Transformation of the Lower Lusatia Landscape in the Context of Climate and Energy Change

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Abstract. The subject of the article is the process of transformation of the landscape of Lower Lusatia – German’s second-largest lignite mining region – shown in the context of contemporary development trends and energy and climate policy. The experience of the last few decades has shown a variety of objectives, directions of development and activities leading to the formation of a new image and landscape identity of the region. The transformation of the landscape of Lower Lusatia is a process of change that is linked to industrial heritage, the tourist potential of the renewed landscape and the energy value based on lignite mining and the acquisition of renewable energy sources. The combination of these three processes is the basis and determinant of creating the current identity of the region. It is also an area of often conflicting interests resulting from various environmental, social and economic conditions. A factor that has a decisive influence on the development of the region is the climate and energy policy implemented in Germany, taking into account environmental objectives, economic needs and social interests to varying degrees. Limiting the adverse consequences of climate threats has now become one of the key strategic actions of the region, reflected both in planning documents and political decisions, as well as in the real landscape. The aim of the article is to show the possibilities and limitations of modern climate and energy policy and to determine the extent of its impact on the landscape, spatial and social transformation of the Lower Lusatia region. The research is also an attempt to answer the question whether the implementation of the adopted energy goals will be sufficient to change the landscape of the region in a sustainable way and sufficient for its development and improvement of the living conditions of its inhabitants.

1. Introduction
Climate change is a key development challenge for all urbanised areas. Many analyses, studies and reports from international organisations indicate the scale of the problem, the sources, and the need for action. They are reflected in the EU, national, regional, and local policies. Climate and energy change are of particular importance for energy regions. The scale of the problems associated with the adaptation of areas whose development was based on coal-power engineering forces political decisions to be taken, which define strategic priorities and actual actions. They are reflected both in planning documents and in the real landscape. At the same time, in practice, there is a lack of sufficient action and sometimes even a surprising scepticism about the problem importance. Sustainability in many regions is still overshadowed by growth policies and social fears of change, loss of jobs, and sources of income.
One of the energy regions undergoing profound landscape, economic, social, and spatial changes is Lower Lusatia, an energy region with significant lignite reserves, located in eastern Germany. Experience of the last few decades shows the diversity of objectives, directions of development, and activities leading to the formation of a new image of the region. They refer to industrial heritage, tourism potential, and acquisition of renewable energy sources, which are the basis and determinant of creating landscape identity. The factor that in decisive manner influences the region development is the policy defining the directions of the energy transformation, taking into account varying degrees of environmental objectives, economic needs, and social interests. The subject of the article is the transformation process of the Lower Lusatian landscape, shown in the context of contemporary development trends and energy and climate policy. The article objective is to show opportunities and limitations associated with them and to determine the extent of their impact on landscape, spatial, and social transformation. The research method used is based on a case study and a critical analysis of Lower Lusatia, carried out in the context of EU and national energy and climate policy, and the actions taken that are visible in the transformed landscape.

2. Climate and energy change in the context of European Union policies

In recent years, climate change has become more and more acute in many cities and regions. No one is questioning them today. However, the very approach to this issue is changing. From purely theoretical considerations carried out at various levels of administration to the pursuit of an informed climate and energy policy implemented progressively through concrete actions. Their environmental, social, and economic consequences affect the quality of life of inhabitants of urbanised areas. The ability to deal with climate threats has become a key development objective and a space for strategic action at the international, national, regional, and local levels. These actions are aimed at limiting the adverse consequences and taking into account varied civilisational challenges.

The European Union has started the process of modernization and transformation of the economy with its climate policy. The European Commission wants Europe to be climate-neutral by 2050 and to have a modern, competitive, and prosperous economy [1]. Great arrangements for European countries include the European Union climate and energy policy framework for 2030 and policy objectives and targets for 2021-2030. The most important of these include:

- reduction of at least 40% of greenhouse gas emissions (compared to 1990 levels),
- at least 32% increase of the renewable sources energy share in total energy consumption,
- at least 32.5% increase in energy efficiency by [2].

