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Technical note

TECHNICAL AND ECONOMIC ASPECTS OF LOW EMISSION REDUCTION IN POLAND

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The paper presents the problem of excessive air pollution in Poland caused mainly by low emission. The emission arises in result of heating flats by means of old and energetically inefficient heating installations.

In Poland and Bulgaria the inhaled air is of the worst quality out of all EU countries. The paper presents economic and technical problems related to low emission occurring during the combustion of solid fuels in local boiler houses.

Furthermore, the most significant economic issues, connected with the reduction of low emission are discussed, as well as technological possibilities of efficient reduction of the amount of pollution in the atmosphere. Conclusions are presented at the end of the article.

Key words: economy, energy, low emission, ecology.

1. Introduction

According to the estimates of the World Health Organization, every year approximately 48 thousand people die prematurely in Poland because of bad quality of air. It has to be noted that at present the whole world faces the challenge of solving problems, which were eliminated in most countries of the European Union several dozen years ago. The *Great Smog of London* affected the British capital in 1952. Great Britain, in a relatively short time, introduced numerous legal regulations which reduced the extent of smog events. It is assumed that low emission comes from emitters located less than 40m above the ground. Low emission constitutes a serious problem in Poland and a major source of air pollution. Low emission is caused by the combustion of solid, liquid and gas fuels. The following are the most important sources of emission in Poland: industry, heating utility water, road transport, heating buildings.

The most important pollutants include sulphur dioxide SO_2, suspended particulates of PM10, PM2.5, carbon monoxide CO, nitrogen oxides NO_X, and polycyclic aromatic hydrocarbons.

The share of particular sources in the emergence of low emission varies in particular regions of Poland. Yet on a national scale, combustion of solid fuels for the purpose of heating buildings, exerts the most negative impact on the environment and human health. In Poland, however, the pollution of air by benzo(a)pyrene (B(a)P) contained in suspended particles is the most difficult problem. Although B(a)P is a substance which can be relatively easily eliminated by means of the application of currently available technical solutions, the pollution of air by this substance in Poland remains the most serious problem relative to all EU countries (Fig.1).

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Combustion of low quality coal in local, energetically inefficient boiler houses constitutes the most significant problem in Poland in relation to low emission [1-3]. That is why reduction of combustion of coal in old type boilers may quickly lead to the achievement of ecological effects, which will be at the same time the most economic solution.

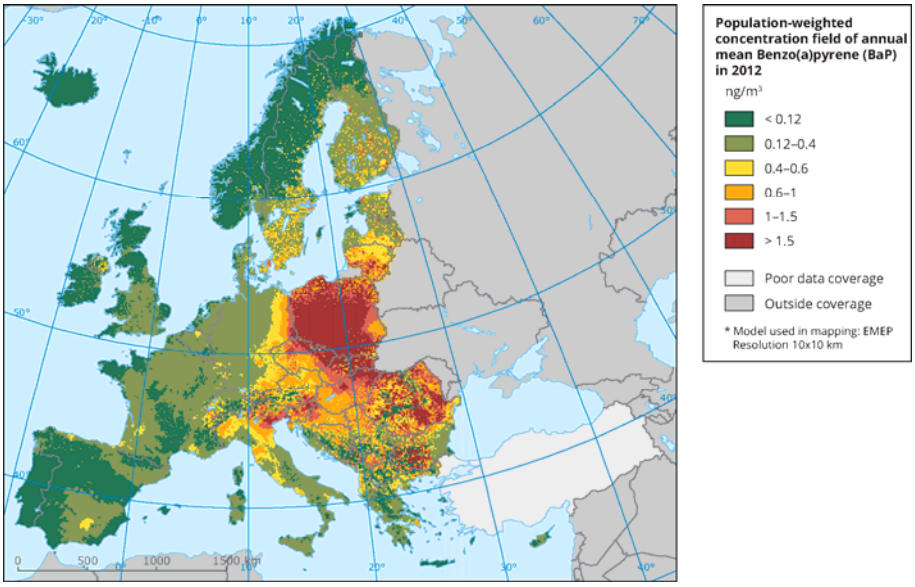

Fig.1. The concentration of carcinogenic B (a) P in Europe in 2012 [4].

2. Economic problems of low emission in Poland

The question of improving the quality of the air, with particular consideration of the minimization of the impact of low emission on the environment, is to a large extent economic in nature. Some districts in Poland have already noticed and started to solve the problem of low emission. *Programmes for the Reduction of Low Emission* have been developed, whose aim, apart from ecological education, is to collect needs and expectations of the citizens, and also acquire funding for thermo-modernization or financial support for replacement of boilers. It needs to be stressed that modernization of boilers results not only in long term economic benefits, but also in benefits for the environment in the sense of reduction of the emission of gases, dust and smaller amount of the combusted fuel in view of higher efficiency of boilers [5].

