

The coal and the current stage of energy transition in Poland – is there a feasible scenario?

A Master's Thesis submitted for the degree of "Master of Science"

> supervised by Dipl.-Ing. Dr. techn. Mario Ortner

Marta Wawrzyniak, BA

12009674

Vienna, 15.06.2022



Affidavit

I, MARTA WAWRZYNIAK, BA, hereby declare

- 1. that I am the sole author of the present Master's Thesis, "THE COAL AND THE CURRENT STAGE OF ENERGY TRANSITION IN POLAND IS THERE A FEASIBLE SCENARIO?", 72 pages, bound, and that I have not used any source or tool other than those referenced or any other illicit aid or tool, and
- 2. that I have not prior to this date submitted the topic of this Master's Thesis or parts of it in any form for assessment as an examination paper, either in Austria or abroad.

Vienna, 15.06.2022

Signature

Abstract

By adopting the EU Green Deal strategy, the European Union decided to fulfill its obligations under the Paris Agreement and fully contribute to the reduction of CO2 emissions, committing itself to closing the coal sector in all 27 Member States by 2030. One country in the community, however, decided not to fulfill its portion and openly opposed Brussels' plans concerning sudden and fundamental changes in its energy system. Poland, which is the largest remaining coal producer in Europe, decided to act on its own terms and chose 2049, not 2030, as the moment to close all coal mines on its territory, giving a number of reasons, heavily neglected by the general international public. The need for comprehensive reforms as well as demanding full financing of the energy transition process has opened a discussion on the real reasons why coal in Poland is such a valuable element that it is worth fighting for its survival. This thesis aims to discuss the role that coal plays in the core formation of the Polish society, to better understand the reasons behind the intensified opposition, by discussing coal's position in economic, social, and political constrains to the phasing-out process. It will also look at the current stage of the renewable energies in Poland as an answer and substitute to the conventional energy sources. All the activities will be conducted to finally answer the question whether there is a possibility of the feasible scenario to the coal sector which will find the balanced ground between the Polish mining and growing effects of climate change.

Table of contents

Abstractii				
Table of contentsiii				
List of abbreviationsin				
Acknowledgements				
1. Introduction & State of Art – Poland at the energy crossroads				
1.1 Coal - environmental bone of contention				
1.2 Poland – the "problematic" coal defender				
1.3 Motivation behind the Thesis' title and research questions				
1.5 Methodology				
1.4 State of Art – Post-Communist Poland, the EU and energy transition				
2. Coal industry in Poland: the SOCIO-economic issue10				
2.1 The historical importance of coal in Poland – the communist stigma				
2.2 The current state of coal production and consumption in Poland				
2.3 Coal as a socio-cultural element19				
2.4 Coal as a political tool23				
3. Energy transition in Poland - A bumpy way to sustainability2				
 3.1 The current state of renewable energies in Poland				
3.1.3 Hydropower				
3.1.4 Bio components, biofuels				
3.1.6 Biogas				
3.2 Poland vs EU – how to meet emission standards faster?				
4. Is there a feasible scenario for the coal sector in Poland?52				
4.1 RES portfolio – how the JTF can support and navigate the Polish coal phase out?				
5. Conclusion				
5.1 Summary of findings57				
Bibliography59				
List of tables				

List of abbreviations

CO2	Carbon dioxide
ETS	Emissions Trading System
EU	European Union
EU-27	27 Members of the European Union
EU MS	European Union's Member States
GHG	Greenhouse Gas
GJ	Gigajoule
GW	Gigawatt
IEA	International Energy Agency
JTM	Just Transition Mechanism
JTF	Just Transition Fund
kW	Kilowatt
LPG	Liquefied Petroleum Gas
N2O	Nitrous oxide
NECP	National Energy and Climate Plan
NOx	Nitrogen oxide
Mtoe	Mega tons of oil equivalent
MW	Megawatts
PIS	Prawo i Sprawiedliwość (Law and Justice party)
RES	Renewable Energy Systems
SO2	Sulphur dioxide
TFEC	Total Final Energy Consumption
TJTP	Territorial Just Transition Plan
TWh	Terawatt hour
VAT	Value Added Tax
UCOME	Used Cooking Oil Methyl Esters

Acknowledgements

Creating these Master's Thesis was not a simple process for several reasons. After completing International Relations at the undergraduate level, I decided to take on the entirely new challenge of starting a program where half would be focused on technical and scientific elements. A rigorous workload connected with numerous internships and traineeships as well as personal hardships did not make the work easy. For this reason, it seems even more important to thank those who have contributed to the creation of a Master Thesis that I can be proud of.

Firstly, I would like to thank my parents, Jolanta and Rafał Wawrzyniak, for their extraordinary support and faith in my abilities, especially when I didn't see any reason to continue fighting.

Secondly, I would like to thank my little 14th ETIA family, but especially my friends, Sabrina Kaschowitz, Yasmine El Kurdi and Iris Zerlauth, for unforgettable moments, support in moments of doubt and laughter, sometimes through tears.

Thirdly, I would like to thank my boyfriend, György Paller, for his indescribable support, love, and patience. Tons of patience.

Fourthly, I would like to express my gratitude to all academic staff of the Diplomatic Academy of Vienna and the Vienna University of Technology, to my supervisor Dipl.-Ing. Dr. tech Mario Ortner, for their guidance, encouragement to work and faith in my abilities.

Finally, I would like to dedicate these Master Thesis to the country without which they would not have been written - Poland, my motherland. I hope that through my work I will be able to effectively contribute to making it a better place, for everyone.

1. Introduction & State of Art – Poland at the energy crossroads

Although it would seem that 'greenifying' almost all elements of life is the preferred and essential aspect at this point of human development, there are still many examples that contradict this trend. There is a lot that can be said about renewable energy. Still, one thing is a definite fact: choosing it over rejecting fossil fuels is an effective way to stop or minimise the effects of global warming. Climate change has become an almost inevitable part of the international political agenda in domestic policies. As far as Europe is concerned, one prominent organisation is leading the way.

The European Union (EU) has taken on the role of pioneering the greenifying of the continent, or at least the economic sectors directly affected, i.e., those located in the 27 individual Member States. Although their membership of this Union does not negate their basic political principle and right to sovereignty, it makes them dependent on joint decisions adopted mainly in directives, at least at the economic and political level. One such binding project is the European Green Deal, which has its roots in the European Commission's 6 Priorities for the 2019 – 2024 period. The plan's central premise is the fight against the effects of global warming and, thus, the degradation of the European environment. At the same time, the Green Deal is supposed to modernise Europe and turn it into a resource-efficient region, characterised by a competitive economy and decoupling economic growth from the stocks consumed (European Commission, n.d.a). The central assumption is to achieve zero net greenhouse gas emissions by 2050 (European Commission, n.d.). In addition, there is to be a levelling of power, i.e., overcoming economic inequalities between different segments of the EU. The Green Deal's secondary objective is to help address the crisis caused by the COVID-19 pandemic. The project is intended to be entirely financed through EU funds, adding up, formally, to one-third of the 1.8 trillion EUR - the amount earmarked for investment under the NextGenerationEU programme (European Commission, n.d.). Resources cover the remaining costs from the EU's seven-year budget plan.

Although the EU Green Deal is intended to be a progressive project and in line with the overall objectives, it was not a 'man-on-the-moon moment' for everyone, as European Commission President Ursula von der Leyen described. While 26 Member States accepted the Community's pro-environmental arrangements and decisions, one member

decided to lay its cards on the table and express strong opposition. Poland outright rejected the 'zero emissions' idea, refusing to subscribe to the general promise of zero net greenhouse gas emissions by 2050. The European political world trembled; public opinion, unsurprisingly, described Poland as 'Europe's naughty child'. Despite Polish objections, the discussion focused on putting the guilt on only one side, and the EU Green Deal pushed forward.

Somewhere in all the chaos of criticism, the critical practice of looking at the situation through the eyes of both sides has been forgotten. The Polish perception of the EU Green Deal was immediately only criticised, and after a short time, the discussion fell silent. Therefore, it is worth asking questions about the Polish government's reasoning behind such a decision and examining the actual Polish attitude towards the energy transition, sustainable development, and the environment in general.

1.1 Coal - environmental bone of contention

After 1945, Europe faced a landscape of ideological and economic division. By establishing a border roughly through the middle of the today's Federal Republic of Germany, the then most prominent victorious leaders determined the fate of millions of people and, as it were, of the environment. The Soviet Union and its satellite states were highly industrialised. The role of physical labour in shaping a strong and prosperous state was almost a cult propaganda item. After the fall of the Berlin Wall in 1989 and the gradual abandonment by individual states of the yoke of communism, almost as if in a domino effect, Europe was faced with the challenge of achieving unity and stability between two regions differing in nearly every way, including their economic development. While pro-environmental ideas began to dominate in the West, the East relied on what had driven its economy for decades, namely, heavy industry. At its heart was an inconspicuous black lump, whose elimination less than two decades later would become the centrepiece of a plan to achieve an EU Green Deal. This element in question is coal.

Coal is a common fossil fuel worldwide, relatively cheap to produce and easy to convert into energy (U.S. Energy Information Administration (EIA), n.d.). However, its combustion contributes to significant environmental pollution, and the types of impact are numerous. When power plants burn coal, significant amounts of various emissions enter the air, which includes chemical compounds such as sulphur dioxide (SO2), nitrogen oxides (NOx), particulates, carbon dioxide (CO2), mercury and other heavy metals, as well as fly and bottom ash. All these emissions contribute to increased global warming. The acid rain and smog caused by these compounds contribute to the degradation of the natural environment in all its aspects and cause numerous respiratory diseases, thus posing a threat to human life. In response to the dangers of burning coal, the industry has made efforts to adjust production and thus reduce emissions of individual impurities. After extraction, modern cleaning methods have been introduced, or coal with reduced sulphur content has been invented (U.S. Energy Information Administration (EIA), n.d.). Scrubbers, the specialised tools used for coal's desulphurisation, clean the coal of this chemical compound before it has time to leave its smokestacks and the steady advances in technology have also made it possible to reduce the amount of mercury and other heavy metals in coal, and numerous projects are now underway to rid coal of excessive CO2 (U.S. Energy Information Administration (EIA), n.d.). A developed global recycling system is also making a significant contribution to reducing the environmental impact of coal, mainly through converting former coal mine sites into public amenities such as airports and golf courses (U.S. Energy Information Administration (EIA), n.d.). The waste products collected by scrubbers can be used to produce items such as cement or synthetic gypsum (U.S. Energy Information Administration (EIA), n.d.). In theory, the world is moving towards a better future, with coal and its destructive elements increasingly under control.

So, the question may be asked: where is the problem? After all, the world has understood that coal is not the future fuel. Its notorious burning and reliance on it will sooner or later have to be negated for environmental protection and to combat climate change. This view, however, is not consistent and is not shared by everyone, particularly in Europe, where a regional 'carbon divide' is evident. Some positive trends can be noted, however. Compared to 2020, the production and consumption of coal in the EU increased, related to the low prices of this raw material in 2019-2020. The main reason for this phenomenon was the economic crisis caused by the COVID-19 pandemic and the demand to become independent from gas supplies after the aggression of the Russian Federation against Ukraine in 2022.

Interestingly, however, and what can be considered a positive trend, the amount of coal produced and burned is still lower in the EU today than in the years before the price drop, i.e., in the pre-2018 era. In 2018, hard coal and lignite consumption decreased by 27% and 25.5% (EUROSTAT, 2022). However, the current political turmoil in Europe and the actual impact of the COVID-19 pandemic will only become apparent in terms of coal production and consumption in a few years. For now, however, the trend appears to be

positive. In 2021, 57 million tons of hard coal were produced within the EU, 79% less than in 1990 (EUROSTAT, 2022). Similarly, the problematic coal consumption significantly reduced overall, standing at 160 million tons in 2021, 59% less than in 1990 (EUROSTAT, 2022).



Production of hard coal in the EU, 1990 - 2021

Figure 1. Production of hard coal in the EU (EUROSTAT, 2022)

When it comes to brown coal, its consumption significantly accelerated in 2019. The consumption of that resource within the EU in 2021 reached 277 million tons, which is 60% less than in 1990 (EUROSTAT, 2022), with a similar situation in production.



Inland consumption of brown coal by EU Member States (1990-2021, million tonnes)

Figure 2. Inland consumption of brown coal by the EU Member States (EUROSTAT, 2022)

Regarding coal's export and import with the EU, due to the ongoing demand and decreased production, the importance of hard coal has accelerated from 2019 onwards, causing a significant import dependency, consistently above 50% (EUROSTAT, 2022). Among the most important suppliers of hard coal to the EU is the Russian Federation – it is also the only hard coal importer whose share in 2021 increased, accounting in 2020 for 56% of hard coal imports, followed by the United States (17%) and Australia (15%) respectively (EUROSTAT, 2022).

