ESTIMATION OF POLLUTANT EMISSIONS FROM ENERGY FACILITIES INTO THE ENVIRONMENT IN BELARUS

Alexander Mikhalevich, Yauheniya Shershunovich

Institute of Power Engineering, National Academy of Sciences of Belarus,
15-2 Academicheskaya str., Minsk, Rep. of Belarus, 220072

Abstract

In Belarus thermal and electric power facilities do not contribute a lot to the total pollutant emissions in the atmosphere. But in case of greenhouse gas emissions their impact together with oil refineries is significant. The article shows the ways to decrease pollutant emissions from energy facilities.

Keywords: *pollutant emissions, electric and thermal power facilities, oil refineries, RES, NPP*

1. INTRODUCTION

Already by the middle of the 90th years of the 20th century it became obvious that it is not the lack of fossil fuels that will be the main cause of changing the type of energy but the threat to the planet's life support system owing to the uncontrollable greenhouse effect. The consumption of these resources by the mankind leads to changing the chemical composition of the atmosphere with the corresponding serious consequences, to the deterioration of natural waters and transformation of both local and global water cycles.

The aim of the presented research is to assess the emissions from large enterprises of the power industry and the oil refining enterprises of Belarus on the ecology of the country.

2. CLASSIFICATION OF EMISSIONS ACCORDING TO THE LEGISLATION OF BELARUS

According to Article 1 of the Law of the Republic of Belarus of November 26, 1992 No. 1982-X II "About Environmental Protection" [1] the pollutant is the substance or mix of substances which intake to the environment causes its pollution.

Emission sources are processing and other equipment, technological processes, machines, mechanisms from which the pollutants get in the atmospheric air (Fig.1).

Emissions in the atmosphere are characterized by 5 attributes:

- by their aggregate state: gaseous, liquid, solid;
- by their chemical composition: sulphurous anhydride (SO_2), carbon monoxide (CO), nitrogen oxides (NO, NO_2), fluorine and its compounds (in terms of fluorine ion), carbon sulfur (CS_2), hydrogen sulfide (H_2S); chlorine (Cl), hydrocyanic acid and cyanides (in terms of CN), mercury and its compounds (Hg), ammonia (NH_3), arsenic and its compounds (As), the sum of hydrocarbons, saturated hydrocarbons, unsaturated hydrocarbons, aromatic hydrocarbons, oxygen containing organic compounds, nitrogen-containing organic compounds, phenol (C_6H_5OH), resinous substances, acids, alkalis, lead and its compounds (in terms of Pb), hydrocarbon black, metals and their compounds, dust and so forth;
- by the size of particles: less than 0.5×10-6 μм, from 0.5×10-6 to 3×10-6 μм inclusive, from 3×10-6 to 10×10-6 μм inclusive, from 10×10-6 to 50×10-6 μм inclusive, from 50×10-6 μм;

