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Sources and techniques of domestic heating within TRITIA region

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Abstract

The paper presents the balance of energy consumption for domestic heating in Opole and Silesian Voivodship (Poland), divided into various media. The report was based on an analysis of approximately 250 documents containing low-carbon economy plans for individual municipalities (gminas). The authors compared the current situation in these voivodships and their districts with the structure of the heating system in Poland as a whole, based on data from the Central Statistical Office of Poland. The data demonstrate that the use of coal-based energy media has not changed significantly over the years and around 55–60% of households with individual heating systems use this type of media. A much more favourable trend is found in large urban centres, where there is a high proportion of district heating. The most common of the lower-emitting fuels (LPG, natural gas, electricity, heat pumps) is natural gas, and the share of the remaining sources within this group are barely significant.

The detailed data on the structure of sources and heating techniques in households presented in this study were used to create a model of pollution dispersion in the AirTritia project, which covered the part of the Czech, Polish and Slovak borderland forming the Tritia functional area.

Keywords: air pollution, households, energy commodities, Tritia region, domestic heating

1. Introduction

According to World Health Organization, air pollution represents the biggest environmental risk to health. It is assessed, that about 3 up to 4,2 million deaths are attributable yearly to outdoor and indoor air pollution. Air pollution accounts for death due to stroke, heart disease, lung cancer, acute and chronic respiratory diseases. Due to the weighty concern of the problem, global organizations issued documents to help to monitor the air pollution and prepared guidelines to improve air quality and health of the inhabitants of the most affected areas [1,2]. The European Environment Agency publishes a yearly reports on the air quality in Europe, to analyze the state and trends of air pollutants emissions, concentrations and exposure of both population and ecosystems. On the other hand reports summarizing international projects assess methods of monitoring and estimating health impacts of air pollution [3–5]. The reduction of air

pollution is also an economic challenge, especially in countries where the energy economy is based on hard coal and lignite. That's why WHO issued the document that describes and discusses the topic of air pollution from a health in all policies perspective. The report reflects the best available evidence from a health, economics and policy point of view and identifies future research areas and policy options [6]. Individual countries struggle with a different scale of the problem of air pollution. The share of pollution sources is changing, from combustion of coal and biomass, through industrial and agricultural emissions from transport. In order to better understand the phenomena of air pollution emission, dispersion, migration and health impact, different visual approaches are created on the base of existing data [7–9]. In the papers of authors from around the world various sources of pollution, their geographic location and factors influencing cross-border transport are analyzed [10–15]. Researchers investigate the problem of air pollution from the

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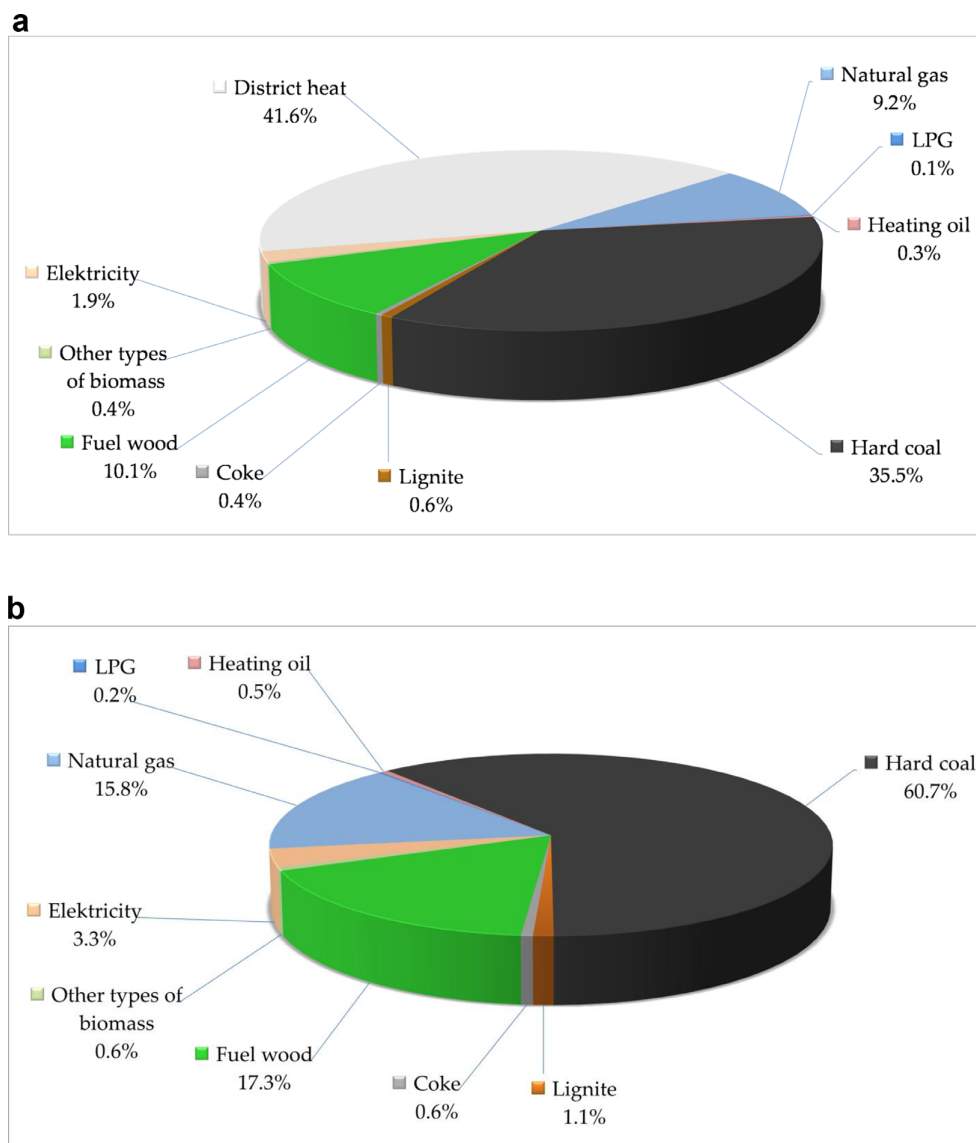


Fig. 1. a. Households in Poland in 2015 using various energy commodities for heating purposes [58]. b. Households in Poland in 2015 using various energy commodities for heating purposes – without district heat [58].

perspective of the entire globe, continents, regions or selected cities [16–19]. In both developed and developing countries, air pollution remains high, especially in industrial, densely populated areas. However, French researchers showed the possibility of changing the trend of air pollution. They stated that maintaining the level of fine dust contamination in accordance with the World Health Organization guidelines, in particular specific local conditions, always results in the decrease of the mortality of the population [20].

The region where air pollution is particularly high is Central Europe, including the Polish-Czech border. Researchers point out the sources of pollution and monitor the changes over time. According to Pokorná et al. [21,22] major source types in the

mid-1990s were ascribed to coal and oil combustion, transport and resuspended dust. The highest air pollution in this part of Europe occurs in the following areas:

- the border area of Czech Republic, German and Poland, due to brown coal combustion,
- the Moravia-Silesia region at the Czech-Polish border – black coal combustion,
- Slovakia, Austria, Hungary, and the Balkans – due to the use of heating oil.

