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EMISSIONS FROM THE UTILITY POWER INDUSTRY IN POLAND - LIMITATIONS AND TRENDS

1. Introduction

The Polish provisions, limiting the emissions of harmful substances to the atmosphere, were significantly modified in 1998. The Decree [1], binding from February 1990 and stating the obligations of the economic units by the terms of the Environment Protection and Creation Act from 1980 (revised at the end of 1997 [2]), was replaced by the new legislation [3], [4] and [5]. Introduction of further decrees, limiting the emissions (e.g. for incinerating plants), is planned at the nearest time.

The revised Act came into force on January 1, 1998, i.e. on the first day of application of the sharpened requirements, concerning the emissions from „old" power plants, imposed by the preceding provisions [1]. The new limits of permissible pollutant concentrations [3], modifying the hitherto existing ones, were presented after further four months, and of emissions from power generation installations [4] after about nine months. The changes, introduced by the mentioned provisions, lead to certain discontinuity, not only in time, in the law in force in this field. The Decrees [3], [4] and [5] were introduced after seven years of operation [6] of the provisions, imposing on the industrial plants with own power units on organic fuel obligations, effecting in large investment costs for building protecting installations. In some cases the new limitations are less restrictive, than the previous ones, in other they are significantly sharpened without any transition period.

With regard to the power generation installations, the detailed limitations concern three categories, differentiated by the size and character of the sites:

- utility electric power, combined heat and power and heating stations - about 100 enterprises, managing over 300 steam boilers of about 102000 t/h live steam total output, and water heaters of about 10000 MW_{th} total capacity;
- 198 captive combined heat and power stations, managing almost 700 boilers of 34000 t/h live steam total output, and few thousand smaller heating plants;
- municipal and settlement heating plants, managing few thousand small heaters of about 7000 MW total capacity.

The mentioned above sites use for their generation needs, almost exclusively, organic fuels, mainly solid ones. The electric energy generation is based in 99%, and the heat generation in 75%, on coal. That causes strong pollution of the atmosphere with combustion products and the resulting necessity of broad implementation of emission reduction programmes.

2. Emissions from the utility power industry

In the utility power industry, modernisation programmes were realised in the last years to reduce the basic pollutant emissions. A great part of the boilers were equipped with low-emission burners or other systems, reducing the emission of nitrogen oxides using primary methods. A sulphur dioxide emission reduction

programme is realised, which is expected to reduce the sulphur emission from the electric power industry to the half of the national limit, determined in the II Sulphur Protocol. The efficiency of the dust extraction systems was also increased.

The data, concerning the emissions from power plants, are collected by the Energy Market Agency and published in the annual issues [9] and [10]. The principles of collecting the data for the utility power industry and district heating were changing from 1989 to 1991. Starting from 1992, this information can be accepted as fully uniform and concerns only utility power and combined heat and power stations. During the previous period, the captive combined heat and power stations were included into the common statistics. The information about basic pollutant emissions from 1989 to 1997 is set in Table 1. A tendency of burning low-sulphur and low-ash coals with much higher calorific value (Table 2) formed during this period. The Polish provisions imposed using of high quality fuels, improving the emission factors (related to the supplied fuel energy). The mean calorific value of the hard coals, burned in the utility power industry, increased from 18280 kJ/kg in 1989 to 21423 kJ/kg in 1997. At the same time, the sulphur content changed from 1.148% to 0.851 %. Such a trend was not observed in relation to lignites. That resulted, as it seems, from the lack of opportunity of changing the fuel supplier.

Table 1. Basic pollutant emissions from the utility power industry in 1989-1997

Year	SO_2 theor. emission	SO_2 real emission	SO_2 real/ SO_2 theor.	NO_2 emission	CO emission (indicatory)	Dust emission
	thousand t	thousand t	%	thousand t	thousand t	thousand t
1989	2190.2	1972	90.04	390		720
1990	1701.6	1570	92.27	370		570
1991	1665.4	1430	85.87	395		480
1992	1510.0	1311	86.84	370	33.5	340
1993	1490.9	1283	86.06	373	33.5	295
1994	1511.2	1272	84.17	378	32.9	259
1995	1527.4	1222	80.00	381	31.0	194
1996	1608.8	1197	74.40	367	32.1	159
1997	1612.4	1110	68.84	317	30.8	118.8

Table 2. Mean parameters of the fuels, used in the Polish utility power industry in 1989-1997

