# CONTRIBUTION OF INDUSTRY TO AIR POLLUTION WITH NITROGEN DIOXIDE OVER STARA ZAGORA, BULGARIA

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**ABSTRACT**

*Introduction*. Stara Zagora is a densely populated town with developed industry and heavy traffic, subjected to the above-threshold pollution by nitrogen oxides.

*Goal*. The aim of the paper is to estimate the contribution of the industry of the city to the annual urban air pollution with NOx.

*Material and methods*. Data of the fuel used in 2012 from the enterprises and institutions in the city of Stara Zagora were received through requests for access to public information. The main energy sources for the industry and the public institutions are natural gas and the biomass. The households use mainly electricity.

*Results and discussion*. The appraisal for the city industry emissions of nitrogen oxides into the urban air for 2012 is total 67,5 t/y. „Biser Oliva AD", which burn biomass is the main NOx emitter between the industrial sources.

***Key words:****Urban air pollution, NOx, Stara Zagora*

## Introduction

Stara Zagora is a densely populated town with developed industry, without centralized heating. The town is located in the foothills of the southern slopes of the Sredna gora mountain. The combination between the compact city layout with heavy traffic added to the industrial sources of pollution and the thousands of closely spaced polluting sources – households determines the local environmental problems associated with urban air pollution. The environmental problems with the urban air pollution of the city have long history. Several events of above-threshold pollution of nitrogen oxides occur over recent years.

The aim of the paper is to estimate the contribution of the industry of the city to the annual urban air pollution.

## Material and methods

Data of the fuel used in 2012 from the enterprises and institutions in the city of Stara Zagora were received through requests for access to public information.

Data were received for:

- The power of the combustion installations, fuel types and modes of industrial combustion for the plants in the city of Stara Zagora in 2012. With the exception of two of them which burn biomass – "Biser Oliva AD" and "Sredna gora AD", the other industrial installations with significant emissions of nitrogen dioxide burn natural gas.
- The burnt gas from industrial plants in the city of Stara Zagora for 2012.
- The burnt biomass (sunflower seed peel) for 2012 from "Biser Oliva AD"
- The burnt biomass (sawdust) for 2012 in "Sredna gora AD".

## Results and discussion

Data by industrial energy sources for 2012 are given in a table 1.

Table 1. Fuel consumption by industry of Stara Zagora for 2012.

| Type of an energy source | Consumption for 2012 |
|---|---|
| Biomass , Mg (t) | 13358 |
| Natural gas , $Nm^3$ | 19421856 |

The net calorific values of the two types fuels used by industry in the city – biomass and natural gas, are given in table 2.

Table 2. Net calorific values for fuels used by industry in the city (Updated methodology for determination of harmful substances emitted into the air, 2005).

| Fuel type: | Net calorific values |
|---|---|
| Biomass , GJ/Mg | 14,7 |
| Natural gas ( CNG ), MJ/m$^3$ | 34,5 |

The values of emission factors for NOx of the fuels (table 2), used in the combustion installations below 50 MW, such as industrial combustion installations in the city plants, are given in table 3.

Table 3. Emission factors for fuels used in the industry of city of Stara Zagora.

| Fuel type : | Emission factor , g/GJ | Source: |
|---|---|---|
| Biomass | 91 | EMEP/EEA emission inventory guidebook 2013, Small combustion, page 31, Table 3-10 |
| Natural gas ( CNG ) | 74 | EMEP/EEA emission inventory guidebook 2013, Small combustion, page 29, Table 3-8 |

The total emissions of nitrogen oxides from the industry of Stara Zagora for 2012 can be calculated by multiplying the relevant data from tables 1, 2 and 3. The result is shown in Table 4.

Table 4. NOx emissions from industry in the city of Stara Zagora 2012

| Type of energy source | NOx emissions, Mg |
|---|---|
| Biomass | 17,869 |
| Natural gas | 49,584 |
| Total | 67,5 |

The final appraisal for the city industry emissions of nitrogen oxides into the urban air for 2012 is total 67,5 t/y.

Industrial combustion installations of the plants in Stara Zagora are powerful sources of nitrogen oxides emissions, which are a prerequisite for potential above-threshold concentrations of this pollutant in certain areas of the city, particularly in the vicinity of the automatic monitoring station (AMS) "Zeleniat klin" in the city.

Three companies (plants) with significant emissions of nitrogen oxides (stationary point sources) are located within a radius of 1,5 km around AMS "Zeleniat klin" (figure 1):

- “Biser Oliva AD” (that is stationary point source with the highest NOx emission in the city, fuel biomass – sunflower seed peel);
- “Zagorka AD” (the second NOx emission source for the city, fuel natural gas);
- “Natalia AD” (fifth NOx emission stationary point source for the city, fuel natural gas).

The contributions of the three companies in the emission of nitrogen oxides in the city are brought in table 5.