Despite decisive achievements in reducing coal production and coal imports, the EU faces problems related to this raw material. There are still more than 200 active coal plants in the Member States, despite the annual investments of billions of euros in creating new ways of obtaining energy, mainly from renewable sources (ClientEarth Communications, 2019). However, the problem of coal as a significant source of energy is not uniform across the EU Member States. With the entry into force of the German 2030 coal exit plan, only three Member States remain in the sphere of energy produced mainly from coal. These countries are Poland, the Czech Republic and Bulgaria, which will alone be responsible for generating more than 95% of their electricity from coal in

2030 (Moore, 2021). In 2021, two years after the EU countries submitted their National Energy & Climate Plans, the EU reduced electricity generation from coal by 58%, which is expected to lead to a final stop of 89-152MT of CO2 emissions in 2030 (Moore, 2021). Compared to this success, between 2015 and 2030, combined generation from coal is projected to fall by 42% in Poland, the Czech Republic and Bulgaria. In the rest of the EU-27, the decrease is as much as 99% (Moore, 2021). Although everything seems to be going in the right direction, the progress is not evenly distributed everywhere, which is at odds with the equal development of the EU as a cohesive community of states.

1.2 Poland – the "problematic" coal defender

As one of the signatories to the 2015 Paris Agreement, the EU has committed as a community to minimalise greenhouse gas emissions by 40% by 2030 and by 80% by 2050 (Widuto, 2019, p. 1). To achieve this goal, many changes will need to be made, both economic and social, which will hopefully lead to greater or lesser structural changes within all Member States. Ending coal mining will mean an increase in unemployment, the destruction of diversification of regions strongly linked to heavy industry, the modernisation of energy infrastructure or the reclamation of land used for mining and the rebuilding of the natural habitats previously found there. The economic development and the size of the national budget in the EU-27 are not uniform, which leads to an intensification of energy transition problems in some countries, especially those that used to be part of the Eastern Bloc, which is heavily dependent on the economic policies of the Soviet Union between 1945 and 1991.

In 2019, EU leaders decided to implement changes which would lead to climate neutrality by 2050; Poland was the only country that raised a vital objection (Arak, 2019). For this one country, it was decided to allow the "opt-out" option within the plan and assumptions of the EU Green Deal, which in practice means that this country is not obliged to comply with the terms of the general agreement and, consequently, its climate-neutrality does not have to be achieved by 2050. It was a movement necessary to work together to combat the effects of global warming and the harmful effects of coal production and combustion in Europe. This situation showed that although the EU is a community of countries, its members are not equal. The approach to specific aspects and the possibilities related to implementing individual concepts is not possible everywhere at the same pace, with the same results.

In its defence, Poland invoked many reasons, demanding increased financing of projects leading to energy transition to achieve the intended emission targets. The opposition's reasoning was mainly justified by the risk of skyrocketing unemployment and the breakdown in the cultural identity of coal-based regions, with Silesia at the centre of discussion. Although the arguments might seem straightforward and well justified, they have faced massive criticism from most EU countries' political sides and public opinion. In a short time, Poland became the "naughty child of Europe" - a rebel state full of opposition to everything the EU proposes.

Despite opposition from Poland, the EU decided to continue the plan related to the gradual implementation of the EU Green Deal, reducing emissions by 40% by 2030 and by 80% by 2050. Poland's position was somewhat set aside, and its adopted opt-out method was accepted as a generally acceptable solution. The idea of equal opportunities and cooperation as a cohesive community, in a sense, ceased to exist, not only in the political but also in academic debate.

1.3 Motivation behind the Thesis' title and research questions

The primary purpose of this Master's Thesis is to analyse the current state of the coal sector and the energy transition in Poland. Although it still relies on coal as its primary source of energy, Poland is a country that has nevertheless made steps towards introducing renewable green alternatives. Considering the last decision of the Polish government regarding the planned closure of the last coal mine in 2049, the analysis of the current state of renewable energy sources in Poland seems to be justified to examine not only the possibilities but also the potential of this country to end coal production once and for all and focus on renewable energy sources. This primary purpose is entirely determined in the following research question: "what is the current state of Poland regarding the energy transition (from coal to renewable energies)?".

The second part of this Master Thesis investigates whether a faster and thus more feasible scenario for the coal sector in Poland is possible. For this purpose, Polish political, economic, and social realities related to the production and consumption of coal will be examined. This will theoretically undermine the opinion that by refusing to accept the assumptions of the EU Green Deal, Poland did not only act to the detriment of the EU but conditioned its decisions on undeniable issues that are not easy to overcome. The research question related to this part of the analysis, which is also a leading one in this Master's Thesis, states as follows: "Is there a feasible scenario for the coal industry which will push Poland towards full energy transition achieved earlier than in 2049?".

1.5 Methodology

Most of this thesis is based on information derived from the internet-based sources, included academic papers, national policy papers, official publications of the EU, as well as national and international publications coming from various stakeholders, including media. The lack or scarce presence of the updated academic sources connected with the topic as well as lack of the accessible and reliable data in some cases had a significant, yet not key impact on the way in which the research was conducted. It is important to note that this thesis is also based on the experiences and opinions of the author. Therefore, this thesis at bringing together existing sources coming both from academia and public sources as well as opinions of author in order to examine whether there is a possible and feasible scenario for Polish coal sector based on the current stage of the energy transition and implementation of renewable energy sources in the economy of the Polish state.

1.4 State of Art – Post-Communist Poland, the EU and energy transition

The literature on the topic of energy transition in Poland, the socio-economic and political factors connected with the coal production, as well as Polish lack of compliance with the EU Green Deal standards are scarce and, considering recent developments mostly outdated, proving the need for further research in this area. However, experts in these fields have compiled their findings into various articles, exposing the opportunities and challenges connected to energy transition in post-communist countries, including those currently considered the EU Member States.

In his article titled "Modernizing our economies through the clean energy transition", Maroš Šefčovič illustrated renewable energies as a source of economic boost for postcommunist countries. However, he based his conviction on the need to implement a just transition, especially in the context of the employment problem that appears along with the elimination of subsequent coal mines. He gave Poland as an example, where by 2018 over 99,000 people were employed in the coal industry - directly in the extraction of raw material as well as in the administrative structures of mines or national coal companies (Šefčovič, 2018, p. 7). Although Šefčovič's article was written in 2018, i.e., before the introduction of the EU Green Deal and The Just Transition Mechanism following it, the article serves as a basis for argumentation to highlight the social problem of the lack of acceptance of the rapid and decisive elimination of coal from the national energy economy, which remains an issue nowadays as well.

Morningstar, Simonyi, Khakova, and Markina in their article titled "European Energy Diversification: How Alternative Sources, Routes and Clean Technologies Can Bolster Energy Security and Decarbonization" focus on the general opportunities stemming from energy transition regarding not only decarbonization and general fight over climate change, but also energy security. They stated, that while natural gas can be considered as at least a transitional substitute for coal-based energy production, the negative attitudes present, especially, within post-communist societies can pose a serious challenge for the energy transition within Europe. The authors focus on the overwhelming role of inequality in the access to electricity and still present energy disparities, which are often more concerning for citizens than environmental harm caused by fossil fuels and their consumption (Morningstar, Simonyi, Khakova and Markina, 2020, p. 3) Based on that, the article functions as a base for the socio-economic debate about the elimination of the coal-based energy industry and the transition towards renewable sources.

In their brief paper "Climate & Energy Snapshot: Poland: The Political Economy of the Low-Carbon Transition", Julian Schwartzkopff and Sabrina Schulz presented a detailed assessment of the political reasoning behind the strong defence of the coal-based economy in Poland, especially considering EU's attempts to increase the presence of renewable energy sources. They pointed out the negative approach towards energy transition presented by the leading Law and Justice (Prawo i Sprawiedliwość, PiS) party and the negation of climate change-related issues in their political agenda (Schwartzkopff and Schulz, 2017, p. 2). The authors discuss the unsustainability of the Polish coal sector and yet still very limited opportunities for the implementation of low-carbon alternatives (Schwartzkopff and Schulz, 2017, p. 2). This paper, in an open and straightforward way, presents the broad political reasoning behind the rejection of EU Green Deal regulations by the current government of Poland.

Finally, in their article titled "The political economy of coal in Poland: Drivers and barriers for a shift away from fossil fuels" Hanna Brauers and Pao-Yu Oei brilliantly present an overview of the resistance to drastic cuts in coal production and consumption in Poland, focussing not only on government and civil society but also on unions and coal corporations. In their argumentation, they focussed on the need for political feasibility and detailed targeting in the creation of EU green policies to make them as effective as possible, minimising the costs accompanying their implementation within affected Member States (Brauers and Oei, 2020, p. 1). This paper works as a base of the whole research, as its focus is purely related to the argumentation line of this Thesis.

It is notable to mention, that all sources used in this Thesis are strongly valued and contribute significantly to the final conclusions. Nevertheless, the majority of proposed solutions are based on the personal experiences of an author and are only inspired by already existing literature.

2. Coal industry in Poland: the SOCIO-economic issue

When discussing the issue of the elimination of the coal-based economy, fiscal arguments are usually the most frequently cited. In the case of Poland, however, this is not the only factor acting against the imminent energy transition. Other factors must be considered to fully understand the situation inside the country and the opposition, especially social ones, against the introduction of changes in line with the assumptions of the EU Green Deal. The analysis of these elements as well as the current state of the coal economy will allow for a thorough examination and understanding of the problem of energy transition. Investigating the current state of the energy transition in Poland will illustrate the scale of the problem and the progress already made towards transforming Poland into a country running not on coal but on renewable energy sources.

2.1 The historical importance of coal in Poland – the communist stigma

Coal mining is almost as old as Poland is, and from nearly the very beginning, it played a specific role in shaping the state and developing its economy. It was used as an energy source since the Middle Ages but, back then, only on a small scale due to the iniquitousness of wood (Szpor and Ziółkowska, 2018, p.2). With the development of industrialisation, coal quickly became more efficient and a more modern energy source. Its miraculous properties were discovered primarily in the Lower and Upper Silesia regions in the 18th century (Szpor and Ziółkowska, 2018, p.2). A century later, coal became the main driving force behind the development of these regions for these regions. The high storage levels of coal attracted new investors, with the annual coal production in the 19th century reaching 1.5 million tons (Szpor and Ziółkowska, 2018, p.2). With the development of transportation, mainly railroads, and the growing demand for electrification not only in industry but also among residential areas, the role of coal in Poland became more than significant.

Due to the coal industry's development, the modernisation of many towns and villages in Lower and Upper Silesia enormously increased in its speed. Therefore, structural changes related to architectural, economic, and social factors became open. With the development of social rights, worker's unions, and movements in general, the rapid progress related to the coal industry started to function not only as a regional booster but also as a national engine (Szpor and Ziółkowska, 2018, p.2). A strong ethos of work corresponding to the nation's strength became part of the culture and national identity, creating the image of coal as a founding element for Polish prosperity (Szpor and Ziółkowska, 2018, p.2).

The intensification of the role of this raw material in the context of shaping not only economic prosperity but also the social identity of the whole country intensified; however, with the end of World War II (1939-1945) and the changes in the political system, not only inside the country, but also in the entire region. The communist economy that characterised Poland from 1945-1989 was mainly focused on different kinds of industry, with the extraction of fossil fuels at its very centre. Coal, as the primary natural resource, has become the leading element driving the economy in Poland, and its extraction took on an almost cult form in communist pro-workers propaganda. The regions characterised by significant resources of hard coal soon became areas strongly promoted by the

government of the Polish People's Republic as an example of a territory strongly contributing to the country's wealth and development. Growing focus on coal strengthened Polish position on the international market, giving it a stable position within the top global producers in the world from 1900 to 1984 and putting it on an equal level with countries such as USSR, United Kingdom, the United States or Germany (Szpor and Ziółkowska, 2018, p.2). The feeling of importance and the stable position within industrialised international power gave an extreme confidence booster to Polish society, which across centuries had its national identity put to the test.

After the 1980s the coal sector stopped being as sustainable as before and it became obvious, that with the upcoming socio-political changes the economy and its shape will need some adjustments as well. Until the late 1970s, the coal production was growing mainly because of the concept, that the countries delivering a significant surplus of their planned production would be able to expect some extrabudgetary investments coming directly from the protective USSR's government in Moscow (Szpor and Ziółkowska, 2018, p.2). With the advent of the Gorbachev era, the approach to heavy industry and the generally accepted centralized planned economy was gradually degraded. The excessive financing of heavy industry and the lack of availability of consumer products have been mentioned so far as the main factor behind the fall of communism in Poland (Szpor and Ziółkowska, 2018, p.2). However, with the economic decline in the value of coal, the social approach did not go hand in hand. Coal remains and is, to this day, strongly associated with Polish national identity.

2.2 The current state of coal production and consumption in Poland

The changes in the coal economy came for Poland with the democratic-liberal transition after the fall of the communist regime in 1989. Along with the abandonment of central planning and the choice of the free market economy as the leading one, previously highly nationalized sectors had to undergo a thorough restructuring (Szpor and Ziółkowska, 2018, p.3). Heavy industry, and thus also the coal industry, had also fallen victim to the upcoming changes, which is also visible in the gradual resignation from excessive coal mining in the country. Importantly, however, the transformation of the coal sector was not aimed at eliminating it, but only at increasing its sustainability, i.e., changing the coal

industry into a more modernized and effective structure (Szpor and Ziółkowska, 2018, p.3).

In 2021, the electricity production in Poland was the highest in history, standing at 179.4 TWh and with a record demand of 180.3 TWh and 99.5% of electricity demand was fulfilled by domestic production (Dusiło, 2022, p. 18).



