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AIR POLLUTION IN SKOPJE: PRACTICE AND AWARENESS IN THE SCOPE OF HOUSEHOLD HEATING

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Abstract
Air pollution is a concern which poses threat to human health and likewise greatly impacts the ecosystem and the environment. By its broader definition, the air pollution is described as increase in the rate of harmful gases and particles in the atmosphere.

Given that the city of Skopje is on the top of the list of most polluted cities in Europe the aim of this study is to analyze the air pollution in Skopje, particularly focusing the attention on the household heating as one of the major sources of ambient air pollution in the city.

A survey on 242 households was conducted in order to obtain information about the ways of residential heating and the willingness of households to use more environmentally friendly heating technologies. The survey was carried out on the territory of the city of Skopje, as it is the most polluted city in the country. The governmental measures for air pollution abatement in Skopje were reviewed as well.

The results show that most of the households although aware about the emission of harmful particles into air when combusting firewood in old traditional stoves, they still use firewood as it is the cheapest mode of heating. The previous is of particular importance and decisive for the low-income households. It was also observed that the respondents were familiar with the possibility for using wood pellets, as more environmentally heating mode, but there was a lack of information concerning the possibility of governmental subsidizing for replacement of the existing firewood with more modern wood pellets system.
The households that have already started to use wood pellets instead firewood, have increased monthly costs (10 - 15%), but nevertheless they still recommend the use of pellets and pellet stoves due to the efficiency of heating, maintenance, cleanliness, and less pollution of air on the long run.

Summarizing, the choice of heating with firewood is more due to the lower monthly incomes and rational cost planning of the households, and less to the lack of awareness of citizens for utilizing more efficient and more environmentally friendly heating technologies.

Key words: emission, harmful gasses, particles, burning, firewood, wood pellets, household
JEL Classification: Q53, Q59

INTRODUCTION

Air pollution is a concern which poses threat to both, the ecosystem and the environment. By its broader definition it is described as increase in the rate of harmful gases and particles in the atmosphere.

The emission of pollutants into the air originates almost from all economic and social human activities (traffic, industry, combustion and energy installations, biomass/solid fuels burning, and construction activities, landfills for waste and agriculture activities). Burning of firewood for heating and cooking, being used by over 3 million people (Suman et al., 2022), was detected as one of the main causes for air pollution.
The impact of polluted air is most strongly felt in two areas:

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- Human health, by causing negative effects on people's health, especially the children, older people, pregnant women and those with pre-existing health conditions. The health impact of air pollution is primarily due to the influence of PM10 and PM2.5 particles (www.eea.europa.eu)
- Ecosystems, where the air pollution disrupts the growth and yield of vegetation, reproduction and development in the animal world on land and water and generally has a harmful effect on biodiversity (Ministry of Environment and Physical Planning, 2022).

There are a large number of air pollutants. However, the air pollutants with the strongest evidence for adverse health outcomes include particulate matter PM (PM 2.5 and PM10 - particles with aerodynamic diameter up to 2.5 μm and 10 μm, respectively), ozone (O_3), nitrogen dioxide (NO_2), sulfur dioxide (SO_2) and carbon monoxide (CO) (WHO, 2022). The attention of this paper will be focused on the fine particulate matter because it is considered as a pollutant with the largest estimated impacts on mortality and health outcomes. An increase of the concentration of the fine particulate matter above the maximum permitted values seriously affects the human health (WHO, 2016).

According the latest report of World Bank (2022) about 6.4 million people died prematurely world-wide in 2019 as a result of exposure to PM2.5 air pollution. 95% of the deaths have occurred in low-income and middle-income countries, and about 70% of the deaths were observed in East Asia, South Asia and the Pacific. The European Environment Agency (EEA) reported that in Europe in 2020 approximately 275.000 premature deaths were attributable to acute exposure to PM2.5, whereas NO_2 was the cause for about 64.000 premature deaths, and O_3 was linked to 28.000 premature deaths (www.eea.europa.eu, 2022).
Latest data show that, as a result of the different instruments and actions for reducing the PM2.5, there is a trend of improving the air quality in EU27. As a result, the number of premature deaths was lowered for about 45% and if this trend continues with a comparable rate then the zero pollution target set by the Zero Pollution Action Plan (to reduce the number of premature deaths caused by air pollution in the EU by a minimum of 55%, relative to those in 2005) would be achieved before 2030 (www.eea.europa.eu, 2022).

