

The future of hard coal compared to other energy carriers

Anna Manowska and Aurelia Rybak

Faculty of Mining and Geology, Silesian University of Technology, Akademicka 2,
44-100 Gliwice, Poland

anna.manowska@polsl.pl

Abstract. Primary energy sources in Poland are mostly fossil fuels, such as: hard coal, brown coal, natural gas, petroleum and other sources, which include, for instance, renewable energy sources. However, the major role is played by hard and brown coals. For many years hard coal has guaranteed energy security as well as energy independence and the forecast about the demand for net electrical energy [TWh] developed by the Ministry for Energy shows that coal will remain the leading source. Polish mining has been one of the most important industrial sectors for a long time, but for the last several years it has been in some dire straits. One of the main problems of the mining industry is lack of national strategy concerning the future of the fuel and energy sector, especially the energy mix.

1. Introduction

In 1990 the Polish government began the reorganization of hard coal mining in order to improve the financial situation of mines and to increase their competitiveness on the global market. Until the end of 1990 there were 70 operating mines in Poland, which employed 387 000 workers and extracted about 150 million tons of hard coal [1]. Currently, there are 23 operating mines, which employ 80 000 workers and extract about 70 million tons of hard coal [2]. The conducted reforms of coal mining included organizational, employment, financial and property restructuring. The reorganization was implemented in five political stages. The first stage between 1990 and 1997 abolished the centralized management system. In 1993 seven coal companies came into being. Between 1990 and 1997 the further 16 mines were closed down. The second restructuring stage took place between 1998 and 2002. 13 mines were closed down and the employment rate was reduced to 140 000. At the end of 2002 only 41 mines were in operation. The conducted changes in the hard coal mining sector caused an improvement of the financial situation of mines. Between 2003 and 2006 the third stage of hard coal mining restructuring took place. 9 mines were closed down, which left 32 mines with 121 000 employees. The fourth stage of the government's policy concerning hard coal mining restructuring occurred between 2007 and 2011. In July 2007 the government adopted another road map for hard coal mining. The premises of the programme were to reduce the coal extraction costs, to take advantage of cutting-edge mining technology, to manage coal companies effectively and to keep financial liquidity in mines.

2. European energy policy

An additional factor influencing the transformations occurring in the mining sector is adjusting the Polish energy sector to the requirements of the European Union [3]. The new Polish energy policy until 2030 is aimed at creating a common energy policy in the European Union and implementing its main objectives. Figure 1 shows energy policy goals for Europe [4, 5, 6].



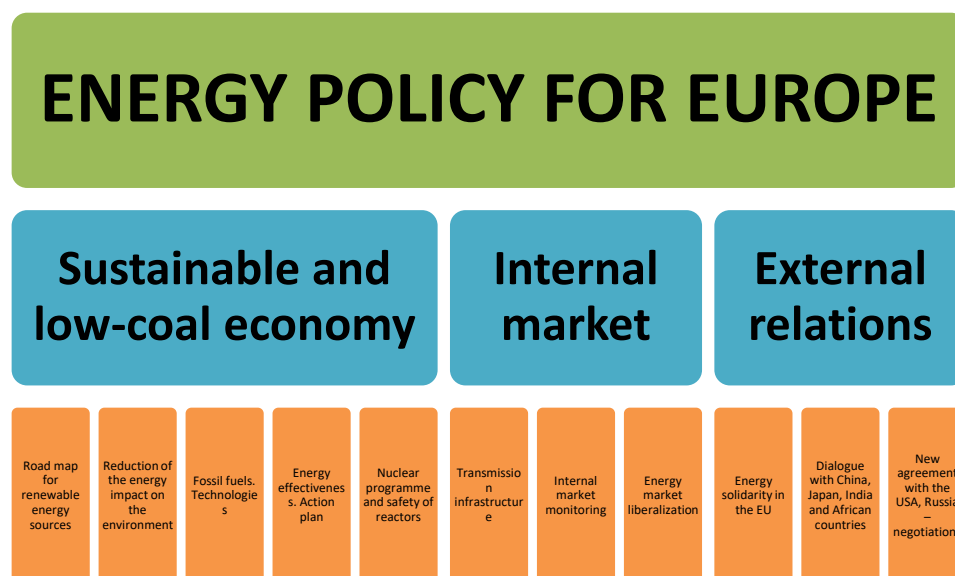


Figure 1. Energy policy for Europe [7].

