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INFLUENCE OF THE INDIVIDUAL GROUP OF ENERGY CONSUMERS ON THE ATMOSPHERIC AIR POLLUTION IN RURAL COMMUNES OF THE ŚWIĘTOKRZYSKIE PROVINCE

Summary

Analysis of the final energy consumption and calculation of atmospheric air pollutant emission on the rural communes' area of the Świętokrzyskie province has been presented in the article. Energy demand for all groups of objects situated on mentioned area has been taken into consideration. For needs of presented elaboration, commune objects were divided into the following sections: housing (concerning households and farming energy consumption), public utility (consists of autonomy administration objects, educational and cultural ones, health service centres and fire stations of voluntary fire brigades) and covered cultivation (where the horticultural production is realized in greenhouses and/or in heating foil tunnels). It enabled better calculation of the total quantity (and the structure) of energetic media in each groups of receivers and, on this base, estimation, what kind of influence they show on the air pollution on country areas of the mentioned province. On the basis of our own studies and modelling-calculations it has been stated, that the greatest influence on the atmospheric air pollution in rural communes shows the housing section, as a main consumer (~ 84%) of the final energy; the participation of public utility objects amounts to 11%, while the horticultural production realised under covers emits about 5% of impurities.

WPŁYW POSZCZEGÓLNYCH GRUP KONSUMENTÓW ENERGII NA ZANIECZYSZCZENIE POWIETRZA ATMOSFERYCZNEGO W GMINACH WIEJSKICH WOJEWÓDZTWA ŚWIĘTOKRZYSKIEGO

Streszczenie

W pracy przedstawiono analizę zużycia energii finalnej oraz obliczono wielkość emisji zanieczyszczeń powietrza atmosferycznego na obszarze gmin wiejskich województwa świętokrzyskiego. Zapotrzebowanie na energię objęło wszystkie grupy obiektów znajdujących się na terenie gmin. Dla potrzeb pracy obiekty gminne podzielono na następujące sektory: mieszkaniowy (obejmujący gospodarstwa domowe i rolne), użyteczności publicznej (w którego skład weszły obiekty: administracji samorządowej, oświatowe, kulturalne, ośrodki zdrowia i remizy OSP), oraz uprawy pod osłonami (gdzie produkcja ogrodnicza jest prowadzona w szklarniach i podgrzewanych tunelach foliowych). Pozwoliło to na obliczenie wielkości i struktury zużycia nośników energetycznych w poszczególnych grupach odbiorców i na tej podstawie określenie jaki mają wpływ na zanieczyszczenie powietrza na terenach wiejskich województwa. Na podstawie badań i obliczeń modelowych stwierdzono, iż największy wpływ na zanieczyszczenie powietrza atmosferycznego w gminach wiejskich ma sektor mieszkaniowy (84%), który jest głównym konsumentem energii finalnej. Udział obiektów użyteczności publicznej wynosi 11%, zaś produkcja ogrodnicza pod osłonami emituje 5% zanieczyszczeń.

1. Introduction

In Poland, the so called communal-living section covers, at present, about 42% of the total original energy consumption, whereof 80% of it has a share in the heating of buildings and preparation of warm usable tap water [5], so, on purposes, in which the energy consumption not only depends on activity of receivers, but also depends on accepted and introduced technical-economic solutions. Needs of mentioned section are mainly fulfilled by combustion of solid fuels, and - as a side effect - emission of harmful impurities to the atmospheric air has taken place. The large participation in the air pollution plays, so called, „the low emission" [1, 3]. The low emission, mostly generated from small boiler rooms, households and farming objects, makes locally the serious problem, particularly on rural-areas, where dominate individual warmth sources dominate [10]. A specificity of the rural-areas, particularly in Krakow districts, is the horticultural cultivation, which substantially bases on greenhouses and/or heating up foil tunnels production, what significantly reflects on the atmospheric air pollution of these areas.

Main aim of the present elaboration is the estimation of the final energy consumption on the commune area and determination of the total emission quantity of the atmospheric air impurities, as well as the participation of each group of above mentioned objects on that emission.

2. Methodology

The goal of the work has been realized based on: statistical data presented in the National General Census [7] and in the General Farming Register [7], data given in the Statistical Yearbook of the Świętokrzyskie province [6] and results obtained from respective gas-works and electricity boards.

The annual consumption of energetic media on country-areas of the province were estimated basing on models describing consumption of final energy in the all country-objects, in relation to demand on the warmth supplied for heating the objects, for the preparation of warm usable tap water and for cooking and the other meals preparation [9, 11].

