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IMPACT OF HOUSEHOLD ENERGY EFFICIENCY ON AIR QUALITY IN SUBURBANS

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ABSTRACT
Household sector has a dominant share in final energy consumption in Bosnia and Herzegovina . It is estimated that this sector accounts for 51 % of total energy consumption and within the sector most energy is used for space heating. It at the same time it means that this sector has significant emissions of pollutants and significant impact on air quality at the local level. This paper analyzes the impact of implementation of energy efficiency measurements in buildings on the air quality in suburban areas in Bosnia and Herzegovina.
Using mathematical software AERMOD, simulation of sulfur dioxide and particulate matters dispersion in the settlement, which occurs as a result of fuel combustion in domestic stoves and boilers for space heating, before and after the implementation of energy efficiency measures has been done.
Keywords: energy efficiency, air pollution, mathematical modeling

1. INTRODUCTION
The primary objective of this research is the impact of the energy efficiency measures implementation in the household sector on air quality in the suburban areas in the Central Bosnia and Herzegovina. It is estimated that this sector accounts for 51 % of total energy consumption and within the sector most energy is used for space heating [1]. Zenica- Doboj Canton is known as a region of intensive use of coal in households, energy and industry. Studies conducted in the regions of Central and Eastern Europe, which by energy structure similar to Central Bosnia, have shown that the combustion of coal for space heating have a significant impact on air quality and human health. Thus, for example, studies on the effects of emissions of pollutants generated by burning coal in households and services sector in Poland has confirmed that this sector has a significant contribution to the total emissions of sulfur dioxide at the national level and that the largest part of this pollutant dry deposited in populated areas where his share reaches up to 80 % of the total deposited sulfur dioxide [2]. Analysis of the impact of domestic stoves and boilers on air quality has shown that in an urban center such as the Krakow in Poland these sources contribute to 30-50% of the total emissions of particulate matter up to 10 microns in diameter (PM_{10}), and a weakly populated area such as Zakopane 80-90% [3]. During the winter months in the villages near Stuttgart, Germany, 59 % of ambient air pollution with PM_{10} particles, can be attributed to the combustion products of fossil fuels for heating purposes [4].
In order to analyze the impact of implementation of energy efficiency in households on air quality at the local level were selected Povezice the typical suburb near the town of Kakanj in Central Bosnia. Objects in this suburban are heated by domestic stoves and local boilers fired with brown coal and

firewood. Boiler rooms are not equipped with catalytic converters or any other installation to reduce emissions of pollutants. One should keep in mind the objective factors that contribute to the emission of pollutants and their retention at the local level such as: low boiler flues which can not provide sufficient buoyancy force to eject combustion products in multiple layers of the atmosphere, the high sulfur content in the local coal, orientation to coal as the primary fuel for affordability and accessibility. Climatic conditions are one of the crucial factors that determine the movement of pollutants in the atmosphere. Valley Bosnia is characterized by frequent fogs that occur as a result of radiation temperature inversions. Mathematical modeling of the pollutants dispersion has shown that during the critical winter domestic stoves and home boilers contribute 64% of ground level concentrations of sulfur dioxide in the area of the village [5].

2. ENERGY ANALYSIS

Energy analysis is done for two scenarios. Scenario I is an analysis of the current situation in terms of the object construction quality, the need for heating energy and fuel consumption. There is wide variety in the quality of construction and dimensions of objects. So it is possible to encounter objects with adequate thermal insulation of polystyrene plates or layers of mineral wool 10 cm thick on the outer walls, roof and wall to the ground, but also there are a number of the objects without any thermal insulation. Scenario II involves the implementation of measures to promote energy efficiency in terms of intervention in the construction elements of buildings by installing insulating layer 10 cm thick on all external surfaces: walls, roofs and wall to the ground. They are not considered measures of other measures such as fuel switching, improved combustion technology, intervention on heating techniques etc.

Detailed calculation of the object heat losses is done according to EN12831. To estimate the annual heat energy demand, precisely defined procedure according to VDI 2067 –Sheet 2 is used. It was analyzed 289 residential and commercial buildings in the Povezice suburb.