The policy framework adopted by the Council of the EU will enable the Community countries to move towards a low-carbon economy and fulfil their commitments under the Paris Agreement. All Member States have been required to develop long-term national strategies and adopt Integrated National Climate and Energy Plans for 2021-2030. They have also been obliged to ensure consistency between these documents. The climate and energy plans shall include individual targets for renewable energies used in the transport, electricity, heating and cooling sectors; taking appropriate policy measures to achieve the national targets, with particular emphasis on cooperation between local, regional and national authorities; establishing cooperation and running joint international projects aimed at developing existing renewable resources [3]. Given the dynamics of change, renewable energy targets have been increased in 2018, which along with increased energy efficiency is an essential part of the overall package of measures needed to reduce greenhouse gas emissions. All scenarios presumed by the European Commission assume complete decarbonisation of energy supply and a radical change in the energy system due to large-scale acquisition and use of renewable energy sources [1]. Energy from renewable sources means energy from renewable non-fossil sources such as wind, solar, aerothermal, geothermal and hydrothermal energy, ocean energy, hydropower, biomass, landfill gas, sewage treatment plant gas and biological sources (biogas) [4]. The transition to clean energy is intended to increase the security of energy supply, accelerate the modernisation of the
economy, stimulate sustainable economic growth and bring significant social and environmental benefits. Rapid application of particular energy sources is expected to generate new industries and jobs, which together with the increase in technological innovation in the energy, buildings, transport, industry, and agriculture sectors, is expected to reduce the costs of applied technologies [1].

Currently, the energy system is mostly based on fossil fuels. However, climate policy, including the promotion of renewable energy sources, puts the coal industry in doubt. The long-term combustion of lignite at current levels will be incompatible with the EU plans to reduce greenhouse gas (GHG) emissions by 80-95% by 2050 (based on 1990 levels) [1]. The International Energy Agency (IEA) scenario indicates that in order to achieve the assumed targets, the European lignite electricity emission would have to decrease on average by 8% per year, i.e. it would have to fall three times faster than the current rate [5]. A systemic solution is therefore needed to enable a gradual transition to a zero carbon economy. Achieving climate neutrality is possible by investing in innovative but realistic technological solutions, empowering citizens, ensuring social justice, and adapting policies to changes in areas such as industrial policy, finance, and research.

The limitations of the adverse consequences of climate threats are reflected not only in planning documents but above all in the real landscape. In the landscape, which is a resource conducive to economic activity and whose conservation, management, and planning can contribute to the creation of employment; the landscape is an essential component of Europe’s natural and cultural heritage and an important part of people’s quality of life. All decisions affecting spatial planning, transport, infrastructure, tourism, and recreation, as well as new initiatives in agriculture, forestry, industrial production, and mining techniques, accelerate the transformation of landscapes [6]. This process, related to the adopted climate change policy, will be particularly visible in energy regions located in all European countries [7]. Taking into account regional access to renewable energy sources and different approaches to the energy market, each country will have to implement its commitments on an individual basis and pursue policies aimed at conservation, economy, and landscape planning.

3. Energy policy in Germany
The European Union objectives for the energy sector decarbonisation are clear. Germany must fulfil its obligations under the Paris Agreement and EU climate and energy policy. Thus, the state has emphasized climate protection and innovative energy policy oriented towards energy efficiency, energy-saving, and renewable energy [8]. A policy defining the direction of the “Energiewende” has been pursued in Germany for many years now. Its assumptions include limiting climate change, limiting imports of energy carriers, stimulating innovation in technology and the “green” economy, and strengthening energy security. The objectives are to be achieved by a complete abandonment of nuclear power, the end of the fossil fuel era, economic eco-neutrality, and the development of clean technologies. The basis of the transformation policy is the use of renewable energy sources, including the development of wind energy, increased biomass energy generation, increased use of photovoltaic, increased share of other RES technologies, development of networks, and energy storage methods. In order to make the “Energiewende” legally binding, legislation has been introduced at various times to abandon nuclear energy, renewable energy, emissions permit trading, pollution tax, cogeneration, biomass heating as well as market incentives (MAP), and also accelerated grid expansion, energy savings, and financial support systems, or eco-design (ErP), etc. [9].