The basic trends in the national policy are consistent with the main goals of the Community energy policy and include such steps as [7]:

- improving energy effectiveness,
- increasing energy security,
- developing renewable energy sources, including biofuels,
- developing competitive fuels and energy markets,
- reducing the impact on the environment.

The presented trends of the national energy policy fit into the goals of the climate and energy package in Poland, especially through:

- increasing energy effectiveness, treated as a priority which combines the realization of other goals of the new energy policy. The major goals of improving energy effectiveness are:
 - pursuing the zero-energy economic growth, i.e. economic development without a growing demand for primary energy,
 - by 2030 reducing the energy consumption of Polish economy to the EU level 15 from 2005.
- growing use of Renewable Energy Sources (RES). The major goals of the energy policy in this area include [8]:
 - growing use of renewable energy sources in the final energy balance up to 15% in 2020 and 20% in 2030,
 - in 2020 reaching the 10% share of biofuels in the transport fuels market and maintaining the level in the following years,
 - protecting forests from excessive exploitation to obtain biomass and sustainable use of agricultural areas for RES, including biofuels, so as not to cause competitiveness between renewable energy and the agricultural sector.
- the aim of reducing the impact of the energy sector on the environment includes goals and steps to reduce the greenhouse gases emission. The steps to reduce the CO₂ emission are, among others, introducing standards lowering the amount of CO₂ emission per electrical energy unit by 20%, which means that for just this one group the goal corresponds with the premise of the climate and energy package, i.e. the 20% reduction of greenhouse gases emission by 2020 in comparison to 2005, as well as the goals proposed in the ETS Directive of lowering CO₂ emission from the sources included in the ETS System by 21% in 2020 in comparison to 2005 [9].

3. Hard coal in the polish energy balance

The forecast developed by the Ministry for Energy predicts that by 2050 the demand for the energy from hard and brown coals should decrease by 15% and 80% respectively in comparison to 2010 [10]. While analysing the data from 2015, it is clearly visible that hard coal share in energy production has already decreased to the level set for 2050. On the other hand, the brown coal consumption has increased by 12% [11]. Hard coal share in the total demand for energy amounted to 46% in 2015. The predicted values are respectively 43% in 2020 and 33% in 2050. Table 1 presents a forecast developed for energy carriers by 2050. The data are given in TWh.

Table 1. Forecasts of demand for energy carriers by 2050 [12].

	2010	2015	2020	2025	2030	2035	2040	2045
Hard coal	87.9	72.5	76.9	75.9	79	84.4	88.8	82.3
Brown coal	48.6	58.4	53.8	49.6	38.1	11.1	11.3	10.7
Natural gas	6.8	5.8	11.8	11.9	13	18.4	17.5	23.3
RES	11.6	20.6	34	36.9	51.9	61.1	65.1	67.5
Nuclear energy	0	0	0	11.8	23.3	45.1	45.4	44.2
Other	2.6	1.4	1.4	1.4	1.4	1.4	1.4	1.4

Table 1 shows that the demand for hard and brown coals is decreasing, whereas there is a growing tendency for RES, natural gas and nuclear energy. It was assumed that from 2025 the energy mix will also include nuclear energy, whose share will gradually grow. However, these premises should be treated with caution, particularly because until 2017 no decisive efforts were taken in this matter and construction of a nuclear power plant takes about 10 years and costs about 5 million Euros/MW. It is also highly probable that the costs will exceed the predicted level and developed analyses of the investment profitability show that after 2040 nuclear power plants will lose their competitive advantage to wind farms or photovoltaics [13].

Another problem of the fuel and energy sector is the depletion of hard coal deposits, which is shown in table 2.

Table 2. Volume of the hard coal reserves in the active deposits as at 01/01/2015 (mln Mg) [14].