The authors claim that the declining trend of concentrations of air contamination and change in the source pattern of the background of fine particles (PM_{2.5}) in Central Europe reflects the economic

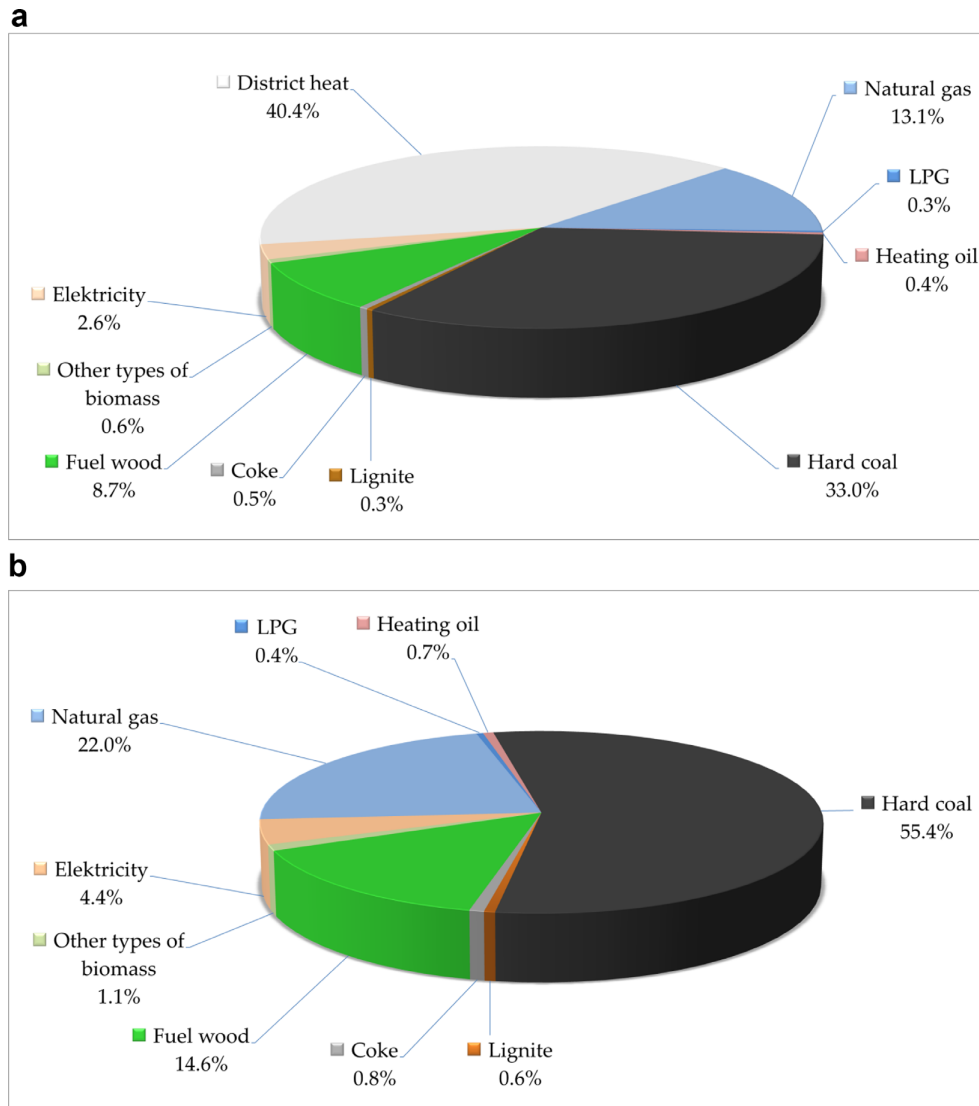


Fig. 2. a. Households in Poland in 2018 using various energy commodities for heating purposes [59]. b. Households in Poland in 2018 using various energy commodities for heating purposes – without district heat [59].

transformation and impact of legislation in Central Europe. Moreover the Czech scientists emphasize that in some rural areas of this part of Europe high concentration of the PM_{2.5} elements is due to the combustion in local heating boilers.

Research on air pollution and the share of industrial and other sources of pollution is also carried out in Poland [23–29]. Investigations conducted in Poland as in the world [30] confirm that elements released to the atmosphere from the combustion of solid fuels in residential sector may pose substantial risk to human health. According to Majewski and Rogula-Kozłowska [31] even in capital city Warsaw, coal and biomass combustion accounts for nearly 18.4% of fine PM. Therefore reducing emission of air pollution in this sector is urgent. There are

numerous review of evidence of the health effects of black carbon (BC) (WHO [32–36]), emitted, among others, from home furnaces [37].

The use of fuel-burning combustion appliances can be a source of indoor air pollution. The combustion products of concern are particular matter, carbon monoxide and nitrogen dioxide. The air quality within and around buildings affects the health of the inhabitants. Health effects from indoor air pollutants may include irritation of the eyes, nose, and throat, headaches, dizziness, and fatigue. The long-term effects, can include for example some respiratory diseases, heart disease and cancer. WHO issued in 2015 report entitled *Residential heating with wood and coal: health impacts and policy options in Europe and North America* [38]. The report

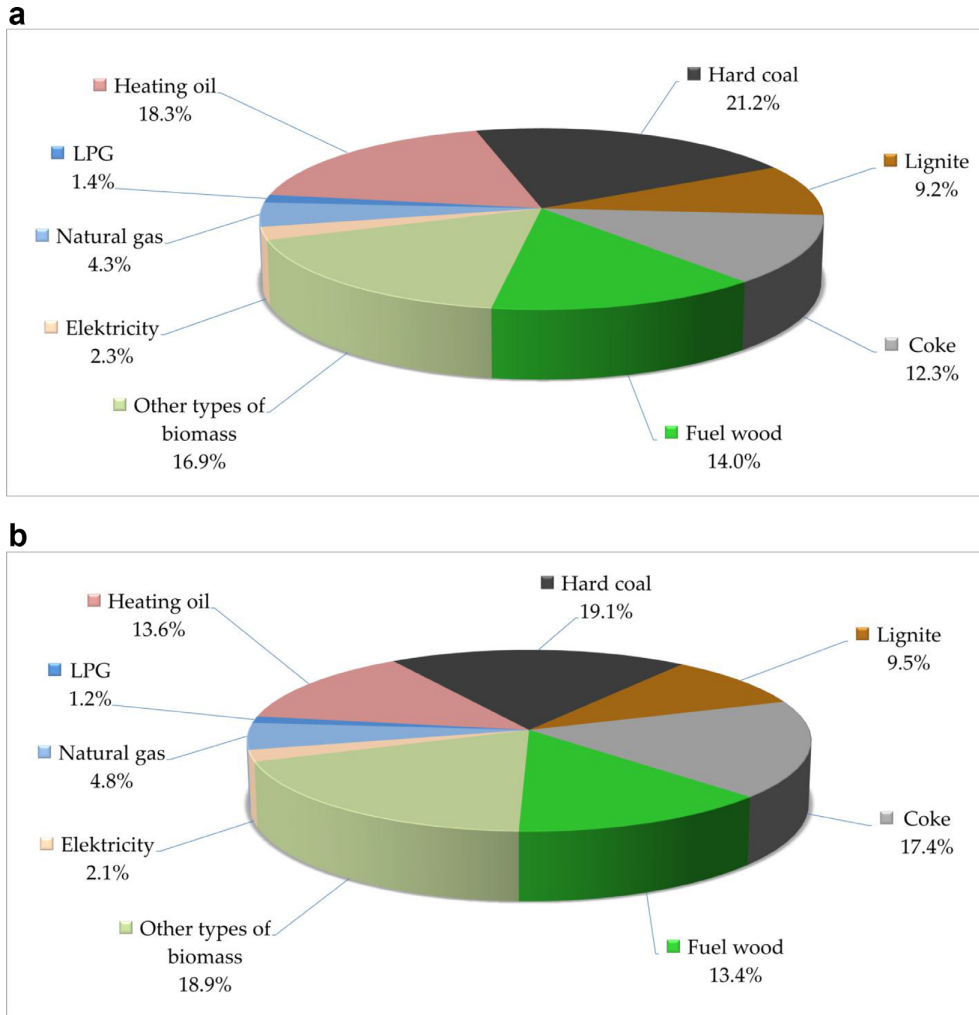


Fig. 3. a. Energy consumption in households in Poland in 2015 using various energy commodities – without district heat [58]. b. Energy consumption in households in Poland in 2018 using various energy commodities – without district heat [59].