Year	Hard coal consumption	Heat value	Sulphur content	Lignite consumption	Heat value	Sulphur content	Liquid fuels cons.	Heat value	Sulphur content
	thousand t	kJ/kg	%	thousand t	kJ/kg	%	thousand t	kJ/kg	%
1989	54340	18280	1.148	70470	8100	0.661	260	40000	2.1
1990	46330	19600	0.973	66418	8290	0.594	260	40000	2.1
1991	45300	20138	0.966	67764	8046	0.575	260	40000	2.1
1992	42134	20920	0.863	64728	8418	0.596	267.54	39892	2.09
1993	40870	21331	0.844	66178	8295	0.597	254.06	40239	2.13
1994	41003	21388	0.847	65058	8265	0.619	261.97	40438	2.14
1995	42752	21463	0.852	62176	8489	0.634	254.56	40770	2.07
1996	44953	21434	0.869	62769	8473	0.649	311.2	40884	2.05
1997	43752	21423	0.851	62296	8504	0.687	294.78	41016	2.00

The observed SO_2 emission drop tendency results from the higher coal quality, but also from the building of desulphurisation installations. The emission of sulphur dioxide from the Polish power industry in 1997 was less than 70% of the theoretical value, calculated from the sulphur content in the fuels. Drop of the NO_x emission can

be also observed in the last years. This result from the mentioned boiler facility modernisations was observed with certain delay.

3. Limitations on emission and concentration of harmful substances in the atmosphere

The new provisions, treating the reduction of emissions of harmful substances from power generation installations, were considerably extended in relation to the version from 1990. An attempt to eliminate some of their widely signalised shortcomings was also made. For example, the very difficult to control relation of the permissible emission to the supplied fuel energy was waived. The new limitations are stated in directly measurable concentration units (mg/m^3), related to standard oxygen contents in flue gases. Following other countries' example, a possibility of operation with increased emission (for 240 hours), in case of cleaning system failure, was introduced.

The data, derived from [1] for Tables 3 and 4 and stated in g/GJ, have been converted, using the following values:

for hard coals 1 g/GJ = 2.85 mg/m^3 (6% O_2);
for lignites 1 g/GJ = 2.52 mg/m^3 (6% O_2);
for liquid fuels 1 g/GJ = 3.57 mg/m^3 (3% O_2);
for natural gas 1 g/GJ = 3.70 mg/m^3 (3% O_2),

and the results could differ from the obtained for concrete fuel, because of the pointed above incoherence.

In the case of hard coal, in the table heads, corresponding to the least capacities (up to 5 MW_{th}), the limits for boilers with stationary-grate furnace were converted; in the capacity range up to 50 MW_{th} - limits for boilers with stoker furnace; and in higher capacity range - limits for boilers with coal-dust furnace and dry slagging. Of course, the boundaries between these capacities should be treated as conventional and only approximately corresponding to the transition between these types of boiler constructions. The comparison was made for hard coal, lignite, liquid fuels and natural gas. In [4] the requirements were defined for different types of gas fuels, and in [1] the limitations were stated exclusively for natural gas.

The converted values of permissible emissions, resulting from the Decree from 1990, are set in Table 3 in first order. The limits, binding from 1998, are presented in the next columns.

The limitations for the plants, built before 1990, are set in Table 4, in four columns each time. The limits, binding till 1998 (the first column), correspond to group A from [1], i.e. the plants, built before 1990. In compliance with [1], the requirements should be sharpened to the level in group B from [1] (the second column) on the turn of 1997. The Decree [4] introduced changes here, and the now binding permissible values (set in the third column) will be sharpened after December 31, 2005, to the level, set in the last column.

Table 5. Comparison of the permissible emissions for high capacity plants (500 MW_{th} and more) on solid fuels in selected countries

Country	SO_x emission	NO_x emission	dust	SO_x emission	NO_x emission	dust
	New plants			Existing plants		
Austria	200	200	50	400/200 **	200	50
France	400	650/1300 *	50	400	650/1300 *	50
Netherlands	200 ****90%	200	50	400 ****85%	100-650	50
Germany	400****85%	200	50	400 ****85%	200	80/125 **

Poland	400	400/460 **	200/50 ***	2500/2350 **	450/540 **	225/350 **
Turkey	940	600	235	940	1875	235
USA	740-1480	860	40	1480	615-740	40
United Kingdom	****90%	650	50	quote limit.	quote limit.	50
Italy	400	200	50	400	300	50
Directions 88/609/EU	400	650/1300 *	50			

* the higher value concerns coals with less than 10% volatiles ** lignite / hard coal
*** the 50 mg/m^3 binds for plants, built after September 1998 **** flue gas desulphurisation obligation

An information about the „dynamics" of the Polish air protection provisions could be derived from the data, presented in Tables 3 and 4. The permissible emissions of sulphur oxides, nitrogen oxides and dust, binding the largest power plants in selected countries [4], [11], are compared in Table 5. The limits, stated in the European Union Directions 88/609, are set in the last row of the Table.

