Environmental aspects for the reconstruction of housing and communal services in the village Listvyanka of Irkutsk region

Olga Lavygina¹, Oksana Grebneva² and Irina Maizel¹

¹Irkutsk National Research Technical University», Institute of Architecture and Construction, Department of Urban development and Economy, 664074, 83, Lermontov street, Irkutsk, Russia
²Melentiev Energy Systems Institute of SB RAS, Department of pipeline systems of Energy, 664033, 130, Lermontov street, Irkutsk, Russia,

Abstract. This paper considers the environmental aspects of the transfer of heating systems from fuel oil to pellets. The pollutant emissions were calculated for two variants: when working on fuel oil and on pellets. The calculation of the pollutants dispersion were made. The results showed that in the operation of heat supply systems using pellet boilers there is a decrease in gross and maximum-one-time emissions of pollutants.

1 Introduction

The objects of the municipal infrastructure in the process of their operation are subject to major repair or reconstruction depending on the degree of their physical and moral. At the same time, the essential factors causing the initiation of these processes are not only technical and material, but also ecological.

To a large extent, housing and utilities facilities, both on the territory of the Russian Federation as a whole, and on the territory of the Irkutsk Region
in particular, do not meet modern technical, operational and environmental requirements. In total, 45 boiler houses with a total capacity of 126 Gcal / h function in the central ecological zone within the Irkutsk Region, of which 28 boiler houses use coal as fuel [1]. In addition to coal-fired boilers there are fuel oil. Also in the boiler can be used diesel and biodiesel [2].

A series of studies aimed at studying the life cycle of emissions for coal and oil shale with liquid fuels, which confirm the presence of greenhouse gas emissions, has been carried out [3], while global trends in the development of energy systems are aimed at reducing greenhouse gas emissions [4].

The object of the study is a boiler house in the village Listvyanka of the Irkutsk Region, which is on the balance sheet of LLC Management Company Service.

2 Topicality of research

The state of environmental components, in particular, atmospheric air, is one of the key indicators of the state of public health, as evidenced by numerous studies. Special requirements are applied on territories that have special protected status. Relating to the Baikal Natural Territory (BNT), a number of administrative sanctions have been developed. These sanctions are intended to reducing the anthropogenic load, in particular, recognizing Baikal as a UNESCO World Heritage Site, ecological zoning of BNT with the establishment of special legal regimes in three zones: the central (CEZ), buffer zone and atmospheric influence zone, etc. [5]. In this connection, measures of environmental value, implemented on the territory of the CEZ of the lake Baikal, obtain extra importance.

Increased sanitary and hygienic requirements in the study area cause not only the control of recreational, industrial, but also economic activity. Thus, the area of housing and communal services, being an integral part of the residential area, must meet modern requirements in the field of environmental protection.

Atmospheric air pollution over the lake, according to results of snow surveys and chemical analysis, is noted near the coastal settlements and in Listvyanka. The results of field studies of show local pollution on some elements and a relatively satisfactory current state of the environment surrounding the lake Baikal and its water protection zone [6].

Initially, the water protection zone of Baikal was considered to be a coastal strip 500 m wide from the water's edge. In accordance with the
Order of the Government of the Russian Federation (No 368 by 05.03.2015 «On Approval of the Limits of the Water Protection and Fish Protection Zones of Lake Baikal»), its external borders combined with the CEZ, which includes the lake Baikal with islands, adjacent water protection zone, as well as a specially protected natural area (SPNA) [7].

3 Problem statement

The reconstruction of the heat supply system of the Listvyanka village in Irkutsk Region, which consists in replacing the water-heating boiler KVA by pellet boiler the Pyrolysis Master of the PELLET PRO industrial series, must meet not only technical but also environmental requirements.

When choosing a boiler in heating systems, the following criteria are considered: the cost of the boiler and its components; estimated delivery time; efficiency and energy consumption to ensure the operation of boilers; the unit cost of the generated heat energy, taking into account the fuel and amortization components; level of boilers control without significant reduction in efficiency [8]. In addition to these factors, also the indicator of environmental friendliness for used heating systems should be considered.

Traditionally, it is considered that the most environmentally friendly fuel is natural gas [9]. Solid fuel systems, even despite the chemical cyclic fuel consumption [10], do not always meet modern environmental requirements. To carry out a complex assessment of the degree of environmental friendliness for the technical re-equipment, it is advisable to compare the emissions of pollutants in quantitative and qualitative terms during the operation period.

For the purpose of comparison, it is necessary to calculate gross (t / year) and maximum-one-time (g / s) emissions with their subsequent dispersion in the atmospheric air and compare with the obtained values in the territory of the kindergarten and the cost of the lake Baikal.

