

## THE AIR POLLUTION PRODUCED BY THE ENERGY SOURCES IN THE CITY AREA OF ORADEA

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**Abstract .** The work presents the level of the main pollutant emissions registered in the Oradea area, produced mainly by The Cogeneration Thermal Plant, running on pulverised low-grade coal and natural gas.

The analysis emphasises the exceed of the allowed limits of the concentration of ash powder and SO<sub>2</sub> emissions from the flue gases exhausted in the environment. The diminishing of the consumed fossil fuels by the improvement of the efficiency of energetic steam boilers, represents an important method of reducing the pollutant emissions.

**Keywords :** coal and natural gas fuel, flyash, sulphur dioxide, nitrogen oxides.

### 1. INTRODUCTION

Coal represents an important primary energy resource of Romania. In the period of 2000-2004, about 38-40 % of electricity and heat obtained in the country was produced by low-grade coal burning in thermal power stations connected to the National Energetic System. This tendency will be maintained on medium term in Romania, due to the limited internal reserves of hydrocarbons, to the uncertain import of natural gases and to the continuous rise of their price, [1].

Energetic industry based on fossil fuels generate, besides electricity and heat, a series of pollutant substances (ash powder, sulphur dioxide, nitrogen dioxide, carbon dioxide), more consistent at pulverised coal burning, which affect the health and the environment on the whole, [1].

The heat requirement in the city of Oradea, estimated at 9,5-10,0 PJ/year, for domestic and industrial purposes in form of steam and hot water, is provided from :

- ♦ thermal stations, placed inside the industrial units, which generates low and medium pressure steam at 1-10 bar and/or warm water at 90/70°C, by burning especially oil fuel and waste wood in powdered state ;
- ♦ the Thermal Power Plant, which generates heat and electricity in a combined thermodynamic process, based on gas fuel and low-grade coal, burnt in pulverised state with oil fuel support. While the electricity is received by the National Energy System, the thermal energy is delivered as medium pressure steam at 10-16 bar (40 bar) to the industrial consumers placed around the thermal plant or as hot water at 120-140°C to more than 55,000 dwellings, connected to a large district heating network in the city of Oradea, for household warm water and secondary heating agent preparation, [2].

The thermal stations firing oil fuel and waste wood have an insignificant impact about the environment in the city area of Oradea. Therefore, the work presents the present-day level of the pollutant emissions exhausted mainly by operation of the Thermal Power Plant, placed in the vest side of the town, in comparison with the levels indicated by the Romanians and Europeans regulations. In the same time are indicated the main technical solutions which may conduct to the diminishing of air pollution.

## 2. THE TECHNICAL CHARACTERISTICS OF THE THERMAL POWER PLANT OF ORADEA

The Thermal Power Plant of Oradea is equipped with 5 turbogenerator units, totalising an installed electric power of 195 MW. The steam necessary for the working of the power plant is supplied by 6 energetic steam generators with natural circulation, having a maximum total installed capacity of 1.830 t/h, [2], (table 1).

The cleaning equipment of the flue gases resulted from the burning process, consists of electrostatic precipitators, 2 units for each steam generator operating on coal (GA-4, GA-5 and GA-6), with a high efficiency of filtering, over 98%. The flue gases are exhausted into the ambient air through two stacks having 112 m and 118 m high.

Table 1. The main technical characteristics of the energetic units installed at The Thermal Power Plant of Oradea

| Energetic unit     | Technical characteristics |                       |                    |       |                                       |                        | Fuels                      |
|--------------------|---------------------------|-----------------------|--------------------|-------|---------------------------------------|------------------------|----------------------------|
|                    | Electric nominal power    | Thermal nominal power | Nominal steam flow |       | Nominal superheated steam temperature | Nominal steam pressure |                            |
|                    | MWe                       | MWt                   | t/h                | kg/s  | °C                                    | MPa                    |                            |
| I                  | 25                        | 127                   | 165                | 45,8  | 540                                   | 13,6                   | Natural gases              |
| II                 | 25                        | 127                   | 165                | 45,8  | 540                                   | 13,6                   | Natural gases              |
| III                | 45                        | 269                   | 350                | 97,2  | 540                                   | 13,6                   | Natural gases and oil fuel |
| IV                 | 50                        | 307                   | 400                | 111,1 | 540                                   | 13,6                   | Coal and oil fuel          |
| V                  | 50                        | 307                   | 400                | 111,1 | 540                                   | 13,6                   | Coal and oil fuel          |
| Steam generator VI | -                         | 269                   | 350                | 97,2  | 540                                   | 13,6                   | Coal and oil fuel          |

The working of the steam generators is continuous: 24 hours/day, 7 days/week, 52 weeks/year, with a high level of activity during the cold season, when the thermal load for the district heating supply have an important share. The operating time of the steam generators between 2001-2004 is emphasised in table 2.

