Lefteris Topaloglou / Eike Albrecht /
Steven Kramm / Niyanta Shetye (Eds.)

Pursuing Societal Transformation in Coal Mining Regions through Education and Knowledge Transfer

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Preface of the Editors

This volume is the outcome of a scientific workshop on Pursuing Societal Transformation through Education and Knowledge Transfer in Kozani.
The workshop was carried out in December 2022 in the framework of a cooperation project financed by the German Academic Exchange Service (DAAD). The project brought together Brandenburg University of Cottbus – Senftenberg (BTU), Germany, and the University of Western Macedonia (UOWM), Kozani, northern Greece.

Climate change stands as one of the most pressing challenges of our time. Halting global warming necessitates significant changes in politics, law, economics, and technology. However, the success of this transformation hinges on having an informed, educated, and engaged society. This imperative is underscored by international agreements, such as Article 6 of the UNFCCC and Article 12 of the Paris Climate Agreement, which highlight the importance of climate education. To achieve these goals, it is essential to establish effective and goal-oriented communication between universities and the general public, fostering a collaborative educational and knowledge transfer landscape for the broader population.

Both UOWM and BTU are located in regions historically tied to lignite mining, which is being phased out due to European and national climate policies. This volume contains various contributions, including case studies of the areas around Kozani and Cottbus/Lusatia, which share similar starting points. In both regions, the cessation of coal usage, industrial decarbonization, and the shift to new economic sectors are paramount societal concerns. Cottbus and Kozani find themselves at the heart of regions undergoing profound changes due to the discontinuation of fossil fuels. Lignite has been a staple of energy production and heating in Cottbus and the surrounding Lusatia region for almost a century, while coal mining formed the basis of energy production in the Kozani area. Consequently, there is an urgent need for decarbonizing production processes and energy generation.

Moreover, Western Macedonia and Lusatia are participants in the Initiative for Coal Regions in Transition, which supports the transition of EU lignite regions toward a low-carbon economy. This initiative also facilitates the exchange of experiences and the establishment of contacts for joint projects. While these regions share significant similarities and challenges in structural change, there are notable differences, particularly in political and financial support. The shift away from lignite coal mining and the transition to other economic sectors have substantial effects on the local population's economic well-being. To foster acceptance of these transformation measures, there is a need for information dissemination, education, and the reinforcement of sustainability principles. The general idea is to prepare former coal workers for employment in alternative sectors, including other industries, startup ventures, renewable energy expansion, or the tourism sector.

Another critical issue is gaining the population's acceptance during this comprehensive transformation process, especially in regions like the East German coal areas, which are undergoing this process for the second time. However, the lignite phase-out also presents opportunities, such as the large areas of former lignite mines that can be repurposed for large-scale renewable energy projects. Leveraging the knowledge, skills, and energy-related infrastructure of an energy region can aid in the transformation and decarbonization of energy production and industries. Achieving a transition to a low-carbon, climate-resilient society while increasing understanding and acceptance of the shift toward a sustainable economy and industry necessitates knowledge transfer and scientific education.

The Kozani workshop facilitated a robust exchange regarding the current state of structural change, particularly in the coal sector, and the associated social challenges in both regions. The workshop primarily focused on research and discussions surrounding climate education, environmental education, environmental law, and environmental policy. Participants included researchers, experts, and students from both universities, representing various perspectives from the central transformation regions in Greece and Germany, with a particular emphasis on social science, environmental science, and law. These workshop proceedings provide insights into these perspectives, which are crucial for understanding objections, delays, deficiencies, and points of contention in the transformation process. Ultimately, this process aims to create a win-win situation for the former coal regions and serve as a model for transformation processes related to phasing out fossil fuels in other parts of Europe and the world.

It is important to note that all contributions in this volume reflect the personal opinions of their respective authors. Despite reasonable efforts, the editors cannot guarantee the accuracy of all the information and data presented in this publication.

On behalf of the editors

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Cottbus/Kozani, 03.11.2023

Forewords

The weight of addressing the formidable challenge of a just transition looms large over our region. It demands significant policy shifts, legal reforms, economic transitions, and technological advancements. At its core, it necessitates a recognition that we cannot accomplish these goals in isolation; we must actively engage and educate our society. With this profound understanding as our guiding principle, we embark on a transformative journey. Our vision is to establish a collaborative education and knowledge transfer network between two esteemed institutions of higher learning, the University of Brandenburg in Germany, and the University of Western Macedonia in Greece. Together, we are united in our commitment to address the vital topics of climate and environmental protection.

Central to this collaborative approach is the active engagement of experts and students from both universities. We recognize that the strength of our endeavor lies in the synergy of our collective efforts. Beyond academia, we aim to actively involve stakeholders in our respective regions, understanding that real change requires the inclusive participation of all who call these places home.

This project is more than an educational endeavor; it is a call to action. We envision it as a catalyst for a dynamic process of dialogue and involvement that transcends geographical boundaries. It is a bridge connecting cultures, disciplines, and, most importantly, the people who share a stake in the future of our regions.

In conclusion, I extend my deepest gratitude to all those who have joined us on this pioneering initiative. It is our collective commitment and dedication that will guide our regions toward a future that is not only sustainable and environmentally responsible but also marked by a just transition that safeguards the livelihoods of the people of Western Macedonia. Together, we stand united to confront the pressing challenges of climate change and environmental protection. Together, we hold the power to craft a brighter and more equitable world for the generations that will follow.

George Kasapidis
Regional Governor of Western Macedonia

The Lusatian lignite mining region is in the middle of a far-reaching transformation process and structural change. With the Coal Regions Investment Act, which came into force on 8 August 2020, the federal government is supporting the Rhineland, Lusatia and Central Germany lignite regions affected by the coal phase-out with a total of up to 40 billion Euros. The Lusatian coal region, which spans the federal states of Brandenburg and Saxony, will receive up to 17.2 billion € in structural support funds.

To establish a functioning unit for the implementation of structural development, we have taken a new path, supported by the federal state and the municipalities affected by the coal phase-out. This means that local actors from the region, the municipalities, politics, ministries, business, research, science and culture develop and qualify thoughts and ideas for projects. So far, this has resulted in a total of 68 projects, most of which are municipal.

In parallel, infrastructure, research and innovation investments are being established in the region through the federal ministries. In addition, the federal state's government, together with the federal government and the state of Saxony, is developing the model region of Health Lusatia with its core of the new university medicine in Cottbus, which focuses on digitalisation in the health sector, teaching and research. Brandenburg established accompanying research on structural change at a very early stage, which has already provided important findings and indications.

It was promptly identified that the existing measures, of which at least 80 % can contribute to an increase in added value, have already compensated for the substitution of the jobs potentially made redundant by the coal phase-out. Much more of a challenge now is to supply the region with labour force, in particular skilled workers. In addition to good jobs with good wages, this can only succeed if attractive living conditions are also offered and communicated.

The BTU is significantly involved in numerous research activities. We are all the more pleased that the exchange with other mining regions in Europe affected by the transformation process, such as the region of Western Macedonia, is being propelled so actively. The joint project shows the similarities but also the different challenges associated with structural change. The great opportunity that lies in the process of change can only succeed if the people of both regions are convinced that Lusatia and Western Macedonia will establish themselves as attractive places to live and do business.

Dr. Klaus Freytag
State Chancellery of Brandenburg
Commissioner for Lusatia of the Minister President

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1 Phasing out Lignite Mining in Germany

Eike Albrecht

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1.1 Introduction

In 2015, the international community of states adopted the Paris Agreement.[1] The central objective is to limit the increase in the global average temperature to well below 2 degrees Celsius and, if possible, to 1.5 degrees Celsius compared to pre-industrial levels in order to keep the effects of global climate change as low as possible (Art. 2 para. 1 (a) Paris Agreement). With regard to this goal, there is some discussion about recognising this as binding as international customary law; then also the non-ratifying states would also be bound to it (Albrecht, 2019), but regardless of this, this goal, which is binding for Germany under international law through ratification of the Paris Agreement, is set out in Art. 1 of the Federal Climate Protection Act[2] (Albrecht, 2023).

The Paris Climate Agreement has been ratified by almost all states in the world (only three states, all states with significant impairments to internal structures, sometimes also referred to as “failed states”, have not ratified), also by the EU[3] and the Federal Republic of Germany[4] (Albrecht, 2023). All parties to the Paris Agreement are working to achieve this goal and are submitting their climate protection goals to the United Nations Climate Change Secretariat in Bonn as so-called Nationally Determined Contributions (NDC) in accordance with Art. 3 of the Paris Agreement (Pastushenko/Albrecht, 2021). The industrialised countries are particularly challenged because of their historical responsibility for the greenhouse gases released since industrialization. The EU as a party to the

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[1] Paris Agreement [Dec. 13, 2015], in UNFCCC, COP Report No. 21, Addendum, at 21, U.N. Doc. FCCC/CP/2015/10/Add.1 [Jan. 29, 2016]; UNTS vol. 54113, p. 1.

[2] Federal Climate Protection Act of 12 Dec 2019, Federal Law Gazette I, p. 2513, amended by Article 1 of the law of 18 Aug 2021, Federal Law Gazette I, p. 3905.

[3] Council Decision (EU) 2016/1841 of 05 Oct 2016 on the conclusion of the Paris Agreement concluded under the United Nations Framework Convention on Climate Change on behalf of the European Union, OJ EU, L 282, p. 1.

[4] Federal Law Gazette 2016 II, p. 1082, 1083.

Paris Agreement targets its responsibility with a policy package, the "European Green Deal",[5] and aims to become the first climate-neutral continent by 2050.

1.2 German Climate Targets

Germany has set itself the goal of reducing greenhouse gas emissions by at least 65 % compared to 1990 levels by 2030 (Art. 3 para. 1 no. 1 Federal Climate Protection Act). Ten years later, greenhouse gas emissions should be reduced by at least 88% and climate neutrality should be achieved by 2045.

1.3 Climate Protection Ruling of the German Federal Constitutional Court

These ambitious goals are by no means just political wishes, as the first Senate of the Federal Constitutional Court decided on 24 Mar 2021[6] and stated that parts of the Climate Protection Act are not compatible with the Constitution. This decision particularly relates to the mandatory reduction of greenhouse gas emissions by 55% by 2030 (compared to 1990). The reason for the unconstitutionality was that the previous Federal Climate Protection Act (2019) lacks sufficient measures with precisely defined numerical values for emission reductions from 2031, but should only be regulated through ordinances. However, this threatens to create a situation in which the next generations could be exposed to the risk that the CO^2 budget will have already been largely used up by then due to a lack of regulations for the period from 2030 onwards. This could lead to serious losses of freedom (without the Federal Constitutional Court having even named specific freedom rights here), because practically all freedom is potentially affected by the emission reduction obligations in the future because almost all areas of life are linked to the emission of greenhouse gases. The use of freedom today cannot be organised without taking into account the freedom of the next generation.

The Federal Constitutional Court relies centrally on Article 20a of the Basic Law, the German Constitution which obliges the state to protect the natural foundations of life and animals, which also includes climate protection measures. Art. 20a Basic Law is not a fundamental right, but (merely) a state objective (Albrecht/Küchenhoff, 2015: marginal no. 194d); In this specific case, however,

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[5] European Green Deal (COM/2019/640 final).

[6] German Federal Constitutional Court, Decision of 24 Mar 2021 – 1 BvR 2656/18, 1 BvR 78/20, 1 BvR 96/ 20, 1 BvR 288/20, BVerfGE (official collection of decisions of the Federal Constitutional Court, volume) 157, p. 30 ff.

this (of course) includes implementing the internationally binding climate protection goals from the Paris Agreement domestically. The Federal Constitutional Court set a deadline of 31 Dec 2022 for amending the Climate Protection Act, during which the legislature must regulate the reduction targets for greenhouse gas emissions after 2030 in more detail.

This decision of the Federal Constitutional Court was described as historic (Kahl, 2021: 273; Faßbender, 2021: 2085), revolutionary (Callies, 2021: 255 f.), epochal (Muckel, 2021: 611), spectacular (Wefing, 2021; Wagner, 2021: 2256), as a milestone (Hofmann, 2021: 1587), probably widely recognized worldwide (Ekardt & Heß, 2021a: 1421; Ekardt & Heß, 2021b: 579). There is nothing to add to this classification.

Apart from the fact that the Federal Constitutional Court's decision has already led to significantly more ambitious goals for the legislature within just a few weeks, the actual meaning is to see compliance with internationally agreed climate protection goals, which are therefore sometimes not viewed as binding domestically, as a constitutional requirement. In this respect, the legislature has been deprived of a significant proportion of its fundamental power to shape matters, and thus also the scope for influencing political action. The Federal Constitutional Court has thus “pacified the battleground” and made it clear that climate protection is a state goal, not sometime in the future, but now (Kahl, 2021: 273).

1.4 Sectors of the Federal Climate Protection Act

The Federal Climate Protection Act sets different reduction pathways for the different sectors, mentioned in Art. 4 para 1 no. 1-6 Federal Climate Protection Act. These are

(1) energy industry (No. 1),
(2) industrial sector (No. 2),
(3) transport (No. 3),
(4) buildings (No. 4),
(5) agriculture (No. 5) and
(6) waste management and other (No. 6)

and they fundamentally have to become climate neutral. This poses particular challenges for the energy-intensive industry, but even more for the energy sector. To achieve this goal for the energy sector Germany is phasing out coal – currently with the goal of the end of 2038 (see Art. 4 para 1 sent. 1 Law to reduce and end coal-fired power generation).[7] Meanwhile, the end of the production of electricity by lignite in the West German Rhenish lignite region is planned for 2030. The respective amendment of the law entered into force Christmas 2022.

Decarbonisation is therefore particularly important as a transition process in the (energy) economy with the aim of significantly reducing and, in the best case, neutral greenhouse gas emissions in industrial production processes. This may be difficult (Frenz, 2021: 203), but it must be implemented by the legislature due to the clear international and constitutional legal situation. Decarbonisation basically affects all sectors and, in the industrial production sector, in principle all branches of industry. Of course, those industries that emit a particularly large amount of CO^2 due to processes are particularly affected and the production of electricity by burning lignite is amongst those branches.

1.5 EU Emission Trading and Phasing out Lignite

Lignite mining and the use of lignite for electric energy production and heating falls widely under emission trading, regulated by EU- and national law. The original idea is to organise the phasing out of CO^2-intens production processes via a market based scheme under the European emission trading.

But this system seems to have some shortfalls. On the one hand side, it obviously does not have the intended regulation effect. Lignite and also black coal power plants are still economic reasonable, in particular in times of high energy prices, which blocks and delays the necessary change to renewable energies. In the other hand, there are several industrial sectors with so high transformation costs for the decarbonisation of their industrial processes that emission trading alone will not be sufficient to change steel, cement or chemical production processes from carbon-intensive to carbon-free technology. In this case, instruments like Carbon Contracts for Difference (CCfD)[8] may be used for

[7] Law to reduce and end coal-fired power generation of 08 Aug 2020 (Federal Law Gazette I p. 1818), lastly amended by Art. 1 of the Law of 19 Dec 2022 (Federal Law Gazette I p. 2479).

[8] A Carbon Contract for Difference (CCfD) is a contract between a corporation and a public administration (so called public law contract according to Art. 54 ff. Administrative Procedures Act (in the version of 23 Jan 2003 (Federal Law Gazette I p. 102), last amendment by Art. 24 para 3 of the Law of 25 Jun 2021 (Federal Law Gazette I p. 2154). A CCfD sets a fixed carbon price over a given period to reduce the investment risk for corporations. It intends a sharing of the CO^2 costs between the public and private corporations. They are particularly important for corporations planning to invest in low-carbon technologies for long-term competitiveness but where the investment costs for transformation of the processes are high and the innovation cycles are long (Gerres & Linares, 2022). Typical examples are steel or cement production sites but also other forms of primary industries.

industry sectors with high process-related emissions to support such industries in the transformation process (German Federal Government 2020), even though there are numerous open questions which seem to be partially still unsolved. Such contracts may contradict EU emission trading, violate EU-state aid law and pose legal objections in respect to national civil rights of corporations to use their property as they like.

But, in respect to the producer of electricity the number of "players" is rather low; thus direct negotiations and a kind of a bidding system may work better than for energy intensive industries where several hundreds of corporations are actively involved in the market. Thus, the phasing out of coal and lignite in the electricity production follows a different pathway which is regulated in the Law to Reduce and End Coal-fired Power Generation. The objective of this law is to phase out coal-fired power generation (latest) by the end of 2038 (see Art. 2 para 2 no. 3 Law to reduce and end coal-fired power generation).

This law is the result of the work of the Commission for Growth, Structural Change and Employment or often just called "Coal Commission" which was set up by the German federal government on 06 Jun 2018. The objective of the Coal Commission was the preparation of recommendations for the social and structural development of the lignite regions as well as for their financial security. This included in particular the consideration of climate protection, economic growth and job protection. This Commission ended its work with a final report suggesting a wide range of measures, activities and policies, including estimations of finances needed.[9]

1.6 Details of the Law to Reduce and End Coal-Fired Power Generation

The phasing-out of coal-fired power generation in Germany is mostly regulated in the Law to Reduce and End Coal-fired Power Generation. This law is the basis for the reduction of coal-fired power plant capacities. Art. 4 of the Law to Reduce and End Coal-fired Power Generation sets a reduction path for this objective. According to this reduction path, the net nominal output of the hard and lignite plants on the electricity market should amount to a total of 30 GW in 2022, 17 GW in 2030 and a total of 0 GW in 2038. The law differentiates between hard coal and lignite power generation: According to Art. 5 Law to Reduce and End Coal-fired Power Generation, the phasing-out of hard coal power generation

[9] The report is available under https://www.bmwk.de/Redaktion/DE/Downloads/A/abschlussbericht-kommission-wachstum-strukturwandel-und-beschaeftigung.pdf?__blob=publicationFile&v=1, last accessed, 11 Nov 2023.

takes place through tenders for power plant capacities that are to be shut down in return for payments from the state, or at the latest from 2027 through official orders, by then without compensation. In respect to lignite-fired power plants, mutual agreements in form of a public law contract according to Art. 54 ff. Administrative Procedures Act[10] with the companies concerned will regulate the phasing out. This contract is already concluded[11] and should concretise details of obligations and rights of the parties (Stürmlinger & Fuchs 2021: 324). The reason for the using of such a public law contract is to secure a high level of legal certainty, in particular by accepting a comprehensive waiver of action by the lignite power plant operators (Schneider, 2022: 11).

Art. 44 para 1 of the Law to Reduce and End Coal-fired Power Generation grants a statutory compensation in total of 4.35 billion € for closures before 2030 for the operators of large lignite plants. These compensation payments are intended to cover the follow-up costs of opencast mining in a timely manner (Altenschmidt, 2021: 532). Art. 14 of the Contract regulates, that there “is agreement between the contracting parties that the compensation for this is used to cover the follow-up mining costs in a timely manner. The Opencast mining operators and the special purpose companies will therefore take care of this bear that at the time when the follow-up costs for opencast mining are due sufficient financial resources are available to cover these costs.”

The special issue of securing, remediation and recultivation of open cast mines are, as well as the greater complexity of lignite-fired power generation a justification to treat the operators differently to the operators of hard coal-fired power plants (Altenschmidt, 2021: 532). But, this poses also some open questions, e.g. is the operator of the lignite mining allowed to invest these finances in – for example – renewable energies for using their revenues for the remediation/recultivation, or would this conflict with the wording or the intention of the Contract.

1.7 Phase-Out Regulations for Lignite-Fired Power Plants

The Law to Reduce and End Coal-Fired Power Generation’s concept for ending lignite power generation regulates – different to the phasing out of hard coal power plants – on a mixture of legal restrictions on the one hand and contractual

[10] Administrative Procedures Act in the version of 23. Jan 2003 (Federal Law Gazette I, p. 102), last amended by Art. 24 para 3 of the Law of 25 Jun 2021 (Federal Law Gazette I, p. 2154).
[11] German Parliament Bulletin (BT-Drucksache) 19/25494 of 05 Jan 2021.

agreements between the Federal Republic of Germany and the operators of the lignite mines and power plants.

According to Art. 40 ff. of the Law to Reduce and End Coal-Fired Power Generation there are specific fixed dates for phasing out lignite power plants latest. Details are regulated in Annex 2 to the law. The final closure date of the Lusatian power plants is 31 Dec 2028 (Jänschwalde A, Jänschwalde B, Jänschwalde C and Jänschwalde D), 31 Dec 2029 (Boxberg N and Boxberg P) and 31 Dec 2038 (Schwarze Pumpe A, Schwarze Pumpe B, Boxberg R and Boxberg Q). The majority of lignite power plants ending their operation are such in the Rhenish lignite region to achieve the goal of reducing lignite power plant capacity to 15 GW by the end of 2022. Ten more power plant blocks will be shut down by 2030, with three of them set to go into a security standby operation. But, there are adaptions to this schedule possible: if the transfer to security standby for the period after 2028 is not necessary from an energy industry perspective, those power plants will be permanently shut down – according to Art. 47 para 2 of the Law to Reduce and End Coal-Fired Power Generation – at the time at which it should be transferred to security standby (Stürmlinger & Fuchs, 2021: 324). The goal is to only have around 9 GW of lignite on the grid by the end of 2030. According to the original intention of law, to shut down the twelve remaining plants, eight of which are located in the East German mining areas, by the end of 2038 at the latest, is meanwhile overtaken by the decision of the operator of the Rhenish power plants to phase out the lignite power plants in the Rhenish region by 2030.

For the final closure of lignite power plants, the operators will receive compensation payments. In accordance with Art. 44 para 1 of the Law to Reduce and End Coal-Fired Power Generation RWE Power AG will get 2.6 billion € and Lausitz Energie Kraftwerke AG (LEAG) 1.75 billion € as compensation for implications in electricity production and trading, for restructuring measures for personnel and should be used for recultivation and remediation (Stürmlinger & Fuchs, 2021: 324). The amount of compensation remains unchanged even in the event that shutdowns occur before the dates specified in Annex 2 of the Law to Reduce and End Coal-Fired Power Generation (Art. 44 para 3 of the Law to Reduce and End Coal-Fired Power Generation).

If this compensation clause and agreement comply with European law is not clear. The EU Commission has initiated an in-depth investigation in March 2021[12] On 2 Mar 2023, the Commission extended the scope of this investigation

[12] State Aid – Germany, State aid SA.53625 (2020/N) — Lignite phase-out; Invitation to submit comments pursuant to Article 108(2) of the Treaty on the Functioning of the European Union (Text with EEA relevance), OJ EU C, p. 50.

into Germany's plans to compensate RWE and LEAG for the early lignite phase-out to consider an amendment to the agreement between Germany and RWE for the accelerated lignite phase-out in the Rhenish lignite mining area by 2030.[13]

The legal requirements are supplemented by the regulations of a public contract between the Federal Republic of Germany and various lignite companies.[14] In this context, in addition to the legal regulations, this also contains a contractual fixation of the decommissioning path. It also regulates details of compensation in accordance with Art. 44 Law to Reduce and End Coal-Fired Power Generation. To regulate specific details of the phasing out of lignite was recommended by the Coal Commission (Stürmlinger & Fuchs, 2021: 324) and honours the specific mining law responsibilities of the opencast mine operators.

The Law to Reduce and End Coal-Fired Power Generation also provides for the option of accelerated decommissioning for lignite plants. According to Art. 47 para 1 of the Law to Reduce and End Coal-Fired Power Generation, as part of the evaluations in accordance with Art. 54 and 56 of the Law to Reduce and End Coal-Fired Power Generation in the years 2026, 2029 and 2032, it will also be checked whether the decommissioning date specified in Annex 2 of the law is after 2030 brought forward by up to three years in each case, so that the completion date of 2035 can also be achieved. However, the security standby period envisaged for such lignite plants should not be shortened.

The existence of the most long-term planning and investment security is of great importance in lignite power plants, also because of the need to generate reserves for the follow-up costs of opencast mining. This is taken into consideration by the public law contract concluded between the Federal Republic of Germany and the lignite companies. On the other hand, the lignite companies were highly interested in achieving a high degree of legal and planning security. This is expressed in various places in the preamble to the contract and in Art. 22 para 2 (c) of the contract.

Furthermore, Art. 20 para 2 of the Contract also emphasizes that the Federal Republic of Germany's legislative competence in the area of energy and climate policy are not restricted by the Treaty. However, in accordance with Art. 20 para 2 sent 2 of the contract, this should not exclude the possibility for claims by the lignite companies to adjust the contract. In the regulatory part of the

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[13] See answer of Commissioner Vestager of 29 Mar 2023, available under https://www.europarl.europa.eu/doceo/document/E-9-2023-000468-ASW_EN.html#def1, last accessed 13 Nov 2023.

[14] For details to this contract see: German Parliament Bulletin (BT-Drucksache) 19/25494 of 05 Jan 2021.

contract, in this context, in Art. 20 para 4, the reviews provided for in Art. 54 and 56 of the Law to Reduce and End Coal-Fired Power Generation and any resulting decommissioning of lignite plants, which may be brought forward by three years, are a circumstance known to the parties, which is can lead to a change in the conditions existing at the time the contract was concluded.

Art. 20 para 4 of the Contract allows so-called early decommissioning. This does not apply to lignite plants that are on safety standby after 2030 according to the decommissioning path. The early decommissioning takes place without compensation in accordance with Art. 22 para 2 (a) of the Contract if the decision in this regard is made at least five years before the early decommissioning date. In this case, the payment modalities of the statutory compensation have to be adjusted (Art. 22 para 2 (c) of the Contract). All other cases of adjustments are regulated in Art. 21 para 1 sent. 3 (a) of the Contract, e.g. requesting an appropriate adjustment of the contract in accordance with Art. 21 para 2 sent. 1 of the Contract. The aim of such a contract adjustment should be to restore contractual equivalence, taking into account all the circumstances of the individual case (Altenschmidt, 2021: 534).

On question in the whole discussion about phasing out hard coal and lignite power plants was the legality of such closure regulation under federal constitutional law in particular to protection trust (Altenschmidt, 2021: 534). This may be subject to a constitutional court decision. But, in particular for lignite power plants, such a constitutional claim will (probably) never been brought up because of the public law Contract which was agreed between the operators of lignite power plants and the Federal Government.

On the other hand, earlier dates for a phasing out of coal fired power plants is not included in the current regulations of the Law to Reduce and End Coal-Fired Power Generation. Any reduction in the remaining operating times of the affected power plants would have a more severe impact on basic rights of the plant operators affected, in particular the protection of property under Art. 14 para 1 of the Basic Law, as well as restrictions on the freedom to practice a profession guaranteed by Art. 12 para 1 of the Basic Law (Altenschmidt, 2021: 534).

1.8 Deletion of CO² certificates

For the operation of hard coal and lignite power plants emission certificates are required (Art. 4 sent. 1 Emission Trading Directive[15] and Art. 4 para 1 of the Greenhouse Gas Emissions Trading Act[16]). If such power plants are stopping operation, the operator may use the certificates which are not needed anymore for other purposes or may sell them. If this would be allowed, phasing out lignite or hard coal will not have any effect for reaching the climate target (Schneider 2022: 22). But, here are obviously some obstacles; recently, a German newspaper wrote: “Emissions trading: The controversial coal phase-out has so far been meaningless” (Mayerhofer, 2023), there are reports stating, that the German Government has failed to delete the emission certificates of those power plants which are already shut down, yet (Mayerhofer, 2023). To avoid inconsistency, the federal government is committed to delete the CO² certificates released due to additional emissions reductions caused by the closure of power plants, even though at the moment the process is to do so is not functioning very well.

1.9 Law for Strengthening Structures in Coal Regions

In addition to the Law to Reduce and End Coal-fired Power Generation the Law for Strengthening Structures in Coal Regions Compromise[17] was set in force. Both acts are the result of long negotiations with all affected political, economic and social groups in the aforementioned Coal Commission and is based mainly on its final report. Thus, it represents a compromise between the different interests of various interest groups which took climate protection, economic growth and protection of employment into account (Reitzenstein et al., 2021: 32 f.). The main goal in respect to employment and economy was to create new, high-quality employment to compensate for the future loss of the jobs in coal mining and electricity production. Furthermore, the infrastructure should be expanded to attract new companies for young people having future prospects. This includes also the extension and strengthening of research and study in the regions.

[15] Directive (EU) 2018/410 of the European Parliament and of the Council of 14 Mar 2018 amending Directive 2003/87/EC to enhance cost-effective emission reductions and low-carbon investments, and Decision (EU) 2015/1814 (Text with EEA relevance), OJ EU L 76, p. 3.

[16] Greenhouse Gas Emissions Trading Act of 21 Jul 2011 (Federal Law Gazette. I, p. 1475), last amended by Art 18 of the Law of 10 Aug 2021 (Federal Law Gazette I, p. 3436.

[17] Law for Strengthening Structures in Coal Regions Compromise of 8 Aug 2020, Federal Law Gazette I, p. 1795.

The financial support is immense. All three German lignite regions will get an additional financial support up to 40 billion € for changing their structures until 2038 on base of an agreement between the Federation and the affected federal states. This agreement makes it possible to implement specific projects in the coal regions and to spend the planned budget funds. This is monitored by annual reports on the implementation status of the investments. First successes are visible: the new maintenance works of German Rail (Deutsche Bahn) in Cottbus is halfway built; even though detailed numbers of newly created jobs are difficult to determined, more than 3,000 new jobs are already created in the lignite regions through the establishment of authorities and federal institutions, as the Federal Government informed at 24 Feb 2023.[18]

1.10 Result

The end of coal-fired power generation in the next decade has been set by law. But such a regulation has – of course – impacts on rights guaranteed under the German Constitution and may be challenged by a constitutional claim. Even though, some of the legal uncertainties are levelled by negotiating a public law contract with the operators of lignite power plants and generous compensation for the closing of lignite power plants. In any case, there is a fundamentally based trust in the existence of 31 Dec 2035 as the earliest possible end date of the state-enforced end to the use of coal-fired power plants to generate electricity (Altenschmidt, 2021: 537). Earlier phasing out is possible only with financial compensation or within a contract between the operator of the plant and the Federal Government, like for the phasing out of the Rhenish lignite mining and power production until 2030 on base of the Law to Accelerate Phasing-out of Lignite in the Rhenish Mining Area.[19]

Concerning the transformation of the lignite regions beyond the phasing out of lignite power production, it may be noted that the financial support of up to 40 billion € is immense. This may ease the phasing out of lignite mining and electricity production and may pacify the situation on ground, in particular in the East German lignite regions, undergoing a structural break a second time after the economic clash in the aftermaths of the reunification (Reitzenstein et al., 2021: 32 f.). But, so far, the expected political dividend is not yet visible. Maybe

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[18] Available under: https://www.bundesregierung.de/breg-de/schwerpunkte/klimaschutz/kohleausstieg-1664496, last accessed 13 Nov 2023.

[19] Law to Accelerate Phasing-out of Lignite in the Rhenish Mining Area of 19 Dec 2022, Federal Law Gazette I, p. 2479.

this changes with visible development of infrastructure, administration and industry. Finally, it should be emphasized that this transformation should involve a just transition through which no one is left behind ("leaving no one behind" according to Principle 2 of the 2030 Agenda for Sustainable Development and its Sustainable Development Goals (SDGs)[20] (Albrecht, 2023). It is therefore important to involve the public in order to build additional trust and create acceptance of the measures. This includes, for example, keeping the energy price for consumers within an affordable price range, possibly through subsidies or other financial compensation, and, ideally, allowing them to benefit from the restructuring of the energy sector.

[20] UN General Assembly, Transforming us World: the 2030 Agenda for Sustainable Development, 21 Oct 2015, A/RES/70/1).

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2 From Coal to Renewables: Using Knowledge Transfer for a Smooth Transition to Green Energy in the EU

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2.1 Introduction

Formed under immense heat and pressure underground, coal is a cheap and abundant source of fuel and energy. Coal became one of the most important factors to support the industrial revolution guiding steel and iron production, power generation, railways, and manufacturing among others (Finkelman, Wolfe, & Hendryx, 2021). However, coal produces significant harm and impacts both the environment and the human health. Due to these same reasons, coal is often referred to as "dirty fuel" and thus alternatives are being sought.

Globally, coal is mostly used as an energy source in the heavy industry sector (BP, 2023). The same holds true for the European Union as well. In 2021, 68.4% of all the available energy in the EU was derived from crude oil, coal, and natural gas where coal alone constituted 10.2% in the energy structure (The European Commission, 2023a). The trend of coal use, however, has been declining since the late eighties. In the recent decade, the International Energy Agency (IEA) recorded the highest decline in coal usage of 2.8% in 2015 followed by another 6.3% decrease in the following year (IEA, 2016a). This was during the same time as the Paris Agreement, where member states of the UNFCCC (United Nations Framework Convention on Climate Change) strongly proposed and showed their commitment towards the key target of holding the global temperature well below 2ºC above preindustrial levels. As coal is the primary culprit in global greenhouse gas emissions – that contribute to global rise in temperature – there needs to be significant mechanisms and strategies to support the phasing out of coal (Edwards, 2019).

However, an energy transition (from coal to renewables) is more than just simply replacing fossil fuel from the energy system but rather, this process involves complex socio-economic obstacles. (Schwab & Diaz, 2020) mentions that the energy transition should be viewed as a "social project" and not simply as a technical and economic task. Stakeholder coordination, public participation and acquisition of knowledge are all important factors for a successful energy transition, the latter of which can provide a platform for communication (Arora & Schroeder, 2022). As such, the purpose of this paper is to propose the possibilities of using knowledge transfer to address these obstacles and facilitate a smooth energy transition. Through literature review we have identified two principal challenges posed by the energy transition

a) Job Security (Hafner & Raimondi, 2020), (Vandeplas, Vanyolos, Vigani, & Vogel, 2022), (Buck, Graf, & Graichen, 2019), (Mrozowska, Wendt, & Tomaszewski, 2021),
b) Social Acceptance (Musall & Kuik, 2011), (Evensen, Becker, & Pidgeon, 2018), (Krick, 2018).

We discuss these identified challenges and how knowledge transfer can be used as a positive intervention to mitigate these challenges. Therefore, the paper tries to present the opportunities of knowledge transfer in opening the way for a smooth energy transition in the EU. The first section of the paper provides an overview of some important EU policies towards reducing emissions focusing on energy efficiency and sustainability. Then the paper presents the challenges (mentioned above) faced by the energy transition and how they affect the implementation of green energy policies. The following section is then dedicated to knowledge transfer and how it can be used as a method to solve the aforementioned challenges of the energy transition.

2.2 EU's Policies and Commitments

Fossil fuels, particularly coal, contribute the most to greenhouse gas emissions highlighting the urgent necessity to reduce coal usage and transition to renewable energy sources (United Nations, 2023). Global greenhouses gas emissions are causing environmental concerns, including increasing temperature, extreme climatic conditions like severe droughts and flooding, biodiversity loss, rising ocean level, and socio-economic concerns like food insecurity, health risk and poverty (United Nations, 2023). These changes have led to significant loss for the EU's. To illustrate, river flooding alone caused the EU €5 billion annually and forest fires cause approximately €2 billion in financial damages (The European Council, 2023). Many studies have emphasized the crucial need to reduce greenhouse gas emissions substantially to mitigate extreme climate impacts and create a sustainable environment and as such various policies have been put in place in the European Union.

After the Kyoto Protocol (1997)[1] and the Doha Amendment (2012),[2] the climate conference in Paris, COP21, participated by 196 countries, led to a new legally binding treaty called Paris Agreement (2015),[3] targeting to limit the global temperature increase to below 2 C, above pre-industrial level, with an aim to cap the increase at 1.5 C. Initially, the EU ratified the agreement in October 2016, committing to a 40% emission reduction by 2030.[4] In December 2020, EU revised their NDC,[5] targeting a 55% reduction by 2030, aligning with the broader 2030 climate and energy framework.

The EU Emission Trading System (EU ETS), effective since in 2005,[6] is the world's largest carbon market. Through this system, emissions in EU have been decreased by 43% in sectors like power, energy-intensive industrial sector, and commercial aviation, which collectively accounts for 41% of the EU's total emissions (The European Commission, 2023b). The Energy Efficiency Directive, first adopted in 2012[7] and amended in 2018[8] and 2023,[9] sets binding targets for improving energy efficiency across various sectors while also assisting in emissions reduction (The European Commission, 2023c). It mandates increased energy efficiency across the entire energy chain, from generation to consumption, initially aiming for 20% improvement by 2020, which was later

[1] Adopted 11.12.1997; entry into Force: 16.02.2005; U.N.T.S. vol. 2303, p. 162; 37 I.L.M. 22 (1998); see for details Albrecht (2022a), pp. 128 ff.

[2] Signed 08.12.2012; entry into force: 31.12.2020; Doc. FCCC/KP/CMP/2012/13/Add.1, Decision 1/CMP.8 (Dec. 8, 2012).

[3] Adopted 12.12.2015; entry into force: 04.11.2016; U.N.T.S. vol. 3156; 55 I.L.M. 740 (2017); see for details Albrecht (2022b), pp. 142 ff.

[4] Council Decision (EU) 2016/1841 of 5 October 2016 on the conclusion, on behalf of the European Union, of the Paris Agreement adopted under the United Nations Framework Convention on Climate Change, OJ EU L 282/1.

[5] Communication from the Commission to the European Parliament and the Council: The Paris Protocol – A blueprint for tackling global climate change beyond 2020 (COM/2015/081 final); Nationally Determined Contributions (NDCs) provide ever increasing ambitious plans and targets against climate change, submitted by the signatories every 5 years.