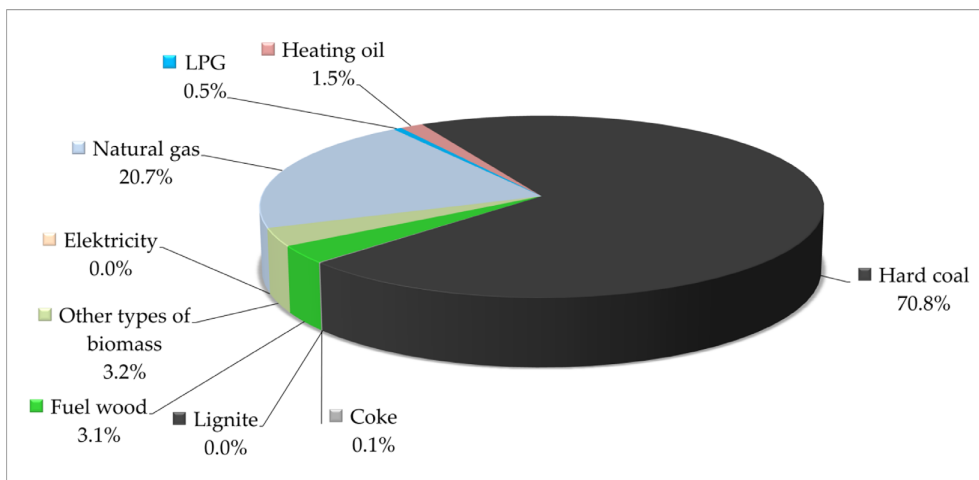


Fig. 4. Upper Silesia District. Energy consumption in households using various energy commodities, 2015.

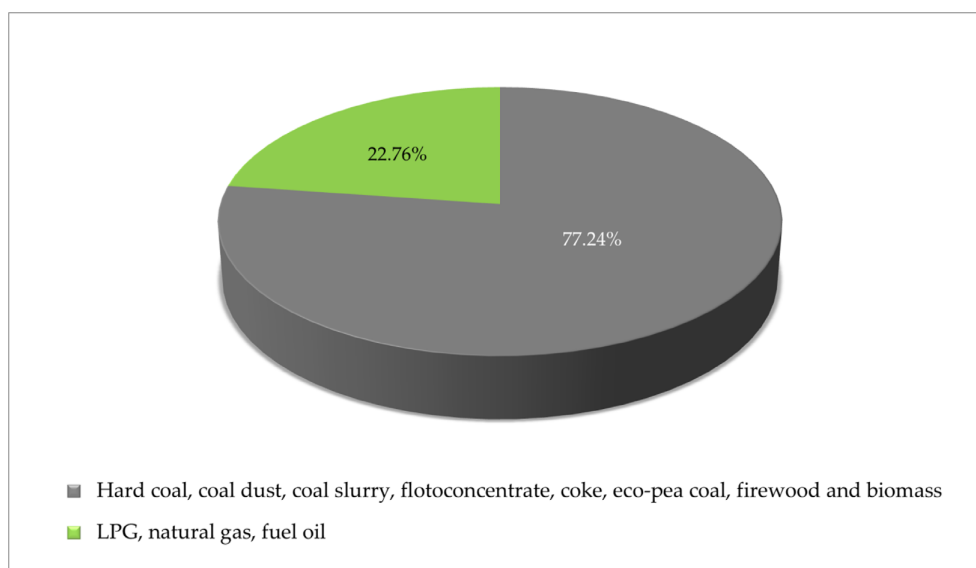


Fig. 5. Share of sources in energy consumption for heating households in Silesia Voivodship.

describes the health effects of residential heating with coal and wood in Europe and the United States. Morawska and co-authors claim that 10–30% of the total burden of disease from PM exposure is due to poor quality of indoor air. Therefore, exposure to fine and ultra fine particles due to indoor sources is likely to be one of the most important environmental factors affecting human health globally [39]. Research on indoor air quality with regard to the problems caused by coal and wood combustion, is carried out around the world [40]. For example in China extensive research on associations between different types of coal use, indoor air pollutants and immunologic/inflammatory markers were performed [41]. Jang and Smith in an alarming report from China state that indoor air pollution from solid fuel use is responsible for

approximately 420,000 premature deaths annually [42]. Some studies have focused on estimating the health benefits of reducing the combustion of solid fuels [43].

Special attention is paid to the problem of children's health, especially sensitive to air pollution [44–50]. The epidemiological evidence from different part of world are focused on the association between outdoor and indoor exposure to solid fuel combustion and adverse respiratory effects in children. However researchers claim that findings from many reviews indicate that measurements and definitions of exposures and outcomes are unclear, need standardization, extended investigation, especially in low- and middle-income countries [51–54]. Indoor pollution research is also conducted in Poland, especially in the area of Upper Silesia,

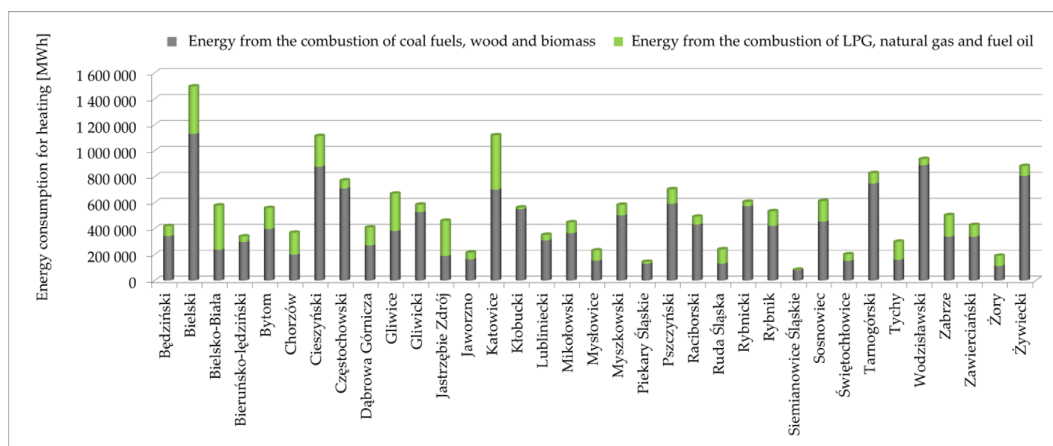


Fig. 6. Energy consumption for heating in gminas of Silesian Voivodship.

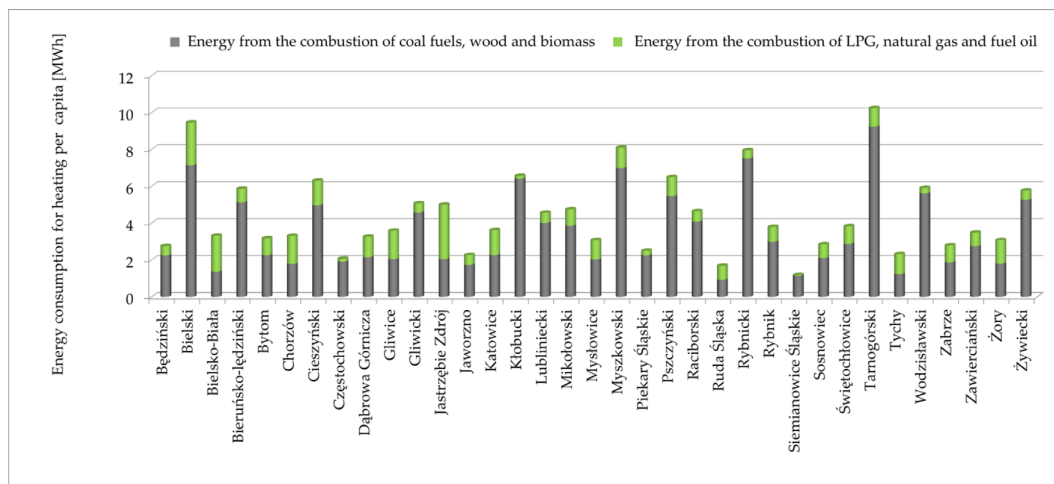


Fig. 7. Energy consumption for heating per capita in districts of Silesia Voivodship.

where most households use hard coal, often of low quality [55]. The results obtained by Błaszczuk et al. indicated that PM and other pollutants occurring both indoor and outdoor of kindergartens in Silesia, are an important source of children's exposure to genotoxic agents. They recommend changing coal stoves to electric or gas ones [56].

