senftenberg.
[45] Fraunhofer IAP, "Fraunhofer Institute for Applied Polymer Research IAP," 2021, https://www.iap.fraunhofer.de/en/about_us/locations.html.

Type	Institution	Location
	Fraunhofer Institute for Photonic Microsystems[46]	Zittau
	Fraunhofer Plastics Technology Center Oberlausitz[47]	Zittau
	German Electron Synchotron (DESY)[48]	Zeuthen
	Institute for Education, Information, and Communication (BIK)[49] (UAS Zittau/Görlitz)	Görlitz
	Institute for Sustainable Processes, Surfacing Technologies, Peat, and Natural Materials (iTN + IOT)[50] (UAS Zittau/Görlitz)	Zittau
	Institute for Ecology and Environmental Protection[51] (UAS Zittau/Görlitz)	Zittau
	Institute for Process Technology, Process Automation, and Measurement Technology[52] (UAS Zittau/Görlitz)	Zittau
	Institute for Transformation, Housing, and Social-Spatial Development[53] (UAS Zittau/Görlitz)	Görlitz
Transfer Offices	Technology Transfer Office BTU Cottbus-Senftenberg[54]	Cottbus
	Technology Transfer Center TUAS Wildau[55]	Wildau
	Start-up Center BTU Cottbus-Senftenberg[56]	Cottbus
	Innovation Center for Modern Industry Brandenburg (IMI)[57]	Cottbus
	Mittelstand 4.0 Competence Center[58]	Cottbus

[46] Fraunhofer IPMS, "Fraunhofer Institute for Photonic Microsystems," 2021, https://www.ipms.fraunhofer.de/en.html.
[47] Fraunhofer IWU, "Zittau - Fraunhofer Kunststoffzentrum Oberlausitz," Fraunhofer-Institut für Werkzeugmaschinen und Umformtechnik IWU, 2021, https://www.iwu.fraunhofer.de/de/Ueber-uns/standorte/zittau.html.
[48] DESY, "DESY - Germany's Largest Accelerator Centre," Deutsches Elektronen-Synchotron DESY A Research Center of the Helmholtz Association, 2021, https://www.desy.de/index_eng.html.
[49] BIK, "Institute of Education, Information, Communication," Hochschule Zittau-Görlitz, 2021, https://www.hszg.de/en/research/facilities/institutes/education-information-communication.
[50] iTN + IOT, "Verbund-Institut für nachhaltige Verfahrensentwicklung, Oberflächentechnik, Torf- und Naturstoff-Forschung (iTN + IOT)," Hochschule Zittau-Görlitz, 2021, https://www.hszg.de/forschung/einrichtungen/forschungsinstitute/verbund-institut-fuer-nachhaltige-verfahrensentwicklung-oberflaechentechnik-torf-und-naturstoff-forschung-itn-iot.
[51] IÖU, "Institute of Ecology and Environmental Protection (IÖU)," Hochschule Zittau-Görlitz, 2021, https://www.hszg.de/en/research/facilities/institutes/ecology-and-environmental-protection.
[52] IPM, "Institute for Process Technology, Process Automation and Measurement Technology," Hochschule Zittau-Görlitz, 2021, https://ipm.hszg.de/en/.
[53] TRAWOS, "Institute for Transformation, Housing and Socio-Spatial Development (TRAWOS)," Hochschule Zittau-Görlitz, 2021, https://trawos.hszg.de/en/.
[54] Christina Müller, "Technologietransfer & Innovation," Brandenburgische Technische Universität Cottbus-Senftenberg, 2021, https://www.b-tu.de/wirtschaft/technologie-und-innovation.
[55] TWZ e.V., "Technologietransfer- und Weiterbildungszentrum an der Technischen Hochschule Wildau," 2021, https://twz-ev.org/.
[56] BTU Cottbus-Senftenberg, "Gründungsservice," Brandenburgische Technische Universität Cottbus-Senftenberg, 2021, https://www.b-tu.de/gruendungsservice/.
[57] IMI, "Innovationszentrum Moderne Industrie Brandenburg," 2021, https://www.imi4bb.de/home.
[58] Mittelstand 4.0, "Mittelstand 4.0 - Kompetenzzentrum Cottbus," 2021, https://www.kompetenzzentrum-cottbus.digital/.

