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Pollutants emission from power industry in Poland — changes after the decade of economy transition

Key words

Coal consumption, electricity production, power industry, SO₂ PM and NO_x emissions

Abstract

Political changes and economical transformation beginning ten years ago in Poland have changed the present image of fuel and energy sector. The first complex legal regulations concerning environment protection in Poland were established indeed in 1980 year, but only last decade brought the important solutions affected power industry: emissions limits, system of fees for using environment and fines paid for exceeding limits.

Electricity and heat generation in Poland is traditionally based on domestic solid fuels: hard coal and brown coal. After 10 years of economy transition process it can be stated that in Polish power industry during the period 1989—1998 coal consumption decreased by 19%, coal quality improved: calorific value increased and sulfur and ash content decreased, SO₂ emission decreased by 49%, particulate matters emission reduced by 87%; electricity production did not change in substance.

Environment protection regulations (both domestic and international), environmentally sound investments undertaken in power plants and in coal mines, have an important impact on the level of the pollutant emissions from power generating industry.

1. Coal production and consumption in Poland

Electricity and heat generation in Poland is traditionally based on domestic solid fuels: hard coal and brown coal.

Poland is one of the biggest hard coal producers in the world for years — over 116 million tons produced in 1998 (in which 94.6 Mt was steam coal) placed Poland on the 7th position

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among world producers. Coal export in 1998 amounted 28 Mt (in which steam coal — 21.5 Mt) that placed Poland on the 5th position among coal exporters. Hard coal is mined in 56 underground collieries at present (some of them are in the closing process because of high mining costs) comparing to 70 coal mines being operational in 1989.

Polish power industry uses about 41 million tons of hard steam coal annually to produce electricity and central heat, the rest of coal is used in cement and chemical industry, agriculture and by individual consumers.

Poland is also an important producer of brown coal, that is mined in 4 big open pits. Present production of brown coal is 63 million tons per year that gives 3rd position in Europe (after Germany and former Soviet Union) and 4th place in the world (after mentioned countries and the USA). Almost entire production of brown coal (95%) is used in 5 big power stations, located in the neighborhood of the pits — 38% of electricity is produced from brown coal.

Table 1 presents the production of hard coal and brown coal in selected years in Poland against a background of world production (Coal... 1999).

TABLE 1

Hard coal and brown coal production in Poland against the background of total world production

TABELA 1

Produkcja węgla kamiennego i brunatnego w Polsce na tle produkcji światowej

	1989*	1990	1995	1998
Poland [million tons]				
Hard coal	177.6	147.7	137.1	116.8
— in which steam coal	146.4	118.6	116.3	94.6
Brown coal	71.9	67.6	63.5	62.4
World total [million tons]				
Hard coal	3 565.0	3 565.0	3 705.4	3 655.8
Brown coal**	1 344.5	1 182.7	924.1	886.9

Source: (Coal... 1999; Mineral... 1999; Statistik... 1999)

Difficult process of Polish economy transition from centrally planned to market economy started in 1989 in very bad economic conditions: recession, high inflation, decrease of industrial production resulting in declined demand for energy and in consequence — decreased demand for coal.

The numbers from table 1 show that coal production in Poland — both hard and brown coal — decreased significantly during last 10 years. Main reason for this reduction was less demand for electricity (closures of highest energy consuming factories in heavy industry). Another reason for decreased coal demand in power industry is an improve of coal quality — particularly calorific value.

TABLE 2

Structure of primary energy production and consumption in Poland [%]

TABELA 2

Struktura produkcji i zużycia energii pierwotnej w Polsce [%]

Primary energy carriers	Production	Consumption	Forecast		
	1990	1998	1990	1998	2020
Hard steam coal	82.4	75.9	62.2	50.6	44.9
Brown coal	13.7	14.5	13.6	14.0	12.0
Crude oil	0.2	0.4	14.0	20.2	18.9
Natural gas	2.4	3.7	9.0	10.2	19.0
Renewables	1.3	5.5	1.2	5.0	5.2

Large domestic coal resources have determined the structure of primary energy consumption in Poland. Changes in structure of primary energy produced and consumed between the years 1990 and 1998 are shown in table 2. Noticeable decrease in share of solid fuels in primary energy consumption for the benefit of hydrocarbon fuels and renewable sources of energy (hydro, biomass and geothermal) can be observed. However, the coals still take the leading position in the balance and will remain it in the future — as it can be seen from the proportions forecast for the year 2020. These numbers correspond with one of the three scenarios considered in “Assumptions for Poland’s energy policy for the year 2020”, so-called “survival” scenario with the lowest annual GDP rate of 2.3% (Assumptions... 2000).