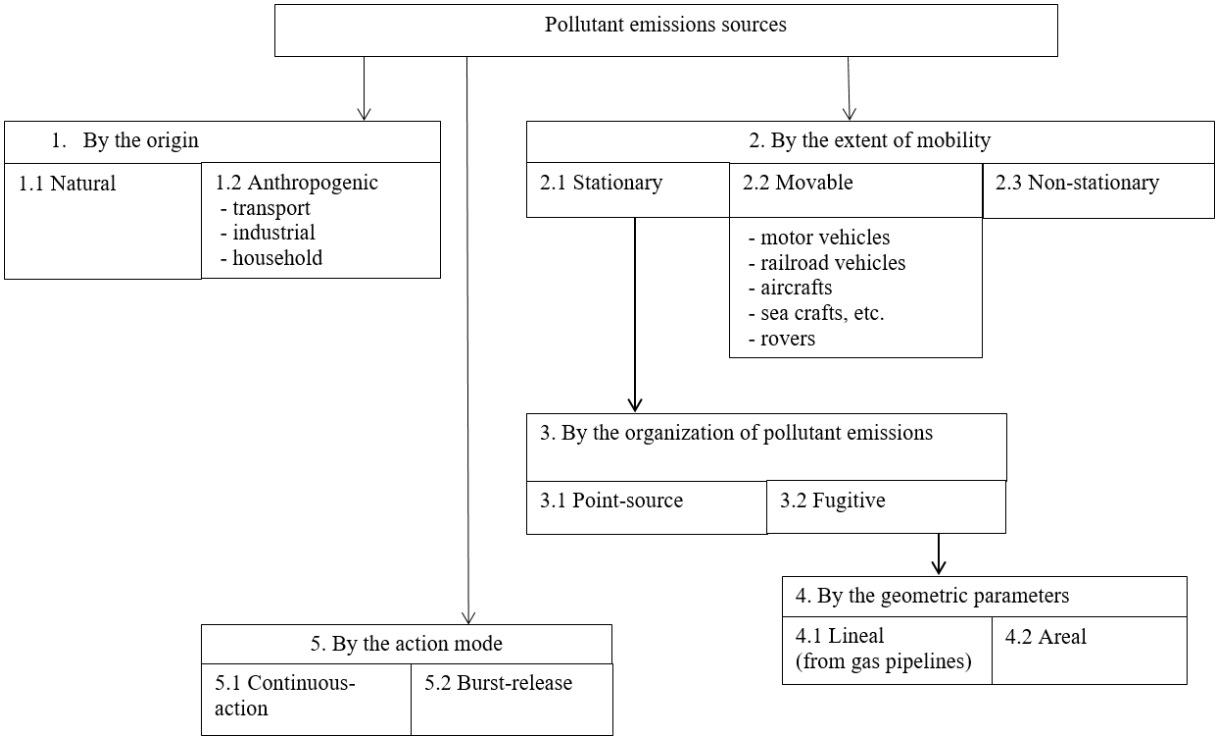


Fig. 1. Classification of pollutant emissions sources

- by the mass of the substance: less than 1 kg/h, from 1 to 10 kg/h inclusive, from 10 to 100 kg/h inclusive, from 100 to 1000 kg/h inclusive, from 1000 to 10 000 kg/h inclusive, from 10,000 kg/h;
- by the extent of their impact on an organism pollutants are subdivided into four hazard classes: the 1st one includes extremely dangerous substances, the 2nd — one highly hazardous substances, the 3rd one — medium hazardous substances, the 4th one — low-dangerous substances [2].

3. POLLUTANT EMISSIONS STRUCTURE BY TYPES OF ECONOMIC ACTIVITY

The three types of economic activity: rural, forest economy and fishery (36%), production of coke and oil products (19%) and supply with the electric power, gas, steam, hot water and the conditioned air (15%) make up the largest specific weight of emissions in Belarus (Fig. 2). It proves the importance of considering the energy facilities as the sources of pollution.

