Coal in Poland: After the sunset
Dr Michal Wilczynski[1]

A summary by Change Partnership

Hard coal still plays a significant role in global energy production. However, international efforts to reduce greenhouse gas emissions coupled with two decades of transformational change in the energy sector have led to a long term decline for this fuel. The first signs of the diminishing importance of hard coal has been evident since 2013. In spite of continuous growth in global hard coal consumption, its growth is falling at the fastest pace when compared to other fuels, and is even falling in absolute terms in the case of the OECD countries.

- *From 2013 the global consumption growth of coal was the slowest among all fuels*. This dynamic was created by a decline in coal use in China, where in 2014 for the first time since 1998, production fell by 100 Mt, while imports decreased by 36 Mt;[2]

- *China's coal imports, as well as national production, will continue to fall. In 2014, despite an increase in GDP of 7.3%, the increase in energy consumption did not exceed 3.9%, showing that the actions of the Chinese authorities towards reducing the energy intensity of the economy are starting to deliver visible results;*[3]

- *Since 2011 coal consumption has been growing in India. In 2014 it grew by 11.1% reaching over 9% share of the global consumption;*[4] *However, from a global perspective, this increase will only partly compensate for the decrease in Chinese imports. Energy Minister of India Piuysh Goyal announced a thorough reform of the energy sector, aiming to achieve 100 GW of installed solar capacity, 60 GW of wind power capacity, 10 GW in biomass and 175 GW in small hydroelectric power by 2022;*

- *In the period of steep price increases, low-cost producers of coal such as Australia, Indonesia and Russia started to expand their production and transport capacities–their launch coincided with a drop in demand in China, the US and the EU. As a result, there has been a serious decline in prices. Unlike oil, a rapid global increase of demand for coal in the future is unlikely, mainly because of the substantial potential for efficiency improvements in Chinese industry and energy sector and the RES programme in India;*

- *Between 1994–2003 global coal prices oscillated between 30–40 USD per tonne. The 65% surge in prices in*

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[1] Change Partnership www.changepartnership.org produced this English version summary of the report by Michał Wilczyński "Węgiel. Już po zmierzchu" (Coal. After the sunset), November 2015 in coordination with the author.

[2] VDKI *Preliminary report*, 2015.

[3] http://ieefa.org/chinas-declining-coal-dependence-evident-data/

[4] BP Statistical Review, 2015

2004 led to a period of instability which lasted until 2014. Since 2012 coal prices are coming back to the average of between 54–58 USD per tonne. The key question for producers is whether the prices will stabilise in this range, or return to the 1994–2003 prices;

- *Forecasts point to a further decline in prices due to existing large stocks of coal in Australia, Indonesia and the US, and decreasing demand, especially in China. Some experts[5] forecast that the price of thermal coal at around 50 USD per tonne will last until 2021 and the sector will never return to prices from the coal boom.*

These trends will have huge impacts on coal prices in world markets. Oversupply will cause a continuation of today's low prices and an irreversible end of the boom of the first decade of the 21st century. Changes in the global coal market pose a serious challenge for the Polish coal sector. Poland, one of the largest producers of hard coal and lignite in the world, is facing a number of difficult questions.

Polish and European policy makers must grapple with:
- How to effectively manage the still primarily state owned, mining sector?
- How to manage its transformation?
- What to do in the face of imminent depletion of coal reserves, when the reserves available for economically viable extraction would only last for approximately 18 years?
- How the energy sector and the authorities responsible for the country's energy security should prepare for the impending need to ensure coal imports?
- How to manage the exploitation of lignite when current reserves of this fuels are being depleted and new lignite mines will require tremendous investment in addition to environmental, climate change and social costs?

Heavily indebted coal production, staggering labor costs and the colossal cost of maintaining unprofitable mines adds to the sense of impending drama for coal in Poland. *Moreover, the depletion of domestic reserves, long term unprofitability of mines and an oversupply of hard coal on the global markets mean coal imports for energy production will have to increase from their current 10%–20% level to over 95% by 2050.*

The only solution to these challenges is a comprehensive strategy that includes not only a definitive restructuring of the mining industry, but also setting out realistic medium and long term goals for mining and energy sectors, compatible with global trends and business models.

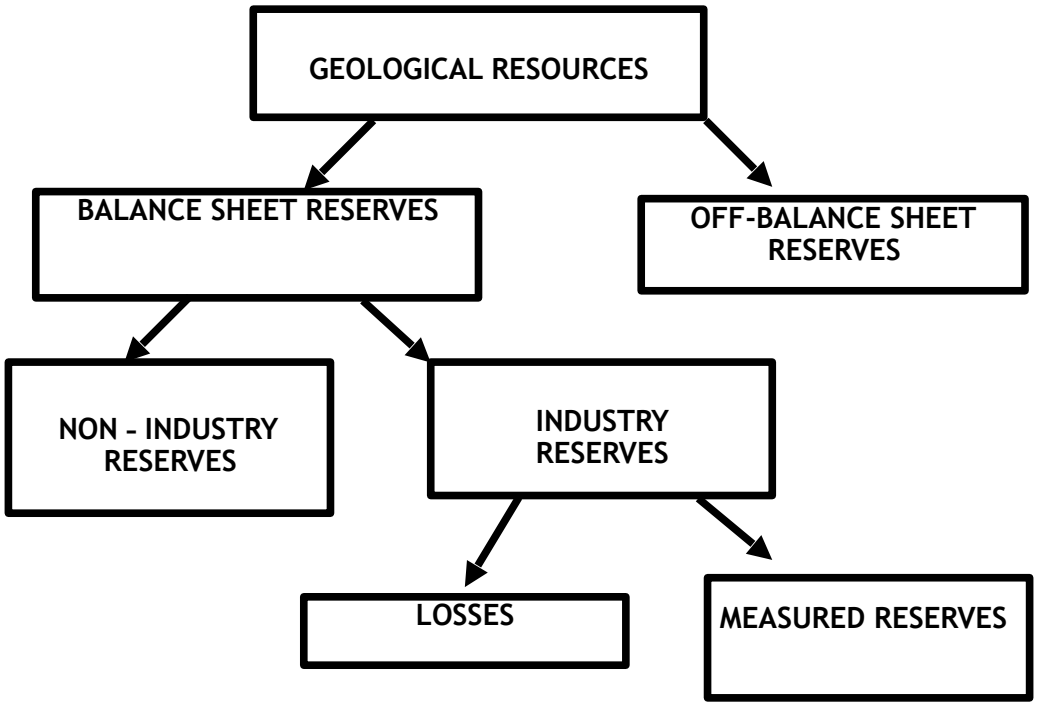
[5] Institute for Energy Economics and Financial Analysis. *The case for Divesting Coal from the Norwegian Government Pension Fund Global.* 2015

The myth of abundance of hard coal in Poland

The low efficiency of coal production in state owned mining companies, high labor costs, and increasingly difficult geological conditions, a decreasing demand in China, a national program of investment in renewable energy in India, significant oversupply of coal on the world market, the oversupply of coal in the internal market in the US, and increasing difficulties with obtaining new funds for investment–all raise a question mark over the future viability of the Polish hard coal mining industry. Dr Wilczynski, alongside other recognised Polish experts[6], predicts that there will be a sudden collapse of mining in Poland between 2025–2030 and that the extraction will be limited to 6–11Mt in 2050.

Hard coal deposits in Poland are located in three regions: Upper Silesia, Lublin region and in Lower Silesia. Authoritative assessment of the real size of domestic coal reserves is difficult as it includes both the documented reserves as well as the resources that are not documented in line with international standards, but may be available for extraction in the future. The results of calculations vary depending on geology, technology, economics of extraction, environmental requirements, and public acceptance of extraction by local communities. All these factors mean that merely formal classification is not sufficient to determine the profitability of production in a given deposit.