The Intergovernmental Panel on Climate Change, operating since 1988 under the auspices of the United Nations, published its fifth report on Earth's climate change in 2014. It states unequivocally that greenhouse gas emissions resulting from human activity contribute to climate change. The Member States of the European Union have adopted the so-called energy and climate package, which, among other things, indicates the need to reduce greenhouse gas emissions by 20%.

Following this, the National Programme for Low-Emission Economy Development was adopted in

Poland, with the main objective of developing a low-emission economy, understood as activities aimed at economic development and improvement of living conditions of people in gminas. The main claim of the document relates to the assumption that local actions satisfy low-carbon principles. The development of a low-carbon economy is possible if the necessary knowledge, gathered from information provided by municipalities, is available on:

- the location and amount of energy we use, and the sources from which it is obtained,
- measures that we can implement to use energy more efficiently and emit fewer greenhouse gases,
- renewable energy sources can be used to produce energy.

In 2013–2015, gminas developed Low Carbon Economy Plans (LCEP), which are documents that

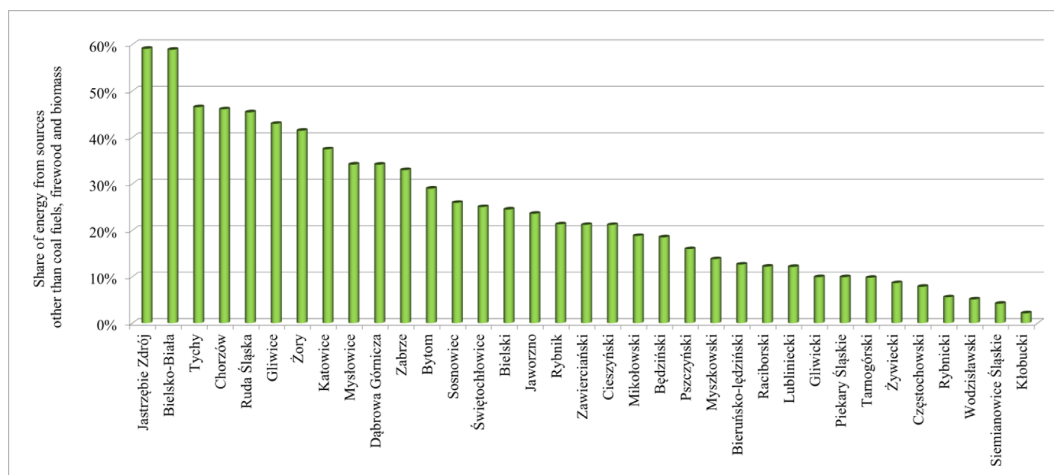


Fig. 8. Share of energy from sources other than coal fuels, firewood and biomass in individual districts of Silesia Voivodship.

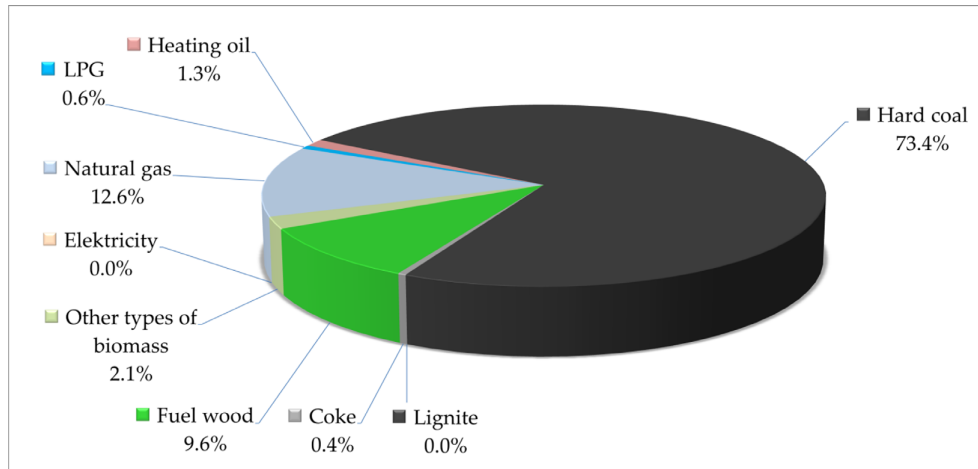


Fig. 9. Opole district, 2015. Energy consumption in households using various energy commodities.

detail the methods for reaching a low carbon economy at a local level. They identify, inter alia, the specific measures that local authorities and possibly private sectors will undertake to meet the targets set out in the adopted climate and energy package by 2020:

- reducing greenhouse gas emissions,
- increasing the share of energy from renewable sources,
- improving energy efficiency,
- improving air quality in areas where exceedances of air quality limits have been registered and air protection programmes (APP) and short-term action plans (SHAP) are implemented.

The Polish-Czech-Slovak border region has for years been among the leading European areas in terms of bad ambient air quality. This is primarily the result of coal and coal products being burned in households for heating purposes, which is also associated with greenhouse gas emissions. This paper presents the results of an inventory of low emission sources (municipal emissions) in the Polish part of the TRITIA area, i.e. the Polish-Czech-Slovak border region, covering the Silesian and Opole Voivodeships. The work was carried out within the framework of the project called AIR TRIRIA (Unified Approach to Air Pollution Management for Functional Urban Areas in the TRITIA Region). The primary objective was to develop an

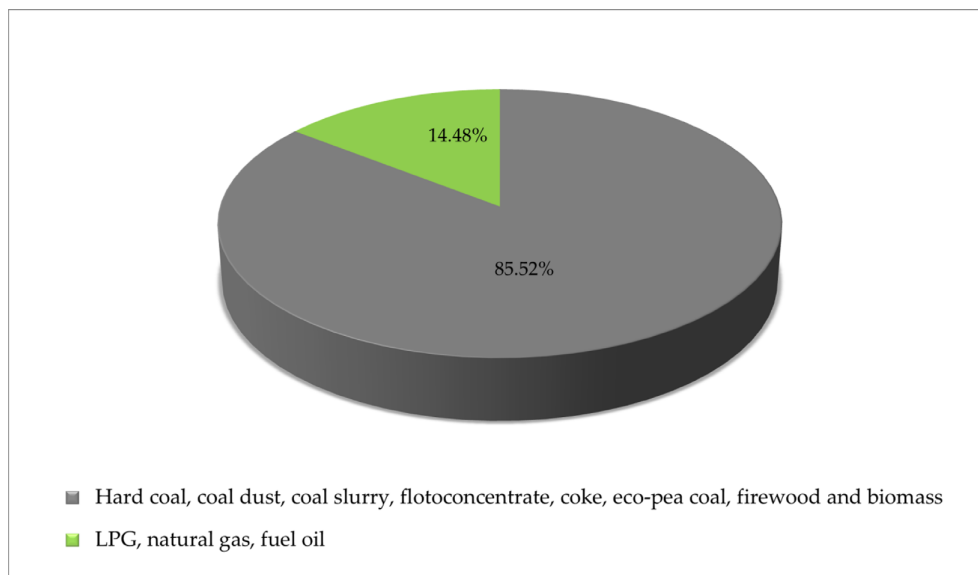


Fig. 10. Share of sources in energy consumption for domestic heating in Opole Voivodship.