Figure 3. Balance of domestic electricity production and consumption in Poland (Dusiło, 2022, p. 18)

Coal production in Poland remains constant, and due to the ongoing conflict in Ukraine, the extraction of this raw material and the demand for its export are constantly increasing. In March 2022, Polish mines produced almost 5.5 million tons of hard coal, which is the highest monthly production level for almost 3.5 years, and about 1 million tons more at the same time in 2021 (Sawicki, 2022). Similar increases are visible in the case of coal sales. Its volume in March 2022 reached the level of 5 million 461.5 thousand tons. This is the highest level of coal exports in the history of modern Poland, i.e., since 1989 (Sawicki, 2022). The last record was set in October 2020, when over 5.5 million tons of hard coal were mined in one month (Sawicki, 2022). Considering the cross-border electricity exchange, the electricity exports in 2021 were equal to 14.21 TWh, which is the highest result since 2016. This was achieved mainly due to quite a low level of pricing of coal-based energy production on the wholesale electricity market (Dusiło, 2022, p. 19).

The leading consumer of steam coal in Poland is the electricity and heat production industry, which accounts for 71.1% of total domestic consumption in 2020, presenting

similar results across the years (Dusiło, 2022, p. 45). Households and agriculture witnessed an increase in electricity share, while the highest decline in coal-based energy usage is observed in transport (Dusiło, 2022, p. 45), where the coal is quicker replaced by the renewable energy sources.



Own elaboration based on GUS data.

Figure 4. Structure of steam coal consumption in Poland in 2020 (Dusiło, 2022, p. 45)

Based on the most up-to-date and available report on the consumption of fuels and energy carriers, in 2020 hard coal consumption amounted to 62.4 million tons (Główny Urząd Statystyczny (GUS), Departament Przedsiębiorstw, 2021). The main consumers include the energy sector (59.2%), industry and construction (23.7%) and households (13.9%), which base their energy consumption in the coal context mainly on heating buildings during the cold season (Główny Urząd Statystyczny (GUS), Departament Przedsiębiorstw, 2021).



Figure 5. Consumption of hard coal in 2020 with voivodeship division (Główny Urząd Statystyczny (GUS) Departament Przedsiębiorstw, 2021)

From 2010 to 2020, the coal demand in Poland significantly decreased from 60 Mtoe to 45 Mtoe, with the visible drop for both hard coal and lignite (from 85 Mt to 64 Mt and from 57 Mt to 46 Mt respectively) (International Energy Agency (IEA), 2022, p. 124). The reduction resulted mostly from the decreased need for thermal coal and lignite coming from both coal-fired electricity and heat generation plants. Most of Poland's coal demand, however, still comes, not from the industry directly, but from the residential heating, which accounted in 2020 for 76% of total coal and 99% of total lignite demand (International Energy Agency (IEA), 2022, p. 124). Notably, the main source of energy for the largest district heating network in Poland is located in coal-fired co-generation and heating plants, with 40% of households connected to district heating in 2019, with coal covering 76% of that energy demand (International Energy Agency (IEA), 2022, p. 124).



Figure 6. Coal demand by sector in Poland, 2000 - 2020 (International Energy Agency (IEA), 2022, p. 124).

In 2020, 7% of total coal demand came straight from residential buildings, with 0.7% coming from services sector buildings (International Energy Agency (IEA), 2022, p. 124). This clearly shows that although the coal sector, with its declining efficiency, may be discouraging to industrial or business actors and even national authorities, socially coal still plays an extremely important role and abandoning its consumption and production is a concern for many Polish citizens, despite the growing pro-environmental campaigns. Notably, the coal covered 49% of the residential heating demand in 2019, which marks not only the highest share among IEA member states, but also is a result standing way higher than the IEA average, accounting for 5% (International Energy Agency (IEA), 2022, p. 124). Importantly, the use of coal is much more popular in the rural than urban areas, as the modernization of heating services is conducted slower and supported with much more minimalized financial resources than in the residential areas of urbanized agglomerations. In 2020, 67% of all rural households in Poland used coal as a main source of heating, comparing to 19% of urban ones (International Energy Agency (IEA), 2022, p. 124).

The coal sector is not, however, only protected by a significant part of the Polish society. A lack of willingness to reduce the mining can be seen especially in the coal sector. Polska Grupa Górnicza, the largest company dealing in coal mining in Poland, announced an increase in the extraction of raw materials in 2023, which will lead to an annual extraction of about 23 million tons (Sawicki, 2022). Other Polish Coal Companies also do not intend to reduce the pace and announce increases in the extraction of this raw material relative to previously intended plans. It is difficult to look for environmentally conscious plans or change the production style to be more sustainable. Tauron

Wydobycie, the second-largest coal-based company in Poland announced a reduction in coal mining by about 25,000 tons a year, which is a reduced plan by 75% from previously announced achievements (Sawicki, 2022).

Poland is also characterized by relatively high coal reserves, with 22.3 billion tons of hard coal located mostly in the Upper Silesian and Lublin coal basins and 1 billion tons of lignite in national reserves (EURACOAL, n.d.). Poland is also a relatively energy independent country within the EU-27 group. Its energy import dependency in 2017 was well below the EU average, which was equal to 55.1% (EURACOAL, n.d.). In Upper Silesia, the coal resources account for 78.9% of total coal storage in Poland, with 71.6% functioning as steam coal, 27% as coking coal and the remaining 1.4% functioning in various other, but still economically workable forms (EURACOAL, n.d.).



Figure 7. Distribution of active coal-mining regions in Poland (EURACOAL, n.d.)

Coal dominates the energy system of Poland but works also as an important factor for the determination of the Polish position on the global and regional market. In 2020, the hard coal production in Poland not only accounted for 96% of the EU's overall production, but also marked the country as a second biggest lignite producer globally (International

Energy Agency (IEA), 2022, p. 127). Traditionally, Poland was classified as a hard coal net exporter, meaning that there were significant areas dependent from the production of this resource and therefore, connected strongly with the Polish industry, boosting its importance. Nowadays however, due to decreased internal production, the imports of coal increased, marking the most importantly thermal coal dependency from Russia. Formerly the main destination for export of hard coal from Poland, Germany, changed its policies to phase out coal, similarly to other former industrial partners. The drop in coal export and increase in import not only limited energy security, but also boosted the vision of low effectiveness of coal sector.

The coal sector in Poland is in an extremely challenging financial situation, in which, without direct governmental subsidies, the coal mining would have disappeared long ago, bringing drastic consequences to the socio-economic stability of the country. The main problems that the coal sector needs to face are connected with profitability and liquidity in the mining of, most notably hard coal, leading to the severe and rapid bankruptcies (Brauers and Oei, 2020, p. 5). The situation looks slightly different in the lignite sector, which still generates some kind of revenue. However, the national reserves of lignite are shrinking in regular speed and with the rising CO2 prices and with the eroding economics of the coal-fired power plants (Brauers and Oei, 2020, p. 5), the coal mining sector brings minimum to none benefit to the development of Polish state, in fact. Additionally, the difficult situation of the Polish energy system is aggravated by the lack of modernization within coal sector's infrastructure, marked mostly by the poor grid network and missing capacities to effectively cover the general demand (Brauers and Oei, 2020, p. 5). Power cuts and serious blackouts started to be more regular than ever, with a predicted increase of this issue if the infrastructure will not be, either improved or, replaced by more developed techniques. It is expected that more than 50% of the currently installed capacity will come offline between 2020 and 2035 (Brauers and Oei, 2020, p. 5). The improvements therefore are needed, in majority of cases, in the coal power plants.

Despite the financial problems challenging the coal sector in Poland, and with several companies facing the risk of bankruptcy, the hard coal and lignite mining industries are facing delays or cancellations in implementation of scheduled modernizations and project development. As an example, the investment plans for the creation of a new coal-fired power plant Ostrołęka C, 1 GW originally existed as a governmental energy security plan for 2019, but by decision made in February 2020 the project got suspended due to the financial problems and until now it remains unclear whether the plant will operate or

will it be transformed into another sort of energy supplier, such as natural gas plant (Brauers and Oei, 2020, p. 5). The amount of such failed investments is numerous, yet still the coal sector receives a significant number of financial resources designated in the national budget annually.

The cited data clearly shows that Poland is still strongly reliant on coal and plans to leave this source, as the main resource in the context of energy production cannot be seen on the near horizon, at least not in the current political and business agenda. Surprisingly, the factor of ineffectiveness of the resource's production and consumption is neglected, similarly to environmental factors. Therefore, it is worth to discuss other elements influencing still existing support towards the Polish coal industry, outside of the traditional approach of trade and finances.

2.3 Coal as a socio-cultural element

The attachment to coal in Poland is also visible in the socio-cultural context. In the region of Upper Silesia, there are still many mining schools that educate future mineworkers at the level of technical education, i.e., in the 16-19 age group. Although their number has been decreasing in recent years, mainly due to the danger associated with the work and the growing uncertainty about the future of the industry, their presence is still visible, especially in highly industrialized regions.

Currently, about 80,000 Polish citizens are employed in the mining industry (BIZNES ALERT, 2021). Due to historical context, many families living in mining regions have been fully associated with coal mining, especially hard coal, for generations. Although the upcoming one is not as eager to work in the mines anymore, the family's commitment to coal is still there. Importantly, it is only in the last two years that reduced interest in mining education is visible, which means a large group of citizens are still employed in the coal industry or strongly associated with this industry culturally, emotionally, and patriotically. The annual mining festival of Barbórka, which falls on December 4, is a confirmation of these statements. On this day, in all mining regions, workers have a day off and put on their mining gala clothes to celebrate with their families at public picnics or other celebrations, often with the presence of regional or even national authorities.

Generally understood ethos of mining work, which is still recognized in Poland as a leading respectable way of life, is an essential element of the social approach towards coal and its role in shaping Poland not only as a country, but also as a community of united citizens. This ethos was particularly developed in Upper Silesia, where both mining and metallurgy played a huge role in the rapid industrialization of the region and the resulting demand for a new type of worker - a miner who was motivated and strongly attached to his place of work (Swadźba, 2001, p. 7). The different nature of the work, the dangers involved, and the increased discipline required the development of new patterns of diligence and solidarity among workers. The resulting employee ethos was initially associated only with work in the mining industry but was soon associated with all physical work performed in heavy industry, where previously there had been no question of work ethic (Swadźba, 2001, p. 7). After Upper Silesia was incorporated into Poland after World War I, the role of the miner's ethos as an element distinguishing these lands from the rest of Poland became even more pronounced. This moment went hand in hand with the increased development of heavy industry, so the slogan of the Silesian work ethos was used almost excessively, and it was set as a role model for all national workers, regardless of the economic sector (Swadźba, 2001, p. 7). During the communist regime, that is, in the years 1945-1989, the glorification of work was, as already mentioned, the main propaganda element, and mining along with the system of values associated with it became an almost symbolic element describing the newly created type of ideal communist, who with his work not only contributed to the reconstruction of the country after World War II, but also inspired multitudes of others, including the younger generation, with its activities and results. Although in the process of restructuration carried out after 1989 the role of heavy industry gradually began to decline, to this day the Polish national ethos of work, hard but productive, is built on that presented by Silesian miners. Physical work, grueling and based on sacrifice, is therefore constantly considered to be the most contributing to the development of the state, and therefore also extremely patriotic. This view was especially strengthened along with the conservative, strongly nationalist values promoted by the majoritarian government of PiS party.

The importance of mining is also expressed by the attitude towards its workers and their relationship with the government. Coal miners host still very prominent role in the socio-political environment and have a great influence on the ways in which the coal industry is shaped. By forming the miners' unions, their voice within the political decision-making sphere grew rapidly, leading for the high employment rate in mines and establishment of the most prominent salaries in the whole hard industry sector, even in times where the coal mining was reaching rock bottom (Brauers and Oei, 2020, p. 4). The favourable status of Polish miners became even more prominent when compared to the sector's employees in other countries. Those working in the coal industry of Poland not only work

fewer hours a day and fewer days a year, but also poses additional public holidays, extra monthly salary, benefits resulting from long-term employment or earlier options of retirement (Brauers and Oei, 2020, p. 4). These working conditions were not established out of nowhere, but rather came as a result of the years-long fights of Solidarność – the biggest workers-based organization responsible for massive strikes and political lobbying in 1980s, which contributed significantly to the fall of communism in Poland. While the government attempted numerously to limit the power of mining' unions throughout years after the transformation starting in 1989, the miners were successfully able to resist all trials and proposed changes and stop the restrictive wages reduction or rapid employment cuts until 1996 (Brauers and Oei, 2020, p. 4). While the restructuring of the coal mining industry after the 2000s brought some bitter innovation to the government-unions relationship, their massive protests allowed them to maintain the standard significant position and proved that the coal mining industry is still a massive "soft spot" in Polish politics and governmental decision-making. With the pro-coal attitude of the PiS party, currently holding a parliamentary majority in Poland, the role of mining unions seems to be stable and unchallenged, without significant changes seen in the foreseeable future.



Figure 8. Coal mining, electricity generation and number of employees in coal mining in Poland from 1990 to 2018 (Brauers and Oei, 2020, p. 4).