Polish classification of coal resources



The Polish system of classification of resources is not compatible with international standards as it does not adequately factor in the economic attractiveness of production. Introduction of classification in line with the standards of the United Nations Framework Classification for Mineral Resources (UNFCR) or Combined Reserves International Reporting Standards Committee (CRIRSCO) would enable a more accurate estimation of the real size of Polish reserves, especially the commercially recoverable ones.[7]

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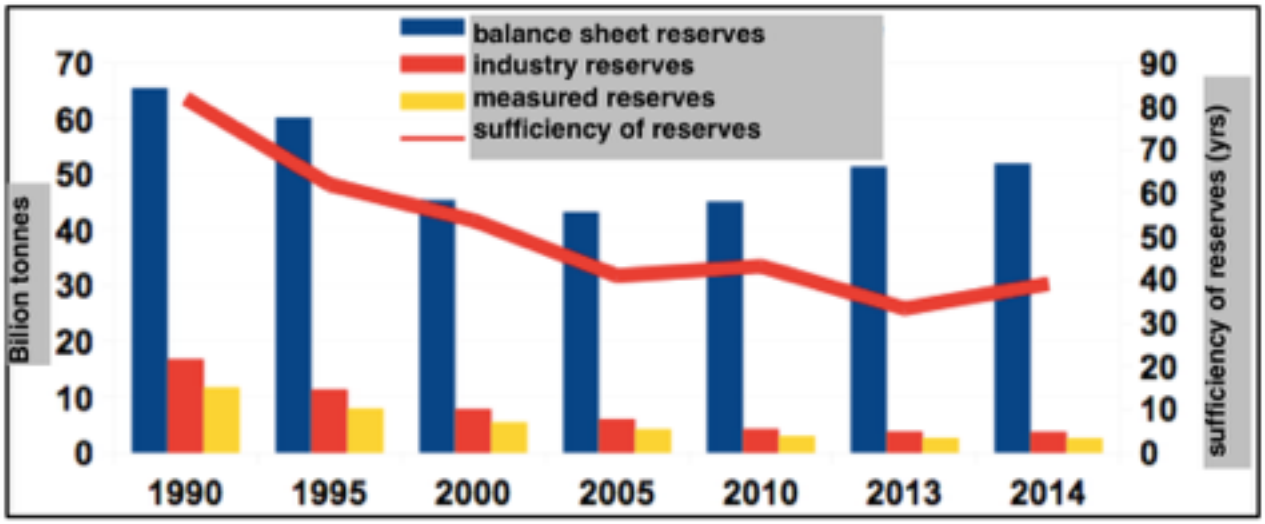
[6]Bukowski M., Maśnicki J., Śniegocki A., Trzeciakowski R. *Polish coal, Quo vadis?Perspectives of development of Polish coal mining sector,* Warsaw Institute for Economic Studies 2015

[7]International terms: *reserves or proven reserves* - economically recoverable reserves available for extraction at current prices and with application of available technologies. *Resources* - resources that currently can not be extracted for technological and/or economical reasons, or resources that are not sufficiently documented but available for extraction in the future. Both terms have no exact equivalent in Polish classification.

According to various estimates, at the end of 2014 the measured reserves of coal in Poland is sufficient for up to 39 years, provided the losses are at the level of 30%.

Structure and sufficiency of hard coal resources in Poland between 1990-2014[8]



However, according to the findings of a report by the High Chamber of Control[9] the sufficiency of reserves requires further downward revision. This report points out that losses in operational reserves reach on average 60% to double the level forecasted in their development plans. The main cause of such high losses is the longwall method of mining.[10] With this level of losses factored in the sufficiency of measured reserves is further reduced from 39 to 17.7 years.

Costly and ineffective restructuring programs

At the dawn of Polish independence in 1989, coal mining was the key sector in terms of number of employees (415,740 persons) and size of annual production (177.4 million tonnes). As of 1990, along with radical economic reform and the end of central planning system, coal prices have been linked to prices on the world market. In the period of 1993–1995, 44 thousand workers left the mining sector, i.e. approximately 13% of employees. During subsequent restructuring between 1996–2000, employment decreased by another 30 thousand.

The most mature restructuring program, equipped with appropriate legal and financial instruments and a well designed social protection package was introduced in the period of 1998–2002 under the government of Professor Jerzy Buzek. The program led to a reduction of approximately 115 workers by the end of 2002. at an estimated cost of 7,180 million PLN in subsidies and 6,900 million PLN in canceled liabilities. By the end of 2001 the programme achieved its main objectives, including net profitability of the sector. However, the next government loosened its policy towards mining industry to such an extent that 2002 ended with a net negative result of 609 million PLN. As a result, in 2003 the amount of state aid granted to coal mining

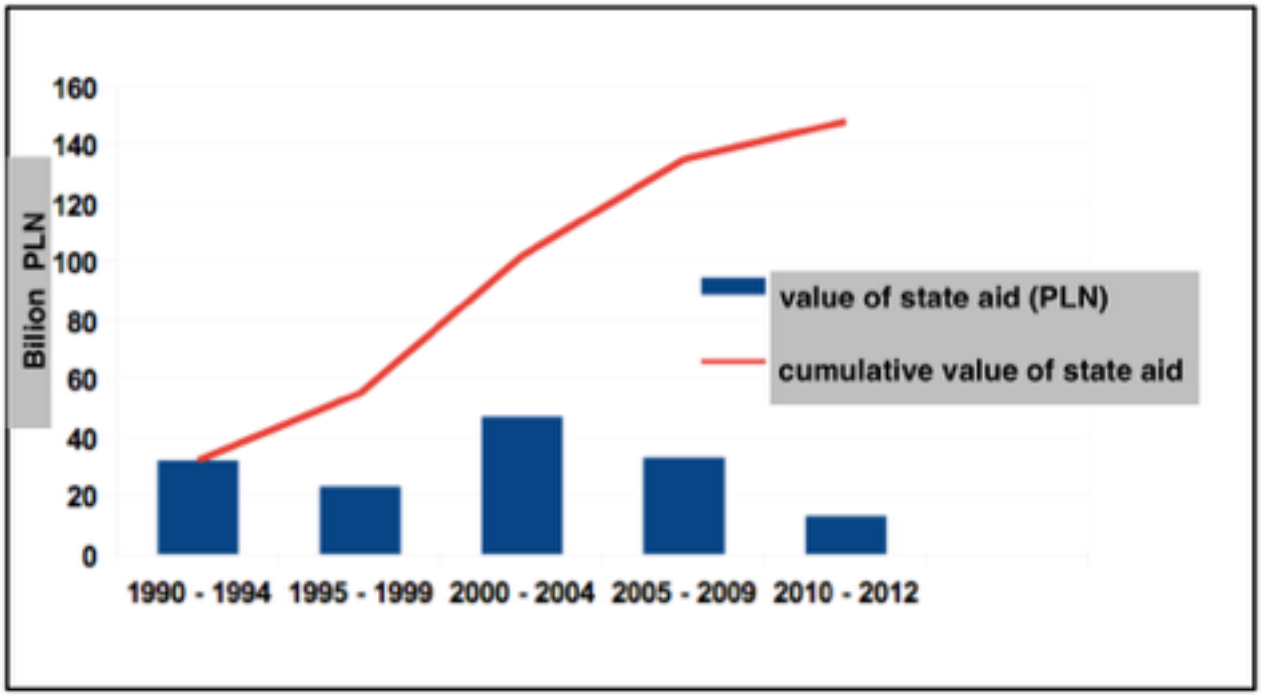
[8]Author's own estimate based on data from Balance-sheet of Mineral Resources and Undergound Waters for 31st Dec. 2014; Polish Geological Institute, Warsaw 2015.

[9]Results of the audit of security of supply of coal (domestic deposits), High Chamber of Control, 2011

[10]Popularity of long-wall mining system reflects the inconsistency of Polish mining industry aiming at profitable extraction at the expense of protection of resources. The advantages of long-wall method (high output, high efficiency and relatively safe working conditions) are undermined by huge losses in resources (The remains of a parcel curved into a geometric shape of the long-wall are included in the statement of losses.) source: Information accompanying the NIK report

shot up to a record high amounting to 2.4% of GDP.[11]

Public aid for coal mining in the years 1990 - 2012 (in 2010 prices.)[12]



Since Polish accession to the European Union, State Aid for mining companies is subject to strict regulation and each instance of public subsidy requires a notification to the European Commission. The Decision of the Council (2010/787/EU) adopted to facilitate the shut down of uncompetitive coal mines allows financial assistance exclusively for coverage of the cost of closures, setting the deadline for 31st December 2018.

Restructuring efforts since 1990 failed to significantly increase labor productivity. Between 1990–2014, coal production per employee in companies with a dominant share of the Treasury ranged from 550–650 Mt/year. For comparison, in the privately owned mining company Bogdanka SA productivity is more than double this amount.

The Ministry's of Economy 'Programme for coal mining activities in Poland in 2007–2015' points to: "... *the lack of normal relations between wage and labor productivity growth*". This diagnosis is correct, however during several years of high coal prices nothing was done to normalise this situation. In the first half of 2015 profitability of coal mining (calculated as the difference between the sale price and the cost of extraction) was at -14%.