2. Electricity production

As it was said above, Polish power generating industry is based on domestic solid fuels. About 94% of electricity is produced by public utility power industry (out of which 97% are thermal and 3% are hydro-power). The remainder of electric energy is produced by industrial power stations, communal heating power stations and small (private) hydro-power plants. After few years of decrease, total electricity production in 1998 almost regained the level of 1989 and is quite stable for last three years. Table 3 presents adequate data in TW·h for ten year period of analysis.

3. Quality of coal used in public utility power industry

The data on consumption and quality parameters of hard steam coal and brown coal used by Polish public power industry are shown in table 4. The improvement of hard coal quality is in part a result of a governmental program for the construction of steam fines coal preparation

TABLE 3

1989—1998 Electricity production in Poland [TW·h]

TABELA 3

Produkcja energii elektrycznej w Polsce w latach 1989—1998 [TW·h]

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Brown coal fired power plants	53.5	52.0	55.4	51.6	52.4	51.6	50.7	50.8	50.8	51.8
Hard coal fired power plants	79.0	72.3	67.3	68.8	68.8	71.4	75.8	79.7	80.0	79.2
Total thermal power stations	132.5	124.3	122.7	120.4	121.2	122.7	126.5	130.5	131.0	130.9
Total power industry	136.9	128.0	126.8	124.6	125.4	126.4	130.6	134.4	134.7	135.2
Total electricity production	145.5	135.4	134.7	132.7	133.9	135.3	139.0	142.7	142.8	142.8

TABLE 4

Consumption and quality parameters of hard steam coal and brown coal used by Polish public power industry

TABELA 4

Zużycie oraz parametry jakościowe węgla kamiennego energetycznego i węgla brunatnego w polskiej energetyce zawodowej

	Unit	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Hard steam coal											
Consumption	10 ⁶ tons	57.0	49.3	46.8	42.1	40.9	41.0	42.8	45.0	43.8	41.7
Net calorific value	MJ/kg	18.3	19.6	20.4	20.9	21.3	21.4	21.5	21.4	21.4	21.6
Ash content	%	28.5	25.6	24.0	22.3	21.2	20.9	20.8	21.2	20.9	20.4
Sulfur content	%	1.13	0.97	0.93	0.86	0.84	0.85	0.85	0.87	0.85	0.87
Brown coal											
Consumption	10 ⁶ tons	70.5	66.4	67.0	64.7	66.2	65.1	62.2	62.8	62.3	62.2
Net calorific value	MJ/kg	8.1	8.3	8.3	8.4	8.3	8.3	8.5	8.5	8.5	8.6
Ash content	%	12.5	11.6	11.2	10.9	11.3	11.9	10.2	10.8	10.9	10.1
Sulfur content	%	0.66	0.59	0.59	0.60	0.60	0.62	0.63	0.65	0.69	0.69

and desulfurization plants. The realization of the program started in the mid of eighties. Decreasing — since 1989 — demand for coal forced the coal producers to look more carefully after the proper quality of coal production and to reduce the mining costs — the latter is the main goal of the Polish coal mining restructuring program being now in progress.

Coal quality improvement were also forced by new emission standards for power plants entered in 1990 and the system of fees for using environment according to specified rules

(quality and quantity of pollutants emitted to the air, wastes storage) and fines paid for exceeding limits of substances allowed to be added to the air (Mokrzycki, Lorenz, Grudziński 1996).