Table 2. The operating time of the steam generators at The Thermal Power Plant of Oradea in the period 2001-2004

| Steam generator | Annual operating time [hours/year] |      |      |      |
|-----------------|------------------------------------|------|------|------|
|                 | 2001                               | 2002 | 2003 | 2004 |
| I               | 3839                               | 581  | 5795 | 5790 |
| II              | 3486                               | 5394 | 2066 | 5709 |
| III             | 1963                               | 1767 | 938  | 606  |
| IV              | 214                                | -    | 35   | 579  |
| V               | 5419                               | 2637 | 3053 | 1915 |
| VI              | 3342                               | 1269 | 2869 | 2419 |

## 3. THE PRESENT-DAY MAIN POLLUTANT EMISSIONS

The factors that influence the pollution level of an electric power plant operating on fossil fuels are:

- ♦ the amount of consumed fuels for electrical and thermal energy production,
- ♦ the burning method used and the physical-chemical characteristics of the fuels.

The Thermal Power Plant of Oradea burns Low-grade coal, brought from the area of Oltenia and Northern Ardeal, with a high content of humidity and ash, oil fuel for sustaining the basic coal dust flame and natural gases. The thermal energy and electricity produced at The Thermal Power Plant of Oradea between 2001-2004 was obtained mostly by burning coal. With the finishing of building the gas fuel pipe line and of the modernising

the three steam generators by changing the combustion from pulverised coal to natural gases in 2003, the share of gas fuel in the generated energy, became significant.

The fuel consumption of The Thermal Power Plant of Oradea in the period 2001-2004 is emphasised in table 3. One can notice the diminishing of the quantity of coal consumed in 2004 to almost a third compared to 2001,

Table 3. The quantities of fuels consumed by  
The Thermal Power Plant of Oradea between 2001-2004

| Type of fuel                                          | 2001    | 2002   | 2003   | 2004   |
|-------------------------------------------------------|---------|--------|--------|--------|
| Low-grade coal<br>[tonnes/year]                       | 1319000 | 848500 | 598500 | 471500 |
| Fuel oil<br>[tonnes/year]                             | 16150   | 15980  | 10990  | 18800  |
| Natural gases<br>[m <sup>3</sup> <sub>N</sub> / year] | -       | -      | 78360  | 135550 |

while the quantity of oil fuel is maintained at a medium level of 15-16 thousand tonnes/year in the analysed period.

The main characteristics of the fuels used and the range of the medium properties, that influence the level of pollution, registered in the period 2001-2004, can be seen in table 4, [2].

Table 4. The average characteristics of the fuels used by  
The Thermal Power Plant of Oradea between 2001-2004

| Fuels         | Average characteristics at the initial state |             |                             |                                                |
|---------------|----------------------------------------------|-------------|-----------------------------|------------------------------------------------|
|               | Total humidity content                       | Ash content | Combustible sulphur content | Inferior combustion heat                       |
|               | $W_t^i$ [%]                                  | $A^i$ [%]   | $S_c^i$ [%]                 | $Q_i^i$                                        |
| Coal          | 25,5 – 44,0                                  | 35,5 – 44,5 | 0,34 – 2,20                 | $Q_i^i = 7780 - 9360 \text{ kJ / kg}$          |
| Fuel oil      | 0,3                                          | 0,1         | 0,41                        | $Q_i^i = 39550 - 40530 \text{ kJ / kg}$        |
| Natural gases | -                                            | -           | -                           | $Q_i^{anh} = 34240 - 34360 \text{ kJ / m}_N^3$ |

The main pollutant substances produced by burning of the fuels, exhausted in the environment through the stacks of The Thermal Power Plant of Oradea, are the following :

- ♦ flyash particles, resulted by the transformation of the mineral mass of the lignite burnt in powder state,
- ♦ sulphur dioxide, formed by the oxidation of sulphur contained by the fuels (lignite and oil fuel),
- ♦ nitrogen oxides, resulted by the oxidation of the nitrogen from the fuel,
- ♦ carbon oxides, resulted by the oxidation of the carbon from the fuels.

In Romania, the maximum admitted limits of the concentration of the pollutant substances in the flue gases, resulted from the burning of fossil fuels is regulated by Order no. 462/1993 of The Ministry of Waters, Forests and Environment Protection. For the energetic steam generators installed in the thermal power plants connected to the National Energetic System of Romania, an agreement has been established of Order 462/1993 by the letter of MWFE no. IJ-12797/1994. The maximal values of the concentration of pollutant emissions admitted in Romania for the steam generators operating in The Thermal Power Plant of Oradea, compared to the standards of the EU [1], are comprised in table 5.