	Balance resources	Industrial resources	Operative resources
The licence duration	14 872	3 230	1 813
For the whole deposit	20 282	6 023	3 390

Taking into account operative resources in the amount of 3 390 million Mg and the current yield level of about 70 million Mg per year, the resource will last for about 48 years, i.e. until 2070, if only we take into account the usual decreasing yield in the final exploitation stage of coal deposits [11]. Obviously, while the coal share in the energy mix decreases, the deposit sufficiency will increase, but at the cost of energy independence. In order to ensure and maintain Poland's energy security, it is necessary to search for alternative solutions providing constant long-term energy supplies. Are renewable energy sources and nuclear energy a solution for Polish energy problems?

4. Renewable energy sources

Renewable energy sources are regulated by the following directives [7]:

- Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently

repealing Directives 2001/77/EC and 2003/30/EC on the promotion of electricity produced from renewable energy sources in the internal electricity market

- Directive 2009/72/EC of the European Parliament and of the Council of 13 July 2009 concerning common rules for the internal market in electricity and repealing Directive 2003/54/EC
- Directive 2005/89/EC of the European Parliament and of the Council of 18 January 2006 concerning measures to safeguard security of electricity supply and infrastructure investment
- The Law on Renewable Energy Sources
- The Directive of the Council of Ministers concerning the sequence of organizing auctions for sale of electrical energy from renewable energy sources in 2017
- The Directive of the Council of Ministers concerning the maximum amount and value of electrical energy from renewable energy sources which may be sold by means of an auction in 2017.

Currently, the renewable energy sources' share is 7% in Poland. The share is constantly growing and is about to reach the level of 15% in 2020. The development of renewable energy sources has an increasing impact on the shape of both the energy policy as well as construction of an electrical energy system [13]. It results from the fact that the EU regulations promote increasingly often the so-called clean energy sources and the climate package is aimed at 'low emissivity' or even 'zero emissivity' [13]. Due to this fact it is necessary to rebuild the Polish National Electrical Energy System, which must be adjusted to receiving energy from dispersed sources.

5. Nuclear energy

The plan to build the first nuclear power plant in Poland is a result of many factors, out of which a growing demand for electrical energy and new environment requirements are the most essential. The Ministry for Energy estimates that by 2030 the demand for electrical energy will have risen by 24%, from the level of 157.7 TWh in 2010 to the level of 206.8 TWh in 2030. Furthermore, the energy and climate package adopted in December 2008, ambitious goals of the climate policy in the European Union and the growing demand for energy resources import along speculative fluctuations of petroleum, natural gas and coal prices make nuclear energy an answer to the previously mentioned issues [14]. It is also necessary to remember about an impact a prospective nuclear power plant may have on Polish energy security, especially considering the uncertainty connected with future natural gas supplies from the east.

The society opposes the energy policy premises adopted by the Polish government, which treats building nuclear power plants as necessary. The first attempt in Poland was undertaken during martial law in 1982, but the society's consistent opposition thwarted the plans. The construction of nuclear power plants in Żarnowiec and Klempicz was suspended. The plans were resumed in 2005. In the next step the Polish Energy Group (PGE) and its daughter company PGE EJ1 planned to build a nuclear power plant between 2009 and 2014. Originally, it was supposed to supply electricity from 2019 [15]. Later the date was postponed several times until it was decided that the power plant was to start operating from 2031. In effect no works on constructing the power plant have begun.

6. Poland's energy structure until 2050

Figure 2 shows the energy structure of Poland until 2050 according to a study carried out by the Ministry for Energy. The study forecasts a gradual decrease in the demand for hard and brown coals. It is predicted that between 2030 and 2050 coal power plants will be gradually closed down. No new mines are being opened. They are replaced by renewable energy sources, nuclear energy and gas. The share of renewable energy sources in the total demand will increase to 33% in 2050. From 2025 nuclear energy will appear in the energy mix. Its share will be gradually increasing until 19% in 2050.