Also it should be noted that when comparing the results of dispersion, emissions from other emission sources were ignored purposefully. These emissions have already been taken into account with calculating of the standards for maximum permissible emissions (MPE). The goal of this paper study is to assess the degree of impact of different types of boilers on different types of fuel (fuel oil and pellets).
4 Theoretical

Despite the presence of natural forest sinks at BNT, regional transfers of pollutants are also noted [11]. According to observational data, short-term and strong influences from local emission sources are recorded with regional impurity transfers at the Listvyanka monitoring station during the winter period [12].

The main factor determining the quantitative and qualitative composition of emissions is the type and properties of combusted fuel [13]. According to some authors [14], biofuel is highly efficient as a direct combustion fuel.

The process of burning of various types fuel (fuel oil and pellets) suggests the presence of gas-air emissions containing various types of pollutants. Moreover, their quantitative and qualitative content is determined not only by the type of fuel, but also by the design features of the boilers. As part of this study, a comparison of the boiler operating on fuel oil KVA 3.0 Gs / Lz with the boiler using pellets as fuel Pyrolysis Master was made. In this case, the performance of the boilers, their operation time, and the relative load were taken into account.

For calculating gross and maximum one-time emissions, the “Methodology for determining emissions of pollutants into the atmosphere from fuel combustion in boilers with a capacity of less than 30 tons of steam per hour or less than 20 Gcal per hour” was used. This method was recommended by Atomic Research Institute for permissible emissions. This took into account such factors as heat loss from mechanical incomplete combustion, heat of combustion of fuel, degree of flue gases recirculation, heat loss due to chemical incomplete combustion of fuel, as well as ash and sulfur content of used fuel.

5 Numerical studies

In the work the calculation of the pollutants dispersion in the atmospheric air was carried out on the basis of the Methodology approved by the Order N 273 of the Natural Resources Ministry of Russia dated June 6, 2017 (table 1). This technique is used to calculate the dispersion of pollutant emissions in atmospheric air in a two-meter layer above the Earth's surface. For this the control points in the most significant territories were defined from the standpoint of the requirements for the quality of atmospheric air, i.e. Kindergarten 3 and on the coastline of Lake Baikal (source of the river Angara). The main indicators used in the calculation were the chimney...
height, the flow rate and temperature of the gas-air mixture, the distance to the control points, the terrain indicator, the prevailing wind directions, and the background concentrations of the studied pollutants.

Thus fields of maximum single concentrations were obtained. These concentrations correspond to a combination of adverse meteorological conditions, including dangerous wind speed, and unfavorable conditions for the release of pollutants into the atmospheric air. It should be noted that the interaction of pollutants in the atmospheric air has a synergistic effect, i.e. there is an increase in the effect of pollutants in they are present together. It leads to the formation of the following summation groups: Nitrogen dioxide and oxide, fuel oil ash, sulfur dioxide, as well as Nitrogen dioxide, sulfur dioxide. Also these groups of summation were analyzed by the calculation method.

The main criterion for assessment of the negative impact degree is the correlation of concentrations of pollutants with the established standards for maximum permissible concentrations. In modern conditions, the following indicators of pollutants in the atmospheric air of urban and rural settlements are used for hygienic assessment: by Nitrogen and Dioxide – 0.2 mg / m³; by Nitrogen oxide – 0.4 mg / m³; by Sulfur dioxide – 0.5 mg / m³; for groups of summation – the combined effect of mixtures of pollutants in air is taken into account in accordance with the requirements of hygienic standards [15].

Table 1. Concentrations of pollutants at control points (quantas of MPE).

| Name of pollutant (summation group) | Operation of the boiler on fuel oil | Operation of the boiler on pellets |
|------------------------------------|-----------------------------------|----------------------------------|
|                                    | Kindergarten 3                    | The source of the river Angara   |
| 0301 (Nitrogen dioxide (Nitrogen IV oxide)) | 0,35 | 0,34 |
| 0304 (Nitrogen II oxide (Nitrogen oxide)) | 0,1 | 0,1 |
| 0330 (Sulfur dioxide (sulfurous anhydride)) | 0,32 | 0,27 |
| 6006 (Nitrogen dioxide and oxide, fuel oil) | 0,46 | 0,39 |

The source of the river Angara:

- 3

- Not formed
The results showed that the reconstruction of the heat supply system by the replacement of the fuel oil boiler with a pellet boiler will lead to a decrease in the concentration of nitrogen dioxide by 20% on the Kindergarten territory, sulfur dioxide – by 88%, summation group, which includes both components – by 47%. Analysis of results for surface concentrations calculations in the watershed at the source of the river Angara showed a decrease in nitrogen dioxide by 18%, in sulfur dioxide – by 85%, in the group of summation, which includes both components, – by 42%. It should be noted that the concentration of nitrogen oxide remains at the same level. At the same time, the group of the summation containing nitrogen dioxide and oxide, fuel oil ash, sulfur dioxide will not be formed during the transition to pellet boilers.

