



# Decarbonization of the Energy Sector in Poland – Gradual Process of Moving Away from Fossil Fuels

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## Abstract

*The paper presents the process of transformation of the energy sector in Poland. Energy transition mainly involves the gradual decarbonization of the economy and the shift towards renewable energy sources (RES). This process is linked to the European Union's climate and energy policy, which aims for Europe to become the first continent to achieve climate neutrality, as well as to the gradual depletion of energy raw material resources. In the case of energy, these raw materials are hard coal and lignite. The need to protect the climate and the desire to leave at least some of the energy resources to future generations forces such actions. The rising costs of obtaining energy resources also play an important role here. The first part of the paper shows how electricity production in Poland has progressed in the last twenty years. Total electricity production as well as production exclusively from hard coal and lignite are presented. The directions of the energy transition, mainly based on the government document Poland's energy policy until 2040 are also presented.*

*The subsequent section of the paper outlines the energy transition plans of Poland's principal electricity producers responsible for ensuring the stable operation of the energy system and maintaining uninterrupted supply of both electricity and heat.*

**Keywords:** energy, transformation, decarbonization, coal, renewable energy sources

## Introduction

For many years, the Polish energy sector has been undergoing a process of transformation from coal-based energy to energy based on renewable energy sources (RES). This process was initiated back in the 1990s, when Poland underwent a regime change and transition from a centrally planned economy to a market economy. These transformations mainly involve eliminating coal from the energy sector and households and replacing it with a cleaner and less environmentally damaging fuel, which is natural gas. The gas will also be used only temporarily as a transitional fuel, and ultimately the energy sector, and the entire Polish economy, is to switch to renewable energy sources.

Our country is not an isolated case. Already in 2019, the EU countries declared a gradual transition from conventional energy to renewable energy sources, so as to reduce emissions by 55% by 2030 (compared to 1990), and to achieve climate neutrality by 2050 [1, 2]. The pace of these changes varies across different countries and depends on how heavily a given country relies on fossil fuels for its energy and how quickly it is able to implement costly changes. Modifications are not only about replacing equipment, but also about social issues related to job loss, the need for retraining, or relocation. It should be remembered that conventional energy production based on hard coal is primarily concentrated in southern Poland, where the coal is extracted. In contrast, lignite-based energy is limited to a few industrial enclaves, the so-called fuel and energy complexes situated in just a handful of locations across the country. Spending on energy resources has also been steadily increasing. In 2023, Poland spent PLN 138 billion on this purpose, including PLN 4.7 billion on imports of raw materials from Russia. Since 2014, this amount amounts to PLN 1.2

trillion [3]. The decarbonisation process concerns not only the energy sector, but the entire economy. According to research from 2023, as many as 97% of companies face various challenges related to decarbonization. These are not only economic, but also technological and organizational challenges [4].

## Electricity production in Poland

Poland, like other countries aspiring to increase the well-being of their citizens, systematically increases electricity production. This is related to the increased demand for energy from the economy, as well as individual consumers, due to the increasing degree of utilization of electrically powered devices. The increased demand is also due to the increasingly common use of air conditioners, which is associated with high temperatures caused by climate warming. This trend is in line with the forecasts of the International Energy Agency (IEA), which predicts an increase in electricity consumption by 4% by 2027 [5]. It is estimated that global electricity consumption will increase by 3,500 TWh over the next three years. Naturally, these increases are due to increased demand in China, India, and Southeast Asian countries, while energy demand is decreasing in highly developed countries. According to data presented by Polskie Sieci Elektroenergetyczne (PSE), total electricity production in Poland increased by 2.05% year-over-year to 166.99 TWh in 2024 [6].

Figure 1 shows electricity production in Poland from 2004, the year of Poland's accession to the European Union, to 2024. There is a clear upward trend in production, reflecting the country's economic growth, although temporary downturns occurred due to global economic crises (2009) and the COVID-19 pandemic (2020).

The paper focuses on the types of energy sources. Over the past decades, electricity in Poland has primarily been gen-

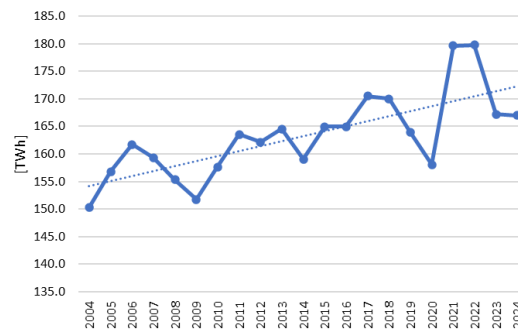


Fig. 1. Total electricity production in Poland. Source: [7]