The changes in the regulations, treating the harmful substance concentrations, introduced in 1998, were also considerable. Basing on [8], the local concentration standards for the basic air pollutants, emitted from power generation installations, are compared in Table 6 to the directions of the European Union, German and American standards, including the known as the most severe in the world Californian ones (CSS - California State Standards). The new provisions soothe the requirements, introduced in 1990 and treating the total suspended dust, but introduce requirement diversification, using special permissible concentration limit for dust with particle aerodynamic diameter up to 10 μm. The limits of the permissible concentration of carbon oxide in the air were considerably soothed. The requirements, concerning sulphur oxides, were slightly soothed, and those for nitrogen oxides were kept on similar level (except the sharpened mean annual value). The new directions of the European Union, treating the concentrations of sulphur and nitrogen oxides, are more severe, than the Polish provisions.

Table 6. Polish pollutant concentration standards, compared to the values, binding in the European Union, Germany and USA, in μg/m^3

Substance	Period	Poland		European Union		Germany	USA	
		acc. to [1] („areas")	[3]	New	Existing		Federal	California
Total supended dust	30min	350	250	-	-	-	-	-
	24 h	150	120	-	-	-	260	-
	year	75	50	-	-	-	75	-
SO_2	30min	500	440	350*	-	400 (3 h)	650 (1 h)	-
	24 h	150 (125 from 2005)	150	125*	250-80	140	365	105
	year	40 (30 from 2005)	32	20 **	80-120	60	80	-
NO_2	30min	500	500	200***	200 (1h)	200 (1h)	-	470 (1h)
	24 h	150	150	-	-	80	-	-
	year	40	50	30**	-	-	100	-
CO	30min	20000	5000	-	-	30000(1h)	40000(1h)	23000(1h)
	24 h	5000	1000	-	-	10000(8h)	10000(8h)	10000(8h)
	year	2000	120	-	-	-	-	-

* from 2005 ** 2 years after admission of the directions *** from 2010

In the place of sharpened limitations (in relation to the basic ones) for the „especially protected areas", the new Decree introduced special, differentiated requirements for health resorts and forest complexes and national parks. These are usually soothed in relation to the previous ones, just like the basic limits, binding in the other regions („areas").

Table 7. Charges for air pollutant emissions in Poland in 1999

Pollutant	Charge in PLZ/t	Charge in EUR/t	Charge in DEM/t
Dust from burning	220	53	103
Coal-graphite dust, carbon black	900	215	423
Lignite dust	350	84	164
Other dust	350	84	164
Sulphur dioxide	330	79	155
Nitrogen oxides (NO_2)	330	79	155
Carbon oxide	90	21.5	42.3
Carbon dioxide	0.17	0.041	0.08

The Polish charges for emission of the most common air pollutants are set in Table 7 [13]. They are changed each year by appropriate decree in relation to the annual inflation rate. The fines for exceeding the emission limitations are ten times larger than the charges.

4. Practical shortcomings of the provisions

The new Polish provisions, treating the emission of harmful substances to the atmosphere, are significantly improved in relation to the hitherto existing ones. However, there still are some practical shortcomings. The most important of them are:

- the lack of trasparent, logical conception and procedures for stating the emission limitations - it is still a decision of administration and is not closely connected to the technological level and progress;
- some of the changes, concerning existing plants, are considerable, and all came into force without a transition period, usually recommended for such regulations;
- the Decree [4] does not regulate emissions from engines and gas turbines, which is the most dynamic sector of the power industry in the whole world (the interest on building installations with gas turbines is at present time very wide in Poland - the first one has already been commissioned, a large number of others (several dozen) is in stage of planning or construction), and the lack of uniform regulations will effect the arranging of the requirements for this facility category in the future;
- lack of uniform method and condition requirements for emission measurements in power installations, which creates opportunity to obtain always „appropriate" results

The changes in the regulations, treating the harmful substance concentrations, introduced in 1998, were also considerable and, unfortunately, inconsistent. 128 new substances were added to the pollutant list in [3], which included 44 items till that time. Even the previous list has already been considered as too large. The present one is a special kind of record. We should not forget, that in compliance with the Polish provisions, the concentration limitations could indirectly lead to emission distribution, obtained using calculation procedures, which results could differ from the real harmful substance concentrations in the atmosphere [7]. The final distribution, resulting from the more severe condition, is determined by decision of the administration.