A Starting Point for Innovation: Lusatia

Smart Specialization of the Economic Profile

Lusatia's economic profile is largely dominated by the sectors industry and public service, the latter of which does not indicate great potential for the endogenous establishment of new market sectors and innovative businesses. The analysis above shows several potential starting points for smart specialization in Lusatia's economic profile: agriculture, forestry, and fishing, industry and energy, and tourism. These are reflected in current regional strategy papers[59,60]. Past Regional Innovation Strategies for Smart Specialization (RIS3) for the states Brandenburg and Saxony highlighted strengthening the clusters of health, energy technology, and ICT, food and agriculture, chemicals and plastics, metalwork, and tourism (Brandenburg)[61] and microelectronics, ICT, nanotechnology, materials, photonics, and biotechnology (Saxony)[62]. A wide range of priority areas for Lusatia is additionally mentioned in the *Strukturstärkungsgesetz Kohleregionen*[63] (national legislation on the structural strengthening of coal regions).

Common to all of these strategies, and highly appropriate given Lusatia's history in the sector, is the development of energy-related industries and technologies. In terms of renewable energy, Lusatia has high potential for wind energy[64,65] and potential for solar energy[66]. Lusatia already hosts several large solar farms in Finsterwalde, Lieberose, and Senftenberg and numerous wind farms, with more planned on retiring coal areas[67,68]. The region, until recently, hosted a production factory for wind turbine blades[69], thus possesses skilled human resources in this area. Currently,

[59] Staatskanzlei, "Das Lausitzprogramm 2038 - Prozesspapier zum Aufbau von Entscheidungs- und Begleitstrukturen im Transformationsprozess," 2020, https://lausitz-brandenburg.de/wp-content/uploads/2020/09/Lausitzprogramm-2038_20200914.pdf.
[60] Wirtschaftsregion Lausitz GmbH, "Entwicklungsstrategie Lausitz 2050," 2020, https://zw-lausitz.de/fileadmin/user_upload/entwicklungsstrategie-lausitz-2050.pdf.
[61] Land Brandenburg, "Regionale Innovationsstrategie Des Landes Brandenburg (InnoBB Plus)," 2014, https://www.isi.fraunhofer.de/content/dam/isi/dokumente/ccp/ris3-strategien/Berlin-Brandenburg_innoBB_plus.pdf.
[62] Staatsministerium für Wirtschaft, Arbeit und Verkehr, "Innovationsstrategie Des Freistaates Sachsen" (Dresden, 2013), https://www.isi.fraunhofer.de/content/dam/isi/dokumente/ccp/ris3-strategien/Sachsen_Innovationsstrategie.pdf.
[63] Deutscher Bundestag, Strukturstärkungsgesetz Kohleregionen.
[64] DTU, "Global Wind Atlas," 2021, https://globalwindatlas.info.
[65] Frondel et al., "Erarbeitung aktueller vergleichender Strukturdaten für die deutschen Braunkohleregionen. Projektbericht für das Bundesministerium für Wirtschaft und Energie."
[66] Solargis, "Global Solar Atlas," 2021, https://globalsolaratlas.info/.
[67] IKEM, "Regional Profile Lusatia, Germany" (Institute for Climate Protection, Energy and Mobility, 2020), https://justtransition.ikem.de/wp-content/uploads/2020/07/IKEM-Lusatia-Regional-Profile.pdf.
[68] Martina Greib et al., "Struktur- Und Intustriepolitische Alternativen Für Die Lausitz," in *Nach Der Kohle: Alternativen Für Einen Strukturwandel in Der Lausitz* (Berlin: Rosa-Luxemburg-Stiftung, 2019), 9–72, https://www.rosalux.de/fileadmin/rls_uploads/pdfs/Studien/Studien_4-19_Nach_der_Kohle.pdf.
[69] Alfons Frese, Thorsten Mumme, and Thorsten Metzner, "Windanlagenbauer Vestas schließt Werk in der Lausitz," *Der Tagesspiegel Online*, 2021, sec. Berlin, https://www.tagesspiegel.de/berlin/mehr-als-ein-schock-windanlagenbauer-vestas-schliesst-werk-in-der-lausitz/27633996.html.