Despite a set of policy measures defining the direction of the energy transition, Germany has not achieved its 2020 climate target of a 40% reduction in greenhouse gas emissions compared to 1990. It is due, among other things, to the fact that Germany is still the world leader in lignite mining. Coal is still the most important primary energy source, it is the cheapest, it is the only energy raw material available on site, it is the most advantageous for ensuring a stable supply of electricity to the grid. Continuing to burn lignite at current levels is incompatible with the EU plans. However, still in 2012-
In 2014, five new units producing energy from coal were put into operation in Germany, including three from lignite. These years also see the largest share of lignite energy: 26%. Only in 2014, in the structure of energy production, 25.8% of renewable energy sources overtook the lignite-based power generation of 25.4% [10]. The subsidisation of renewable energy has resulted in a considerable decrease in technology costs, which has facilitated the global spread of wind and solar power. Already in 2018, the share of renewable energy sources in the structure of energy production was 35.2%, with energy coming from coal amounting to 35.3% in total, including lignite: 22.5% [11].

The failure to meet the targets for reducing greenhouse gas emissions in Germany has resulted in the need to set new goals and take additional measures to adapt emissions to the country climate targets. Such an approach was presented in the Government Climate Action Plan adopted by the federal government, which was adopted in late 2016 [12]. It set out the process of achieving the approved climate targets, the main one being to achieve energy neutrality by 2050. The assumptions for greenhouse gas emissions have been made and are expected to fall by 55% by 2030 compared to 1990 levels. It has also adopted policy targets for individual sectors with the necessary development paths, monitoring, and updating. Among these, further restructuring of the energy sector is a key aspect. Based on the “Energiewende”, the further expansion of renewable energies and the gradual phasing out of electricity from fossil fuels is emphasised. This plan points out the need to develop realistic perspectives for coal regions. The Commission will also support the development of the strategies, implementation modalities, and financing conditions for those affected by structural changes. It also points to the need to cooperate with the industry to develop a research and development programme aimed at reducing emissions from industrial processes [12]. This support for coal regions is particularly important as climate policy will have a disproportionate impact on them and should be manifested in maximising the potential of individual regions and focusing on environmentally, socially, and economically sustainable activities. It is also extremely important to have a conscious policy that provides the right technological, financial, and systemic conditions for the whole process. It will enable regions to move away from coal in an economically viable and socially equitable way and provide general principles, strategies, and guidelines that will allow targeted development of the landscape and specific measures to protect, plan and create it.

4. Transformation of the landscape of Lower Lusatia

Lower Lusatia is a region in the eastern part of Germany, comprising the federal states of Saxony and Brandenburg. The largest city in the region is Cottbus, and the closest urban agglomerations are Dresden (in the south), Leipzig (in the west), and Berlin (in the north). The first economic boom in Lusatia, based on the development of crafts and trade, dates back to the Middle Ages. However, the region's real industrial revolution, based on lignite mining, took place during the period of industrialisation. The first mine was opened in 1844. Mines, power plants, briquetting plants, coking plants, as well as brickyards and glassworks, which processed overburden layers from coal deposits, became part of the Lusatian landscape. In a period of intense economic development, until the 1980s, Lusatia developed into the largest coal-energy region in eastern Germany. The period of rapid industrialization left behind great changes in the landscape. Exploitation resulted in the transformation of all elements of the environment, including disturbance of the soil geological stability, disruption of water relations, increase of the level of acidity of ground and surface waters, destruction of the soil structure, and its biological values, air pollution, etc. Over 5 thousand km² of the ground surface was completely transformed. In the 1990s, the region began to undergo a dynamic restructuring process. After a sudden and complete collapse of the mining industry, associated with the collapse of the socialist economy, there remained unexploited excavation fields, areas left without reclamation, and degraded areas in need of restoration. Within 13 years, many mines, power and processing plants have been closed and demolished. The initiated changes were aimed at transforming the degraded post-mining landscape into a human and environmentally friendly one. The aim of the region transformation was to change the profile of the economy from robbery to an economy developed on
the basis of clean technologies and renewable energy sources. The development of renewable energies on post-industrial wastelands was seen as the first positive opportunity to transform the region into a more “green” and sustainable one [13]. Reclamation and revitalization works have been initiated to create a useful, natural landscape that would change the image of the region and the quality of life of its inhabitants. As a result, Lower Lusatia has become the largest landscape construction site.