On the basis of the obtained data, it is possible to conclude that the level of environmental safety is increasing both for the population of village Listvyanka and for the BNT in general.

6 The practical significance of research

In the course of the study, the feasibility of heating system reconstructions in village Listvyanka of Irkutsk Region was proved and scientifically grounded by replacing the fuel oil boiler with a pellet boiler from the standpoint of environmental safety.

The necessary part of tariffs formation for energy resources are also payments for emissions of pollutants [16]. Consequently, the reduction of gross emissions into the atmospheric air is necessary factor in the study feasibility of the heat supply system reconstruction.

The obtained experimental data indicate an increase in the level of environmental safety in the transition from fuel oil to pellets. This fact can serve as a basis or an additional argument justifying the need for reconstruction of enterprises operating similar heating systems. Particularly relevant is the reduction of emissions in specially protected natural areas, in recreational areas, as well as in general for populated areas.
7 Conclusion

In connection with the recent changes in environmental legislation, more and more attention is being paid to the state of the environment in the Baikal Natural Territory and negative impact factors. As part of this study, an assessment of the reconstruction impact degree on the atmospheric air of the village Listvyanka in Irkutsk region was made. The results showed that during the operation of the pellet boiler nitrogen dioxide and sulfur dioxide emissions will be significantly reduced.

Thus, the reconstruction of the boiler house in the village Listvyanka, Irkutsk region will not only optimize the technical and economic indicators for the operating enterprise (UK "Service"), but also lead to a decrease in pollutant emissions. Reducing the values of maximum one-time emissions will reduce the anthropogenic load on the source water area of the Angara River, the ecosystem within the CEZ, as well as reduce the degree of air pollution in the recreational zone of the Listvyanka. Quantitative reduction of gross emissions will lead to savings for the operating enterprise by reducing payments for the negative impact in air pollution.

The authors are grateful for the provided material to the General Director of LLC "Management Company Service" Korabenkova O.N.

The studies were carried out within project III.17.4.3 of the basic research program of the Siberian Branch of the Russian Academy of Sciences (AAAA-A17-117030310437-4)

References

[1] Ivanova I.Yu. Energy: management, quality and energy efficiency, collection of works of the eighth international scientific and technical conference, 330 (2015).
[2] V. Charitha, S. Thirumalini, M. Prasad, S. Srihari. Renewable Energy, 134, 1081 (2019).
[3] Huairong Zhou, Qingchun Yang, Shun Zhu, Ying Song, Dawei Zhang. Resources, Conservation and Recycling, 144, 74 (2019).
[4] Aylin Çiğdem Köne, Tayfun Büke. Renewable Energy, 133, 914 (2019).
[5] Gagarinova O.V. Geography issues, 145,374 (2018).
[6] Belozertseva I.A. Water resources, 44 (3), 340 (2017).
[7] Kalikhman T.P., Kalikhman A.D. News of the Altai Branch of the Russian Geographical Society, 2, 24 (2017).
[8] Khan V.V. News of universities. Investments. Building. The property, 4 (19), 146 (2016).
[9] Hao Chen, Jingjing He, Xianglin Zhong. Journal of the Energy Institute, corrected proof (2018), In press.
[10] J. Adánez, A. Abad, T. Mendiara, P. Gayán, F. García-Labiano. Progress in Energy and Combustion Science, 65, 6 (2018).
[11] Boqiang Lin, Jiamin Ge. Journal of Cleaner Production (2019), In press.
[12] Makukhin V.L. Biosphere, 6 (4), 352 (2014).
[13] Hu Wang, Xumin Zhao, Laihui Tong, Mingfa. Fuel, 227, 457 (2018).
[14] Hong Il Choi, Jeong Seop Lee, Jin Won Choi, Ye Sol Shin, Sang Jun Sim. Bioresource Technology, 273, 341 (2019).
[15] Resolution ch. sanitary doctor of the Russian Federation of December 22, 2017 N 165 On the approval of hygienic standards GN 2.1.6.3492-17.
[16] Khan V.V. News of universities. Investments. Building. The property, 7 (1), 84 (2017).