a new solar farm is planned in Bohrau[70], a wind farm was recently proposed on recultivated areas of the open-cast mine Jänschwalde[71], and a biomass cultivation farm and carbon sink will be established on the rehabilitated open-cast mine Reichwalde[72]. Finally, on the newly created East Lake Cottbus (*Cottbuser Ostsee)*, formerly the open-cast mine Cottbus-Nord, Germany's largest floating solar farm to date is planned[73], supported by a preexisting power substation.

A barrier to implementing a transition to decarbonized energy generation involves a shift from centralized fossil fuel-based energy production to decentralized and comparatively small-scale renewable energy production. Not only will such a shift involve large investments into grid improvements[74], but also presents governance challenges. A shift away from fossil-fuel based energies also includes the decarbonization of local industry, which can in part be achieved through the electrification of these industries. Local research institutes, particularly the BTU Cottbus-Senftenberg are proactively addressing these challenges. Several local institutes have recently partnered to form the Cluster Decarbonization of Industry (CDI)[75].

Local firms are taking a proactive approach to the transition by developing key competences to direct the transformation of the energy system. The LEAG has planned several new business ventures[76] for the transition away from lignite. Among these are BigBattery Lausitz[77] (a large-scale energy storage facility) at the site of the Schwarze Pumpe and a waste-to-power plant at the former site of the Jänschwalde coal power plant[78]. LEAG is also developing energy cubes[79], described as combining decentral, smaller-scale renewable energy generation into a virtual power plant to

[70] LEAG, "Landwirte und LEAG vereinbaren gemeinsame Flächennutzung für PV-Energiepark Bohrau," Pressemitteilung LEAG, 2021, https://www.leag.de/de/news/details/landwirte-und-leag-vereinbaren-gemeinsame-flaechennutzung-fuer-pv-energiepark-bohrau/.
[71] LEAG, "LEAG reicht Genehmigungsantrag für ihren ersten Windpark ein," Pressemitteilung LEAG, 2021, https://www.leag.de/de/news/details/leag-reicht-genehmigungsantrag-fuer-ihren-ersten-windpark-ein/.
[72] LEAG, "Biomasse am Tagebau Reichwalde soll Kohlendioxid binden," Pressemitteilung LEAG, 2021, https://www.leag.de/de/news/details/biomasse-am-tagebau-reichwalde-soll-kohlendioxid-binden/.
[73] LEAG, "Cottbuser Ostsee soll schwimmende PV-Anlage erhalten," Pressemitteilung LEAG, 2021, https://www.leag.de/de/news/details/cottbuser-ostsee-soll-schwimmende-pv-anlage-erhalten/.
[74] Öko-Institut, "Renewables versus Fossil Fuels - Comparing the Costs of Electricity Systems: Electricity System Designs for 2050 - An Analysis of Renewable and Conventional Power Systems in Germany" (Agora Energiewende, 2017), https://www.agora-energiewende.de/fileadmin/Projekte/2016/Stromwelten_2050/Agora_Gesamtkosten-Stromwelten-EN_WEB.pdf.
[75] KEI, "Cluster Dekarbonisierung der Industrie," Kompetenzzentrum Klimaschutz in energieintensiven Industrien, 2021, https://www.klimaschutz-industrie.de/cluster/.
[76] Daniela Hertzer, "Wie die LEAG sich auf den Strukturwandel einstellt," LEAG - Seitenblick Blog, 2019, https://www.leag.de/de/seitenblickblog/artikel/wie-die-leag-sich-auf-den-strukturwandel-einstellt/.
[77] LEAG, "Innovative Lösungen für eine sichere Energiewende," LEAG Speicherprojekt BigBattery Lausitz, 2021, https://www.leag.de/de/bigbattery/.
[78] EVA Jänschwalde, "Energie- und Verwertungsanlage Jänschwalde," 2021, https://www.eva-lausitz.de/.
[79] LEAG, "Effiziente Energielösungen aus einer Hand," LEAG energy cubes, 2021, https://www.leag.de/de/energycubes/.