[6] Directive (EU) 2023/959 of the European Parliament and of the Council of 10 May 2023 amending Directive 2003/87/EC establishing a system for greenhouse gas emission allowance trading within the Union and Decision (EU) 2015/1814 concerning the establishment and operation of a market stability reserve for the Union greenhouse gas emission trading system (Text with EEA relevance), OJ L 130, p. 134.

[7] Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC (Text with EEA relevance), OJ L 315, p. 1.

[8] Directive (EU) 2018/2002 of the European Parliament and of the Council of 11 December 2018 amending Directive 2012/27/EU on energy efficiency (Text with EEA relevance.), OJ L 328, p. 210.

[9] Directive (EU) 2023/1791 of the European Parliament and of the Council of 13 September 2023 on energy efficiency and amending Regulation (EU) 2023/955 (recast) (Text with EEA relevance), OJ L 231, 20.9.2023, p. 1.

amended to a more ambitious target of 32.5% improvement compared to 2007 levels, aligning with the EU's 2030 climate and energy framework.

The 2030 climate and energy Framework, approved by the European Council in 2014 as an extension and enhancement of the 2020 climate and energy package, aims to strengthen the EU support system, making it more competitive, secure, and sustainable. The main goals of this framework include 55% reduction in greenhouse gas emissions (revised from the 40% reduction), a 32% share of renewable energy and a 32.5% improvement in energy efficiency. This, along with the Paris Agreement, advances the European Green Deal's objective of achieving a climate-neutral economy.

Introduced in 2019, European Green Deal[10] outlines a comprehensive strategy to transition the EU's economy into a sustainable and climate friendly model by 2050. It focuses on climate, energy, environment, biodiversity, transport, agriculture, industry, and sustainable finance to achieve its goal of climate neutrality. These targets are written into law by the European Climate Law, published in 2021. It legally enforces the targets for reducing emission by 55% by 2030 and a full climate neutrality by 2050. Furthermore, it includes mechanisms for monitoring progress and adjusting policies, aligning with the commitments of the Paris Agreement, and undergoing a five-year cycle review.

The "Fit for 55 package" is a collection of proposals to review and update EU regulations and initiate new processes for EU policies to align with the European Union's climate targets (The European Council, 2023). This initiative prioritizes a just energy transition, enhances technological innovation, and aims to bolster the EU's leadership role in combating climate change. Moreover, this package also suggests revisions to key directives like the EU ETS, Energy Efficiency Directive, and Renewable Energy Directive to better align with current climate targets.

Established in 2009 with a target of 20% renewables by 2020, The Renewable Energy Directive (RED)[11] underwent a 2018 amendment[12] setting a 32% binding target by 2030 for the entire EU economy. The directive not only brings new measures to expand renewables but also encourages public participation

[10] Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions, The European Green Deal (COM/2019/640 final)

[11] Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC (Text with EEA relevance), OJ L 140, p. 16 (RED I).

[12] Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources (recast) (Text with EEA relevance), OJ L 328, p. 82 (RED II).

in the process (The European Commission, 2023d). In March 2023, a provisional agreement aimed to raise the 2030 target to at least 42.5%, in response to the global energy market disruption caused by Russia-Ukraine war (IEA, 2023). This adjustment lines up with the REPowerEU initiative under the “Fit for 55 package” (IEA, 2023) (The European Commission, 2023d). This process expedites the EU’s transition from Russian fossil fuels through energy savings, supply diversification, and accelerated deployment of renewable energy.

2.3 Challenges of the Energy Transition

One of the most obvious challenge of the energy transition would be seen in the labour market. The coal industry has been a central part of the socio-economic structure in many parts of Europe. Despite numerous studies suggesting an optimistic growth of ‘green jobs’ in the EU market because of the energy transition, the answer is not that straightforward. The industry provides employment to approximately 230,000 people through mines and power stations across eleven EU member states and 31 regions (The European Commission, 2023e). It is expected that around 77,000 cumulative jobs could be lost by 2025 with job losses reaching 2030 (Hafner & Raimondi, 2020). Regions and communities that are the most reliant on fossil-fuel would be the most vulnerable (Buck, Graf, & Graichen, 2019). Even communities with less direct jobs related to fossil fuel production will suffer a hit as the decommissioning of power plants effects the local economy (Cozy & Motherway, 2021).

Even if the “job-growth” arguments are correct, it is not a net benefit if the countries undergoing the transition initially do not have a growing production sector (Hafner & Tagliapietra, 2020). In cases like these, workers could be motivated to move to a region with more production activities, but migration may not always be possible (Cozy & Motherway, 2021). These spatial difficulties are also mentioned by (Vandeplas, Vanyolos, Vigani, & Vogel, 2022) which also states that the transition between jobs affect medium-skilled male workers more, as they may not always meet the increased skill cap of a newer industry as traditionally, coal dependent regions have lower educational priorities (Esposito & Abramson, 2021). Similarly, taking on new jobs may reduce the worker’s pay as well (Vandeplas, Vanyolos, Vigani, & Vogel, 2022). Job cuts can further bring unwanted social change like economic inequalities and energy poverty (Axon & Morrissey, 2020) (Streimikiene, 2022). These socio-economic inequalities also provide the second major challenge associated with the energy transition.

In the discussion it is stated that energy transition not only causes loss of jobs from the fossil fuel industry, but also make stakeholders lose their influence and profit (Arora & Schroeder, 2022). This leads the energy transition to face backlashes from the fossil fuel workers as well as the stakeholders who stand to lose money. It is also mentioned the same highlighting the probability of resistance from powerful stakeholders who profit from the current energy industry and workers most impacted by the transition (García-García, Carpintero, & Buendía, 2020). Such resistance can curve the momentum of the energy transition and can undermine, change, or delay the process (Arora & Schroeder, 2022). Public acceptance of energy change considers certain social dynamics between the energy transition process and the end consumers. A study in the UK (Evensen, Becker, & Pidgeon, 2018) showed that respondents primarily find governments and corporations to be responsible for the costs of energy system transitions rather than themselves. If respondents feel that the energy transition process is unjust and the cost are too high, they become reluctant to accept additional costs with regards to energy transition (Evensen, Becker, & Pidgeon, 2018). The German government faced difficulties in gaining public support for its *Energiewende*[13] and one the reasons was the unfair allocation of cost burden. The high distribution costs were borne by the private consumers in the form of higher energy prices, whereas the energy heavy industries were exempted from the surcharge to maintain their global competitiveness (Krick, 2018).

The consumers' willingness towards the energy transition is also dependent on their own personal perspectives as well. Segreto et al. identified and presented many factors that influence the social acceptance of renewables in Europe (Segreto, et al., 2020). These factors include economic and environmental benefits, public participation, trust in their institutions and fairness in the policies. Public support plays an instrumental role in determining the success or failure of energy system change because without acceptance, the transition may face oppositions from local communities and stakeholders resulting is delay or discontinuation (Segreto, et al., 2020).

2.4 Knowledge Transfer as a Solution

The concept of knowledge transfer is quite self-explanatory. It is the process of sharing or transferring information, ideas, experiences, abilities (collectively knowledge) between individuals or organizations with aims to encourage innovations and boost efficiency (Brown, 2023). Herfeld and Lisciandra provides a

[13] Energy transition from fossil to renewable energy (including phasing out nuclear power).

highly thorough definition of the topic (Herfeld & Lisciandra, 2019). The article defines knowledge transfer as a process with three requirements

a) there is knowledge in the source and not just institutions;
b) the knowledge is passed from the source to the target as per the context of a need; and finally,
c) the transferred knowledge satisfies the need i.e., either solves an existing problem or gets desired results.

It is important to note however that knowledge transfer is not the same as training, even though they are sometimes interchangeable. Nor is knowledge transfer the same as technology transfer. According to Gopalakrishnan and Santoro, training is a much narrow form of knowledge transfer that focuses on teaching specific procedures and skills for a particular task or job (Gopalakrishnan & Santoro, 2004). On the other hand, knowledge transfer is a broader concept focusing on providing knowledge that gives the understandings behind the reason for change and which can be applied in wider contexts. To add more, technology transfer refers to the move towards newer innovations, methodologies, products that act as specific tools to change the environment. Knowledge transfer, in a simpler term, can also be defined as a process of changing knowledge to action (Ward, House, & Hame, 2009). However, there is always a need of "intermediaries" in knowledge transfer (Lindkvist, et al., 2019). The role of these intermediaries is discussed later in the paper.

Knowledge transfer has been stated as a way to quickly jumpstart the renewable energy transition by making renewable technologies a global commodity (United Nations, 2023). In Europe, the European Commission has envisioned a cost-effective solution based on interregional and international projects in renewable energy, which can benefit from knowledge transfer and leads to innovation, performance improvement and economic processes (Grigorescu, Ion, Lincaru, & Pirciog, 2022). Effective knowledge transfer is important in order to promote better innovations, economic growth as well as social development (The European Commission, 2007). In terms of the energy sector, knowledge transfer is important because it can enable the increase of innovations and improvement of efficiency. Through knowledge transfer, firms can upgrade existing tools and develop new products, invest in new technologies that have been proven to be effective, collaborate on research projects while also remaining competitive (Johnson, Acri, & Moore, 2019). The primary objective of knowledge transfer in energy transition is to enable individual and communities to adapt to the changing energy systems while taking ownership of the energy projects by promoting social acceptance and public participation (Hanno, 2020).

Knowledge transfer can have a significant impact on the improving job security. The process of knowledge transfer involves the distribution of knowledge, ideas, and the best methods in order to improve individual and collective performances in the energy sector (Mattes, Schröter, Rohde, Hirzel, & Rainfurth, 2012). By sharing best practices and approaches, knowledge transfer helps in accelerating the adoption and deployment of new technologies. This can produce new employment opportunities in areas like research and development (R&D), engineering, project management among others (Ringrose, et al., 2013). Additionally, knowledge transfer is also important in the energy sector for increasing companies' performances, which again can help improve working conditions. To summarize, knowledge transfer is important to ensure job security in the energy sector as it helps workers acquire advanced skills, boost organizational performances, and allows for a competitive advantage for enterprises (Mattes, Schröter, Rohde, Hirzel, & Rainfurth, 2012).

Furthermore, knowledge transfer can also be an important tool for building trust and social assets among local stakeholder that help in the implementation of energy policies (Lutz, Fischer, Newig, & Lang, 2017). Krick provides an example of the German government's "consensus management strategy" that established a network of regional agencies in order to facilitate knowledge transfer and capacity building among local stakeholders (Krick, 2018). Such initiatives encourage public participation and can attract the public towards the policies and can make their implementation smoother. Likewise, the transfer of knowledge can also foster social acceptance through successful demonstrations of sustainable energy practices (Terrapon-Pfaff, Gröne, Dienst, & Ortiz, 2018).

Knowledge transfer is not only dissemination of existing knowledge but also creation of new information. Referred to as "citizen science" by (Tõnisson, et al., 2021) highlights that involving the public in scientific research (in this study air quality monitoring) can help scientist co-produce knowledge with the public while at the same time raising awareness about the issues and promoting a sustainable behaviour change and social acceptance. Another example of knowledge transfer being used as a platform to develop social acceptance and public participation is illustrated by Vega who also stated that the lack of knowledge transfer is the main challenge of energy transition (Vega, 2014). As such, this project aimed to enhance the energy efficiency in the Mediterranean area by introducing a knowledge transfer approach.

Here, it is important to mention the need of intermediaries for a successful knowledge transfer process. Intermediaries are individuals or organizations that play a key role in facilitating knowledge transfer between diverse stakeholders with different knowledge pools during different stages of the energy transition process. These intermediaries can be universities, non-governmental organizations (NGOs), local governments, among others that can make efficient and effective frameworks to distribute knowledge around the energy initiatives (Medved, Golob, & Kamin, 2023). These intermediaries play an important role in managing knowledge for innovation dissemination, coordination of information between stakeholders and promote public participation to gain social acceptance (Lindkvist, et al., 2019). For example, universities can act as a bridge in knowledge transfer between academic and non-academic agents. Their roles could range from customized educational programs, co-research, and direct knowledge delivery. They can furthermore also facilitate dialogue and collaboration while building trust between various stakeholders (Peer & Stoeglehner, 2013).

CECs[14] are also another example of intermediaries through which nurture knowledge transfer to promote alternatives to non-sustainable energy systems. CECs can serve as a learning setting for a wider social audience. The success and positive outcomes from these communities can provide case studies and means to attract more communities to substitute existing systems with more sustainable options. They can also focus on often neglected angle of learning and knowledge transfer as an integral part of innovation development (Medved, Golob, & Kamin, 2023).

2.5 Conclusion

The recent resurgence of coal in the EU is mostly correlated to the war between Russia-Ukraine and although it is true, this narrative fails to provide a full picture. Coal had already started to resurface primary to jumpstart the economies after the pandemic lockdown and other factors like severe draughts, issues and closure of nuclear plants also compounded together to create the energy crisis (Myllyvirta, 2023). The war simply added more stress on the weakened energy sector for countries to be more aggressive in using their available coal. And while countries that are slightly more generous towards the fossil fuel claim that coal is now a permanent source, most countries still are ambitious in distancing themselves away from coal.

[14] Clean Energy Communities (Medved, Golob, & Kamin, 2023) are groups of people who come together to produce, utilize, and distribute renewable (clean) energy, like solar, hydro or wind energy.

However, the transition of energy sources is a multi-layered process that deals with complicated connections and relationships in the social, economic, environmental, and geo-political scenarios. Furthermore, renewable energy development requires not only new technologies but also funding and legal issues, installation, and operational arrangements (Lutz, Fischer, Newig, & Lang, 2017). Local communities and stakeholders may also have a completely different outlook on the energy transitions, and it often becomes a challenges for good policies to navigate through these perspectives towards its attempted targets (Schwab & Diaz, 2020). As such it becomes crucial to address these diverse opinions and mitigate any foundational errors in the implementation of the transitional process.

Knowledge transfer is crucial for the energy transition. It is mentioned that knowledge transfer can play an important role in creating a mechanisms for different parties to share sustainable practices facilitating mitigation and adaptation among various stakeholders (Roy, 2019). Knowledge transfer also helps facilitate the exchange of existing knowledge between experienced practitioners and experts (Lutz, Fischer, Newig, & Lang, 2017). In addition to the distribution and sharing of knowledge, the knowledge transfer can also help renewable firms become more competitive through innovation and introduction of new and more efficient technologies which is beneficial for investors.

Knowledge transfer can also be used to provide the platform required for bringing these diverse opinions together while also disseminating knowledge about renewable energy technologies and sustainable practices. Implementation of sustainable energy projects require coordination between different stakeholders with multidisciplinary knowledge and expertise and through knowledge transfer between the stakeholders, intermediaries can help to ensure that these projects are socially equitable and considers the needs of the local communities.

However, it is recommended that the role of the intermediaries in the knowledge transfer process be improved, and their contributions strengthened. Intermediaries should be allowed to cultivate new knowledge in sustainable energy systems and should be made effective to be able disperse their newfound innovation and knowledge among their members and outside their communities. This can be done through transdisciplinary co-production of knowledge (between stakeholders), international exchanges and public involvement in research processes. It can also be recommended that universities and other educational/academic institutions play an important role to bring different stakeholders together for the purpose of knowledge transfer.

These institutions, in particular, should engage in collaborative ways of education in a formal as well as informal learning environments. These may include for example, vocational and technical training which can ready people employed (or previously employed) in existing energy systems to transfer to the upcoming renewable transition. Furthermore, intermediaries can work together to develop curricula, establish information centers and departments along with updated technical, legal, and financial information that is relevant to their region and communities. Intermediaries can also collaborate with key actors in the energy sector to develop common values, visions, and actions, all to support a smooth energy transition.

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3 Transformation Projects on Post-Mining Landscapes – The Cottbus-Nord Open-Cast Mine: From Lignite Mining to Renewable Energies

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3.1 Lignite Mining in Lusatia

Lignite mining and power generation in Lusatia[1], which has the largest deposits in Germany after the mining area in North Rhine-Westphalia, have been a decisive factor in the industrialisation of the region over the last 150 years. At the same time, it was and still is associated with serious environmental pollution, the use of settlements and landscapes, and massive impacts on the water balance. In 2020, the Coal Phase-out Act (Kohleausstiegsgesetz)[2] stipulated the end of coal extraction in Germany by 2038. In Lusatia, all still active opencast mines and lignite-fired power plants will then gradually cease operation. But this will also create new challenges for the design of the post-mining areas.

The tasks for spatial planning are complex here, because in addition to the necessary mining recultivation, the construction of a new landscape will also take place in Lusatia. The comprehensive expansion of renewable energies will play a decisive role in this. Lusatia is to develop from a former coal-mining region into a centre for renewable energies. In this context, however, new conflicts of use are likely to arise. There is a broad consensus in Germany that the accelerated expansion of renewable energies is absolutely necessary in order to achieve the climate goals at the national level according to Art. 3 Federal Climate Act (Klimaschutzgesetz).[3] How and where, and with which concrete spatial interventions, this transformation will then be connected, is currently increasingly leading to questions. A lack of participation in the planning of these

[1] The Lusatia region is defined according to the conventional, historically developed definition and encompasses the districts of Oberspreewald Lausitz (OSL), Spree-Neiße (SPN), Elbe-Elster (EE) and the urban district of Cottbus (CB) in the State of Brandenburg and the districts of Görlitz (GR) and Bautzen (BZ) in the State of Saxony. In contrast, the Lusatian lignite field is more narrowly defined; It includes the lignite fields in this region.

[2] Coal Phase-out Act of 8 August 2020 (Federal Law Gazette I p. 1818), as amended by Article 3b of the Act of 3 December 2020 (Federal Law Gazette I p. 2682).

[3] Federal Climate Act of 12 December 2019 (Federal Law Gazette I p. 2513, as amended by Artikel 1 of the Act of 18 August 2021 (Federal Law Gazette I p. 3905).

transformation processes and thus a lack of acceptance among the population must not be allowed to arise.

The role of the planning and approval framework in shaping the post-mining landscape will be exemplified in the following four contributions. The area around the former Cottbus-Nord open-cast mine will be examined as an example. These case studies for renewable energies show new possibilities of use, but also the challenges of ecological and water management remediation. However, in order to understand the complexity of the multi-level planning and approval procedures, it is first important to give a brief overview of the legal framework.

3.2 Planning levels in lignite mining

Long-term planning for the use of the landscape by opencast mining operations and the subsequent recultivation form the basis for lignite mining. However, this planning is not only a process. If the term is understood instrumentally, it is about the production of a plan or set of rules, the implementation of which is intended to serve the achievement of predefined goals under predefined legal framework conditions (Ramsauer, 2018). In Germany, spatial planning forms the basis for this. This is an overall state planning system whose aim is to steer the development of spaces in the Federal Republic of Germany in accordance with certain principles of spatial planning, as regulated in Art. 2 (Spatial Planning Act [Raumordnungsgesetz], ROG)[4]. Spatial planning is essentially a matter for the federal states. For this purpose, regional plans for specific uses and corresponding regional plans have been developed for sub-areas of the respective federal state, which regulate, among other things, lignite planning. These have to deal with special standards, as the activities in the lignite mining areas are subject to extraordinarily long time horizons of 50 to 100 years (Umweltbundesamt [Federal Environment Agency] UBA, 2023).

In Germany's lignite regions, corresponding lignite mining plans have therefore been enacted to regulate the extensive and long-lasting intervention. The large-scale operation of opencast lignite mines is characterised by particularly far-reaching interventions in the environment, settlement and infrastructure, and the water balance. The completion of recultivation and in particular the restoration of the water balance can take decades to centuries (UBA, 2023; Lausitz Energie und Bergbau AG (LEAG), 2019).

[4] Spatial Planning Act of 22 December 2008 (Federal Law Gazette I p. 2986), as last amended by Article 1 of the Act of 22 March 2023 (Federal Law Gazette 2023 I No. 88).

3.3 The Federal Mining Act as the Basis for Mining and Remediation

As part of regional planning, lignite planning is closely linked to preliminary, accompanying and subsequent administrative procedures under mining and water law. This makes it all the more important to closely interlink planning, mining and water law administrative procedures at an early stage. The Federal Mining Act (Bundesberggesetz – BBergG)[5] forms the legal basis for all mining activities. Permission to explore, extract and acquire ownership of mineral resources is granted to the entrepreneur by the competent mining authority through a mining licence pursuant to Art. 6 Federal Mining Act (Frenz, 2019). In the multi-level mining licensing procedure, this only represents the granting of the exclusive right of disposal over the mineral resource. The specific exploration and extraction activities are subject to the obligation to prepare an operating plan pursuant to Section 51 BBergG. In §§ 52, 53 BBergG, the actual mining activities from exploration to the cessation of operations are legally regulated in a system of operating plans with different subjects of regulation, duration of validity and binding effects. On the basis of the general operating plans, the respective main operating plans are then issued as the mining operation progresses, which have the effect of granting permission to mine the coal (Frenz, 2019).

According to Art. 2 para. 1 no. 2 BBergG, the remediation of the surface used by mining is an integral part of mining activities (Keienburg, 2016). The fulfilment of the obligation to remediate and the necessary precautionary measures is already regulated within the framework of the operating plan procedure pursuant to section 55 para. 1 sentence 1 no. 7 BBergG. The remediation is only examined in detail and approved in the final operating plan procedure pursuant to Section 53 (1) sentence 1 BBergG. In addition to the cessation of mining operations, the securing of the opencast mine and the dismantling of the technical facilities, the final operating plan also includes the termination of the groundwater management necessary for mining purposes. The public interest must be taken into account during recultivation (Keienburg, 2016).

In the case of planning projects that are significantly directed towards influencing the environment and creating a new landscape, however, indirect, sustainable changes to political, social and economic systems are also to be expected (Czada, 2016). This applies specifically to the case of a large-scale project that is planned for many decades, such as lignite mining and the subsequent remediation. Such large-scale projects generate process dynamics that are difficult to determine and social consequences that are incompletely calculable.

[5] Federal Mining Act of 13 August 1980 (Federal Law Gazette I p. 1310), as last amended by Article 4 of the Act of 22 March 2023 (Federal Law Gazette 2023 I No. 88).

The plans for the opencast lignite mines in Lusatia were all planned between the 1960s and 1980s, i.e. during the time of the GDR (German Democratic Republic). They were originally oriented towards the energy policy guidelines of the socialist planned economy and the social system in force at the time; environmental concerns played no role. Now, however, after more than 60 years, completely different economic, ecological and social conditions have arisen. These become particularly clear in the task of recultivation.

3.4 Recultivation and Subsequent Use of Opencast Mining Areas

The mining of lignite requires long-term and large-scale groundwater lowering because the coal seams are mainly located below the groundwater table. This leads to changes in the groundwater level and the direction of groundwater flow. By 1990, a groundwater drawdown funnel had developed in Lusatia with a total water deficit of about 13 billion m^3 (UBA, 2023). These drainage measures cause considerable changes in the catchment area of the surrounding rivers, such as the Spree. The natural groundwater inflow to rivers and lakes decreases, while at the same time pumped-up groundwater from the opencast mines is largely discharged into the Spree again.

After coal extraction, the large opencast pits are usually flooded by rising groundwater or by the discharge of surface water, and opencast mining lakes are created. This is the cheapest and often the only way to compensate for the mass deficit caused by the mining of the coal seams. For the mining companies, it is generally more favourable if this residual lake occupies as large an area as possible while the volume of the lake remains constant, because this reduces the costs for agricultural or forestry recultivation of the areas that are not flooded, while the costs for the dumps and banks restoration hardly increase. From an economic and ecological point of view, however, it is better if as small a part of the opencast mine as possible is flooded. This reduces the length of slopes that have to be secured against landslides and reduces evaporation losses that have to be replaced (Öko-Institut, 2022).

Especially the increasing evaporation on the large shallow opencast mining lakes can become an additional problem. According to preliminary calculations, an approximate order of magnitude emerges: for the future lake area of opencast mining lakes in Lusatia of approx. 15,000 ha, their average evaporation will be up to 3.57 m^3/s (Abgeordnetenhaus Berlin [Berlin House of Representatives], 2020). The depth and size of the opencast mining lakes also has a decisive influence on water quality. Deep and narrow opencast lakes have better water quality. After mining operations, the groundwater also rises again, but this creates new problems. Aeration of the soil causes geochemical processes that lead to considerable changes in the substance balance in the groundwater. The post-mining rise of the groundwater causes a release of sulphate, iron and hydrogen ions. This is accompanied by acidification, which also leads to the dissolution of heavy metals. This contamination of the groundwater occurs in the dump areas, but also in the mine-drained areas. There is a deterioration of groundwater quality, which also affects the mining lakes and flowing waters into which the groundwater enters (UBA, 2023). Iron and sulphate influence negatively water ecology and water use, e.g. for drinking water supply. The rising groundwater can also mobilise contaminated sites from industry and chemicals in the soil, leading to persistent contamination of the groundwater. A restriction of use for drinking water production is therefore possible.

All these processes are already taking place in the remediation and the recultivation of the mines. However, these processes will probably intensify in the future after the end of currently active lignite mining (UBA, 2023). The costs of restoring the opencast mining areas and the water balance are currently difficult to forecast (Öko-Institut, 2022, UBA, 2023). In part, these are costs that will have an "eternal" impact. In this context, the term "eternity costs" was created (LMBV, 2022). Against this background, the current plans for the post-mining landscape, also on the part of the private owners, the Lausitz Energie und Bergbau AG[6] (LEAG, 2023a), are developing more and more in the direction of large-scale use for renewable energies.

3.5 From Open-Cast Lignite Mining to the "Cottbuser Ostsee"[7]

A descriptive example of the current transformation process of a former open-cast mine is the creation of the Cottbuser Ostsee. The Cottbus-Nord open-cast mine had already been planned from the end of the 1960s. Coal extraction took place from 1981 to 2015, which was marked by numerous social and environmental conflicts. Five villages were devastated and over 860 people lost their homes and had to be resettled (Archiv der verschwundenen Orte [Archive of Vanished Places], 2010). The nature reserve "Lakomaer Teiche" was also the

[6] Brand of the corporations Lausitz Energie Bergbau AG (Lusatia energy mining corporation) and Lausitz Energie Kraftwerke AG (Lusatia energy power stations corporation).
[7] The official name of the lake being created in the residual area of the Cottbus-Nord open-cast mine is "Cottbuser Ostsee", (Cottbus East Lake) according to a resolution passed by the Cottbus city council on 29 May 2013.The name is based on the location in the eastern part of the city of Cottbus.

first Natura-2000 habitat in the European Union to be completely removed for an economic project (LBGR, 2019). The Cottbuser Ostsee is the first opencast mine in Lusatia to be remediated by a private company. All other opencast mines have so far been remediated by a state-owned remediation company the Lausitzer und Mitteldeutsche Bergbau-Verwaltungsgesellschaft mbH, LMBV.

An opencast mining lake is also planned for the mine Cottbus-Nord for post-mining use. For this purpose, the dump areas and the lake and bank areas were first secured. The size of the lake will be approx. 18.8 km^2. The total water requirement for the creation of the lake and for the filling of the groundwater subsidence area is about 280 million m^3. The filling with water from the Spree River was started in April 2019 (LBGR, 2019). The mining company LEAG is responsible for the project. The start of filling the mine was preceded by a planning approval procedure under water law that lasted almost five years. At that time, a period of about six years was forecast until the lake could be used (LBGR, 2019). In recent years, however, there has been a significant delay due to the persistent dry periods and the resulting lack of Spree water discharges. Furthermore, unexpected landslides are currently occurring in the banks, which require additional remediation measures (LEAG, 2023b). This shows how difficult it is to forecast long-term recultivation and what additional challenges arise.

3.6 Current developments

Due to the current geopolitical situation and the need for energy efficiency, the expansion of renewable energies in Germany is currently a matter of particular urgency. The German government has initiated various laws on immediate measures for the accelerated expansion of renewable energies, such as an amendment to the Renewable Energy Sources Act (Erneuerbare-Energien-Gesetz – EEG).[8] It aligns the expansion of renewable energies with the 1.5 degree path of the Paris Climate Agreement[9] and takes into account the climate protection decision of the Federal Constitutional Court of 24 March 2021.[10] The

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[8] Renewable Energy Sources Act of 21 July 2014 (Federal Law Gazette I p. 1066), last amended by Article 4 of the Act of 26 July 2023 (Federal Law Gazette 2023 I No. 202). Last amended by Article 4 G v. 26.7.2023 I No. 202; for details see Albrecht & Zschiegner (2023a) and Albrecht & Zschiegner (2023b).

[9] Law on the Paris Agreement of 12 December 2015, of 28 September 2016, Federal Law Gazette II p. 1082, UNTS No. 54113, (PA); see also Paris Agreement adopted 12.12.2015; entry into force: 04.11.2016; U.N.T.S. vol. 3156; 55 I.L.M. 740 (2017); see for details Albrecht (2022), pp. 142 ff.

[10] Federal Constitutional Court, Decision of the First Senate of 24 March 2021 - 1 BvR 2656/18 -, 1 BvR 78/20 - - 1 BvR 96/20 - - 1 BvR 288/20 - (climate protection) marginal no. 1-270; BVerfGE 157, 30 ff.; see for details Albrecht (2023)

expansion target for renewable energies for 2030 is raised to 80% of gross electricity consumption. In order to achieve this target, the expansion paths for solar and onshore wind will be significantly extended. The EEG 2023 is part of a legislative package that redefines the framework conditions for renewable energies. It is supplemented above all by the Wind on Land Act, (Wind-an-Land-Gesetz – WindBG)[11] which expands the areas available for wind power plants and accelerates the approval procedures.

The large contiguous post-mining areas and power plant sites with their partly already existing supply and transport infrastructure represent a great potential. Lusatia as an energy region can and should transform itself from a coal region into an innovative centre for renewable energies for solar, wind and hydrogen use. The expansion of renewable energies in former opencast mines is characterised by complex planning and licensing framework conditions. The following contributions use practical examples to show how these tasks can be implemented and what challenges still exist. At the same time, it becomes clear how innovative and dynamic the transformation can be in an area that will change from a coal-mining area to a centre for renewable energies.

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4 Transformation Projects on Post-Mining Landscapes – Floating Photovoltaics on the Cottbuser Ostsee

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4.1 Introduction

The current global crises highlight the need for a transition from fossil fuels to renewable energy sources. In response to this, the German government agreed in 2022 to accelerate the expansion of renewable energies within the framework of a comprehensive legislative package (Bundesministerium für Wirtschaft und Klimaschutz, BMWK [Federal Ministry of Economics and Climate Protection], 2022). In particular, the Renewable Energy Sources Act[1] was reformed so that renewable energies are now in the overriding public interest according to Art. 2 of the Renewable Energy Sources Act (Albrecht & Zschiegner 2023). The latest reforms have also created a new legal framework for so-called floating photovoltaic systems. In the course of the new energy policy orientation, the construction of Germany's largest floating solar plant on the former open-cast lignite mine Cottbus-Nord is an exemplary project for future sustainable energy supply. With a capacity of 29 megawatts, the plant is intended to cover the annual energy needs of around 8,250 households and at the same time establish the emerging Cottbuser Ostsee[2] as a model region for renewable energies (Lausitzer Energie und Bergbau AG, LEAG, 2023).[3] The following chapters describe the legal requirements that must be fulfilled in accordance with spatial planning, water and building law in order to enable the implementation of the floating photovoltaic system.

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[1] Renewable Energy Sources Act of 21 July 2014 (Federal Law Gazette I p. 1066), last amended by Article 4 of the Act of 26 July 2023 (Federal Law Gazette 2023 I No. 202). Last amended by Article 4 G v. 26.7.2023 I No. 202.

[2] The official name of the lake being created in the residual area of the Cottbus-Nord open-cast mine is "Cottbuser Ostsee", [Cottbus East Lake] according to a resolution passed by the Cottbus city council on 29 May 2013.The name is based on the location in the eastern part of the city of Cottbus.

[3] Brand of the corporations Lausitz Energie Bergbau AG [Lusatia energy mining corporation] and Lausitz Energie Kraftwerke AG [Lusatia energy power stations corporation].

4.2 Water Law Requirements

Floating photovoltaic systems are permanent artificial installations of relevance to water management and are subject to the provisions of the Water Management Act.[4] Under the Water Management Act, the construction of a floating photovoltaic system could require a permit/authorization for water use under Art. 8 Water Management Act in conjunction with Art. 9 Water Management Act. However, the construction of such a system is not understood as water use in the sense of Art. 9 Water Management Act, as waters are only used as building ground (Müller & Burtin, 2021). For this reason, approval requires a permit pursuant to Art. 36 para 1, sent. 1 Water Management Act in conjunction with Art. 87 para 1 of the Brandenburg Water Act.[5] According to this, installations must be constructed and operated in such a way that they do not cause any harmful changes to water bodies and do not unnecessarily complicate water maintenance. A statement by the Brandenburg State Office for the Environment (Landesamt für Umwelt, 2021) confirmed the compatibility of the project with the requirements of Article 36 para 1 Water Management Act. The statement highlights that the proportion of the photovoltaic plant of about 1 % of the total water area is so small, that no harmful effects on the water body are to be expected. In addition, it is emphasized that the distance from the shore of about 360 meters and the placement of the plant outside the planned navigation routes do not significantly affect the maintenance of the lake. However, according to Art. 87 para 2 Brandenburg Water Act, water areas may also only be taken up if this is absolutely necessary and, according to Art. 87 (3) Brandenburg Water Act, no impairment of the general public interest occurs. An alternative assessment confirmed that no further areas of the planned size are available in the Cottbus urban area in the short term (Stadt Cottbus, 2022a). In addition, the use of the surface waters is in line with the recommendations of the Ministry of Agriculture, Environment and Climate Protection of the State of Brandenburg (Ministerium für Landwirtschaft, Umwelt und Klimaschutz – MLUK), which advocate the use of former open-cast mining sites and artificial lakes for large-scale ground-mounted photovoltaic plants (MLUK, 2021). However, due to the novelty of the technology, there is currently a lack of scientific long-term studies on the real

4 Water Management Act of 31 July 2009 (Federal Law Gazette I p. 2585), last amended by Article 5 of the Act of 3 July 2023 (Federal Law Gazette 2023 I No. 176).

5 Brandenburg Water Act of 02.03.2012 (GVBl. I No. 20), last amended by Article 1 of the Act of 04 December 2017 (GVBl. I No. 28).

environmental impact and the general welfare. For this reason, additional regulations for the operation of floating photovoltaic systems were laid down within the framework of Art. 36 (3) Water Management Act. Accordingly, construction is only permitted on artificial or heavily modified water bodies. The installation may not cover more than 15 % of the water surface and the distance to the shore must be more than 40 meters. With reference to the statement of the State Office for the Environment, it appears that these criteria were taken into account in the context of the project on the Cottbuser Ostsee, so that overall the water law prerequisites for approval are fulfilled.

4.3 Requirements under Building Planning Law

In view of the classification as structural installations (Pauli & Tritschler, 2020) according to Art. 29 para 1 of the German Building Code,[6] floating photovoltaic systems are also subject to the provisions of building planning law. This means that, in addition to a permit under water law, they also generally require a building permit due to the provisions in the respective federal state's laws. How to license floating architecture, under which floating PV also can be counted, differs in the different federal states and is subject to an ongoing legal debate (Jentsch, 2023). However, according to Art. 35 para 1 of the German Building Code, they do not have any special privileges in the external area under building planning law. According to Art. 35 para 2 Federal Building Code, only a case-by-case authorization is possible, provided that the project does not affect public interests and its development is guaranteed. In contrast, according to Art. 35 para 3 Federal Building Code, public interests are impaired if a spatially significant project contradicts, among other things, the representations of the land-use plan and regional planning. Therefore, a review of the compatibility of the project with the objectives of spatial planning was essential.

In the context of the creation of the Cottbuser Ostsee, a planning approval procedure (Landesamt für Bergbau, Geologie und Rohstoffe Brandenburg [Brandenburg State Office for Mining, Geology and Raw Materials] LBGR, 2019)[7] was carried out in accordance with Art. 67 para 2 Water Management

[6] Building Act in the version published on 3 November 2017 (Federal Law Gazette I p.3634), as last amended by Article 1 of the Act of 28 July 2023 (Federal Law Gazette 2023 I No. 221).

[7] LBGR (2019): Planning approval decision for the project "Gewässerausbau Cottbuser See, Teilvorhaben 2 – Herstellung des Cottbuser Sees". Ref.: c10-8.2-1-2. https://lbgr.brandenburg.de/lbgr/de/planfeststellungstrategie/planfeststellung-energie/planfeststellungsverfahren/, Last accessed 08. May 2023.