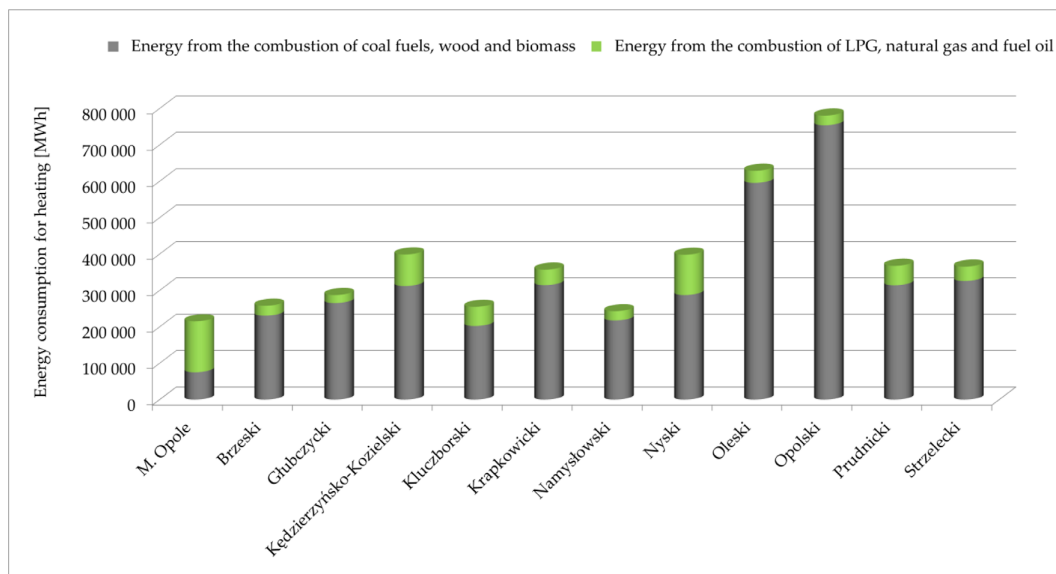


Fig. 11. Energy consumption for domestic heating in districts of Opole Voivodship.

effective method of air quality management at the regional level of the Czech Republic, Poland and Slovakia, with the potential to apply solutions also in other countries of the European Community with similar environmental problems.

2. The method

An inventory of energy media used for heating residential buildings and heating techniques applied was based on Low Emission Management Plans of

individual gminas of Silesian Voivodeship (177 documents) and Opole Voivodship (71 documents).

In their Low Emission Management Plans, gminas present the main sources of air pollution in their areas. Particular emphasis is placed on assessing the impact of emissions from diffuse sources from domestic boiler rooms and furnaces (so-called low emissions). The data collected were presented separately for each powiat in Opole and Silesia Voivodeships and total for both voivodeships.

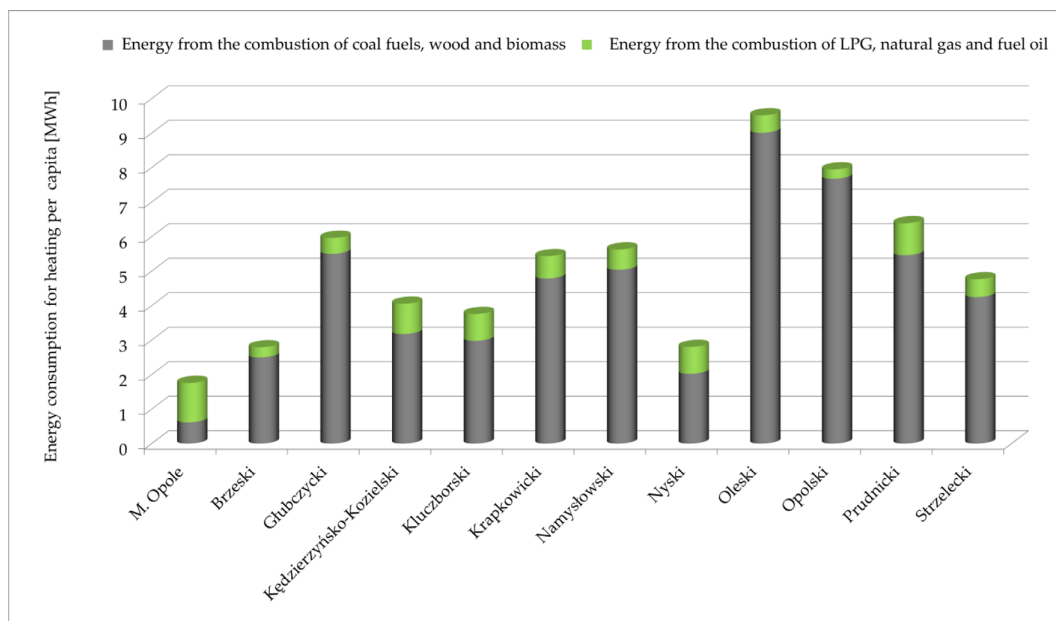


Fig. 12. Energy consumption for heating per 1 inhabitant in districts of Opole Voivodship.

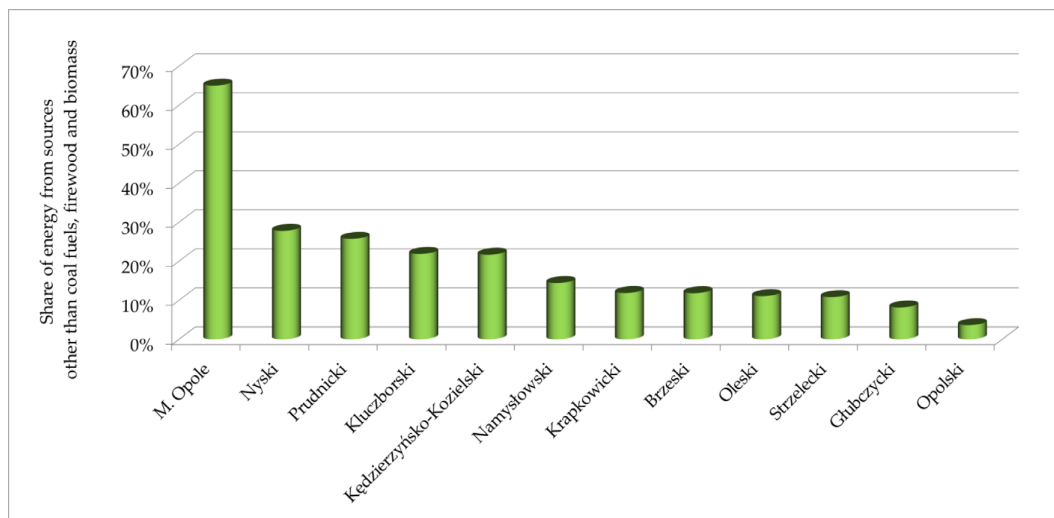


Fig. 13. Share of energy from sources other than coal fuels, firewood and biomass in individual districts of Opole Voivodship.

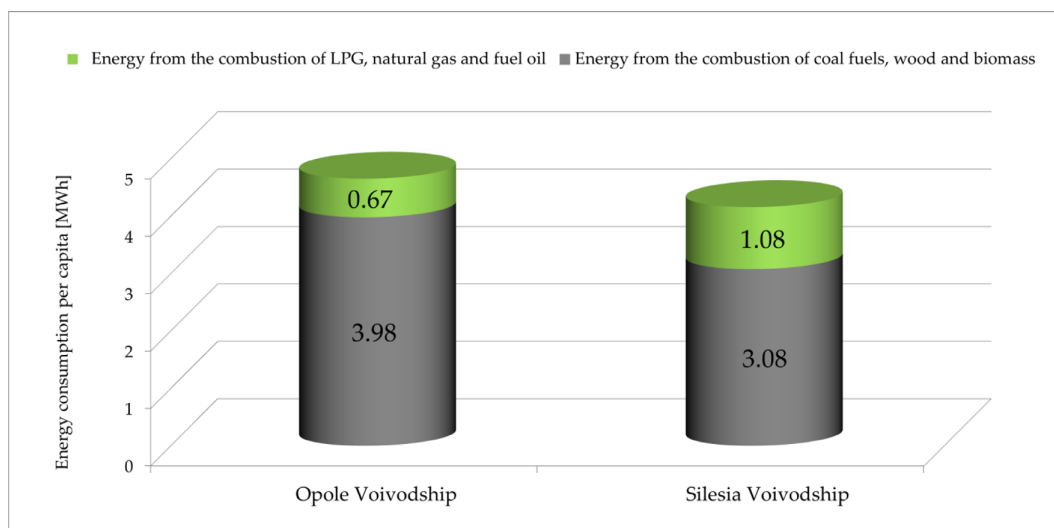


Fig. 14. Comparison of energy consumption from different sources for domestic heating in Silesia and Opole Voivodeships, per capita.

The plans for the individual gminas were prepared by different specialised companies based on surveys and available data on the consumption of energy media. This, therefore, did not affect the uniformity of the documents, which varied in quality and accuracy. This occasionally made it difficult to analyse them, especially when considering the heating techniques used.