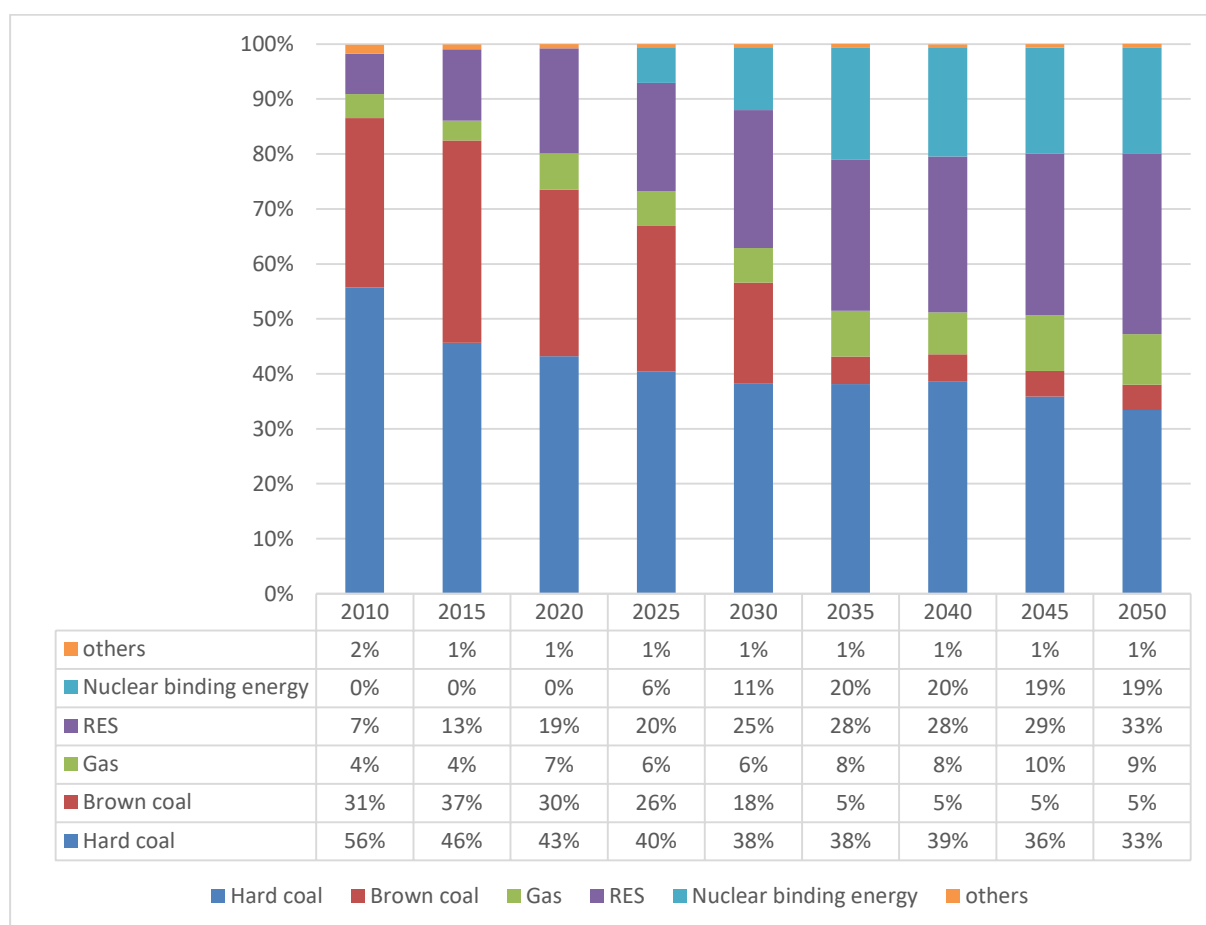


Figure 2. Structure of Poland's energy mix [12].

Figure 3 shows a detailed structure of the energy mix highlighting the most important changes occurring in Poland's energy structure.

The energy sector is changing. It is forced by acts and directives of the European Union. The discussed forecasts of the Ministry for Energy undoubtedly show the trends of these changes. Due to a high unpredictability of the energy market, the key issue is an analysis of mega-trends since they determine the direction of the energy development. Not only is it important to adapt to current conditions, but also to plan ahead. Therefore, it is crucial to answer the question whether the objectives will be accomplished within the determined timeframe?