reduce the complexity and volatility of distributed renewable energy generation. Power-to-X technologies (surplus energy conversion and storage from renewables) are key to Lusatia's smart specialization in the energy sector[80,81,82]. Battery recycling facilities have also been discussed with great potential for Lusatia's circular economy[83].

Lusatia was also named a HyStarter region and since 2019 has been receiving funding for research into hydrogen energy and storage thereof from the German federal government[84,85]. There is ambition to develop Lusatia into a model region for H_2, an industry which could compensate for between 45-83% of the jobs lost through the exit from lignite[86].

Tourism in Lusatia is largely centered around nature due to abundant nature reserves, waterways, and spa towns. Former open-cast lignite mines have been redeveloped as the Lusatian Lake District[87], covering 140 square kilometers[88]. The region is also the traditional home of the Sorbs, whose cultural uniquities are a drawing point for tourists. It has been planned to develop a regional "brand" for Lusatia to promote and unify the local tourism industry and increase identifiability of the region's offering[89]. Tourism is a comparatively new branch of industry, but already has approximately the same number of employees as the region's lignite industry[90].

At the center of Lusatia's smart specialization lie the needs of the local population. Consequently, Lusatia is aiming to become a model region for health with the establishment of a medicine campus at the BTU Cottbus-Senftenberg, the introduction of and research into virtual healthcare,

[80] Deutscher Bundestag, Strukturstärkungsgesetz Kohleregionen.
[81] Agora Energiewende, "Eine Zukunft Für Die Lausitz - Elemente Eines Strukturwandelkonzepts Für Das Lausitzer Braunkohlerevier," Impulse, 2017, https://www.agora-energiewende.de/veroeffentlichungen/eine-zukunft-fuer-die-lausitz/.
[82] Greib et al., "Struktur- Und Intustriepolitische Alternativen Für Die Lausitz."
[83] Katrin Nicke et al., "Batterierecycling Als Beschäftigungsperspektive Für Die Lausitz" (Frankfurt/Main: Otto Brenner Stiftung, 2019), https://www.otto-brenner-stiftung.de/fileadmin/user_data/stiftung/01_Die_Stiftung/04_Stiftung_Neue_Laender/02_Publikationen/SNL_10_Batteriestudie.pdf.
[84] NOW GmbH, "HyStarter I: Wasserstoffregion Lausitz," Hyland, 2021, https://www.hy.land/hystarter-wasserstoffregion-lausitz/.
[85] IKEM, "Regional Profile Lusatia, Germany."
[86] A. Kratzsch et al., "Studie: Perspektiven Und Potentiale Einer Sektoren-Übergreifenden Wasserstoffwirtschaft in Der Wirtschaftsregion Lausitz" (Zukunftswerkstatt Lausitz, 2020), https://zw-lausitz.de/fileadmin/user_upload/01-content/03-zukunftswerkstatt/02-downloads/studie-wasserstoffwirtschaft-in-der-lausitz.pdf.
[87] Tourismusverband Lausitzer Seenland e.V., "Lausitzer Seenland - Junge Urlaubsregion Zwischen Dresden & Berlin," 2021, https://www.lausitzerseenland.de/de.html.
[88] IKEM, "Regional Profile Lusatia, Germany."
[89] Norbert Hoffman and Martina Taubenberger, "Tourismusstrategie Lausitz 2025" (Zukunftswerkstatt Lausitz, 2020), https://zw-lausitz.de/fileadmin/user_upload/01-content/03-zukunftswerkstatt/02-downloads/KulturKonzepte_Tourismusstrategie_Lausitz_Bericht_fin_30JUL20.pdf.
[90] Agora Energiewende, "Eine Zukunft Für Die Lausitz - Elemente Eines Strukturwandelkonzepts Für Das Lausitzer Braunkohlerevier."