The development and implementation of the *Programmes for the Reduction of Low Emission* for particular districts and towns is of particular significance. The programmes aim at systemic reduction of the emission of harmful substances to the atmosphere by means of building insulation, replacement of currently used sources of heat, which are inefficient and use low quality fuel. According to the assumptions of most *Programmes for the Reduction of Low Emission* eliminated sources of heat should be replaced by installation of new, more ecological and energy saving heating systems and by implementation of renewable sources of energy. It has to be stressed, that quite often a simultaneous implementation of a number of solutions, e.g. replacement of sources of heat and implantation of renewable sources of energy, are assumed in the *Programmes for the Reduction of low Emission.*

Reduction of air pollution translates into better health condition of children and adults and may exert a positive impact on encouraging citizens to undertake more intensive outdoor physical activity. The situation may influence the level of fitness of people and reduce medical treatment expenses, which in turn to a certain extent translates in to the improvement of the economic situation of the citizens. Increased income from the development of tourism may constitute another benefit [6].

Despite a series of positive aspects of the reduction of low emission, the problem remains unsolved in Poland. Unfortunately, most Poles live in an unfavourable financial situation, which influences the choice of

more economic forms of heating. Legal regulations, which permit the purchase and sale of boilers combusting solid fuels in an inefficient way, are a serious problem in Poland. This situation constitutes one of the most significant causes of poor air quality during the heating season almost in the entire area of Poland. Mainly for economic reasons, the problem to a large extent applies to Silesia, since transport of low quality hard coal for longer distances is not economic, and hence it is combusted locally, close to the place of mining [7].

The fact that in urban areas, which despite high level of emission are popular among tourists, the reduction of low emission may intensify interest on the part of the visitors and lengthen the tourist season. This is particularly significant in places located in the mountains, where tourist traffic is intensified in winter, as the improvement of the quality of the air at that time, when low emission is particularly high, may contribute to the increase of the number of tourists. Furthermore, in the mountainous areas, local emissions often remain at the same place due to the land in view of the landform.

While analyzing the causes of low emissions, it has to be noted that they are often triggered by economic factors. Many Poles live in buildings which are insufficiently insulated. and use low quality coal combusted in local boiler house, simply because their financial situation does not allow a higher standard. That is why the reduction of low emission may be influenced by an improvement of the financial situation of Poles, which for obvious reasons will be difficult to achieve in the short-term period. Co-financing various projects contributing to the reduction of low emission is of particular significance [8].

Such action usually consists in co-financing the replacement of old inefficient boilers by modern, low emission ones, supplied by fuel other than coal and additionally operating at higher efficiency. Reduction of low emission also includes thermal modernization of buildings. The problem of low emission usually applies to places in which it is generated. That is why permissible values of concentration are often exceeded during windless weather, particularly in compact settlements. At the same time during windy weather the pollutants may be transmitted as far as at several dozen kilometres away. Pollution generated in neighbouring countries cause additional problems, yet the issue applies only to borderland areas, as it is presented in Fig.2, and do not constitute a dominating factor contributing to a high level of concentration of hazardous substances in the air. It has to be stressed that air pollution whose source is low emission, may be transmitted for several dozen kilometres. The problem applies mainly to western Poland because of the wind direction. Yet, poor quality of the air in Poland is not caused by emissions from Germany.

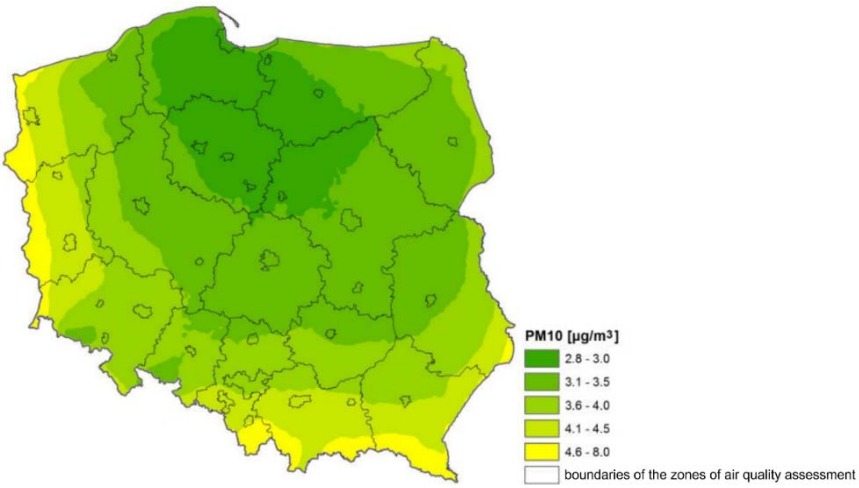

Fig.2. The emissions from neighboring countries [9].