Is it possible to determine if Poland will realize the EU requirements by 2050 only through analysing the potential of national energy sources and the rate of their development?

For this purpose, a statistical analysis has been carried out on historical data concerning the use of individual fuels to produce primary energy and changes resulting from the energy policy have been taken into account. Obviously, it is extremely difficult to capture the national and EU policies mechanisms in modelling, which significantly influences the model's credibility. Therefore, a theoretical model based on linear regression has been built. The model of the development tendency of individual energy carriers is characterized by the ex post error of 8% and Poland's energy structure until 2050 has been based on this model (figure 4).

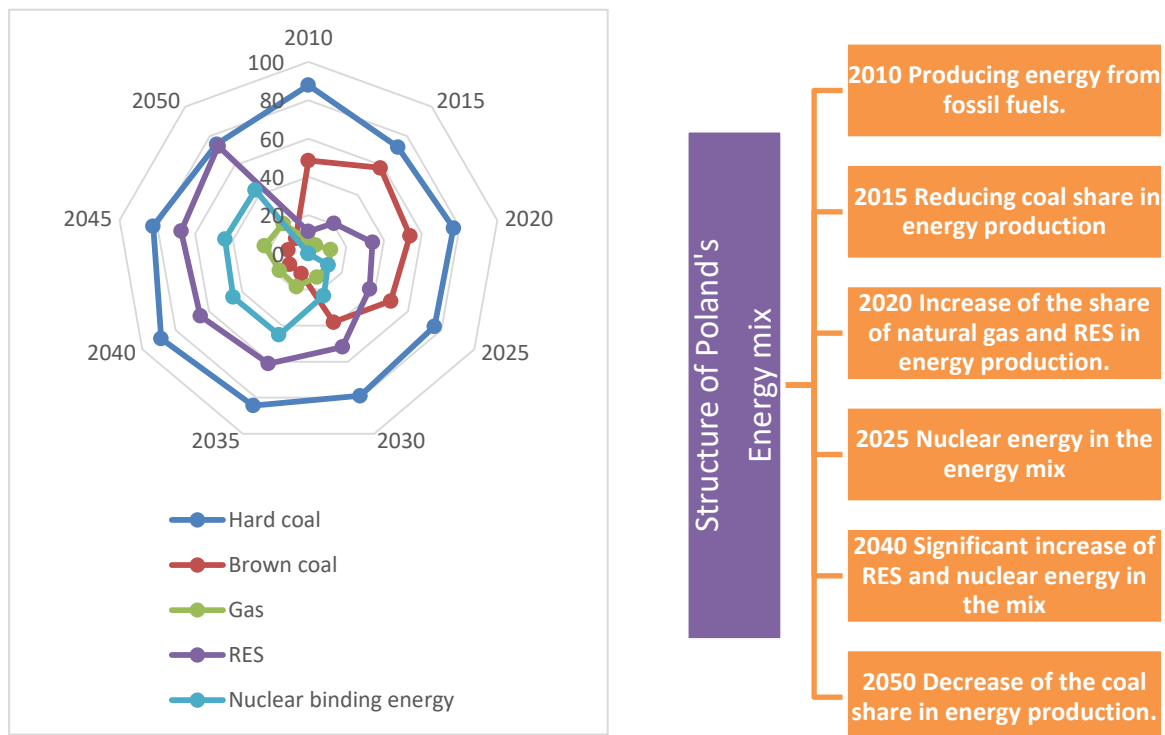


Figure 3. Structure of Poland's energy mix.