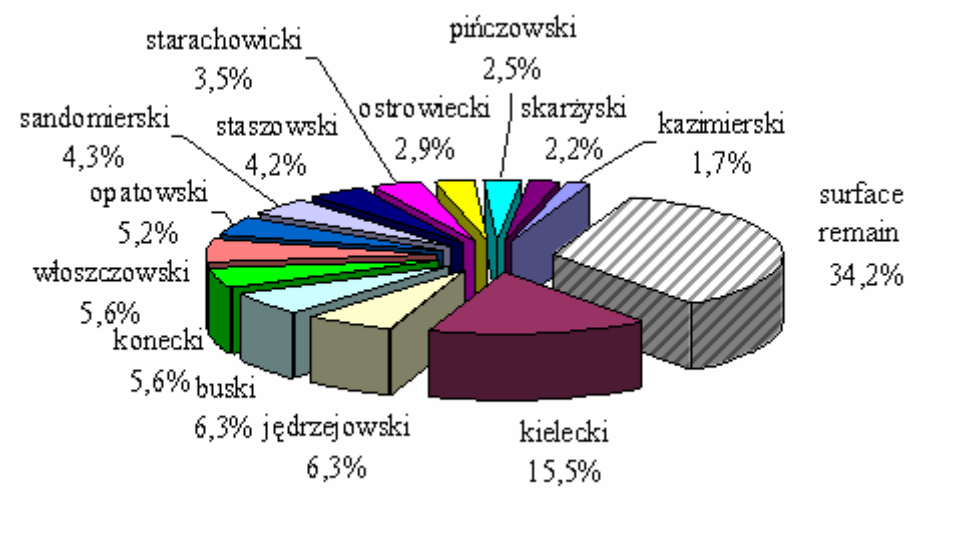

Fig. 1. Rural communes' area structure according to administrative districts (counties**)**
Source: author's evaluation - on the base of the General Statistical Office (GUS) data

Table 1. List of buildings data in rural communes of Świętokrzyskie province

Specification	Area [in thousand of m^2]	Cubature [in thousand of m^3]
Housing Section	11 818	30 843
Public utility section	1 996	6 987
Covered cultivation	242	–

Source: The National General Census 2002, the General Farming Register 2002

Table 2. Final energy consumption of individual sections

Specification	Thermal energy consumption [in thousand of tpu]	Participation [%]
Housing Section	425.01	83
Public utility section	71.08	14
Covered cultivation	17.08	3
Total	513.17	100

The model describes the consumption of energy in all objects being found on the commune territory, which were gathered in three sections:

– housing section (consists of households and farming objects),
– public utility section (concerning objects of socio-economically infrastructure)
– agricultural-productive section (concerning cultivation – mainly horticultural production - inside the covered and heating up objects).

3. Characteristics of studied area

Calculations were done in 13 administrative districts, consist of 72 rural communes, which cover the area of 770500 hectares, what in turn is about 65,8% of the total territory of Świętokrzyskie province. (Fig.1). In the territory of above mentioned rural communes live approx. 40 % of the province inhabitants.

4. Discussion on results

In the table 1 a general characteristics of communal objects – divided into previously mentioned 3 sections - has been presented. The composition concerns also the area of covered cultivation, because part of farms deal in an early crop of vegetables in greenhouses and in foil tunnels, heating up by means of solid fuels.

5. Estimation of energy demand in communes

For their own specificity, energy-demands of each section strongly diverse in respect to the kind and the manner of the energy utilization. The demand contains as both the thermal energy (heat) as the electric power. Thermal energy is used up for heating of rooms, heating up of tap water and the meals preparation.

Calculations executed with the model of the end-use method [9, 11] enabled estimation of the entire consumption of final energy [5] on the area of rural-communes of the Świętokrzyskie province. Comparison of the final energy consumption in each section – expressed in tons of theoretical standard fuel (in the present article shortly qualified as tpu; 1 tpu = 29.3 GJ) and each section's participation in the total thermal energy consumption is presented in table 2.

The dominant position in the energy consumption occupies the housing-section, which absorbs approx. 425 thousand of tpu, what is 83% of the entire energy consumption of in rural-communes of the province. The second place occupies the public utility section which consumes about 14% of final energy. The least participation was noticed for the section of Covered cultivation where for heating purposes the annual consumption is on the level of 17 thousand of tpu (only 3% of share).