Table 5. The maximal allowable values of the concentration of the pollutant emissions for the steam generators installed at The Thermal Power Plant of Oradea

| Pollutant emissions | Maximal allowable values [ $mg / m_N^3$ ]<br>(thermal power between 100-500 MW <sub>t</sub> ) |                                      |                                  |
|---------------------|-----------------------------------------------------------------------------------------------|--------------------------------------|----------------------------------|
|                     | Order MAPPM<br>Nr. 462/1993                                                                   | Agreement MAPPM<br>Nr. IJ-12797/1994 | Environmental standards<br>in EU |
| Flyash particles    | 100                                                                                           | 225                                  | 100                              |
| Nitrogen oxides     | 400                                                                                           | 800                                  | 500                              |
| Sulphur dioxide     | 2000-400<br>linear decreasing                                                                 | -                                    | 2000                             |

The average annual concentration ( $mg / m_N^3$ ) of the pollutant emissions resulted at The Thermal Power Plant of Oradea by burning fossil fuels in the period 2001-2004 was determined knowing the annual quantities of noxious substances and the total volume of flue gases exhausted through the stacks in the environment. In table 6 are presented the average annual values of the concentration of ash particles, sulphur dioxide and nitrogen oxides ( $mg / m_N^3$ ) between 2001-2004, calculated at the reference percentage of  $O_2$  in the flue gases of 6%.

Table 6. The main pollutant emissions at The Thermal Power Plant of Oradea in the period 2001-2004

| Pollutant emissions | Average annual values |                  |          |                  |          |                  |          |                  |
|---------------------|-----------------------|------------------|----------|------------------|----------|------------------|----------|------------------|
|                     | 2001                  |                  | 2002     |                  | 2003     |                  | 2004     |                  |
|                     | [t / an]              | [ $mg / m_N^3$ ] | [t / an] | [ $mg / m_N^3$ ] | [t / an] | [ $mg / m_N^3$ ] | [t / an] | [ $mg / m_N^3$ ] |
| Flyash particles    | 2268                  | 398              | 1937     | 644              | 1249     | 469              | 1118     | 423              |
| Sulphur dioxide     | 27666                 | 4862             | 18384    | 5994             | 9669     | 3623             | 8463     | 3204             |
| Nitrogen oxides     | 1583                  | 278              | 1083     | 360              | 940      | 352              | 1078     | 408              |

The average annual values of the emission of ash particles in the period 2001-2004 are situated over the limit admitted in the EU of  $100 \text{ } mg / m_N^3$ . One can notice values situated over  $600 \text{ } mg / m_N^3$  in 2002, which are

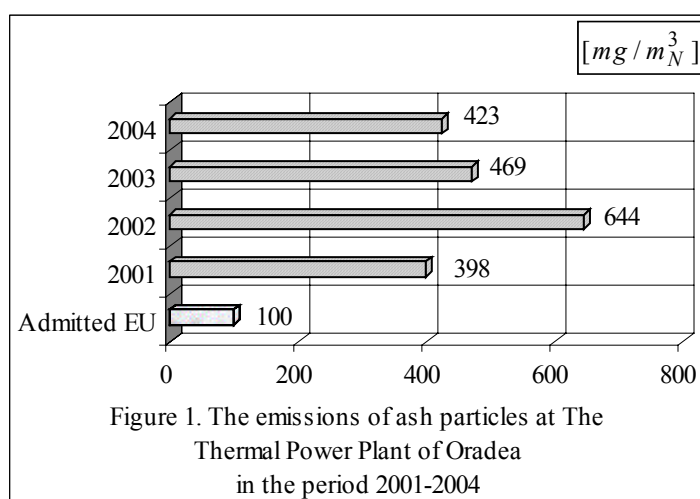


Figure 1. The emissions of ash particles at The Thermal Power Plant of Oradea in the period 2001-2004

decreasing in 2003 and 2004 to  $469 \text{ } mg / m_N^3$  and  $423 \text{ } mg / m_N^3$ , (figure 1). These values are closer to the limit of  $225 \text{ } mg / m_N^3$  approved by the derogation of The Resort Ministry for the energetic burning systems from the

power plants of Romania. The diminishing of the concentration of ash from the flue gases exhausted in the atmosphere was mainly due to the partial replacement of coal by natural gases in 2003 and 2004.

The emissions of sulphur dioxide have average annual values over those admitted in the EU. Figure 2 emphasises some values over  $5900 \text{ mg} / \text{m}_N^3$  in 2002. One can notice a decreasing evolution in 2003 and 2004 towards lower levels of  $3623 \text{ mg} / \text{m}_N^3$  and  $3204 \text{ mg} / \text{m}_N^3$ , which exceed, however, the limit value of the EU, established at  $2000 \text{ mg} / \text{m}_N^3$ . The content of sulphur from the coal of over 2% contributes to a great extent to the exceeding of the admitted concentration of sulphur dioxide from the flue gases exhausted in the environment.