Brown coal is not beneficiated in Poland; its quality results from coal quality in deposits and from the exploitation technology used — so, there is no significant changes in brown coal quality in these years.

4. Emission changes in power industry

Using solid fuels in power generating industry results in toxic gases emissions and formation of huge amounts of solid waste materials (ashes and slags). Fossil fuels combustion is considered as a main source of emissions originating from human activity. In Poland, public power industry is responsible for over 90% of CO₂ emission, 20% of NO_x and 50% of SO₂.

Polish regulations limit the emissions of sulfur dioxide (SO₂), particulate matters (PM) and nitrogen oxides (NO_x). New levels of permissible emissions were established in 1998 and additional restrictions for carbon monoxide (CO) were added. This regulation also entered new schedules for further emission reductions which are approximate to the terms of Second Sulfur Protocol requirements.

Changes in emissions of particulate matters (PM), sulfur dioxide and nitrogen oxides from Polish public coal fired power plants during ten years of analysis are presented in table 5. In 1990, the less coal consumption influenced on considerable decrease of emission levels. The impact of coal quality improvement on the amount of pollutants emitted can be seen in subsequent years. Most of power stations are now fitted with very efficient particulate control systems (electrostatic precipitators) comparing with previously used old cyclones and multi-cyclones of low efficiency. Before the year 1992 none of Polish power plants were fitted with Flu Gas Desulfurization (FGD) units. At present there are 31 FGD plants installed in 14 power and heat and power stations, out of which 13 use wet method, 11 — semi-dry

TABLE 5

Changes in pollutant emissions from Polish public coal fired power plants

TABELA 5

Zmiany emisji zanieczyszczeń z polskich elektrowni węglowych

Emissions	unit	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Hard coal											
PM	10 ³ tons	554.6	397.3	323.9	219.0	185.0	148.8	119.7	110.0	83.9	67.5
SO ₂	10 ³ tons	1 257.8	920.3	847.4	697.4	656.6	653.1	675.9	691.2	615.8	535.2
NO ₂	10 ³ tons			270.0	277.5	282.2	286.2	292.8	278.0	233.4	187.3
Brown coal											
PM	10 ³ tons	184.1	176.5	143.2	121.3	109.8	110.6	74.0	48.7	34.9	26.3
SO ₂	10 ³ tons	748.0	632.9	630.2	613.8	626.4	619.0	546.1	505.9	494.5	502.9
NO ₂	10 ³ tons			124.0	92.4	90.6	91.6	88.1	88.9	83.8	83.7

and 3 — dry method and there are 3 fluidized bed combustion boilers. These units allowed to reduce SO₂ emission in 1998 by 309 thousand tons.

The NO_x emissions in table 5 are expressed as NO₂ emissions. These data are available only since 1991 — in the period 1991. 1998 the emissions decreased by over 30% as a result of boilers modernization (low NO_x burners) — these activities started in 1991 (EMITOR).

5. Adjusting Polish power industry to the environmental requirements in the European Union

A further reduction of the emissions from power industry is also necessary to meet requirements resulting from international commitments undertaken and signed by Poland and to adjust Polish environmental regulations to the European Union law. The latter is the obligation to become the member of the European Community.

The process of integration started in December 1991 by signing “Europe Agreement establishing an association between the European Communities and their Member States, of the one part, and the Republic of Poland of the other part”. Adjusting Polish regulations in the field of environment protection to the EU requirements is one of the most important problems being a requisite of Poland’s accession to the EU.

One of the most important EU Directives on environment protection is the Directive No 88/609/EC on emission reduction of some pollutants from large energetic objects to the air. This Directive sets the terms of annual emission reduction from all existing sources larger than 50 MW, obliges the plants to work out the programs of gradual emission reduction with adequate timetables and procedures and to provide complete cataloguing of emissions.

The realization of requirements concerning new power plants should not be a problem in Poland. Some difficulties may appear with fulfilling the terms concerning existing objects (for example: global limits for the country setting individually for existing sources that might be too tough to particular power plants) — these issues will have to be negotiated between Polish government and EC executives in the nearest future.