6. The structure of the energetic media consumption

At the participation estimation of the fuels consumed by each group of receivers in the commune, it was taking into consideration the data supplied by energy tradesmen (The Electricity Generating Board, Gas-Works), as well as the information obtained from energy consumers. Energetic media consumption in communes (recalculated as tpu) and structure of their consumption is shown in table 3.

Table 3. Thermal energetic media consumption and structure of their demand in rural communes

Specification	Energetic media consumption in rural communes [in thousand of tpu]	Participation [%]
Coal	287.38	56
Wood (firewood, brushwood)	118.03	23
Gas for household purposes - delivered by pipeline net system	61.58	12
LPG gas	15.40	3
Electric energy	30.79	6
Total	513.17	100

On the examined area a basic energy-carrier is the black coal, whose participation reaches 56 % of whole consumption. Wood, as the basic energy-carrier was used in about 5 % farms.

In remaining objects - heating by solid fuels- coal is used as the supplementary fuel. The entire participation of the firewood is on the level of 23 %. The participation of the network (earth) gas amounts to approx. 12%. The participation of consumed fuels in each section is presented in Fig.2.

In households and farming, black carbon is still the basic energy-carrier but from economic or practical points of view it starts to be substituted by the other carriers. Most often it is substituted by fire-wood and/or the earth gas which more frequently is used for the heating - especially in new buildings or in those ones, which heating systems are modernised.

Public utility section, for heating purposes, consumes about 48% of earth gas; in communes adapted for net gas delivery, vast majority of objects is ready for gaseous fuel application – the rest communes still use boiler houses fed with solid fuel. Thermal energy consumed by horticultural production completely originates from the combustion of coal, particularly in form of coal-dust.

7. The level of the impurities emission to the air

For the purpose of the qualification of the thermal energy production arduousness in communes in respect to the atmospheric air pollution, the quantity of pollutants emitted by all groups of each, individual commune has been calculated. Emission range of selected pollutants was calculated on the base of the indicatory method [4] and mathematical relation (1) as follows:

$$E_{SO_2,CO,CO_2,NO_2,Dust} = B_j \cdot W_j \tag{1}$$

where:

$E_{SO_2,CO,CO_2,NO_{2x},Pył}$ – Emission of the impurities, [kg],

B_j – Consumption of ***j***-type of the fuel [Mg] or [m^3],

W_j – Emission index of ***j***-type of the fuel [kg/Mg] lub [mg/m^3].

Quantity value of emission indexes for defined pollutants was accepted in compliance with the Act of Protection and Formation of Environment [12] and also with recommendations of the Department of the Environment concerning the manner of the estimation of pollutants quantity [4, 8].

To be able to compare the arduousness of different impurities emissions one introduced the additional coefficient - so called the equivalent emission [2].

Equivalent emission – it is the emission of two or more kinds of pollutants from one source of emission, in terms of sulphur dioxide. In present work the equivalent emission was calculated according to formula:

$$Er = \sum_{i=1}^{4} E_i \cdot k_i \tag{2}$$

where:

Er – Equivalent emission [Mg],

E_i – Emission of ***i***-type of pollutant. [Mg],

k_i – Factor (coefficient) of toxicity for ***i***-type of pollutant.