Information on the situation in the gminas of the Silesia and Opole Voivodeships was compared with the situation in the whole country, using data provided by the Central Statistical Office of Poland in 2015 and 2018. Statistical data from 2015 makes it possible to compare the use of individual energy media in the voivodeships of the TRITIA area with their use in the country as a whole. A comparison of

statistics from 2015 to 2018 shows the trend of changes in the use of different energy sources in Poland.

3. Inventory of low emission sources in the Polish part of the TRITIA area

The greatest emission load on the atmospheric air in the border area was caused by combustion of solid fuels – hard coal, hard coal dust, hard coal slurry, flotation concentrate, coke, eco-pea coal, firewood and biomass. Many factors determine the amount of harmful emissions from the combustion of solid fuels, the most important of which are the type of fuel and its calorific value, the ash content and finally the efficiency of the device used for

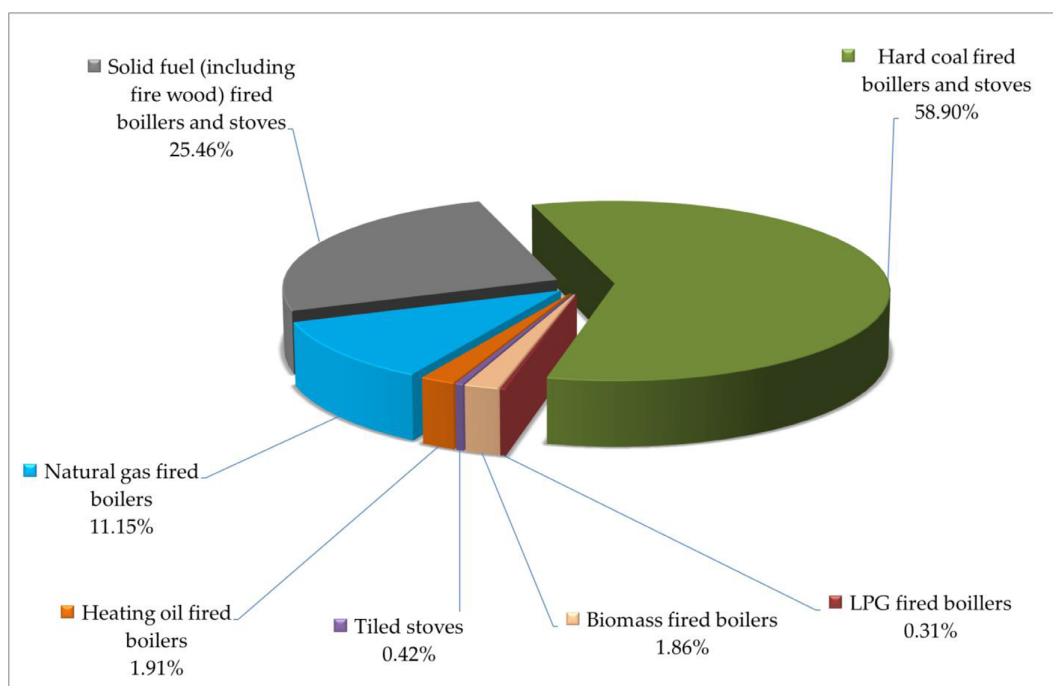


Fig. 15. Silesia District. Equipment of households with space heating appliances.

combustion [57]. Information on the situation in the gminas of Silesia and Opole Voivodeships was compared with the situation in the whole country. According to the Central Statistical Office (CSO), the primary source of energy in households in Poland is solid fuels [58].

Figs. 1a, b, and 2a, b present the structure of energy consumption in households in Poland in 2015 and 2018, based on data compiled by the Central Statistical Office [58,59].

Analysing all dwelling types, in 2015 hard coal was used in 35.5% of all households (Fig. 1a). The share of lignite, coke and biomass was low, as these energy media were used in 1.4% of households. Network heat was used in almost 42% of households and natural gas in over 9%. Only less than 2% used electricity. The share of other energy media such as solar panels, wind energy, heat pumps was negligible and was not included in the statistical summary. In order to trace the use of energy sources in detached houses, statistics are compiled, excluding district heating (Fig. 1b). It was assumed that district heating mainly heats collective buildings. The main fuels used for heating detached buildings, mainly single-family houses, were hard coal (60.7%) and wood (17.3%). The other energy media were used in slightly more than 20% of the buildings.

In 2018, slightly fewer households used hard coal. The number of all households using hard coal fell

by 2.5%. In detached buildings (not using district heating), the downward trend is higher: 5.3% fewer households used hard coal. Fewer households also used firewood, while natural gas and electric heating were used to a greater extent. In buildings not using district heating, the most significant change in the consumption structure of energy media was an increase of 6.2% in the number of households heated by natural gas.

Fig. 3a and b shows the percentage of energy consumption from each source in Poland, in households not using district heating, in 2015 and 2018. Consumption of fossil fuels (hard coal, lignite and coke) has increased slightly by 3.3%. There has been a minor change in the degree to which individual fuels are used: the consumption of hard coal has decreased by around 2%, while the consumption of coke has increased by around 5%. The use of wood remained at a comparable level, while the use of other types of biomass increased. Electricity use is just over 2% of total energy consumption. The share of energy from renewable sources is marginal.

Data from LCEP documentation for individual gminas were used to gather information on the use of energy sources in Silesia and Opole Voivodeships. LCEP documents specify the fuels burned in more detail than the data provided by the Central Statistical Office in Poland. They estimate, for example, the share of coal-derived fuels such as

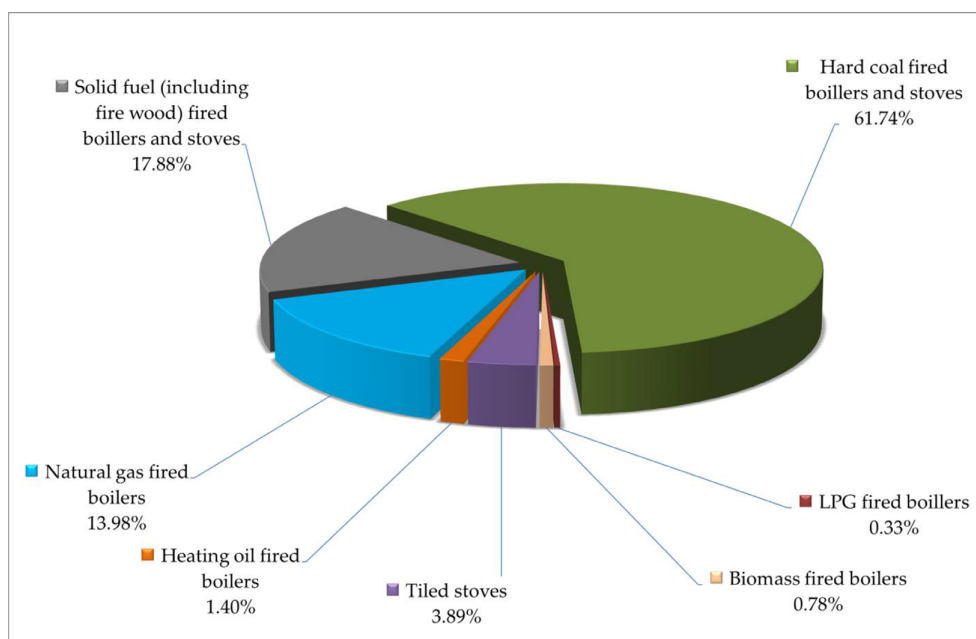


Fig. 16. Opole district. Equipment of households with space heating appliances.

slurry, dust, and enrichment waste – flotation concentrates. The data are important to understand the reasons for the poor state of air quality in the Polish-Czech-Slovak border area. The 2016/2017 heating season was the last one in which slurry and flotation concentrates were allowed to be burnt. At present, these fuels must not be burned in domestic boilers because of high emissions of air pollutants, including heavy metals, compared to other coal fuels. Information on the use of low-quality coal fuels was included in the analysis presented, as they were still being used in Silesia and Opole Voivodeships during the project implementation years. Regulations implementing the Fuel Quality Monitoring and Control System Act [60], which aim to eliminate solid fuels unsuitable for domestic combustion from the market, were published in the Official Journal of Law on 04 October 2018 [61–64]. As a result of this legislation, fuels unsuitable for domestic combustion – coal slurry and flotation concentrate – have been eliminated from the retail market.