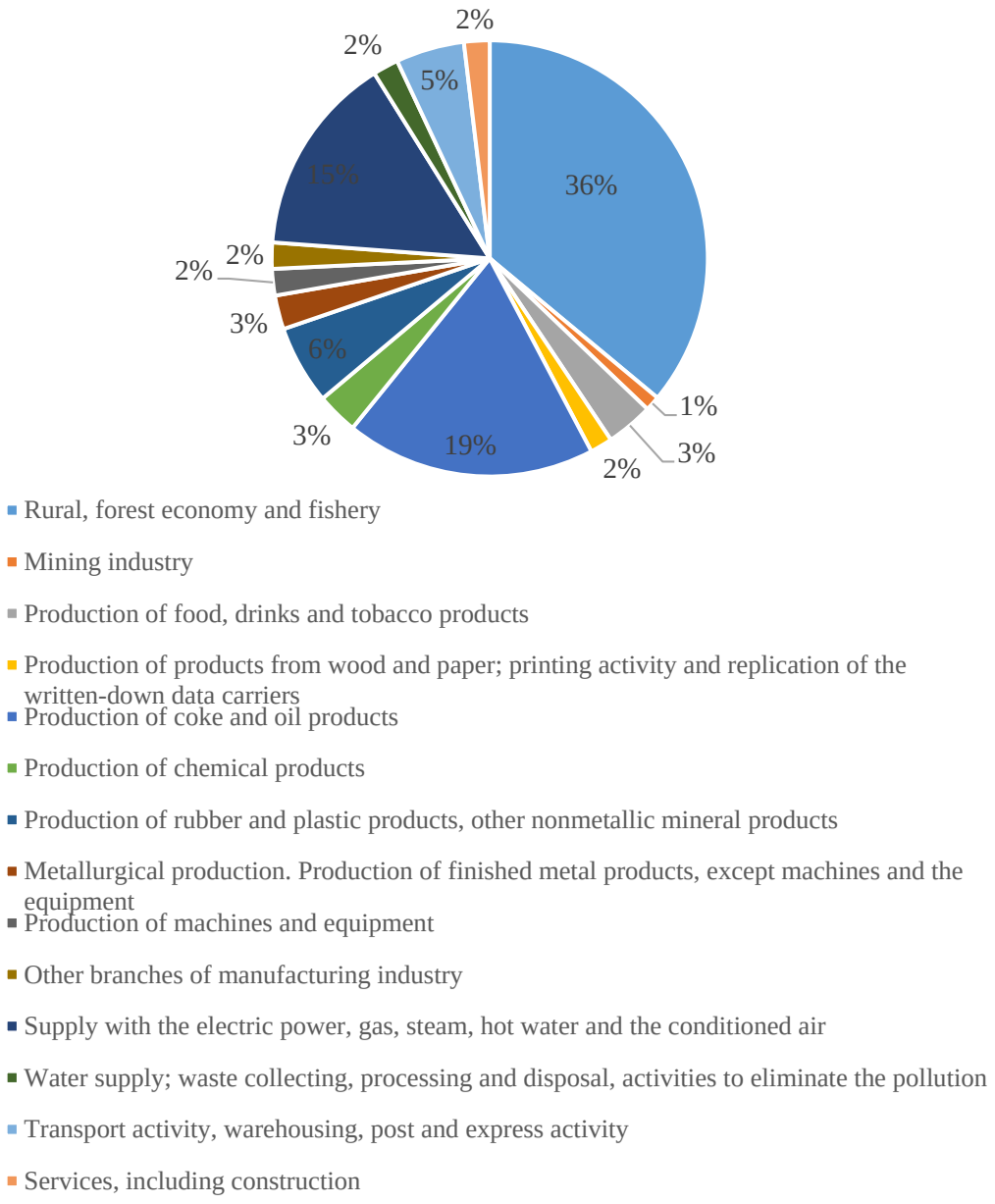


Fig. 2. Structure of pollutant emissions by types of economic activity in 2016

Figure 3 shows the pollutant emissions in Belarus in 2013-2017. The share of emissions from thermal and electric power production in 2017 reached 7.03%, having increased from 6.56% in 2013.

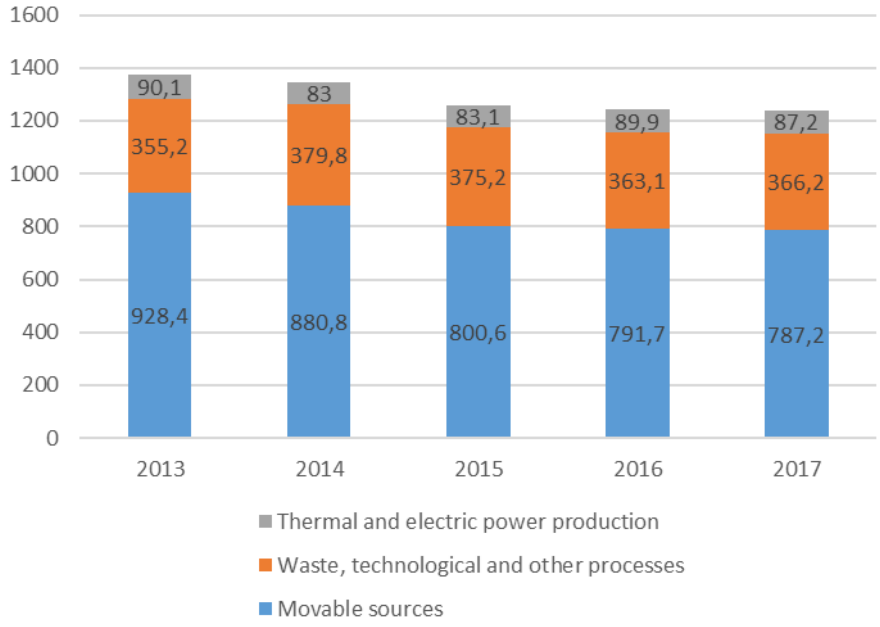


Fig. 3. Pollutant emissions in Belarus in 2013-2017, thousand tons

This picture shows pollutant emissions by mass without taking into account their impact on the environment, except for the direct pollution of the atmospheric air. 'Greenhouse gasses' and other hydrocarbon compounds play the key role in climate change. That's why the thermal and electric power facilities and oil refineries will be further analyzed as the main stationary sources of this pollution in Belarus.

4. ENERGY FACILITIES AS SOURCES OF EMISSIONS

Combustion of carbon-containing fuel is the main source of greenhouse gases formation. At fuel combustion carbon dioxide (CO_2), carbon oxide (CO), nitrogen oxides (NOx), water evaporation (H_2O) and other substances of direct and indirect greenhouse action are formed.

Fuel resources are generally used for generating thermal and electric power energy and also as technological fuel in the industry. The leaks and emissions of methane and not methane volatile organic compounds (NMLOC) during transporting and storage of gaseous and liquid fuel and at oil refineries are an additional source of greenhouse gases formation in the fuel and energy industry.