5. Recapitulation

The utility power industry is the main supplier of common pollutants to the atmosphere in Poland. Because of the concentration of the largest sources in small

number of high capacity plants, the activities in this sector determine in great part the national emission, success of the national air protection programmes and meeting the international obligations.

As it was presented above, the emission of harmful substances from the utility power industry in Poland has been reduced, and there is a stable tendency for further reduction. The market conditions in combination with emission and concentration limitations impose using of more calorific and clean fuels and implementing of low-emission burning and cleaning technologies.

The regulation of the Polish environment protection provisions by the requirements of the European Union is the most expensive, after the agriculture reform, integration undertaking. The whole programme is estimated to cost about 35 billion euro, including 14 billion euro air protection requirements acceptance costs.

The last changes in the Polish air protection provisions led to soothing of some limitations and sharpening of others at the same time. In a certain manner, it had to be an attempt to correct the shortcomings of the previous provisions [1], especially the inordinate severity in relation to some facility categories. The changes lead to partial uniformity of the „plant" limitations with the proposed by the European Union. We should remember, that the corrected provisions impose modernisation costs of industrial installations, which greater part should be borne by the power plants with largest units. The investors, building new plants, have to meet practically the same as EU requirements.

Consistently formulated requirements, representing the technical and financial capabilities, determine the effect of the modernisation efforts. Labour-consuming procedures, allowing to define the opportunity of using the attainable technologies, do duty for that. There is a lot to be done in this field in Poland.

Bibliography

[1]Decree of the Minister of Environment Protection, Natural Resources and Forestry from February 12, 1990, concerning the air pollution control (Dziennik Ustaw nr 15 pos. 92) and Ministry comments from August 14, 1990.

[2]Revision of the Environment Protection and Creation Act and some other acts from August 29, 1997 (Dziennik Ustaw nr 133 pos. 885).

[3]Decree of the Minister of Environment Protection, Natural Resources and Forestry from April 28, 1998, concerning permissible polluting substance concentrations in the air (Dziennik Ustaw nr 55 pos. 355).

[4]Decree of the Minister of Environment Protection, Natural Resources and Forestry from September 8, 1998, concerning polluting substance emissions to the air from technological and technical processes (Dziennik Ustaw nr 121 pos. 793).

[5]Decree of the Minister of Environment Protection, Natural Resources and Forestry from September 18, 1998, concerning particular principles of determining the permissible polluting substance types and quantities to be emitted to the air and requirements to be met by the documentation, indispensable for decision, determining the permissible polluting substance types and quantities to be emitted to the air (Dziennik Ustaw nr 124 pos. 819).

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[12]Gostomczyk M. A., Lemański J., Majchrzycki K.: „SO_2 Emission Reduction Costs". Archiwum Ochrony Środowiska 1-2/1996.
[13]Decree of the Government from December 30, 1998 (Dziennik Ustaw nr 162).

Table 3. Permissible emissions from power plants; comparison of the requirements from 1990 and 1998. Permissible content [mg/m3] (6% O2; hard coal fired plants, built after 1990)

Source thermal capacity [MWth]	SOx		NOx		dust		
	1990 Decree	1998 Decree	1990 Decree	1998 Decree	1990 Decree	1998 Decree licences before 1998	1998 Decree "fresh" licences
<5	1850	1500	100	400	3900	700	100
5-50	570	1300	270	400	1710	400	100
50-100	570	850	480	460	370	350	50
100-500	570	850-400	480	460	370	350	50
>500	570	400	480	460	370	200	50

conversion factor from g/GJ to mg/m3 = 2.85 (1990 Decree; less than 5 MWth - stationary-grate boilers; 5-50 MWth - stoker boilers; 50 MWth and more - coal-dust boilers with dry slagging)

Permissible content [mg/m3] (6% O2; lignite fired plants, built after 1990)