and establishment of the local Carl-Thiem Clinic as a leading digital hospital[91]. Several other smart specialization initiatives exist, for example into aquaculture and new forms of agriculture.

Reshaping the Regional Innovation System

Strengthening, expanding, and reshaping the organizational setting within Lusatia is at the core of regional strategy papers[92,93], with special emphasis on transforming Lusatia into a model region for modern and digital health(care). These strategies also outline reinforcing and reestablishing the R&D for Lusatia towards hydrogen fuels, renewable energy, low-carbon industries and technology, circular economies, sustainable land-use, and more.

To this end, the institutional setting of Lusatia's RIS must be undertaken, strengthening each pillar of the RIS: universities to draw academics and researchers into the region as well as boost the education of the local population, the establishment of spaces for young businesses like industrial and technological parks as well as research centers and institutions, while building up the connection between industry and research through transfer offices. The following section discusses Lusatia's a number of recent and planned developments in this regard.

A new concept in Lusatia's RIS are innovation hubs. Innovation Hub 13[94], founded in 2018, is a cooperation between the TUAS Wildau and the BTU Cottbus-Senftenberg which offers a wide range of facilities including the services of transfer scouts, a form of specialized intermediary between (potential) knowledge transfer partners which seek out and, uniquely, often take on a role of knowledge creation within the knowledge transfer process[95]. Also born of a cooperation between the TUAS Wildau and BTU Cottbus-Senftenberg, Startup Revier EAST[96] is a new start-up center and coworking space offering entrepreneurship education among other services.

Newly settled research institutes in Lusatia are summarized in Table 5. The establishment of nine further innovation centers is currently planned at the BTU Cottbus-Senftenberg[97], including an

[91] Wirtschaftsregion Lausitz GmbH, "Entwicklungsstrategie Lausitz 2050."
[92] Staatskanzlei, "Das Lausitzprogramm 2038 - Prozesspapier zum Aufbau von Entscheidungs- und Begleitstrukturen im Transformationsprozess."
[93] Wirtschaftsregion Lausitz GmbH, "Entwicklungsstrategie Lausitz 2050."
[94] InnoHub13, "Innovation Hub 13," 2021, https://innohub13.de/.
[95] Anika Noack and Heike Jacobsen, "Transfer Scouts: From Intermediation to Co-Constructors of New Knowledge and Technologies in Germany," *Research Policy* 50, no. 4 (2021): 104209, https://doi.org/10.1016/j.respol.2021.104209.
[96] TUAS Wildau and BTU Cottbus-Senftenberg, "Startup Revier EAST," Startup Revier EAST, 2021, https://www.startuprevier.de/.
[97] BTU Cottbus-Senftenberg, "BTU-Initiativen - geplante Innovationszentren," Strukturwandel Lausitz - Projekte und Initiativen an der BTU Cottbus-Senftenberg, 2021, https://www.b-tu.de/universitaet/strukturwandel-lausitz.

Energy Innovation Center, the Center for Hybrid Electric Systems Cottbus (CHESCO), the Lausitz Academy, the Center for Sustainable Development of a Multifunctional Landscape, the Center for Structural Change and Regional Development, the Cottbus Center for Climate Change and Cultural Heritage (4C), BioH Lausitz – Biotech-Health Campus Lusatia, and SpreeTecNext.

Table 5: Research institutes established in Lusatia since 2018.