One of the examples of the ongoing influential position of the mining unions in Poland is the social contract agreed upon in May 2021 between the national authorities and the coal trade unions, which set quite clear guidance and schedule regarding closure of all hard coal mines in Poland, with the exclusion of the coking coal ones (International Energy Agency (IEA), 2022, p. 128). The date chosen was the year 2049, and the agreement includes the introduction of an official governmental plan for the generous financial support towards workers and heavily industrialised regions of Poland, guaranteeing the stable job position until retirement or severance package in case of the need of an employment cut off. The financial agreement, officially called Silesia Transformation Fund, intends to use public funds in order to subsidise the whole transition process of the coal mines and allows for all necessary changes in the planned support system in case of the need to address drastic changes in ETS prices or those coming from the evolving climate change policies, both on the national and international level (International Energy Agency (IEA), 2022, p. 128). Importantly, the agreement covers only the hard coal sector, not the lignite one, meaning that there are no targets or end dates set for this part of the mining industry. Therefore, the changes will not cover all miners and will allow those currently employed in the hard coal industry to shift their job position to a lignite one, without any difficulties. This example clearly shows the impact which mining unions still have on the Polish governmental structures and their decision-making processes.

From the financial point of view, the Polish coal sector is still fully supported by the government, either in the form of direct aid, but also through the indirect mechanisms, whose aim is to ensure the stability of income streams or facilitate the costs and risks stemming from the daily coal sector activities. Importantly, Polish coal mines are not required to cover any costs of the planned closures or restructuration, as the state-owned SRK takes control over the unproductive mines and covers all decommissioning costs, passing them directly to taxpayers (International Energy Agency (IEA), 2022, p. 128). Estimates coming from the European Commission (EC) and The Organisation for Economic Cooperation and Development (OECD) states that the value chain of coal benefits comes from the growing level of subsidies yearly (International Energy Agency (IEA), 2022, p. 128). Justifying it by energy security, the Polish government is therefore spending the financial resources of taxed citizens on the industry, that doesn't bring significant revenue, harming not only economy, but also environment and human health instead.

Outside of the coal mining regions, the approach to the coal industry significantly differs, which is presented in the result of the various social surveys. General findings are that Polish citizens are less interested in the coal industry situation and are far more concerned about energy affordability (Brauers and Oei, 2020, p. 4). Among all available energy sources, coal is not the most chosen one by citizens, with a significant amount of the population supporting the idea of energy transition based on renewable sources (Brauers and Oei, 2020, p. 4). Arising opposition towards the coal-mining industry is not however as based on environmentally related issues as in the other EU Member States but is mostly conditioned by the relocations of citizens due to increasing air pollution, especially in the Upper Silesia region (Brauers and Oei, 2020, p. 4). However, as in many other issues, Polish society is polarized around the fate of coal mines, with 64% of society demanding equal treatment of coal mines in comparison to other companies while the remaining 36% would support the coal mining unions at all costs if the national authorities would decide to shut down all existing mines (Brauers and Oei, 2020, p. 4).

Public opinion in Poland is, therefore, divided over the issue of coal mining, which doesn't make the whole process of energy transition any easier. The only work that is actively working for coal mining closure is NGOs such as Greenpeace or Client Earth (Brauers and Oei, 2020, p. 5). However, the pro-coal ongoing legislation is not showing much development regarding the energy transition process and with the approach of the Polish government currently in the office, the situation doesn't seem to be progressing in an environmentally friendly direction.

2.4 Coal as a political tool

During the celebration of Barbórka in 2018, President of Poland Andrzej Duda presented the following statement during his official speech:

Please do not worry: as long as I hold the office of president in Poland, I will not allow anyone to murder the Polish mining industry." Speech of President Andrzej Duda in Bieszczady, Poland (RMF24, 2018) [translated to English from Polish by the author]

With these words, he summed up the approach of the PiS government to the role of coal in shaping the Polish economy. Cynically, in the same statement, the President highlighted the importance of sustainable development but introduced in a way, in which the harm to the Polish economy will be almost invisible.

Politically, Poland is not showing much willingness for pro-environmental energy transition changes. The PiS party presents a strong pro-coal stance, which is one of the main elements of its political agenda, considered often as their "victory ticket" for winning the parliamentary majority in 2018. Its main political pro-coal stance is based on the general social fear of unemployment, rising energy prices and overall energy security and loss of energy independence. The strong position within the country is still in the hands of miners' unions, whose demands are gradually approved by the currently ruling government. It is especially visible in the recent developments of the government-union talks, where agreements were reached to shut down all coal mines until 2049, at a much slower rate than the one planned within the EU Green Deal framework.

Even in the general and upcoming Polish political agenda the development of renewable energy sources and its importance to the national energy sector, there are some major contradictions present. In the latest available political program of PiS from 2019, the role of environmental protection is described as one of the most important pillars of shaping a modern welfare state and a fundamental element of changes aimed at achieving nationwide sustainable development. By shining light on the "green economy" and "green energy", PiS argues about countless programs aimed at establishing climate neutrality as soon as possible (Prawo i Sprawiedliwość (PiS), 2019). Programs such as "Energia Plus" or "Polska Geotermia Plus" offer bold theories regarding the introduction of renewable energy to the world in Poland (Prawo i Sprawiedliwość (PiS), 2019). At no stage of the program, however, is there any question of abandoning the production and consumption of coal, but only shaping this industry sector towards improving its efficiency¹.

Poland's political determination to keep the coal industry almost unchanged is particularly evident in the context of the border crises related to mines. Such was the case with the mine in Turów - the largest open-pit mine excavating lignite in the border region between Poland, the Czech Republic and Germany (Easton, 2021). Water pollution caused by coal mining in this region has been a "bone of contention" between neighboring countries for years, yet still, Poland remained unmoved in the face of, above all, Czech proposals for improvements in water management. After granting Turów

¹ For the full text of 2019 Program of PiS see: https://pis.org.pl/dokumenty

another six-year operating license in 2020, the Czech government decided to accuse Poland of environmental pollution and bring the case to the European Court (Easton, 2021). This resulted in the imposition on Poland of a periodic penalty payment of 500,000 Euros per each day of continuous cross-border environmental hazards performed in the region (Easton, 2021). While the ruling was considered valid, Poland didn't agree with it and refused to close the mine and pay the fine. As a result, the European Commission decided to reduce the funds flowing into Poland, which were intended for energy transition initiatives (Deutsche Welle, 2022). Once again, the Polish government had the opportunity to prove all around by the propaganda that EU decisions only work to the detriment of the Polish state, and not to improve the lives of its inhabitants.

The example of Turów clearly shows the remarkable opposition of the Polish government to any climate change, conditioning sustainable development on its own beliefs and principles. The political element is therefore extremely important in the context of energy transition within the country, possibilities of faster development of the pro-climatic strategies and ensuring the achievement of emission standards put down in the EU Green Deal until its official deadlines - 40% until 2030 and 80% until 2050.

3. Energy transition in Poland - A bumpy way to sustainability

Despite the continued reliance on coal as the main energy source, the share of renewables is growing gradually, although still slowly, and their presence in the national energy market is still small. In 2018, 10.9% of national energy was produced by various renewable sources, where it was mainly used for heating, cooling, electricity and transport (Dziennik Gazeta Prawna, 2021). Advocates of renewable energy sources argue that the cost of energy produced in this way, despite consistently high production-related ones, also brings significant environmental as well as health benefits due to reduced emissions of pollutants, especially CO2 - so they are openly competitive with fossil fuels.

All of Poland's energy targets are determined by the wide range of EU directives, which influenced at least some national laws regarding the implementation of renewable energy systems and their further development. For example, the NECP adopted by Polish government in 2019, includes the clear definitions regarding targets for 2030 for non-

ETS GHG emissions, renewable energy, and energy efficiency with an aim to support the achievement of the 2030 emissions target established by the EU (International Energy Agency (IEA), 2022, p. 21). Importantly, Poland achieved its targeted number of renewables in gross final energy consumption scheduled for 2020, mostly due to improved way of collecting data on biomass use for residential heating. Importantly, the 2020 energy efficiency target regarding the final energy consumption was successfully achieved in 2019, while 2020 saw the target of primary energy consumption almost hit and missed by just 0.1 Mtoe (International Energy Agency (IEA), 2022, p. 22). While the results look impressive, the share for renewables still remains below the indicative trajectories, especially with regard to electricity and transportation sectors. Moreover, the positive results don't necessarily come from the innovative policies and economic strategies but are based on the unforeseen circumstances of changed energy demand coming from the switch of work habits connected with the COVID-19 pandemic and the numerous lockdowns. The most visible example of the slow and non-compliance with the original plan development of renewables in Poland is the fact that despite reaching the target of 4% electricity interconnection, the result was still much lower than the 10% required by the EU (International Energy Agency (IEA), 2022, p. 22). The planned increase of 8.7% until 2030 still will not fulfill the demanded objectives and won't yet again be in line with the EU directives.

Table 1. Poland's 2020 status and 2020 and 2030 energy sector targets (International Energy Agency (IEA), 2022, p. 22).

		2020	2020	2030
		status	targets	targets
Non-ETS GHG emissions	CO2-eq emissions versus 2005	+10%	+14%	-7%
Energy efficiency	Primary energy consumption	96.5	96.4	91.3
(Mtoe)	Final energy consumption	71.0	71.6	67.1
Renewable energy share	Gross final energy consumption	16.1%	15%	23%
	Electricity*	16.2%	19%	32%
	Heating and cooling*	22.1%	17.4%	28.4%
	Transport*	6.6%	10%	14%
Cross-border electricity interconnection		4%	4%	8.7%

*indicative trajectories

The current achieved targets were not seen particularly positively within the EU structures, with the EC noting the unambitious nature of the 2030 target for 23% renewables allocation in gross final consumption, proposing the share of 25% instead, to which Poland didn't react in any way, keeping its previous plans on (International Energy Agency (IEA), 2022, p. 22). As a response to the allegations, Poland introduced a new national energy strategy called "The Energy Policy of Poland until 2040," or EPP2040 for short², whose main goal was to align projects and plans aimed at pushing the country towards a zero-carbon economy. It is important to note, however, that the EPP2040 doesn't in any way define a year for Poland to achieve climate neutrality and, despite a number of strategies related to renewable energy development, it doesn't include any clear plan to end coal mining and consumption (International Energy Agency (IEA), 2022, p. 22). Among various energy transition process related targets, the policy focusses mostly on the targets connected with household heating, aiming at cutting the coal-fired heating by 2030 in urban and by 2040 in rural areas, where the systems are planned to be changed to the zero or low-emission systems, such as heat pumps.

² For the full text of Poland's EPP2040 see:

https://www.gov.pl/web/climate/energy-policy-of-poland-until-2040-epp2040

Table 2. 2030 targets of EPP2040 (International Energy Agency (IEA), 2022, p. 23).

Indicator	2020 status	2030 target	
Coal in electricity	79.7% (2021)	≤ 56% to 37.5%*	
generation			
Offshore wind generation	0 GW	5.9 GW (8-11 GW in 2040)	
capacity			
Solar PV generation	7.7 GW (2021)	5-7 GW (10-16 GW in	
capacity		2040)	
Nuclear generation	0 GW	1 reactor: 1-1.6 GW in	
capacity		2033	
		6 reactors: 6-9 GW in 2043	
Renewable heating and	22.1%	+1.1% per year through	
cooling		2030	
Natural gas network	Unknown	10%	
capacity hydrogen			
Total CO2 emissions (ETS	271.5 Mt	241 Mt**	
and non-ETS)			
Communes with an energy	20.2%	100%	
planning document			
Households in energy	10.1%	< 6%	
poverty			
Electricity distribution	118.7	≤ 85	
system reliability: System			
Duration Index (SAIDI)			
Electric vehicle (EV)	509 (2019)	49 000-85 000	
EV fast charging points	375 (2019)	11 000-15 000	
(above 22 kW) Zero-emission vehicle	4% (2018)	100% (2025)	
purchases in public		100 /0 (2020)	
transport***	2% (2018)	100%	
the public transport***			
End consumers equipped	12%	80% (2028)	
Households using district	5.28 million (2018)	1.5 million new	
heating		connections	

* Based on EPP2040 scenarios assuming an ETS price of EUR 35-54 per tonne in 2030 (ETS price exceeded EUR 89 per tonne in 2021). ** A 30% reduction compared to 1990 levels excluding land use, land-use change and forestry (LULUCF).

*** In vehicle fleets of cities with more than 100 000 inhabitants.

Poland's new policy proposals on developing renewable energy and achieving climate neutrality, however, do not go hand in hand with the EU's new strategies in this area. A year before the introduction of EPP2040, the EU decided to increase the community-wide GHG emissions reduction target from 40% to 55%, and the process focused on developing even more ambitious 2030 targets for both renewables and the energy efficiency associated with them is still ongoing (International Energy Agency (IEA), 2022, p. 22). Poland is therefore openly developing its own strategies for reducing GHG emissions and conducting the energy transition outside the rules of the EU directives and regardless of the targets set by them. It is therefore likely that the targets described in Table 2 will have to be revised and adapted to the ongoing changes at the EU level. For the time being, however, given the lack of willingness to make decisive changes related to the coal sector, it may prove extremely challenging to reach the targets set in EPP2040. Poland is making progress on renewable energy in many sectors, but the process is still not commensurate with needs, and the share of coal in the national energy sector is still leading.

3.1 The current state of renewable energies in Poland

Driven by the growth in heating-related wind generation and direct use of the solid biomass, the share of renewable energies in Poland's total final energy consumption (TFEC) increased from 2010 to 2020 from 9.5% to 16%, with the largest improvement noted in 2018 (International Energy Agency (IEA), 2022, p. 71). However, despite the significant achievements in the area, the share still remains quite low. In 2020, energy coming from renewable sources covered only 16% of Poland's final energy consumption, with 16% of electricity generation, 22% of heating and cooling demand and 6% of transport needs (International Energy Agency (IEA), 2022, p. 71).