Besides causing less-livable conditions and health problems, the air pollution also imposes a significant economic and social costs. These include the cost to society of premature deaths, the costs of healthcare for the sick due to poor air quality, and the loss of labor productivity associated to the sickness and/or caregiving for oneself or others (Sanchez Martinez et al., 2018). Polluted air reduces worker's cognitive and physical capabilities thus inducing absenteeism at work (www.openknowledge.worldbank.org). It was evaluated that all previously described effects induce reductions in economic output at the aggregate level i.g. 1 $\mu g/m^3$ increase in PM2.5 concentration causes 0.8% reduction in real GDP per capita (OECD, 2019). Hence, significant health gains and cost savings can be achieved through air pollution abatement.

Skopje, the capital of North Macedonia is one of the cities being reported as most polluted in the world and is continuously struggling with poor air quality. The heavy air pollution in Skopje results from the traffic flows, the rapid and intensive urbanization, the activities of industries located in the city, the landfills and the household heating. Additionally, the topography and meteorological conditions, especially during the winter period, also contribute for the increased concentrations of particulate matter in the air.

In this paper, a study for the city of Skopje in terms of air pollution, policy measures for improving the air quality and their implementation by the local population with focus on the household heating will be carried out.

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MATERIAL AND METHODS

The aim of this study is to investigate the air pollution caused by households heating with firewood. Furthermore, an analysis of the public awareness to implement the recommended measures by the government for air pollution abatement was performed.

A desk research for investigating the air pollution in Skopje in a period from 2014 to 2022 was done. Data from the air quality monitoring stations in Skopje (Gazi Baba – urban background, Rectorat – urban traffic, Lisice- suburban industrial, Centar-traffic, Karposh – traffic) were used. Also, the policy measures for reduction of air pollution were reviewed.

In order to obtain information about the modes of residential heating and the willingness of households to use more environmentally friendly heating technologies a survey on 242 households was conducted. Two types of purposive samples were used, the first one referring to the households that use firewood for heating and the second one included households that have changed the heating from firewood to wood pellets. The survey was carried out on the territory of city of Skopje, given that it is on the top of the list of most polluted cities in Europe.

RESULTS AND DICSUSSION

Air pollution in North Macedonia

The latest two reports on the quality of environment in North Macedonia, published by the Ministry of Environment and Physical Planning of North Macedonia (MOEPP) indicate that the PM10 concentrations in the air are high above the EU daily limit of 50mg/m^3 (www.eea.europa.eu, 2021). The main sources of this ambient condition, as noted by the reports, are the residential heating (with a share of TSP[1] emission of 33% in 2017 (MOEPP, 2019) and 39% in 2020 (MOEPP, 2022)), the industry with (a share of TSP of 32% for 2017 and 10% in 2020) and the electricity and heat production sector (25% and 24% in 2017 and 2020 respectively) (Fig. 1).