Among international commitments and conventions on environment protection the most important are following documents:

1. The 1979 Convention on Long-range Transboundary Air Pollution (ratified by Poland in 1985) and subsequent protocols to the Convention (below there are listed only these ones ratified or signed by Poland:

- (I and) II Sulfur Protocol — 1994 (signed in 1994, ratified in 1999)
- I Nitrogen Protocol — 1988 (signed in 1988, not ratified)

2. The United Nations Framework Convention on Climate Change — Rio de Janeiro 1992 (ratified in 1994) — concerning stabilization of green house gases (GHG) emission

- The Kyoto Protocol to the Convention on Climate Changes — 1997 (signed in 1998 — Poland declared 6% reduction of GHG by the year 2010 in relation to 1988 base year).

The Second Sulfur Protocol and so-called Second Nitrogen Protocol (protocol on nitrogen oxides and related compounds — negotiated at the moment) are of the most importance for Polish energy generating industry. The UN Framework Convention and the Kyoto Protocol interfere very deep in economies of all countries — for that reason they can be recognized as an energetic convention and protocol. The targets pointed in these documents can be reached by improving energy production and consumption efficiency and by increasing the share of energy carriers others than coal. It could change significantly the image of the Polish energy economy (Gajda, Barc 1999).

Conclusion

After ten years of economy transition in Poland and activities undertaken by power plants it can be stated that SO₂ emission decreased by 49% (as a result of less coal consumption — but of better quality — and new FGD plants adopted), particulate matters emission reduced by 87% (as a result of more efficient electrostatic precipitators introduced into practice and less coal consumption — but with lower ash content). In that time coal consumption in power industry decreased significantly and coal quality improved. Electricity production did not change in substance.

Environment protection regulations both domestic and international (e.g. sulfur protocols) and activities undertaken for integration with European Communities also influence on pollutant emissions reduction.

Environmentally sound programs being now in the course of realization and new investments in power plants will allow to keep the limits for all pollutants (PM, SO₂, NO_x) in 56% of power stations (in relation to nominal capacity) in the year 2005 (Gajda, Barc 1999). The remaining plants will have to invest considerable funds, mainly in FGD installations.

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EMISJE ZANIECZYSZCZEŃ Z ENERGETYKI ZAWODOWEJ W POLSCE — ZMIANY PO 10 LATACH TRANSFORMACJI GOSPODARCZEJ**Słowa kluczowe**

Zużycie węgla, produkcja energii elektrycznej, energetyka zawodowa, emisje: SO₂, pyłów i NO_x

Streszczenie

Zapoczątkowane w Polsce 10 lat temu zmiany polityczne i przekształcenia gospodarcze zmieniły dzisiejszy obraz sektora paliwowo-energetycznego. Pierwsze kompleksowe rozwiązania prawne związane z ochroną środowiska w Polsce podjęto co prawda już w 1980 roku, lecz dopiero ostatnia dekada przyniosła daleko idące rozwiązania dotyczące sektora wytwarzania energii, w tym wprowadzenie norm emisji, obowiązkowe opłaty za emisje i składowanie odpadów oraz kary za przekroczenia dopuszczalnych limitów.

Wytwarzanie energii elektrycznej i ciepła w Polsce tradycyjnie opiera się na krajowych paliwach stałych: węgla kamiennym i brunatnym. Po dziesięciu latach transformacji gospodarczej można stwierdzić, że w polskiej energetyce w latach 1989—1998 zużycie węgla zmniejszyło się o 19%, a poprawiła się natomiast jakość węgla: wzrosła wartość opałowa węgla, a spadła zawartość siarki i popiołu, emisja SO₂ zmniejszyła się o 49%, a emisja pyłów o 87%; produkcja energii elektrycznej w tym czasie w zasadzie nie uległa zmianie.

Znaczący wpływ na poziom emisji z sektora wytwarzania energii wywierają również regulacje prawne dotyczące ochrony środowiska (zarówno krajowe, jak i międzynarodowe), a także podjęte w elektrowniach oraz w kopalniach węgla inwestycje proekologiczne.