Thus, energy facilities as emission sources can be divided into two big groups: 1) electric and thermal power facilities (CHPs, state district power stations, boiler houses); 2) oil refineries.

The following factors of energy facilities are responsible for adverse influence on the environment and the quality of life:

- pollutant emissions in the atmosphere by energy facilities;
- disposal of pollutants in water bodies caused by technologies of processing raw materials;
- thermal pollution of water bodies used for cooling systems;
- electromagnetic environmental pollution by power stations, high-voltage lines and other facilities of energy infrastructure;
- noise environmental pollution, including low-frequency inaudible noise, as a result of power stations and other electric power facilities operation;
- visual and esthetic pollution of landscapes by industrial facilities and power lines.

Electric and thermal power facilities represent anthropogenic industrial stationary point-source emissions sources of continuous action.

They are sources more than 300 types of pollutant substances among which the main share is made by sulfur dioxide; carbon oxides; nitrogen oxides; dust of various origin.

Table 1 includes the most probable pollutant emissions from electric and thermal power facilities.

Table 1. Main types of the gas and aerosol pollutant emissions from electric and thermal power facilities

Fuel	Particulate pollutants		Gaseous emissions					
	Ash	Hydrocarbon black	CO_2	H_2O	NO_2	SO_2	NO	CO
Natural gas	–	–	+	+	+	–	+	+
Fuel oil	+	+	+	+	+	+	+	+
Coal	++	+	+	+	+	+	+	+

In table 1 the following symbols characterizing the probability of emissions emergence when burning different types of fuel are used: "++" — very high; "+" — high; "–" — is absent.

Pollutant emissions by separate ingredients from fuel combustion to generate thermal and electric power in 2016 in Belarus are presented in table 2.

Table 2. Pollutant emissions by separate ingredients from fuel combustion to generate thermal and electric power in 2016 in Belarus

Substances	Thousand tons	In % of total emissions by the substance
sulfur dioxide, **SO_2**	12,5	23,5 %
carbon oxide, **CO**	32,9	5,5 %
nitrogen dioxide, **NO_2**	26,4	19,6 %
hydrocarbons	3,5	1,1 %
others	14,6	10,4 %
Total:	**89,9**	**7,2 %**

Oil refineries are anthropogenic industrial stationary point-source and fugitive aerial sources of emissions of continuous action and burst release.

Oil refining is one of the key categories of pollutant emissions sources, such as nitrogen oxides and NMLOC.

At oil refineries pollutant emissions are generated from technological processes (including emissions from evaporation); emissions from burning are insignificant.

Oil refineries represent complex industrial enterprises of the petrochemical industry involved in oil refining and production of different types of products. So, at the enterprises the following technological processes are carried out: primary oil refining; hydrotreating of diesel fuel and kerosene; catalytic reforming, catalytic cracking, selective purification of oils; dewaxing of oils; tar deasphaltizing; production of bitumen, sulfuric acid, additives to lubricating oils, paraxylol, ethyl benzene and other products. There are also automatic filling lines for lubricating oils and solvents; for reception and storage

of raw materials and oil products the enterprise possesses the developed system of reservoir parks with a capacity of 5, 10, 20 thousand tons and production loading facilities. The provided list confirms complexity of not only technological processes, but also accounting of emission sources and their division.

Here different pollutant emissions in the atmospheric air take place according to the type of intake: from industrial processes, burning processes and also as a result of evaporation. The peculiarity of oil refineries is a high share of fugitive emissions (via respiratory valves of capacities, air vents, all-exchange ventilation).

The average concentration of sulfur dioxide in flue gases taking into account a contribution of sources (typical for conditions of Belarus) in total emissions makes 1220 mg/m3.

A number of units (units for production of bitumens — oxidizing columns, installations of monoethanol amines regeneration) includes incinerators. The efficiency of hydrogen sulfide elimination is more than 99,8%.

Emissions of NMLOC from operations of loading, storage and unloading of oil products at the oil refineries of Belarus make more than 50% of their gross emissions.

About 92% of NMLOC emissions of fall to the share of saturated hydrocarbons; on the second place — aromatic hydrocarbons. Saturated hydrocarbons of an aliphatic row dominate (alkanes) dominate among specific LOC.

The available information on oil refineries of Belarus confirms considerable concentration of NMLOC in fugitive emissions at loading and unloading operations with oil products: content of hydrocarbons reaches 1500–2500 mg/m3. LOC emissions are generated from tanks via respiratory valves. The systems of LOC elimination are absent.