Act in conjunction with Art. 68 para 1 Water Management Act. The main objective of this procedure is to transform the former open-cast mining areas by flooding for a future follow-up use and to create a water area of about 1,880 ha with a target lake level of + 62.5 m above sea level (+/- 0.5 m) by the middle of this decade. The main starting point for this planning approval procedure was the overarching spatial planning plan for the Cottbus-Nord lignite opencast mine [Braunkohlenplan Cottbus-Nord].8 Pursuant to Art. 12 para 1 of the Regional Planning and Lignite Remediation Planning Act,9 lignite plans are drawn up on the basis of the joint state development programs/plans. These programs and plans set out the basic objectives of regional planning for the State of Brandenburg and define the design of the post-mining landscape in accordance with Art. 12 para 3 of the Regional Planning and Lignite Remediation Planning Act. According to the established lignite mining plan, the design of the post-mining landscape of the Cottbus-Nord opencast mine must take into account the requirements of a versatile use with regard to, among other things, agricultural, forestry, water management and tourism aspects, whereby the promotion of tourism use is in the foreground. Since the area of the planned floating photovoltaic plant is located within the scope of the Cottbus-Nord lignite mining plan, it must be ensured during implementation that the objectives of the lignite mining plan, in particular the prioritized tourist use, are not impaired. In this context, an assessment by the Joint State Planning Department (Joint State Planning Department [Gemeinsame Landesplanung Berlin-Brandenburg], 2021) has shown that the realization of the Cottbus-Nord lignite mining plan will not be impaired and that the planned PV-system is considered spatially insignificant. In connection with the construction of the floating photovoltaic system, however, the question arose as to whether the requirements for a water body expansion pursuant to Art. 67 para 2 Water Management Act also apply to the system itself and whether a separate planning approval procedure is therefore required. However, a water body expansion in accordance with Art. 67 para 2 Water Management Act only exists if a substantial transformation of the water body or its banks takes place. The decisive factor for the assessment is the water body status determined by the LBGR's planning approval decision after completed renaturation. Due to the comparatively small area of the PV plant in relation to the total area of the lake,

[8] Ordinance on the Lignite Plan for the Cottbus-North Opencast Mine as amended on 18.07.2006. Law and Ordinance Gazette for the State of Brandenburg, Part II - Ordinances. Available online at https://bravors.brandenburg.de/de/verordnungen-212413, last accessed on 17. Aug 2023.

[9] Regional Planning Act and Lignite and Reclamation Planning Actin the version promulgated on 8 February 2012 GVBl. I No. 13.

the Environmental Protection Agency of the federal state of Brandenburg has not identified any significant water management changes for the lake (Environmental Protection Agency [Landesamt für Umwelt], 2021). Accordingly, the planned PV plant does not meet the criteria of water body expansion pursuant to Art. 67 para 2 Water Management Act. This interpretation is also shared by the LBGR in its statement (LBGR, 2021). Consequently, the plant is to be assessed as a new project and requires a stipulation in the development plan for the building permit. However, the required development plan could not be realized due to deviations from the binding land use plan of the city of Cottbus. Therefore, an adjustment of the binding land use plan (Stadt Cottbus, 2022b) was made to secure the area for the planned floating photovoltaic plant in accordance with Art. 11 para 2 of the German Building Use Ordinance.10 For this purpose, a special construction area was designated in the binding land use plan. This representation enabled a binding definition in the parallel development plan (Stadt Cottbus, 2022c), which was adopted on 26.10.2022 and thus created the building planning prerequisites.

4.4 Conclusion

In the previous chapters, the planning and legal challenges for implementing a sustainable energy supply in Germany with the help of floating photovoltaic systems were outlined. The relevance of the technology for a sustainable energy transition is particularly evident in its technical potential, which is estimated at around 44 gigawatts for artificial lakes in Germany. However, the economically feasible potential is currently limited to only around 2.74 gigawatts due to various factors, including legal and environmental constraints (Fraunhofer Institute for Solar Energy Systems ISE, 2021). Above all, the regulations set out in Art. 36 para 3 of the Water Management Act prevent the realization of the usable technical potential, which is why the solar industry is calling to lift these restrictive regulations (Wirtschaftswoche, 2023). In addition, including PV plants into the privilege clause according to Art. 35 of the German Building Code could ensure that projects could also be realized without a development plan. An alternative is to define relevant water areas in the development plan with the purpose "photovoltaics" in order to ensure an accelerated project implementation (Ministry for Infrastructure and Regional Planning of the State of Brandenburg [Ministerium

[10] Building Use Ordinance in the version published on 21 November 2017 (Federal Law Gazette I p. 3786), as last amended by Article 2 of the Act of 3 July 2023 (Federal Law Gazette 2023 I No. 176).

für Infrastruktur und Landesplanung des Landes Brandenburg], 2022). Despite the new overriding public interest in renewable energies according to Art. 2 of the Renewable Energy Sources Act, restrictions are still evident. Nevertheless, the potential in Germany illustrates that overcoming the extensive framework conditions is worthwhile and can pave the way towards a future sustainable energy supply. The federal state of Brandenburg also recognizes the signs of the times and is planning solar expansion, including financial support for floating photovoltaic projects (Ministerium für Wirtschaft, Arbeit und Energie des Landes Brandenburg [Ministry for Economy, Labor and Energy of the State of Brandenburg], 2023).

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5 Transformation Projects on Post-Mining Landscapes – Wind Turbines on Open-Cast Mining Areas at the Cottbuser Ostsee

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5.1 Initial Situation

The basis for the past and current as well as future use of the opencast mining areas at the Cottbuser Ostsee[1] is the Ordinance on the lignite mining plan for the opencast mine Cottbus-Nord of 18.07.2006.[2]

Lignite and remediation plans are drawn up on the basis of the joint state development program and the joint state development plans pursuant to Articles 7 and 8 of the regional planning agreement and after coordination with regional planning authority. Pursuant to Art. 12 para 1 of the Law on Regional Planning and on Lignite and Remediation Planning (Gesetz zur Regionalplanung und zur Braunkohlen- und Sanierungsplanung – RegBkPlG),[3] the lignite and remediation plans establish principles and objectives of regional planning to the extent necessary for orderly lignite and remediation planning. The lignite plans have the goal of enabling an environmentally and socially compatible as well as long-term secure energy supply. The remediation plans, on the other hand, pursue the goal of compensating for the consequential mining damage as far as possible, in accordance with Art. 12 para 3 of the Regional Planning Act.

Such a lignite and remediation plan was also enacted for the Cottbus-Nord opencast mine. Since mining activities ceased in 2015, the part on dealing with the post-mining areas of the lignite and remediation plan is of particular importance for the present and future. In the Ordinance on the lignite mining plan

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[1] The official name of the lake being created in the residual area of the Cottbus-Nord opencast mine is "Cottbuser Ostsee", [Cottbus East Lake] according to a resolution passed by the Cottbus city council on 29 May 2013.The name is based on the location in the eastern part of the city of Cottbus.

[2] Ordinance on the lignite plan for the Cottbus-Nord opencast mine of 18 July 2006 (GVBl.II/06, [No. 22], p.370) amended by article 3 of the act of 27 may 2009 (GVBl.I/09, [No. 08], p.175, 184). https://bravors.brandenburg.de/de/verordnungen-212413. Last accessed 07.08.2023.

[3] Regional Planning Act and Lignite and Reclamation Planning Actin the version promulgated on 8 February 2012 GVBl. I No. 13. https://bravors.brandenburg.de/gesetze/regbkplg. Last accessed 07.08.2023

for the opencast mine Cottbus-Nord, specifications and goals for the design of the post-mining landscape were specified. According to objective 16 of the Ordinance on the lignite mining plan for the Cottbus Nord opencast mine, the interests of agriculture, forestry, fisheries and water management as well as nature conservation, landscape management and recreation must be considered when designing the post-mining landscape.

The creation of the Cottbuser Ostsee by filling with water from the river Spree represents the main focus of mining remediation. In the given scales for the different uses, areas for renewable energies were not provided for. This is due, among other things, to the time of the first version of the Ordinance from 2006, in which enabling a long-term secure energy supply through lignite was the goal and energy supply through renewable energies was secondary.

In accordance with objective 19 of the lignite mining plan, the conditions for multiple use of the emerging opencast mine lake must be created, taking into account water management, fishing, nature conservation and tourism aspects. Priority is given to tourist use. Furthermore, the shore areas and banks of the lake are to be diversified and different uses are to be separated from each other by suitable measures. Areas for renewable energies were left out of consideration.

However, due to today's framework conditions, it is essential to make the energy supply sustainable, environmentally friendly and independent. The Russian war against Ukraine violated democratic values, which cannot be accepted in this way. For this reason, the German government has successfully ended its energy dependence on Russia, and instead, natural gas is being supplied from Norway and the Netherlands, as well as additional liquefied natural gas imports (Bundesregierung, 2023a).

In addition, the consequences of climate change are becoming increasingly apparent as temperatures, sea levels, and the number of heat days rise, sea ice melts, and the increase in the number of sunshine hours (Bundesregierung, 2023b).

Against this backdrop, the Paris Climate Agreement, was adopted at the World Climate Conference in Paris on December 12, 2015.[4] For a sustainable development, 195 countries pledge to mitigate climate change and transform the global economy in a climate-friendly way. The three main objectives of the agreement are set out in Art. 2 of the Paris Agreement. In summary, the increase

[4] Law on the Paris Agreement of 12 December 2015, of 28 September 2016, Federal Law Gazette II p. 1082, UNTS No. 54113, (PA); see also Paris Agreement adopted 12.12.2015; entry into force: 04.11.2016; U.N.T.S. vol. 3156; 55 I.L.M. 740 (2017); see for details Albrecht (2022), pp. 142 ff.

in the global average temperature is to be limited; emissions are to be reduced and adaptation to climate change must take place; and financial resources are to be directed in accordance with climate protection goals (Bundesregierung, 2023c).

Among the 195 countries is Germany, which has set a more stringent goal of reducing greenhouse gas emissions by at least 65% from 1990 levels by 2030 and by at least 88% by 2040, as well as achieving net greenhouse gas neutrality by 2045 and negative greenhouse gas emissions after 2050 (Ministry for Economic Affairs and Climate Protection [Bundesministerium für Wirtschaft und Klimaschutz] BMWK, 2022).

To achieve these goals, numerous laws and legislative changes have been enacted at the European and national levels. In addition, planning and approval procedures are to be accelerated in order to achieve the expansion targets for renewable energy plants. What is new in this context is the special importance of renewable energies and the overriding public interest of renewable energies as stipulated in Section 2 of the Renewable Energy Sources Act (Erneuerbare-Energien-Gesetz, EEG).[5] Accelerating the expansion of wind power contributes to meeting the aforementioned goals. The contents of the new laws and amendments to the law with regard to wind power include, for example, the introduction of the 2% area target for all federal states, the possibility of expanding wind energy in landscape protection areas, or the adaptation of the Federal Building Code ([Baugesetzbuch], BauGB)[6] for repowering. Another new feature is the use of post-mining landscapes for wind turbines in accordance with Art. 249b (1) of the Federal Building Code.

5.2 Planning Regulations

The question of the implementation and realization of projects for the expansion of wind turbines on post-mining areas is very complex and must be assessed on the basis of an interweaving of different aspects. Both mining and planning law as well as nature conservation and environmental protection issues are considered (Landtag Brandenburg, 2022).

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[5] Renewable Energy Sources Act of 21 July 2014 (Federal Law Gazette I p. 1066), last amended by Article 4 of the Act of 26 July 2023 (Federal Law Gazette 2023 I No. 202). Last amended by Article 4 G v. 26.7.2023 I No. 202

[6] Building Code in the version published on 3 November 2017 (Federal Law Gazette p. 3634), as last amended by Article 3 of the Act of 12 July 2023 (Federal Law Gazette 2023 I No. 184).

5.2.1 Permissibility of Wind Energy Use under Planning Law

Spatial planning on wind energy turbines has been one of the main tasks of regional planning since the privileging of wind turbines since the end of the 1990s. There are five regional planning communities in the Federal State of Brandenburg. The regional planning community "Lausitz-Spreewald" [Regionale Planungsgemeinschaft Lausitz-Spreewald] is responsible for the regional planning of the districts Oberspreewald-Lausitz, Dahme-Spreewald, Elbe-Elster and Spree-Neiße as well for the City of Cottbus, and thus also for the former opencast mine Cottbus-Nord. Due to changes in the legal framework, current court rulings as well as knowledge gained, several draft plans have been prepared so far, plans have been cancelled or discarded during preparation. Most recently, the specific regional plan on wind energy, effective as of 16 June 2016, was legally binding (Regionale Planungsgemeinschaft Lausitz-Spreewald, 2016). With the rulings of 10 June 2020, the Federal Administrative Court ([Bundesverwaltungsgericht], BVerwG) dismissed the appeal for non-admission against the rulings of the Higher Administrative Court ([Oberverwaltungsgericht], OVG) of Berlin-Brandenburg of 24 May 2019,[7] whereby the rulings of the Higher Administrative Court of Berlin-Brandenburg are legally binding. This was accompanied by the invalidity of the specific regional plan on wind energy.

In accordance with Art. 2c para 1, sent. 1 of the Act on Regional Planning and Lignite and Reclamation Planning, the responsible regional planning community, in this case the regional planning community "Lausitz-Spreewald", has to initiate without delay a procedure for the new preparation, amendment or updating of a regional plan, which must also include objectives and principles of spatial planning for the spatial control of the planning and construction of spatially significant wind energy plants. At present, the specific regional plan on wind energy is being drawn up.

However, permissibility under planning law is governed by Art. 35 of the Federal Building Code. All areas or areas that are neither within the scope of a qualified or project-related development plan (Art. 30 para 1 and 2 of the Federal Building Code) nor within a coherently developed district (Art. 34 of the Federal Building Code) are referred to as “external areas”.

In principle, the “external area” is to be kept free of development, unless the structural facilities belong to these areas (Ernst et al., 2022). The Federal Building Code enumerates the so-called privileged projects in Art. 35 para. 1.

[7] Decision of the Higher Administrative Court Berlin-Brandenburg of 24 May 2019, AZ.: OVG 2 A 4.19, OVG 2 A 5.19, OVG 2 A 6.19, OVG 2 A 7.19, OVG 2 A 8.19; NVwZ 2020, 253 (Main Arguments) (with commentary of Albrecht & Zschiegner, 2020)

According to no. 5 of Art. 35 para 1 of the Federal Building Code, these include projects that serve the research, development or use of wind energy in accordance with Art. 249 Federal Building Code.

According to Art. 35 para. 1 Federal Building Code, these privileged projects are permissible in the "external area" if public interests are not impaired and sufficient development is ensured. Not every public interest constitutes an impairment. Rather, it is a matter of balancing the purpose of the project against the public interest, considering the legal privileged status. For this balancing process, Art. 35 para 3, sent. 3 Federal Building Code stipulates that public interests are generally impaired to a project in accordance with para 1 no. 2-6, even if a designation has been made elsewhere for these projects by means of representations in the land use plan or as spatial planning objectives. Through this so-called plan reservation, municipalities could restrict privileged projects according to Art. 35 para 1 no. 2-6 Federal Building Code in the respective planning area to certain areas through a positive site designation. Art. 2 of the Act to Increase and Accelerate the Expansion of Onshore Wind Energy Systems (Wind-an-Land-Gesetz – WindBG),[8] which came into force on 01 Feb 2023, amended Art. 249 para 1 of the Federal Building Code to the effect that the planning reservation referred to is no longer applicable to projects for the development, research and use of wind energy pursuant to Art. 35 para 1 no. 5 of the Federal Building Code.

5.2.2 Competence Clause to Issue Ordinances (Art. 249b Federal Building Code)

Due to the preload of the post-mining areas in terms of environmental protection and neighboring impacts as well as the good development, they are particularly suitable for the expansion of renewable energies (Bundestag, 2022).

As a result, Art. 249b of the Federal Building Code authorizes the state governments to issue Ordinances so that post-mining areas can be used more quickly for the development of renewable energies. The wording of Art. 249b para 1 of the Federal Building Code provides as follows:

The Federal State governments are authorized to determine by statutory order that the following requirements apply to the decision on the permissibility of a project pursuant to section 35 (1) no. 5 which serves the research, development

[8] Wind Energy Area Requirements Act of 20 July 2022 (Federal Law Gazette I p. 1353), as last amended by Article 6 of the Act of 26 July 2023 (Federal Law Gazette 2023 I No. 202)

or utilization of wind energy within the mining area of a lignite mining or remediation plan, but that the requirements for permissibility remain otherwise unaffected:

1. *Representations in land use plans and objectives of regional planning do not oppose the said project; however, the recultivation objectives according to the lignite or remediation plan shall be considered appropriately and*
2. *the project should not significantly affect mining activities.*

The scope of the statutory instrument may be limited to certain parts of a mining area. The legal consequences of Art. 249 para 2, sent. 1 and 2 shall not apply within the scope of the statutory instrument.

However, this wording does not imply any obligation to issue these Ordinances. It is currently not foreseeable whether and with what content such Ordinance will be issued.

Accordingly, Art. 249b para 1 of the Federal Building Code provides that special provisions apply to the admissibility of projects that serve the research, development or use of wind energy. However, the requirements for permissibility pursuant to Art. 35 para 1 of the Federal Building Code remain unaffected. This results in an additional facilitation of permissibility under planning law, because these Ordinances can stipulate that neither the representations in land use plans nor the objectives of regional planning as public interest can conflict with these projects. Nevertheless, the recultivation objectives of lignite or remediation plans (in this case, the Ordinance on the lignite mining plan for the Cottbus-Nord opencast mine of 18 July 2006) should continue to be given appropriate consideration and projects involving mining activities should not be significantly impaired. Accordingly, there is no concrete commitment to the recultivation goals. In addition, due to this regulation, the plan reservation, as listed in Art. 35 para 3, sent. 3 Federal Building Code, does not apply; existing designations of areas for wind energy use at other locations can no longer be objected to as a public interest (Bundestag, 2023).

In addition, the federal state's government can limit the scope of the Ordinances to certain parts of the opencast mining areas pursuant to Art. 249b para 1, sent. 2 Federal Building Code. For example, it is possible to exclude designated renaturation or recreation areas from the lignite or reclamation plan from the scope of the Ordinance (Landtag Brandenburg, 2022). This results from the objective of the competence clause to issue Ordinances, from which it is clear that low-conflict areas in particular are to be included; refraining from longstanding planning processes, as in the case of lignite and reclamation plans, is justified by this lack of conflict (Bundestag, 2022). If recultivated areas have already been used as recreational areas for a long time, the assumption just mentioned should no longer apply, and if these areas are designated for renewable energies, it would have to be examined on a case-by-case basis whether a planning process would be more suitable for this (Bundestag, 2022).

Currently, the Brandenburg federal state government has not yet issued a corresponding Ordinance.

Finally, for the dismantling of wind turbines after the end of their operation, the current planning law contains a provision in Art. 35 para 5, sent. 2 Federal Building Code, which is accompanied by a deconstruction obligation as a further condition of permissibility (Landtag Brandenburg, 2022). Accordingly, a declaration of the operator of the wind turbine to deconstruct the project after permanent abandonment of the permitted use and to remove soil sealing has to be submitted.

5.3 Requirements under Approval Law

The requirements under approval law must take into account, in particular, issues relating to building regulations and mining law, as well as ensuring the stability of the facilities (Bundestag, 2022). The responsibility for assessing the permissibility of wind turbines on post-mining areas is derived from state law in conjunction with the relevant mining regulations (Bundestag, 2022).

In principle, the post-mining areas can only be "overplanned" for renewable energies after full restoration (fulfillment of objectives), such as wind turbines (Landtag Brandenburg, 2022). Based on the approval of the operation plans by the Brandenburg State Office for Mining, Geology and Raw Materials (LBGR), these operation plans are implemented in compliance with specified and binding requirements for the creation of the respective areas for the mining operator (Landtag Brandenburg, 2022). In this context, agricultural areas are generally considered restored after implementation of a seven-year recultivation crop rotation; forestry areas are considered restored after official determination of a secure (forestry) crop by the State Forestry Office, generally 10-15 years after reforestation; and in the case of renaturation areas, the restoration period depends on the type of renaturation area, since implementation is carried out with scientific support and is subject to official monitoring in the process (Landtag Brandenburg, 2022).

5.3.1 Approval in Accordance with the Federal Immission Control Act

The Brandenburg State Office for the Environment, is responsible for technical environmental protection. It mainly carries out licensing procedures for installations in accordance with the Federal Immission Control Act and develops technical standards and requirements. According to Art. 1 para 1 of the Federal Immission Control Act (Bundes-Immissionsschutzgesetz – BImSchG),9 the aim is to protect people, animals and plants, the soil, water, the atmosphere as well as cultural and other material assets against harmful effects on the environment and to prevent the occurrence of harmful effects on the environment. There are two types of approval procedure: the formal approval procedure pursuant to Art. 10 of the Federal Immission Control Act in conjunction with the 9th Ordinance on the Implementation of the Federal Immission Control Act10 and the simplified approval procedure pursuant to Art. 19 of the Federal Immission Control Act. The allocation is made via Art. 19 para. 1 Federal Immission Control Act and Art, 2 of the 4th Ordinance on the Implementation of the Federal Immission Control Act.11 For installations marked with a "G" in column c "Type of procedure" of the annex to the 4th Ordinance a formal procedure must be carried out.

The formal procedure is divided into the preliminary consultation, the application with application documents, a public announcement, public participation and the decision of the authority. For installations marked with a "V" in column c "Type of procedure" of the appendix to the 4th Ordinance, the simplified procedure is generally carried out, except in the case of Art. 19 para 3 of the Federal Immission Control Act when the operator applies for the formal procedure. Art. 19 para 2 Federal Immission Control Act lists the regulations of Art. 10 of the Federal Immission Control Act that are not to be applied. Thus, there is no public announcement, no display of the documents for inspection, no request to raise objections and no publication of the decision.

[9] Federal Immission Control Act in the version published on 17 May 2013 (Federal Law Gazette I p. 1274; 2021 I p. 123), as last amended by Article 11(3) of the Act of 26 July 2023 (Federal Law Gazette 2023 I No. 202)

[10] 9th Ordinance on the Implementation of the Federal Immission Control Act in the version of 29 May 1992 (Federal Law Gazette I p. 1001), last amended by Art. 10 of the Act of 22. March 2023 (Federal Law Gazette I No. 88).

[11] 4th Ordinance on the Implementation of the Federal Immission Control Act in the version of 31 May 2017 (Federal Law Gazette I, p. 1440), last amended by Art. 1 of the Ordinance of 12 Oct 2022 (Federal Law Gazette I p. 1799.

5.4 Environmental Requirements

In principle, the interests of nature conservation and landscape management or other public interests are to be examined in accordance with Art. 35 para 1 of the Federal Building Code and should, however, only be opposed in exceptional cases (Bundestag, 2022).

For the examination of species protection for onshore wind energy, the federal government decided on simplifications in 2022, whereby there were changes in the environmental procedure law. On the one hand, there is a shortened public participation in the approval procedure according to Art. 31f Federal Immission Control Act as well as a waiver of discussion meetings according to Art. 31f para 4 of the Federal Immission Control Act. Furthermore, an environmental impact assessment and a species protection assessment are to be waived if a strategic environmental assessment has been carried out at the planning level. The background to this is Art. 6 EU Regulation 2022/2577[12] and implementation in national law with Art. 6 of the Act to Increase and Accelerate the Expansion of Onshore Wind Energy Systems. National parks, nature conservation areas and Natura 2000 areas are the exception to this. According to Art. 26 para 3 of the Federal Nature Conservation Act (Bundesnaturschutzgesetz – BNatSchG),[13] landscape conservation areas are additionally "opened up" for wind turbines. On the other hand, at least regulations on species protection have been made in Art. 45b-45d Federal Nature Conservation Act, which concern, for example, standards on the prohibition of killing of breeding bird species at risk of collision, changes to the conditions for granting an exception under species protection law, regulations on repowering or the establishment of national species assistance programs.

5.5 Conclusion

It seems obvious that, due to the prevailing framework conditions and the climate protection goals, there must be both new legal possibilities and accelerations in implementation. To this end, the focus has now shifted to post-mining areas. But is this really necessary? The goal of all the recent legislative amendments is the transformation to a sustainable and greenhouse gas-neutral power supply that is completely based on renewable energies. With a view to climate

[12] Council Regulation (EU) 2022/2577 of 22 December 2022 laying down a framework to accelerate the deployment of renewable energy, OJ EU L 335, p. 36.
[13] Federal Nature Conservation Act of 29 July 2009 (Federal Law Gazette I p. 2542), as last amended by Article 3 of the Act of 8 December 2022 (Federal Law Gazette I p. 2240).

and environmental protection, onshore wind energy is to be promoted through accelerated expansion. For this purpose, area contribution values have been specified for each federal state in the Act to Increase and Accelerate the Expansion of Onshore Wind Energy Systems. According to the annex (to Art. 3 para 1) of this Act, the area contribution value to be achieved by 31 Dec 2027, is 1.8 % of the federal state's area; the area contribution value to be achieved by 31 Dec 2032, is 2.2 % of the federal state's area.

According to the report of the Cooperation Committee between the Federation and the Federal States (Bund-Länder-Kooperationsausschuss) on the status of renewable energy expansion and on areas, plans and permits for onshore wind energy use to the federal government (Bund-Länder-Kooperationsausschuss, 2022) of 26 Oct 2022, the share of area designated for wind turbines in 2021 for the federal state of Brandenburg was 7,378 ha, which corresponds to 13.8 percent of the target area for 2027 and 11.3 percent of the target area for 2032. Thus, there is demand in terms of achieving the area target. But along with this, there are major challenges that cannot be ignored. There is plenty of resistance to the expansion of renewable energies in the public. Here, it is important to strengthen acceptance; Information events should be offered to explain the development of the electricity price, the added value for the environment as well as the independence from third party countries, e.g. Russia. In addition, there are also economic models that allow residents to participate financially in the profits. Furthermore, there are many unanswered questions and ambiguities regarding the protection of nature and species. The aforementioned amendments to the approval procedure currently have a weakening effect on this. Nevertheless, this transformation from the use of fossil fuels to sustainable renewable energies can bring great opportunities. It is doubtful, however, whether all interests can be taken into account as a consensus via the lowest common denominator.

It is questionable whether the expansion of renewable energies should be carried out at the expense of nature and species conservation as well as residential and quality of life. Former opencast mining areas can certainly be occupied with wind turbines in order to achieve the area targets by 2027 and 2032. However, this must be done in a proportionate manner with detailed consideration of nature and species conservation in particular with the objectives of recultivation and the residential and living needs of the people. A generally applicable privilege for wind turbines for all former opencast mining areas does not seem to be expedient. In view of these parameters, the transformation from fossil energy to renewable energy can succeed.

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6 Contaminated Sites in the Post-Mining Landscape of the Cottbuser Ostsee

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6.1 Introduction

Since 2019, the largest lake in Brandenburg and the largest post-mining lake in Germany, the Cottbuser Ostsee,[1] has been created on the site of the former Cottbus-Nord opencast lignite mine (Lausitzer Energie und Bergbau AG[2] LEAG, 2023). The Cottbus-Nord lignite mining plan specifies the design of the post-mining landscape and the objectives of regional planning in accordance with Art. 12 para. 1 Regional Planning and Lignite and Remediation Planning Act (Land Brandenburg, 2006). The basis for the necessary restructuring of the area is the extraction of the second Lusatian lignite seam, with a thickness of about ten metres, at a depth of about 40 metres, which took more than 30 years (Lausitzer und Mitteldeutsche Bergbau-Verwaltungsgesellschaft mbH [Lusatian and Central German mining management company] LMBV, 2015). In order to be able to carry out the extraction technically and safely, a lowering of the groundwater level was necessary, in the process, the groundwater-bearing layers above the coal are drained and the pressure water level below the coal is relieved (Knauff, 1998).

This drainage and the resulting lowering of the groundwater level was already noticeable since the 1980s, in the form of dried-up ditches and streams and crop losses (LMBV, 2015). Furthermore, the natural water balance is significantly disturbed in the entire catchment area (Wittig, 1998). After the end of mining, the retention of groundwater is no longer necessary. In addition, the successive shutdown of the filter wells will fill partially the Cottbuser Ostsee with groundwater (Landesamt für Bergbau, Geologie und Rohstoffe Brandenburg [Brandenburg State Office for Mining, Geology and Raw Materials] LBGR,

[1] The official name of the lake being created in the residual area of the Cottbus-Nord opencast mine is "Cottbuser Ostsee", [Cottbus East Lake] according to a resolution passed by the Cottbus city council on 29 May 2013.The name is based on the location in the eastern part of the city of Cottbus.

[2] Brand of the corporations Lausitz Energie Bergbau AG [Lusatia energy mining corporation] and Lausitz Energie Kraftwerke AG [Lusatia energy power stations corporation].

2019). The resulting rise in the groundwater level not only poses a potential risk of increasing groundwater levels in the surrounding area (Knauff, 1998), but can also cause "a mobilisation of pollutants from contaminated and suspected contaminated sites" (LBGR, 2019). This article is intended to provide a brief insight into the situation of the former Cottbus-Nord opencast mine in relation to surrounding contaminated sites and to show how these correlate with the rise in groundwater.

6.2 Groundwater

In the pre-mine situation in the Cottbus-Nord area, the entire area of the opencast mine has a corridor distance of ≤ 2m for the unconfined groundwater in the unconsolidated rock. This also applies to a large part of the area southeast to northwest of the opencast mine. The Jänschwalde lignite power plant site as well as parts of the villages Schmellwitz, Ströbitz and Dissenchen, which are nearby, have between > 2m and < 5m groundwater surface distance. What is relevant here is that the entire area is not protected against pollutants penetrating over a wide area (Zentrales Geologisches Institut Berlin [Central Geological Institute Berlin], 1984). Groundwater lowering has fundamentally altered this old stock. In the *map application of groundwater monitoring wells* of the Brandenburg State Office for the Environment (Landesamt für Umwelt, 2023), it can be clearly seen how the groundwater levels have strongly decreased in the entire southern area. This also influences the direction of groundwater flow. Thus, the original, pre-mining groundwater flow direction was in the downslope direction from southeast to northwest.

Due to anthropogenic interventions, however, the discharge shifted in the direction of the Cottbus-Nord and Jänschwalde opencast mines. It is predicted that the old flow direction will return (LBGR, 2019), which will then return to the river Spree and its floodplains as well as the surrounding Natura-2000 habitats (Land Brandenburg [Federal State of Brandenburg], 2015). It is possible that the groundwater inflow from the southeast will exceed a discharge of 0.05 m^3/s (Bündnis 90/Die Grünen, 2015). The use of the water and thus the creation of the lake is subject to § 68 of the Federal Water Management Act3 and the resulting planning approval decision (LBGR, 2019).

[3] Water Resources Act of 31 July 2009 (BGBl. I p. 2585), as last amended by Article 5 of the Act of 3 July 2023 (BGBl. 2023 I No. 176).

6.3 Contaminated Sites

According to the Art. 2 para 5 of the Federal Soil Protection Act (Bundes-Bodenschutzgesetz – BBodSchG),[4] contaminated sites are "closed-down waste management installations and other real properties, in/on which waste has been treated, stored or landfilled (former waste disposal sites) and real properties that house closed-down installations, and other real properties on which environmentally harmful substances have been handled, except for installations that can be closed down only under a license to the Atomic Energy Act (former industrial sites)" (Mulloy, Albrecht & Häntsch, 2001; Ministerium für Landwirtschaft, Umwelt und Klimaschutz [Ministry of Agriculture, Environment and Climate Protection of the State of Brandenburg] MLUK, 2023a) and are regulated by this act. In the case of Cottbus-Nord, these are located in the area of the Jänschwalde power plant, in the city centre of Cottbus, a nearby industrial area and in most of the surrounding villages (LBGR, 2019). According to the Ordinance on the Cottbus-Nord lignite mining plan, these areas must be analysed and, if necessary, supervised or remediated.

This has already taken place, for example, in the case of waste deposits at the gravel pit in Merzdorf (Land Brandenburg, 2006). However, the total volume of suspected and contaminated sites currently comprises 255 sites. In particular, various storage areas on the site of the Jänschwalde power plant and the landfill site in Bärenbrück are of greater relevance, as the groundwater level there will rise to < 1.5 m below ground level. On another site (ref. 102-6 VK1), which also falls under this assessment, the suspicion has already not been confirmed (LBGR, 2019). However, the other suspected areas are also considered as a potential hazard to soil and groundwater (LEAG, 2019). This consideration is legally necessary, as according to Art. 7 of the Federal Soil Protection Act, there is a precautionary obligation with regard to soil protection and according to Art. 6 para. 1 sent. 1 no. 2 of the Federal Water Management Act, impairments to water bodies must be avoided.

6.4 Interconnection of Groundwater and Contaminated Sites

As already mentioned at the beginning, the problem that arises from the rise in groundwater is that it can cause a mobilisation of contaminants in the mining area. The mining groundwater flow is in the direction of the open pit. The flow

[4] Federal Soil Protection Act of 17 March 1998 (BGBl. I p. 502), as last amended by Article 7 of the Act of 25 February 2021 (BGBl. I p. 306).

movements now re-establishing themselves in the upper aquifer are defined by the aforementioned original groundwater flow in a north-westerly direction (Land Brandenburg, 2006). The possibly mobilised pollutant loads would thus also change their direction of movement.

There are several demands and comments from different institutions (e.g. City of Peitz, City of Cottbus, etc.) concerning evidence and forecasts of the known suspected contaminated sites. This concerns, among other things, a disused landfill in the village Schlichow and thus possible pollutant inputs into the Cottbuser Ostsee. According to the planning approval decision, the forecasts for the area state that the groundwater rise is in the range of > 5 m, so there is no risk. This is based on the fact that in the studies, areas with an expected groundwater rise of < 1.5 m are primarily treated as at risk (LBGR, 2019). However, this consideration does not fulfil the necessary depth, as the following example explains.

On the site of a former roofing felt factory in Cottbus, coal tar was used in production until 1965. Spread over a total of six tar pits, pollutants were released into the soil and groundwater over several decades. The main pollutants are PAHs (polycyclic aromatic hydrocarbons), BTX (aromatic hydrocarbons: benzene, toluene, xylene and ethylbenzene) and MCH (mineral oil hydrocarbons). Remediation has been taking place on the site since the early 1990s (Stadt Cottbus, 2017). Since 1994, the financial basis for this has been the contaminated site exemption (Stadt Cottbus, 2017), which represents a liability exemption with the aim of removing obstacles to investment due to disproportionately high pollutant clean-up costs at commercial sites (MLUK, 2023b).

Based on the 2016 remediation study for the factory site, the tar-containing material is being excavated to a depth of eight meters to prevent further spreading (Stadt Cottbus, 2017). However, the spread that has existed to date has already led to restrictions. Since 2019, the drilling for groundwater in the direction of flow of the contaminated groundwater is prohibited (Stadt Cottbus, 2019). The course of the contaminated groundwater is directed to the east or northeast, straight towards to the former open-cast mining area and to the Cottbuser Ostsee (Stadt Cottbus, 2017).

In the planning approval decision, the site of the former roofing felt factory is located as a marginal area of the groundwater rise and is thus supposed to be independent of the flooding of the opencast mine (LBGR, 2019). However, a movement of the contaminant groundwater has already been observed since 2020. As already indicated at the beginning, this is taking place in a northerly direction, following the pre-mining groundwater flow. This is problematic in view of the local conditions, as the stream “Hammergraben” lies in the northern catchment area of the contaminant groundwater (Stadt Cottbus, 2017). Water from the “Hammergraben” is discharged into the Cottbuser Ostsee (LBGR, 2019). In addition, the “Hammergraben” crosses the Natura-2000 habitat “Spreeaue” and flows into the Natura-2000 habitat “Peitzer Teiche” (Land Brandenburg, 2015). It is not known whether the pollutant load reaches the “Hammergraben” or flows underneath it (Stadt Cottbus, 2017). However, a further rise in the groundwater level could also lead to a higher probability of input into the “Hammergraben”.

This example clearly shows that the assumption of contamination risk from < 1.5m groundwater level is not generally applicable. In the case of the former roofing felt factory, an extensive monitoring programme with groundwater extraction points was installed in the course of the remediation (Stadt Cottbus, 2017). This is also necessary for other suspected sites.

6.5 Conclusion

Lignite Mining in Lusatia has had drastic consequences. Even without considering the contaminated site situation, the groundwater body in the Cottbus area is in poor chemical condition. The objectives of the Water Framework Directive,[5] which primarily represent a good status of surface waters and groundwater bodies, cannot be met in this area (Braun et al., 2010). A mobilisation of pollutants could possibly worsen the situation. In addition, the threats to both the groundwater body and the surface waters and their adjacent habitats have not been monitored extensively enough. The example shows that even more remote contaminated sites must be taken into account by restoring the former groundwater conditions. This raises the question of liability with regard to Art. 4 Federal Soil Protection Act.

The fact that subsidence may have occurred as a result of the lowering of the groundwater level at that time is still completely unnoticed. According to the planning approval decision, the groundwater level will "not rise to a higher level than it would have been if the project had not been carried out" (LBGR, 2019). However, the subsidence will not rise back to its starting point after the level has been reset (Bündnis 90/Die Grünen, 2015). The situation therefore remains difficult and unforeseeable. Damage can only be prevented by adequate monitoring over a wide area. The transformation of the mining areas will therefore be a long-term task for all parties involved, in which the question of responsibility and

[5] Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy, OJ L 327, p. 1.

liability is likely to be strongly debated, since environmental protection is the task of all social forces and the public has a right to participate.

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7 Education as a Vessel – Transformative Spaces and Relations for a Sustainable Higher Education with Transdisciplinary Aspirations

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7.1 Introduction

Conceptually understanding education as a vessel suggests the importance of being in relationship with oneself. Especially when the vessel is filled with breath, provides space to and protects the breath (as the inhaled and expressed expression of oneself). The breath emerges from consciousness, indicating that it holds great value. It is important to preserve it for as long as possible in a comfortable vessel of appropriate form. In his trilogy Spheres I, II, and III, philosopher Peter Sloterdijk (1998) uncovered a cultural-historical treasure of humanity, titling it in the form of bubbles, globes, and foams. In this introduction, Sloterdijk's metaphor helps to descend from transformative heights and to venture an outlook based on values, emotions, and the relationships that emerge from them (Sloterdijk, 1998). Educational concepts are designed by crucial individuals within structures in which they live and act normatively. They are applied to challenges, such as those to transform coal exit region as model applications for change and transformative learning. Knowledge concepts in such a sense, make it possible to bring structural change, e.g. through transdisciplinary approaches, to realization. In this context, the university as a scientific institution is itself under transformation pressure, since it must generate future-relevant overall statements as a knowledge mediation and knowledge generation institution at the center of the transformation process. This is also true of concepts for higher education. They include liberties, but only after meeting access restrictions, such as those of the Numerus Clausus (NC) concept in Germany as restrictions on access to degree programmes. These restrictions can ensure disciplinary scientific orientations, instead of inter- and transdisciplinary orientations. The perspective of performance-oriented evaluability raises the question if self-efficacy is restricted or not. Self-efficacy is not meant to be understood here in the sense of self-optimization, it refers to an individual's capacity (and belief in their ability) to successfully execute action and attain a desired outcome in a given situation (Bandura, 1982).