The required amount of fuel is specified by a lower thermal power fuel: coal H_d=13,000 kJ/kg, firewood H_d=10,500 kJ/kg and assuming that 85% of users use coal and 15% biomass. Table 2.1. gives a summary of the number of buildings in Povezice suburb with their surface, heat loss and annual fuel requirements by both scenarios.

Table 2.1 Summary of required heat capacity, annual heating demands and fuel requirements in Povezice suburb by both scenarios

<table>
<tr><td colspan="4">Scenario I Before energy efficiency measure implementation</td><td colspan="2">Scenario II After energy efficiency measure implementation</td></tr>
<tr><td colspan="2"></td><td>Residential</td><td>Service</td><td>Residential</td><td>Service</td></tr>
<tr><td colspan="2">Space (m^2)</td><td>31.260</td><td>5.285</td><td>31.260</td><td>5.285</td></tr>
<tr><td colspan="2">Total annual heating demands (MWh)</td><td colspan="2">8.571</td><td colspan="2">4.114</td></tr>
<tr><td colspan="2">Average annual demand for heating energy (kWh/m^2)</td><td>246.90</td><td>161.40</td><td>118,48</td><td>104.90</td></tr>
<tr><td rowspan="2">Fuel</td><td>Brown coal (t)</td><td colspan="2">2.840</td><td colspan="2">1.363</td></tr>
<tr><td>Wood (t)</td><td colspan="2">620</td><td colspan="2">279</td></tr>
</table>

3. ENVIRONMENTAL ANALYZES

3.1. Emissions of sulfur dioxide and particulate matters

Based on the amount of fuel that is burned for space heating in the Povezice suburb an assessment of emissions of sulfur dioxide and particulate matter (PM_{10}) for both scenarios is done. Assessment of emissions is done according to CORINAIR methodology-detailed mode. Emission factors are determined by the conditions in the combustion chamber (capacity boilers up to 50kW, manually firing, no advanced techniques combustion boilers and stoves have catalytic converters or other ways of reducing emissions). Emissions of sulfur dioxide from combustion depends on several factors: the temperature in the combustion chamber, fuel sulfur content and chemical composition of the ash. The emergence of particulate matters in the combustion process is a direct consequence of the presence of ash in the fuel. Emission of these particulate matters from solid fuels can be significant because of the very high ash content in the fuel. Table 3.1. shows the annual emissions of sulfur dioxide and particulate matter from the house boiler in the Povezice suburb for the Scenario I and Scenario II .

Table 3.1. Emission of sulfur-dioxide and particulate matters from domestic stoves and boilers in Povezice suburan

	Scenario I	Scenario II
Sulfur-dioxide (t/a)	91,93	45,05
Particulate matters (t/a)	20,27	9,12

3.3. Modeling of sulfur dioxide and particulate matters distribution in the atmosphere at the suburb Povezice.

Estimation of sulfur dioxide and particulate matters dispersion from the house boilers in the Povezice was performed using the software package AERMOD. For dispersion modeling of ground level concentrations of sulfur dioxide is necessary to know more input parameters [6]. Requested data can be classified into three groups:

- Climatic data (cloudiness, temperature, humidity, pressure, wind speed and direction, mixing height and horizontal global radiation)
- Data on emissions (the flow of pollutants and the height of discharge)
- Information on the terrain (loaded via the Google Earth)

The modeling of the ground level concentrations dispersion of o sulfur dioxide and particulate matter for both scenarios was done. Critical winter period December-January is analized because for this period meteorological data on the location of the Povezice suburban is aviable [7,8].

Figure 1 shows the distribution of the modeled ground level concentrations of sulfur dioxide in the wider area of the Povezice in the critical winter period December-January, which result from the combustion of fuels for space heating for both scenarios.