Since 2013 Kompania Weglowa, the largest mining company in Europe, has produced coal at a loss. In the first half of 2015, Kompania was selling stocks at a much lower price than the extraction costs, causing a decline in coal prices on domestic market which negatively affected other mining companies. In 2014, the loss of coal sales for the entire mining industry amounted to 2,278 million PLN, and the liabilities of the coal mining sector amounted to 11.7 billion PLN ,including 693 million PLN of tax liabilities.

The restructuring programme limited to Kompania Weglowa proposed by the government in the summer of 2015 was to take place at the expense of energy companies. Companies controlled by the Ministry of

[11] M. Bukowski, Śniegocki *Hidden bill for coal - the analysis of economic support for the electricity and mining coal in Poland*. Warsaw Institute of Economic Studies, 2014

[12] Bukowski M., Maśnicki J., Śniegocki A., Trzeciakowski R. *Polish coal, Quo vadis?Perspectives of developement of Polish coal mining sector,* Warsaw Institute for Economic Studies 2015

Treasury were to provide the necessary funding through shares in the capital of a new restructured entity —Nowa Kompania Weglowa. These measures according to Wilczynski's own estimates would have been sufficient for the functioning of the new entity only for 3–4 months. Continuation of functioning of unprofitable mines in the current shape will cost 10–25 billion PLN up to 2020 according to the Ministry of Economy's own estimates.[13]

The reform of coal mining between 1990–2010, apart from the period of Buzek government, proved to be highly inefficient and costly for taxpayers. The root cause is inconsistency of actions, or inaction of successive governments, stemming from fears of miners' strikes.

Exorbitant direct costs of coal use in Poland are accompanied by external costs associated with emissions of pollutants. However, studies and analysis on future energy policy by the Ministry of Economy[14] and the Chancellery of the Prime Minister[15] completely ignore this issue. According to one independent study[16] the cost of production of energy from lignite almost triples with the inclusion of external costs. In official calculations which take into account only direct costs, production of 1 MWh from lignite costs 150 PLN, while the remaining 275 PLN is passed on to other market participants, mainly citizens.

[13] *Program naprawczy dla Kompanii Węglowej SA*. Ministerstwo Gospodarki, 2015.

[14] Ministry of Economy, *Polish Energy Policy until 2050* Draft for public consultation, August 2015

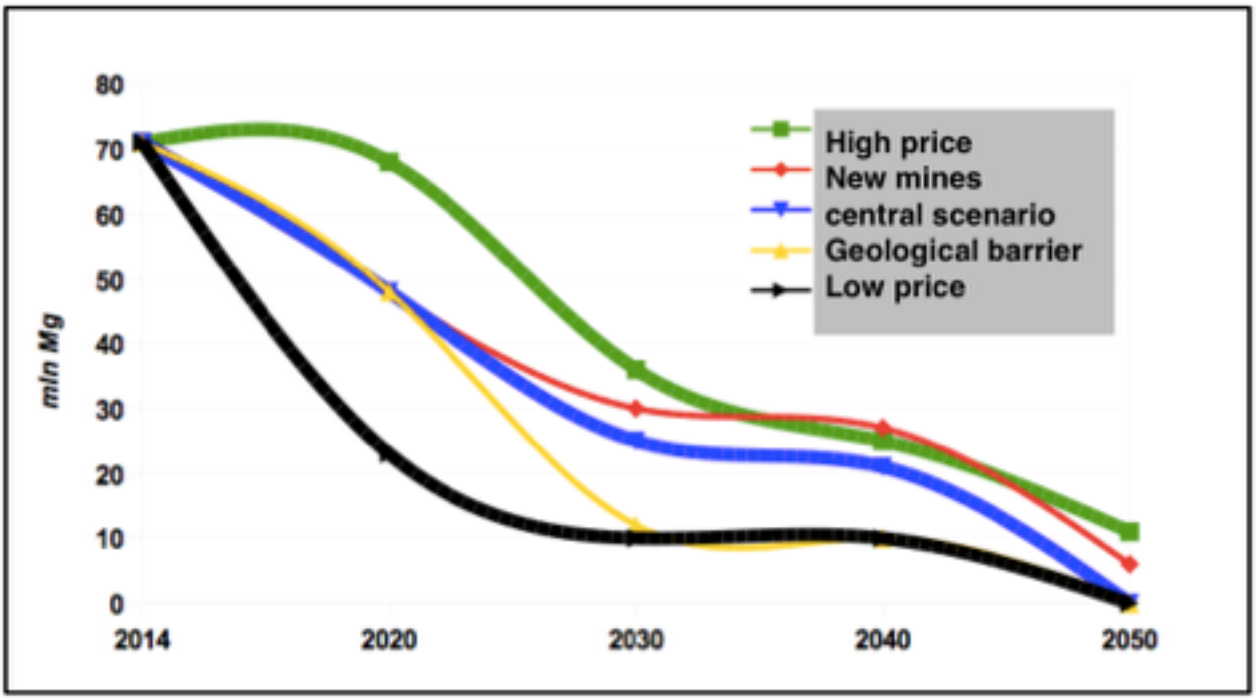
[15] Chancellery of Prime Minister, *Optimal Energy Mix for Poland by 2060*, Warsaw 2014

[16] Popczyk J. *Distributed power generation*, Institute for Sustainable Development, Warsaw 2011.

Future of coal in Poland–Reliance on imported coal or change of direction?

Rapid deterioration of the economics of coal mining in Poland between 2014–2015 sparked a serious debate about the future of the industry and its role in the energy sector. The key problem is very low productivity and related high labor costs per unit. However, even a successful restructuring effort will not enable the mining sector to function in unchanged shape in the coming decades. The forecast of the supply of coal up to 2050 carried out in one authoritative study[17] contains five scenarios, all pointing to a collapse of coal mining after 2020. All scenarios forecast closures of mines. In the extreme scenario of "low prices", a sharp decline in production volumes is forecasted even before 2020. Even in the two most optimistic scenarios, "high price" and "new mines," coal production in 2050 will decrease to 11 and 6 million Mt, respectively.

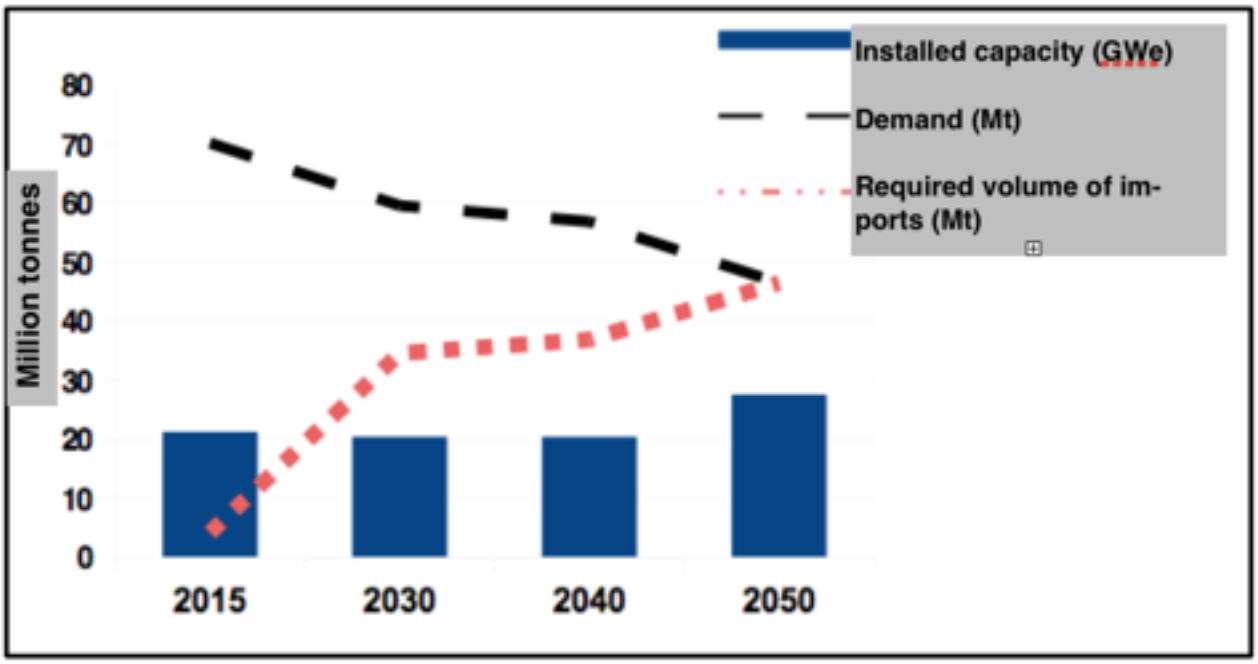
Forecast of coal mining in Poland up to 2050



The mining sector faces an inability to raise capital for investment in the reconstruction or construction of new mines as the largest banks are withdrawing from the financing of new coal assets. Withdrawal of shares by investors (including by Norwegian Pension Fund) from Polish mining companies listed on the stock exchange resulted in a decrease in value by 40%, of the economically healthy private mine Bogdanka in the first six months of 2015, while the shares of JSW SA mining company with a dominant share of the Treasury lost more than 70% of their value between July 2014 and July 2015.