4.1. IBA Fürst-Pückler-Land - new landscapes workshop
In the face of the complexity and scale of the problems of spatial, social, and economic restructuring of the region, new, informal planning instruments were used, such as informal concepts of district development or Regional Agenda 21. Between 2000 and 2010 the transformation of the landscape was combined with the ideas and projects of the IBA Fürst-Pückler-Land International Building Exhibition. The IBA in Lusatia focused primarily on the problems of landscape design. The programme covered the city of Cottbus and the following four districts: Oberspreewald-Lausitz, Dahme-Spreewald, Spree-Neisse and Elbe-Elster that make up the Lausitz-Spreewald Planning Community. The critical problems undertaken within the IBA framework were the search for a new life quality for the inhabitants of urbanised areas and finding ways of the region economic activation. The programme of the exhibition included: support for restructuring processes by focusing on shaping the landscape with a new aesthetic value; preservation of the region’s heritage by combining elements of the pre-industrial and industrial cultural landscape in new landscape concepts; design of new urban, architectural and artistic accents in the landscape, which would provide an impulse for the development, protection and formation of urbanised and natural areas; development of a tourist product in the form of a landscape undergoing transformation, made available to visitors under the slogan “Mine landscape as an adventure”. The large-scale reclamation and revitalisation of post-mining areas were to lead to the construction of a new landscape identity, making the region exciting and innovative. The former coal-energy district was to be transformed into a region where state-of-the-art technologies would be applied, new production, service, leisure and tourist facilities would be developed, new solutions in the fields of science, architecture, urban planning, art and landscape shaping would be used [14]. The various forms of obtaining renewable energy sources were to become the driving force of the region’s development, and new anthropogenic lakes emphasising the attractiveness and diversity of the landscape were to enable its tourist use [15]. The projects carried out as part of the exhibition have shown that landscape can become a field of creative search, provoking thinking, and acting. The experience of the International Building Exhibition influenced the formation of the transformation model of the post-industrial landscape and also triggered a discussion on the essence of 21st century landscapes.

4.2. Contemporary transformation of the Lower Lusatia landscape
Ten years after the conclusion of the International Building Exhibition, the landscape of Lower Lusatia is still in the process of transformation and identity search. The ongoing landscape restoration is centred around concepts that are derived from the IBA period. The emerging landscape is a combination of different, complementary elements. The first thing that characterizes it is the largest anthropogenic lake district in Germany, stretching over an area of 3,000 km² - attractive for residents and tourists, with infrastructure suitable for sailors, cyclists, pedestrians, offering the opportunity to practice sports, participate in cultural events and spend free time in contact with nature. Many of the previous excavations have already fully adapted to the new functions, others are still being filled in, others - already filled - are still not fully adapted to use. In most cases, the redesigned landscape shows the artificiality and the effort that man makes to complete the process of change. It manifests itself in overly geometric shores of water bodies; vegetation that does not want to adapt to new conditions; large areas of degraded land that are too slowly succumbing to the processes of natural succession, and finally in emptiness and a small number of users not yet fully transformed landscape.
The second face of Lower Lusatia landscape is its post-industrial heritage - signs of the region’s past, including post-industrial objects, post-mining machinery, and natural elements transformed by anthropogenic activity. They are intertwined with details of the historical cultural landscape, which is reminiscent of the achievements of Prince Pückler. Some of the objects that were adapted for new functions have already become a permanent feature of the Lusatian landscape (F60 Lignite Transfer Bridge), while others, gradually forgotten, have remained on the margins of tourist trails (Lauchhammer Bio Towers). Respect for heritage is particularly crucial for the inhabitants of the region. For them, the elements visible in the landscape, referring to the past, give a sense of security, strengthen their identity, strengthen the strong emotional bonds of the place. Both the transformation of the elements of the degraded natural environment and giving them tourist values, as well as the revival of post-industrial objects and complexes, become an expression of the search for places and symbols of landscape identity important in the creation and strengthening of genius loci [16].