Since April 2012, universities have submitted themselves to the Bologna concept as an evaluation standard for their work. The aim is to achieve better comparability and facilitate students to transfer between institutions. Performance recognition is based on a transparent credit point system (the ECTS system) in this sense. In addition to all the entry restrictions, assessment criteria and performance tests that must be taken in order to enter the higher education system, students and university members today are confronted more than ever with complex crises and wicked problems. Wicked problems are complex and systemic issues that are difficult to define, have multiple causes and consequences, and lack a clear solution, as described by Arjen Wals (2017, 2014). Anthropogenic climate change and biodiversity loss are examples of this. These existential problems challenge mainstream lifestyles of industrialised nations. This criticism of the Anthropocene (Crutzen, 2002) highlights the unequal distribution of resources and the impact of unsustainable consumption patterns on the Global South, as discussed in academic literature on environmental justice and postcolonial theory (Shiva, 2008; Escobar, 2012). The critical question is whether universities today are able to equip students with the necessary skills to address wicked problems, to confront them and to become part of the solution in the sense of change agents. It cannot be the claim that all higher education institutions and students in Germany meet these requirements – nevertheless, a discourse and serious efforts in this direction are more than desirable yet not sufficiently met (Elkana & Klöpper, 2013).

What do the introductory thoughts lead us to in terms of future-oriented educational concepts at German universities in light of the tasks set out in this text? Before answering the question, we here explain the structure of this paper. CoSR is aware of having produced a rather unusual article, which follows an associative-intuitive process and understanding. However, the questions that it attempts to address defy linear answers, for they are indications of the need for possibly a new path that might allow inspiration to unfold. In order to help generate the capacities for self-efficacy and effective action towards sustainability, this paper emphasizes the importance of creating transformative spaces while cultivating relations as a life-affirming attitude. The authors understand the adverb "transformative" as an addition to the previous transformation research discourse in the sense of being actively involved in transformation processes (Schneidewind & Singer-Brodowski, 2014). To achieve this, transdisciplinary educational concepts must be developed as a resource for catalysing effective transformations (Lewis & Williams 1994: 5) and for bridging the knowledge-behaviour gap, as will be elaborated in the course of this paper.

The text will therefore first discuss a societal need as the starting point for such concepts and highlights transformative change. In the next section, the theoretical framing will be demonstrated through implementation-oriented ideas in thinking and acting. The German Society of Human Ecology (DGH), as well as transformative educational concepts relating to transdisciplinarity, are practical examples of the emergence and integration of transformative ideas. The practical applications of the Silence Spaces and TransLABs concepts form the conclusion of a framework for transdisciplinarity. Knowledge integration through experience of is in the focus, which leads to pay attention to processes and increased awareness through this work. Such an approach chooses CoSR not in principle as an opposition but as a homogeneity of a knowledge-society process that results from inclusion rather than integration.

7.2 Transformative Chance

A forward-looking orientation of higher education may need the support of miracles. As already reflected upon in the introduction, education also needs to be oriented towards the social, ecological and economic processes of society as a whole and the wicked problems that society faces today. Disciplinary quantification and conventional academic evaluation metrics seem rather limiting at this point. Therefore, CoSR will broaden the view a little in order to relate social phenomena to the design of educational concepts. Shouldn't transformation happen on all the levels mentioned to be profound and lasting? Sustainable development refers to the process of creating a more sustainable, equitable, and resilient society (Brundtland, 1987). At its core, transformation involves a shift in our understanding of sustainability, which goes beyond preserving the planet's resources for future generations (IPCC, 2018) and the traditional focus on efficiency (Sustainable Development Commission, 2006) as well as adaptation mechanisms. According to Overdevest et al., (2010) as well as Göpel (2016), transformative change involves a holistic and fundamental shift in values, structures, and behaviors, as well as a deep understanding of the interconnectedness of social, economic and environmental systems (Raskin, 2002). A critique of the growth paradigm (Schluchter & Renschhausen, 2007), which is based on the idea of infinite economic expansion, is an essential part of the process of socio-ecological transformation (Jackson, 2009): It is in conflict with the limits of our planet and the need for sustainability (IPCC, 2018; Steffen et al., 2015; Meadows et al., 1972).

Social-ecological transformation efforts, therefore, must not only address the root causes of environmental degradation, but must also challenge the underlying values and structures of the capitalist system (Göpel, 2016). This may involve exposing and combating greenwashing and fake sustainability,[1] as well as advocating for alternative economic models that prioritize sustainability and social justice (Foster et al., 2010). It is not just a matter of finances, success and innovation, but a matter of separation and competition that leads to social, individual and ecological divides (Rosa, 2019; Eisenstein, 2018; Göpel, 2016; Käufer & Scharmer, 2013). Innovation can be seen as a key driver of economic growth and competitiveness (Schumpeter, 1934). It is narrowly defined as the introduction of new technologies or processes and is typically focused on incremental improvements rather than more fundamental change (Paech, 2005; Meadows et al., 1972).[2] Transformative approaches focus on the active involvement of individuals and communities as a key role in this transformation processes (Foster et al., 2010; Schneidewind & Singer-Brodowski, 2014). By valuing processes that take the inner landscape, own attitudes and the mind-set into account, these approaches can help to build the capacities needed to navigate the challenges of a rapidly changing, accelerated world. From what has been described, it is clear that transformation efforts are strongly dependent on one's own beliefs and attitudinal issues in industrialized nations. Inner transformation, as emphasized and discussed for instance by Charles Eisenstein (2011), Joana Macy (2012), Maja Göpel (2016) and Christine Wamsler together with Jami Bristow (2022), plays a crucial role in this process. It involves shifts in individual and collective values, behaviors, and world views, and is essential for creating the conditions necessary for outer transformation.

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[1] Companies may engage in greenwashing, or the practice of misleading consumers about the environmental benefits of their products and services (de Freitas Netto et al., 2020). Greenwashing allows companies to continue business as usual while appearing to be environmentally responsible, and can create barriers to the adoption of more sustainable practices and technologies (ibid.). Fake sustainability involves the adoption of superficial, narrow and shallow sustainability initiatives that do not fundamentally challenge the growth paradigm (Meadows et al., 1972). These initiatives may serve as distractions from more transformative change and can produce a false sense of progress, while still allowing the exploitation of natural resources and the externalization of environmental costs to continue (Göpel, 2016).

[2] In this context, the idea of "exnovation" Paech (2005) is an interesting concept regarding efforts towards transformation. Exnovation refers to the process of deliberately shedding outdated or harmful technologies, practices and values in order to make room for more sustainable alternatives (Paech, 2005). This concept challenges the traditional focus on innovation and emphasizes the importance of unlearning and letting go of unsustainable practices (Paech, 2005).

7.3 Concepts of Higher Education and Transformative Potentials

Educational concepts can be traced back to the earliest civilisations, when knowledge was passed from generation to generation. According to Bowen`s (1981) historical analysis, education has evolved from informal knowledge transmission in prehistoric times to the development of formal education systems. This chapter does not aim to review and critically reflect on the history of higher education. Rather, CoSR is interested in highlighting and discussing what potentials exist in the field to promote the socio-ecological transformation, healthy relations and facilitation.

According to UNESCO (2014), the primary purpose of education is to promote human flourishing, which is defined as the full realization of human potential, in all its dimensions, for the benefit of individuals and societies. This suggests that education should not only focus on preparing students for the labour market but should also aim to help them develop the skills, knowledge, and values that are necessary for a fulfilling and meaningful life. It needs to be highlighted that the modern educational system has traditionally been focused on the growth paradigm as pointed out. The modern educational system often promotes a reductionist and instrumental view of nature, leading to a disconnection between humans and the natural world (Wals, 2017). Quantitative result orientation sets the tone, while qualitative values are subordinate to it (Langner & Voggenreiter, 2020).

Facing the future(s) regarding wicked problems accompanied by a high degree of uncertainty demands according to CoSR a timely understanding and transformative impact of higher education. Higher education carries the inherent potential to develop as well as to provide knowledge as the foundation of an educated citizenry which leads to a thriving, sustainable and just society (Barth et al., 2007). Higher education generally though might rapidly lose its potency in the economic realities of the twenty-first century, unless it finds ways to respond to the critical and often non-disciplinary concerns of society (Gibbs, 2017: 6). What ways and approaches enable higher education to mitigate societal struggles? Which concepts of education and learning spaces are necessary in universities for the perception and cultivation of relationship and reflexive attitude? Does today's higher education system support learners' relationships with themselves, their peers, and the world? Focusing on sustainability might offer multiple ways to address these pressing questions. Therefore, CoSR is providing a selection of meaningful, transformative educational concepts:

Table 1: Examples of transformative educational concepts

Transformative educational concepts	Inner and outer transformative potentials	Fostering relations and facilitation
(1) Education *for* Sustainable Development (ESD I) and Education *as* Sustainable Development (ESD II) *ESD emphasises an individual's capacity building by learning through environmental awareness, reflecting lifestyles, and promoting social commitment.* (de Haan & Harenberg, 1999)	ESD I: Holistic approach to education that aims to equip individuals with the knowledge, competencies, and values necessary to create a more sustainable future (UNESCO, 2014; Wals, 2014; de Haan, 2010) ESD II: A form of learning which is systemic and gives guidance on how to deal with complex and wicked problems and act upon them (Wals, 2014; Jickling & Wals, 2008).	"Learning for, within and from sustainable development" (Wals & Peters, 2017: 790); Opens learning spaces in which people can learn and try out political co-creation in their role as citizens together (Wals, 2014) "Sustainable development doesn't just depend on learning; it is inherently a learning process" (Vare & Scott, 2007: 194)
(2) Transformative Learning *Means an education for participation which combines knowledge of the world with individual transformation experiences and personal development.* (Schneidewind & Singer-Brodowski, 2014)	Enables processes of deep personal and social transformation that occurs when individuals encounter new ideas and experiences that challenge their existing beliefs and ways of thinking. Practices refer to service learning[3], combining technical learning with extracurricular social engagement in places of social innovation (Barth et al., 2007; Mezirow, 1974).	Serves relationality by promoting critical reflection and dialogue, leading to a deeper understanding and connection between individuals (Mezirow, 2000; Freire, 1970)
(3) Single, double, and triple loop learning *Single loop learning involves making minor adjustments to existing strategies, while double loop learning questions underlying assumptions, and triple loop learning creates new learning strategies to increase organizational performance* (Argyris, 1991; Wals, 2017).	Enabling individuals and institutions to reflect on their assumptions and values, identify inconsistencies, and make changes at different levels of their thinking and behavior (Schneidewind & Singer-Brodowski, 2014; Wals, 2007).	Promoting critical reflection on the assumptions and values underlying our actions, leading to a deeper understanding of our relationship with others and the environment (Wals, 2007; Senge, 2008).

[3] Service learning is a form of learning in which young people's social engagement is linked to subject-specific learning at school and university (UBA 2021).

(4) Transformative Education for Sustainable Development (Trafo ESD) *Takes greater account of inequalities and supports learners in discussing fundamental (global) social power relations and systemic conflicts of interest* (Danielzyk, 2013; Kaufmann et al., 2019).	It is about a profound unlearning of previously uncritically learned patterns of thinking, feeling, and acting (UBA, 2021).	Fostering mutual understanding, respect, and collaboration among diverse groups of people outside academia; Emphasising the importance of learner-centered and participatory approaches that enable learners to co-create knowledge and engage in critical reflection and action (UBA, 2021; Böhnke-Henrichs & Thomas, 2018).
(5) Transformative Literacy *"(...) has the ability to read and utilise information about societal transformation processes, to accordingly interpret and get actively involved in these processes"* (Schneidewind, 2013: 83)	Has the ability to question an individual's beliefs, attitudes, and values (Freire, 1970). Creates a framework to comprehend and embed transformation processes into actions, as individuals and through political and economic decisions. (Schneidewind, 2013; Göpel, 2016)	Involves engaging with others to challenge dominant perspectives and creating meaningful social change through education. (Schneidewind, 2013)
(6) Bildung *"Bildung is elusive but grasps the complex interplay between individual development, learning and collective culture"* (Andersen, 2020: 23).	*A*n all-encompassing concept that refers to personal and societal development, a lifelong process of becoming and unfolding potential, and acquiring knowledge and skills (Andersen, 2020; Horlacher, 2012; Taylor, 2017).	Has the potential to create spaces for strong relationships, as it encourages individuals to engage in critical reflection and dialogue with others (Andersen, 2022).

These concepts make it obvious that understanding one's own experiences, thought and reflection processes in the context of the world for a meaningful life should be one of the central goals of higher education. These approaches emphasise that education is not only about the acquisition of information and knowledge, but rather about how to deal with learning content. CoSR wants to highlight the necessity of inviting learning processes, which allow learners to experience embeddedness to implement what they have learnt and to facilitate transformative change.

Certainly, it is not only the learners and teachers who need to open up to transformative processes in their habitual ways of thinking, learning and facilitation of teaching. The higher education institutions themselves are also called to be open to transformation. The whole-institution approach as a systematic approach can provide a framework by addressing all aspects of an institution, including policies, practices and culture to promote sustainable development and positive change (Brock, Haan, Etzkorn & Singer-Brodowski, 2018). The question is if universities manage to anchor these approaches within their current structures and curricula or whether completely new institutions have to be created in order to let transformative education formats unfold more vividly. As described the European College for Human Ecology (COHE) wants to enhance higher education in Europe by combining natural sciences, engineering, humanities, social sciences, and the liberal and fine arts by using the concept of human ecology. The college aims to guide education, research, practical work, interaction and communication among those involved. COHE raises questions about disciplinarity and the way science is lived. In the following we would like to find out how this process can unfold in the most meaningful way.

7.4 Transdisciplinarity as a Methodological Opportunity

In order to be able to explore transdisciplinarity (TD) methodically, a space is needed as a format that makes transdisciplinary processes on site possible in real terms or allows it to emerge.

This is then specifically about understanding the scope of science for neutrality and integrity. Since there will always be different knowledge and also different social processes and thus also different effects and consequences, it is important to pursue such requirements. For this reason, there is a discernible need to re-develop science methodologically – ergo: to think anew.[4]

With reference to the DGH perspective highlighted also the previously presented educational concepts based on transformative sustainable development, there is now a need for a new methodological design of procedures that explore change processes and present relevant results. Disciplines have always met these challenges within the scope of their possibilities and thus produced interdisciplinarity (Kocka, 2015). The permanent situation with ever new challenges, made clear by the ever increasing transparency of information, makes it imperative to answer the questions of people from all over the world in a meaningful way. For this reason, the methodological path that has already been taken must be taken further and likewise transformed in such a way that boundaries that have hitherto functioned as paradigmatic can be overcome or reconnected. In

[4] Cf. the theme of the Year of Science 2018: Working Worlds of the Future. More information regarding this can be found on the corresponding BMBF-Website https://www.wissenschaftsjahr.de/2018/ (last accessed, 29.10.2023).

order to establish such connections, from the CoSR's point of view it is purposeful to recognise "relationship and space" in such a way that only aspects of transdisciplinary science enable a procedure for transformations that follow a comprehensible pattern.

In order to better understand such preconditions of today's sustainability and transformation discourse, the important work of Erich Jantsch entitled *Inter- and Transdisciplinary University as the Systems Approach to Education and Cognition* should be mentioned as the birth of the term and concept of transdisciplinarity (Jantsch, 1970). Jantsch makes it possible to think and understand transdisciplinarity paradigmatically in terms of the discipline-oriented system concepts of multi-, cross-, inter- and transdisciplinarity. Its first definition was the result of the OECD conference *Interdiscipliarity, Problems of Teaching and Research in Universities* (Nice, 7-12 September 1970).

From today's perspective, the question arises as to why, despite these early and concrete guidelines, it has not yet been possible to produce a syntax that already constituted a normative effect. Jean Piaget's (1972) contribution at the same conference read as follows: "*Finally we may hope to see a higher stage succeeding the stage of interdisciplinary relationships. This would be transdisciplinarity which would not only cover interactions or reciprocities between specialised research projects, but would place these scientific relations within a total system without any firm boundaries between disciplines*".[5] A second definition by Scholz (2001) 30 years later reads: "*Transdisciplinarity is an approach of study organizing processes that link scientific, theoretic, and abstract epistemics with real-world factors that are based on experimental knowledge from outside academia. Information about real-world factors comes from relating human experimental wisdom to the analytical rigor of science and academic methodology." (Scholz, 2011, S. 549).*

According to Scholz (ibid.), in contrast to Weber's categories of the normative concept of legitimacy (developed in the years 1910 to 1920), the scientific view elaborated here should claim a process-based causality to the extent that corresponding aspects of such interactions of and through domination are taken into account (Weber & Winckelmann, 2009). It may be assumed that social differences are only compensated for to a small extent, as the understanding of

[5] "Finally, we can hope that the level of interdisciplinarity will be followed by a higher level. This would be a transdisciplinarity that not only captures the interactions or mutual exchanges between specialised research projects, but also places these relationships in an overall system without fixed boundaries between disciplines." Piaget (1972), translation Dirk Marx (2018).

domination would not allow this in principle (Breuer, 2014; Derman, 2012). However, with the help of transdisciplinary educational concepts and formats, of which this paper is a part, it can be possible to set standards. Transdisciplinarity and its research are not intended to be an exaggerated solution option for all the challenges that need to be differentiated, but to continue to rub up against obviousness and thoroughly established interpretations. One important aspect of transdisciplinarity is its focus on the relationships between human and the world and space as dealt with. This includes not only the interactions between humans and the natural environment, but also the social, cultural, and economic systems that shape and are shaped by these interactions. By considering these relationships from multiple disciplinary perspectives, transdisciplinarity allows for a more comprehensive and nuanced understanding of the complex issues that arise in these contexts. One consequence of this is the sharpening of attention to, for example, a new interface for a new scientific and social perspective and this corresponds to the work on transdisciplinary contexts of institutional and integrative research (Geels, 2022; Renn, 2021; Scholz et al., 2021; Wuelser et al., 2021; Nicolescu, 2002; Mittelstraß, 2003).

7.5 Critical Reflection

This critical reflection refers to the Collective for Space Relations (CoSR) and its positions regarding their subjective articulations, the developed explanations in this paper, and their compiled substrates. Recognizing changes in our society and discussing them consciously is a challenge that requires incorporating real life circumstances. Therefore, this paper can only be a small part of the whole, and the authors are aware that a reference to the whole describes a hegemonic act. The better it succeeds in explaining and addressing the surrounding issues transparently, the more it can stimulate an inclusive discourse in form of a dialogue. CoSR is well aware that such an intention may involve a contemporary presumption and asks all readers to understand such a statement not as a retreat from responsibility for discourse but as a conscious self-reflective action and the adoption of such an attitude if necessary. In particular, we refer to our own role as western-socialized, non-marginalized academics and facilitators. The presented projects are still prototypes that rely on being adopted and experimented with further. The selection of the preceding topics is of great importance to CoSR but is dialectically not mandatory. Nevertheless, it can be understood as a contribution to the current academic discourse on the transformation of higher education in Germany. For these and many other reasons, no claim can be made to completeness.

7.6 Conclusion

When and why does it happen that a person begins to hope for miracles? The writing inspires hope in CoSR that the desire for miracles can be a driving force to cultivate relationships that value different perspectives as a resource and create spaces of experimentation. Patience is necessary to wait for the moment when a miracle, so to speak, occurs. How can we reach people in a way that does not require a miracle now? According to this paper, miracles do not happen on the outside, but on the inside, in regard to a change of perception consciousness. The miracle is therefore a deeply active process that concerns the cultivation one´s own attitude and the different levels of relationships. Miracles might happen in a space made available for this purpose or simply by making these available. Vehicles create change as soon as it is possible to get in touch with one's own consciousness so that it can realign itself constructively (as a learning experience) and not through dogmatism.

This paper is meant to inspire experimentation in this regard. Universities have an institutional mission, which includes education for training purposes. This applies to practical as well as theoretical references, which, individually written, invite us to engage in a generally valid value chain. However, this is by no means the same as the idea presented by Sloterdjik (1989) in the introduction. The social integration through educational concepts occurs with reference to an assumed freedom, as described at the beginning, but only after the hurdle (access barrier) has been overcome as flawlessly as possible. Qualities and selection criteria regulate access to universities and thus require a civilizational, unquestioned adaptation.

However, how imaginable are studies at the university that are no longer solely measurable by numbers, but that help participants to cultivate relationships in safe enough spaces that strengthen and motivate future-oriented action? For an inner world: from fear and lack, from the feeling of not being good enough, or from all the stories on underperformance – up to love – there is hardly any or no space, yet they make up a large part of human experience and remain conceptually underdeveloped.

Our generation is not the first, and probably not the last, to grapple with urgent questions of wicked problems. However, it may be the generation that is called upon, more than any other before, to recognise the planet as our most sacred space. This paper therefore addresses the pressing question of how to care for the earth and to navigate through wicked problems. In order to address students as change agents, "we need a cultural and spiritual transformation. And we scientists don’t know how to do that." (Speth, 2015 cited by Oram, 2016: 40). By referring to inner transformation processes, a definition of learning in terms of uncovering what is already present in learners is desirable.

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8 Vetschau`s Long Way of Finding a Post-Mining Identity

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8.1 Introduction

In 2019, I got to know the small town of Vetschau which is situated in the heart of the Lusatian transformation region. I was living and working in Berlin at the time but wanted to move to the countryside with my family, still having the advantages of the big city within easy reach. So, first thing, the place would have to be connected to the rail network. I wanted to buy and renovate an old house myself, without getting a too high loan. So secondly, the town had to have potential, which hadn't been fully developed, otherwise real estate prices would be out of reach for me as a mid-thirties employee with no heir. When I found out that I would write my doctoral thesis at Brandenburg University of Technology Cottbus - Senftenberg (BTU), I went on a bike ride along the railway between Berlin and Cottbus and came across Vetschau on my way. While tourism was big at previous towns, in Vetschau one could admire derelict industrial ruins in the heart of the city.

However, I was touched by the modest beauty of the cottage gardens and individually designed peasant houses, the colours of the Lusatian Heath and the uniqueness of the surrounding Spreewald, with its canals as waterways. In addition, on this summer evening, Vetschau was full of international young people, some of whom sat at the curbs drinking beer together. I couldn't identify this part of the population right away. But I took it as an indication of the lack of right-wing extremist structures, that had threateningly spread above other places in Lusatia. The diversity of the people in the cityscape also let me hope that the town cultivated a relaxed approach on difference and would thus break up the homogeneity of some small towns, which can lead to sense of being controlled by the public opinion. So, I began searching for a house in Vetschau and eventually bought an old, abandoned carpentry, which I converted into our new home in the middle of the pandemic.

The beauty of the surrounding countryside remained charming, but some expectations turned out to be idealizations. The international young people were almost exclusively harvest workers from south-eastern Europe who spoke no

German and little English and therefore kept to themselves under precarious conditions. It was more difficult for me to meet local people than expected. First, I blamed it on the pandemic and then later on the lack of contact points in the city, since I worked at the university in Cottbus and my little daughter was also looked after by a childminder there. When that lady stopped working in spring 2023, I was home without childcare for a while. That was my opportunity to get to know Vetschau and its residents and I quickly designed a study for the publication you are reading. My approach was to find out why – despite its surrounding beauty and well-connectedness, an hour's drive from the centre of the booming capital Berlin, in a country whose economy was doing well – Vetschau kept the oppressive charm of fallow German Democratic Republic history.

8.2 Methods

I created a research design with a catalogue of twelve questions regarding one's own emotional connection to Vetschau, the perspective on the city's problems and delays in development, and the personal approach for possible solutions. All interview partners were informed by me beforehand about my background and the aim of the study. Conversations were almost always recorded, except for unexpected ones or when the person requested me not to. I assured all interviewees that I would maintain their anonymity, not quote them by name, and ensure that no personal harm could result from their statements. I wanted to ask the questions orally to increase participation by addressing my potential interviewees personally and to keep the entry barrier low by asking them in a conversational style. Due to the visibly low level of social involvement in the city, I suspected that the response rate of a written survey would be too little. Additionally, for an important group of people, I wanted to include, I projected them to be hesitant to write down anything. Contrary to my expectations, the willingness to participate was very high and, in addition, all interviews exceeded my planned schedule. Since I was touched by the willingness to make time for my study and at the same time, I was afraid to offend my interviewees and influence the quality of the interview by making them answer my questions in a short and concise way, I expanded the number of in-depth interviews to 60 and tried to interview only population groups that I perceived as marginalized in the city – adolescents, families, socio-economically weak/long-term unemployed and other residents with special needs – in a representative way. This turned out to be more difficult, simply because it was complicated to meet those people, as there is virtually no place for them to meet in town. There is neither a family centre nor a youth club or any other meeting place where one could just show up. Therefore, I had to take any opportunity that came up and partly capture spontaneous conversations, which is why in those conversations I could not follow through with my pre-set questions nor record them systematically.

At the end of the conversation many participants would ask me how I would personally retribute the results of my study to the city. I was invited to take on a political office immediately, I was given membership applications for clubs, I was suggested suitable sports. And yet, during the research, I felt lonely in a way that I sometimes do on international field trips, where I meet interesting people during the day, but stay left alone in my accommodation at night, and only during the analysis fully realized why. Therefore, it seemed important to me to write this article as a mixture of a systematic qualitative social scientific survey and an ethnography with the experiences of my three years of participant observation as a resident. Vetschau is the ideal example of a small town in perpetual structural change after the coal mining industry has left. But it is also my hometown now and that of all interviewees. To only analyse and evaluate the structures between different abstract agents would leave out the emotional complexity that comes with it.

8.3 Results

Many peoples have passed through Vetschau and temporarily coexisted during its history (Stadt Vetschau 2023).[1] Within the last century, this dynamic has however intensified. In the first half of the 20th century, Vetschau was a peasant town, in which some residents still spoke Wendish as first language, with 4,490 inhabitants in 1959 (VEB KW Vetschau 1967). Then the construction of the largest power plant in the GDR began,[2] which had an output of 1,200 megawatts when it was completed. The power plant changed the city fundamentally. More than 4,000 workers from all over the GDR settled within the following decade. For those workers, 1,844 flats in prefabricated blocks were build. Those buildings were for many workers the main incentive to come to the city in the first place being technological avant-garde at that time, with a private bathroom inside the flat and connection to district heating. The spare heat from the power plant was also used to operate a complex of greenhouses in the middle of the

[1] Evidence of this, is the still existing German-Wendian double church, dating back from the 13th century, which is unique in Germany in this form.

[2] Eventually a VEB (People owned company) together with the neighbouring city Lübbenau was founded, that managed a potential of 2.500 megawatt.

city where fruit and vegetables were grown all year long. Schools and day-care centers were built, there was a House of Culture and several dance venues where people would come together (Lidschun 1982). In addition to the power plant, the Institute for Power Plants was founded, with about 1,000 employees at its peak (Interview 4, 13.07.2023), and in the rail wagon factory Lowa around 700 workers constructed metal components in two plants in the city (Interview 3, 10.07.2023). Vetschau had suddenly become a crowded modern industrial town, where several thousand people traveled by bus or on foot to the power plant at the beginning of each shift (Interview 4, 13.07.2023).

In 1990 divided Germany was reunited and on 30th June 1996, the power plant closed its doors forever, causing thousands of people to lose their jobs. The Institute for Power Plants remained as a planning company but was sold multiple times (Dornier-group 2023) and has currently around 200 employees (Interview 51, 02.08.2023). The Lowa company changed owners and went through three bankruptcy processes before it closed down on 30th June 2023 and laid off its last 72 workers (rbb 2023). The green houses lay in ruins. Since 1990, Vetschau city has lost around 40 % of its residents and has repeatedly had to incorporate smaller neighboring villages[3] through local government reforms in order to remain an independent municipality (Stadt Vetschau 2023a). That means in the last 70 years Vetschau has experienced tremendous changes, first through rapid settlement and industrialization, and afterwards 30 years of the opposite process.

All of these processes were accompanied by social transformations. As early as 1990, some workers started looking for employment in newly established private-sector companies and thus escaped the large wave of layoffs (Interview 18, 25.07.2023). To their misfortune, they also missed out the high compensation sums that the remaining workers received, when the power plant closed for good. After this began what during the interviews has been referred to as the golden years of Vetschau (Interview 3, 10.07.2023). The coincidence of never known amounts of private money and opportunities for consumption started a local Shopping Spree. Local businesses rose and flourished as many people invested in their homes or bought cars. But in the background, however, another phenomenon had already begun: especially young people started moving away. Too many workers had been laid off at the same time and could not be reintegrated in the labour market of a sparsely populated rural area. Some workers found jobs in surrounding towns, others went to relatively close-by power plants (Interview 19, 26.07.2023) or retired early, but many left for the

[3] Vetschau consists now of a city and ten incorporated villages.

Western part of the republic. As especially young people were looking for opportunities outside the region, it led to a demographic break that is still having an impact today, leaving mainly elderly people and socio-economically weak populations behind. The structural change, that took place in East Germany after the reunification in general, but especially in de-industrialised, shrinking cities struck in full (Staemmler 2014). Many of the once so fancy buildings have been demolished and still, 28 % of the left flats remain empty (Interview 25, 31.07.23). The average age of the population is significantly higher than the German average with 49 years (AdminStat Germania 2023) and unemployment reached peaks of 23,9 % on multiple times during the decades following the power plant close-down (DSK 2018).

It can be assumed, that many people were having personal crises with families breaking apart spatially, existential financial fears and a lack of orientation. This mixture of substantial problems and personal responsibility was previously unknown to most individuals, but also to the city as such. Under the socialist regime, not only did everybody have a job, but the state also organized the economy, politics and people´s lives centrally. This lack of experience also affected Vetschau, as the city was supposed to self-govern and democratically decide amid the ongoing crisis and dramatically changing circumstances, without having the capable personnel for that task (Interview 16, 22.07.23). Vetschau at that time had something like a monocultural working environment. Most people who had come to Vetschau in previous decades steamed from technical professions, but had no training in administration or retail, etc., which was suddenly needed.

To make things worse, it was not only the young, but also rather highly qualified and innovative people that followed the call of work to new shores causing a brain drain, when "brain" was the thing, most needed in Vetschau. So, without effective countermeasures, the decline in population led to the extinction of a lot of social institutions. Associations and clubs lost their members (Interview 24, 31.07.23), while dancing venues closed, resulting in a very limited civil life and little economic activity in the city, that led to a further closing of a lot of shops, cafes, and restaurants (Interview 4, 13.07.23).

The hole, deindustrialisation had left in the city´s life, became even physically tangible. With buildings left abandoned and industrial sites in ruins, the city was left without a vivid centre. There are still a few shops, but there is neither hustle and bustle on the market. There is no longer a central venue for social activities such as dancing, meeting or even drinking a coffee together,[4] so that the individual groups do not actually meet, as there is neither a need nor an opportunity to get in touch with residents of other parts of the city.

This decomposition shows in every aspect of city life. It is the main argument of this article, that the fragmentation of Vetschau and the isolation of different societal groups and actors in the city is the reason why the city is not capable to overcome the burden of structural change and implement any successful development within the city´s margins. Instead, it continues to provide a quality of live that is perceived as low by many residents (Interview 6, 14.07.23) and cannot even take advantage of the improved circumstances on the national level. The German as well as the local economy have recovered, both maintaining a solid number of 6 % unemployment rate during the last years (Niederlausitz Aktuell 2023). With that in mind, the immediate need of moving away to seek for a job has disappeared.[5] Socio-economically weak groups of the population should not be such a big problem anymore.

But the segmentation of society is not only a consequence of structural change but also the prerequisite for averting positive development and therefor actively self-perpetuating. There are too many “exclusive by accident”-circles in the city, be it in the political, cultural, or social sphere. Active members try to make a difference but at the end operate within a self-referring system. In consequence, it is an energy-draining intent, as the smallness of those circles leaves a lot of responsibility on the shoulders of few people, who never accomplish their imagined goals, as they are not able to reach and integrate other subjects neither on the providing nor on the receiving side. The longer (groups of) people stay apart from each other the bigger become their projected prejudices and the more natural it seems to have a distance between them. That leaves vulnerable groups alone with their problems, interested citizens without contact points and the city without a uniting identity.

8.4 Point of no Contact No. 1 – Living Infrastructure

And in terms of housing the city is growing further apart, with the demolition of those prefab buildings increasing the distance between their residents from those of single-family housing estates.

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[4] I conducted most interviews in people´s private homes, as there was no available public meeting space.

[5] Now it is up to young people to voluntarily move to urban centres, as those offer a wide variety of what one needs at that stage of life, but no necessity.

So, who does still live in Vetschau? There are still some power plant retirees and residents of single-family houses, who have set themselves up nicely in recent years. Latter also tend to grow old on average because only few of their children stay for their grandchildren to grow up in town.

Then there are the residents of those socialist worker blocks. The buildings have been partially renovated but their standard is by now not even state of the art anymore. Between them one can find aging playgrounds. The main group of residents is characterised by strong family bonds within the group but little involvement outside. Among this group there are many young people who raise large families with, for example, five children. They also have strong intergenerational bonds with grandparents, parents and grandchildren living in the same area and sharing the care work. I noticed during my walks through town they often meet up near playgrounds in large groups of 30 people in the afternoon. What can be seen as problematic about this population group is that on average its members tend to have a low educational background and are less integrated in the labour market (Interview 52, 28.07.23). As their participation in public volunteer work is below average and they sometimes have a rough tone of verbal expression in daily life, they can seem hard to approach (Interview 17, 24.07.23). That leaves them well connected between each other but isolated within the city scape leading in some cases to social welfare abuse and petty crime tendencies, that are passed on to the next generation within the same family.[6] So there is definitely a perpetuation of existing unfavourable structures out of the city´s perspective.

Who is new to Vetschau? First, there are the residents of the incorporated villages. Those villages lost their autonomy through local government reforms and are now governed and administered by Vetschau. They have honorary mayors who are consulted on matters affecting the village and a citizens' budget of 5 € per inhabitant and year at their free disposal, but everything beyond that must be passed on to the central administration (Interview 17, 21.07.23). That means politically and administratively the structures of local self-government in the rural areas have been weakened as those residents lost a great part of their self-determination and are politically underrepresented, as they make up almost 40 % of the population but have only two representatives (out of 17) in the city parliament.

[6] The police of Vetschau stated that as it is a small town, they always keep an eye on the notorious delinquents and can often predict who will be next as they have noticed this pattern of intergenerational inheritance over the years.

The second group of new residents are people with a history of international migration, often as refugees. Germany has been the destiny of a large wave of Syrian migrants since 2015 and with the beginning of the war in Ukraine in 2022, more than a million Ukrainians have come to Germany (Bundesregierung 2023). Those war refugees are distributed among districts and have been send in large numbers to Vetschau, as there is empty housing at affordable rent available in those socialist worker blocks. Between those migrants are also Afghans, Somalis and Chechens (Interview 9, 18.07.23). From spring to autumn up to 500 of those harvest workers mentioned in the introduction add to that group (Grieger 2023), so that people with an international background make up 15 % of the city population at times.

8.5 Point of no Contact No. 2 – Social Institutions / Public Infrastructure

Public social institutions could mitigate the isolation and build a bridge for those residents but instead are enforcing the separation. Some examples are:

There are two public day-care centres for children in the city. One of them is located in an antique townhouse that was fully renovated in 2011. It is nicely equipped and is situated between old town and single-family home area. This day-care centre is always booked out years in advance. The other day-care centre is a visible remnant of the GDR, is situated in the workers building area and always has free capacities available. In 2021, this day care centre received a lot of media attention as it could hardly be maintained open, because many employees resigned within a very short time and the management had to be fired due to internal quarrels. Afterwards the day-care centre received a coaching, a new name and new management (Hofmann 2023). Latter had the difficult task of pacifying the remaining staff, finding new staff despite the miserable reputation and a complex set of clients. Those are the kids of the already mentioned weakly institutionally integrated families, kids from mainly war refugee families, that might be traumatised and speak no German and all others, who could not register years in advance (if they have no alternative). After the end of the crisis coaching, the day-care centre receives no further support for this task from any social institution that could enhance their services with additional staff, offer low-threshold family work or German lessons for the kids and/or parents (Interview 10, 20.07.23).[7] My daughter went to this day-care centre temporarily during research, so I was able to observe the level of stress the employees were exposed to daily. When I then addressed social organizations and political actors in the

[7] In general, there are no German language classes offered in Vetschau outside school.

city with my perception of the state of social institutions, the conversation almost always came to a standstill because the other side insisted that there was no problem, that no additional support was needed and that the matter had long been settled (Interview 30, 04.08.23). That means the unequal distribution of public resources starts soon after birth for some, keeps others completely without tools such as language for their possible involvement and leaves many without access points for possible (self-) help or support and reinforces social inequality. It is made worse by the ignorance of public actors, I perceived to be in the position of changing the situation.