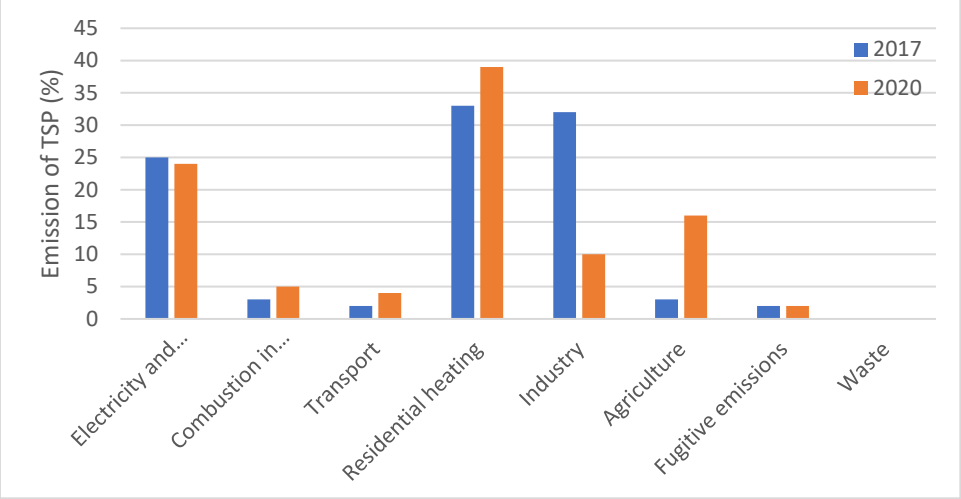

Figure 1. TSP emission by sectors in North Macedonia
Source: Ministry of Environment and Physical Planning (2019). The quality of the environment in the Republic of North Macedonia-Annual report for 2018; Ministry of Environment and Physical Planning (2022). The quality of the environment in the Republic of North Macedonia-Annual report for 2021.

[1]TSP - Total Solid Particles

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According the Census in North Macedonia in 2021 the share of households which are using firewood as primary source for heating is 52.15% (State Statistical Office, 2021), up to 31% of the households are heating with electricity and very few are using central heating and wood pellets (up to 10% for both). Similar observations were noticed for the years before 2021 as well. Namely, about 62% in 2014 (State Statistical Office, 2014) and 49.18% in 2019 (State Statistical Office, 2019) of the households were using firewood as primary heating source (Fig. 2). This state of condition most probably is due to the lack of connections of the residential buildings to the public heating plants and/or the high expenses for heating using electricity sources.

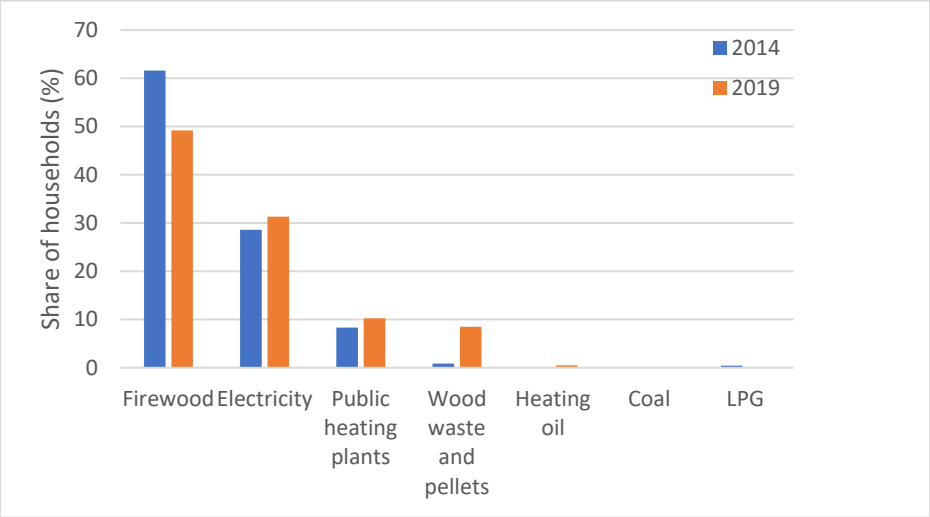

Figure 2. Share of households in the total number of households by primary energy source used for heating
Source: State statistical office (2014). Energy consumption in households; State statistical office (2019). Energy consumption in households.

The analysis of the air quality has shown that about 99% of the estimated emissions of solid PM particles and harmful gases in the air arise exactly from biomass combustion (Finnish Meteorological Institute & MOEPP, 2016) (Tab. 1).

Table 1. Total emission of solid PM particles and harmful gases from the households heating

Heating fuel	Pollutant (tonnes / year)					
	CO	NH_3	NM VOC[2]	NO_x	SO_x	PM
Biomass	10.247	179	1.537	128	28	2.049
Coal	39	0	4	1	8	4
LPG[3]	0	n/a	0	1	2	0
Heavy oil, liquid oil	2	0	0	2	2	0
Total	10.289	179	1.541	132	41	2.053

Source: Finnish Meteorological Institute& Ministry of Environment and Physical Planning (2016). Air quality improvement plan for Skopje agglomeration. EU report.