Figure 9. Renewable energy in TFEC in Poland in years 2000-2020 (International Energy Agency (IEA), 2022, p. 72).



Figure 10. Renewable energy key metrics in Poland in years 2000-2020 (International Energy Agency (IEA), 2022, p. 72).

Regarding Poland's energy policy, the generation of electricity from renewables, especially from small-scale solar PV and offshore wind, remains one of the main strategies for the coal-fired electricity displacement without significant import dependency, with the increased role of prosumers in electricity markets (International Energy Agency (IEA), 2022, p. 71). The main focus is put on the transport and residential heating sectors, with an aim to replace oil with biofuels and coal-based heaters with bioenergy or heat pumps.
In the period from 2010 to 2020, the generation of electricity from renewable sources tripled, coming from 10.9 TWh to 28.2 TWh, with the visible increase in share from 7 to 18%. The growth was mainly driven by two leading sources, namely onshore wind generation (from 1.7 TWh to 15.8 TWh) and solid biomass (from 4.9 TWh to 6.9 TWh) (International Energy Agency (IEA), 2022, p. 72). Notably, the electricity generation from solar PV also increased quite rapidly, coming from 0.2 TWh in 2017 to 2.0 TWh in 2020 (International Energy Agency (IEA), 2022, p. 72).



Figure 11. Renewable energy in electricity generation in Poland in years 2000-2020 (International Energy Agency (IEA), 2022, p. 73).

The role of renewable energies in heating and cooling sector also experienced significant improvement. Between 2010 and 2020, the share in this area grew from 4.7 Mtoe to 8.5 Mtoe and from 12% to 22% in total heating and cooling demand (International Energy Agency (IEA), 2022, p. 72). Yet again, the most significant growth was recorded in 2018, mostly thanks to the modernized methods of data collection on the biomass use. Notably, the position of solid biomass as the strongest within the heating and cooling based renewables, followed by heat pumps, biogas, and renewable waste, which is still a sector highly underdeveloped in Poland (International Energy Agency (IEA), 2022, p. 72).



Figure 12. Renewable energy in heating and cooling sector in Poland in years 2000-2020 (International Energy Agency (IEA), 2022, p. 73).

As the transportation sector is one of the main focusses of EEP2040's energy transition targets, it is worth noticing the less spectacular growth in this area. Between 2010 and 2020 the overall increase in renewable energies in transport accounted only for 0.2 Mtoe growth. This resulted mostly from the illegal trade of transport fuels on the black market, which notably reduced the demand for fuel sold in official retail stations, obliged to provide fuels consisting of a minimum biofuels content (International Energy Agency (IEA), 2022, p. 73). The legal solutions now in place have effectively reduced the scale of this incident and allowed for the creation of better strategies to address market demands. This can be seen in the increased data for renewables in transport coming from 2016 and 2017. Notably, the position of renewables in transport is related to biofuels mixed together with diesel and gasoline, which accounted for 76% of shares in 2019, followed by bio gasoline (16%), renewable energy in rail (7.1%) and renewable electricity in road transport (0.2%) (International Energy Agency (IEA), 2022, p. 73).



Sources: EC (2022).

With regard to energy transition investments, the Polish government has already made some steps towards progressive implementation of related strategies. It is estimated that upgrading the Polish sector and achieving the NECP's 2030 targets will require a financial effort of EUR 195 billion between 2021 and 2030, representing 3.5% of total annual GDP (International Energy Agency (IEA), 2022, p. 27). Total cost of energy transition is expected to be even higher, with 155 billion euros spent in total until 2040. Therefore, it is worth looking closely at the current development of renewable energies in Poland based on its various different types.

It is important to note, that generally accessible data regarding the renewable energies and their implementation in Poland is in some cases quite limited and outdated. Therefore, the examples and statistics used might not fully correspond to the current situation of some sectors within the national economy.

3.1.1 Onshore wind energy

Despite growing global trends in wind energy, Poland still appears to be relatively resistant to upgrading in this area. Despite this, according to 2020 data, it is onshore wind farms that provide the largest amount of clean energy, with 6.35 GW of installed capacity (TPA Poland / Baker Tilly TPA, 2021, p. 6). That same year, total renewable

Figure 13. Renewable energy in transport in Poland, 2004-2020 (International Energy Agency (IEA), 2022, p. 73).

electricity generation was about 28 TWh, of which 16 TWh came from wind power (TPA Poland / Baker Tilly TPA, 2021, p. 6). Energy production with the help of modern wind turbines seems to be the most beneficial alternative to generating energy from fossil sources such as coal, whose extraction due to constantly increasing CO2 emission prices and changing international regulations. Wind energy is relatively cheap, but above all, it is extremely beneficial in terms of counteracting global warming and achieving climate neutrality. In the country like Poland, where the weather is strongly determined by the relatively significant number of windy days and with the moderate climate, the development of wind energy seems to have the most advantageous background to develop.



Figure 14. Wind distribution in different regions in Poland given in MW (Rolniczy Magazyn Elektroniczny, 2010)

In 2021, there were more than 1200 wind energy turbines installed in Poland, with the installed capacity over 5900 MW (about 65% of all types of renewable energy installations currently in use within the country) (International Trade Administration, 2021). 160 further wind farms are under construction and their implementation will add approximately 2500 MW of energy more (International Trade Administration, 2021).

The onshore wind power sector is much more developed than the offshore one in Poland, mainly due to the overwhelming amount of land in relation to the surface of territorial waters. However, it is worth noting that the potential of the overwhelming area of the Baltic Sea is still not explored in terms of its wind power infrastructure potential, so there are still opportunities associated with increasing the share of offshore wind power generation in Poland's energy economy. Notably, the amount of the wind power projects in Poland is constantly progressing, with many of them still awaiting the approval of passing from the IEA. The overwhelming majority of the currently installed and planned wind plants is located either in Northern or Western Poland, due to the location of those territories either close to the Baltic Sea or the national border with Germany (Kaczmarek, 2014, p. 21).



Figure 15. Wind farms distribution in Poland (Mirowski, 2020)

The development of the onshore wind power plants got restricted in 2016, when President Andrzej Duda officially signed a bill, which made building turbines within 2 km from other infrastructure, including residential buildings and forests (International Trade Administration, 2021). The regulations thus introduced have made the Polish onshore wind law one of the most restrictive in the entire EU. By introducing the so-called 10H rule, the government has introduced restrictions that allow the construction of new wind farms only if the minimum offset distance between residential buildings, which is 10 times the height of the turbine, is maintained (Czyżak, 2021). This means that if the regulation remains in its original form, 99.72% of the country's land area is automatically excluded from the possibility of building new wind farms and the available onshore wind capacity is reduced to just 10 GW (Czyżak, 2021). By comparison, in Germany's latest energy transmission plan, the same amount of onshore wind capacity is planned to be added each year, and the only more restricted law is in force in Hungarian legislation, where due to several law enforcements, the production of energy through onshore wind plants

is completely banned (Czyżak, 2021). Importantly, while majority of EU-27 assume the minimum distance to be between 500-1000 m, in Poland the restrictions stretched it to 2000 m.

The impact of restrictive laws on the development of wind energy capacity in Poland can be seen from its evolution from 2013 to 2020:

Table 3. The evolution of onshore wind energy capacity in Poland (2013-2020) (TPA Poland / Baker Tilly TPA, 2021, p. 7)

Year	Installed capacity of onshore wind installations [GW]	Increase in installed capacity of onshore wind installations [GW]
2013	3.39	-
2014	3.84	0.45
2015	4.58	0.74
2016	5.81	1.23
2017	5.85	0.04
2018	5.86	0.01
2019	5.92	0.06
2020	6.35	0.43

In 2021, the Polish government decided to consider an amendment to the 2016 law to introduce the possibility of reducing the distance to 500m through the municipalities' spatial planning process. This would bring about a 25-fold increase in the amount of land suitable for the establishment of wind farms, and thus allow for a potential of over 40 GW (Czyżak, 2021). However, despite open public consultations and the passage of more than a year, the amendment still has not entered into force.

Notably, the costs play an important role in the development of the wind energy in Poland. The average investment costs for a small wind farm, that will have a capacity of 1 MW, will be able to produce annually 2500 MWh of electricity and will power around 400 residential settlements, estimates around 1.5 million Euro (Kaczmarek, 2014, p. 22). While this presents a huge opportunity especially for the rural areas, without proper governmental funding, the projects will never be able to fully come into force. Facing the

current restrictive measures, the onshore and still underdeveloped offshore wind energy sector is therefore significantly paralysed in Poland.

3.1.2 Photovoltaics

Generally, the sun is considered the most powerful renewable energy source existing, as it produces six thousand times more energy than is generally consumed all around the world (Kaczmarek, 2014, p. 19). Therefore, the potential of photovoltaics in the energy transition is enormous. Supply of the energy in that case strongly depend, however, on the length and frequency of the solar radiation in general, which in Poland is relatively irregular and uneven, with only five to six months of the sufficient radiation reaching Poland per year, due to its northern location (Kaczmarek, 2019, p. 19).



Figure 16. Sum of sun radiation in Poland per year (Planergia, n.d.)

Contrary to many other renewable energy sources, photovoltaics is developing very favorably in Poland, characterized by great support not only from industry but also from the government. In 2020, the value of solar power output installed tripled, reaching 2635 MW in comparison to 823 MW in 2019 (International Trade Administration, 2021). This allowed Poland to take the honorable fourth place in the EU in terms of PV market position, right after Spain, the Netherlands and Germany. It is predicted that while maintaining the currently established pace of development, total PV capacity in Poland will reach 8.3 GW by 2024, with a solar boom reached at every level, starting from small privately-owned and home-installed PV systems to nationwide solar plants (International Trade Administration, 2021). The number of currently registered private and home solar systems, i.e., those whose energy capacity does not exceed 6.5 kW, increased from 155,000 in 2019 to 457,400 at the end of 2020 International Trade Administration, 2021). On top of that, growing number of the large-scaled PV projects recently received preliminary grid connection permits (International Trade Administration, 2021).

The development of photovoltaics also has considerable support from the Polish government. The established Agroenergia program with a budget of EUR 50 million is designed specifically to support farmers in the construction of solar power systems with power capacity between 50 kW and 1 MW and provides them with low-interest loans or direct financial support (International Trade Administration, 2021). In addition, the Polish government introduces large-scale "balancing" programs to support the development of photovoltaics among small and medium-sized enterprises, which are also exempt from paying VAT through the installation of solar panels with less than 50 kW (International Trade Administration, 2021).

In addition to projects that require funding, the Polish solar energy market is also developing outside of government support. The large solar project located in Witnica has an energy capacity of 64 MW and provides energy to the local cement factory (International Trade Administration, 2021). An increasing number of companies in Poland also rely on energy self-sufficiency from solar panels installed in their headquarters.

3.1.3 Hydropower

In Poland, the hydropower sector is responsible for the production of approximately 1.5% of the total electricity generation (Fodrowska, 2021). Such a small share of the energy potential of water is mainly caused by natural factors, such as unfavorable climatic conditions, low average rainfall or unfortunate topography. The best area for building hydropower plants is an area with large natural slopes or those in which the water has been somehow compressed artificially, and there are not many such areas in Poland.

There are many advantages and disadvantages to building and generating energy from hydropower plants. The benefits certainly include the pro-environmental aspect, because using the potential of water does not emit harmful gases and leads to a relatively stable source of energy, because flowing water does not slow down and does not appear periodically. As a hydropower plant does not need any additional fuel to generate energy, the operating costs in this case are significantly lower than with conventional power plants, for example those powered by coal (Fodorowska, 2021). Poland can also be proud of the presence of a significant number of rivers showing a high energy potential.

Water system	Potential (GWh/year)
Wisła with its basin	9270
Wisła	6177
Odra with its basin	2400
Odra	1273
Dunajec	814
San	714
Warta	351
Bóbr	320
Bug	309
Rivers of Przymorze	280

Table 4. Polish biggest water systems and their power generation potential (Fodrowska, 2021)

However, it is also worth mentioning the negative sides of hydropower plants. Their construction constitutes a serious interference in the natural environment and its costs are two or even three times higher than the financial outlays necessary to create a

conventional power plant, based on, for example, coal combustion. In addition, the construction of a hydroelectric power plant can seriously affect the flow of water in rivers, which will prevent the transport of sediment and, consequently, by aggravating erosion, will also contribute to the intensification of local droughts. Sedimentation of organic suspensions, which are fermented while falling to the bottom, may also lead to silting of rivers and reservoirs, and water damming may affect the flooding of residential spaces and agricultural areas, causing forced migrations of people (Fodorowska, 2021).

In the case of Poland, small hydropower plants are much more numerous than their larger counterparts, mainly due to the capital expenditure as well as the depreciation time for large hydropower plants. However, this is not different from the pan-European situation, where as much as 91% of the existing or planned hydropower plants are classified as small, i.e. those with a power of less than 10 MW (Fodorowska, 2021). However, unlike its continental neighbors, Poland uses only 19% of the technical potential of rivers by small hydropower plants. The increased amount of existing infrastructure is in conflict with the noticeable slowdown in the development of this sector of the economy, especially in the case of domestic hydropower plants, the operating costs of which are much lower than in the case of power plants using conventional sources for energy production (Fodorowska, 2021).