[17] Bukowski M., Maśnicki J., Śniegocki A., Trzeciakowski R. *Polish coal, Quo vadis?Perspectives of developement of Polish coal mining sector,* Warsaw Institute for Economic Studies 2015

Forecast for hard coal in Poland[18]



Taking into account the forecasts of future coal prices on world markets, the current state of the mining sector and production forecasts, a growing need for future coal imports becomes obvious. Expansion of capacity of coal-fired power plants and CHP plants will result in a rapid increase in imports, and there is high probability that by 2050 the demand for coal will be almost entirely covered by these imports.

Environmental and social effects of coal mining and combustion

The impacts on the environment and society are visible in two different areas: as a result of mining operations and due to combustion of coal for energy production.

The main effects of mining activities include surface deformities, water pollution, waste and methane emissions:

- Coal production in Poland relies exclusively on deep excavation, sometimes 1,000 metres below the surface. Liquidation of mine excavations results in ground deformities on the surface. Continuous deformities cover almost the entire surfaces of mining areas, with land sinking values reaching up to 1 meter per year. Land sinking is a root cause of overflows, flooding and swamping in mining regions. In the Silesian Agglomeration land sinking can reach up to 30 meters in some areas. Discontinuous deformations on the surface are also commonplace in Silesia; they are difficult to predict, particularly harmful and dangerous as they cause damage to buildings, industrial facilities and transportation routes. An example being the newly built highway A4 which has been deformed by transverse cracks on several occasions.

- Mining requires the dewatering of rock mass, and the pumping of waste water usually into surface waters. Long term analyses of waters in coal bearing formations have shown the existence of 30 harmful substances (including sodium, potassium, ammonium nitrogen, iron, chlorides, sulphates, bar, boron). The levels of pollutants exceeds, by a few hundred to a thousand times, the maximum legally permitted values for water coming from the irrigation of mines. Significant concentrations of barium, lead, nickel, arsenic, selenium and radium, uranium and thorium are particularly dangerous for both people and

[18]Prepared by the author based on forecasts by National Agency for Energy Savings (KAPE) for Polish Energy Policy 2050 (Draft Version 0.6), 2013

environment.[19]

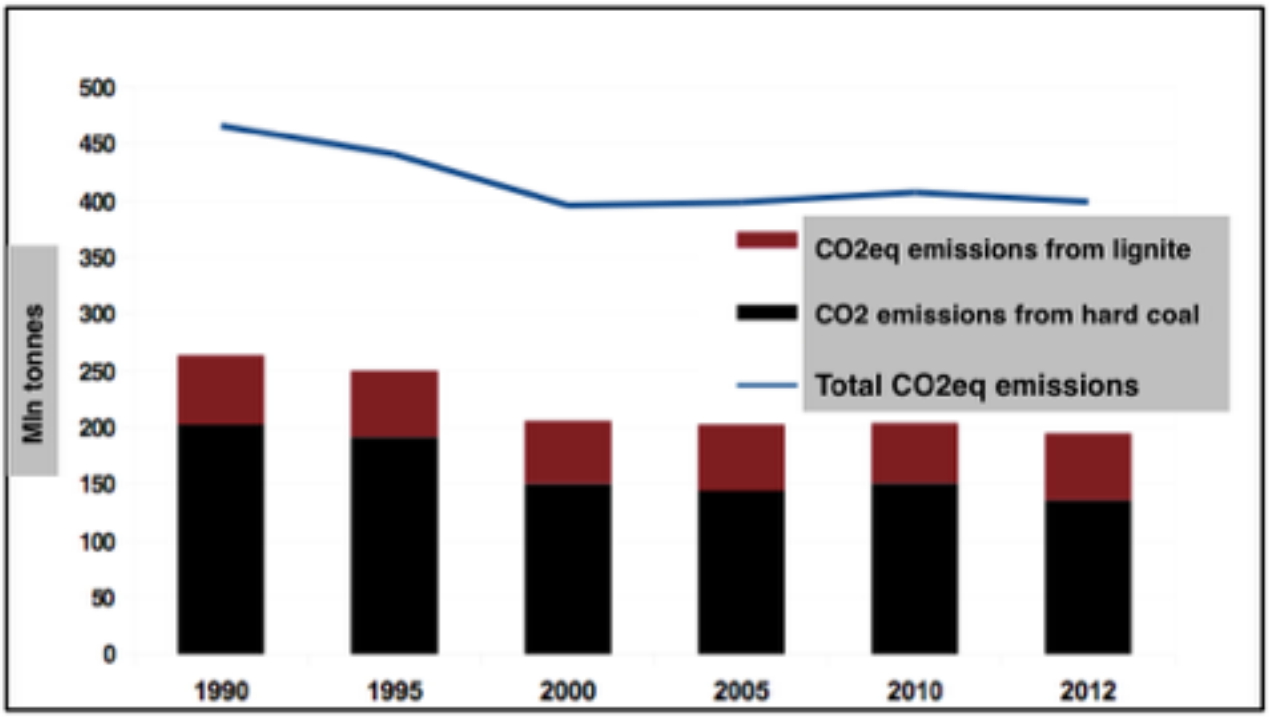
- Dumps with mining waste are inherent part of the landscape of Silesia; in the Upper Silesian Coal Basin the area of 2,331 hectares is degraded as a result of mining activities.[20] In the whole region there are 510 million tonnes of industrial waste, 76% of which is waste associated with coal mining.

- Methane drainage is treated by the mining companies solely as a way to prevent the risks of gas explosions. Very rarely is methane identified as a gas contributing to climate change and ozone layer depletion, and most of the captured methane is released into the atmosphere. In 2014 drainage mining stations captured 293.4 million m3 of methane.[21] There is lack of data on the share used economically and the share released into the air.

The main effects of coal combustion include GHG emissions, and emissions of other major pollutants and harmful heavy metals:

- Starting from the early 90s, greenhouse gas emissions in Poland have been decreasing mainly due to transformation of the economy and the liquidation or modernisation of energy intensive industries. CO2 emissions from the combustion of coal decreased by 66.5 million tonnes per year, therefore the reduction can be almost 100% attributed to the parallel reduction in coal consumption over 25 years.

Historical CO2 emissions levels[22]



[19]Olkuski T. Stala-Szlugaj K., *Presence of radioactive elements in hard coal from Upper Silesian Coal Basin, in the rocks, mine waters and waste*. Management of Mineral Resources vol. 25 IGSM Academy of Sciences, Cracow, 2009.