A similar case are teenagers. There is no place and no activities for young people. There is a kid's centre, which is mainly frequented by children aged ten to twelve and some sport activities that are open for teenagers too (Interview 22, 27.07.23). Apart from that, there is no public place for them to meet and socialise. When they began to gather on a bench and left traces such as trash and beer bottles, the solution was to dismantle the bench to let the problem disappear (Interview 22, 27.07.23). Now the youngsters either meet in lower amounts in their private homes or else switch to more remote places such as the ruins on the power plant site, where there are visible signs of youth culture in the form of graffiti, sofas, and bottles. When asked about the responsibility of the ruins, which are virtually freely accessible, I noticed that all parliamentarians knew nothing about this gathering point up to this moment (Interview 30, 04.08.23).

As with the new management of the day-care centre, the problem with teenagers had already been resolved in the city's perception. This approach is not only dangerous[8] but also counteracts the city's goals of keeping its young potentials. Youth emigration is still high and local companies are facing problems finding new employees. It is precisely in this formative phase that young people are physically pushed out of the city limits, do not feel welcome and are not involved in the city life (Interview 2, 06.07.23).

8.6 Point of no Contact No. 3 – City Parliament / Political Infrastructure

I kept encountering this defensive attitude of just getting rid of the acute problem without planning on improving the situation long term again and again and interpreted it as a result of the history and state of local self-government. As it was

[8] As the industrial ruin has broken glass everywhere, holes in the ground, access to roof terraces and exit points, that could be used for adolescent mischief, which then if gone wrong could lead to injuries in a very isolated and hard to access place.

mentioned in the historical outline, the city´s parliament has always had a difficult time governing the city. There are people in the city parliament who have been active since 1990 and say it has never been easy (Interview 16, 22.07.23). In many cases, the reason why they are still there is a sense of responsibility towards the city combined with the smouldering fear that if not, nobody else would care. However, as the city parliamentarians are getting older and more exhausted, the vicious circle of non-development, non-modernization and increasing non-representativeness has long begun. At the moment, 16 men and one woman are active in the city parliament. Two of the parliamentarians have children in elementary school, many more are pensioners and as it has been mentioned only two represent the incorporated villages. Thus, the city parliament is neither representative in terms of gender distribution, proportion of immigrants, city/village residents and families with children either of kindergarten age or young people.

The parliamentarians themselves complain about the gruelling slowness of decision making and mutual blockage of political groups within parliament and are also frustrated that only few citizens get involved (Interview 17, 24.07.23). But city employees are not allowed to get involved in politics as private individuals (Interview 26, 01.08.23). People who work in Vetschau, but do not live here, are not allowed to express themselves at all at public political meetings (Interview 22, 27.07.23). If concerned citizens speak up at committees, parliamentarians can go very hard on them, which in turn reduces the will of the public to participate further (Interview 42, 09.08.23). After the public question time, following the protocol no citizen is allowed to say anything in the public part of political meetings anymore anyway. And documents from those public meetings, that must be freely accessible by law, one has to request individually from the administration – again raising the burdens for residents to stay informed (Interview 41, 18.08.23). As a result, the parliament is basically isolating itself from interacting with the citizens they officially represent. And without new ideas and initiatives or exchange of information, development logically becomes slow, ineffective and draining for the active volunteers. Therefore, the quality of the parliament´s work worsens structurally, but also individually. As the members of parliament have no obligation to continue educating themselves and make informed decisions, some tend to continue to follow strategies and opinions that have been outdated by now. Others use the intransparency for encroaching behaviour, thus weakening the institutional structures of self-government further. In consequence, citizens and other parliamentarians have little insight into whether the limitations of the administration are inevitable or political will (Interview 30, 04.08.23).

At an organizational level, the city suffers from the fact that there is no separation of powers necessary for a well-functioning democracy. The citizens are stuck in a position where they can only complain about their political representatives vice versa, but cannot really interfere, apart from official elections every few years. Civil society is too weak to realize its watchdog function over the quality of the work of administration and political sphere. The press as important actor in the public sphere is also no longer a strong institution with less papers sold and few reporters, they must provide what potential buyers want to read instead of complex investigative journalism.

And so the focus of the parliament continues – as it has done since the 1990s – on the strengthening of the local economy by getting more industry to settle. It ignores that Vetschau already has a lot of massive industry, has no high unemployment rates to fight anymore (but instead no available workers) and the trade tax revenue is offset against municipal redistribution. With that more industries do not equally mean more public money to spend (Interview 26, 01.08.23). Quite the opposite could another industrial park rather be an obstacle to the diversification of the local economy as some industries[9] oppose others, for example tourism.

Meanwhile, there is a massive amount of 3,6 billion euros in subsidies spread across the region. Municipalities can apply for a funding of up to 90 percent for projects that are remotely related to the coal phase-out (Land Brandenburg 2022). But Vetschau claims it can get no approval as there are no good ideas, nobody capable of filling out the required application forms, the preparatory work for the applications would be too time-consuming and is just not feasible for such a small town (Interview 26, 01.08.23).

8.7 Overcoming Structural Change by creating Points of Contact

This declaration is proven wrong from Vetschau´s neighbour Lübbenau, were the other part of the power plant had been constructed and demolished equally. The city started under similar conditions, with the same symptoms of structural change in the aftermath of the power plant close-down. But instead of Vetschau, Lübbenau has developed well in recent years. Residents perceive their quality of life to be much higher. There are many cultural institutions in the city, tourism and retail benefit mutually (Huber et al. 2023). The main difference in their approaches of the city´s development is that Lübbenau is basing its decisions on cooperation and the involvement of as many actors from different spheres as

[9] Vetschau for example has the biggest pigsty in the whole state of Brandenburg.

possible. For that, an association was funded, called Lübbenaubridge,[10] whose aim it is to bring political decision makers together with actors from the housing sector, cultural institutions, (residential) business owners and residents. One can tell the seriousness of their approach as the members go on a multiple day trip together each year to decide on the next steps for the city´s future. This means that the opinions of various actors in the city are heard, and they can contribute their strengths in their field of expertise. The multitude of participants causes that many aspects of city life are seen and attended. In turn, citizens also get involved, as they notice they can make a difference. Because the city is developed by many, it is also the city of many and the inhabitants take increasing pride in their beautified hometown. This attitude also shows in the city´s administration. As public employees are trusted more, they have more professional space to develop their projects and this reputation attracts new qualified personal to apply for open position (Interview 42, 09.08.23).

Given this set-up the housing cooperative has reduced the amount of worker buildings, renovated the remaining ones individually to raise the physical living quality and has now a vacancy rate of two percent. The same housing cooperative, even though it is a business, has its own seniors social club organized by a full-time employed social worker and a children's and youth club. It also manages an adventure water park, where visitors can swim with penguins. The attraction is economically self-sufficient and does not need public subsidies but gets a lot of touristic attention. And now the city has participated in the coal phase-out competition and has just gotten approval for two multimillion-euro projects: a touristic Cucumber centre[11] and a co-working space (Interview 25, 31.07.23).

But one does not need to look as far as Lübbenau to find examples of overcome structural change by cooperation. The same has happened already – unnoticed by the central administration – in many of the incorporated villages of Vetschau. While the demographic numbers of the city keep being dramatic, most of the surrounding villages have stabilised their total amount of population (and some have even grown). The moving away of a generation has left a curve in the age demography but has been stabilised since the economic and employment situation of the region allows young people to either stay or come back to raise their families in the village (Interview 38, 28.08.23).

[10] https://www.luebbenaubruecke.de/
[11] Cucumbers are one of the main harvest products and representations of the region.

The villages have made use of the same principle as in Lübbenau on a smaller scale. People enjoy the high quality of life of those villages created between themselves. By cooperating with their neighbours, they are experiencing their self-efficacy and get tangible results out of it. While they build, design or organise something together, they make their own surrounding more beautiful and create their own source of pride and identification. The residents will also tread those installations differently, knowing who has built it and how much effort went in it. In consequence, the responsibility for the physical well-being of the place is spread among many shoulders (Interview 32, 10.08.23). But it is not only about responsibility, but also fun. While the residents create together, they engage socially with their neighbours, reduce reservations, and form a social network of trust. Several interviewees mentioned the closeness of cooperation as an important component. In some cases, they refuse to use digital ways of communication with the sole purpose of staying in personal contact, because that is their way of keeping the differences small that will always exist between people. Most of the village residents I interviewed also mentioned the aspect of working together and eating or celebrating together explicitly as an important point because it combines useful and beneficial things (Interview 31, 09.08.23). In many villages there are at least two clubs with which more than 50 % of the population are associated with (Interview 18, 25.07.23). Many villages have a “Home club” and the voluntary fire brigade, but in some places one can find the church or a sports club to be an important gathering point. Those clubs also organize an annual village festival. That means they provide a physical and social space for the residents to meet, on a day-to-day basis but also extraordinary occasions to come together.

The difference to Vetschau´s closed social circles is that the villagers’ networks do not exclude others. They actually make it easier for strangers to get into the social web and get involved. In many villages live people who have moved there from other regions, some of whom pursue non-traditional local activities, such as international youth encounters (Alte Ziegelei Gahlen), art (Kunsthaus Laasow) or ecological agriculture (Gut Ogrosen). The villager’s cooperation is also not only limited to cooperation within the village but can develop quite a lot of power if necessary. At the beginning of the Ukraine war, Ogrosen, which itself has only 200 inhabitants, accommodated 30 Ukrainian women and kids in the village’s vicarage, organized and self-financed by the local church association. The activists cooked food for those family they had been given from the population, provided them with everything they needed on site and organized a life for them in the region (Interview 31, 09.08.23).

And equal to Lübbenau this attitude of trust and responsibility effects not only the quality of work structurally but also individually. There are several examples of public employees in the villages filling out their positions way more favourable for all, as the restricted public employees in the central administration. There is an elementary school in one of the villages, that tightly involves parents, organizes its own project funding and managed to remodel the school for students with (physical) disabilities to attend (Interview 17, 24.07.23). The public day-care in Raddusch, another village, applied with the help of the local mayor for funding and organized its own trailer for the kids to rest, while they spend their weekly day in the forest (Interview 29, 04.08.23). The village of Raddusch additionally is home to a multitude of initiatives that together form a think tank for sustainable development, dealing with topics such as ecological building, civil society networking or district development (Interview 28, 04.08.23). That means there exists actually a high number of intellectual resources and knowledge about how to improve the city´s development. This initiative is also a hub and could network with other actors increasing the development potential even more. So far there have been cooperations within the village where several (especially ecological) projects have been implemented, but Vetschau city has not taken advantage of that beneficial situation (Interview 37, 21.08.23). I also only learnt – doing research about the hardships and restrictions of funding applications for small towns – that one of the parliamentarians has a daughter working at the very institution where Vetschau is unable to get its funding applications accepted. When I confronted the parlamentarian about the situation, they contested, that the others would not take up their offer of knowledge transfer to not let them show off with their family relations (Interview 53, 23.08.23).

8.8 Conclusion

In conclusion, the current underdeveloped state of the city of Vetschau is a direct result of the societal fragmentation, that has been left behind by the absence of the power plant as core of city life and has not been mend ever since. Through their isolation (potential) actors do only have very limited resources at their disposal, as they have no wide network of knowledge available. From a strategic point of view, this slows down and misleads development, foreclosing the use of presenting opportunities. From an emotional point of view, it lowers the living quality of all, as living and especially getting engaged in Vetschau is not a joyful activity at the moment. Without that network of trust, as it is practiced in the villages, engagement is a rather lonely and energy consuming activity, and can feel like a burden instead of a mean to self-efficacy. The loneliness I felt during my research I also sensed in some of my interview partners, especially the ones I felt were purposely delaying the end of our conversation. A city that cannot attend the emotional needs of its inhabitants is hard to make one's home. And who feels responsible or capable to welcome newcomers if there is nothing one can identify with or take pride in? The title of this anthology is pursuing societal transformation through education and knowledge transfer, but Vetschau serves as an example that this is not a linear chain reaction. In Vetschau exists the bi-directional need of societal transformation and knowledge transfer at the same time as both are prerequisites for the improvement of the other. And the education it needs for that is actually to learn to collaborate on equal terms, embrace diversity and weirdly – after so many years of hard draining developmental work – to enjoy each other's company.

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9 Comparative Analysis on Key Socioeconomic and Environmental Issues related to Coal-driven Activities in Seven EU Post-Mining Territories

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9.1 Introduction

Fossil fuels, which include coal, oil, and natural gas, account for approximately 50% of the total net electricity generated in the EU (Eurostat, 2016). Among these, coal, in the form of both hard coal and lignite, plays a crucial role, contributing one-fourth of the production of primary energy in the EU. The coal industry in the EU is a substantial economic sector, worth multibillion euros. It provides employment opportunities to thousands of EU citizens and contributes millions of euros to public finances through taxation. The industry is responsible for providing jobs to about 240,000 people, with approximately 180,000 working in the mining of coal and lignite, and around 60,000 employed in coal- and lignite-fired power plants (EC, 2018). This shift necessitates the implementation of just transition strategies to support the affected regions and ensure a smooth and sustainable transition towards alternative, more environmentally friendly energy sources and economic activities.

Mining is inherently a temporary activity with a finite lifespan, and its duration depends on factors such as the size, quality, and quantity of the coal deposit being extracted. Once the supply of natural mineral resources is depleted or when operations are no longer profitable (when marginal cost equals marginal revenue), mine closure becomes necessary (D'Angelo and Pijpers, 2018). The closure of mining activities raises important discussions about the future of the landscapes that have been severely degraded and adversely affected by extraction operations.

These post-mining areas may have experienced environmental damage, such as soil erosion, loss of biodiversity, and water pollution, among others (Bainton and Holcombe, 2018). Planning for post-mining land uses is crucial to ensure that these regions can transition successfully to alternative economic activities and that the environmental impacts of mining are adequately addressed. Land restoration and reclamation become essential components of the post-mining phase to rebuild ecological functionality and integrity across the affected landscapes (Ministry for Economic Affairs, Labour and Energy, Land Brandenburg, 2019).

The paper proceeds as follows. The next section provides a theoretical discussion and a synthesis of existing bodies of literature on socioeconomic and environmental impacts related to transition in post-mining areas. The following section presents the empirical findings of the research, while the next section attempts a comparative analysis among 19 operating coal mines in 7 EU countries. Conclusions and policy recommendations are provided in the last part.

9.2 Literature Review

The transition from coal towards a green and climate neutral path is a crucial step in achieving the EU's climate and sustainability goals. However, the transition away from coal also presents challenges, particularly for regions heavily reliant on coal-driven activities. As coal plants are gradually phased out, there can be a negative impact on the local economy and employment (Marinakis et al., 2020). The reduced operation and eventual shutdown of lignite plants can lead to rising unemployment rates, increasing poverty, and a decline in professional opportunities, especially for younger generations (Schwartzkopff and Schulz, 2015). These factors can contribute to continuous degradation and depopulation in coal regions.

Some regions with a heavy reliance on the coal industry may face economic limitations and become what is known as "coal lock-in" economies, where their economic development is heavily dependent on coal mining activity, hindering the growth of other sectors (Rentier et al., 2019; Trencher et al., 2020). These regions may struggle to diversify their economies and face challenges in adapting to the transition to renewable energy. To address the negative impacts of the transition, it is crucial to implement just transition strategies. These strategies should focus on supporting affected communities by creating alternative job opportunities, promoting economic diversification, and investing in retraining and reskilling programs (Krawchenko and Gordon, 2021; Abram et al., 2022). Additionally, there should be a focus on post-mining land restoration and environmental rehabilitation efforts to promote sustainable development in the regions affected by the transition (Keenan and Holcombe, 2021).

The literature has extensively studied local community perspectives in mining areas, particularly in the context of the transition from coal to more sustainable energy sources (Yang and Ho, 2019; Bec et al., 2016; Karasmanaki et al., 2020). Several research works have investigated different aspects related to the just transition and the challenges faced by communities heavily reliant on coal-driven activities. Achieving a just energy transition is a significant challenge for European countries with a long history of coal mining and a heavy dependence on solid fossil fuels, especially lignite, such as Germany, Poland, Czech Republic, Bulgaria, Serbia, Greece, and Romania, which have relied on coal as a primary energy source for many decades due to the abundance of lignite resources in Europe's subsoil (Stognief et al., 2019; Nikas et al., 2020). While coal has played a crucial role in meeting energy demands and supporting economic growth in these countries, it is also a major contributor to greenhouse gas emissions and air pollution.

9.3 Empirical Evidence

Operating coal mines

The empirical research concerns coal extractions operations which are currently taking place in 19 operating coal mines in seven EU countries, as portrayed in Table 1, with an annual production which amounts to 183.2 million tonnes, representing 36.8% of the total EU production. Western Macedonia (Greece) hosts the largest number of coal mines in the consortium with eight extraction sites, followed by Yugoiztochen (Bulgaria) with four coal mines, and Észak-Magyarország (Hungary) and Brandenburg (Germany) with two coal mines each. Łódzkie (Poland) is the largest producer with 42.1 million tonnes annually, followed by Western Macedonia (37.5 million tonnes) and Brandenburg (34 million tonnes). Lignite is predominantly mined in these territories through mostly surface extraction operations in the form of open pits; underground mining operations are carried out only in Yugoiztochen (Bulgaria) and Savinjska (Slovenia). The average productivity of mines stands at 5,550 tonnes per employee, ranging from 9,994 in Brandenburg (Germany) and 8,849 in Western Macedonia (Greece) to 2,512 in Savinjska (Slovenia) and 2,264 in West Oltenia (Romania). The deepest coal mines are located in Łódzkie (Poland) and Yugoiztochen (Bulgaria) with 300 and 182 m. depth respectively.

Table 1: Empirical Research on 19 operating coal mines in 7 EU countries (Source: Decarb Project https://projects2014-2020.interregeurope.eu/decarb/)

Region	No. of mines	Type of coal	Mine Type	Production (Mt)	Coal depth (m)	Coalfield
Yugoiztochen (BG)	4	Lignite	Open pit & underground mine	32.6	182	Maritsa lignitefield
Łódzkie(PL)	1	Lignite	Open pit & underground mine	42.1	300	Belchatów
Észak-Magyarország(HU)	2	Lignite	Open pit mine	9.3	n/a	Matra
Sud-Vest Oltenia (RO)	1	Lignite	Open pit mine	24	n/a	Oltenia Basin
Brandenburg (DE)	2	Lignite	Open pit mine	34	110	Lusatian Area
Dytiki Makedonia (EL)	8	Lignite	Open pit mine	37.9	175	West Macedonia Lignite Centre
Vzhodna Slovenija (SI)	1	Lignite	Underground mine	3.3	160	Premogovnk Velenje

Coal-fired power plants

All territories host coal-fired power plants (see Table 2). There are 17 coal fired-powered plants in operation with a total capacity of 21 GW, making up about 2.1% of the total European power generation capacity. With regards to the type of coal, lignite is used as the primary fuel in almost all territories except for Észak-Magyarország (Hungary) which uses hardcoal. The territory with the most installed capacity is Łódzkie (Poland) with around 5500 MW, followed by Brandenburg (Germany) and South-West Oltenia (Romania) with 4600 MW and 3900 MW respectively. The power plants with the lowest operational capacity among territories are located in Nordjylland (Denmark) and Észak-Magyarország (Hungary) with 740 MW and 1130 MW respectively.

The examined lignite fueled power plants are located in close proximity to mine sites and are connected with them with rail networks/infrastructures to make the supply of raw materials easier and more convenient. The vast majority of coal-fired plants were commissioned over 30 years ago. These plants are, on average, 34 years old with an estimated efficiency of a mere 33.6%, which is below the EU average (35%). Efficiency is a proxy to assess the performance of a power plant. It depicts the share of energy contained in the fuel that is converted into heat and electricity and is calculated based on known plant parameters (age, type, fuel) and environmental conditions. The higher the efficiency of a coal fueled power station, the less the production costs and carbon dioxide (CO2) emissions. The efficiency of coal-fired plants is within a range of 29%-37%. The most efficient power plants, fitted with Best Available Technologies (BAT), are located in Savinjska (Slovenia), Łódzkie (Poland) and Nordjylland (Denmark) with rates greater than or equal to 37%.

Table 2: Empirical Research on 17 fire-powered plants (Source: Decarb Project https://projects 2014-2020.interregeurope.eu/decarb/)

Country	Region (NUTS2)	Capacity (MW)	Age (years)	Average effi-ciency (%)
Bulgaria	Yugoiztochen	3504	44	34%
Poland	Łódzkie	5472	23	36%
Hungary	Észak-Magyaror-szág & Közép-Dunántúl	1130	44	29%
Romania	Sud-Vest Oltenia	3900	37	33%
Germany	Brandenburg	4600	27	34%
Greece	Dytiki Makedonia	3401	31	30%
Slovenia	Savinjska[1]	1029	22	37.5%

In the early 1960s, coal mining, closely intertwined with the rise of industrial economy in Europe, created millions of jobs in coal intensive regions and secured a good standard of living for rural communities. InGermany alone, the coal industry provided permanent employment to over 600,000 people. Nevertheless, over the past few decades the number of coal related jobs in Europe is steadily decreasing as the production and consumption of coal in the EU has been in steady decline due to the closure of uncompetitive coal mines and the growing role of renewables in the EU countries' energy mix.

Still, the coal industry remains a major employer in regions with substantial mining and coal-based power generation activity. It is estimated that the coal industry directly employs 49,027 people in the territories of the examined sample; 38,306 (78.1%) in coal mines and 10,721 (21.9%) in coal-fueled power plants. The territories with the highest overall employment in the coal industry are South-West Oltenia (Romania) and Yugoiztochen (Bulgaria). Coal related employment in the territories ranges from 12,300 jobs inYugoiztochen (Bulgaria) and 13,000 jobs in South-West Oltenia (Romania) and 1,500 jobs in Savinjska (Slovenia).

Yugoiztochen (Bulgaria) and South-West Oltenia (Romania) are on the top of the list regarding employment in coal extraction activities, each hosting more than 10,500 direct jobs in coal mine sites.Łódzkie (Poland) and Western Macedonia (Greece) follow with around 6,400 and 4,300 employees respectively while Savinjska (Slovenia) and Észak-Magyarország (Hungary) account for less than 1,600 employees. When it comes to coal power stations, South-West Oltenia (Romania) and Łódzkie (Poland)account for the largest number of job positions among the territories with over 2,500 employees. On the other side, Savinjska (Slovenia) provides 250 and 311 jobs respectively in coal-based energy production.

Based on Alves Dias et al. (2018), these jobs have mostly to do with equipment and machinery manufacturing and supply, supporting services and R&D. Throughout the coalvalue chain in the examined territories, the number of indirect jobs is estimated at 94,781. For these territories, the ratio between indirect and direct jobs is 1.93. This implies that for every direct job created in the coal industry, almost two additional jobs are created and preserved in the local economy in support of coal driven operations. The highest ratio between indirect and direct jobs is observed in Brandenburg (Germany) and Łódzkie (Poland) with 4.44 and 3.33 respectively.

For some territories, the coal industry represents a major source of employment for local populations. For instance, in Western Macedonia (Greece), coal mining and power generation activities account for 6.3% of the regional employment. Remarkably, the coal industry is responsible for 45.9% of job positions in the secondary sector, without considering the indirectly employed created by coal driven activities.

Table 3: Empirical research on coal related employment in territories in 7 EU countries (Source: Decarb Project https://projects2014-2020.interregeurope.eu/decarb/)

Territory	Employment in coal mines	Employment in coal fired power plants	Indirect employment	Total employment
Brandenburg (DE)	3,402	1,107	20,000	24,509
South West Oltenia (RO)	10,600	2,600	8,000	21,200
Western Macedonia (GR)	4,283	1,398	5,200	10,881
Yugoiztochen (BG)	10,773	1,885	19,558	32,216
Savinjska (SI)	1,255	311	2,500[7]	4,066
Łódzkie (PL)	6,338	2,538	30,305	39,181
Eszak-Magyarorszag (HU)	1,655	632	5,697	7,984
All territories	**38,306**	**10,721**	**94,781**	**143,808**

Expected socio-economic and environmental impacts from the coal phase-out

The EU has embarked on an energy transition to decrease its carbon emissions by 40% below 1990 levels until 2030. This entails the decarbonization of the EU economy, which requires a switch from fossilfuels (especially coal) to cleaner and more sustainable sources of energy such as renewables. However, this transition will not come without challenges for territories strongly dependent on coal. The shrinkage of the coal industry, as anticipated with the closure of coal fields and the decommissioning of coal fueled power plants over the next decade, will inevitably create a shockwave for coal intensive regions, to be experienced in the form of severe losses in local employment and income. Therefore, the future of these regions should be designed on the foundations of a just transition strategy that will exploit region's competitive advantages and strengths, to diversify the economy and set forward an alternative route for sustainable and inclusive growth away from coal and mineral resources. This subsection presents the magnitude of socioeconomic impact from the shutdown of coal driven activities in the examined territories.The territories that will most probably confront the highest impact are those with high unemployment rates, lower regional GDP per capita, and undiversified economy (see Table 4).

Table 4: The socio-economic profile in territories in 7 EU countries (Source: Decarb Project https://projects2014-2020.interregeurope.eu/decarb/)

Territory	Unemployment rate	Coal related jobs (bothdirect & indirect) as a share in economically active population	Regional GDP per capita versus thenational average	Share of coal industry in the regional output
Brandenburg (DE)	4.5%	2%	27% lower	13%
Southwest Oltenia (RO)	5.5%	2.9%	20% lower	4.5%
Western Macedonia (GR)	27%	9.9%	25% lower	39.4%
Yugoiztochen (BG)	5.7%	6.1%	20% lower	34.4%
Savinjska (SI)	5.5%	3.4%	7.5% lower	6%
Łódzkie (PL)	6.2%	3%	6.5% lower	1.3%
Eszak-Magyarorszag (HU)	5.8%	0.7%	21% lower	Not available (but low)

From the examined territories, Western Macedonia (Greece) and Yugoiztochen (Bulgaria) are expected to witness the most severe socioeconomic impact from the coal phase out scenario. Western Macedonia (Greece) with a particularly high unemployment rate (27% in 2018) and GDP/capita 25% lower than national average will suffer a major hit, if an additional 3.5% of active population will be at risk of losingits employment status due to the closure of coal mines and coal-fired power plants. Another territory that might be significantly affected is Yugoiztochen (Bulgaria). Yugoiztochen with GDP/capita almost 20% below than national average and 12,300 jobs at risk might reach an unemployment rate at the level of 10%.

Savinjska (Slovenia) is expected to experience a lower social impact (low to moderate), compared to Western Macedonia (Greece) and Yugoiztochen (Bulgaria), considering that the unemployment rate is relatively low (5.5%) and the coal industry represents only a small share of the total GDP produced in the region (5.7%). Yet, Slovenia is a relatively small country and both within the context of the Savinjska region and the country as a whole, the lignite-sector is one of the largest sources of electricity production and of great importance currently for a well-balanced energy mix for security of supply reasons and thereforethe biggest factor to consider in terms of wider impacts caused by a future phase-out of coal on a national level as well.

In Brandenburg (Germany), the permanent shutdown of coal-driven activities is expected to lead to the loss of around half of the jobs directly or indirectly sustained by the coal industry. The total number of job losses can reach up to 3500, resulting in a 26.7% increase in the region's unemployment rate from 4.5% to 5.7%. With a low unemployment rate and despite the fact that the GDP per capita is 27% lower than the national average, Brandenburg (Germany) will most probably be able to absorb job losses by re-employing a significant portion of coal-related workforce in RES energyproduction; Brandenburg (Germany) is a forerunner in the use of solar and wind energy, biomass, geothermal and hydroelectric power.

Finally, Southwest Oltenia (Romania) region with GDP per capita almost 20% lower than the national average and ~13200 coal (direct) related jobs at risk might experience a high increase in the number of unemployed persons, which may reach 22%. Southwest Oltenia (Romania) will be one of the EU regions to experience the highest job losses from the shutdownof coal driven activities in absolute numbers. Nevertheless, the region thanks to its low unemploymentrate (5.48%), and the fact that the share of jobs at risk in economically active population is 1.1%, anddespite the significant number of job losses, might experience a low to moderate medium social impact with the possibility to absorb the decline in employment on medium to long term.

With 9,000 direct jobs and 30,000 indirect jobs at risk, Łódzkie (Poland) will be the most affected region in absolute numbers among the territories. Notwithstanding this, Łódzkie might experience a low social impact, as it is characterised by a low unemployment rate (4%) and a highly diversified economy.The same stands for Észak-Magyarország (Hungary), which features a small number of workers in coal driven activities (2,200), a low unemployment rate and the coal industry represents only a small share of the regional product. The positions that may face a higher risk are those in coal extraction processes as previous experience shows that the remaining coal-fueled power stations will not permanently close but will most probably switch their input fuel to natural gas or biomass thus maintaining the previous employment status.

From the environmental pollution point of view, coal extraction and combustion for the production of electricity is one of the leading causes for the emission of harmful air pollutants such as PM10, NOx and SO2 particles, with detrimental effects on human health and the environment. At a time when the EU has stepped up its efforts to phase-out fromcoal and meet its climate change targets, coal is responsible for almost 15% of total EU emissions (Agora Energiewende and Sandbag 2018). In 2016, coal driven activities in the examined countries generated 540.7 million tons of GHG emissions. This volume ranges from 265.6 million tons in Germany and 129.3 million tons in Polandto 6.8 million tons in Hungary. In these territories, coal combustion accounts on average for 24.5% of total GHG emissions generated at country level. The highest shares are observed in Bulgaria (44%), Poland (36%), Greece (31%) and Germany (29%). It is well known that coal is a high polluting industry; however, the situation is exacerbated in the examined territories from the fact that the vast majority of active coal fueled power plants have been commissioned over thirty years ago and most of them have not undergone the necessary retrofitting and technology upgrading to meet the new EU standards in accordance with the Industrial Emissions Directive. For instance, in Western Macedonia (Greece), air pollutants caused by Thermal Power Plants exceed the European limit values by more than 20%.

The negative environmental impacts from coal are not limited to air pollution but include the destruction of local ecosystems and agricultural land, extensive deforestation, biodiversity loss, underground and surface water pollution (e.g. acidification), soil degradation, ground contamination and dust pollution. In some cases (e.g. Southwest Oltenia) the intensity and depth of excavation activities in have led to the drainage and contamination of water resources, leaving entire villages without drinking and clean water. In addition to the environmental damage, coal extraction and combustion release substances that are profoundly hazardous to human health. Exposure to these pollutants can damage people's cardiovascular, respiratory and nervous systems, increasing the risk of lung cancer, stroke, heart disease, chronic respiratory diseases and lethal respiratory infections. According to "Europe Beyond Coal",[1] coal is responsible for over 9,000 premature deaths annually while in coal intensive regions life expectancy is much lower compared to other parts of EU countries.

Based on the provided analysis, we can rank the expected socio-economic impact of land repurposing initiatives in the examined territories into three levels: high, medium, and low (see Table 5). The ranking is based on factors such as the magnitude of coal mining operations, the potential for economic diversification, the feasibility of implementing various repurposing strategies, and the current socio-economic context of each region. More specifically, high impact is expected in territories with large coal mining operations, high annual production, and significant potential for economic diversification through sustainable land repurposing. These regions may have multiple opportunities for eco-industrial sustainable development, renewable energy projects, and other high-impact initiatives. Medium impact involves territories with moderate coal mining activities and production levels. These regions may have opportunities for reforestation, agricultural and agroforestry practices, and some level of eco-industrial development and community-

[1] For details see: https://beyondfossilfuels.org/data/; some estimates are even higher up to 34,000 deaths per year (Dunne, 2021).

based initiatives. Low impact is expected in territories with relatively smaller coal mining operations and production levels. These regions may have limited options for land repurposing but can still benefit from initiatives like ecological restoration, recreational and tourism activities, and water management projects.

Table 5: The socio-economic impact in territories in seven EU countries (Source: Decarb Project https://projects2014-2020.interregeurope.eu/decarb/)

Territory	Socioeconomic impact
Western Macedonia (GR)	**High**
Yugoiztochen (BG)	**High**
Brandenburg (DE)	**Medium**
South West Oltenia (RO)	**Medium**
Savinjska (SI)	**Medium**
Łódzkie (PL)	**Low**
Eszak-Magyarorszag (HU)	**Low**

9.4 Conclusions

Following an announcement for coal phase-out, competent authorities at either the national or regional level (depending on the governance structure) play a vital role in drawing up and implementing a just transition plan. This plan is essential to lay the groundwork for the necessary transformation and restructuring of affected economies and to guide the process of land restoration. The just transition plan focuses on addressing the needs of affected workers and communities, promoting alternative, sustainable economic activities, and ensuring the successful restoration of mined lands. By developing and implementing a comprehensive just transition plan, competent authorities can effectively address the challenges of coal phase-out, support affected communities, promote sustainable economic development, and ensure the successful restoration of mined lands, contributing to a greener and more sustainable future for the region.

The most critical step and key prerequisite for successful land restoration and environmental restitution in the examined territories' mine sites is the existence of a firm commitment from national governments to phase out coal-powered electricity within a given time interval. This commitment must be strongly supported by regional authorities and local communities. Such a commitment sets the foundation for a clear and time-bound transition away from coal-based energy production, creating a favorable environment for planning and implementing land restoration initiatives. However, it is essential to accompany this commitment with effective policies, support mechanisms, and inclusive engagement with stakeholders to ensure a just transition. Engaging regional authorities and local communities in the decision-making process and supporting community-led initiatives are crucial for the successful implementation of land restoration and sustainable development efforts in these territories.

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10 A Methodology in Identifying Good Practices on Coal Phase-Out and Clean Energy Transition

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10.1 Introduction

Coal is a major source of greenhouse gas emissions, particularly carbon dioxide (CO2). Transitioning away from coal is essential to mitigate climate change and achieve global emission reduction targets, as outlined in international agreements like the Paris Agreement (Burke et al., 2020). Coal combustion releases not only CO2 but also various pollutants, including sulfur dioxide (SO2), nitrogen oxides (NOx), and particulate matter, which contribute to air pollution and pose serious health risks. Phasing out coal can significantly improve air quality and public health (Rokni et al., 2018).

Transitioning from coal to cleaner energy sources, such as renewable energy (e.g., solar, wind, hydro), is necessary to accelerate the adoption of sustainable and low-carbon energy technologies. Reducing dependence on coal can enhance energy security by diversifying the energy mix and reducing reliance on fossil fuel imports. It can also lead to greater energy independence (Bahgat, 2006). On the other hand, clean energy transition creates new economic opportunities in terms of job creation, innovation, and the growth of renewable energy industries. However, a just transition from coal should ensure that affected communities, including coal workers and regions heavily dependent on coal, are supported in the process, and that the transition benefits all members of society (Harrahill and Douglas, 2019).

This paper describes a methodology designed to identify and assess good practices for decarbonization within the energy sector, with a specific focus on regions heavily reliant on carbon-based energy production. The primary objective of this methodological approach is to gather empirical evidence from successful interventions and processes that have contributed to the development of energy policy ecosystems aligning with the goal of achieving clean transitions. It involves a combination of data collection, analysis, and evaluation to highlight the key elements that contribute to the formation of energy policy ecosystems conducive to decarbonization objectives.

Sharing good practices globally facilitates collaboration among countries and regions, enabling them to learn from each other's successes and challenges, and accelerating the overall transition to cleaner energy. Identifying and disseminating good practices in coal phase-out and clean energy transition can provide valuable insights into effective strategies, policies, and technologies that have been successfully implemented in various contexts. It enables policymakers, businesses, and communities to make informed decisions and implement measures that lead to a more sustainable energy future.

The paper proceeds as follows. The next section provides an overview on decarbonization background and relative scenarios. The following section provides the proposed context for evaluating decarbonization best practices. The last section provides conclusions and policy recommendations.

10.2 Decarbonization Background and Scenarios

Decarbonization is not just about shifting to carbon-free energy sources; it involves far-reaching consequences that affect a wide range of policy domains, including social cohesion, health, transportation, education, and more. Achieving successful decarbonization involves multiple dimensions, with specific goals such as a carbon-free energy mix and reduced coal intensity in fossil fuel consumption (Fankhauser and Jotto, 2018; Longa et al., 2022). Decarbonization drives innovation in energy technologies, creates new industries, and fosters job opportunities. Investments in renewable energy, energy efficiency, and sustainable infrastructure can stimulate economic growth. As the transition progresses, economies may adapt to these changes, leading to the emergence of new markets, skilled jobs, and sustainable business models (Arent et al., 2022; Raimi et al., 2021).

A just transition is crucial, especially for regions and communities heavily dependent on carbon-intensive industries. By designing policies that consider the social and economic well-being of affected individuals and regions, decarbonization can be more equitable. Supporting workers and communities in transitioning to new opportunities, providing retraining programs, and ensuring that the benefits of clean energy reach marginalized populations are essential aspects of a just transition (Carley and Konisky, 2020; Newell and Mulvaney, 2013).

While there are challenges and costs associated with decarbonization, it is essential to recognize that proactive policies can mitigate these challenges and lead to positive outcomes. By fostering innovation, embracing a just transition, and taking a holistic approach that considers the broader socio-economic context, decarbonization can be a sustainable and beneficial process, contributing to a cleaner and more resilient future. Balancing the costs and benefits, along with careful planning, can help create a more manageable path towards a carbon-free energy future (Nordhaus, 2013; Hottenroth et al., 2022).