Figure 17. Location of the small hydropower stations in Poland (Fodorowska, 2021a)

In 2017, 766 hydropower plants were operating in Poland, with a total installed capacity of almost 988.38 MW. 756 of them were plants with a capacity of less than or equal to 10 MW, and 680 of them with a capacity of less than 1 MW. For comparison, only 11 hydropower plants in Poland have a capacity of over 10 MW, but they are responsible for the production of almost 60% of the total hydro energy. Process of development of hydropower in Poland, as mentioned before, is currently quite limited and the lack of the upcoming large projects correspond to this stagnate vision.

3.1.4 Bio components, biofuels

The market for biofuels in Poland is still not highly developed, however, there are more and more new projects aiming to change this situation. The leading leader in the biofuel production sector is the Grupa Lotos, whose main assumptions are based on the production of biocomponents derived either from used cooking oil or cereals. At the end of 2020, the company announced the production of the first extensive deposits of biopropane and liquid biocarbons in the history of Poland, which gives hope for the positive development of biofuels and their wider participation in the national energy transition (Świat OZE, 2021). Biopropane is a pro-environmental element of LPG, while liquid biocarbons are part of diesel fuel. Unfortunately, large-scale projects for both biopropane and liquid biocarbon production have been significantly delayed due to legal aspects as well as lack of funding from the Polish government.

However, when it comes to Grupa Lotos's current ongoing projects, they are primarily focused on the production of UCOME, a second-generation biofuel that is produced directly from used cooking oil (Świat OZE, 2021). In the case of Poland, the main oil used in this process is the rapeseed one, as its production is by far the largest on the national market, thus its consumption. The project aimed at adding natural esters derived from vegetable oils to diesel fuel is supervised by a part of Grupa Lotos, called LOTOS Biopaliwa, located in Czechowice-Dziedzice in Upper Silesia (Świat OZE, 2021). The expansion of the installation as well as the ongoing financing of the project allows for the production of approximately 50,000 UCOME per year (Świat OZE, 2021).

Grupa Lotos is also considering the development of hydrogen production as a fuel of the future, which has not yet been implemented on a large scale in Poland. The company has already started production of hydrogen of very high purity in 2021, cooperating with Toyota Motor Poland in the framework of declared cooperation aimed at intensive development of technologies using hydrogen in automobile transport (Świat OZE, 2021). However, the main goal of the project so far is not the introduction of hydrogen as a substitute for fossil fuels, but more the construction of the necessary infrastructure, such as an increased number of refueling stations and a significant improvement in their frequency. Lotos Group has recently announced that it plans to put into operation an infrastructure designed to produce and sell hydrogen of 99.999% purity by October 2023 (Świat OZE, 2021). At this point, however, it is impossible to say whether the plans will be implemented as planned and with the intended splendor.

Grupa Lotos's leadership in the development of biofuels in Poland does bring some hope for the development of this sector of the national economy. The company's refinery is among the top 10 least emitting refineries in Europe and its CO2 emission factor is below 29.5 kg per ton (Świat OZE, 2021). The future of biofuels in Poland is still in its infancy, but the projects being implemented, with the right financial and legal support, have a chance of success.

3.1.5 Waste incineration plants

In Poland, about 12 million tons of waste is produced annually, which creates an ideal basis for the development of renewable energy production by waste incineration plants. Municipal waste in 2020 contributed to 1.84% of fuel consumption for heat production, equal to 7.76 million GJ (Wierzbowska-Kujda, 2022). It is worth noting, however, that the largest amount of coal is still used for waste incineration in Poland (67.72%), followed by natural gas (10.60%) and biomass (9.86%) (Wierzbowska-Kujda, 2022), which makes it only an indirect pro-climate contributor to achieving the full energy transition.

Revenues from the sale of heat generated from municipal waste in 2020 amounted to nearly PLN 140 million (approx. 32 million EUR) in Poland, which, when compared with the revenues from the overall heat sales, places waste incineration on a distant position with the result of 0.16% (Wierzbowska-Kujda, 2022). The average price of municipal waste heat in 2020 was 34.91 PLN per GJ. This is the second highest rate on the market, after lignite (Wierzbowska-Kujda, 2022). Production of heat energy from municipal waste is therefore not only environmentally friendly, but also cost effective.

There are currently eight incineration plants operating in Poland, treating a total of about 1.1 million tons of waste per year, thereby contributing to increased energy production of both heat and electricity (Skłodowska and Elżbieciak, 2021). Two more incineration plants in Gdańsk and Olsztyn are currently under construction and the construction of another two in Łodz and Bełchatow is planned for the coming years. At present, the capacity of the existing incineration plants makes it possible to manage approx. 10% of all municipal waste generated in Poland (Skłodowska and Elżbieciak, 2021). It is assumed that thanks to the reconstruction and construction of new waste incineration plants, the incineration capacity will increase in the coming years and will reach about 2 million tons per year (Skłodowska and Elżbieciak, 2021).



Figure 18. Location of the waste incineration plants in Poland (Skłodowska and Elżbieciak, 2021)

The development of district heating energy production from waste incineration and the construction of plants designated for this purpose is currently financed by the National Fund for Environmental Protection under the "Rational Waste Management" program (Wierzbowska-Kujda, 2022). The program assumes an increase in energy generation from waste between 2021 and 2030, and their full management in a nationwide recycling strategy. It is also worth mentioning that current legal regulations impose an obligation on heating companies to purchase heat generated from waste incineration plants.

3.1.6 Biogas

The biogas market in Poland is slowly developing but is still far behind the EU MS in terms of biogas achievements. There are currently more than 100 agricultural biogas facilities in Poland with an electrical capacity of just over 125 MW (Więckowska, 2022).

Compared to Germany, where the number of biogas plants exceeds 9000, the Polish result is quite mediocre.



Figure 19. Location of the major biogas plants in Poland (Magazyn Biomasa, 2022)

Interestingly, as a highly agricultural country, Poland has a much larger area of farmland than its western neighbor and a much more developed agri-food processing sector, which additionally produces a significant amount of bio-waste. For example, Poland is the EU leader in manure production with about 100 million tons per year. Manure is a kind of natural form of biogas as it emits not only methane but also N2O, which is a greenhouse gas that has a greenhouse effect 298 times stronger than CO2 (Więckowska 2022). The potential for the development of the biogas sector is huge, however, one should remember about the limitations related to the still unclear legal regulations and the lack of appropriate financing from the government.

In 2020, over 513 million cubic meters of agricultural biogas were produced in registered installations (Więckowska 2022). It is worth noting that, according to experts from the University of Life Sciences in Poznań, the annual potential of biogas in Poland is 13 to 15 billion cubic and 7-8 billion cubic of biomethane (Więckowska 2022). It is estimated that approximately 18 million cubic meters of natural gas are consumed annually in Poland, which means that with increased investments, the production of biogas in Poland would satisfy most of the needs of the economy in this area.

However, recent years have made a negative mark in the history of Polish biogas production, mainly due to the significant stagnation in the sector's development related to difficulties in obtaining the so-called blue certificates allowing for the production of biogas on a large scale (Więckowska 2022). The lack of clarity in the context of legal regulations has also become a problem. The Methane Emission Limitation Strategy announced in 2020 by the European Commission and the so-called methane tax introduced did not go hand in hand with the development of similar national regulations in Poland, which resulted in ambiguities and limitations related to the development of biogas production (Więckowska 2022). Additional legislative solutions as well as increased cooperation with state authorities in this case seem to be extremely justified.

Recently, however, there was hope for a revival of the biogas industry in Poland. The signing of the Agreement on Cooperation for the Development of Biogas and Biomethane in 2021 provides some basis for building plans around increasing the role of biogas in the Polish energy economy and at the same time leading to an intensified energy transition process and establishing another alternative for the production and consumption of coal (Więckowska 2022).

3.2 Poland vs EU – how to meet emission standards faster?

Summarizing the considerations on the development and possibilities of renewable energy in Poland, and before starting the discussion on the feasible scenario for the coal sector, it is worth taking a look at the main solution proposed by the EU to improve and accelerate the energy transition process among the EU-27. The Just Transition Mechanism (JTM), which is an inseparable and fundamental element of the EU Green Deal, is to fulfill the main assumption of the project, which is to provide support for everyone for whom abandoning coal in favor of renewable sources involves some financial detriment, may lead to unemployment, or otherwise hinder the day-to-day functioning. This description applies in particular to those regions of Europe where there is still intensive coal mining. The JTM aims to ensure equality in the energy transition by providing the most disadvantaged regions with a fund of EUR 65-75 billion in 2021-2027 (Ślimko, Bartecka and Pogoda, 2021, p. 4).

Strongly associated with JTM is the Just Transition Fund (JTF), which mainly aims to finance all the challenges that individual regions will have to face from a socio-economic perspective during the coal phase-out in their country. The JTF with a value of EUR 17.5 billion in 2018 prices therefore consists of EUR 7.5 billion from the EU budget for 2021-2027 and EUR 10 billion from external revenues to be assigned from the Recovery and Resilience Facility (available in 2021 - 2023) (Ślimko, Bartecka and Pogoda, 2021, p. 4). JTF funds are to be distributed equally among the most deprived regions and are designed to support them in investing in small and medium-sized enterprises, creating new jobs in the renewable energy industry, carrying out research and necessary innovations, and reconstructing lands formerly occupied by coal mines and in which the former ecosystem is either significantly damaged or completely extinct.

Regions inside the EU that would be interested in using the JFT to transform their coal mining regions were obliged to prepare Territorial Just Transition Plans (TJTPs), later sent to the EC for further negotiations. For TJTPs to be complete, the state had to prepare a set of documents, which includes the description of the expected transition towards net zero economy, schedule for coal phase-outs in particular regions affected, assessment of socio-economic challenges coming from transition, types of planned actions as well as description of ways in which public participation will be ensured and monitored and then correctly evaluated (Ślimko, Bartecka and Pogoda, 2021, p. 5). The EU places particular emphasis on the role of civil society in the energy transformation process and observatory participation of the environmental, local NGOs in the public consultations and the decision-making process.

Poland, putting financial support as the main element for the fulfillment of the EU Green Deal conditions, issued documents proving support for individual regions through the JTF process.



Map of Polish Just Transition regions based on the Program on European Funds for Just Transition, prepared by the Department for the Coordination of Implementation of EU Funds at the Polish Ministry of Funds and Regional Policy, April 2021.





Not all applications from Polish regions applying for a JTF grant have been approved at the moment. However, Poland has prepared both a timetable and regional plans for the phase-out once funds are secured. *Table 5.* Timetable for the regional coal phase-out in Poland (Ślimko, Bartecka and Pogoda, 2021, p. 9)

Eastern Wielkopolska and the Wałbrzych	Phasing out coal in the power and heating
sub-region	sector by 2030
Upper Silesia and Western Małopolska	Completion of mining operations in 2049
Łódzkie region	Shutting down power units in the Bełchatów Power Plant will commence between 2030 and 2036, the ongoing exploitation of lignite deposits in the Bełchatów and Szczerców fields will end in 2026 and 2038 respectively
Lubelskie region	No information is available on the mining phase-out date. By 2040, the mine is expected to reduce coal mining by nearly 75 %.
Zgorzelec County	Completion of Turów mine in 2044.

Table 6. Declared CO2 emissions reduction targets by region in Poland (Ślimko, Bartecka and Pogoda, 2021, p. 10)

Eastern Wielkopolska	Achieve climate neutrality in the sub- region by 2040 and reduce CO2 emissions in the electricity sector by more than 90 to 95 % by 2030, and by 80 to 90 % in other sectors by 2040; by 2030 there will be a reduction in greenhouse gas
	emissions by over 55 %, increasing the share of energy from RES in total consumption to exceed 32 % and increasing energy efficiency by 32.5 %.
Upper Silesia	In compliance with climate and energy targets in the National Energy and Climate Plan. A 62.1 % CO2 energy sector reduction by 2030.
Wałbrzych sub-region	A 55 % reduction in CO2 emissions in the sub-region by 2030 and achievement of climate neutrality by 2040.
Łódzkie region	A 77 % reduction in CO2 emissions by 2030 for the Bełchatów Energy Complex.
Western Małopolska	In compliance with earlier EU 2030 climate targets (40 % greenhouse gas emissions reduction). An energy and industry sector reduction of nearly 50 %.
Lubelskie region	A 35 % reduction of greenhouse gases in the region by 2030.

Based on information provided, the two main problems are quite clear when it comes to the Polish TJTPs. First, not all regions have a specific date of end coal mining. Secondly,

even if they have a specific time to achieve coal phase-off, CO2 emission reduction targets are far from what the EU stipulates in the EU Green Deal regulations. The question then remains: in the face of the thoroughly discussed factors working strongly against energy transition (political, social, and renewable-related industrial ones), can we even speak of a feasible scenario for the coal sector achieved according to the JTM values?

4. Is there a feasible scenario for the coal sector in Poland?

Poland is still a country with strong ties to the coal economy not only because of economics, but also because of politico-social constrains. Finding a feasible scenario for the coal sector in that case will not be easy but is to some extent at least manageable. The progressive development of renewable energy sectors as well as the increasingly active pro-environmental social opposition to the coal economy allow us to believe in scenarios that will yield the best possible results and push Poland towards meeting the conditions of the EU Green Deal in less than 2049.