Table 5. Relative emissions of nitrogen oxides from the three closest to AMS "Zeleniat klin" enterprises in Stara Zagora. Source: Regional Inspection of Environmental Protection – Stara Zagora.

| Enterprise | Share in emissions of nitrogen oxides in the town of Stara Zagora ,% | |
|---|---|---|
| | ***2009*** | ***2012*** |
| "Biser Oliva AD" | 60,54 | 66,32 |
| "Zagorka AD" | 13,63 | 9,23 |
| "Natalia AD" | 3,69 | 1,66 |


Figure 1. Three plants (small markers) in city of Stara Zagora with industrial combustion installations off to 1520 m from AMS "Zeleniat klin" (the big light marker). After the name of the source is given its distance to the station in meters and direction from the station to the source in angular degrees.

In table 6 in numbered columns are given the distance between the chimneys of each of the three combustion installations and AMS "Zeleniat klin", measured by the software Goole Earth, fuel burned in November 2012 from each of them, emissions of nitrogen oxides, calculated by the burned fuel and NOx concentration at which these emissions would have fulfilled a circular cylinder with single height and radius of the base equal to the distance to the AMS "Zeleniat klin".

Table 6. Potential of the three closest to AMS "Zeleniat klin" large enterprises as sources of air pollution with nitrogen oxides. The columns are designated with numbers as follows: 1 – the distance between the stacks of the three installations, and AMS "Zeleniat klin", m; 2 – the volume of a circular cylinder with a single height (1 m) and the radius of the base equal to the distance from the stack to AMS "Zeleniat klin", $m^3$; 3 – fuel burned in November 2012 (the month with registered pollutions above the threshold limit) for each of three companies – burned biomass in Mg (tons) or

burned gas volumes expressed in $Nm^{-3}$ (normal cubic meter brought to one atmosphere and 0°C); 4 – emission of NOx for November 2012, expressed in g, calculated from fuel consumption; 5 – NOx concentration in $\mu g/m^3$, corresponding to the emissions in a cylinder with volume, given in column 2.

| Enterprise | *1* | *2* | *3* | *4* | *5* |
|---|---|---|---|---|---|
| „Biser Oliva AD" | 1521 | 7267889 | 1549,79 | 2073154 | 285248 |
| „Zagorka AD" | 1318 | 5457336 | 173857 | 359884 | 65945 |
| „Natalia AD" | 1077 | 3644024 | 72899 | 150901 | 41411 |

Figure 2 shows graphically the comparative potential of the three companies as sources of air pollution with nitrogen oxides concentrations assessed in column 5 of table 6.

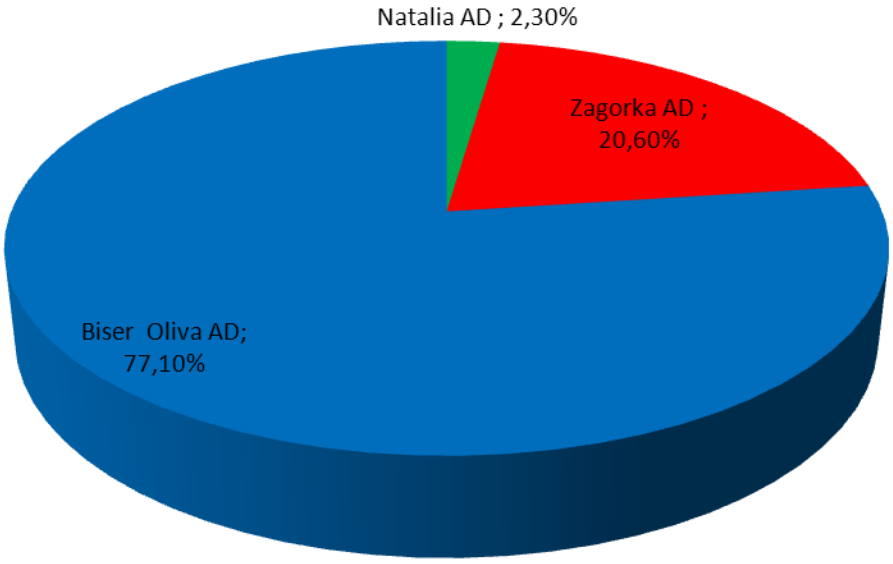


Figure 2. Comparative potential of the three sources to cause contamination of the nitrogen oxides, compared by the concentration, with which they could fill a cylinder with a unit height and a base radius equal to the distance between the stack of their combustion installation and AMS "Zeleniat klin". According to this criterion, the potential of "Biser Oliva AD" to cause suprathreshold air pollution with nitrogen oxides is more than 2,5 times higher that of the other two companies combined.

**References**

1. Updated methodology for determination of harmful substances emitted into the air, 2005. Fuels_tables.xls, Bulgarian Ministry of Environment. (In Bulgarian)
2. EMEP/EEA emission inventory guidebook 2013, Small combustion, page 31, Table 3-10
3. EMEP/EEA emission inventory guidebook 2013, Small combustion, page 29, Table 3-8