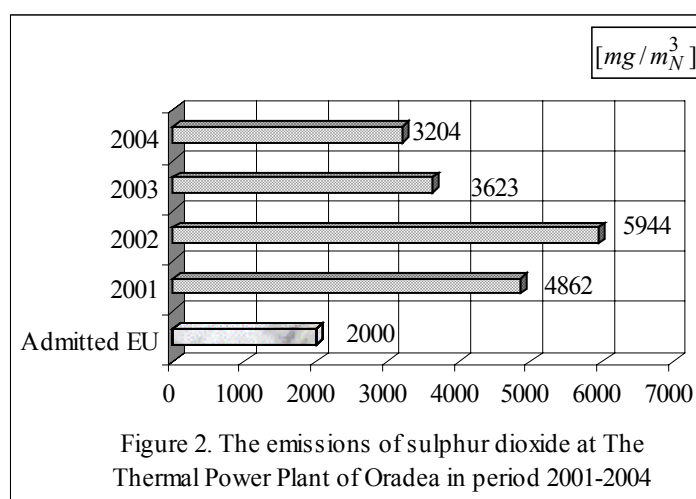


Figure 2. The emissions of sulphur dioxide at The Thermal Power Plant of Oradea in period 2001-2004

Regarding the emissions of nitrogen oxides, their average annual concentration is situated between  $278\text{--}408 \text{ mg} / \text{m}_N^3$ , which, though they are increasing between 2001-2004, are still below the limit value from the EU of  $500 \text{ mg} / \text{m}_N^3$ , (figure 3).

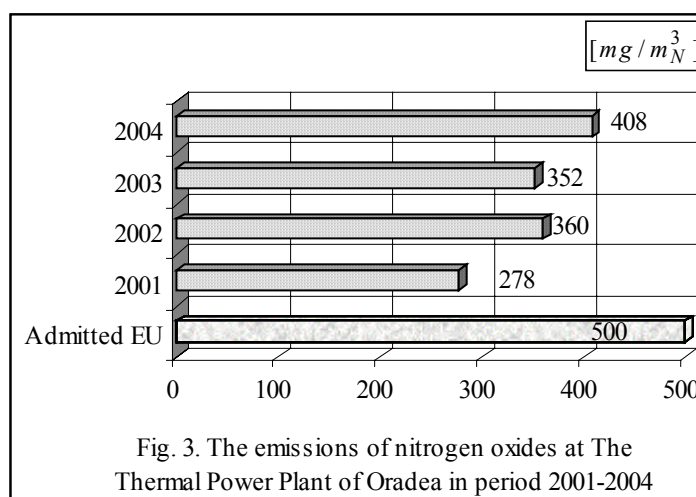


Fig. 3. The emissions of nitrogen oxides at The Thermal Power Plant of Oradea in period 2001-2004

The analysis of the concentration of atmospheric pollutants on the base of the average annual values, emphasised in figure 1 – figure 3, reflects the reality only partially. It is well-known that, during the cold season, the quantities of consumed fuels have high values due to the thermal load for district heating, the share of coal being important. Thus, the values of the daily concentration of the pollutant emissions may register, in shorter periods, but with an intense operation of the burning systems, an exceeding of the average annual value.

#### 4. CONCLUSIONS

The study of the emissions of pollutant substances resulted at The Thermal Power Plant of Oradea by burning coal and natural gases emphasises the exceeding of the concentrations admitted by the EU standards for the particles of ash and sulphur dioxide. The causes of this situation are connected to the use of coal with high content of ash and to the low efficiency of the pulverised coal combustion in present-day stage of this burning technology, put into practice in Romanian power plants.

The main possibilities of reducing the pollutant emissions in the atmosphere, that would be optimal for the Oradea Power Plant, [2], [3], are:

- ♦ using of some coal with lower contents of ash and sulphur,
- ♦ improving the efficiency of the burning process of pulverised coal by modernising the burning equipment,
- ♦ using the combined thermodynamic cycle for heat and power generation,
- ♦ reducing the concentration of sulphur dioxide from the flue gases by introducing a reagent (dry limestone) in the furnace together with the powdered coal,
- ♦ modernising the electric precipitators and maintaining them in a proper technical state.

Mankind has enough fossil fuel resources, so that the coal remains the key to all medium and long-term solutions of solving the always present interest in the energetic problem. More and more, the legislation of different countries will demand that the technologies of using coal in power plants be “clean” by imposing a minimal efficiency level of producing energy.

The limits of the noxious emissions will be more restrictive than in the present, especially concerning the sulphur content, which makes the introducing of new technologies in current thermal power plants on pulverized coal necessary, through adapting the burning technology of the steam generators found in function at the burning of coal in fluidized bed system, for a more efficient function with lower emissions of atmospheric pollution.

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