For this to happen, however, a few significant changes must occur. It is clear that the biggest enemy of the restructuring of the Polish coal industry and its gradual closure is the PiS government, which wants to play a two-front game with its funding while strongly supporting the coal mining sector and RES development. It is also not surprising that such a strategy will not yield any tangible results in the long run. The funding for RES is too small to allow for significant development, and the pro-coal campaigns do not contribute to reducing GHG emissions and achieving the intended targets; on the contrary, they exacerbate the problem and may lead to a situation where Poland, as a climate policy, will be completely alienated from the rest of the EU-27.

In order to effectively develop the renewable energies sector, favourable policy-making processes as well as adequate financing are of paramount importance. Apart from photovoltaics, no other form of pro-environmental energy transition is adequately supported, neither economically nor politically, by the Polish government. On the contrary, as the situation with wind power farms has shown, new laws introduced every now and then block any new development opportunities and stop bold and modern projects to modernize the Polish energy industry. The policy of the Law and Justice party

shows no signs of change, so the only element capable of change is public opinion, without whose support all government activities reducing the role of environmental protection in shaping the national economy will have no raison d'etre.

In order to enable the development of renewable energies in Poland, we need to focus first of all on restructuring the society, or rather on changing its way of thinking about what is beneficial for the nation and what is not. At the moment, coal is seen as the guarantor of energy security, as it has been one of the key elements of the country's development over the years, also during moments of crisis such as the communist regime in the years 1945 - 1989. Coal gave Poland an important position among the economically developed countries of Europe and made many countries commercially dependent on Poland. It is therefore not surprising that the Polish society, which for the most part still consists of people who remember the times of lack of energy security in their daily lives due to various historical turbulences, strongly relies on coal as an assurance of security and accepts modern technologies, unknown so far, with a certain reserve.

In order to change this system of thinking, an educational process of the Polish population is needed, which will show not only the benefits of using renewables, but also convince the public that Poland's energy security has long ceased to depend on the survival or destruction of the coal sector. In this context, the EU should focus on conveying a portrait of positive energy transition elements that will not worsen but improve people's lives in a more open and accessible way for the average citizen. The current JTM is strongly focused on the financial aspects, as if emotionally ignoring the elements that come from different experiences. After all, Europe is not homogeneous and interstate situations differ significantly from each other, and thus also the approach of European societies to changes.

Internally, educational campaigns aimed at bringing closer the positive aspects of renewable energies and overall energy transition are already being carried out by various NGOs as well as the government itself, which, however, while promoting coal as an indigenous element of Polishness, contradicts itself. Poland will fulfill the assumptions it set for itself and will end coal mining in 2049. However, educating the public and building a strong pro-environmental identity seems to be the key to achieving prominent results faster in this regard.

4.1 RES portfolio – how the JTF can support and navigate the Polish coal phase-out?

The financial factor is one of the main elements that Poland lists as drivers for achieving climate neutrality and total coal phase-out within its borders. Although the JTF and its resources are intended to meet the direst needs of the heavily industrialized regions and help them make an energy transition based on the introduction of renewable sources, the Law and Justice government is constantly trying to push the point of view that fulfilling the greenhouse gas reduction plan contained in the EU Green Deal will plunge Poland into debt for years to come. Jacek Sasin, the Polish Minister of State Assets, recently spoke out on this issue, arguing that Poland cannot afford to accept the ambitious Fit For 55 plan - a package of climate regulations introduced by the EU as part of the EU Green Deal, which is expected to reduce greenhouse gas emissions by 55% by 2030 (Bełdowicz, 2022). However, it is worth checking whether these words are not mistaken.

According to a report prepared by the European Parliament (EP) in 2021, Poland's greenhouse gas emissions reached an average of 10.4 tons of CO2 equivalent (CO2e) per capita in 2019, which is 2 tons more than the EU average of 8.4 tons (European Parliament, 2021, p. 1). In the same year, Poland accounted for 10.5% of the total GHG emissions of the whole EU, falling short of the targeted 19% reduction between 2005 and 2019, unlike the other EU MS (European Parliament, 2021, p. 1).



Figure 21. Total greenhouse gas emissions (tCO2e) per inhabitant in 2019 (European Parliament, 2021, p. 1)

At the European Council on July 21, 2020, it was decided to grant Poland as much as 4.4 billion EUR from the JTF to address energy transition needs in the regions most associated with the coal economy (Marynowicz, 2022). Upper Silesia will be the biggest beneficiary, with €440 million earmarked for the development of Silesian companies and €405 million targeted for the development of entrepreneurship in mining regions. Importantly, these funds can be used to create new pro-environmental infrastructure, including investments such as new wind farms, or increased solar panels (Marynowicz, 2022). These funds create significant support for already introduced government projects directed to support heavy industry transformation and RES development across the country. It is also worth noting that under the EU effort-sharing legislation, Poland has been given official permission to scale back the greenhouse gas reduction rate required by the EU Green Deal and now only needs to achieve a 7% reduction by 2030 in comparison to the emissions levels from 2005, which back then accounted for 306,745,980 tons (European Parliament, 2021).

As far as energy production is concerned, in 2021 it amounted to 173 583 GWh in Poland and consumption was equal to 174 402 GWh (Rynek Elektryczny, 2022). In fulfilling the Polish condition of energy security and independence, it is therefore necessary to consider the amount of consumption and to increase the capacity of power plants in such a way that they produce the amount of energy necessary to meet all needs without the need to import energy from abroad. In 2021, hard coal continued to be the leading raw material in energy production, from which roughly 91 998 GWh of energy was generated (Rynek Elektryczny, 2022). In comparison, in 2021 approximately 29 000 GWh of generated energy came from renewable sources (around 9% of general consumption) (Rynek Elektryczny, 2022). This means that in order to fully transform the way Poland generates energy to one based on renewables and eliminate coal, the share of green energy needs to increase about five times. The overall target of Poland is to increase the share of renewable energy in final energy consumption by at least 23% until 2030 (Reuters, 2021). In order to achieve that, Poland needs to boost its green energy capacity by 14%. In other words, in order to achieve 23% increase in share of renewable energy in final energy consumption, Poland needs to achieve approximately 40 115 GWh of energy coming directly from renewables, so 11 115 GWh increase.

Of the renewable contributions to overall generation, in 2021 around 15 000 GWh came from wind power, around 2800 GWh from hydropower, around 2000 GWp from solar panels and roughly 8000 GWt from biomass/biogas (Rynek Elektryczny, 2022). In order to calculate the needed investment costs to reach the 14% increase needed to achieve the target of 23% share of renewables in final energy consumption, the following investment benchmarks were taken into consideration:

Table 7. Investment benchmarks of renewable energy sources

Wind	1600 EUR/kWe
Biogas	5000 EUR/kWe
Biomass CHP	4500 EUR/kWe
Biomass HoB	600 EUR/kWt
PV	700 EUR/kWp

As of 2021, wind energy contributed by around 52% to overall energy generation from renewables, compared to roughly 28% from biomass/biogas and approximately 7% from solar panels. Based on that share, the predicted investment costs for the increase needed to reach the target of 23% will be calculated. In the biomass/biogas number,

biogas reflects for the bigger share, similarly to biomass CHP over biomass HoB. Therefore, as an assumption, biogas contributes by 15%, biomass CHP by 10% and biomass HoB by the remaining 3%. From the overall generation of electricity, 23% of energy generated in total is equal to approximately 39924 GWh. Therefore, investment needs to be made to increase generation of electricity from renewables by 10 924 GWh. Based on percentages provided before, 52% should come from the wind energy sector, so roughly 5680 GWh. Similarly, 28% should be generated from biomass/biogas, and with the division done before regarding that sector, this accounts for around 1638 GWe from biogas, around 1092 GWe from biomass CHP and roughly 328 GWt from biomass HoB. From the solar energy generation, 7% should be achieved, which equals to approximately 765 GWe. To equalize the units of measure, all were reduced to kWe and the assumed calculation states as follows:

Table 8. Calculation of investment costs needed in order to reach the renewable energy shared of 23% by 2030

Renewable	Price	The needed	Calculation	Total cost
energy source		amount		
Wind	1600	568000000	568000000 x	9 088 000 000
	EUR/kWe	kWh	1600	000 EUR
Solar	700 EUR/kWp	756000000 kWh	756000000 x	529 200 000 000
			700	EUR
Biogas	5000	1638000000	1638000000 x	8 190 000 000
	EUR/kWe	kWh	5000	000 EUR
Biomass CHP	4500 EUR/kWe	1092000000	1092000000 x	4 914 000 000
		kWh	4500	000 EUR
Biomass HoB	600 EUR/kWt	328000000	328000000 x	196 800 000 000
			600	EUR
Total				22 918 000 000
				000 EUR

The received sum of 22 918 000 000 EUR of investment costs related to achieving the target of 23% share of renewable energy sources in overall energy generation constitutes about half of the funds allocated to Poland from the JTF. Therefore, Poland would be able to achieve further stages of the energy transition without overexploiting its own budget and without the threat of bankruptcy or increasing public debt, at least in financial terms.

5. Conclusion

5.1 Summary of findings

The aim of this thesis was to present the essence of coal in Poland from various, so far rarely discussed, perspectives in order to present a more detailed picture of the problem of energy transition and shift to renewable energy inside the country. The research focused on the historical, political, social, and finally economic aspects of the coal economy in Poland and on analyzing the current state of the national renewable energies sector in order to draw conclusions on the next steps towards achieving climate neutrality by Poland earlier than in the 2049 planned by the PiS government.

The first part of the thesis presented the theoretical background of the thesis, namely discussed the background for understanding the problematic case of coal in the energy transition environment introduced by the regulations coming from the EU Green Deal. It also presented the harmful effects that coal combustion poses on the environment and set the background for the elaborative discussion over the need to eliminate coal-based economies to effectively fight over the climate change.

The second part of the thesis presented the situation of the coal industry in Poland, focusing on its historical aspects and thus drawing a picture of a country in which heavy industry has become almost a fundamental element of national identity. It discussed the current state of coal production and consumption in Poland, proving the ineffectiveness of the system and the necessity for radical changes. In order to explain the slow coal phase-out system, the socio-cultural and political aspects have been presented to illustrate the deeper problem of eliminating coal from the Polish economic system.

The third part of this thesis focused on the analysis of the current state of renewable energies in Poland. By analyzing all types of green energy sources, it has been proven that Poland does not achieve sufficient results in terms of the effective energy transition and does not even meet the targets set by the state itself. The analysis revealed the lack of adequate financing of green projects as well as the difficulties related to not so environmentally friendly national legislation concerning the renewables. Finally, in fourth part, the question whether the feasible scenario regarding coal sector in Poland can be achieved was answered by stating social education as a major key to success. In the absence of the political will to act to end the coal economy, it seems reasonable to say that Poland's achievement of climate neutrality must begin with a change in the mindset of a part of society still seeing coal as the core of the national energy security. Additionally, the costs connected with the achievement of 23% of the share of renewable energy sources in overall energy generation by 2030 were calculated to prove, that the funds from the JTF are sufficient to support the energy transition of Poland.

Ending carbon reliance on a national energy economy is essential to achieving climate neutrality and thus contributing to reducing the harmful effects of CO2 emissions on climate change and global warming. For this to happen, however, the social conditions of individual EU MS must be considered, not only for financial reasons, but also because of the moral model shaped around carbon among some nations. Time is running out and there are no positive changes on the horizon. It's time to change the attitude and concentration of EU climate-related policies not on grants and subsidies, but on people themselves.

Bibliography

Arak, P., 2019. *Why Poland couldn't sign up for Green New Deal*. [online] EUobserver. Available at: https://euobserver.com/opinion/146932 [Accessed 29 May 2022].

Bełdowicz, A., 2022. *Pekao: Polskę stać na Fit for 55. Nie stać nas na rezygnację (Poland can afford Fit for 55. We can't afford to give up)*. [online] Rzeczpospolita Polska. Klimat. Available at: https://klimat.rp.pl/ekotrendy/art19308911-pekao-polske-stac-na-fit-for-55-nie-stac-nas-na-rezygnacje [Accessed 6 June 2022].

Brauers, H. and Oei, P., 2020. The political economy of coal in Poland: Drivers and barriers for a shift away from fossil fuels. *Energy Policy*, [online] 144(1), pp.1-12. Available at:

https://www.researchgate.net/publication/343317160_The_political_economy_of_coal_in_Poland_Drivers_and_barriers_for_a_shift_away_from_fossil_fuels [Accessed 29 May 2022].

BIZNES ALERT, 2021. *ARP: Polska ma już mniej niż 80 tysięcy górników (Poland already has less than 80,000 miners)*. [online] BiznesAlert.pl. Available at: https://biznesalert.pl/zatrudnienie-gornictwo-wegiel-odchodzenie-od-wegla-sprzedaz-wegla-gornictwo [Accessed 29 May 2022].

ClientEarth Communications, 2019. *Coal in Europe: it's time to stop digging*. [online] ClientEarth. Available at: https://www.clientearth.org/latest/latest-updates/stories/coalin-europe-it-s-time-to-stop-digging/> [Accessed 29 May 2022].

Czyżak, P., 2022. *Change is in the Wind* | *Poland Wind Power Policy*. [online] EMBER. Available at: https://ember-climate.org/insights/research/change-is-in-the-wind/ [Accessed 3 June 2022].

Deutsche Welle, 2022. *Turow coal mine: EU to withhold Poland funds over dispute* | *DW* | *08.02.2022*. [online] DW.COM. Available at: https://www.dw.com/en/turow-coal-mine-eu-to-withhold-poland-funds-over-dispute/a-60705585 [Accessed 30 May 2022].