The current decarbonization trajectory in the European Union (EU) is represented by the EU reference scenario 2020, which is a comprehensive framework used to project the future development of energy-related factors within the region (European Commission et al., 2021). The EU reference scenario builds on the legally binding targets set for 2020, specifically focusing on greenhouse gas (GHG) reductions, the uptake of renewable energy sources (RES), and improvements in energy efficiency. The emphasis on reducing coal consumption in the EU reference scenario aligns with the understanding that coal is a primary contributor to carbon emissions and a key target for decarbonization efforts. The scenario recognizes the differences in carbon intensity among fossil fuels, with the aim of transitioning away from the most carbon-intensive sources while considering the role of gas in the short-to-medium term. The Energy Roadmap, outlines six scenarios to assess different potential pathways for the energy sector's development:

<u>Business as Usual (Common Reference Scenario):</u> This scenario represents a continuation of current trends without major policy changes, providing a reference point for comparison with other scenarios.
<u>Current Policy Initiatives:</u> This scenario considers the impact of existing policies and measures in place at the time of the roadmap, aiming to achieve energy and climate targets.
<u>High Energy Efficiency Scenario:</u> This scenario explores the potential benefits and outcomes of significantly enhancing energy efficiency measures across various sectors.
<u>High Renewable Energy Sources (RES) Scenario:</u> This scenario focuses on the increased integration and utilization of renewable energy sources, such as wind, solar, hydro, and biomass, aiming to reduce dependence on fossil fuels.
<u>Delayed Carbon Capture and Storage (CCS) Scenario:</u> This scenario assesses the implications of a delayed implementation of carbon capture and storage technology, which plays a role in mitigating emissions from certain sectors.
<u>Low Nuclear Scenario:</u> This scenario examines the effects of reducing the reliance on nuclear power, a low-carbon energy source, in the overall energy mix.

These scenarios allow policymakers and stakeholders to analyze the potential outcomes, advantages, and challenges associated with different policy directions and technology pathways, providing valuable insights for decision-making in the energy sector.

10.3 Context for Evaluating Decarbonization Best Practices

Within the scope of this contribution, it is considered that all coal-related activities form the coal value chain. To this end, we can analyze them into the categories of mining, refining, manufacturing and distribution in primary energy sector as presented in Figure 1. Moreover, we take into consideration, the types of professional groups employed in mining activities, the types of coal-fired power plants and the types of indirect professional types in coal related activities.

<table>
<tr><td colspan="12">Primary energy sector</td></tr>
<tr><td colspan="3">Mining</td><td colspan="3">Refining</td><td colspan="3">Manufacturing</td><td colspan="3">Distribution</td></tr>
<tr><td colspan="12">Types of professional groups employed in mining activities</td></tr>
<tr><td colspan="4">Production employees</td><td colspan="4">Auxiliary employees</td><td colspan="4">Mine management & support staff</td></tr>
<tr><td colspan="12">Types of coal-fired power plant professional groups</td></tr>
<tr><td colspan="4">Construction</td><td colspan="4">Operation</td><td colspan="4">Maintenance</td></tr>
<tr><td colspan="12">Types of indirect professional types in coal related activities</td></tr>
<tr><td colspan="6">Supply chain</td><td colspan="6">Industries</td></tr>
</table>

Figure 1: Proposed domains for the evaluation of decarbonization practices (Source: Decarb project, own elaboration)

Based on the context above, it is essential to analyze the entire coal value chain comprehensively when studying good practices on coal phase-out. By analyzing these aspects comprehensively, we can gain a thorough understanding of the coal value chain, its associated professional groups, and the potential environmental, economic, and social implications of coal-related activities in identifying good practices. This knowledge is essential for making informed decisions about energy transitions and addressing the challenges associated with decarbonization.

Moreover, evaluating the level of consistency with the EU's climate and energy goals and low carbon economy targets (demonstrated in Figure 3) is a crucial step in identifying good practices for coal phase-out and clean energy transition.

	2020	2030	2050
Climate & Energy	20% cut in greenhouse gas emissions (from 1990 levels)	At least 40% cuts in greenhouse gas emissions (from 1990 levels)	By 2050, the EU should cut greenhouse gas emissions to 80% below 1990 levels
	20% of EU energy from renewables	At least 27% share for renewable energy	Milestones to achieve this are 40% emissions cuts by 2030 and 60% by 2040
	20% improvement in energy efficiency	At least 27% improvement in energy efficiency	All sectors need to contribute
Low carbon economy targets			The low-carbon transition is feasible & affordable

Figure 2: Emissions' reduction targets (Source: Decarb project, own elaboration)

Such consistency can be achieved by mobilizing diverse ***policy targets*** whose implementation can be understood as supporting decarbonization transitions, taking into consideration the following parameters:

(a) Energy security: Energy security implies relative independence from imported fuels or minimization of the risk thereof (i.e. diversification of supply sources)

(b) Sustainable socio-economic and environmental development: Coal-phase out and the introduction of new technologies are having the effect of job loss along the coal value chain, increased costs for consumers, emerging need for vocational training, need for land restitution and post- mining management

(c) Public health: Public health policies are determinants of decarbonization. Burning fossils is the main emissions' factor.

(d) Transport policy: If current policies dictate the electrification of transport (to reduce direct emissions), it remains a question whether or not electricity production is coal-intense or otherwise

(e) Fiscal policy & equilibrium: Either at the national level or at regional/local level, fiscal policy is a key aspect and potential driver of decarbonization.

In terms of ***infrastructure*,** there are basically three ways to reducing GHG emissions in energy production:

(a) Renewables (RES)
(b) Nuclear energy
(c) Carbon Capture and Storage (CCS) approach.

Each of these approaches has its advantages and challenges. RES offer a sustainable and abundant energy source but may have intermittency issues (solar and wind) and require substantial investment in grid integration and energy storage technologies. Nuclear power is low-carbon and provides a consistent energy supply but has concerns related to nuclear waste, safety, high initial costs, and public perception. CCS can help mitigate emissions from existing carbon-fueled plants but has infrastructure and cost challenges, as well as questions about long-term storage safety and the scalability of the technology.

1. General emissions reduction policies (climate-change and non-climate changepolicies as decarbonisation drivers)	– Energy security – Sustainable socio-economic development – Public health – Transport policy – Fiscal equilibrium
2. Infrastructure development /transformation	– Renewable energy sources – Carbon Capture and Storage (CCS) – Nuclear – Grid renewal
3. Economic / fiscal instruments	– Carbon taxing – EU ETS – Public / private financing of RES – Lift of fossil fuel subsidies
4. Public awareness & capacity building	– Awareness campaigns – Educational programmes
5. Post-mining socioeconomic &environmental management	– Employability / unemployment – Vocational/ transitional training for RES – Land restitution – Bottom up planning – Carbon leakage evasion plan

Figure 3: The five key-parameters of energy decarbonization (Source: Decarb project, own elaboration)

When it comes to ***economic instruments affecting demand for carbon and/or renewables***, the following factors come into play:

(a) The EU Emissions Trading System (EU ETS): The EU ETS has been designed to function in combination with other policies and measures, including those related to the energy sector. The system is a cornerstone of the EU's efforts to combat climate change, and it plays a crucial role in incentivizing emissions reductions in industries covered by the scheme.

(b) The Carbon pricing: Carbon prices, including carbon taxes and emissions trading systems, can be subject to fluctuations, and fiscal policy can have significant effects on both the demand for and supply of carbon-intensive products and services.

(c) The finance of RES: Financing renewable energy sources is a strategic and effective approach for achieving a reduction in the demand for fossil fuel-intense energy, contributing to a sustainable and low-carbon electricity supply.
(d) The Fossil Fuel subsidies: Subsidies can significantly influence the relative costs of different energy sources. When there are substantial subsidies, tax advantages, or financial incentives for coal-intensive electricity, it can lead to artificially lower prices for this energy type, making it more attractive to consumers.

Identifying good practices should also take into account the level of ***awareness, capacity building*** activities and the ***post-mining socio-economic and environmental management***. To this end, the level following implications could be examined:

(a) Raising public awareness on emissions reduction, decarbonization of energy: Raising public awareness about emissions reduction and the decarbonization of energy is a crucial step in achieving sustainable environmental goals. By investing in public awareness and education, societies can create a groundswell of support for emissions reduction and accelerate the transition to a sustainable energy future.
(b) Streamlined educational programs on clean energy: Streamlined educational programs focused on clean energy are indeed a valuable tool for promoting sustainability, raising environmental awareness, and fostering a future generation of informed and environmentally conscious citizens.
(c) 'Green employability': "Green employability" focuses on the development of skills, vocational training, and re-skilling opportunities for individuals seeking employment in the renewable energy sector and other environmentally sustainable industries.
(d) Coal mining phase out. Managing socio-economic effects: By proactively addressing the socio-economic effects of coal mining phase-out, regions can transform the challenges associated with dependence on raw resources into opportunities for sustainable development, job creation, and improved quality of life for their communities. A comprehensive and well-planned approach is essential to ensure that no one is left behind in the transition to a cleaner and more sustainable energy future.

(e) Coal mining phase out – managing prospective land uses: Managing prospective land uses in former coal mining areas during the phase-out is a complex but essential aspect of the transition to cleaner energy sources. By effectively managing prospective land uses during coal mining phase-out, regions can transform former mining areas into valuable assets that contribute to environmental conservation, economic diversification, and the overall well-being of communities, while setting a positive example for future energy transitions.

(f) Bottom-up planning & schemes: Bottom-up planning, coupled with public-private partnerships (PPPs), is a powerful approach to post-mining land restitution and sustainable development in coal-mining regions. By combining bottom-up planning with public-private partnerships, coal-mining regions can not only restore and repurpose post-mining lands but also foster social cohesion, strengthen local economies, and set the stage for sustainable and inclusive development in the wake of coal mining phase-out.

(g) Carbon leakage evasion planning: Carbon leakage is a significant concern, particularly for energy-intensive industries that face the risk of relocating to regions with less stringent climate regulations, leading to a potential increase in global emissions. Balancing the need for emissions reduction with the economic competitiveness of energy-intensive industries requires careful planning, targeted policies, and collaboration among governments, industries, and stakeholders.

To effectively discern the best practices in decarbonization pathways and present them comprehensively, it is necessary to rephrase the criteria and related categories as research questions. These questions could serve as a structured framework for analyzing and evaluating different aspects of decarbonization efforts. To this end, in the case of an empirical research, the following research questions could be addressed:

- *Which policy interventions have proved effective in curbing GHG emissions in the energy sector?*
- *What infrastructural development and energy mix better supports the aim of emissions' reduction?*
- *Which solutions have been the most cost-effective, in terms of managing sustainability-driven energy transitions? Why have these cases proved successful along environmental, social and economic lines?*
- *What are the main challenges encountered prior to and during the implementation of these processes and practices (where processes refer to policy interventions and practices of deepening decarbonization)?*

- *What benefits and in what other field, sector etc., have these policy interventions and investments delivered?*
- *Can these processes and practices be easily replicated in other areas?*
- *Are these processes and practices essential for promoting decarbonization of the energy sector? Can the regions? Are they considered an inextricable part of any water conservation policy?*

10.4 Conclusions

The purpose of the paper is to establish an index of Good Practices for decarbonization within the energy sector. This index aims to provide a comprehensive framework for evaluating and understanding the transition from carbon-dependent energy systems to more sustainable and low-carbon alternatives. The paper focuses on data and information collection across five distinct categories of interventions and infrastructure development. These categories play a pivotal role in assessing the extent of carbon-dependence and the effectiveness of decarbonization efforts.

The foremost purpose of this contribution is not to conduct a comprehensive evaluation of decarbonization trajectories for specific territories. Instead, the focus is on the collection of evidence related to the thematic aspects of decarbonization, with a particular emphasis on regional and national contexts. Each thematic aspect could be individually assessed within different regions and countries. The assessment of each thematic aspect aims to identify and understand the best practices employed by these regions and countries concerning their decarbonization efforts. By evaluating these aspects individually, the intention is to rank the various approaches used in different territories. The final goal of this ranking is to highlight the most effective methods of addressing each thematic aspect.

While the analysis may lead to the identification of a tentative 'best' decarbonization pathway that performs well across all the metrics collectively, this overarching aim does not overshadow the central focus on uncovering the best practices for each individual thematic metric. The primary objective is to gain insights into what works well in each category, allowing policymakers, stakeholders, and researchers to learn from successful approaches in different regions. In summary, this activity seeks to capture the diverse strategies and practices employed by regions and countries to address the various aspects of decarbonization. The ultimate outcome is a better understanding of the most effective practices for each aspect, which can contribute to a broader knowledge exchange and drive more successful decarbonization efforts.

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11 Exploring Success Factors on Environmental Restoration in Coal Regions towards a Just Transition Path

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11.1 Introduction

The description of the energy transformation in Europe indicates a significant shift away from coal-driven activities. Several factors, such as restrictions on coal use, stricter industrial emissions standards, declining profitability of coal mines, and the Union's commitment to phasing out coal for electricity generation, have resulted in the shutdown or limitation of coal-related operations in various regions across Europe. Regions heavily reliant on coal-based economies, now face the challenge of adapting to the shrinking coal industry (Montmasson-Clair, 2021; Weller, 2019). Without appropriate measures, these regions risk experiencing stagnation and introspection, which can have adverse effects on local communities. To address this, the paper proposes the implementation of just transition strategies to facilitate a smooth and sustainable transition away from coal-based activities.

We argue that the primary focus of these just transition strategies should be focused on two key aspects. First, Restoration and Environmental Restitution, and second on Selection of Post-Mining Land Uses towards a sustainable and resilient development paradigm. To this end, on the one hand, the paper emphasizes the importance of restoring the ecological functionality and integrity of degraded landscapes. Land restoration aims to heal the environmental harm caused by decades of coal mining and industrial activities.

By restoring the landscape, the affected regions can mitigate the negative environmental impacts and create a healthier ecosystem. On the other hand, the paper explores the key success factors for land restoration based on Restoration Opportunities Assessment Methodology (ROAM). The goal is to identify alternative, sustainable, and diversified economic activities that can secure employment and promote social cohesion in these regions. By embracing new economic opportunities, the affected communities can transition towards a more resilient and prosperous future.

The paper proceeds as follows. The next section provides a theoretical discussion and a synthesis of existing bodies of literature on issues related to air pollution, water contamination, soil erosion, biodiversity loss, landscape alteration and land degradation in post-mining areas. The following section presents the empirical findings of the Restoration Opportunities Assessment Methodology applied in 7 EU countries involving 19 operating coal mines. The last section provides conclusions and policy recommendations.

11.2 Literature Review

While coal-powered energy has provided socioeconomic benefits, such as employment opportunities and rural development, it is essential to acknowledge the significant environmental impacts associated with coal-driven activities. Given these environmental impacts and the urgent need to address climate change, many countries and regions have made commitments to transition away from coal and reduce their reliance on fossil fuels. The move towards renewable energy sources and more sustainable practices aims to mitigate the environmental harm caused by coal-driven activities and promote a greener, more sustainable future (Marinakis et al., 2020). Coal mining and the use of coal for energy production have been found to cause major disturbances to the natural environment, leading to various forms of land degradation and ecosystem disruption (Kumar et al., 2022).

According to the Food and Agriculture Organisation of the United Nations (FAO UN, 2015), some of the key environmental issues related to coal-driven activities include, first, *Air Pollution* which involves the combustion of coal, which releases various pollutants, including sulfur dioxide (SO2), nitrogen oxides (NOx), particulate matter (PM), and greenhouse gases (GHGs) like carbon dioxide (CO2). These emissions contribute to air pollution, smog formation, and climate change, leading to adverse health effects and environmental degradation (Hill, 2020).

Second, *Soil Erosion*, since coal mining often involves the removal of large amounts of soil and overburden, leading to soil erosion and degradation. This can result in the loss of fertile topsoil and disrupt natural soil ecosystems, impacting agriculture and vegetation growth (Artiola et al., 2019).

Third, *Water Contamination*, for the reason that coal mining can lead to water pollution through the release of various chemicals and heavy metals into water bodies. Acid mine drainage (AMD) is a common issue associated with coal mining, where acidic water with high concentrations of toxic substances can harm aquatic life and contaminate water sources (Akhtar, 2021).

Fourth, *Biodiversity Loss*, as the destruction of natural habitats due to coal mining activities can lead to a loss of biodiversity. Plants and animals native to these regions may be displaced or face extinction, disrupting local ecosystems and reducing overall biodiversity (Sonter et al., 2018).

Fifth, *Landscape Alteration*, since coal mining operations can significantly alter the landscape, causing deforestation, subsidence, and changes in land topography. These alterations can have long-lasting effects on the visual appearance and natural functions of the affected areas (Kuter, 2013; Popelkova & Mulkova, 2018).

On this basis, *Land Degradation* is a critical environmental issue that refers to the reduction or loss of a landscape's ability to provide goods and services to its beneficiaries. It encompasses various negative changes in land structure and properties, such as soil fertility decline, destruction of natural habitats, loss of biodiversity, and deterioration of ecosystem services (Smith et al. 2020).

Land degradation and desertification involve any changes or disturbances to the landscape that are perceived as harmful or undesirable, leading to a decrease in the overall value of the biophysical environment. This process can occur naturally due to geo-climatic conditions and natural hazards, such as soil erosion, wind erosion, and characteristics of fragile soils that make the environment susceptible to degradation and desertification. However, human activities play a significant role in exacerbating land degradation (Stephen, 2016).

Activities like deforestation, overgrazing, over-exploitation of vegetation, intensive agriculture, and inappropriate land management, including coal mining, contribute to the deterioration of land resources. The consequences of land degradation are far-reaching and have serious economic and social implications (Scanes, 2018). It affects the stability of land-dependent communities and poses a threat to food production and security. Land degradation reduces crop yields, leading to increased use of harmful inputs like fertilizers, and may eventually force farmers to abandon their lands. Biodiversity loss and the depletion of natural resources are additional outcomes of land degradation (Cardoso, 2015). Desertification, a severe form of land degradation, can lead to economic downturn, instability, and migration in affected regions.

The Economic and Land Degradation (ELD) Initiative estimates that these losses exceed 10 trillion dollars worldwide. As a result, halting land degradation and restoring degraded land have become key priorities in many countries and regions to promote sustainable land use and preserve the environment for future generations. Implementing sustainable land management practices and transitioning towards more environmentally friendly activities are essential steps to combat land degradation and ensure the resilience of ecosystems and societies (ELD Initiative, 2015). In post-coal mining areas, land repurposing involves transforming previously mined or disturbed lands into alternative uses that can benefit the environment, economy, and local communities. What follows is the various potential type of land repurposes in these areas.

11.3 Empirical Evidence

Key success factors for land restoration initiatives

Aiming to run a self-assessment exercise part of the need analysis, the approach of the Restoration Opportunities Assessment Methodology (IUCN and WRI, 2014), has been applied, since this Handbook (ROAM) is devoted in assessing forest landscape restoration opportunities at the national or sub-national level. The ROAM is a systematic and comprehensive approach developed by the International Union for Conservation of Nature (IUCN) to assess and prioritize opportunities for land restoration. ROAM helps guide decision-making and planning for large-scale restoration initiatives, ensuring that they are effective, sustainable, and socially inclusive. To this end, ROAM is designed primarily to provide relevant analytical input to policy and operational processes, such as a national biodiversity strategy and action plan. This diagnostic tool involves a preliminary assessment of the extent to which key success factors are in place to facilitate restoration at scale. These factors include the motivations of key actors, the enabling conditions in the country and the capacity and resources for implementation. The analysis can also look at the extent to which the ecological and social conditions in the assessment area are conducive to scaling up restoration efforts.

Applying this tool can help decision-makers and restoration stakeholders focus their efforts on getting the missing key success factors in place – before large amounts of human, financial, or political capital have been invested. In more detail, the tool, which is based on lessons learnt from over twenty forest landscape restoration ‘case examples’ around the world, classifies the key success factors into three themes:

(a) *A clear motivation:* decision-makers, landowners, and/or citizens need to be aware of the need for forest landscape restoration and inspired or motivated to support it. This means that the case for restoration must be presented in their terms and speak to their priorities.
(b) *Enabling conditions in place:* a sufficient number of ecological, market, policy, legal, social, and/or institutional conditions need to be in place to create a favorable context for forest landscape restoration and
(c) *Capacity and resources for sustained implementation:* Capacity and resources need to exist and be mobilized to implement forest landscape restoration on a sustained basis on the ground. The following table presents the different themes and factors evaluated in the context of the present needs analysis.

Taking into consideration the themes, features and factors exhibited in Table 7, it seems that the ROAM diagnostic provides a robust foundation for designing and implementing successful land restoration projects. By following this guide, decision-makers can make informed choices, prioritize interventions, and work collaboratively with local communities and stakeholders to achieve positive outcomes in restoring degraded landscapes and promoting sustainable land use. Based on the above, Table 8, presents the outputs of this diagnosis per case study as follows: CS-1: Brandenburg (DE), CS-2: Southwest Oltenia (RO), CS-3: Western Macedonia (GR), CS-4: Yugoiztochen (BG), CS-5: Savinjska (SI), CS6: Lodzkie (PL), CS-7: Eszak-Magyarorszag (HU). The assessment of the significance of each factor are 1 for low significance, 2 for low significance and 3 for high significance.

Table 7: The ROAM diagnostic of the key success factors for land restoration (Source: IUCN and WRI, 2014)

Theme	Feature	Factor
Motivation	Benefits	- Land restoration creates economic benefits - Land restoration creates societal benefits - Land restoration creates environmental benefits - Land restoration provides opportunities for sustainable development
	Awareness	- Green economy awareness among companies - Public awareness on green economy and its potential benefits - The benefits associated with decarbonisation are widely known - Opportunities for restoration are identified
	Legal requirements	- Legal framework on post mining land restoration exists - Law regulating active coal mines and requiring land restoration exists - Restoration regulations are widely enforced
Enabling conditions	Environmental conditions	- The extent of environmental degradation makes land restorationfeasible - Plants and animals that can impede restoration are absent - Native flora and fauna are readily available
	Market conditions	- There is increasing demand/interest for the degraded land - Market reforms to make smooth the transition to a post coal era arebeing implemented - Green market segmentation is developing
	Social conditions	- Local community can benefit from restoration opportunities - Local community participates in decision making concerning restoration
	Institutional conditions	- Integrated planning for land restoration exists - Roles and responsibilities are clearly defined - Effective cross-department coordination is in place
Capacity &resources	Leadership	- Political commitment towards decarbonisation exists - Transition plan to a post coal era exists
	Knowledge	- Geospatial data is available - Restoration know-how exists - Collaboration schemes with environmental agencies and knowledgeinstitutes are in place - Collaboration schemes between mining companies and conservation bodies are in place
	Finance	- Incentives to shut down coal driven activities are provided - Investment capital for restoration interventions is readily available

Figure 1: Assessment Forms

Theme	Feature	Factor	CS-1	CS-2	CS-3	CS-4	CS-5	CS-6	CS-7
Motivation	Benefits	Perception that land restoration creates economic benefits	1	1	1	1	1	1	1
		Perception that land restoration creates societal benefits	2	2	2	2	2	2	2
		Perception that land restoration creates environmental benefits	3	3	3	3	3	3	3
		Perception that land restoration provides opportunities for sustainable development	2	3	2	2	2	2	2
	Awareness	Green economy awareness among companies	2	2	3	3	2	2	2
		Public awareness on green economy and its potential benefits	2	2	2	2	2	2	2
		The benefits associated with decarbonisation are widely known	1	1	1	2	1	1	1
		Opportunities for restoration are identified	2	1	1	2	1	2	3
	Legal requirements	Legal framework on post mining land restoration exists	3	3	3	3	3	3	3
		Law regulating active coal mines and requiring land restoration exists	1	1	1	1	1	2	1
		Restoration regulations are widely enforced	1	1	1	1	1	1	3
Enabling conditions	Environmental conditions	The extent of environmental degradation makes land restoration feasible	1	3	1	3	1	3	1
		Plants and animals that can impede restoration are absent	1	1	1	1	1	2	1
		Native flora and fauna are readily available	1	3	3	1	3	2	2
	Market conditions	There is increasing demand/interest for the degraded land	3	3	3	3	3	3	3
		Market reforms to make smooth the transition to a post coal era are being implemented	3	3	3	3	3	3	3
		Green market segmentation is developing	2	2	2	2	2	2	2
	Social conditions	Local community can benefit from restoration opportunities	2	2	2	2	2	2	2
		Local community participates in decision making concerning restoration	1	1	1	1	1	1	1
	Institutional conditions	Integrated planning for land restoration exists	1	1	1	1	1	1	1
		Roles and responsibilities are clearly defined	1	3	3	1	3	2	2
		Effective cross-department coordination is in place	3	3	3	3	3	3	3
Capacity and resources	Leadership	Political commitment towards decarbonisation exists	3	3	3	3	3	3	3
		Transition plan to a post coal era exists	2	2	2	2	2	2	2
	Knowledge	Geospatial data is available	2	2	2	2	2	2	2
		Restoration know-how exists	1	1	1	1	1	1	1
		Collaboration schemes with environmental agencies and knowledge institutes are in place	1	1	1	1	1	1	1
		Collaboration schemes between mining companies and conservation bodies are in place	2	2	2	2	2	2	2
	Finance	Incentives to shut down coal driven activities are provided	1	1	1	1	1	1	1
		Investment capital for restoration interventions is readily available	1	1	1	1	1	1	1

Source: Decarb project, own elaboration

11.4 Conclusions

To achieve a coordinated and integrated approach for assessing possible and alternative land uses in post-mining areas, it is essential to involve all relevant stakeholders and ensure collaboration across sectors and levels of government and engage all relevant stakeholders, including environmental institutions, economic operators, local communities, and citizens, who have an interest in the area and will be affected by future land uses.

Stakeholder engagement promotes transparency, inclusivity, and ownership of the decision-making process. Environmental institutions can provide valuable expertise on ecological restoration and environmental considerations, while economic operators can offer insights into viable and sustainable economic activities. Local communities and citizens, being directly affected by the transition, can provide valuable input on their preferences, concerns, and aspirations for the future land uses.

Collaboration across sectors and levels of government is equally essential. The transition process involves various aspects, including environmental rehabilitation, economic diversification, social well-being, and policy coordination. By bringing together representatives from different sectors and government levels, decision-makers can develop a comprehensive understanding of the challenges and opportunities involved in the transition.

This inclusive approach ensures that diverse perspectives are considered and fosters ownership and support for the land restoration process. By adopting a coordinated and integrated approach that involves multi-stakeholder engagement, collaboration across sectors, and coordination between different levels of government, post-mining land restoration can be effectively planned and implemented, leading to sustainable and resilient outcomes for affected areas and communities.

To this end, involving environmental institutions, economic operators, local communities, and citizens, decision-makers can gather valuable insights and expertise from various stakeholders. This broad participation helps identify potential challenges, opportunities, and innovative solutions that may have been overlooked otherwise. By adopting such a coordinated and integrated approach, post-mining land restoration can be effectively planned and implemented, leading to positive outcomes for the environment, the economy, and the affected communities. The restoration process becomes more resilient and adaptive, able to address changing societal needs and environmental conditions over time.

Finally, increasing investment capital for environmental restitution and land restoration interventions is crucial for the successful restoration of mined lands and the promotion of sustainable post-mining activities. One effective way to achieve this is through the establishment of a dedicated fund, financed by state revenues from environmental taxes imposed on coal-driven and associated activities. By using revenues from environmental taxes, the dedicated fund can ensure a sustainable and reliable source of funding for land restoration projects. These funds can be specifically earmarked for restoration efforts and not subject to fluctuations in other revenue sources.

Imposing environmental taxes on coal-driven activities creates an economic incentive for industries to reduce their environmental impact. The revenue generated from these taxes can then be reinvested in restoration efforts, effectively closing the loop between environmental damage and restoration. A dedicated fund provides a long-term commitment to land restoration. It ensures that funds are available over the long term, even after the phase-out of coal-driven activities, to support ongoing restoration initiatives and ensure the success of post-mining land uses.

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12 Potential Post Mining Uses in Seven EU Post-Mining Areas

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12.1 Introduction

The process of identifying appropriate post-mining uses involves considering the physical and ecological characteristics of the area, as well as the economic and social needs of the local communities. Potential uses may include ecological restoration, reforestation, agriculture, renewable energy projects, recreational areas, or other sustainable and economically viable activities. In the context of the energy transformation and the shift away from coal, thoughtful planning for post-mining land uses becomes even more critical. Just transition strategies aim to ensure that these regions can recover and thrive economically while also prioritizing environmental restitution and the well-being of local communities (Dou et al., 2019; Smith et al., 2019).

The process of identifying appropriate post-mining land uses is a complex endeavor that requires consideration of various factors, including physical and ecological characteristics, economic viability, and social needs. This process becomes even more critical in the context of the energy transformation and the transition away from coal-driven activities. The physical and ecological characteristics of the area play a significant role in determining what types of land uses are feasible and sustainable. Factors such as soil quality, topography, water availability, and existing ecosystems need to be evaluated to ensure that the chosen land uses are compatible with the natural environment. To this end, the paper examines the issue of selecting appropriate land uses that are both physically feasible and socially beneficial, in which regions can create a positive and lasting impact on their landscapes and communities.

The paper proceeds as follows. The next section provides a theoretical discussion and a synthesis of existing bodies of literature on a series of different potential post-mining uses and the role of local community's engagement. The following section presents the empirical findings of the research among 19 operating coal mines in seven EU countries. The last section provides conclusions and policy recommendations.

12.2 Literature Review

A. *Ecological Restoration*

Restoring mined lands to their natural state is a common post-mining land repurposing strategy. By restoring mined lands to their natural state, ecological restoration aims to bring back the original ecosystem's structure, functions, and biodiversity. This process involves various practices and interventions to facilitate the recovery of the degraded landscape such as re-establishing native vegetation, habitat and soil restoration, biodiversity enhancement, invasive species control and natural ecosystem functions by applying monitoring and adaptive management. Ecological restoration not only benefits the environment but also supports local communities and economies. Restored landscapes can offer recreational opportunities, provide ecosystem services, and contribute to sustainable land use practices. Additionally, by enhancing ecological resilience, restored areas become more resilient to future disturbances and contribute to the overall conservation of natural resources. To this end, it is important to involve local communities, experts, and stakeholders in the ecological restoration process. Their input and collaboration can ensure that restoration efforts align with local needs, values, and knowledge, leading to more successful and socially inclusive outcomes. This process can help recover biodiversity, improve water quality, and enhance overall ecological resilience (Lei et al., 2016; Young et al., 2022).

B. *Reforestation*

Reforestation entails planting trees on formerly mined lands to create new forests. Trees help sequester carbon dioxide, improve air quality, and contribute to the conservation of biodiversity. Reforestation efforts can also support sustainable timber and non-timber forest product industries. This practice offers numerous benefits for the environment, biodiversity, and local communities. Trees play a vital role in mitigating climate change by sequestering carbon dioxide from the atmosphere through photosynthesis. Reforestation helps to absorb and store carbon, reducing greenhouse gas emissions and contributing to global efforts to combat climate change. Forests act as natural air purifiers, filtering pollutants and improving air quality. By restoring tree cover through reforestation, the post-mining areas can experience reduced air pollution, benefiting both human health and ecosystems. Reforestation creates new habitats and corridors for wildlife, promoting biodiversity conservation. As trees and forests return to the landscape, they provide homes and food sources for various plant and animal species, contributing to ecological diversity and ecosystem resilience. Tree roots help stabilize soil, reducing erosion and preventing further land degradation. Reforestation can improve soil quality and prevent sedimentation in water bodies, protecting water quality and supporting healthy ecosystems. Trees play a crucial role in regulating water cycles. Reforestation efforts can help restore natural water flows and improve water availability in post-mining areas. Engaging local communities in reforestation initiatives fosters a sense of ownership and empowers them to participate in environmental conservation efforts. Reforested areas can enhance the resilience of the landscape to climate change impacts. To conclude, reforestation projects are an essential part of sustainable land use and environmental restoration efforts in post-mining areas (Fox et al., 2020; Adams et al., 2017).

C. Agricultural and Agroforestry Practices

Converting post-coal mining areas into agricultural lands or agroforestry systems can provide opportunities for sustainable food production and livelihoods. Agroforestry combines tree planting with agricultural crops, offering multiple benefits such as improved soil fertility, enhanced biodiversity, and diversified income streams for farmers. Establishing agricultural fields or agroforestry systems allows for the cultivation of crops, providing a local source of food and supporting food security in the region. Agroforestry systems, in particular, help enhance soil structure, nutrient cycling, and organic matter content, leading to healthier and more productive soils. By incorporating trees into agricultural landscapes, agroforestry promotes biodiversity. Farming and agroforestry activities can help reduce soil erosion by providing ground cover and stabilizing the soil. Agroforestry systems are generally more resilient to climate change impacts compared to monoculture agriculture. Trees in agroforestry systems act as carbon sinks, sequestering carbon dioxide from the atmosphere. This contributes to climate change mitigation efforts and reduces the carbon footprint of agriculture. By engaging local communities in agricultural and agroforestry practices, post-mining areas can enhance community resilience and empower farmers with sustainable livelihood options. Agriculture and agroforestry can aid in the restoration of degraded lands, helping to reclaim areas affected by mining activities and restoring their ecological functions. To ensure the success of agricultural and agroforestry practices in post-coal mining areas, it is crucial to consider factors such as soil quality, local climate, suitable crops, and tree species. Integrating traditional knowledge with modern sustainable agricultural practices can further enhance the productivity and sustainability of these systems. By embracing agricultural and agroforestry practices, post-mining areas can transform into productive and resilient landscapes, supporting the well-being of local communities and contributing to the conservation of natural resources (Raj et al., 2019; Kay et al., 2019).

D. *Renewable Energy Projects*

Repurposing mined lands for renewable energy projects, such as solar farms or wind farms, can help transition from coal-based energy to cleaner alternatives. These projects contribute to reducing greenhouse gas emissions and promoting sustainable energy generation. Solar farms and wind farms produce clean energy from renewable sources, reducing the dependence on coal-based energy and decreasing greenhouse gas emissions. This shift contributes to global efforts to combat climate change and reduce the carbon footprint of energy production. Repurposing mined lands for renewable energy projects minimizes the ecological impact and promotes the sustainable use of land resources. Unlike coal mining, renewable energy projects do not involve the extraction of non-renewable resources. Solar and wind energy are considered carbon-neutral, as they do not release carbon dioxide or other harmful pollutants during operation. Investing in renewable energy projects helps mitigate the effects of climate change and fosters a more resilient environment. Renewable energy projects create job opportunities in various sectors, including installation, maintenance, and operation. Additionally, these projects can attract investments and stimulate economic growth in post-mining regions. By producing clean energy locally, post-mining areas can enhance energy security and reduce reliance on external energy sources, contributing to greater energy independence. Developing solar farms or wind farms involves minimal land disturbance compared to mining activities. Renewable energy projects can complement land restoration efforts and contribute to improving the ecological condition of the area. Renewable energy projects typically have long operational lifespans, providing sustainable benefits to the region for decades without depleting finite resources. Engaging local communities in renewable energy projects can foster a sense of ownership and participation. Community involvement in decision-making and project development can lead to increased support and acceptance. Developing renewable energy projects in post-mining areas can serve as educational opportunities, promoting awareness of clean energy and advancing technological capabilities. Transitioning post-coal mining areas into hubs for renewable energy generation aligns with global efforts to combat climate change, improve air quality, and promote sustainable development. These projects not only offer economic benefits and job opportunities but also contribute to the long-term well-being of local communities and the preservation of the environment (Igogo et al., 2021; Wei et al., 2010).

E. Recreational and Tourism Activities

Recreational and tourism activities are an excellent way to repurpose post-coal mining areas, offering multiple benefits for both the environment and local communities. By converting these lands into recreational spaces and nature reserves, the regions can tap into the potential of eco-tourism and leverage the restored landscapes to attract visitors. Restoring mined lands into recreational areas, parks, and nature reserves can create opportunities for nature-based tourism. Tourism can stimulate local economies by generating revenue from visitor spending on accommodation, dining, transportation, and local products. This economic boost can benefit nearby communities and support small businesses. Developing recreational and tourism facilities in post-mining areas can lead to job opportunities in the tourism sector, ranging from hospitality to guided tours and other tourism-related services. Recreational and tourism activities involve the local community in the promotion and management of tourist attractions. This fosters community pride and a sense of stewardship over the restored landscapes. Nature reserves and recreational areas offer educational opportunities for schools and visitors, promoting environmental awareness and conservation efforts. Repurposing mined lands for recreational and tourism purposes ensures sustainable land use, promoting environmental conservation and responsible use of resources. Creating recreational spaces and nature reserves in post-mining areas not only attracts visitors but also enriches the quality of life for local communities. By leveraging the natural beauty of the restored landscapes, post-mining regions can embrace eco-tourism and contribute to sustainable development, environmental conservation, and the overall well-being of their residents (Copic et al., 2014; Alavalapati & Adamowcz, 2000; Armis & Kanegae, 2020).

F. *Water Management and Wetland Restoration*

Water management and wetland restoration are essential components of post-coal mining land repurposing efforts. These practices aim to address water-related challenges resulting from mining activities and can provide multiple benefits for both the environment and local communities. Implementing water management projects, such as constructing retention ponds or creating wetlands, helps regulate water flow, reducing the risk of flooding during heavy rainfall. These measures can also contribute to water storage during dry periods, supporting water availability for various uses. Wetlands play a crucial role in water purification, acting as natural filters that remove pollutants and sediment from water. Restoring wetlands in post-mining areas can improve water quality by trapping and breaking down contaminants, contributing to healthier ecosystems. Wetlands are significant carbon sinks, sequestering carbon dioxide from the atmosphere. By restoring wetlands, post-mining areas can contribute to climate change mitigation efforts. Wetlands and water management projects can help control soil erosion, preventing sediment runoff and reducing further land degradation. Restored wetlands and water bodies can offer recreational opportunities, such as birdwatching, fishing, and boating, attracting visitors and supporting ecotourism initiatives. Wetlands act as natural buffers against extreme weather events, such as storms and hurricanes. Restored wetlands can help mitigate the impacts of climate change and enhance the resilience of the landscape. Integrating these practices into land repurposing initiatives helps ensure sustainable water resources, ecosystem health, and resilience. Furthermore, these efforts contribute to the overall restoration of the degraded landscapes, creating a balance between human activities and the preservation of vital ecological services (Weinstein et al., 1996; Pfadenhauer & Grootjans, 1999).