The third face of the Lusatian landscape is related to the acquisition of renewable energy sources, climate change, and energy policy. This scenario is attractive not only because of the possibility of changing the image of the region, but also because of the existing network connections, available infrastructure, and qualified staff. It involves the establishment of wind farms in areas of former lignite mines, photovoltaic parks on post-mining wastelands, the cultivation of bioenergy plants in degraded areas, and the use of rising mine waters as a source of the geothermal energy used to produce heat or electricity. These activities have intensified, especially in the last decade due to government subsidies, strong public support, and appropriate legislation. The most significant incentive for the development of renewable energy was the Renewable Energy Act (EEG) and related support programmes at the federal and state levels [17]. Wind power has the highest position among renewable energy sources in Lusatia. Large wind farms towering over tree crowns, water reservoirs, or urban buildings, located near existing parks, recreational areas, near bicycle paths, and renovated spaces, have become a prominent sign in the landscape. (Düben-Süd/Lausitz-Spreewald, Chransdorf/Aldöbern, Großräschen; Klettwitz/Schipkau, etc.) [13]. The second place is solar energy, which emphasises the location in the region of large photovoltaic farms visible in the landscape (Solar Farm/Schipkau, Großräschen, Senftenberg, etc.). The third is environmentally friendly and sustainable, the use of biomass and the cultivation of energy crops, which extend over large areas, affecting the perception of the landscape. Projects related to these sources are gaining more and more support from the local community, and the nuisance involved is considered relatively moderate and is gradually being accepted. Many initiatives to implement renewable energy are carried out at the local level. They foster the cultural transformation of the local community, trigger its creativity, change its way of thinking, stimulate economic development. Alongside fewer and fewer chimneys and cooling towers, windmills, photovoltaic panels, and vast areas of energy crops have gradually become characteristic features of the coal basin landscape. Their ubiquity is a sign of the times, but also an expression of the energy and climate policy. These elements participate in building a new image of the region as an energy area producing “green” energy.

When lignite mining ceases, Lower Lusatia will remain a land of 50,000 ha of forest and more than 140 lakes of about 26,000 ha [18]. Their combination with industrial heritage, tourism development strategy, zero-carbon economy, and socio-economic sustainability will determine the originality of the region [19]. Such an image of Lusatia launched at the International Building Exhibition and is gradually being implemented and increasingly apparent in the landscape, is one face of the region. The second image is due to things hidden under the ground. Lower Lusatia has 11.8 billion tonnes of geological lignite reserves, of which 3.3 billion tonnes are still commercially exploited. 94% of lignite production is used to produce electricity and heat. Currently, there are four open cast mines in the region: Welzow-Süd, Nochten, Jänschwalde, and Reichwalde, two of which are located in the Brandenburg region and two in Saxony. These mines power three power plants, Jänschwalde, Schwarze Pumpe, and Boxberg. Among them, the Jänschwalde power plant is on the list of TOP-5, the
largest CO2 emitters in the European Union [20]. Their fate is not clear. Energy companies in Germany are in the hands of private capital and therefore make decisions based on economic considerations. The Jänschwalde Lignite Mine will be exhausted as early as 2023, but in other mines, the coal seams are far from exhausted. Decisions on plans to expand them are cancelled or restricted (Jänschwalde Nord, Nochten II, Welzow II). However, in some cases, they are still being considered (expansion of the Welzow-Süd mine). [21]. Such an approach shows a contradiction between potential lignite mining plans and the current climate goals [22].