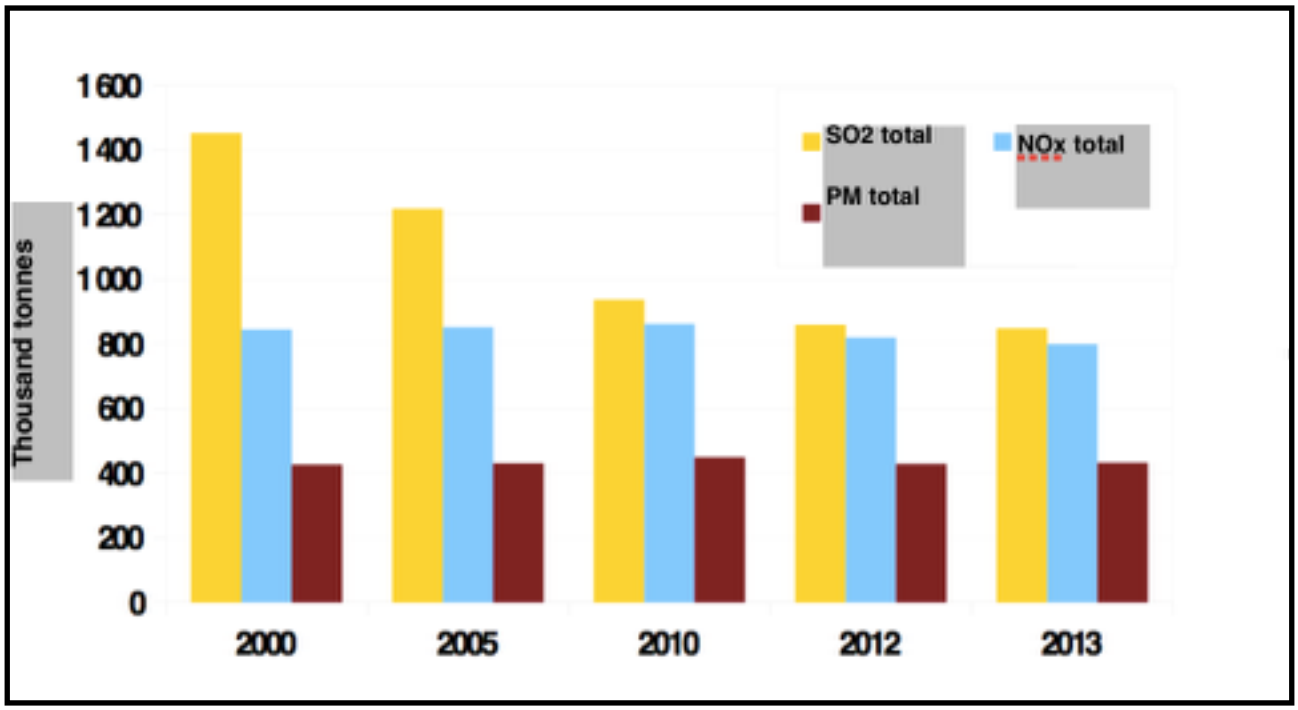
[20]Olkuski T. Stala-Szlugaj K., *Presence of radioactive elements in hard coal from Upper Silesian Coal Basin, in the rocks, mine waters and waste*. Management of Mineral Resources vol. 25 IGSM Academy of Sciences, Cracow, 2009.

[21]*Balance-sheet of Mineral Resources and Groundwater in Poland as of 31 December 2014*, Polish Geological Institute, Warsaw 2015.

[22]Author's calculation based on data from The National Centre for Emissions Balancing and Management (KOBIZE)

- Important reductions in emissions of sulphur dioxide were achieved between 2000 and 2013, slightly more than 41%. However, the emissions of nitrogen oxides and particulate matter remain unchanged since 2000. In 2013, the concentrations of PM10 above permitted levels were recorded daily in 36 of 46 designated monitoring zones. The main cause of the exceeded permitted levels of PM10 was dust emission from individual heating. Given the serious health implications, high levels of PM 2.5 are of particular concern. It is estimated that excessive exposure to PM 2.5 emissions in Poland will on average cause shortening of lifespan by 6 years.[23] The average exposure indicator (AEI) for PM 2.5 in 2013 in Poland was at the level of 26 ug/m3 and among all the other EU countries, was higher only in Bulgaria. Poland was among the seven countries which exceeded the ceiling of 20 ug/m3 by 2015 required by the Directive on Ambient Air Quality and Cleaner Air for Europe.

Emissions of SO2, NOx and particulate matter[24]



Between 2010–2013 Poland achieved significant reduction in emissions of cadmium and mercury, but there was an increase in emissions of arsenic and lead. Under the provisions of Industrial Emissions Directive, Poland will need to strengthen the control of emissions of heavy metals, including mercury, which is particularly dangerous for human health. Unfortunately, the annual report on air quality from National Institute of Environmental Protection (PIOŚ) does not include data on emissions of mercury in Poland. The health costs of mercury pollution have been estimated at 2.3 billion PLN[25], while the total costs of mercury pollution are estimated to be four times higher than the costs of health care, 3.7 to 9 billion PLN per year. Numerous other highly toxic compounds, often omitted in general publications, include dioxins, hydrogen chloride, hydrogen isotopes of uranium, mercury compounds, chlorine and chlorine dioxide gas as a component of the highly toxic dioxins. For example emissions of dioxins and furans in 2013 increased by around 7.3% compared to 2012. The source of 40% of these poisonous compounds is domestic combustion of coal and waste.[26]

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[23]Jagusiewicz A. *Challenges arising from the draft directive on ambient air quality and cleaner air in Europe (CAFE Directive)*. GIOŚ - Regional Forum CAFE

[24]Author's calculation based on reports by The National Centre for Emissions Management, *Poland's informative inventory report 2010. Poland's informative inventory report 2015*. PIB, KOBIZE, Warsaw

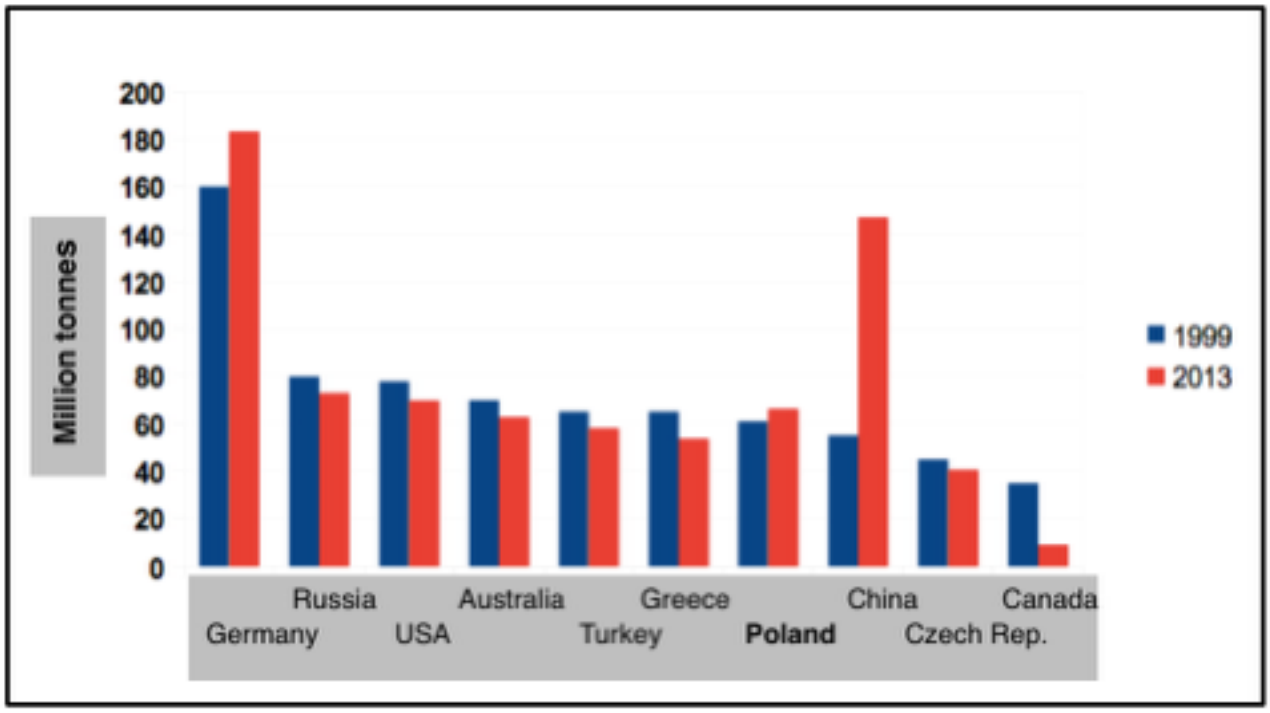
[25]Panasiuk D., et al., *Analysis of costs and benefits for human health and the environment related to the reduction of mercury emissions in Poland,* GIOŚ, Warsaw 2010

[26]*Poland's informative inventory report 2015*. IOŚ-PIB, KOBIZE, Warsaw, 2015

Lignite in the world and in Poland

Economically recoverable reserves of lignite documented globally amount to 280 billion tonnes. Lignite deposits are located primarily in Russia, Australia, Germany and the US. Global production of lignite reached its peak in 1989 (1,250 million tonnes), only to subsequently fall throughout the 90s (to 923.3 million tonnes in 1999), and to regrow over the next several years (up to 1,056 million tonnes in 2013). Europe's largest lignite deposits are located in Germany, Poland, Turkey, Greece and Czech Republic. Germany is the largest producer of lignite, both worldwide and in Europe.