G. *Eco-Industrial Sustainable Development*

Eco-industrial sustainable development is a forward-looking approach to repurposing post-coal mining areas that focuses on creating environmentally friendly and economically viable industrial zones. By transforming these lands into eco-industrial zones or sustainable development hubs, regions can foster green economic growth and promote sustainable practices. Eco-industrial zones attract businesses and industries committed to environmental sustainability. This fosters green economic growth, creating job opportunities and promoting innovation in clean technologies and sustainable practices. Implementing circular economy principles in eco-industrial zones encourages the reuse, remanufacturing, and recycling of products and materials, reducing waste and promoting a sustainable and regenerative approach. Eco-industrial sustainable development promotes the adoption of clean and renewable technologies, such as solar energy, wind power, and energy-efficient processes. Developing eco-industrial zones often involves integrating green infrastructure, such as green spaces, water management systems, and sustainable transportation options, which improve the quality of life for residents and workers. Eco-industrial development can lead to the emergence of sustainable supply chains, where businesses prioritize environmentally friendly sourcing and production practices. By fostering partnerships, stakeholders can leverage resources and expertise to implement sustainable strategies. By adopting eco-industrial sustainable development practices, post-mining areas can transition to environmentally conscious and economically vibrant regions. This transformation not only attracts responsible businesses but also supports long-term environmental conservation and contributes to global efforts to achieve a more sustainable and resilient future (Sarkar, 2013; Shevchuk et al., 2021; Petrushenko et al., 2022).

The role of local communities' engagement

Engaging local communities in the land repurposing process through community-based initiatives is a crucial aspect of responsible and sustainable development in post-coal mining areas. Local communities possess valuable knowledge about the area, its resources, and its cultural significance. Involving them in the decision-making process ensures that this knowledge is taken into account, leading to more informed and contextually appropriate choices for land repurposing. When local communities are involved in planning and decision-making, they are more likely to support and take ownership of the chosen strategies. Community-based approaches often prioritize long-term sustainability, considering the well-being of future generations and the resilience of the community and environment (Reid, 2016). Involving local communities fosters social cohesion and trust-building between community members, local authorities, and other stakeholders involved in the land repurposing process. Local communities are well-positioned to monitor the outcomes of land repurposing initiatives and provide valuable feedback for adaptive management, ensuring that strategies are adjusted as needed for optimal results (Schipper et al., 2014).

To implement successful community-based initiatives, it is essential to facilitate meaningful participation through transparent and inclusive decision-making processes. Listening to community concerns, respecting diverse perspectives, and providing opportunities for meaningful engagement are critical steps to ensure that the land repurposing strategies align with the needs, aspirations, and values of the local communities. Additionally, supporting community capacity-building and providing access to relevant information and resources can strengthen the effectiveness of community-led efforts. To this end, each post-coal mining area may require a tailored approach to land repurposing based on its specific characteristics and the preferences of the local communities. Effective land repurposing strategies should aim to create sustainable and diversified opportunities while promoting ecological restoration and social well-being (Abhilash, 2021; Fischer et al., 2021).

12.3 Empirical Evidence

Potential post mining land uses

Though the primary purpose of land restoration is to re-build ecological functionality and integrity across worked out sites, and return the degraded land into a productive and usable state, the biggest challenge in the examined territories is to implement a just transition strategy (for the post-coal era) with alternative, sustainable economic activities that will aid to offset the losses from the shutdown of coal driven activities providing new job opportunities and economic value to affected communities, as well as contributing to a more secure energy supply. The post mining land uses that are physically feasible and exhibit the higher value for local communities include but are not limited to renewables, tourism, and agriculture. These uses combine intensive activity, substantial growth potential and a low environmental footprint, are not related to coal and are of sustainable nature and can justify land restoration investments.

Converting mine sites or coal plants into renewable energy generation facilities can be an attractive option for the post coal era. Renewables, as a viable and reliable source of energy, can contribute to regional energy security and supply, secure previous employment status, and ensure social and economic prosperity for affected populations. In coal intensive regions, RES development projects can also benefit from pre-existent infrastructures and land availability. The study revealed that all the territories are well suited to investing in renewable energy. Southern territories such as Western Macedonia (Greece), Yugoiztochen (Bulgaria), South-West Oltenia (Romania) and Savinjska (Slovenia) – including Brandenburg (Germany) at a lesser extent – exhibit high solar availability and hence are well placed for solar power generation. In contrast, mine sites located in Central and Eastern EU countries (Brandenburg and Łódzkie) present higher suitability for wind power generation, as they share substantial wind resource availability because of high altitudes and strong wind speeds. All the territories can also benefit from high temperatures geothermal resources in mine sites (especially

Western Macedonia and Brandenburg) and abundant water resources (where relevant, especially South West Oltenia) to engage in geothermal and hydro power production. Successful examples of mine site redevelopment for solar and wind energy generation can be retrieved from Brandenburg (Germany) and Észak-Magyarország (Hungary).

Table 6: Potential post mining land uses (Source: Decarb Project https://projects2014-2020.interregeurope.eu/decarb/)

	Solar Energy Development	Wind Energy Development	Hydropower Development	Geothermal Energy Development	Agriculture	Tourism
Brandenburg	Medium	High	Low	Medium	Low	High
Southwest Oltenia	High	Low	High	Medium	High	High
Western Macedonia	High	Low	Low	High	High	Medium
Yugoiztochen	High	Low	Low	Medium	Medium	Medium
Savinjska	High	Low	Low	Medium	High	High
Łódzkie	Low	High	Low	Medium	Medium	High
Eszak-Magyarorszag	Medium	Low	Low	Medium	High	Low

Tourism and recreation use exhibit also attractive growth potential in most of the territories, which can be further unleashed by utilizing the natural wealth and industrial heritage of mining sites and surrounding areas. In particular, most of the territories are characterized by rich diversity of natural features that include protected areas, natural parks, mountains, caves, non-polluted rural areas, mineral waters and spas. Therefore, land restoration and revitalization programmes need to include targeted interventions to enhance environmental quality in former mine sites, valorize natural heritage assets therein (e.g. man-made lakes, green areas) and provide for attractive leisure opportunities. New sustainable growth opportunities can emerge in cultural, therapeutic, religious and eco-tourism sectors. The territories that are better suited to investing in tourism are Brandenburg (Germany), South-West Oltenia (Romania), Savinjska (Slovenia) and Łódzkie (Poland).

Agriculture is traditionally one of the main pillars of rural economies, and as such can re-position itself as a key economic driver for the territories in the new post post-coal economic reality. Cultivated area already accounts for a considerable portion in the examined territories, and further area available for farming can be made available after the closure of mine sites. The territories that demonstrate the higher potential for agricultural development thanks to favorable climate conditions and unique naturalingredients are Southwest Oltenia, Western Macedonia, Yugoiztochen and Savinjska.

12.4 Conclusions

Successful post-mining land restoration requires long-term planning and participatory decision-making processes that reflect the local community's needs and emerging socioeconomic challenges and focuses on strengthening the resilience of landscapes, recovering ecosystem services, and creating future options for sustainable territorial growth. Regulatory authorities usually mandate mine closure and post-mining land use plans before a mining permit is granted to a construction or coal mining company. These plans demonstrate how coal related activities will influence the natural environment, prescribe actions to minimize adverse environmental impact and eliminate threats to human health, and plan the next day following the closure of mine sites or the decommissioning of coal power plants by addressing contamination and post mining land uses. Certainly, restoration is a forward-looking and dynamic process that cannot be determined at a mining designation stage as many aspects will change over time. On the contrary, restoration strategies require multi-year visions of the ecological functions and benefits to human well-being, and proactive risk management to adapt to changing societal needs and address latest technological developments.

The legal framework for land restoration in mine sites is a crucial aspect of ensuring environmental protection and post-mining rehabilitation. It is positive to note that all territories have legal acts in place that define mine operators' obligations on mine reclamation and environmental restitution in worked-out sites. Having such legal requirements helps ensure that mine operators take responsibility for the restoration of the land after mining activities have ceased. To this end, a robust legal framework for land restoration in mine sites is crucial for ensuring responsible mining practices, environmental protection, and supporting a just transition away from coal. By legally binding mine operators to fulfill their restoration obligations and allocating funds for post-mining land restoration, territories can promote a more sustainable and resilient future for affected regions.

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13 Analyzing the Socio-Economic Dynamics of the Coal Value Chain: Implications for Decarbonization and Just Transition

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13.1 Introduction

The global imperative to address climate change and transition towards sustainable energy systems has brought to the forefront the urgent need to reduce greenhouse gas emissions (Fankhauser et al., 2022; Wang et al., 2021). Among the most significant contributors to carbon emissions is the utilization of coal for energy generation. As a result, governments, industries, and societies worldwide are grappling with the challenge of phasing out coal and transitioning to clean energy sources. While the environmental benefits of this transition are widely recognized, it is crucial to acknowledge and address the potential socioeconomic impacts on communities and regions heavily dependent on coal-based industries (Skczkowski et al., 2021; Carley & Konisky, 2020).

The decision to phase out coal carries profound consequences, not only for the energy landscape but also for the livelihoods, economic stability, and overall well-being of individuals and communities. The transition towards clean energy offers a promising pathway to mitigate climate change, reduce air pollution, and create a sustainable energy infrastructure (Owusu et al., 2016). However, the success and fairness of this transition hinge on our ability to identify, understand, and proactively address the areas of socioeconomic impact that arise during the process.

This paper seeks to provide a comprehensive examination of the multifaceted socioeconomic effects resulting from the phase-out of coal and the adoption of clean energy alternatives. By studying real-world case examples, analyzing relevant data, and considering a range of perspectives, we aim to shed light on the challenges and opportunities that arise in the wake of coal phase-out policies.

Our objective is to identify key areas of impact, understand their implications for communities, and propose strategies to ensure a just and equitable transition that empowers affected regions.

A successful transition away from coal not only hinges on technological advancements but also on the ability to navigate the complex interplay of economic, social, and environmental factors (Hillerbrand, 2018; Van Tulder & Van Mil, 2022). By exploring the socioeconomic dimensions of coal phase-out, we aim to inform policymakers, industry leaders, and advocates for social equity, thereby contributing to a more holistic and well-informed decision-making process that leads to a sustainable and inclusive energy future.

The paper proceeds as follows. The next section provides an overview on the EU strategy of reducing GHG emissions and socioeconomic parameters. The next section explores the coal value. The section that follows attempts to provide an integrated socioeconomic model for coal value chain analysis. The last section provides conclusions and policy recommendations.

13.2 The EU Strategy of Reducing GHG Emissions and Socioeconomic Parameters

The European Union's ambitious Energy Roadmap 2050 sets a clear trajectory for member states to significantly reduce their greenhouse gas (GHG) emissions, aiming for a remarkable 80-95% reduction by the year 2050. These milestones emphasize the importance of concerted efforts to combat climate change and ensure a sustainable future for the region (Delreux & Ohler, 2019; Matthes et al., 2019).

The first key milestone on this journey was established under the Europe 2020 strategy, with member states committed to reducing their emissions by a minimum of 20% by the year 2020, as compared to the baseline year of 1990. This 2020 target, often referred to as '20-20-20', encapsulates three fundamental objectives: achieving a 20% share of renewable energy in the overall energy production, improving energy efficiency by 20%, and making a 20% reduction in greenhouse gas emissions. These ambitious targets provide a comprehensive framework for member states to align their efforts and contribute collectively to the EU's climate goals (Misik & Oravcova, 2022; Hafner & Raimondi, 2020).

Looking ahead, the 2030 climate and energy framework outlines critical interim targets for the year 2030. Member states are tasked with achieving a 40% reduction in greenhouse gas emissions, further underscoring the EU's commitment to emission cuts. Additionally, the framework emphasizes the importance of renewable energy sources by setting a target for member states to reach a 27% share of renewable energy in their energy mix. This focus on renewable energy not only mitigates emissions but also drives innovation and strengthens energy security. Alongside these goals, there is a call for a 27% improvement in energy efficiency, further emphasizing the need for sustainable energy consumption practices (Dogan at al., 2023; Khan et al., 2020). These milestones and targets underscore the EU's leadership in global climate action, setting a clear path for reducing emissions, transitioning to renewable energy sources, and enhancing energy efficiency. Achieving these targets will require ongoing collaboration, innovation, and policy implementation across member states, making the journey towards a more sustainable future a shared endeavor for the entire European Union.

The above prerequisites are rooted in the concepts of sustainability, resilience, and forward-thinking resource utilization. By addressing these aspects, the EU underscores the urgency of transitioning away from carbon-intensive practices and emphasizes the need for a more environmentally responsible approach. The concept of sustainability plays a central role in framing the necessity for decarbonization. It highlights the imperative for systems, societies, and economies to withstand changing circumstances while ensuring that future generations can thrive. In the context of decarbonization, sustainability is invoked to underscore the unsustainability of unbridled carbon dioxide (CO_2) emissions.

Notably, the energy sector shoulders the lion's share of these emissions, making it a pivotal focus area for effective decarbonization efforts. At the same time, the EU's decarbonization strategy seems to go beyond mere emission reduction. It's a multifaceted approach that addresses the core principles of sustainability, resilience, and forward-looking resource use. While decarbonization efforts are vital for achieving environmental sustainability in the short and long term, it's crucial to recognize that such initiatives carry the potential to impact communities, regions, and states in complex ways. The risk of socio-economic turbulence arising from decarbonization efforts is a significant concern, with potential consequences ranging from diminished social cohesion and increased unemployment to fiscal challenges (Capros et al., 2019; Geden et al., 2019).

The transition to cleaner energy sources and the reduction of carbon-intensive practices can have far-reaching effects on local economies, industries, and employment opportunities. Sectors heavily reliant on fossil fuels may experience disruptions, leading to job losses and economic instability in those regions (Newell & Mulvaney, 2013; Mercure et al., 2018). These socio-economic challenges, if not adequately addressed, can strain social cohesion, exacerbate inequality, and potentially create political tensions. Moreover, the fiscal implications of decarbonization cannot be overlooked. The reallocation of resources, the need for infrastructure upgrades, and the support required for affected communities and industries can place a strain on public finances. Balancing the imperative to reduce emissions with the need to manage economic and fiscal concerns is a delicate task, requiring carefully designed policies and strategies that ensure a just transition for all stakeholders (Robinson, 2017; Victor-Gallardo, 2022).

To navigate these potential challenges, it's essential to adopt a comprehensive and inclusive approach to decarbonization. Policymakers must take into account the socio-economic impacts on communities, assess vulnerabilities, and develop measures that mitigate negative effects. Initiatives that prioritize workforce transition, skill development, and support for affected regions can play a pivotal role in ensuring that the benefits of decarbonization are distributed fairly and that no one is left behind. While decarbonization is essential for environmental sustainability, it must be carried out with a keen awareness of the potential socio-economic consequences. By addressing these challenges proactively, the path towards a low-carbon future can be one that not only mitigates climate change but also promotes social equity, economic stability, and overall well-being for communities, regions, and states (Jakob et al., 2020; Li & Chen, 2021; P'Neill et al., 2017).

13.3 Exploring the Coal Value Chains

The coal industry has historically played a significant role in global energy production, serving as a cornerstone of many economies. Understanding the intricate coal value chains, which encompass the entire lifecycle of coal from extraction to consumption, is crucial for policymakers, industries, and stakeholders as the world transitions towards cleaner and more sustainable energy sources. This comprehensive analysis delves into the key aspects of coal value chains, highlighting the various stages, stakeholders involved, and the socio-economic and environmental implications.

The value chain begins with coal extraction from mines. This stage involves exploration, mining operations, transportation, and logistics. It's essential to consider the safety of workers, environmental impacts (such as land reclamation and water management), and the economic significance of coal mining in regions dependent on this industry. Once extracted, coal often undergoes processing to remove impurities and prepare it for specific applications, such as power generation or industrial use. This stage includes coal washing, sizing, and sorting. The efficiency of these processes affects the final quality of coal products and their environmental footprint. The transportation of coal from mines or processing facilities to end-users is a critical link in the value chain. This stage involves various modes of transport, including railways, ships, and trucks. Balancing the need for efficient transportation with environmental concerns, such as emissions and safety, is essential.

The primary utilization of coal involves power generation and industrial processes. Understanding the technological aspects of coal-fired power plants, as well as the environmental consequences (such as air pollution and carbon emissions), is crucial for energy transition strategies. Many countries are both coal producers and consumers. Coal is also an important commodity in international trade. Analyzing the global coal market, export-import dynamics, and the geopolitical implications of coal trade is essential. The coal value chain has significant socio-economic effects on communities and regions dependent on coal-related activities. Job creation, economic development, and fiscal contributions are aspects that must be considered alongside the environmental impact when discussing the future of coal.

Given the imperative to reduce carbon emissions, exploring strategies for transitioning from coal to cleaner energy sources is essential. This includes examining policies for a just transition for affected communities and industries, promoting renewable energy adoption, and addressing the challenges of phasing out coal. Technological advancements, such as carbon capture and utilization, can potentially reshape the coal value chain. Examining innovative solutions and prospects for sustainable coal use is critical. By understanding the complexities and challenges of coal value chains, we can make informed decisions on how to navigate the transition to a more sustainable energy future.

Based on the above background, the Figure 1 represent a simple form of the ‘coal value chain’ based on the elements of inputs, mining, transport and end-market.

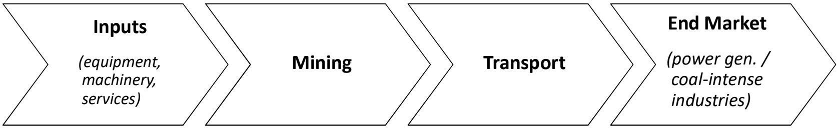

Figure 1: The Coal Value Chain Source: Decarb project, own elaboration

Inputs encompass the industries that provide the necessary resources and equipment for coal mining and transport. Inputs may include Coal Mining Equipment Manufacturing, Fuel Supply (Oil and Coal), Rubber and Conveyor Belt Production, Specialized Machinery Manufacturing, Infrastructure Development *Mining* involves the actual extraction and processing of coal, by involving Coal Extraction, Coal Processing (Washing, Sizing, Sorting), Mine Safety and Operations. *Transport* covers the movement of coal from mining sites to processing facilities and, ultimately, to end-market consumers. Transport might encompass Intermediary Coal Transportation (Trucks, Trains, Conveyor Belts), Freight Vehicles, Shipping and Port Facilities. *End Market* includes the utilization of coal for energy production in power plants and its consumption by coal-intensive industries in various applications. End Market may include Electricity and Heat Production (Coal-fired Power Plants), Coal-Intensive Industries (Iron & Steel, Cement, Textiles), Other Industries (Using coal as a component). To this end, Figure 2, provides a simple working typology to assess the impact of coal phase-out.

	Inputs	Mining	Transport	End market
Direct	equipment, security	Coal mining, Surface activities, Rescue station, others	Road transport, Railway	Production of heat, Electricity production, Carbon-intense industries
Linked	Industries: Rubber, metallurgic, Engineering, Petrochemical, Timber and processing, Transport, Food			

Figure 2: A working typology to account for the impact of decarbonization, Source: Decarb project, own elaboration

13.4 Integrated Socio-Economic Model for Coal Value Chain Analysis

Developing a comprehensive model that accounts for the levels of dependency and changes in values of inputs, outputs, and final demand, is crucial for understanding the socio-economic impact of decarbonization and for planning a just transition. Such a model could be articulated upon the following structure.

Regional Economic Dependency on the Coal Value Chain (Energy Mix):

- Define a metric to measure the regional dependency on the coal value chain. This can be based on the proportion of energy produced from coal within the region (energy mix).
- Correlate this metric with economic indicators, such as employment, GDP contribution, and industrial output, to quantify the direct and indirect impact of coal dependency on the regional economy.
- Consider the region's exposure to energy price fluctuations and the potential for diversification to renewable sources.

Dependency Factors among Sectors/Businesses within the Value Chain:

- Develop a dependency index that reflects how interconnected each sector/business within the value chain is to others.

- Quantify the impact of changes in one sector on others. For instance, the closure of coal mines may impact transportation, equipment manufacturing, and energy production sectors.
- Identify agglomerations and clusters within the value chain based on their interdependencies, shedding light on vulnerable points and areas where support for transitioning is needed.

Changes in Values of Inputs, Outputs, and Final Demand (Expenditure, Turnover):

- Establish a dynamic model that simulates changes in the value of inputs, outputs, and final demand as the coal value chain evolves.
- Integrate external factors like policy changes, technological advancements, and shifts in energy demand to project future scenarios.
- Analyze the economic implications of transition strategies (e.g., renewable energy investments, job retraining programs) on input suppliers, coal-dependent industries, and the overall economy.

Data Integration and Scenario Analysis:

- Combine the above components into an integrated model that takes into account regional dependency, inter-sectoral dependencies, and changes in value.
- Use this model to run scenario analyses, considering different levels of decarbonization, policy interventions, and economic diversification efforts.
- Evaluate the socio-economic impacts of various scenarios, including employment changes, shifts in GDP, changes in input/output values, and the resilience of the regional economy.

At the same time, regional energy-source value chains are closely tied to specific professional groups employed within each sector of the energy industry. The nature of the work, the skills required, and the demographics of these professional groups play a significant role in shaping the socio-economic dynamics of a region as it relates to energy production and consumption. Understanding the composition of these professional groups is essential for assessing the impact of transitions within the energy sector. To this end, the labor-intensity of the coal value chain is a crucial metric that provides valuable insights into the employment structure within the energy sector and the overall energy production efficiency. It serves as a bridge between the socio-economic impact of the value chain and its environmental implications. Based on Alves Dias et a., 2018, below are listed a number of relevant indicators designed to account for labour characteristics of coal value chains.

- Number of jobs in coal mines at each NUTS-2 region
- Overall Number of jobs in coal power plants and coal mines in NUTS2 regions
- Share of jobs in coal mines
- Share of jobs in coal fired power plants
- Number of coal related direct jobs
- Number of persons employed in the manufacture of machinery for mining, quarrying and construction, in coal producing countries
- Number of enterprises engaged in the manufacture of machinery for mining, quarrying and construction, in coal producing countries
- Share of total jobs in countries (or regions) with coal mines
- Number of enterprises within the mining of coal and lignite NACE sector in 2015
- Types of professional groups employed in mining activities
- Share of professional groups employed in mining activities

To conclude, labor intensity is a useful metric because it allows comparisons between labor inputs of coal value chains to labor input of renewables value chain, or in other words, between a carbon-intense energy mix and a less carbon-intense energy mix.

13.5 Conclusions

The paper explores the intricate interplay of the coal value chain, emphasizing its socio-economic impact in the context of decarbonization efforts and the imperative for a just transition. It presents a comprehensive model that accounts for the degree of dependency on the coal value chain within regional economies, the interdependencies among sectors within the value chain, and the changes in values of inputs, outputs, and final demand. This model offers a nuanced understanding of the multi-faceted aspects of the coal value chain, enabling policymakers and stakeholders to navigate the complexities of transitioning to cleaner energy sources while addressing the socio-economic well-being of affected communities.

The analysis highlights the importance of regional energy-source value chains and their association with specific professional groups employed within each sector. By considering the energy mix, the paper examines the level of dependency of the regional economy on the coal value chain, shedding light on the potential vulnerability or resilience of communities as decarbonization progresses. The dependency factors among sectors within the value chain are dissected, revealing agglomerations, clusters, and the number of jobs affected by changes in one sector due to transitions in another.

The paper underlines the significance of labor-intensity as a relevant metric for understanding employment structure and energy production efficiency within the coal value chain. This metric serves as a bridge between the socio-economic and environmental aspects, guiding policy decisions for a just transition that mitigates job losses while advancing environmental sustainability.

Ultimately, the paper provides a comprehensive framework for evaluating the socio-economic implications of decarbonization. It emphasizes the need for well-informed policies that consider regional context, workforce transition, and the socio-economic fabric of communities while striving for a low-carbon future. This work serves as a vital resource for policymakers, industry leaders, and stakeholders seeking to navigate the challenging path of decarbonization with fairness and effectiveness, ensuring that no one is left behind in the global transition towards a sustainable energy future.

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14 Coal Phase Out and Just Transition: Exploring an Ex-Ante Impact Analysis Methodology

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14.1 Introduction

The global imperative to address climate change and transition towards more sustainable energy systems has catalyzed discussions around the phased reduction of coal consumption and production (Sen & Ganguly, 2017; Healy & Barry, 2017). As the adverse environmental impacts of coal become increasingly apparent, governments, policymakers, and international organizations are seeking strategies to transition away from coal-based energy sources. However, the urgency to combat climate change must be balanced with the imperative to ensure social justice and inclusivity throughout this transition process (Borras & Franco, 2017; Seddon et al., 2021).

The concept of a "just transition" has gained prominence as a fundamental framework for guiding the shift to more sustainable economies while safeguarding the rights and well-being of workers, communities, and vulnerable populations directly affected by these changes. A just transition underscores the importance of equitable distribution of benefits and costs, as well as the provision of support and opportunities for those adversely impacted by economic and environmental transitions (Cedergren et al., 2022; Vona, 2023; Pickering et al., 2022).

This paper explores the intricate relationship between coal phase-out strategies and the imperative of a just transition. While the environmental rationale for reducing coal consumption is widely acknowledged, the societal implications of such transitions necessitate careful consideration (Rogge et al., 2017; Dincer, 2000). The potential for job displacement, economic disruption, and social inequities demands proactive planning and comprehensive impact assessments to minimize adverse effects and maximize positive outcomes.

At the core of this exploration is the introduction of an ex-ante impact analysis methodology specifically tailored to coal phase-out scenarios. This methodology, rooted in the principles of anticipation and prevention, aims to predict and address potential socioeconomic consequences prior to the implementation of coal phase-out policies. By integrating qualitative and quantitative assessments, this methodology seeks to provide decision-makers with a holistic understanding of the multifaceted impacts on local economies, employment dynamics, public health, and community well-being.

This paper contributes to the evolving discourse surrounding just transition policies by presenting an innovative approach to analyzing the potential outcomes of coal phase-out strategies. The ex-ante analysis methodology outlined herein not only offers insights into the potential challenges and opportunities associated with transitioning away from coal but also emphasizes the importance of proactive policy design, stakeholder engagement, and inclusive planning. By exploring the potential benefits of integrating such a methodology into decision-making processes, this research aims to advance the pursuit of sustainable, equitable, and environmentally conscious energy transitions that prioritize justice and societal welfare.

The paper proceeds as follows. The next section provides a literature review on the ex-ante impact analysis and decarbonization. The next section discusses the intervention logic in ex-ante impact analysis. The section that follows addresses baselines and hypothetical scenarios by using regression analysis. The last section provides conclusions and policy recommendations.

14.2 Ex-Ante Impact Analysis and Decarbonization: A Literature Review

The literature surrounding ex ante impact analysis in the context of decarbonization and coal phase-out reflects a growing recognition of the need for proactive, evidence-based planning to ensure the success of energy transition strategies while minimizing adverse social, economic, and environmental impacts. Scholars, policymakers, and researchers have explored various aspects of ex ante impact analysis to shed light on its application, methodologies, challenges, and potential contributions to the complex task of transitioning away from coal-based energy systems.

Researchers have highlighted diverse methodological approaches to conducting ex ante impact analyses in the context of decarbonization and coal phase-out. These approaches encompass a mix of qualitative and quantitative techniques, modeling tools, scenario analyses, and stakeholder engagement methods. Studies such as those by Hering et al. (2018), Fay et al. (2015) and Vogt-Schilb et al. (2015) emphasize the importance of integrating economic, social, and environmental dimensions within modeling frameworks to comprehensively evaluate the potential outcomes of transition strategies. The economic repercussions of coal phase-out and decarbonization remain central concerns. Ex ante impact analyses have been used to assess potential shifts in employment, economic growth, and investment patterns. Some studies, like those by Helming et al. (2011) and Lang et al. (2019), underscore the need to consider sectoral dynamics, regional disparities, and the potential for new job creation in emerging green sectors.

Just transition principles emphasize the importance of addressing social equity concerns during decarbonization efforts. Researchers like Kikuchi et al. (2021) and Sovacool et al. (2020) have examined how ex ante impact analyses can be employed to identify vulnerable communities, assess potential inequalities, and design policies that safeguard the well-being of affected populations. The environmental benefits and risks associated with decarbonization and coal phase-out are also subject to scrutiny. Researchers, such as Sovacool et al. (2021) and Steckel et al. (2020), highlight the role of ex ante impact analyses in assessing potential emissions reductions, air quality improvements, and the implications for renewable energy deployment.

The use of ex ante impact analysis to inform policy and decision-making is a recurring theme in the literature. Studies by van Ruijven et al. (2019) and Creutzig et al. (2018) emphasize that robust impact assessments can guide policymakers in selecting optimal strategies, designing supportive measures, and avoiding unintended consequences. Scholars also acknowledge the challenges and uncertainties inherent in ex ante impact analyses. The difficulty of predicting complex interactions, technological advancements, and socio-economic changes is a recurrent concern. Research by Pfenninger et al. (2017) highlights the need for sensitivity analyses, stakeholder involvement, and adaptive policy frameworks to address these challenges.

In conclusion, the literature on ex ante impact analysis in the context of decarbonization and coal phase-out underscores its significance as a tool for informed decision-making and policy design. The multifaceted nature of energy transitions requires comprehensive assessments that account for economic, social, and environmental dimensions, ensuring that the pursuit of sustainability aligns with principles of justice and inclusivity. While challenges persist, the evolving methodologies and insights presented in the literature contribute to the development of effective strategies that navigate the complexities of decarbonization while minimizing negative impacts and maximizing positive outcomes.

14.3 The Intervention Logic in Ex-Ante Impact Analysis

At its core, the ex-ante impact analysis functions as a mechanism for evaluating the future consequences of existing or proposed interventions. In essence, it endeavors to "predict" the probable outcomes of various alternative interventions, with the aim of identifying the option(s) that offer the optimal balance of minimized "cost" and maximized "benefit." To elaborate, the ex ante impact analysis operates as a robust tool for discerning the positive and negative repercussions of an intervention across specific areas, commonly referred to as "impact areas." This assessment is carried out based on predefined criteria, providing a systematic means to evaluate the multifaceted impacts of an intervention on different dimensions. By embracing this approach, decision-makers gain insights into the potential consequences of their actions, enabling them to weigh different alternatives and select the course of action that yields the greatest benefits while minimizing drawbacks.

In the context of the ongoing discourse surrounding the decarbonization of the energy sector and the imperative to phase out coal-based energy activities, the application of ex ante impact analyses emerges as a particularly pertinent tool. In the subsequent sections, we delve into the specifics of how ex ante impact analyses can be tailored to address the intricacies of the coal phase-out and just transition scenarios. By harnessing the power of this analytical approach, we aim to provide insights that contribute to the development of well-informed policies and strategies aimed at aligning energy transition goals with the principles of social justice and inclusive development.

The intervention logic model (see Figure 1) provides a structured framework that outlines the logical connections between the objectives of a program or policy and the specific actions intended to achieve those objectives. It serves as a roadmap to understand how interventions are expected to lead to desired outcomes. In the context of considering the socio-economic impact of decarbonization in the energy sector, an intervention logic model can help illustrate the key elements involved and the causal relationships between them.

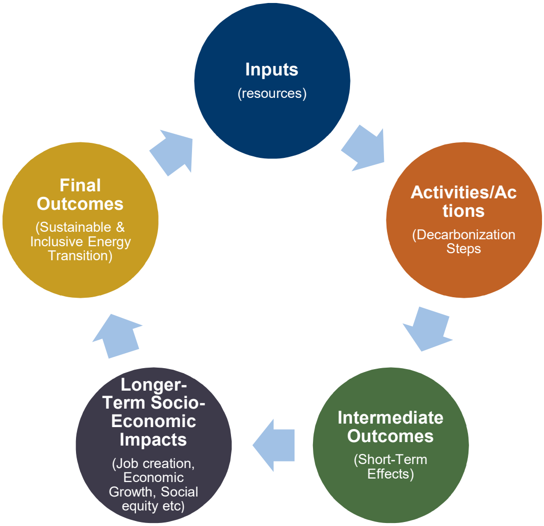

Figure 1: The intervention logic model Source: Own Elaboration

In the above intervention logic model diagram, **Inputs** are the resources allocated for the decarbonization efforts. They could include financial resources, technology, human capital, policy frameworks, etc. **Activities/Actions** represent the concrete steps taken for decarbonization, such as transitioning to renewable energy sources, improving energy efficiency, and implementing policy changes. **Intermediate Outcomes** are the immediate effects resulting from the activities, such as reduced carbon emissions, increased adoption of renewable technologies, and changes in energy consumption patterns. **Longer-Term Socio-Economic Impacts** are the broader societal and economic changes brought about by decarbonization. They include job creation in the renewable sector, economic growth due to new industries, improved social equity through targeted policies, etc. **Final Outcomes** represent the ultimate goals of the intervention, which include a sustainable and inclusive energy transition characterized by reduced carbon emissions, energy security, enhanced well-being, and equitable distribution of benefits. To this end, this intervention logic model diagram serves as a visual representation of the logical sequence from inputs to desired outcomes, helping to clarify the relationships and dependencies among various elements of the decarbonization process. It provides a foundation for conducting ex ante impact analyses by identifying critical points of intervention and tracing the anticipated impacts throughout the process.

14.4 Baseline and Hypothetical Scenarios

Conducting an ex-ante impact analysis involves comparing the current state of affairs with future scenarios to assess the potential effects of an intervention, such as decarbonization of the energy sector. To do this effectively, a systematic approach is required. Using regression analysis to compare the development over time of correlations between different variables can be a robust method for conducting an ex-ante impact analysis. This approach allows for a quantitative assessment of the potential impacts of different scenarios, particularly when exploring the relationship between CO_2 reduction targets and energy production labor intensity. Figure 2, presents the methodological approach, using regression analysis.

The benefit of this approach is three-fold. First, regression analysis provides a quantitative basis for comparing scenarios and assessing the potential impacts (*Quantitative assessment*). Second, the method considers how the relationships between variables change over time, allowing for more nuanced insights (*Time Dynamics*). Third, researchers can tailor scenarios to match specific policy objectives or ambitions, making the analysis highly adaptable (*Customization*).

At the same time, some crucial challenges associated with using regression analysis for ex-ante analysis, come to the fore. First, reliable historical data is the foundation of any regression analysis. Inaccurate or incomplete data can lead to misleading results. Data collection, validation, and accuracy are critical to ensuring the integrity of the analysis (*Data Quality & Availability*). Second, regression analysis assumes a linear relationship between variables. However, real-world relationships can be more complex. If the true relationship is nonlinear, using a linear model might lead to inaccurate or biased results (*Linearity Assumption*). Third, external factors that influence the relationship between CO2 reduction targets and labor intensity can confound the analysis. These factors might not be explicitly captured in the model, leading to omitted variable bias (*Confounding Factors*).

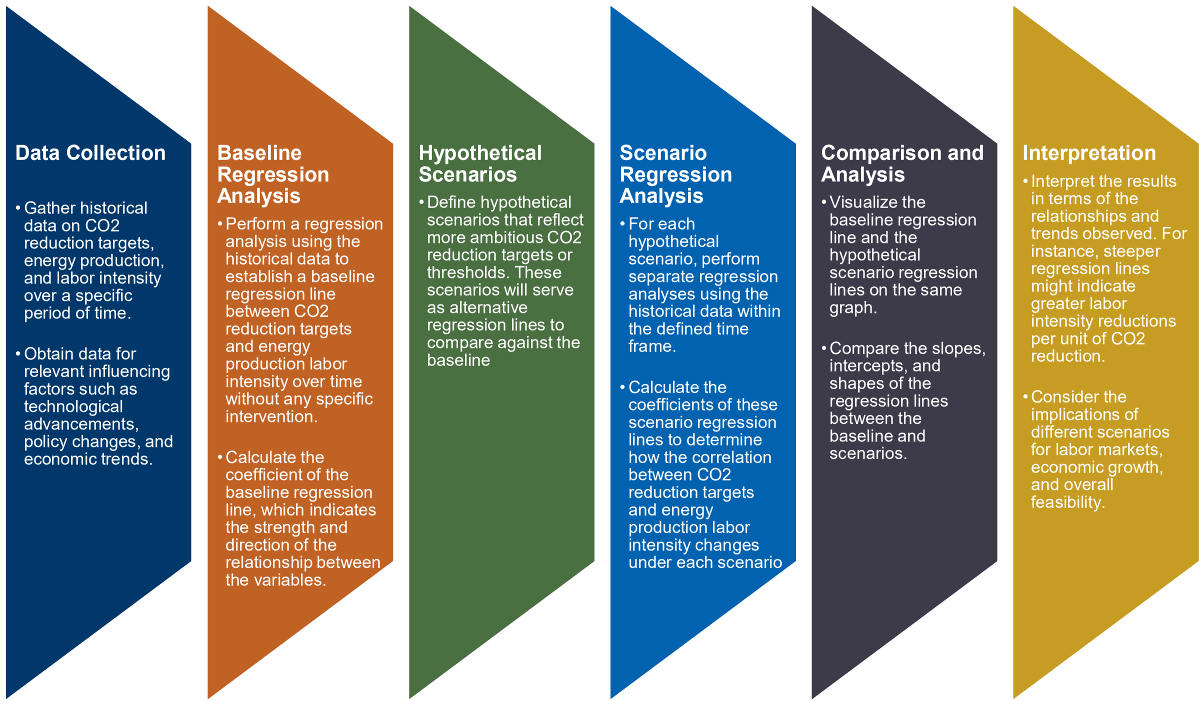

Figure 2: Methodological approach: Ex-ante Impact Analysis Using Regression Analysis Source: Own elaboration

Challenges	Mitigating Challenges
Data Quality and Availability	**Data Validation:** Implement data validation procedures to identify and rectify errors in data before analysis. **Multiple Sources:** Cross-reference data from multiple reliable sources to ensure accuracy. **Missing Data Handling:** If data is missing, explore imputation methods or assess the impact of missing data on results.
Confounding Factors	**Control Variables:** Include relevant control variables in the regression analysis to account for external influences on the relationship being studied. **Control Group:** If possible, use a control group that is not subject to the intervention to better isolate the effects of CO2 reduction.
Linearity Assumption	**Nonlinear Models:** In case of nonlinear relationships, consider using polynomial regression, spline models, or other techniques that can capture nonlinear patterns.
Causality vs. Correlation	**Causal Inference Techniques:** If establishing causality is crucial, explore techniques like instrumental variables, propensity score matching, or regression discontinuity.
External Factors	**Inclusion of Factors:** Whenever possible, include variables representing potential external influences on account for their effects. **Expert Input:** Consult domain experts to identify and validate factors that might influence the relationship you're analyzing.