3. Technical methods of reducing low emissions

Application of more efficient heating installations constitutes an important technical element contributing to the reduction of low emission and air pollution. There are numerous methods for identifying efficient technical solutions before their installation. Life Cycle Assessment (LCA) is one of them, and its

aim is to assess the impact of generation of any product on the environment by means of identification and quantitative evaluation of raw materials and energy used and waste channelled to the environment [10-11]. LCA facilitates the comparison of various technical solutions used for heating rooms, mainly boilers in single family houses. LCA assessment may identify the boiler which to the least degree affects the environment. LCA is based on actual input and output process data. The International Organization for Standardization ISO defines LCA as a technique of assessment of environmental aspects and the potential impact of the product [12-13]. SimaPro version 7.1 software was used for the purpose of the research. LCA results were expressed in the eco-index points (Pt), where 1 Pt is the value of one thousandth of the annual load of the environment per one citizen of Europe [14-16]. The definition of eco-efficiency can be written as follows [17]

$$E = \frac{\text{IEPP}}{IE} \tag{3.1}$$

where E is the eco-efficiency, *IEPP* is the intentional effect of the production process and *IE* is the impact on the environment.

While implementing the evaluation by means of the LCA technique, it is vital to remember about defining the limits of the system for analyzed sources, which in this case include the generation of a specific unit of heat energy, irrelevant of the impact of the production of boilers and the phase of their further recycling. The evaluation does not include the impact on the environment resulting from production and construction of the infrastructure necessary for transmission and/or storage of fuel. The functional unit, assumed for the purpose of the research specifies the demand for heat energy in kWh based on a building representative on the annual basis [18-21].

Table 1. The operating parameters and emission analyzed heat sources [22].

Type of the heat source	Coal boiler	Coal boiler with feeder	Biomass boiler	Gas boiler
The fuel	Coal different assortment	Coal peas	Biomass	Natural gas
The energy efficiency of the heat source [%]	70	82	85	94
The parameters of fuel MJ/kg	24	26	12	42.8
Fuel consumption	7.3 [Mg/year]	5.7 [Mg/year]	11.9 [Mg/year]	3629.5 [m^3/year]
Cost of fuel [EUR]	956	882	708	1469
Total cost of operation [EUR]	995	913	772	1505
Save/increase in operating costs [EUR /year]	-	-82	223	-510
The total emission of pollutants [kg/year]	604	423	131.08	1.03
CO_2 emissions [kg/year]	14600	11400	0	7128
CO emissions [kg/year	329	257	78.72	0.98
SO_2 emissions [kg/year]	93	46	2.38	0.01
NO_X emissions [kg/year]	7	6	8.33	0.00
Emissions of dust [kg/year]	175	114	41.65	0.04
Ecological effect in relation to the building representative: • reduction of emissions of pollutants [kg/year], • reduce carbon dioxide emissions [kg/year]	 X X	 181 3200	 473 14600	 603 7472
LCA value of the environmental impact of heat sources [Pt/year]	573	370	112	29.2

The LCA based research indicates (Tab.1) that the replacement of the boiler with a more ecological one significantly lowers the impact of the generation of heat energy on the environment. It has to be remembered that the replacement of the boiler will be fully efficient even if the building is not insulated. Yet the replacement of the heating installation by a more ecological one gives the best ecological effect, considering relatively low financing, compared to full thermal modernization of the building including the insulation of walls, roof and replacement of windows. Considering relatively high share of single-family buildings in Poland, action consisting in the replacement of low energy efficiency boilers will result in the reduction of the use of fossil fuels and in consequence in the improvement of the quality of the air. It has to be stressed that in the old types of stoves not only low quality coal can be combusted, not permissible for sale in other countries, whereas in modern type stoves combustion of waste is not possible, which particularly detrimentally affects the quality of air in Poland. LCA research results show that the most optimum variant consists in the replacement of the old type coal boiler (column 2) with a gas boiler (column 5). LCA research results presented in the last line in Tab.1 indicate that gas installations have the lowest impact on the environment. The problem applies not only to the cost of the fuel, but also the purchase of a new gas boiler, which is relatively high. The replacement of the old coal boiler with a bio-mass boiler seems to be more economical [22]. Unfortunately the combustion of bio-mass results in significant emission of suspended particulates.

4. Conclusions

The problem of excessive concentration of some substances in the air requires substantial economic outlay. That is why in order to reduce low emission in Poland efficiently, there is a need to look for more economical solutions, as the majority of the society does not possess surplus financing, which could solve the problem on a short-time basis. The market offers numerous solutions, which would allow a reduction of the emissions from local boiler houses in a significant way. While choosing the most pro-ecological ones, the decision making process should be supported by advanced techniques, such as LCA. The problem is, that in order to encourage households to make investments consisting in the replacement of old boilers, powered by fossil fuels (mainly coal), there is a need to introduce various solutions, partly co-financing the replacement. The ban on the use of coal for heating introduced in Kraków seems to be an interesting solution. The ban will be in effect from 2019, and the local citizens may apply for co-financing of the replacement of old coal boilers by more ecological ones.

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