

EFFECT OF ACTIONS RATIONALIZING POWER CONSUMPTION ON A DECREASE IN ATMOSPHERIC AIR POLLUTION

Summary

The work presented within the models connecting reduction of the level of atmospheric air pollution in a typically agricultural region of southern Poland with a range of rational energy consumption activities. Among rational energy consumption activities taken into account were building thermomodernisations, replacements of old coal boilers with innovative, more efficient ones, with gas boilers, with wood and straw burning boilers, and with heating pumps. These models may be used for the planning of local pro-ecological strategies in conditions of limited regional financial means for aid of rational energy consumption activities.

WPŁYW DZIAŁAŃ RACJONALIZUJĄCYCH ZUŻYCIE ENERGII NA ZMNIĘSZENIE POZIOMU ZANIECZYSZCZEŃ POWIETRZA ATMOSFERYCZNEGO

Streszczenie

W pracy przedstawiono modele wiążące zmiany poziomu zanieczyszczeń powietrza atmosferycznego w typowo rolniczej gminie z terenów Polski południowej z zakresem działań racjonalizujących zużycie energii. Spośród działań racjonalizujących zużycie energii uwzględniono termomodernizacje budynków, wymianę starych kotłów węglowych na nowoczesne o wyższej sprawności, na kotły gazowe, na kotły do spalania drewna i słomy oraz na pompy ciepła. Modele te nadają się do wykorzystania przez samorządy terytorialne przy planowaniu strategii proekologicznych w warunkach ograniczonych środków finansowych gmin na wsparcie przedsięwzięć racjonalizujących zużycie energii.

Introduction

Poland, according to constitution register (2), regarding its social-economic activity, has an obligation of balanced development. The rule of balanced development means administrating in a way that assures balance between energetic safeties, meeting social needs, competitiveness of economy as well as natural environment protection, and engages all rungs of national administration and economy organizations.

On the local rung, the rule of balanced development has to be realized, based on among others, a plan of supplying every region with heat, electric energy, and gas fuels (5, 7). This plan should be an elaboration of the region energetic needs balance and the existing possibilities of satisfying them, with specific regard of local, including renewable, energy source use. The plan also has to include propositions of executing ventures that lead to the decrease of energy consumption and limiting pollution emissions.

Local energy planning is a relatively new concept. The region autonomies do not have enough experience to realize these types of assignments with lack of studies that could aid the planning. There is a specific lack of studies for energy economy aid at the rung of the country region with regard to affiliation with its effect on the natural environment.

The aim of the work was the construction of models that describe the effect of chosen activities which rationalized energy consumption within country counties on the reduction of pollution emissions of atmospheric air caused by so called *low emission* in a form usable in practice by territorial autonomies.

Materials and methods

The aim of the work was realized based on studies of typical agricultural counties with gas access on the terrains of southern Poland.

For the needs of this project, a model that illustrates the need of heat energy in country counties was used (8, 10), within which the need of heat is explained with the help of variables accessible from statistic listings of counties, such as the number of inhabitants, number of households and their structure regarding the amount of residing people, number of buildings and date of their construction, heated surface, heating system efficiency. This model was used to designate the need for heating within counties and, in regard, the amount of atmospheric air pollution, as well as studies simulating the effect of chosen activities rationalizing energy consumption on the decrease of the pollution level.

Results

The indicators that are a trait of an average agricultural region in southern Poland are presented in Table 1.

Table 1. Indicators characterizing of an average agricultural region in southern Poland

Specification	Indicator value	
Population depth [number of inhabitants/km ²]	130	
Building depth [number of residential buildings/km ²]	35	
Age structure of residential buildings [%]	constructed before 1960	28
	constructed after 1990	18
Average household area [ha]	3,2	
Average amount of residents within household	4	

The yearly heat energy consumption in such a region is the amount of needed heating in all country buildings and includes its usage for the needs of heating buildings, preparation of utilizable warm water and meals. Within an average typical agriculture region of southern Poland there is

around 4 TJ of heating energy used yearly with conversion to km² of the area. 86% of this usage is the heating of residential buildings. The basic energetic carrier is black coal, which has about a 64% share in the fuel balance of an agricultural region. Around 18% of the heating needs are met by the burning of firewood, 16% by natural gas use.

To assess the effect of heating energy generation on the state of atmospheric air an indicator method was used and values of singular indicators of specific pollution emissions were accepted according to the Statute of Environment Protection and Development (1980) and the Environment Ministry guidelines (1). For comparison, the so-called balancing emission E_r was also indicated, which determines the emissions of all pollution converted to sulphur dioxide (3). The values of specific pollution for a typical agricultural region are presented in Table 2.