Rys. 1. Całkowita produkcja energii elektrycznej w Polsce. Źródło: [7]

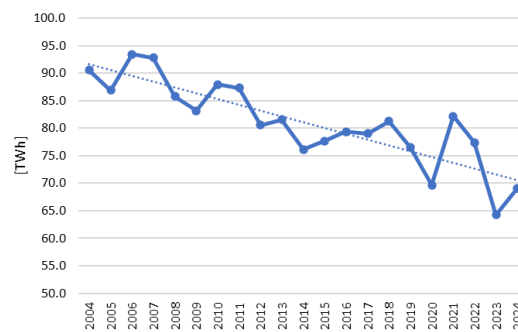


Fig. 2. Electricity production from hard coal in Poland. Source: [7]

Rys. 2. Produkcja energii elektrycznej z węgla kamiennego w Polsce. Źródło: [7]

erated from hard coal and lignite (Fig. 2). A clear downward trend can be observed. Given the ongoing energy transition, this trend is likely to persist.

Table 1 shows hard coal-fired power plants. These include both large power plants with installed capacity of more than 1 GW, such as: Koziencice Power Plant, Opole Power Plant, Połaniec-Węglowa Power Plant, Rybnik Power Plant and Jaworzno 3 Power Plant, as well as small power plants: Skawina Power Plant, Siersza Power Plant, Blachownia Power Plant, or Jaworzno 2 – (coal-fired) Power Plant. The above-mentioned power plants generated more than 50 TWh of electricity in 2023, accounting for more than 30% of the domestic production.

Fig. 3 shows the production of electricity from lignite. Similarly to hard coal, a downward trend can also be observed here. The reason for this phenomenon is similar – the decarbonization of the economy, as well as the depletion of accessible lignite reserves and the lack of approval for launching new open-pit mines such as Ościłowo [8] or Złoczew [9].

Table 2 shows all lignite-based power plants in Poland. In 2023, they generated over 34 TWh of electricity, which accounted for almost 21% of domestic production. Currently, in June 2025, the installed capacity of lignite-fired power plants and, consequently, the volume of production decreased, as on December 28, 2024, two coal-fired units of the "Pątnów" power plant with a total capacity of 444 MW were shut down [10].

Electricity production from lignite takes place in only a few locations in Poland: the Bełchatów mine and power plant, the Turów mine and power plant, and the Pątnów-Adamów-Konin Power Plant Complex (ZE PAK). The Adamów mine and power plant were closed in 2018, and the last coal

units at the Pątnów power plant, along with the Konin mine, are scheduled to cease operations in the first half of 2026.

According to PSE data, coal (both bituminous coal and lignite) and renewable energy sources (RES) accounted for 62.85% and 27.11% of total electricity production in 2024, respectively [6].

### Energy Transformation

In February 2020, the Ministry of Climate and Environment published the document Energy Policy of Poland until 2040 (PEP2040) [11]. This document sets the framework for the energy transformation in Poland aimed at building a low-carbon energy system. It was prepared in accordance with the guidelines of the Paris Agreement concluded in December 2015 during the 21 Conference of the Parties to the United Nations Framework Convention on Climate Change (COP21) [12]. PEP2040 is based on three pillars: Pillar I – Just Transition, Pillar II – Zero Emission Energy System, Pillar III – Good Air Quality. All activities must be subordinated to the main goal of energy policy, which is energy security. According to the Energy Law [13], energy security means a state of the economy that enables the coverage of current and prospective demand for fuels and energy in a technically and economically justified manner, while maintaining the requirements of environmental protection. The key indicators of PEP2040 include a maximum coal share in electricity generation of no more than 56% by 2030; renewable energy sources (RES) must account for at least 23% of final gross energy consumption by 2030; the first nuclear power unit is to be launched in 2033; greenhouse gas emissions are to be reduced by 30% in 2030 compared to 1990 levels; and pri-

Tab. 1. Hard coal-based power plants. Source: [7]

Tab. 1. Elektrownie opalane węglem kamiennym. Źródło: [7]

No.	Name	Installed capacity [MW]	Production [GWh]
1	Koziencice Power Plant	4 071,8	15 190,6
2	Opole Power Plant	3 408,0	11 304,9
3	Połaniec Power Plant (coal-fired)	1 649,0	5 688,2
4	Rybnik Power Plant	1 380,0	2 937,1
5	Jaworzno 3 Power Plant	1 380,0	2 329,8
6	Nowe Jaworzno Power Plant	910,0	3 234,2
7	Łaziska Power Plant	920,0	1 974,3
8	Dolna Odra Power Plant	908,0	2 378,8
9	Ostrołęka B Power Plant	690,0	1 760,1
10	Łagisza Power Plant	460,0	1 326,4
11	Skawina Power Plant	330,0	727,1
12	Siersza Power Plant	306,0	669,9
13	Błachownia Power Plant	165,6	357,1
14	Jaworzno 2 Power Plant (coal-fired)	140,0	448,8
	<b>TOTAL</b>	<b>16 718,4</b>	<b>50 327,2</b>