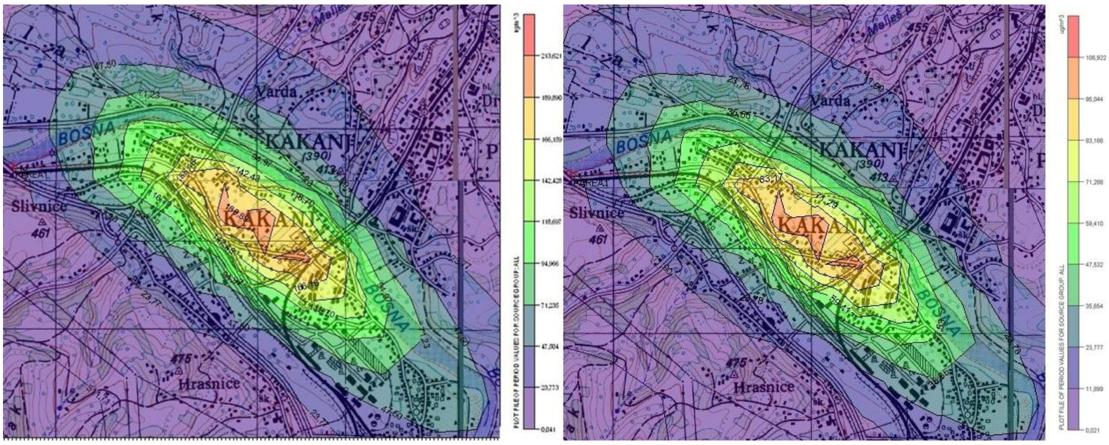

Figure 1. Mean values modeled ground level concentrations of sulfur dioxide emitted from the house boiler in the Povezice suburban Scenario I vs Scenario II

Figure 1. shows the distribution of the modeled ground level concentrations of particulate matters in the wider area of the Povezice in the critical winter period December-January, which result from the combustion of fuels for space heating for both scenarios.

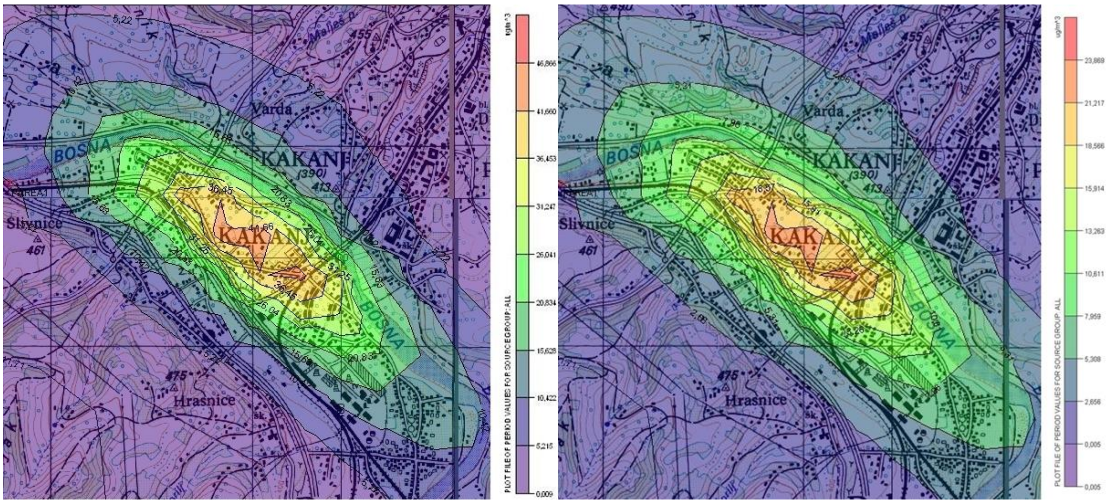

Figure 2. Mean values modeled ground level concentrations of particulate matters emitted from the house boiler in the Povezice suburban, Scenario I vs Scenario II

4. CONCLUSION

The effect of implementation of energy efficiency measures in household sector on air quality at the local level is carried out through the analysis of heat losses from buildings, consumption of heat energy and fuels, emissions of pollutants and mathematical modeling of the dispersion of pollutants in two scenarios: the current state of objects and assumed scenario of object thermal insulation. Air quality modeling was performed by using the software AERMOD for critical winter period in the Povezice suburb, Central Bosnia.

Based on the model results can be concluded that during the critical winter period ground concentrations of sulfur dioxide were reduced by 53% and particulate matter by 56%, which significantly contributed to the improvement of air quality at the local level.

5. REFERENCES

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