In general, due to the high complexity and scale of oil refineries it is only possible to receive only very approximate characteristics of emissions level on the basis of the branch specific indicators. Pollutant emissions in the atmospheric air from oil refining for 2010-2016 in Belarus are presented in tab. 3.

Table 3. Pollutant emissions in the atmospheric air from oil refining for 2010-2016 in Belarus, thsd. tons

Indicator	2010	2011	2012	2013	2014	2015	2016
Pollutant emissions in the atmospheric air from oil refining	71,9	73,8	88,3	84,4	82,6	90,4	84,0

NMLOC and sulfur dioxide take the main share in the structure of emissions from oil refining (Fig. 4).

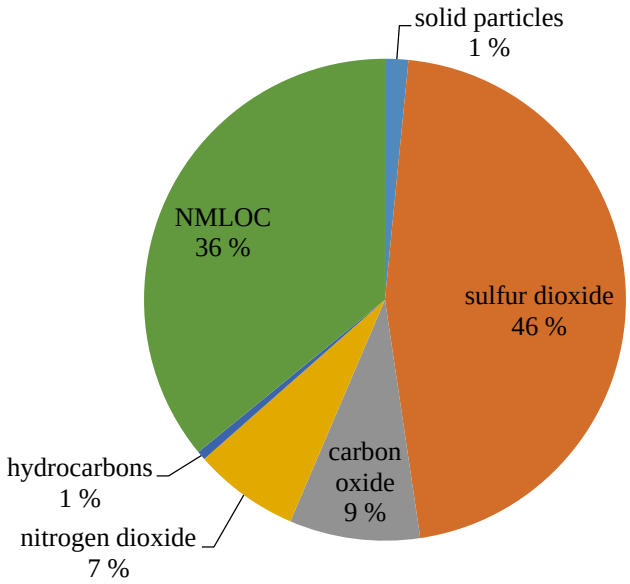


Fig. 4. Structure of pollutant emissions in the atmospheric air from oil refining for 2016

5. MEASURES TO DECREASE POLLUTANT EMISSIONS FROM ENERGY FACILITIES

At present two units of Belarus NPP are under construction. The electrical capacity of each unit is 1194 MW. The first unit is planned to be commissioned in 2020, the second - in 2021. The designed capacity factor is estimated to be 0,92, life-time of the power unit operation is 60 years; electrical efficiency is 36.56% (gross) Operation of two nuclear power units will reduce the burning of natural gas by 4.5 billion cubic meters per year [3]. Another important measure to decrease pollutant emissions from energy facilities is to introduce cleaner sources of energy. Belarus is taking active steps in this direction (Table 4).

Table 4. Capacity of RES units by the end of 2021

	Capacity, MW	Volume of electric power generation, mln kWh
NPP	2388	18 000
RES installed by March 1, 2019	397,30	821,1
RES planned to installation by 2021	439,4	789,7
Total	3224,7	**19 610,8**

6. CONCLUSIONS

Analyzing the structure of emissions, it is possible to draw a conclusion that in Belarus the energy facilities (thermal and electric power enterprises and energy refineries) emit more than 30% of all the pollutants in the atmospheric air.

Nitrogen oxides, carbon oxides, sulfur oxides and solid substances are the main pollutants emitted by the electric and thermal power enterprises. At the same time more than 60% of all the emissions are the share of carbon dioxide.

The oil refineries are the sources of emissions of sulfur dioxide, NMLOC, nitrogen dioxide, carbon oxide. Sulfur dioxide (46%) occupies the largest specific weight in the structure of emissions from the oil refineries.

439,4 MW of RES units and 2 NPP units (1194 MW each) are planned for introduction into the energy system of Belarus by 2021, which will help to decrease pollutant emissions from the energy facilities in the country by 2 times minimum.

ACKNOWLEDGMENTS

The research is being conducted and financed within the project of the Belarusian Republican Foundation for Fundamental Research № X18EA-003 «Methods and technologies of energy impact assessment on the geoecology of the region».

The authors express gratitude for their contribution to the other participants of the project: T. Zoryna, S. Aliaksandrovich, A. Tarasionak.

REFERENCES

1. National legal Internet portal of the Republic of Belarus, *About Environmental Protection*, the Law of the Republic of Belarus of November 26, 1992 No. 1982-XII, 2017, 2/2489.
2. All-Union State Standard 17.2.1.01-76, Classification of emissions by their structure, viewed 10 May 2019, < http://www.docload.ru/Basesdoc/4/4717/index.htm>.
3. A. Mikhalevich, 2018, 'Ecological Aspects of Energy Security in Belarus', *Journal of International Scientific Publications*, Ecology and Safety, Volume 12, pp. 212-219.