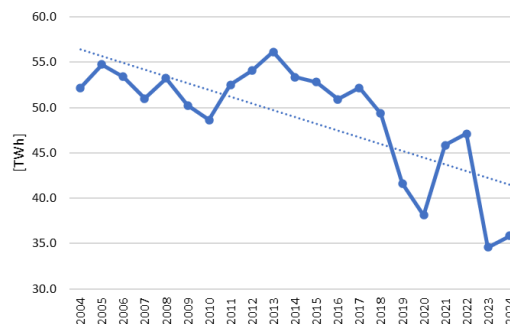


Fig. 3. Electricity production from lignite in Poland. Source: [7]

Rys. 3. Produkcja energii elektrycznej z węgla brunatnego w Polsce. Źródło: [7]

mary energy consumption is to be reduced by 23% by 2030 compared to the 2007 consumption forecasts [11]. These are the directions of activities intended for the implementation of Poland's energy policy, which, however, do not necessarily have to be fully implemented. Poland's energy policy assumes, in accordance with the Energy Law Act, a systematic (every 2 years) update of assumptions for the next 20 years.

An interesting direction of the energy transformation in Poland is the construction of nuclear units in coal mining areas. In March 2025, the Ministry of Industry announced that Konin and Bełchatów were the two preferred locations for the construction of the second nuclear power plant in Poland [14]. Such a solution is supported by the energy infrastructure located in these areas and the need to ensure continuity of employment for local residents.

The energy transformation means not only benefits, but also challenges faced by entities forced to carry it out. These represent significant costs that the Polish public must incur to reach climate neutrality in the future. Calculations by Prof. Mielczarski from 2022 indicate that the costs of Poland's energy transition will exceed 1,000 billion złoty under the gas option, and over 1,100 billion złoty assuming the construction of a nuclear power plant. A just transition should not be overlooked, as highlighted in the 'Poland's Energy Policy until 2040' document [11]. It states that by transforming coal regions, it is necessary to create new jobs and build new industries that participate in the transformation of the energy sector. Approximately PLN 60 billion was allocated to the transformation of coal regions. When transforming the economy, one cannot forget about the social agreement signed in 2021 regarding the transformation of the hard coal mining sector

[23]. The provisions in the agreement present a schedule for the termination of hard coal mining in individual mines by the end of 2049. Miners also received a statutory employment guarantee for all until the acquisition of pension rights [24]. However, the situation is changing dynamically and according to the Update of the National Energy and Climate Plan for 2030 prepared by the Ministry of Climate and the Environment, it is assumed that the domestic consumption of hard coal will not exceed 22.5 million tons in 2030 [25]. The report prepared by the Mining Chamber of Commerce and Industry shows that the liquidation of the industry is only a matter of time and may take place earlier than 2049 [26].

#### Energy transformation plans of major energy producers

The plans of the largest energy groups in Poland provide for a gradual transition to alternative energy sources. During the transition period, it will be mainly natural gas, but ultimately it will be nuclear and renewable energy. Thus, in 2020, Polska Grupa Energetyczna (PGE) SA announced a new strategy for decarbonizing production, predicting the achievement of climate neutrality in 2050 [16]. Also in the current year, the company's structural changes towards modern, low-emission methods of energy production have been maintained. During the 3rd scientific and technical conference "The Role of Conventional Units in the Era of Energy Sector Evolution" in Bełchatów in June of this year, it was announced that key projects include the development of large-scale nuclear power and SMR (Small Modular Reactor) technology, the expansion of renewable sources, the development of gas-fired power as a bridging technology, investments in energy storage, the construction of pumped storage power plants, the conversion

Tab. 2. Lignite-fired power plants. Source: [7]  
 Tab. 2. Elektrownie opalane węglem brunatnym. Źródło: [7]

No.	Name	Installed capacity [MW]	Production [GWh]
1	Bełchatów Power Plant	5 096,7	23 843,5
2	Turów Power Plant	2 059,5	9 421,6
3	Pałnów Power Plant	1 244,0	707,0
4	ZE PAK Power Plant	464,0	739,9
	TOTAL	<b>8 864,2</b>	<b>34 711,9</b>

of coal-fired units to biomass and biomass co-firing, and the development of post-mining areas for new industrial and service investments. The plans concern, among others, Rybnik, Dolna Odra, Opole, Turów and Bełchatów, i.e. the main centres of electricity generation in Poland [17].