Table 2. Indicators of singular atmospheric air pollution caused by the so-called *low emission* in Mg/km² in an average agricultural region in southern Poland

SO_2	NO_2	CO	CO_2	$Dust$	E_r
1,1	0,2	5,3	285	2,0	10,1

Source: own calculation

Accounting for the preferences of region inhabitant and territorial autonomies, there was a simulation of affection for the decrease of atmospheric air pollution, thermomodernisation of buildings and of heating systems by replacing old coal boilers with: new, more dependable coal boilers, gas boilers, biomass boilers in which wood or straw may be burned, alternatively with heating pumps. Regarding the fact that in country counties, the largest share in energy consumption, and what goes with it in air pollution, belongs to the residency sector, the simulations were only made for residential buildings.

The simulation data acquired was used for the development of models connecting the change of the region's yearly air pollution with the number of households that rationalize energy use. The best formula ($R^2=0,9\div 0,97$) was acquired by use of multiple regression equation with the form of:

$$\Delta E = e_1 \cdot g_1 + e_2 \cdot g_2 + e_3 \cdot g_3 + e_4 \cdot g_4 + e_5 \cdot g_5 + e_6 \cdot g_6 \quad (1)$$

where:

ΔE – decrease of atmospheric air pollution emissions within the region [%],

- g_1 – participation of households which had thermomodernized buildings [%],
- g_2 – participation of households which had coal boilers replaced with new ones [%],
- g_3 – participation of households which had coal boilers replaced with gas boilers [%],
- g_4 – participation of households which had coal boilers replaced with wood burning boilers [%],
- g_5 – participation of households which had coal boilers replaced with hay burning boilers [%],
- g_6 – participation of households which had coal boilers replaced with heating pumps [%],
- e_1, \dots, e_6 – model parameters.

In Table 3, e parameter models were listed, describing the decreasing of emissions of specific types of atmospheric air pollution, also in the form of balancing emission, within a typical southern Poland agricultural country region.

The exemplary parameter values of the ΔE_{E_r} model indicate that the biggest influence on decreasing the level of air pollutions have activities based on replacing coal boilers with gas boilers or heating pumps.

Analyzing of activities decreasing the level of air pollution is costly. Local authorities who want to urge inhabitants toward them should activate an information campaign encouraging rational energy use activity, especially regarding the heating of residential buildings. The campaign should show the benefits involved with such activity and point out financial aid possibilities. Territorial autonomy units can also support the inhabitants themselves by granting non-returnable loans. However, the regional financial means designated for these activities are limited and it is important to administrate them in a way that will assure the attainment of the intended pro-ecological aim. In regard to this, the presented models were used to optimize the distribution of financial means in chosen agricultural regions for the support of rational energy consumption in a way that assures the demanded decrease of the atmospheric air pollution level (4).

The executed calculations confirmed the authors' earlier studies (9) that regions which have very limited means for the protection of atmospheric air, to achieve the intended ecological effect, should use them mainly for aiding the purchases of gas boilers, which may amount to 50% of the total replaced boilers. As regional autonomies increase the amount of investment means for pro-ecological activities, they should increase the financial aid of replacing coal boilers with biomass burning boilers.

Table 3. E parameter model values of changing emissions of atmospheric air pollution in an average agricultural region in southern Poland

Specification	e_1	e_2	e_3	e_4	e_5	e_6
ΔE_{SO_2}	0,23	0,12	0,81	0,85	0,67	0,79
ΔE_{NO_2}	0,23	0,11	0,28	0,12	-0,02	0,74
ΔE_{CO}	0,23	0,12	0,80	0,84	0,60	0,78
ΔE_{CO_2}	0,23	0,10	0,34	0,70	0,70	0,70
ΔE_{dust}	0,23	0,12	0,79	0,27	0,26	0,76
ΔE_{E_r}	0,23	0,12	0,82	0,40	0,33	0,82

Source: own calculation

Summary

Country regions, especially within southern Poland, are directing themselves toward recreation and tourist operations. With regard to this, they pay more attention to the realization of statutory obligations concerning natural environment protection, including atmospheric air protection. Subsequently, there is a need of acknowledging, already in the phase of planning rational energy consumption activities, their effect on natural environment, with the purpose of introducing activities that bring the biggest ecological benefits.

Stating the pro-ecological activity of country regions of southern Poland may be simplified by the use of the presented regression models connecting reduction of the level of atmospheric air pollution with a chosen extent of rational energy consumption activities.

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