Dusiło, M., 2022. *Energy Transition in Poland. 2022 Edition*.. [online] Forum Energii. Available at: https://forum-energii.eu/en/analizy/transformacja-2022 [Accessed 1 June 2022].

Dziennik Gazeta Prawna, 2021. *Rozwój odnawialnych źródeł energii (OZE) w Polsce* (*Development of renewable energy sources (RES) in Poland*). [online] Serwisy.gazetaprawna.pl. Available at: <https://serwisy.gazetaprawna.pl/energetyka/artykuly/8077402,zrodla-energiiodnawialnej-w-polsce-oze-odnawialne-zrodla-energii-elektrycznej.html> [Accessed 30 May 2022].

Easton, A., 2021. *Turow: Vast Polish coal mine infuriates the neighbours*. [online] BBC News. Available at: https://www.bbc.com/news/world-europe-57484009 [Accessed 30 May 2022].

EURACOAL, n.d. *Poland*. [online] EURACOAL - the voice of coal in Europe. Available at: <https://euracoal.eu/info/country-profiles/poland/> [Accessed 29 May 2022].

European Commission, n.d. *European Green Deal*. [online] European Commission. Available at: https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_pl [Accessed 14 May 2022].

European Parliament, 2021. *Climate action in Poland. Latest state of play*. EU progress on climate action – How are the Member States doing?. [online] pp.1-6. Available at: https://www.europarl.europa.eu/RegData/etudes/BRIE/2021/698766/EPRS_BRI(2021)698766_EN.pdf> [Accessed 6 June 2022].

EUROSTAT, 2022. *Coal production and consumption see rebound in 2021*. [online] EUROSTAT. Available at: https://ec.europa.eu/eurostat/web/products-eurostat-news/-/ddn-20220502-2 [Accessed 20 May 2022].

Fodrowska, K., 2021. *Elektrownie wodne w Polsce*. [online] enerad.pl. Available at: https://enerad.pl/aktualnosci/elektrownie-wodne-w-polsce/ [Accessed 3 June 2022].

International Energy Agency (IEA), 2022. Poland 2022. Energy Policy Review. [online]InternationalEnergyAgency(IEA).Availableat:<https://iea.blob.core.windows.net/assets/b9ea5a7d-3e41-4318-a69e-</td>f7d456ebb118/Poland2022.pdf> [Accessed 1 June 2022].

International Trade Administration, 2021. *Poland - Country Commercial Guide - Energy Sector*. [online] International Trade Administration. Available at: https://www.trade.gov/country-commercial-guides/poland-energy-sector [Accessed 3 June 2022].

Kaczmarek, M. 2014. *Poland and its Strategy to reach European Renewable Energy Targets 2020*. Diploma thesis, Vienna University of Technology (TU Wien), Vienna.

Magazyn Biomasa, 2022. *Mapa biogazowni w Polsce (Map of biogas plants in Poland)*. [online] Magazyn Biomasa. Available at: <https://magazynbiomasa.pl/mapa-biogazowniw-polsce-naturalna-energia-2/?lang=en> [Accessed 3 June 2022].

Marynowicz, G., 2022. *W pogoni za Zielonym Ładem - Fundusze UE na "zielone" inwestycje (In pursuit of Green Deal - EU funds for "green" investments)*. [online] Bankier.pl. Available at: https://www.bankier.pl/wiadomosc/W-pogoni-za-Zielonym-Ladem-Fundusze-UE-na-zielone-inwestycje-8314387.html [Accessed 6 June 2022].

Mirowski, P., 2020. *IEO: 1,8 GW projektów wiatrowych powinno zdobyć pozwolenia na budowę - ŚwiatOZE.pl (IEO: 1.8 GW of wind projects should get construction permits - ŚwiatOZE.pl)*. [online] ŚwiatOZE.pl. Available at: https://swiatoze.pl/ieo-18-gw-projektow-wiatrowych-powinno-zdobyc-pozwolenia-na-budowe/ [Accessed 3 June 2022].

Moore, C., 2021. *Remaining EU Coal Power Polluters*. [online] Ember. Available at: https://ember-climate.org/insights/research/remaining-eu-coal-power-polluters/ [Accessed 29 May 2022].

Morningstar, R., Simonyi, A., Khakova, O. and Markina, I., 2020. *European Energy Diversification: How Alternative Sources, Routes, and Clean Technologies Can Bolster Energy Security and Decarbonization*. [online] Atlantic Council, pp.1-16. Available at: https://www.jstor.org/stable/resrep23548?seq=1 [Accessed 29 May 2022].

Planergia, n.d. *Trzy parametry, które powinien znać przyszły prosument (Three parameters that a future prosumer should know)*. [online] Planergia.pl. Available at: https://www.planergia.pl/post/trzy-parametry-ktore-powinien-znac-przyszly-prosument-1892 [Accessed 3 June 2022].

Prawo i Sprawiedliwość (PiS), 2019. 2019 Program Prawa i Sprawiedliwości (2019 Law and Justice Program). Polski Model Państwa Dobrobytu. KW Prawo i Sprawiedliwość.

Reuters, 2021. *Poland adopts 2040 energy 'compass' to navigate away from coal.* [online] Reuters. Available at: https://www.reuters.com/article/us-poland-energy-idUSKBN2A225K> [Accessed 6 June 2022].

RMF24, 2018. Andrzej Duda: Węgiel to największy skarb Polski. Nie pozwolę zamordować polskiego górnictwa (Andrzej Duda: Coal is Poland's greatest treasure. I will not allow to murder the Polish mining industry). [online] RMF24.pl. Available at: <https://www.rmf24.pl/ekonomia/news-andrzej-duda-wegiel-to-najwiekszy-skarb-polskinie-pozwole-z,nld,2714293#crp_state=1> [Accessed 29 May 2022].

Rolniczy Magazyn Elektroniczny, 2010. *Wiadomości Rolnicze. Wykorzystanie energii wiatrowej w Polsce* (Agricultural News. The use of wind energy in Poland). [online] Cbr.gov.pl. Available at: https://cbr.gov.pl/rme-archiwum/2010/rme40/dane/7_1.html [Accessed 3 June 2022].

Rynek Elektryczny, 2022. Produkcja energii elektrycznej w Polsce (Electricity productioninPoland).[online]Rynekelektryczny.pl.Availableat:<https://www.rynekelektryczny.pl/produkcja-energii-elektrycznej-w-polsce/>[Accessed6 June 2022].

Sawicki, B., 2022. *Mocno rośnie wydobycie węgla w polskich kopalniach (Strong growth in coal extraction in Polish mines)*. [online] Rzeczpospolita. Available at: https://energia.rp.pl/wegiel/art36219551-mocno-rosnie-wydobycie-wegla-w-polskich-kopalniach> [Accessed 29 May 2022].

Schwartzkopff, J. and Schulz, S., 2017. *Climate & Energy Snapshot: Poland: The Political Economy of the Low-Carbon Transition*. [online] E3G. Available at: https://www.jstor.org/stable/resrep17776?seq=1 [Accessed 29 May 2022].

Šefčovič, M., 2018. Modernizing our economies through the clean energy transition. *International Issues & Slovak Foreign Policy Affairs*, [online] 27(3-4, CODES OF E[U]NERGY), pp.3-10. Available at: https://www.jstor.org/stable/26592134?read-

now=1&refreqid=excelsior%3Afe4dee581bec0d8ac4e5e3fdfe53b33f&seq=2> [Accessed 29 May 2022].

Skłodowska, M. and Elżbieciak, T., 2021. Śmieci zamiast węgla i gazu. Przybywa spalarni (Garbage instead of coal and gas. There are more and more incinerators).. [online] WysokieNapiecie.pl. Available at: https://wysokienapiecie.pl/40523-smieci-zamiast-wegla-gazu-przybywa-spalarni/ [Accessed 3 June 2022].

Soliński, J. and Gawlik, L., 2012. *Rys historyczny, rozwój i stan obecny światowego i polskiego sektora energii (Historical outline, development and current state of the global and Polish energy sector)*. [online] Kraków: Instytut Gospodarki Surowcami Mineralnymi i Energi PAN, pp.142 - 149. Available at: <https://elektroenergetyka.pl/upload/file/2012/3-4/Solinski.pdf> [Accessed 29 May 2022].

Swadźba, U., 2001. Śląski Etos Pracy: Studium Socjologiczne (The Silesian Work Ethos: *A Sociological Study*). [online] Katowice: Wydawnictwo Uniwersytetu Śląskiego. Available at: https://www.sbc.org.pl/dlibra/publication/65240/edition/63211/content [Accessed 15 June 2022].

Szpor, A. and Ziółkowska, K., 2018. *The Transformation of the Polish Coal Sector*. [online] Global Subsidies Initiative (GSI). Available at: <https://www.iisd.org/system/files/publications/transformation-polish-coal-sector.pdf> [Accessed 29 May 2022].

Ślimko, E., Bartecka, M. and Pogoda, A., 2021. *Territorial Just Transition Plans for Polish Coal Regions*. [online] Bankwatch, pp. 1-19. Available at: https://bankwatch.org/wp-content/uploads/2021/10/2021-10-20_TJTP_Poland.pdf> [Accessed 4 June 2022].

Świat OZE, 2021. Jak wygląda rozwój biopaliw w Polsce? - ŚwiatOZE.pl (What is the development of biofuels in Poland? - ŚwiatOZE.pl). [online] ŚwiatOZE.pl. Available at: https://swiatoze.pl/jak-wyglada-rozwoj-biopaliw-w-polsce/ [Accessed 3 June 2022].

TPA Poland / Baker Tilly TPA, 2021. Onshore wind energy in Poland Report 2021.[online]DWFLPP.Availableat: https://sites-dwf.vuturevx.com/10/4168/uploads/onshore-wind-energy-in-poland-report-

2021.pdf?intIaContactId=4WOabLGV9g%2fOoV5%2bmKIj1g%3d%3d&intExternalSyst emId=1> [Accessed 2 June 2022].

U.S. Energy Information Administration (EIA), n.d. *Coal and the environment*. [online] U.S. Energy Information Administration (EIA). Available at: <https://www.eia.gov/energyexplained/coal/coal-and-the-environment.php> [Accessed 20 May 2022].

Widuto, A., 2019. EU support for coal regions. [online] EPRS | European ParliamentaryResearchService.Availableat:<https://www.europarl.europa.eu/RegData/etudes/BRIE/2019/642217/EPRS_BRI(2019)</td>)642217_EN.pdf> [Accessed 29 May 2022].

Wierzbowska-Kujda, M., 2022. *Ile ciepła produkuje się z odpadów? Raport URE (How much heat is produced from waste? URE report)*.. [online] Teraz-Środowisko. Available at: https://www.teraz-srodowisko.pl/aktualnosci/lle-ciepla-produkcja-z-odpadow-komunalnych-koszt-Raport-URE-11615.html [Accessed 3 June 2022].

Więckowska, M., 2022. Polskie biogazownictwo chce uwolnić swój potencjał. Raport nie pozostawia złudzeń (Polish biogas industry wants to unlock its potential. Report leaves no illusions). [online] Teraz-Środowisko. Available at: https://www.teraz-Środowisko. Available at: https://www.teraz-Środowisko. Available at: https://www.teraz-Środowisko. Available at: https://www.teraz-Środowisko.pl/aktualnosci/raport-biogaz-2022-potencjal-biogazownie-11685.html

List of tables

Table 1. Poland's 2020 status and 2020 and 2030 energy sector targets	26
Table 2. 2030 targets of EPP2040	28
<i>Table 3.</i> The evolution of onshore wind energy capacity in Poland (2013-2020)	37
Table 4. Polish biggest water systems and their power generation potential	40
Table 5. Timetable for the regional coal phase-out in Poland	50
Table 6. Declared CO2 emissions reduction targets by region in Poland	50
Table 7. Investment benchmarks of renewable energy sources	55

List of figures

Figure 1. Production of hard coal in the EU	4
Figure 2. Inland consumption of brown coal by the EU Member Sta	ates 5
Figure 3. Balance of domestic electricity production and consumption	ion in Poland 13
Figure 4. Structure of steam coal consumption in Poland in 2020	14
Figure 5. Consumption of hard coal in 2020 with voivodeship divisi	ion 15
Figure 6. Coal demand by sector in Poland, 2000 – 2020	16
Figure 7. Distribution of active coal-mining regions in Poland	17
Figure 8. Coal mining, electricity generation and number of emplo	yees in coal mining
in Poland from 1990 to 2018	21
Figure 9. Renewable energy in TFEC in Poland in years 2000-202	0 30
Figure 10. Renewable energy key metrics in Poland in years 2000-	-2020 30
Figure 11. Renewable energy in electricity generation in Poland in	years
2000-2020	30
Figure 12. Renewable energy in heating and cooling sector in Pola	and in years
2000 - 2020	32
Figure 13. Renewable energy in transport in Poland, 2004-2020	33
Figure 14. Wind distribution in different regions in Poland given in I	MW 34
Figure 15. Wind farms distribution in Poland	36
Figure 16. Sum of sun radiation in Poland per year	38
Figure 17. Location of the small hydropower stations in Poland	42
Figure 18. Location of the waste incineration plants in Poland	45
Figure 19. Location of the major biogas plants in Poland	46
Figure 20. Regions under the JTF process in Poland	49
Figure 21. Total greenhouse gas emissions (tCO2e) per inhabitant	t in 2019 54