Largest producers of lignite in the world[27]

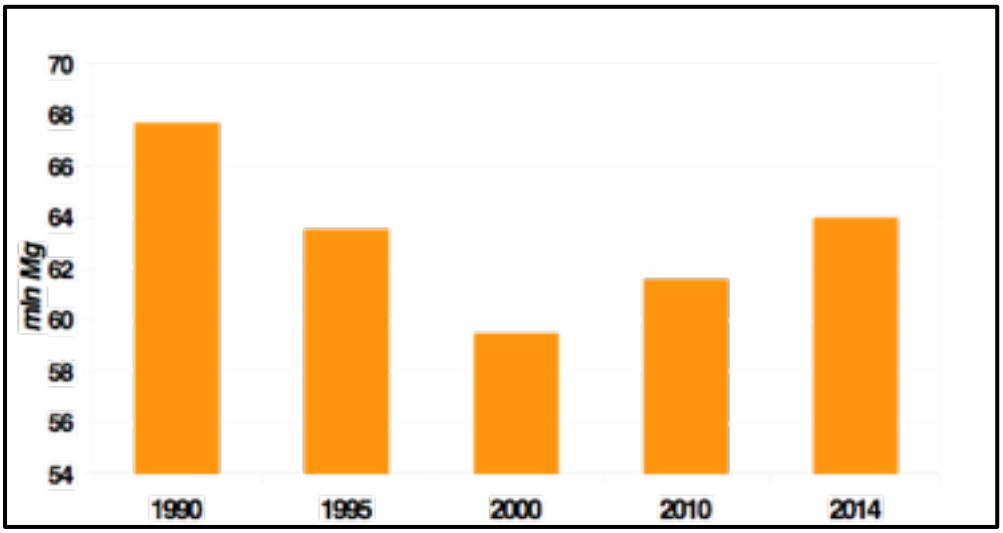


[27] *Energy study 2014, reserves, resources and availability of energy resources 2013*.Federal Institute for Geosciences and Natural Resources (BGR), Hanover, 2014

Lignite in Poland

At the end of 2014 total geological balance sheet reserves of lignite in Poland grouped in 90 deposits amounted to 23.5 billion tonnes—6% of which are recoverable reserves located in 9 developed deposits. Production of lignite decreased by 20% since 1989 (to 57 million tonnes in 2007), to begin to increase again after the start of the new 858 MWe power plant in Belchatow.

Production of lignite[28]



Overly optimistic scenarios for lignite

Several scenarios of economic development of Poland formulated in past decades, forecasted the annual production of lignite at about 65 million tonnes by 2030. Polish Energy Policy (PEP) until 2030, a governmental roadmap adopted in 2009, provides more realistic assumptions, forecasting production of lignite in 2020 to be lower by more than 8 million tonnes than in 2010, and amounting to less than 60 million tonnes in 2030.

However PEP 2030 states that "(…) *due to the gradual depletion of coal in currently operational deposits, exploration and opening of new deposits is planned in the horizon of 2030. For this reason, it is necessary to secure access to strategic resources of coal, including by protecting the areas where they occur from development of non-energy related infrastructure and to incorporate them in national and local spatial development plans and in the long term national development strategy*."[29]

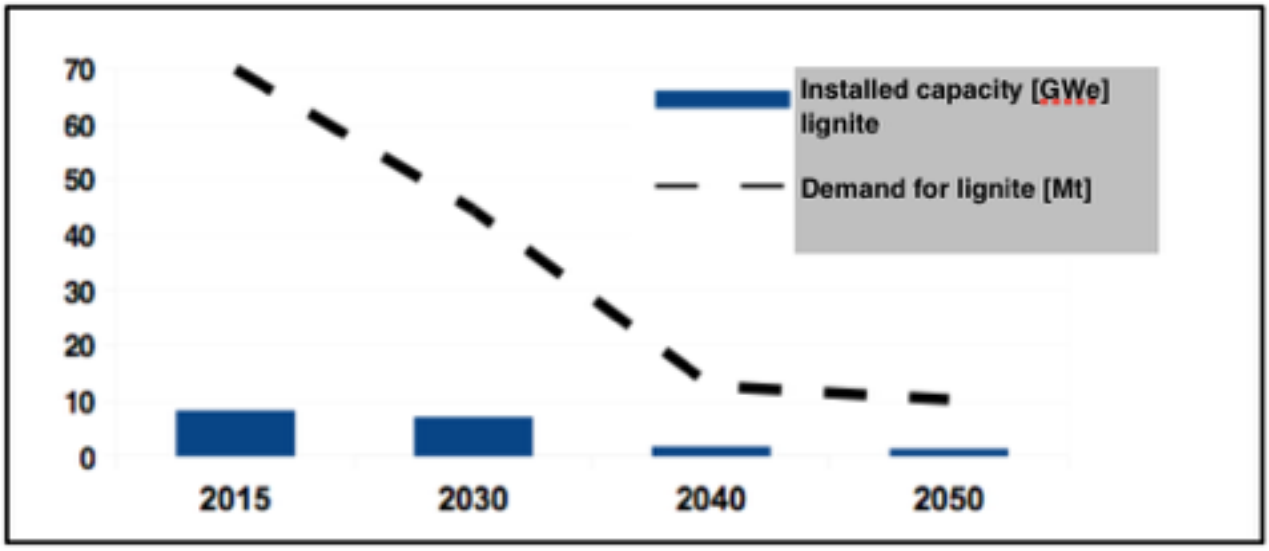
Similarly, a draft Polish Energy Policy by 2050 (PEP 2050) presented for public consultation in August 2015 by the Ministry of Economy envisages in its leading 'sustainable' scenario construction of new lignite mines in the near future. Realisation of these plans would make it impossible to fulfil the 40% emission reduction target included in the EU Council conclusions adopted in October 2014. For Poland this target translates into a reduction of CO2 emissions by 186 million tonnes per year. At the same time the annual decline in lignite mining, as a result of depletion of deposits, will reduce CO2 emissions only by 14 million tonnes per year.

Partial forecast, used as a starting material for preparation of the Polish Energy Policy until 2050 provides for gradual decline of installed capacity in power plants fired with lignite by 84% in 2050, and for exhaustion of reserves of lignite in majority of active mines already by 2040, with exception of only two open pit mines: Turow and Szczercόw where the output will remain at 20–30 million tonnes. The question remains whether the economy needs to build new giant mining energy complexes Gubin-Brody and Legnica?

[28] *Balance-sheet of Mineral Resources and Groundwater in Poland as of 31 December 2014*, Polish Geological Institute, Warsaw 2015.

[29] *Polish Energy Policy up to 2030*, adopted text, Warsaw 2009

Forecast of demand of the energy sector for lignite[30]



Over-reporting of size of resources of lignite

The overly optimistic forecasts of some experts show that lignite resources in Poland could be sufficient for 300 years of energy production. This simplistic prognosis is obtained by dividing the geological balance resources by the size of current annual production, without taking into account the economic, environmental and social factors, not to mention the operational losses.

Multifaceted geological, economic, environmental and social analysis[31] of 41 prospective deposits shows that only 5 locations can be realistically considered for production. In this situation Poland faces an alternative gradual abandonment of energy production based on lignite or construction of new open cast mines.

The aforementioned analysis establishes a ranking of 41 major deposits based on economic criteria. The evaluations based on environmental impact of the investment indicates particularly large conflict with the environment for 25% of the deposits potentially considered for development. Some should be excluded due to being located under urban areas, or in protected natural areas, others due to protection of agricultural land. As a result out of 41 fields that met the economic criteria, at least 12 had to be rejected because of the extremely high level of potential exploitation of the environment. Additionally, another 16 locations of deposits were in serious conflict with protecting the environment and were further analysed only conditionally.

In the next stage, the level of social acceptance was assessed taking into account factors such as unemployment rate, presence of mining industry, land use plans, community wealth, rate of industrialisation, population density, attractiveness for tourism and recreation, and the special nature of agricultural production

After this social evaluation, another 6 deposits were eliminated, however the authors note volatility in the public opinion with regard to construction of open cast mines and lignite-fired power plants. Examples include the communities of Gubin and Brody, which in 2006 expressed an unconditional approval for the investment, whereas in 2013 70% of the population taking part in the referendum was against the investment.