Although it is well known that biomass in general is renewable source of energy and if it is combusted efficiently it may be almost CO_2 neutral source of energy, the use of wood as residential fuel under non-optimal operating conditions (old non-regulated stoves, stoves lacking proper maintenance, bad burn practices, incomplete combustion) entails negative

[2]NMVOC –Non-methane volatile organic compounds
[3]LPG - Liquefied petroleum gasses

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consequences (Viana et. Al, 2016). Furthermore, some studies have observed that the concentration of harmful substances from wood combustion in the air depends on the type of biomass (firewood or wood pellets), the type of stove (old traditional stoves versus pellet stoves) and the stage of combustion process (initial phase of combustion, full filling of the stove and partial filling of the stove). These observations are presented in Table 2 where the concentrations of gas components (carbon monoxide-CO, nitrogen oxides-NOx, gaseous hydrocarbons-CxHy), and of solid PM10 particles, emitted during different stages of combustion of firewood and wood pellets are given (Schmidl et al, 2011).

Table 2. Average concentrations of emission of harmful gasses and particulate matter from combustion of firewood and wood pellets

Type of biomass	Type of test	Ƞ (%)	CO (mg/m^3)	NOx (mg/m^3)	CxHy (mg/m^3)	PM10 (mg/m^3)
Firewood	SU	88	1046	93	28.3	44.2
	FL		52	145	1.5	20.9
	PL		325	124	5.9	28.1
	Total		***1423***	*362*	*35.7*	***93.2***
Wood pellets	SU	94	178	125	17.1	13.0
	FL		51	128	4.1	12.1
	PL		751	121	24.3	4.6
	Total		***980***	*374*	*45.5*	***29.7***

Ƞ - efficiency coefficient, SU – initial phase of combustion, FL – full filling of the stove, PL – partial filling of the stove

Source: Schmidl C., Luisser, M., Padouvas, E., Lasselsberger, L., Rzaca, M., Ramirez-Santa Cruz, C., Handler, M., Peng, G., Bauer, H., Puxbaum, H. (2011). Particulate and gaseous emissions from manually and automatically fired small scale combustion systems. Atmospheric Environment, 45, 7443-7454.

It can be seen that the total emission of CO and the release of PM10 particles in the air when burning only 1 m^3 of firewood is 45% and 213% more than the emission of these components when burning wood pellets. When the emission of nitrogen oxides and hydrocarbons is concerned, the difference is insignificant, that is, it is 2-4% more when burning wood pellets compared to firewood (Tab. 2). It can be also noticed that the concentration of harmful substances in the air is significantly dependent of the type of stove (Tab. 3) and the combustion stage in the stove (Tab. 2). The results imply that the use of more modern stoves can noticeably reduce emissions of harmful substances, in particular the PM particles.

Table 3. Emission factors of different combustion plants

Type of stove	PM (mg/m^3)	NOx (mg/m^3)	PAH ($\mu g/m^3$)	CO (mg/m^3)	SOx (mg/m^3)
Open fireplace	81.75	2.46	5.96	196.99	0.54
Traditional stove	73.87	2.46	5.96	196.99	0.54
Energy saving stove	36.94	3.94	5.96	196.99	0.54
Pellet boiler	5.91	3.94	0.49	14.77	0.54

Source: Mentes, D., Kovacs, H., Nagy, G., Csaba, P. (2019). Investigation of air pollutants from residential heating. Materials Science and Engineering, 44(2), 44-66.

Taking in account 1) the great number of households that heat with firewood, 2) the significant total annual consumption of firewood in North Macedonia (970.715,00 m^3, i.e. 1.71m3 per household) (State statistical office, 2019) and 3) the significant amount of emitted PM solid particles from firewood combustion, along with 4) the air pollution coming from other sectors,

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the exceeding of the average annual concentration of PM particles in North Macedonia at all measuring points in the country (State statistical office, 2021) is more than obvious.