Fig. 4 presents the share of energy media in the total consumption of energy for heating homes in Silesia Voivodeship, excluding district heating. Of the energy sources analysed, approximately 70% are coal and derived products and wastes from enrichment: coal dust 3.04%, coal slurry 1.11% and flotation concentrate 0.14%. The use of sludge, coal fines and flotation concentrates does not exceed 5%. The share of these media in the total energy

consumption in Silesia is therefore not high, but it should be remembered that low-quality coal fuels, often burnt in outdated cookers and boilers, contribute very significantly to air pollution emissions. Firewood, whose poor quality can also result in increased emissions of harmful agents during the combustion process, produces 3.14% of the energy used for heating homes. The share of energy from the use of lignite is insignificant.

Fig. 5 presents the structure of energy consumption for heating of households divided into two groups of energy media. The first group includes coal-based fuels (hard coal, hard coal dust, slurry, flotation concentrate, coke, eco-pea coal), firewood and biomass. The second group includes LPG, natural gas and fuel oil. In Silesia, the total amount of energy consumed to heat households using solid coal fuels, firewood and biomass is 77%. Only about 23% of energy comes from sources that have a lower environmental impact – fuel oil, natural gas and LPG. The contribution of other sources to domestic heating, such as electricity or geothermal energy, for example, is negligible.

Energy consumption in individual powiats of Silesia Voivodeship varies considerably (Fig. 6). The differences are mainly due to the size of the district area, the number of inhabitants, the type and age of buildings and many other factors. It is evident that in rural powiats (such as Wodzisław, Kłobuck), the consumption of energy from fossil fuels is higher than in urban counties. This is probably since, in

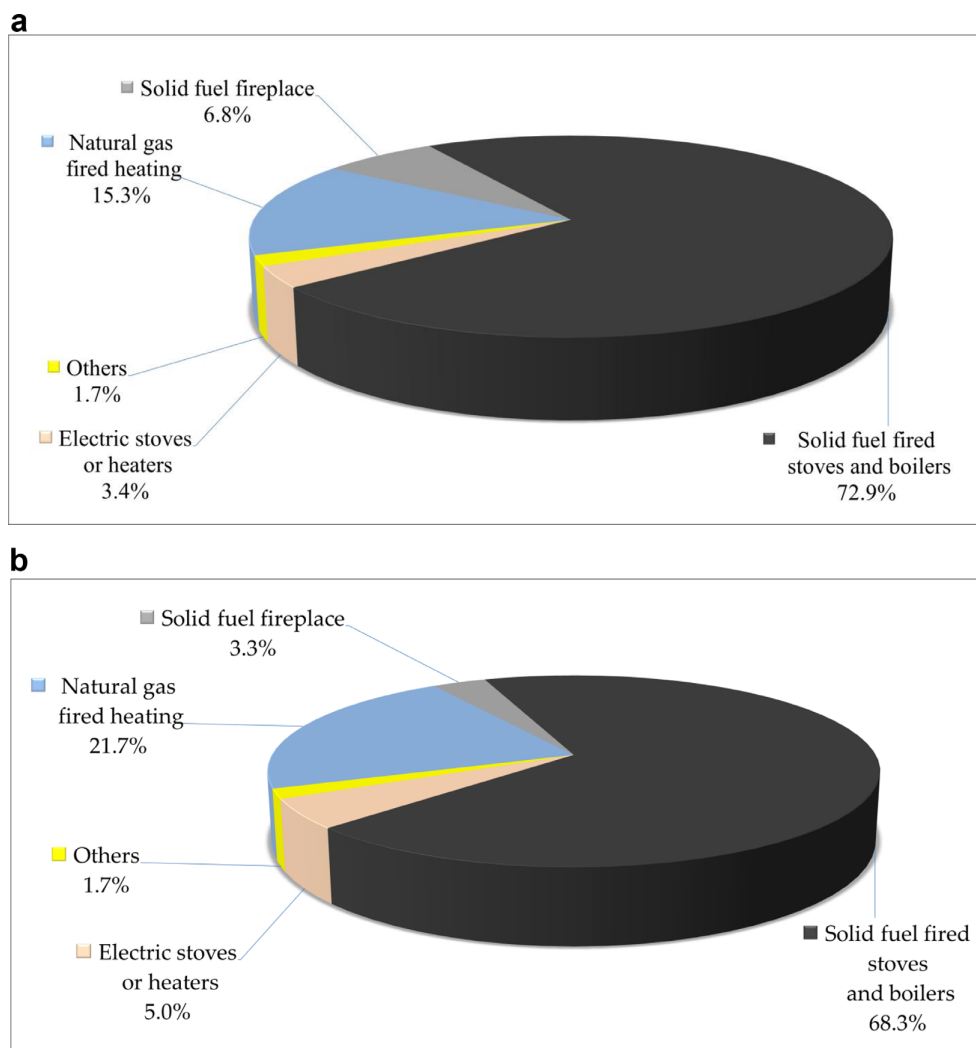


Fig. 17. a. Equipment of households in Poland with space heating appliance without district heat, 2015 [58]. b. Equipment of households in Poland with space heating appliance without district heat, 2018 [59].

cities, a large proportion of the population lives in block housing, where heat is supplied by a system, buildings are more often insulated, and the surface area of flats is smaller than in the case of single-family houses. The villages are dominated by single-family housing with a high proportion of old buildings that do not meet energy efficiency criteria. Fig. 7 shows energy consumption per capita in the counties of Silesia Voivodship. In rural powiats with predominantly dispersed housing, energy consumption per capita is significantly higher than in urban districts. The lowest energy consumption is in cities. In cities, the share of non-carbon energy and firewood is higher than in counties. The percentage share of energy from sources other than coal fuels and firewood in the total energy consumed for heating buildings in the districts of Silesia Voivodship is shown in Fig. 8. The leaders in the use of

energy media, the combustion of which emits less pollution into the air, are the cities. In five of them (Jastrzębie Zdrój, Bielsko-Biała, Dąbrowa Górnicza, Ruda Śląska, Tychy and Gliwice) more than 50% of the energy consumed comes from non-carbon sources, which are less harmful to the environment. However, in as many as seven powiats the share of fuels other than coal does not exceed 10%.

In Opole Voivodship, the share of hard coal in energy production for heating households is even higher than in Silesia Voivodship and amounts to 72.5% (Fig. 9). Adding together all coal fuels, including hard coal dust and slurries, coke, eco-pea coal as well as firewood and biomass gives 85.5% of the energy, while fuels such as fuel oil, natural gas, and LPG account for 14.5% (Fig. 10). Similarly to Silesia Voivodeships, the share of solar energy, wind energy, electricity, heat pumps and lignite is

Table 1. The balance of substance production as a result of heating apartments in the Silesian voivodeship.

Description	SO ₂	NO _x	CO	CO ₂
Average production kg/(person·year)	14.3	5.9	52.0	2374
Percentage of the voivodeship population for which the results were available (%)	4.3	4.3	3.9	2.3
Estimated production of substances for the entire voivodeship (Mg/year)	82 900	34 200	302 400	13 812 700
Population in the voivodeship	5 820 000			

(based on Low Carbon Economy Plans).

negligible. The analysis of energy consumption in individual powiaty illustrates that the total energy consumption in Opole Voivodeship is lower than in Silesia Voivodeship (Fig. 11), which is understandable given the differences in the populations of the two regions. Energy consumption per one inhabitant in none of the districts of Opole Voivodeship is lower than 1 MWh, and in most districts, it ranges between 2 and 6 MWh. In Silesia Voivodeship, in one city with powiat rights, energy consumption is lower than 1 MWh, and in most cases, it is between 2 and 4 MWh (Fig. 12). Opole is the only powiat in which the share of fuels other than coal burned in households exceeds 60%. In the remaining districts, the use of non-carbon media varies between about 4% and about 28% (Fig. 13).