In summary, after consideration of economic, environmental and social factors only 24 out of 41 deposits can be deemed prospective and fulfilling approximately all of the criteria of the previously mentioned analysis. The total balance sheet reserves in these deposits amount to 5,241.2 million tonnes and converted

[30] Author's calculation based on prognosis of National Agency for Energy Savings (KAPE) for PEP 2050 (draft version 0.6), 2013

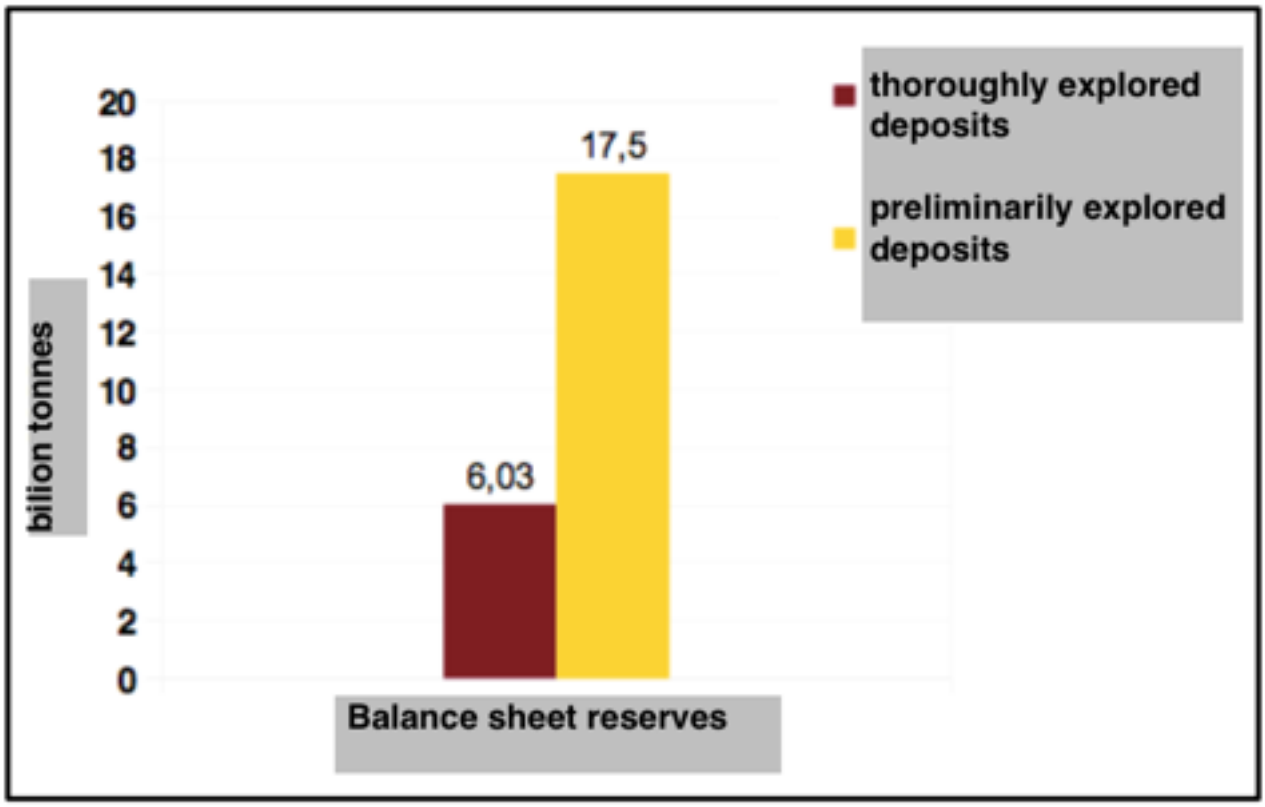
[31] Kasiński JR Piwocki M. Mazurek S. *Valorisation and ranking of lignite deposits in Poland,* National Geological Institute Vol.187, Warsaw 2006

into economically recoverable reserves amount to 3.7 billion tonnes.

However, the majority of the remaining 24 deposits are located in places of economic importance. Only 5 locations—Mosty, Trzcianka, Zloczew, Rogóźno and Gubin—with total balance sheet reserves of 2.6 billion tonnes can be considered prospective. After the deduction of operating losses, in practice 28%, the extraction of 1.87 billion tonnes is deemed possible.

Full assessment of prospects for development and use of these deposits would be possible after more detailed geological exploration. However, the geological balance sheet reserves that have only been preliminarily explored represent 3/4 of total proven reserves of lignite. The reserves that have not been thoroughly explored cannot serve as a basis for calculation of volume of readily available resources, nor affect the shape of the country's energy policy for next decades.

Stages of exploration of undeveloped deposits of balance-sheet reserves at the end of 2014[32]



The economics of production and use of lignite in Poland

Lignite is not a market commodity since close to 100% is supplied to nearby power plants and the sale price is essentially a form of settlement between the entities within the energy group. With regard to sales prices of lignite and the liberalisation of the electricity market Wilczynski notes two facts: decline in energy prices and rapidly increasing production from RES. The average selling price of electricity on the competitive market fell by 10% between in 2013 and 2014. In 2014 production of energy from lignite was lower by 4.82% than in the previous year. In turn, production from other sources grew rapidly, mainly for wind power, by 23.38% and gas by almost 4%.[33]

Serious scientific studies claim that the cost of producing electricity from lignite is lower by 50% than from hard coal.[34] This is true provided that the price of thermal coal on global markets exceeds 85 USD per

[32] *Balance-sheet of Mineral Resources and Groundwater in Poland as of 31 December 2014*. Polish Geological Institute, Warsaw 2015.

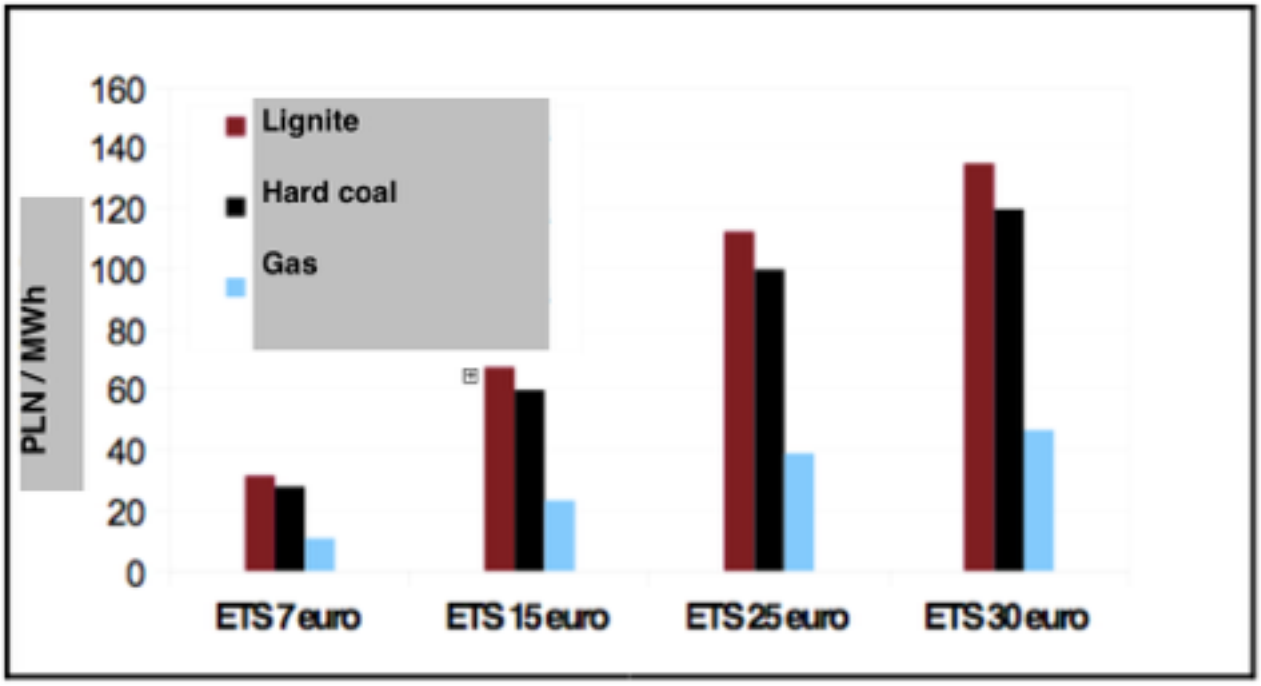
[33] *Report on the activities of the President of Energy Regulatory Office in 2014*, Energy Regulatory Office (URE), Warsaw 2015

[34] FOOTNOTE

tonne. Over the last 40 years this situation happened only between 2007–2013. Between 2014–2015 the price of thermal coal dropped to 50–60 USD per tonne. Wilczynski argues that prices will remain at low levels which means that the cost of lignite will be similar to, or slightly higher than, the cost of hard coal imports from ARA including transport costs. Thus the limit of "competitiveness" of lignite is the price of hard coal in the ARA market at 53 USD per tonne plus transportation costs to Poland.