TAURON Polska Energia SA foresees a similar transformation. The transformation of this energy group began in 2019. Tauron's so-called 'green transition' was announced and started at that time. In 2021, Class 120 coal-fired units with a capacity of about 1 GW were shut down and the process of and the decarbonization process of the heating sector was initiated through the construction of gas-fired boilers in Katowice and Bielsko-Biala power stations [18]. In 2022, Tauron sold its hard coal mines, which were part of Tauron Wydobywanie, to the State Treasury for a symbolic PLN 1 [19]. Further shutdowns of coal-fired power plants are planned. Specifically, this concerns the Siersza, Łaziska, Łagisza, and Jaworzno power plants, where Tauron owns ten units of 200 MW each, whose capacity market support system expires after 2025 [20]. Tauron's authorities are considering options for converting the Siersza power plant to another type of fuel, such as biomass, or creating an energy storage facility in the area.

Enea SA also intends to develop renewable energy sources (RES). The company's strategy from 2022 assumed the so-called green transition [21], which, as the name suggests, consists of developing Renewable Energy Sources based on modern technologies by 2030. ENEA'S current development strategy until 2035 still assumes the transformation of the company's operations. The main goal is a tenfold increase in the capacity of renewable energy installations to approximately 4.9 GW and a reduction in carbon dioxide emissions by at least 60%. The expansion of energy storage facilities with a capacity exceeding 1 GW is also planned, which is intended

to ensure the flexibility of the energy system and the stability of supplies [22].

### Conclusions

The decarbonization process has been implemented in the European Union for many years. This phenomenon can also be observed in Poland, although the process is somewhat delayed. It is related to historical circumstances. The Polish energy sector was based on coal in over 90% and although its share in the production of electricity and heat is systematically decreasing, it is not possible to switch the economy to other energy sources overnight. This is caused by a number of factors. One of them is the difficulty of finding a replacement for coal, which is a fuel that is easy to obtain (a large number of producers and exporters), easy to transport and store, and does not require the construction of transmission infrastructure like that needed for oil or natural gas. Consequently, it is less susceptible to terrorist attacks or supply disruption threats. Another factor contributing to the slow transition to alternative energy sources is cost. Gas, as a transitional fuel, is an expensive resource and highly vulnerable to fluctuations in global markets. Gas has been used as leverage in geopolitical strategies, particularly to exert pressure on specific countries or regions. The slow pace of decarbonization in the Polish economy is also driven by concerns about future stability and economic security. The unstable situation on global markets continues to delay investments over concerns regarding their profitability. At times, resistance to change on the human level is also a contributing factor.

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## *Dekarbonizacja sektora energetycznego w Polsce – stopniowy proces odchodzenia od surowców kopalnych*

*W artykule przedstawiono proces transformacji sektora energetycznego w Polsce. Transformacja energetyczna polega głównie na stopniowej dekarbonizacji gospodarki i przechodzeniu na odnawialne źródła energii (OZE). Proces ten związany jest z polityką klimatyczno-energetyczną Unii Europejskiej zakładającą osiągnięcie, jako pierwszy kontynent, neutralności klimatycznej oraz ze stopniowym szczypaniem się zasobów surowców energetycznych. W przypadku energetyki tymi surowcami są węgiel kamienny i węgiel brunatny. Konieczność ochrony klimatu i chęć pozostawienia przynajmniej części surowców energetycznych przyszłym pokoleniom wymusza takie działania. Również rosnące koszty pozyskiwania surowców energetycznych odgrywają tu ważną rolę. W pierwszej części artykułu pokazano, jak przebiegała produkcja energii elektrycznej w Polsce w ostatnim dwudziestoleciu. Przedstawiono zarówno sumaryczną produkcję energii elektrycznej, jak i produkcję wyłącznie z węgla kamiennego i wyłącznie z węgla brunatnego. Następnie zaprezentowano, głównie na podstawie dokumentu rządowego Polityka energetyczna Polski do 2040 roku, kierunki transformacji energetycznej. W dalszej części artykułu przedstawiono plany transformacji energetycznej głównych wytwórców energii elektrycznej w Polsce, czyli firm odpowiadających za stabilną pracę systemu i brak obaw o przerwy w dostawach prądu i ciepła.*

**Słowa kluczowe:** energetyka, transformacja, dekarbonizacja, węgiel, odnawialne źródła energii