Fig. 14 presents a comparison of energy consumption per capita concerning solid coal fuels, wood and other fuels in Opole and Silesia Voivodeships. Presumably, the reason for the differences in the structure of energy consumption in the two areas is the larger share of rural households and single-family housing in Opole Voivodeship compared to Silesia Voivodeship.

4. Analysis of heating techniques in the Polish part of the TRITIA area

The scale of emissions in the heating process is determined mainly by the type of device (heating technique) and its efficiency. Figs. 15 and 16 show the percentage share of individual heating units in households, excluding district heating. These

diagrams were obtained based on the results of surveys obtained during the development of the LCEP. Unfortunately, not all LCEP documents contained full and comprehensive information. For example, these data were missing from Opole and Katowice. The vast majority of households that provided information on the heating techniques used to heat use coal-fired boilers. The share of coal-fired boilers accounts for about 60% of all types of heating units in both voivodeships. Solid fuel boilers, including wood and biomass, rank second in terms of percentage share. Although wood and biomass do not worsen the overall balance of carbon dioxide emissions into the atmosphere and consequently do not harm climate change, their combustion also causes more emissions than the combustion of fuels such as gas, fuel oil or LPG.

As the basic fuel used in both provinces for heating homes is hard coal, the share of coal-fired boilers in the structure of heating equipment is dominant. These are often old off-grade or class 3 and 4 boilers. Compared to class 5 boilers, class 3 boilers can emit up to around four times more dust, and class 4 boilers up to 50% more dust. Formally, since some time the sale of boilers with a nominal power of up to 500 kW, intended for burning of solid fuels only, which meet the criteria specified for class 5 boilers, are permitted in Poland. This means for boilers with automatic fuel loading that the emission limit for CO₂ is no more than 500 mg/m³, the emission limit for dust is no more than 40 mg/m³ and the emission limit for gaseous organic pollutants is no more than

Table 2. The balance of substance production as a result of heating apartments in the Opole Voivodeship.

Description	SO ₂	NO _x	CO	CO ₂
Average production kg/(person·year)	17.0	2.9	38.2	3175
Percentage of the voivodeship population for which the results were available (%)	1.5	1.5	1.5	1.5
Estimated production of substances for the entire voivodeship (Mg/year)	16 300	2800	36 700	3 046 000
Population in the voivodeship	959 000			

(based on Low Carbon Economy Plans).

20 mg/m³. However, it is difficult to forecast how quickly the share of class 5 boilers will increase in the structure of heating equipment over the next few years.

Fig. 17a and b shows CSO data from 2015 to 2018 (CSO, 2015; to compare the use of individual heating techniques in Silesia and Opole Voivodeships overall data from Poland [3]. In 2015, the share of coal-fired boilers was lower in Opole and Silesia Voivodeships than in the whole of Poland; the use of solid fuel boilers, including wood, was higher. In contrast, heating techniques using natural gas are much more common across Poland. It is worth noting that the use of natural gas is increasing nationally.

Combustion of coal causes not only CO₂ emissions, but also other harmful substances such as SO₂, NO_x and CO. Tables 1 and 2 show the estimated values of the emissions of oxides in the Śląskie and Opolskie Voivodeships. Unfortunately, only a small number of municipalities (about 10%) in their documents Low Carbon Economy Plans, provide data on the emission of SO₂, NO_x, CO, and CO₂ as the result of the heating of households, and therefore the information presented may not be representative for the entire TRITIA area.

Presently a lot of households still use the solid fuel fired boilers – see Figs. 14–17, and coal is the basic fuel used for heating flats in both voivodships. Often these are also non-class boilers or class 3 and 4. Compared to class 5, class 3 boilers can emit up to about four times more dust, and class 4 boilers – 50% more dust. Formally, for some time in Poland it has been allowed to sell only such boilers with a nominal power of up to 500 kW intended for burning solid fuels that meet the criteria specified for class 5. For boilers with automatic fuel loading, this means that the limit of CO emission is not more than 500 mg/m³, the limit value for dust emission is not more than 40 mg/m³, and the limit value for emission of gaseous organic pollutants is not more than 20 mg/m³. However, it is difficult to forecast how quickly the share of class 5 boilers in the energy balance will increase over the years.

Carbon dioxide (CO₂) is the most prominent of the greenhouse gases, therefore it is worth analyzing the reduction in the emission of this factor as a result of changes in the type of energy source used. Different energy sources produce different amounts of carbon dioxide during combustion that is decisive for the calculation of carbon dioxide savings. For example, the combustion of lignite produces emissions that are much higher – around twice – than the combustion of natural gas. For example burning lignite produces around twice as

Table 3. CO₂ emissions from various energy sources (after Quaschnig [65]).

Energy source	Emission [kgCO ₂ /GJ]
Wood	209.9
Lignite	106.0
Hard coal	94.6
Heating oil	77.4
LPG	63.1
Natural gas	55.8

much carbon dioxide in relation to its energy content as burning natural gas. In the table below (Table 3) the emission of CO₂ from different fuels, in relation to the primary energy content is presented.

Analyzing data presented in Table 3, we can see that for long-term climate protection, only ways to reduce carbon emissions is producing more energy from renewable sources and using fuels with lower carbon contents. According to data from the Central Statistical Office of Poland, 1.77% of households were equipped with solar collectors in 2015, and 0.08% with heat pumps [58,59]. However, solar collectors for home heating were used by only 0.14% of households, while heat pumps were the primary source of heating only in 0.03% of households. It should be emphasized that the share of solar collectors in energy consumption by households is only 0.21%, and geothermal energy 0.09%. In 2018, the percentage of households equipped with heat pumps increased significantly to 0.48%, while in the case of solar energy the share reached 1.98%. Compared to 2015, the share of heat pumps as a basic source of heating in households has become more common than solar cells: 0.15% and 0.13% respectively. Despite the upward trend, the share of these sources in home heating will not become significant in the next few years, although large funds are allocated to co-finance such investments. Presently in Poland started process of collecting data do build up the Central Emission Register of Buildings CEEB. CEEB will be used to identify sources of low emissions from buildings such as residential buildings, public buildings, including small local heating plants, production plants, warehouses, garages, farms, and even churches and hospitals. The providing information to this data base is obligatory. It is expected that data collected in CEEB will support all programmes and countermeasures to improve air quality.

5. Conclusions

In large cities of the TRITIA area, such as Opole, Katowice, Jastrzębie Zdrój, Ruda Śląska, more than 50% of the energy consumed for domestic heating is not connected with burning coal in domestic boilers. The source in this case is district heat. In smaller

towns and rural districts, fossil solid fuels, wood and biomass are the dominant energy sources.

In towns with predominantly single-family housing and rural districts, the use of solid coal and wood fuels reaches about 80% of the total energy balance. Until the 2016/2017 heating season, it was allowed to burn low-quality solid fuels such as coal slurry, coal dust and flotation concentrates. In Silesia Voivodship, the share of these fuels accounted for about 5% of all fuels in 2015. The structure of the energy sources used and the continued presence of outdated coal-fired boilers and cookers are the direct cause of emissions of harmful substances into the air.

Alternative energy sources such as electricity, including solar panels and heat pumps, are still marginally used. Households with such installations represent about 2% for electricity and less than 1% for solar collectors and heat pumps. Of the fuels with lower emissions, such as natural gas, LPG and heating oil, natural gas used in 13% of households is the most significant, even if system heat is included.

Statistical Office (GUS) data shows that solid fuels are most commonly used in private households. The two most important and widely used solid fuels are hard coal and firewood, while other fuels (other types of biomass, lignite, coke) are used less frequently. Hard coal and firewood are usually consumed simultaneously or interchangeably in the same boilers and cookers. Fewer households used only coal or only wood. The fuels are usually burned interchangeably, depending on current availability and price conditions and the time of year.

Conflicts of interest

None declared.

Ethical statement

The authors state that the research was conducted according to ethical standards.

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