CO2 emissions from combustion of lignite are at least 13% higher than from burning hard coal. Further increase in the price of ETS allowances will create problems for energy generation using both types of coal. The ETS price above 10 euros would require reduction by at least 20% of technical costs of lignite electricity production, in order to maintain the competitiveness of this fuel.

Forecast of costs of CO2 emissions for coal and gas fired power plants under different scenarios of ETS prices[35]



External Costs

General comparisons of the costs of electricity generation for various fuels overlook the external cost of mining and the combustion of lignite. Data from the NEEDS project[36] shows that operation of conventional plant with the capacity of 4,600 MW without CCS which meets emission standards in force after 2015 within the limits of standards, generates external costs of about 5 billion PLN/year. Operation of the same technology with more stringent emission standards generates the external cost of 3.8 billion PLN/year. Oxy-fuel technology allows to minimise the adverse impact of gaseous pollutants to a level of 0.7 billion PLN/year[37].

Wilczynski estimates that during the 40 years of operation of two planned lignite fired power plants (Gubin, Legnica), each with capacity of 4600 MWe the external costs, only with regard to emissions, would amount to between 28–200 million PLN. He argues that replacement of these power sources with RES is possible, as exemplified by Energiewende in Germany, where photovoltaic and wind annual power generation exceed total Polish consumption.

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[35] Author's own forecast

[36] *NEEDS – New Externalities Development for Sustainability*, www.needs-project.org

[37] Kudełko M. *External costs of electricity production for the proposed energy-mining complexes Legnica and Gubin and the energy sector in Poland,* 2012

The impacts of mining of lignite on the environment

In Poland, lignite is mined in 3 areas: Central Poland (Belchatow power plant), Greater Poland (Pątnów, Adamow Konin Power plants), and Lower Silesia (Turow plant). During the past 60 years the mines produced about 2,740 million tonnes of lignite, while a total of more than 10.45 billion m3 of overburden was removed. Drainage of deposits results in formation of a cone of depression, which causes desiccation of soil, decline in groundwater levels and landslides.

Examples of impact of lignite mining and combustion in key areas:

- The mining energy complex Belchatow in central Poland is a particularly good example of the destructive impact of lignite mining. The reoccurring seismic activity in the area caused displacement of hundreds of millions of tonnes of ground. Tectonic movements started in 1980 in the initial phase of the removal of overburden from the pit, the last one was recorded in November 2014. Average seismic activity over the past 30 years ranged from 4 to 4.9 on Richter scale. The Belchatow complex has significant impact on the reduction of water flows in all rivers within the cone of depression in the area[38]. To compensate for the removal of water, the construction of a water supply system serving more than 18 thousand people was required. Farmers in 123 villages in the region receive subsidies as compensation for soil desiccation.
- Major problem with the functioning of the mining energy complex Pątnów-Adamow-Konin (PAK) in Greater Poland include the use of lake water in an open circuit cooling system for two power plants; Pątnów and Konin I, and location of lignite mines supplying the fuel to the power plants in the immediate vicinity of a landscape park and nature reserve. Several other protected landscape areas and nature reserves and three Natura 2,000 sites are located in the region. Plans to build new open pit mines pose a serious threat to the unique natural and recreational values of Greater Poland.
- The mine supplying lignite to the power plant Turow in Lower Silesia led to deep environmental damage during the course of more than a century long operation. The pit covers the area of 28 km2 and the majority of drainage water is pumped into a neighbouring river. The plan to move operations further south will result in an increase in polluted water infiltrations due to increasing number of permeable layers. The power plant Turow, despite extensive modernisation in the last 20 years, is still one of the largest sources of greenhouse gases in Poland and 19th in Europe[39].

Increase of emissions from combustion of lignite

Five years ago there were hopes that emissions from lignite combustion would drop significantly after old units with total capacity of 600 MW were shut down in Turow and with the start of modern highly efficient units with supercritical parameters—the new 858 MWe unit at the Bełchatów power plant (which additionally was supposed to be equipped with CCS installation) and the 474 MWe unit in the Pątnów II. Annual reduction of CO2 emissions by at least 5–10 million tonnes was forecasted at the time. However, in 2012 after the completion of the above mentioned investments, the emission benchmark rose to a level almost identical to that from 1990 which with an increasing consumption of lignite has increased the emissions by 6 million compared to 2010. The share of CO2 emissions from combustion of lignite in relation to total emissions of greenhouse gases rose by 15% between 2010 and 2012. The reason for the failure to reach the intended parameters of CO2 emissions is left without explanation.

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[38]Wachowiak G., Galiniak G., Ionian W., Martyniak R. *Assessment of runoff in the catchment of Widawka river in the hydrogeological year of 2010 under the influence of mining and energy investment in the region of Bełchatów*. Mining and Geo-engineering, Vol 35, Issue 3, AGH Cracow, 2011

[39]*Dirty Thirty – Ranking of the most polluting power stations in Europe*. WWF, Brussels 2014

Combustion of lignite generates significant amounts of toxic gases such as sulphur dioxide, nitrogen oxides, and particulate matter. The share of sulphur dioxide and nitrogen oxides in total emissions of these gases is relatively small taking into account the share of lignite in energy production—this can be explained by a good technical condition of boilers. The main pollutant is mercury and its compounds, other heavy metals are emitted in small amounts.

Public opposition to new projects

Plans to launch new lignite mines (Tomisławice, Gubin-Brody, Legnica,) face growing public resistance. In addition to the leading role of national and international environmental NGOs, vocal and active anti-lignite protests and actions are being regularly organised by civil society organizations, community associations and local authorities in the affected regions. One example is the planned exploitation of the deposit of Legnica which poses a threat to approximately 10 thousand hectares of forest, and a number of nature reserves, ecological and landscape protection areas and the Natura 2000 network elements in the area. If the project goes ahead, the resettlement of around 20 thousand people may be necessary. The investment is under attack by a civil society campaign "Stop Odkrywce", protests, demonstrations, parliamentary questions.

The referenda in municipalities where new investments are being planned show that up to 90% of voters oppose construction of power plants and open pit mines. The voices of local communities, however, are clearly underestimated by the government, as reflected in the draft PEP 2050 (August 2015) which states that "…*From the point of view of maintaining a high level of energy security the government considers it expedient to provide conditions for the exploitation of lignite deposits, among others, in deposits in the vicinity of Legnica and Gubin*".

Conclusions

Mining of coal, especially deep excavation mining is globally in its the final stage globally. As a result of well-developed mining of shallow coal deposits (Australia, Indonesia, Colombia, South Africa, Russia), the price of steam coal will stay in the range of 45–55 USD per tonne and the sector will not return to prices from the coal boom period.

Poland, as a country of medium size, has to adjust its strategy to regional (EU) and global trends. **Polish deep mines (800–1100 m) will not be able to compete with coal from the aforementioned countries** and any form of import restrictions will face repercussions from the World Trade Organisation. Given the catastrophic financial state of Polish mining industry it is not foreseeable that the costs of production will be reduced in the short term to a level necessary to make domestic coal competitive.

Poland wasted the short period of high global prices and relative prosperity of mining sector when profound restructuring with a focus on investments in the most prospective deposits should have happened. At the same time Poland should have started the process of structural changes in energy system leading to an increase in distributed generation and in the share of gas and renewables in the energy mix.

The plans of replacement and expansion of installed capacity in coal fired power plants and CHP plants during current financial and technical collapse of coal sector will result in a rapid increase in imports of coal as of 2020. The optimistic plans to use "huge" stocks of coal and lignite are not realistic—the Polish system of classification of reserves introduced over 60 years ago for the needs of central planning will simply not work in the free market with increasingly stringent environmental requirements.

Taking into account the low economic competitiveness of coal, the huge scale of environmental degradation, air pollution and the opposition of local communities, it is more reasonable to consider gradual "blanking" of the industry spread over 30–40 years instead of investing tens of billions of PLNs into new mines and large power plants. The scenario "Gas + RES" from PEP 2050 which provides up to 55–60% share of renewables in the energy mix by 2050 becomes an obvious choice. Increases in the share of renewable energy would improve energy security through introduction of distributed sources of generation and reduction of imports of fuels. While Poland does not have sufficient recoverable reserves of gas to fully cover the current and future demand, the country is already largely integrated into the EU network of transmission pipelines, underground storage sites and LNG terminals, all of which enable diversification of more than a half of current imports.

Finally, the matter of extreme importance—human health. Public health considerations alone are enough to justify urgent need for transformation towards an energy system based on prosumer-friendly distributed renewable energy generation.