Figure 3: Challenges in ex-ante impact analysis & mitigating challenges Source: Own elaboration

Fourth, Regression analysis can show correlations between variables, but it doesn't establish causality. While you might observe a correlation between CO2 reduction and labor intensity, it's important to ensure that changes in CO2 reduction are driving changes in labor intensity, and not the other way around (*Causality vs Correlation*). Fifth, factors beyond CO2 reduction targets can influence labor intensity. These might include economic conditions, technological changes, policy shifts, and more. Isolating the effect of CO2 reduction can be challenging (*External Factors*). Mitigating the above challenges requires a combination of careful methodological considerations, robust data practices, and transparent reporting. Figure 3 provides summary information on how we can enhance the rigor and credibility of the ex-ante impact analysis.

14.5 Conclusions

This article has explored the methodologically intricate landscape of ex ante impact analysis within the context of decarbonization and coal phase-out. Throughout our discussion, several key themes have emerged, underscoring the multi-faceted nature of this analytical approach and its relevance in shaping informed and effective policy decisions. As we reflect on the journey undertaken, we draw several notable conclusions.

Ex ante impact analysis represents a systematic approach to grappling with the complexities of transitioning from coal-based energy systems to more sustainable alternatives. By employing rigorous methodologies that integrate economic, social, and environmental dimensions, decision-makers can navigate the intricate web of interactions inherent in such transformative endeavors.

The marriage of quantitative techniques like regression analysis with qualitative assessments enables the acquisition of holistic insights into the potential ramifications of decarbonization scenarios. These insights empower policymakers to make well-informed decisions that consider not only the environmental imperatives but also the social equity and economic implications of their choices.

Challenges, as illuminated throughout our exploration, are an inherent aspect of ex ante impact analysis. From data quality concerns to the complexities of causal relationships, these challenges require diligent mitigation strategies. Transparency, expert input, sensitivity analyses, and adaptive methodologies are the tools that fortify the analytical process against these obstacles.

Our discussions have underscored the importance of balancing ambitious decarbonization goals with pragmatic considerations. Through the lens of regression analysis, we've seen how different CO2 reduction targets can influence labor intensity. This analytical lens guides the formulation of strategies that are not only environmentally robust but also socio-economically tenable.

Central to the discourse is the concept of a just transition. Ex ante impact analysis serves as a pathway to achieving this noble aspiration. By identifying potential disparities, vulnerabilities, and opportunities, it contributes to the creation of policies that prioritize equity, safeguard livelihoods, and enhance societal well-being during periods of transition.

In the ever-evolving landscape of sustainable development, energy transition, and climate action, ex ante impact analysis stands as an invaluable compass. It guides us toward policies that hold the promise of a cleaner, more equitable future. Yet, as we conclude, we acknowledge that this journey is ongoing. As methodologies evolve, data quality improves, and challenges transform, our commitment to rigor, inclusivity, and innovation will continue to shape the trajectory of ex ante impact analysis, steering us closer to a world where environmental responsibility and social justice thrive in harmony.

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15 Responsible Research and Innovation in Energy Transition: A Citizens' Perspective

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15.1 Introduction

Responsible Research and Innovation (RRI) has been a relatively new and multi-dimensional topic for both scientists and policy makers in the past two decades. In fact, the RRI discussion has been characterized by two key trends: Considering that governance "would need to be based on the principle of inclusivity involving all actors at an early stage," the first trend places emphasis on the significance of social public consultation and involvement (Owen et al., 2012). In that case, the values on which European governance should be based, accrue exclusively from democratic activities and procedures. The other trend focusses on anchoring the procedure of policy making on specific pre-set regulatory filters, such as common goals included at a European Commission level, which may provide ethical integrity, financial sustainability, and social acceptability (van den Hoven et al., 2013). These two distinct approaches of the same model constitute only two possibilities of the entire range of available opportunities offered by the concept of RRI, which may involve the mixing-up with other decision-making approaches that include specific policy goals.

In the aforementioned perspective, energy transition as a distinct policy process, may be promoted through RRI adding its extra qualitative elements that differentiate the core of its policy principles. Energy transition from a fossil-fuel based production model to a sustainable development paradigm, has been a challenging issue for every region and policy-making framework (Byrne & Lund, 2017). Adding a level of “responsibility” in energy transition policies is a must for all helices of the quadruple helix and mostly for the helix of citizens. In fact, civil society most often perceives energy transition with skepticism, showing the greatest levels of resistance (Smith, 2012).

The Region of Western Macedonia (RWM) in Greece is in the process of energy transition since 2021, implementing the mega task of abandonment of its lignite-based production model, to a new development model, based on sustainability and innovation. The paper's goal is dual: At first, it attempts to uncover the core policies proposed by stakeholders regarding the implementation of RRI principles in energy transition. Secondly it reveals the evaluation of those policies by the side of citizens, through an empirical interactive process according to which, citizens give their evaluation and their feedback on how the proposed actions are currently rated, can be improved or totally transformed to new socially-beneficial policy actions.

15.2 Literature Review

According to von Schomberg (2011), Responsible Research and Innovation is a *"transparent, interactive process by which societal actors and innovators become mutually responsive to each other with a view on the (ethical) acceptability, sustainability and societal desirability of the innovation process and its marketable products (in order to allow a proper embedding of scientific and technological advances in our society)"*. What the researcher actually states in this case, is the multi-task nature of RRI as an empowerment lever of innovation, in the direction of achieving a socially-beneficial perspective that may include any kind of policy that is ethical, sustainable and participative. The socially-beneficial perspective is even more transparent on the definition given by the European Union a few years later, where the concept is imprinted as *"the ongoing process of aligning research and innovation to the values, needs and expectations of society"* (Italian Presidency of the Council of the European Union, 2014). Stilgoe et al. (2013) initiate RRI's four major dimensions (AIRR dimensions) of anticipation, inclusiveness, reflexivity and responsiveness, as the pillars for implementing RRI framework in the decision-making. This framework is further complemented with a set of policy agendas (also called RRI keys) defined by the European Commission, which are gender equality, open access, science education, public engagement and ethics. These nine elements constitute the scope of embedment of every single decision-making policy that may incorporate innovation into a specific policy area.

Despite being a relatively new concept, RRI has been slightly transformed its implementation scope in the recent years. From exclusively being an innovation framework that provided the rules under which innovation and science should be implemented, it has been transformed to a policy-making tool that incorporates science and innovation principles. According to scholars, RRI targets a specific section of the political process, politicising the policy 'inputs' that have been "depoliticized" in recent times (Fawcett & Marsh, 2014), indicating that is primarily a policy-making framework that focuses at embedding the sustainable principles of research. In fact, RRI should be perceived as an effort to readjust the politics of research governance between the input and output sides rather than as an effort to repoliticise research governance (Hartley et al., 2017).

Apart from the role that RRI can take for specific technologies, there is also a role of RRI for distinct socio-technical transformation procedures (including a large spectrum of different technologies) such as the transition of the energy system toward carbon neutrality (Buchmann et al., 2023; Owen et al., 2013). Thus, based on the view of Owen et al. stating that *"the aim of RRI policy is that research and innovation should have a societally beneficial impact"* (Fitjar et al., 2019), RRI can be operationalized in the form of a tool for leading energy transition to societally beneficial directions (Buchmann et al., 2023). The purpose of this paper, is to create a framework of evaluation of the main energy transition policies by the main beneficiaries of social benefits – the citizens themselves. In fact, the participation of citizens in RRI has been highlighted by scholars as considerably important, as the alignment of policy making with moral and socially beneficial values may bring a societal consensus on the policies that lead to the conduction research and innovation in a responsible manner (Weinberger et al., 2021). Considering energy transition specifically, such transformative policy frameworks can be successful in the long term, only if citizens participate of the transition processes (Weinberger et al., 2021).

15.3 Empirical Process and Findings

The empirical research of the study is based on specific project activities implemented under the umbrella of the "Leveraging Leadership for Responsible Research and Innovation" (RRI-LEADERS) H2020 project. The main goal of the project has been to develop future-oriented strategies and action plans that have the potential to implement RRI as a guiding framework in territorial Responsible and Innovation (R&I) governance, in specific core policy areas of each participating region. For RWM, the main policy area is energy transition. More specifically, the creation of a clean energy transition strategy based on stakeholder engagement, efficient territorial governance and development of a methodology aiming to a smooth and innovative transition towards an alternative development 'paradigm'. In that framework, the project foresaw the implementation of a deliverable that investigates the evaluation of the citizens on the project findings about effective policies to achieve the policy area. The deliverable is the Citizen Review Panel (CRP), a workshop consisting of 25 citizens from RWM that had the task to evaluate and re-adjust 15 core policy actions that have been proposed by the stakeholders who participated in previous project activities.

CRP is considered one of the final steps of the co-creation process, which involved several activities such as mapping of the potential stakeholders and policy documents, questionnaire structuring, Delphi workshops, etc. The format and the manuals of the CRP were designed by the Danish Board of Technology, while for RWM, the event was conducted by the Local Government Association of Western Macedonia (LGA-WM) and it was divided into three main sections according to which, 25 randomly selected citizens from RWM had to assess:

i) the acceptability of actions
ii) the potential improvement of actions
iii) the prioritization of actions

In Section 1 (acceptability of actions), citizens had to assess 11 initially set actions belonging to three major objectives, about RRI adaptability to a clean energy transition strategy in the region. These actions have been accrued from previous project activities of the co-creation process. The three major objectives and initial actions as well as the time frame of actions' implementation, are shown in table 1. All the actions are specifically proposed for RWM. Citizens had to evaluate each specific action, by inserting a green, a yellow or a red color – indicating the current level of acceptability of the action. Green color indicated that the evaluated action is accepted in its current form, yellow indicated that the action is accepted with minor adjustments for its improvement and the red color indicated that the action is not accepted at all, due to its content.

Table1: Objectives and initial actions of the Citizen Review Panel

OBJECTIVE 1: Putting forward an extensive upskilling of the local workforce through the creation of efficient, decentralised and innovative procedures, where the local research institutions will play a primary role.	**TIME FRAME**
Action 1.1: Conduction of a Regional Foresight Study for re-and-upskilling that will set the exact educational and training needs of citizens that have been mostly affected by energy transition.	*2024-2025*
Action 1.2: Establishment of a broad and inclusive upskilling programme that will be mainly focused to the citizens that have been mostly affected by energy transition (miners, electricity production workers, etc). University of Western Macedonia will be the primary pillar of the action.	*2024-2025*
Action 1.3: Integration of digital transformation infrastructure for easing and supporting effective upskilling that will be directed to all social backgrounds and offer high tech training solutions. This will include high-speed networking, user-friendly distance-learning platforms, scientific database for energy and other subjects, etc.	*2024-2027*
Action 1.4: Creation of innovative energy-related upskilling entities such as a Hydrogen University Course.	*2025-2027*
OBJECTIVE 2: Creation of an entrepreneurial ecosystem in the Region of Western Macedonia.	**TIME FRAME**
Action 2.1: Initiation of an Action Plan for entrepreneurial growth in the region by the regional authority, the municipalities, the university and the local professional chambers. The plan will foresee specific incentives and funding will accrue from the regional authority / municipalities.	*2023-2025*
Action 2.2: Establishment of an innovation zone.	*2023-2025*
Action 2.3: Creation of a spatial plan that will clearly foresee land usage and distinguish areas for major investments, RES infrastructures, agricultural activities and other usages.	*2024-2025*
OBJECTIVE 3: Development of a regional energy efficiency model with the inclusion of actions towards the achievement of environmental sustainability.	**TIME FRAME**
Action 3.1: Programme for achieving regional energy efficiency on an industrial and consumption level in connection to the Just Development Transition Programme. The programme will include a foresight study for current and future energy needs per municipality in the region, taking into consideration major investment plans.	*2024-2026*
Action 3.2: Setting up a holistic action plan for environmental restoration of ex-mine lands.	*2024-2027*
Action 3.3: Create an "Environmental sustainability and circular economy" university master-degree course.	*2025-2026*
Action 3.4: Initiate an "environmental tariff" to non-green investments and environmental activities that will be exclusively used for environmental restoration purposes at a regional level.	*2024-2027*

The color marks were assigned to each action in three district criteria. Table 2 indicates the three criteria which citizens had to put their color marks upon:

Table 2: Criteria of CRP actions

Criterion 1	Criterion 2	Criterion 3
Do you think this action will help reach the objective?	*Do you think the possible negative effects of the action are acceptable?*	*Do you think the action addresses the needs of the citizens and/or intended target group(s)?*

The findings of the acceptability of actions sections are shown in Table 3, on the next page. Table 3 shows that some actions received high levels of acceptability while others received considerable levels of non-acceptance. As depicted, action 3.4 – the initiation of an environmental tariff – has received the highest number of red as well as yellow votes, in all three criteria. In fact, citizens seem to be very hesitant to accept more financial bargains for potential and current investments, implying that this is a highly anti-investment measure. Similarly, actions 1.1 and 3.1 have both been marked with the second highest number of red votes, constituting the second most rejected actions (5 red votes). It seems that a considerable of citizens do not consider the conduction of a Regional Foresight Study for re-and-upskilling of the local workforce will have the necessary impact towards the development of the region. Likewise, citizens do not perceive regional energy efficiency as a critical action regarding its developmental perspective. Action 1.2 – the establishment of a broad and inclusive upskilling programme that will be mainly focused to the citizens that have been mostly affected by energy transition – also received a considerable number of rejection votes. As indicated in the other sections of the CRP, citizens consider that workers in RWM already have high expertise in specific professional areas and they do not need more training but support to find a new job or financially improve their current income.

Considering the actions that have been chosen as “acceptable to some extend”, again action 3.4 has received the most votes, implying that even for citizens who accept the content of such action they consider that modifications are needed. Action 2.3 which foresees the creation of a spatial plan for land usage and distinguish areas for major investments, was the action that received the second highest number of yellow votes, implying that the spatial plan is necessary but probably it should be further specialized into specific predictions such as the terms for land usage by RES investments.

The action considering a programme for achieving regional energy efficiency on an industrial and consumption level (3.1) received the third highest number of yellow votes, indicating a similar tendency with the red voting. Again, citizens show their hesitation in initiating energy efficiency in the region, most probably due to the demanding financial resources that will be needed.

The next section of the CRP was about the improvement of actions. Section 2 concerned only actions that have been voted with the yellow color – "improvement to some degree" actions. In that section, citizens proposed a series of improvements, regarding both the actual context of the actions as well as their syntactic structure. For instance, those who voted with yellow color action 3.4 – the most rejected (according to other citizens) action – considered that the word "tariff" could be substituted with the word "tax" which may chance the action syntactically but not context-wise. Others proposed the substitution of the whole action with another action proposing the granting of financial incentives to businesses not to pollute, rather than imposing them with a green tax or a tariff. However, this can be considered also a brand-new action, targeting at the same goal: a motive (positive or negative), not to pollute. The improvement of actions indicated other interesting proposals. For example, the initiation of a spatial plan (action 2.3) that will exclusively concern RES investments which face the largest resistance from citizens in the region, would not cause any bureaucratic burden to other kinds of investments and would set a detailed framework for RES investments regarding their installation areas. In total, very few proposals regarding the improvement of actions have been proposed and most actions were accepted in their current form.

In the same section, a few new actions regarding two objectives have been proposed by citizens. Citizens proposed the creation of extensive infrastructures in the region (action 1.5), the build-up of digital networks by the Regional Authority that will provide free and fast internet to local citizens and businesses as well as cloud services provided for free (action 1.6) and the initiation of a tourist plan, specifically directed at alternative tourism forms.

Table 3: Findings of the “acceptability of actions” section of the CRP

	Criterion 1			Criterion 2			Criterion 3			Total				
	Green	Yellow	Red	Green	Yellow	Red	Green	Yellow	Red	Green	Yellow	Red	Most rejected actions	Most "acceptable to some extend"
Action 1.1	19	1	2	16	6	0	18	1	3	53	8	5	2-3	
Action 1.2	18	3	1	12	10	0	17	3	2	47	16	3	4-5	4
Action 1.3	21	1	0	11	11	0	16	6	0	48	18	0		
Action 1.4	17	5	0	15	7	0	17	5	0	49	17	0		
Action 2.1	19	2	1	10	11	1	17	4	1	46	17	3	4-5	
Action 2.2	22	0	0	21	1	0	22	0	0	65	1	0		
Action 2.3	5	17	0	15	6	1	15	6	1	35	29	2		2
Action 3.1	15	6	1	10	10	2	11	9	2	36	25	5	2-3	3
Action 3.2	19	2	1	11	10	1	17	5	0	47	17	2		
Action 3.3	20	2	0	21	1	0	22	0	0	63	3	0		
Action 3.4	6	2	14	0	7	15	3	4	15	9	13	44	1	1

Table 4: Findings of the “the prioritization of actions” section of the CRP

Action No	Description	Votes	Action No.	Description	Votes	Action No.	Description	Votes
1.1	Conduction of a Regional Foresight Study for re-and-upskilling that will set the exact educational and training needs of citizens that have been mostly affected by energy transition.	5	2.1	Initiation of an Action Plan for entrepreneurial growth in the region by the regional authority, the municipalities, the university and the local professional chambers. The plan will foresee specific incentives and funding will accrue from the regional authority / municipalities.	7	3.1	Initiation of a Programme for achieving regional energy efficiency on an industrial and consumption level in connection to the Just Development Transition Programme. The programme will include a foresight study for current and future energy needs per municipality in the region, taking into consideration major investment plans.	5
1.2	Establishment of a broad and inclusive upskilling programme that will be mainly focused to the citizens that have been mostly affected by energy transition (miners, electricity production workers, etc). University of Western Macedonia will be the primary pillar of the action.	13	2.2	Establishment of an innovation zone.	11	3.2	Action 3.2: Setting up a holistic action plan for environmental restoration of ex-mine lands.	7
1.3	Integration of digital transformation infrastructure for easing and supporting effective upskilling that will be directed to all social backgrounds and offer high tech training solutions. This will include high-speed networking, user-friendly distance-learning platforms, scientific database for energy and other subjects, etc.	14	2.3	Creation of a spatial plan that will clearly foresee land usage and distinguish areas for major investments, RES infrastructures, agricultural activities and other usages.	4	3.3	Create an "Environmental sustainability and circular economy" university master-degree course.	14
1.4	Creation of innovative energy-related upskilling entities such as a Hydrogen University Course.	12				3.4	Initiate an "environmental tariff" to non-green investments and environmental activities that will be exclusively used for environmental restoration purposes at a regional level.	1
1.5 (New)	Extensive creation of infrastructures in the region	9				3.5 (New)	Creation og a Waste Management Plan and spatial planning of waste storage.	1
1.6 (New)	Installation of digital infrustucture in the Regional Authority	4						
1.7 (New)	Creation of an Industrial and anternative tourism plan.	3						

At the same logic, a holistic plan for waste management was also proposed, in the direction of financially exploiting waste and protect local environment at the same time (action 3.5).

Table 4 shows the prioritization of actions (section 3), based on each (positive) vote that each action has received. In table 4, citizens vote for the most significant actions, in terms of (positive) effect on the accomplishment of the policy area, including the four new actions that have been added in the previous section. Each citizen could give up to five votes, which could be distributed to five separate actions or to less actions (meaning that one action can receive more than one vote up to all five votes that each citizen is permitted). It has to be pointed out that the obvious tendency would be that citizens prioritized the actions that have been primarily received the green votes. However, according to the findings that was the case in most cases but not all. Starting from the most significant actions, action 1.3 was prioritized on top, foreseeing the integration of digital transformation infrastructure for easing and supporting effective upskilling that will be directed to all social backgrounds and offer high tech training solutions. This will include high-speed networking, user-friendly distance-learning platforms, scientific database for energy subjects, etc. In spite of its genericity, it is not surprising that citizens directed their choice to that specific action. That is due to the fact that it includes the creation of those specific infrastructures that may actually strengthen both local businesses but also citizens from all social and financial backgrounds to enhance their competences and knowledge capital, helping them to cope with the harsh effects of energy transition in RWM.

Action 1.4 – the creation of innovative energy-related upskilling entities such as a Hydrogen University Course, was prioritized as the second most significant action. The ongoing energy transition in RWM has indicated the region has to follow a path of innovation in specific sectors rather just investing with no focus. Since the region has been served as the national energy hub of Greece since decades, the abandonment of energy produced from lignite has to be substituted with the production of alternative green and innovative energy sources. Hydrogen nowadays is amongst the most promising and challenging at the same time energy sources, demanding large amounts of financial resources, human capital and scientific research in order to be developed to a financially viable energy alternative for energy transition regions (Kovač et al., 2021).

Action 2.2 is about the establishment of an innovation zone in RWM. In the framework of Just Development Transition Programme (JDTP), plans for the creation of an innovation in RWM have already been put in place (Zervas et al., 2021). However, construction works have not been started and the citizens of the region reconfirm the necessity for the creation of such a project for the future of RWM. A poly-thematic innovation zone may allow the development of the scientific capital in the region, along with the support to the regional entrepreneurial system with skilled workers and innovative applications.

On the bottom, the red-voted actions and three new actions are shown (see Table 4). For instance, the “rejected” action 3.4 (imposing an environmental tariff) received just one positive vote, followed by the conduction of a regional foresight study about the skilling needs of the local workforce (action 1.1 - 5 votes) and the initiation of a regional energy study for local energy needs (action 3.1 – 5 votes). This was also imprinted in Table 3, as these are the actions that received the reddest votes. However, it was surprising that some of the new actions proposed by the citizens, were also rated low in comparison the initially set actions. For instance, the installation of digital infrastructure in the Regional Authority did not receive a high number of votes. The explanation given in plenary by the citizens not in favor of that action, was that the high-speed wireless connections by the national providers offer a sufficiently attractive digital environment and installation of extra wired networks is not necessary. Similarly, the creation of a waste management plan – despite the agreement by the citizens to be included in the action list – just received one positive vote. The obvious explanation for this general picture, is the initially proposed actions by the stakeholders and the project experts were considered as most significant by the citizens too, even in comparison to their own.

15.4 Conclusions

The CRP showed that in principle, the citizens’ perceptions of the actions that should be taken in order to strengthen the “responsibility” of energy transition in the region do not differ significantly to those of the stakeholders. They still heavily support actions that have the potential to provide a fully developmental footprint in RWM. These actions may be in the form of upskilling, training, providing financial incentives to businesses & local workers, and building infrastructures or legislation frameworks (e.g. spatial plan) that may ease development in the region. Their minor objections, have been in the direction of slightly conceptually improving the actions, by adding more elements regarding potential social benefits or just making the actions more concrete and precise.

However, there has been noted a qualitative differentiation at a specific sector: Citizens categorically oppose actions and measures that may have a negative impact on financial development, even if they have a green mark. For instance, the imposition of any kind of green taxes, tariffs or penalties, is considered a "red rag" by them. That is still the case, even if the money from the taxes is projected to be returned to the region, in other financial or social activities. The explanation for this, lies in the harsh effects they have already experienced over the past years, because of the vertical drop of financial activity in the region due to the lignite abandonment. In fact, the citizens of RWM are very specifical about the implementation of any measure that have the potential to harm or decrease financial activity today and may improve the environment or even the local economy tomorrow. This conclusion should probably trigger policy makers to re-consider a lot of measures that may have a positive impact on the long term, but societies are not able to cope with them in the short term.

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16 From Smokestacks to Sunbeams: Kozani's Decarbonization Symphony

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16.1 Introduction

The global focus on climate change and global warming has driven countries like Greece to transition to renewable energy and reduce greenhouse gas emissions. The Greek Province Western Macedonia with its capital Kozani is leading this shift away from high-carbon lignite energy. Despite being a major lignite producer, Kozani is now embracing a sustainable and low-carbon energy strategy due to the environmental and health concerns associated with lignite. This study explores Kozani's decarbonization process and its broader impact on the region and country, addressing four key research questions:

a) Why did Kozani start the process of decarbonization?
b) What is the alternative for the people who used to work in the igniting places?
c) What is the future of the previous ignite location?
d) How can Greece benefit from the Kozani trail of turning green?

This paper will start by explaining the significance of decarbonization in addressing climate change, focusing on Kozani's unique context due to its history of lignite use. It will detail the region's shift toward decarbonization, including economic, environmental, and political factors. The methodology section will outline data collection and analysis techniques. The research findings will showcase Kozani's current decarbonization status and potential alternative employment avenues. The paper will then analyze these findings' implications for Kozani, Greece, and global decarbonization efforts, offering policy recommendations. This study contributes to decarbonization literature, spotlighting Kozani as a case study with potential policy insights for local, national, and international sustainability efforts. The urgency of transitioning to a low-carbon economy has grown due to climate change impacts. Art. 2 para 1 a) of the Paris Agreement,[1] agreed by almost all states of the World, sets a limit of global warming to 2°C,

[1] Adopted 12.12.2015; entry into force: 04.11.2016; U.N.T.S. vol. 3156; 55 I.L.M. 740 (2017); see for details Albrecht (2022), pp. 142 ff.

better 1.5°C until the end of the Century, which finally requires to achieve net-zero emissions by mid-century. The European Union (EU) is leading this effort, targeting climate neutrality by 2050 through the European Green Deal.[2] Greece, facing climate vulnerabilities, aims for 35% renewable energy by 2030 and climate neutrality by 2050, aligned with EU objectives (Von Der Leyen, 2019).

The Kozani region's pivotal role in meeting targets is rooted in its history of lignite production and usage. Lignite, a low-grade coal, has been Greece's primary electricity source, but its environmental and health impacts – air and water pollution, soil degradation, and emissions – are concerning. The industry has also harmed local communities through health issues, noise, and displacement. Despite employing many, it has waned due to renewable energy competitiveness, regulations, and awareness. Western Macedonia aims for 60% renewable energy by 2023 and a lignite phase-out by 2028, driving significant change, including new jobs, repurposed mines, and renewable energy potential. This transition has broader implications: Greece's renewable potential, post-COVID-19 recovery, EU climate goals, and the region's exemplary status for similar challenges. (Coaltransitions.org, 2021)

16.2 Literature Review

Why did Kozani start the process of decarbonization? The journey toward decarbonization in Kozani is shaped by multiple influences. Notably, the European Union's ambitious climate goals, striving for net-zero emissions by 2050, have propelled this transition. Kozani's alignment with these targets, driven by the European Green Deal and Greece's commitment, underscores the need to lessen lignite dependence due to its substantial greenhouse gas emissions (Europa.eu, 2019).

The health and environmental impacts of lignite mining are increasingly evident, affecting air, water, and soil quality and leading to health issues in nearby communities. This awareness has driven pressure for the lignite industry to shift toward more sustainable energy sources. Additionally, the fading competitiveness of lignite has accelerated Kozani's decarbonization, with wind and solar energy becoming cost-effective replacements (Heinrich-Böll-Stiftung, n.d.). Decarbonization's significance in Kozani extends to former lignite industry workers,

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[2] Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions, The European Green Deal (COM/2019/640 final).

who need alternative employment options. The literature outlines various pathways:

a) The growing renewable energy sector offers substantial job opportunities, spanning engineering, construction, and maintenance of wind and solar projects, fostering skills and job growth.
b) The circular economy presents chances for recycling, waste management, and resource recovery. Waste byproducts like fly ash and bottom ash can be repurposed in construction or cement production. Reclaiming and reforesting former lignite mine areas also creates environmental jobs.
c) Kozani's rich heritage in sites like Meteora's monasteries and Pindos National Park opens doors to ecotourism, cultural, and rural tourism, attracting visitors and potentially boosting the hospitality sector and employment (Wehnert et al., 2018).

The transition to decarbonization in Kozani prompts considerations about repurposing previous lignite sites, with options spanning reclamation, reforestation, sustainable agriculture, and industrial development. This transformation can greatly benefit Greece, fostering economic growth through renewables, environmental enhancement, and social advancement, including food security and cultural preservation. Overall, this process offers a spectrum of opportunities and challenges, demanding comprehensive strategies to address employment shifts, location repurposing, and sustainable development. Consequently, the impacts of de-carbonization on the Kozani region encompass a wide range of economic, social, and environmental aspects, which will be more deeply explored in the following section (IEA, 2023).

Economic impacts: Kozani's decarbonization will reshape its economy, causing job shifts from lignite to renewable energy and the environment. The pace of change will influence job losses and new opportunities.

Social impacts: Local communities' involvement will determine outcomes, including potential displacement near lignite sites. Addressing this means offering alternative livelihoods and training for new jobs.

Environmental impacts: De-carbonization will improve air, water, and soil quality by closing lignite facilities. Yet, new renewable infrastructure may introduce unintended environmental effects, necessitating careful consideration for a sustainable transition (IEA, 2023).

16.3 Methodology

This literature review employs a systematic approach, involving policy documents and media analysis to understand Kozani's decarbonization process. Steps include:

Developing a comprehensive search strategy encompassing online databases, and government, and NGO websites.

Applying inclusion and exclusion criteria for policy documents and media coverage in Kozani, with language restrictions.

Extracting data from documents, noting titles, authors, dates, and key themes, organized in a spreadsheet (Fragkos et al., 2021).

Policy documents include governmental policies, regulations, and plans, shedding light on strategies for emissions reduction and sustainable energy transition. Media analysis involves news articles and reports, offering insights into public perception, challenges, and opportunities. Expert interviews will supplement the analysis, providing a deeper understanding of decision-making, economic, and social implications, and public attitudes toward the transition.

This comprehensive approach, integrating various data sources and analysis methods, ensures a thorough exploration of Kozani's decarbonization journey (Ziouzios et al., 2021).

16.4 Discussion

Kozani's decarbonization drive is rooted in Greece's response to EU directives. To align with the EU's ambitious goal of cutting greenhouse gas emissions by 55% by 2030 (compared to 1990), Greece enacted a National Energy and Climate Plan.[3] This strategy prioritizes emission reductions through increased renewable energy adoption and phasing out fossil fuels.

Kozani, a significant coal-producing region, emerged as a key focus for decarbonization efforts. Greece, responsible for 2.4% of the EU's greenhouse

[3] As defined in Art. 2 para 1 and required by Art. 3 para 1 of the Regulation (EU) 2018/1999 of the European Parliament and of the Council of 11 December 2018 on the Governance of the Energy Union and Climate Action, amending Regulations (EC) No 663/2009 and (EC) No 715/2009 of the European Parliament and of the Council, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament and of the Council, Council Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) No 525/2013 of the European Parliament and of the Council (Text with EEA relevance), OJ L 328, p. 1; see the National Energy and Climate Plan of the Hellenic Republic, available under https://faolex.fao.org/docs/pdf/gre212037.pdf.

gas emissions, has already reduced its carbon intensity faster than the EU average since 2005, particularly in the energy sector, which saw a 45% emissions drop between 2005 and 2019, with further reductions anticipated as lignite-fired power facilities are phased out. The most significant emission decrease (54%) was seen in the transportation sector. (European Commission, 2019; European Parliamentary Research Service, 2019)

16.4.1 Economic Impact of Decarbonization

Kozani's move towards decarbonization will significantly affect the local economy. Lignite-based energy production, a major contributor to Western Macedonia's GDP, particularly in Kozani, underscores the need for measures to address employment and societal effects, with upskilling playing a key role. Despite a small fraction of the workforce (less than 1.2%) being in energy-intensive sectors, the potential exists for green jobs through energy efficiency enhancements and the expansion of wind and solar energy (European Commission, 2022).

16.4.2 Growing Investment in Renewable Energy

Growing investment in renewable energy is apparent in regions impacted by lignite phase-outs. An illustrative example is the 204 MW Kozani photovoltaic (PV) plant, operational since April 2022. Adjacent to several lignite mines, it serves as the inaugural component of Greece's three GW solar PV strategy for lignite regions, constituting the most potent utility-scale solar field in southeastern Europe (Newsroom, 2022).

16.4.3 Alternative Employment for Former Lignite Workers

Kozani's employment landscape is characterized by a historic reliance on the lignite industry for jobs, particularly for individuals with limited education and opportunities, which has shaped Kozani's employment trends. The region of Western Macedonia, encompassing Grevena, Kastoria, Kozani, and Florina districts, reported a 17.2% unemployment rate in the fourth quarter of 2021, the second-highest in Greece. The area holds 2.67% of Greece's officially recognized unemployed population (European Commission, 2021).

In response to lignite-related job losses, the Greek government has implemented diverse policies and initiatives to facilitate a transition to alternative sectors to open new job avenues. Measures include promoting renewable energy projects, aiding startups, and supporting retraining initiatives. The Greek Public Employment Service (OAED) assists workers in launching businesses or pursuing training in emerging fields (European Commission, 2021).

Worker retraining stands central to Kozani's decarbonization efforts. The Greek government, often in collaboration with local educational institutions, has devised training programs to equip individuals with skills pertinent to new industries like renewable energy and sustainable agriculture. These programs may comprise hands-on training and apprenticeships. But, while retraining and fresh employment opportunities exist, ex-lignite workers encounter hurdles in transitioning.

Challenges encompass limited access to education and training, geographical constraints, the stigma associated with their previous industry, and the reluctance to relocate for new prospects within Greece (Pavloudakis, 2023).

16.4.4 Future of Former Lignite Sites

The closure of lignite facilities in Kozani opens avenues for sustainable redevelopment. The Greek government plans to involve repurposing these areas for eco-friendly industries, including large-scale solar and wind energy projects. Sustainable agriculture and tourism are also proposed (Rovolis & Kalimeris, 2016).

The lignite industry's environmental impacts prompt environmental remediation efforts. The Greek government aims to address issues like pollution, soil degradation, and habitat loss through testing, site remediation, and habitat restoration (Rovolis & Kalimeris, 2016).

Despite challenges, Kozani's shift to green industries offers economic and social prospects. Renewable energy, sustainable agriculture, and eco-tourism can create jobs, attract investment, and foster resilience. Additionally, restoring damaged ecosystems supports biodiversity and sustainability (Rovolis & Kalimeris, 2016).

16.4.5 How Greece can Benefit from the Kozani Trail of Turning Green?

Kozani's decarbonization can inspire similar regions, addressing job losses and environmental concerns, thus can be a role model. Its success can drive broader carbon reduction efforts in Greece and Europe. Kozani's shift offers job creation, investment, and export opportunities, notably in the renewable energy sector. Transition brings emissions reduction, ecosystem restoration, and biodiversity protection. Improved health, equity, and quality of life are among the social benefits, fostering a fairer society for all Greeks (Rovolis & Kalimeris, 2016).

16.5 Results

The study's comprehensive analysis underscores the transformative impact of Western Macedonia's decarbonization efforts on various fronts: economy, environment, and society. As coal-based industries give way to sustainable alternatives, positive outcomes emerge alongside formidable challenges. The closure of mines and power plants has triggered workforce shifts, necessitating the creation of fresh prospects in green sectors, a process reliant on substantial investments. Environmental gains encompass emissions reduction and ecosystem restoration, although judicious land use remains a multifaceted consideration.

The social landscape is positively altered through the proliferation of sustainable industries, contributing to local well-being, yet ensuring an equitable transition demands concerted efforts. The study's insights illuminate the intricate tapestry of Kozani's decarbonization journey, advocating policy measures such as worker support, retraining initiatives, and the formulation of robust sustainable regulations to ensure enduring resilience and fairness. These aims align with Greece's strategic Just Development Transition (SDAM) blueprint (Argyropoulos, 2021).

16.6 Conclusion

The decarbonization process in Kozani, Greece, presents a complex yet insightful process that embodies regional challenges and opportunities. Shifting away from coal-based industries has yielded profound economic, social, and environmental effects, underscoring the need for a comprehensive approach. Kozani's experience offers broader lessons on employment dynamics, policy orchestration, and international collaboration for climate action. As we glean insights from Kozani and analogous contexts, we collaboratively strive for a resilient, sustainable future. This ongoing transition demands continuous innovation, green industry investment, and support for affected communities. Monitoring and local engagement remain paramount, highlighting the intertwined nature of regional and global efforts. Kozani's story resonates as a microcosm of a worldwide shift towards harmonizing growth, social welfare, and environmental integrity.

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