Source thermal capacity [MWth]	SOx		NOx		dust		
	1990 Decree	1998 Decree	1990 Decree	1998 Decree	1990 Decree	1998 Decree licence before 1998	1998 Decree "fresh" licence
<5	500	1500	380	400	240	700	100
5-50	500	1300	380	400	240	400	100
50-100	500	850	380	400	240	350	50
100-500	500	850-400	380	400	240	350	50
>500	500	400	380	400	240	200	50

conversion factor from g/GJ to mg/m3 = 2.52 (1990 Decree; boilers with dry slagging)

Permissible content [mg/m3] (3% O2; plants on liquid fuel, built after 1990)

Source thermal capacity[MWth]	SOx		NOx		dust	
	1990 Decr.	1998 Decr.	1990 Decr.	1998 Decr.	1990 Decr.	1998 Decree
<50	4460	850	320	400	-	5
50-300	610	850	430	460	-	5
300-500	610	850-400	430	460	-	5
>500	610	400	430	460	-	5

conversion factor from g/GJ to mg/m3 = 3.57

Permissible content [mg/m3] (3% O2; plants on natural gas, built after 1990)

Source thermal capacity[MWth]	SOx		NOx		dust	
	1990 Decr.	1998 Decr.	1990 Decr.	1998 Decr.	1990 Decr.	1998 Decree
<5	-	35	130	150	-	5
5-50	-	35	130	300	-	5
>50	-	35	310	350	-	5

conversion factor from g/GJ to mg/m3 = 3.7

Table 4. Permissible emissions from power plants; comparison of the requirements from 1990 and 1998

Permissible content [mg/m3] (6% O2; hard coal fired plants, built before 1990)

Source thermal	SOx				NOx				dust			
capacity [MWth]	till 1998	after 1998	till 2006	after 2006	till 1998	after 1998	till 2006	after 2006	till 1998	after 1998	till 2006	after 2006
<5	2820	2050	2000	1500	100	100	400	400	5270	3900	1900	700
5-50	2820	1820	2000	1500	460	270	400	400	2280	1710	1000	400
50-100	3530	2480	2000	1500	940	480	540	540	740	370	350	200
100-300	3530	2480	2350	1500	940	480	540	540	740	370	350	200
300-500	3530	2480	2350	1200	940	480	540	540	740	370	350	200
>500	3530	2480	2350	1200	940	480	540	540	740	370	350	100

conversion factor from g/GJ to mg/m3 = 2.85 (1990 Decree; less than 5 MWth - stationary-grate boilers; 5-50 MWth - stoker boilers; 50 MWth and more - coal-dust boilers with dry slagging)

Permissible content [mg/m3] (6% O2; lignite fired plants, built before 1990)

Source thermal	SOx				NOx				dust			
capacity [MWth]	till 1998	after 1998	till 2006	after 2006	till 1998	after 1998	till 2006	after 2006	till 1998	after 1998	till 2006	after 2006
<300	3880	2700	2500	2000	570	380	450	450	490	240	225	225
300-500	3880	2700	2500	2000	570	380	450	450	490	240	225	225
>500	3880	2700	2500	2000	570	380	450	450	490	240	225	100

conversion factor from g/GJ to mg/m3 = 2.52 (1990 Decree; boilers with dry slagging)

Permissible content [mg/m3] (3% O2; plants on liquid fuel, built before 1990)

Source thermal	SOx				NOx				dust			
capacity [MWth]	till 1998	after 1998	till 2006	after 2006	till 1998	after 1998	till 2006	after 2006	till 1998	after 1998	till 2006	after 2006
<5	6140	4460	4375	850	430	430	450	450	-	-	50	50
5-50	6140	4460	4375	1700	430	430	450	450	-	-	50	50
>50	6140	610	3500	1700	570	570	630	630	-	-	50	50

conversion factor from g/GJ to mg/m3 = 3.57

Permissible content [mg/m3] (3% O2; plants on natural gas, built before 1990)

Source thermal	SOx				NOx				dust			
capacity [MWth]	till 1998	after 1998	till 2006	after 2006	till 1998	after 1998	till 2006	after 2006	till 1998	after 1998	till 2006	after 2006

<5	-	-	35	35	220	130	150	150	-	-	5	5
5-50	-	-	35	35	220	130	300	300	-	-	5	5
>50	-	-	35	35	540	310	350	350	-	-	5	5

conversion factor from g/GJ to mg/m3 = 3.7