Institution	Location
Lusatian Center for Artificial Intelligence[98]	Cottbus
Competence Center for Electromagnetic Fields[99]	Cottbus
Fraunhofer Institute for Geothermal Systems and Energy Infrastructure[100]	Cottbus
University Medical Clinic[101]	Cottbus
Institute for Low-Carbon Industrial Processes[102]	Cottbus, Zittau
CASUS (Center for Advanced System Understanding) [103]	Görlitz

Again, the development of the RIS illustrates that Lusatia has been used as a sort of test laboratory for manifold areas of research. Moreover, the policy for developing Lusatia's RIS, based largely on drawing new research institutes into the region, has begun to shift from drawing in smaller institutes to drawing in larger research organizations and firms. Though indicative of successful development, it is important to ensure that these new, larger organizations draw on endogenous research supply and human resources (as opposed to drawing on long-distance commuters from more populous, central areas), working and cooperating with established local firms and other organizations to establish a lasting presence in and impact on Lusatia's innovation with spillovers for the wider society. Establishing clusters that connect research and industry could be a key to developing the local RIS and encouraging lasting innovation.

[98] BTU Cottbus-Senftenberg, "Lausitzer Zentrum für Künstliche Intelligenz (LZKI)," 2021, https://www.b-tu.de/lausitzer-zentrum-ki/.
[99] BfS, "Das Kompetenzzentrum Elektromagnetische Felder," Bundesamt für Strahlenschutz (BfS, 2021), https://www.bfs.de/DE/themen/emf/kompetenzzentrum/das-kompetenzzentrum/das-kompetenzzentrum.html.
[100] Fraunhofer IEG, "Fraunhofer-Einrichtung für Energieinfrastrukturen und Geothermie," 2021, https://www.ieg.fraunhofer.de/de.html.
[101] Niederlausitz Aktuell, "Strukturwandel beschlossen: Cottbuser CTK wird Universitätsklinik," Niederlausitz Aktuell - Regional - Lokal - Aktuell, 2020, https://www.niederlausitz-aktuell.de/cottbus/82953/strukturwandel-beschlossen-cottbuser-ctk-wird-universitaetsklinik.html.
[102] DLR, "Institute of Low-Carbon Industrial Processes," 2021, https://www.dlr.de/di/en/desktopdefault.aspx/tabid-13342/23331_read-54008/.
[103] Helmholtz-Zentrum Dresden-Rossendorf, "CASUS - Center for Advanced System Understanding," 2021, https://www.casus.science/.

Conclusions

Lusatia's ultimate coal phase-out, to be undertaken by 2038, poses a great hurdle for a region already faced with low innovation and depopulation. In critically assessing local conditions around the RIS and potentials for smart specialization, it was shown that Lusatia lacks central coordination while testing a wide range of novel strategies. The diversity of the outlined strategies reflects the challenge of creating a common vision for such a disparate region—ranging for example from the outskirts of Berlin to the core mining region around Cottbus, Spremberg, and Weißwasser but also to regional touristic hotspots. Successful, future-proof regional development measures might therefore concentrate on matching economic progress with decarbonization efforts and digitalization or harmonizing the improvement of the regional quality of life with attracting a new, highly skilled workforce. The establishment of the Cluster Decarbonization of Industry and the regional investment into developing healthcare and medicine are examples of such measures.

Finally, Lusatia's role as a model region in a transition from coal reveals several important lessons learned. First, for engendering enduring improvement to innovation in the region, it is vital that newly introduced organizations and concepts become closely linked with and make use of unique endogenous knowledge sources and human resources. Another, matching the newly established research institutes and firms to existing local specializations is important to create lasting change. It must be emphasized that though drawing in new research supply alone is not enough to reform the RIS, a critical mass of research institutes within the region may help to draw new businesses into the region.

The diverse array of research and development areas within Lusatia will continue to result in great learning opportunities for peripheral regions in transition. The solutions and strategies discussed in this policy brief should be considered in the context of the economic and social situations of similar regions. To this end, a comparative perspective between the three regions discussed throughout this series of policy briefs should be examined.