The regulatory initiatives to reduce lignite emissions proposed at the national and regional levels have an impact on how to manage structural change and promote economic transformation. In its final report of January 2019, the Commission for Growth, Structural Change, and Employment (KWSB), established in 2018, called for a gradual phasing out of coal by 2022, and by 2038, coal mining is to be completely stopped [23]. The total abandonment of coal entails further structural changes in Lower Lusatia [24]. The tourism industry developed in the region, although essential and constituting a significant share of the region’s economy, may not be sufficient to sustain economic development, and renewable energy sources may not ensure its energy security. Currently, the lignite industry provides employment for a significant number of the region’s inhabitants. The fear of losing one’s job causes the residents employed in the industry to collect signatures for the development of opencast mines. On the other hand, the opening of new open-pit areas is associated with further resettlement. This is causing protests from those who have started to tie their future to the tourism sector. The continuation of mining is also a further degradation of the environment, which has aroused protests of regional and national environmental organizations, such as Greenpeace or Friends of the Earth [25]. At the same time, the “Energiewende” being carried out in Germany, is directing residents’ attention towards the search for new opportunities, creative solutions, and innovative technologies [26]. The involvement of the region's inhabitants in the process of defining a new vision of the future, creating healthy, safe, and stable living conditions and new jobs based on the opportunities offered by “green energy” is increasingly evident [27]. The individual experience of the transformation through small renewable energy projects, such as domestic biogas power plants, experimental windmills, solar panels on roofs, is a sign of a change in the way of thinking of the region’s inhabitants and the first step in adapting to the new reality without coal [26]. Social trends, corporate social responsibility initiatives, and appropriately selected regulatory tools complement each other and allow for rapid change and adaptation of the landscape to the new challenges of civilization [1]. And though it is a landscape full of contradictions, it reflects the direction of change that modern climate and energy policy gives it.

5. Results and discussions
The closure of a vast lignite basin, the development of concepts for the future of the region, and the conversion of the area into a sustainable direction are priorities for the transformation of Lower Lusatia. This transformation brings with it opportunities and threats to the landscape. Its strength lies in the opportunities it offers for shaping a sustainable landscape based on the achievement of the adopted energy targets. Strategic management towards climate protection and adaptation to change emphasises the acquisition of renewable energy sources and strengthening energy security. It provides an opportunity for innovation and creativity and can bring significant social and environmental benefits. However, economic priorities that often overshadow environmental objectives can be a threat. The result of the inconsistent development of the region’s energy policy may result in renewed environmental degradation, social regress, and the loss of the benefits that Lusatia has gained from restructuring. The withdrawal from coal can take much longer than expected. These are the years when the landscape will change. Gradually closed mines require extensive reclamation work and the development of new concepts and techniques for shaping and conserving the landscape so that in the future, the land is safe and reusable for agriculture, forestry, tourism and the economy. The key challenges in shaping a new landscape identity include striving to balance the development, change
the image, and improve the living conditions of the residents. Policies should give clear guidance to energy regions and define structural and systemic ways to support them. Clear guidelines can enable people to participate more fully in the life of the region and engage in the transformation process. However, this will not be possible without the support of national and regional authorities. Adequate communication and transparent provision of information on the benefits and potential losses of the measures taken is essential. The revival of a region with a demographic crisis requires the development of infrastructure, transport systems, media, training facilities, industrial modernisation, a closed economy, clean mobility, and green and blue infrastructure. It is essential to increase the sense of control and effectiveness of actions taken at the local level.

6. Conclusions
Creating a harmonious landscape in Lower Lusatia is a time-consuming and costly task. Still, it can bring a lot of satisfaction and tangible benefits to all its users: natural, cultural, social, and economical. By linking a bold vision based on natural values, cultural heritage, tourism potential, and energy transformation with the pragmatic side of the renewal process - with appropriate legal, financial, and organizational methods and instruments - there is a chance for the effectiveness of the actions taken. They will be measured by the new quality of the landscape. And it is on this quality and image based on the green energy that Lower Lusatia is building its new economic and social future and its new landscape identity.

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