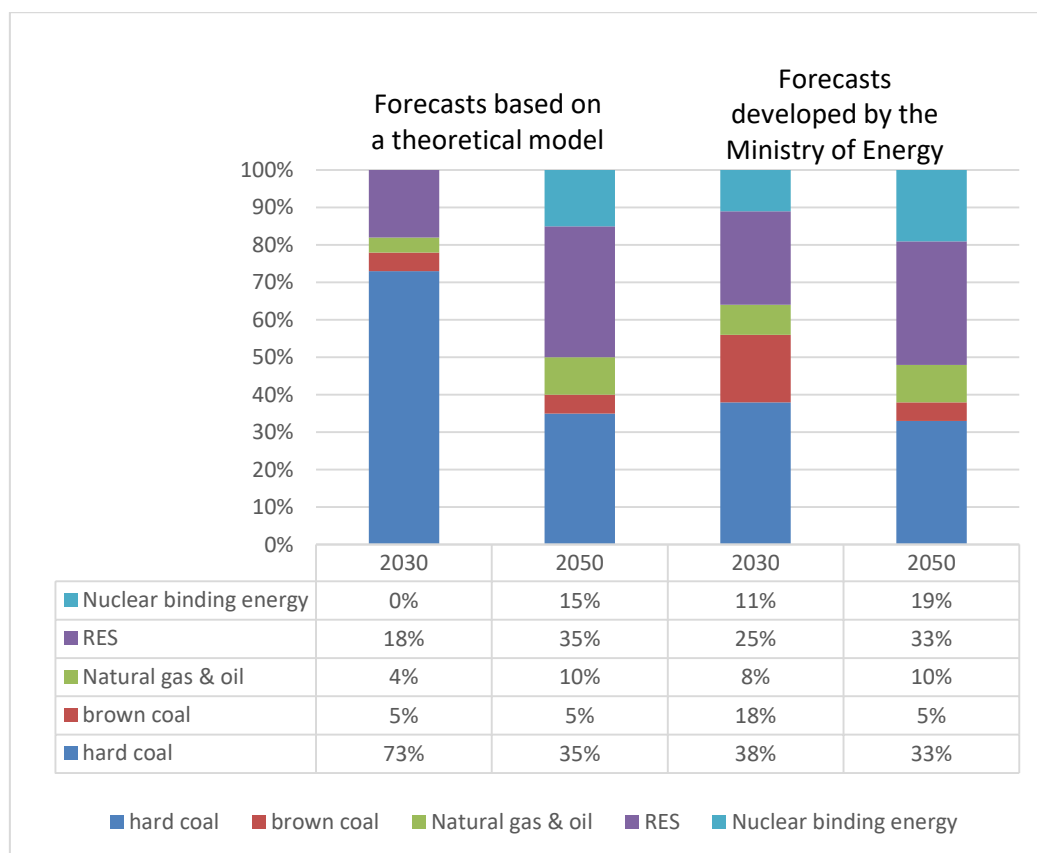


Figure 4. Forecasted structure of energy mix in Poland.

The constructed model undoubtedly proves that the objectives assumed by the Ministry for Energy concerning the energy structure between 2025 and 2050 will not be accomplished. The developed model shows the energy mix compatible with current trends and without undertaking further steps the objectives will not be attained. Problems with achieving the goals connected with nuclear energy and natural gas share are especially evident. The theoretical model shows the natural gas and petroleum shares as imported sources. The import will grow because Poland does not have such resources at its disposal as to be able to meet its own demands. It is also apparent that the energy sector will be mainly based on coal.

7. Conclusions

The Polish energy policy has been in preparation for many years and the proposed directions of actions are changing. Such instability disagrees with the development of the energy sector in Poland. A major part of the discussed steps concentrates on realization and implementation of the European Union policy. The Polish energy policy, apart from following the European Union expectations and implementing the Community regulations, should reach out to global trends in the energy development [7]. Additionally, there are numerous issues on the internal market, which include: running out of national hard coal resources, no effective programmes of developing RES on a larger scale, the necessity to rebuild the Polish National Electrical Energy System or large social reluctance towards nuclear energy. Poland also struggles with the problem of supplies diversification of energy resources, such as natural gas and petroleum, where it is important to create new supplies directions of these resources.

The developed theoretical model shows that the tendency of changes in the energy sector is not coherent with the postulates of the Ministry for Energy. The model solely includes programmes currently in progress but it is a suitable moment to show that it is high time to take necessary steps so as to keep commitments with regard to the energy mix or CO₂ emission. While analysing the forecasts developed for 2030-2050, it is obvious that coal plays a major part in primary energy production. Nevertheless, it is an extremely risky scenario if we consider the system costs, technology costs, problems with covering the national coal resources and increasingly rigorous environment standards.

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