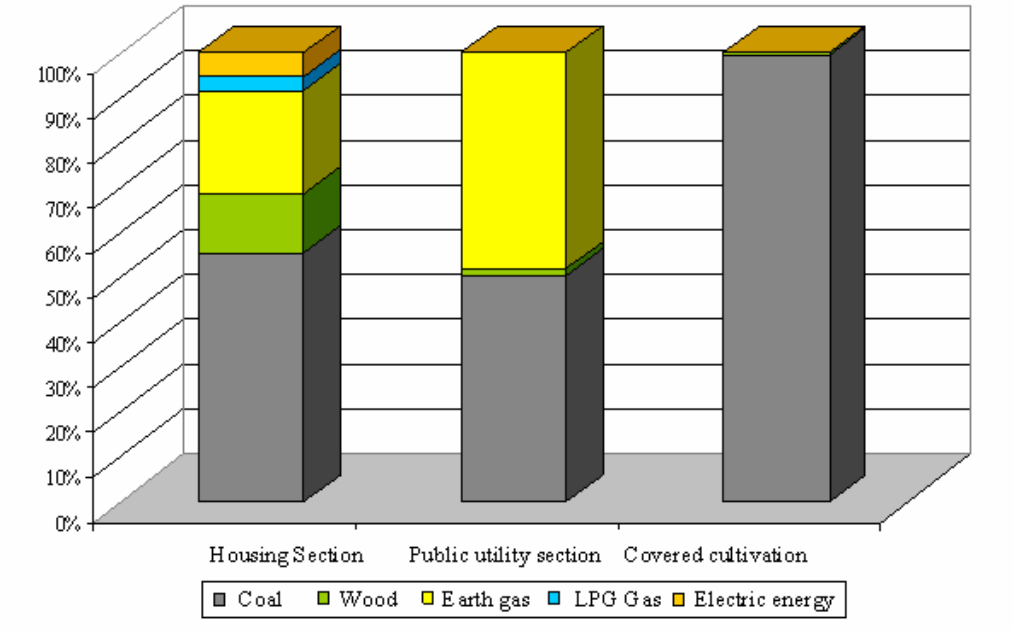

Fig. 2. The structure of energetic media consumption in each sections

Table 4. Air pollutants emission range in rural-communes of the Świętokrzyskie province

The emission of pollutants of the air [Mg/a]						
Specification	SO_2	NO_2	CO	CO_2	Dust	Er
Housing Section	2401	419	11394	678662	4699	22942
Public utility section	341	76	1615	127200	583	3060
Covered cultivation	180	20	839	39300	252	1389
Total	2922	515	13848	845162	5534	27391

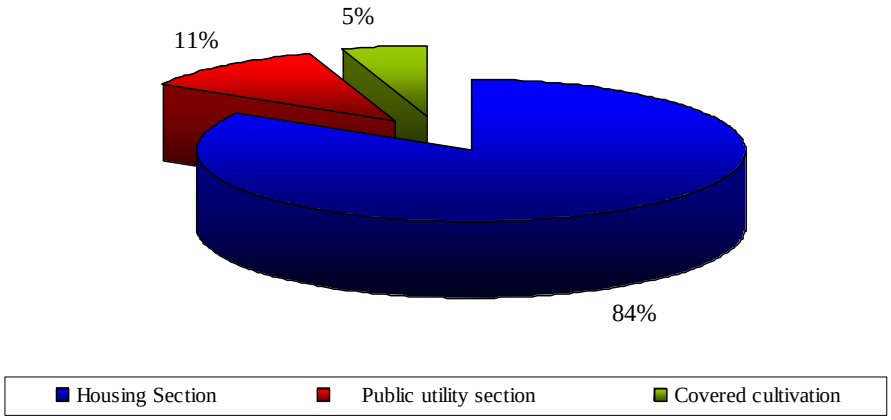

Fig. 3. The participation of each section in the impurities emission to the air on the area of rural-communes of the Świętokrzyskie province

The coefficient of toxicity - it is the ratio of the value of the admissible average-annual SO_2 concentration to the value of admissible average-annual concentration of the given pollutant. In calculations there were accepted suitable values of this coefficient respectively equal to: 1 for SO_2; 2.9 for NO_2; 0.5 for CO and 2.9 for dust.

Emission quantity of each pollutant on the area of examined communes were compared in the table 4, and the proportional participation of each group of consumers of the energy in the entire emission was expressed in the form of the equivalent emission and presented in fig. 3.

From obtained results of calculations one may state that on the area of rural-communes of the Świętokrzyskie province a basic source of all impurities is the housing-section. It results from its unprofitable fuel structure, where most of farms use black coal as the basic energy-carrier. The horticultural production using up about 3% of final energy emits only about 5% of impurities, as a result of the coal combustion at the warmth production. The public utility section using about 14% of the thermal energy on the area of rural-communes introduces into atmosphere about 11% of pollutants.

8. Conclusions

On the base of analysis of the final energy consumption and its influence on the atmospheric air pollution in rural communes of the Świętokrzyskie province the following conclusions have been stated:

1. The entire annual final energy consumption in the commune amounts to 513 thousand tons of the theoretical standard fuel.
2. A greatest receiver of the energy in the commune is the housing-section, whose the participation amounts up to 83%.
3. Heat in housing-section is mainly generated during combustion of solid fuels: coal (56%) and wood (23%). Heating needs of the public utility section, in approx. 48 %, are covered by earth gas utilization.
4. Households and farming grouped in the housing-section yearly emit to the atmosphere about 84% of impurities - this results from the significant quantity of households and farming objects and the unprofitable fuel structure.
5. The horticultural production, in which the whole warmth used for the objects heating, is obtained during coal combustion, shows rather small (5%) participation in the air pollution.

9. References

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