Economic consequences from the air pollution in North Macedonia

Besides causing less-livable conditions and health problems, the air pollution also imposes a significant economic and social costs. According to the studies for quantifying the economic consequences of health deterioration and premature mortality due to air pollution, about 3800 people per year die in North Macedonia due to air pollution with PM particles (WHO, EU & OECD, 2015). Of these 1700 premature mortalities were caused by polluted outdoor air, whereas 2100 were due to polluted indoor air arising from heating with firewood and other non-ecological fuels. The report of World Bank, the Institute of Public Health of the North Macedonia and the Faculty of Medicine – Skopje (2015) has shown that the pollution with particulate matter causes annual health costs in the amount of 253 million euros, that is, about 3.3% of the gross domestic product (GDP). About 45% of these costs (or around 113 million euros) belong to Skopje. These costs are direct and are closely related to the costs of medicines and medical services, as well as the costs for lost working days (i.e. reduced work capacity of workers) due to absenteeism and the death of 1350 people per year. Furthermore, the study of Meisner (Meisner et al., 2015) has shown that if the concentration of PM10 and PM2.5 is reduced by only 1 μg/m^3, it would lead to savings of 34 million euros per year. The estimated values of potential annual savings as a result of reduction in emission of PM10 and PM2.5 particles are given in Table 4:

Table 4. Potential economic savings associated with reduced emissions of PM particles

Level of reduction in ambient PM10 and PM2.5 (μg/m^3)[a]	Annual health savings (in million euros)
0	0.0
1	34.1
5	98.9
10	133.6
15	161.5
20	184.9
EU standards met[b]	151.5

a - Example reductions were equally applied to both PM10 and PM2.5 at the same time.
b - PM10 = 40 μg/m^3 and PM2.5 = 20 μg/m^3
Source: Meisner C, Gjorgjev D, Tozija F. (2015). Estimating health impacts and economic costs of air pollution in the Republic of Macedonia, SEEJPH 2015

In addition to the direct costs associated with health services, the economic consequences also arise from 1) indirect unrealized costs of premature mortality due to air pollution, i.e. the money that the persons would have spent if they had remained alive, and from 2) lower realized benefit/income ratio for employers due to the loss of the employee. In accordance with the results from the WHO and OECD (2015) the direct and indirect economic consequences in North Macedonia imposed by the premature mortality due to polluted air for 2010 were estimated at about 5 000 000 000 $/ year, i.e. about 20% as a share of GDP. Till 2019 (latest reported data concerning this issue) the annual costs of health damages from PM2.5, although decreased to 15.9% as a share of GDP, they are still high (Tab. 5).

Table 5. Annual cost of health damages from PM2.5, percent equivalent of GDP

	2005	2010	2019
US $ (in millions)	1834	4755	n/a
Percent equivalent of GDP (%)	25.31	19.9	15.9

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Source: WHO & OECD (2015), Economic cost of the health impact of air pollution in Europe: Clean air, health and wealth. Copenhagen: WHO Regional Office for Europe; World Bank (2022). The Global Health Cost of PM2.5 Air Pollution: A Case for Action Beyond 2021. International Development in Focus. Washington, DC: World Bank.

Air pollution in Skopje and measures for its abatement

The attention within this paper is be focused on the fine particulate matter because it is considered as a pollutant with the largest estimated impacts on mortality and health outcomes and is used as indicator for estimating health impacts of ambient air pollution mixture.

The most characteristic feature for the air quality in Skopje is the enormously high concentration of PM10 and PM2.5 solid particles in the air. Data obtained from the State statistical office show that in Skopje the period from 2011 to 2020 the concentration of PM10 has exceeded the 24-hour limit value of 50 μg/m^3, as well as the average annual concentration of 40μg/m^3 at all measuring points in Skopje (State statistical office, 2021). The exceeding mainly occurs during the winter period, as a result of the intensive heating season and the weather conditions. It was shown that major part of the primary PM emissions originate from firewood burned in the households. About 33% of the households in Skopje region use firewood for heating and knowing that the annual consumption of firewood in Skopje region is around 190.000,00 m^3 the air pollution is more than expected and measures should be taken.

In order to mitigate the air pollution from residential heating, especially in the city of Skopje, the Government of North Macedonia has adopted a Plan for improving the air quality in Skopje region (Finnish Meteorological Institute & Ministry of Environment and Physical Planning, 2016). In this plan it is stated that on a long term a replacement of the heating mode of the households from stoves with firewood to usage of gas or another type of fuel is planned, but on a short term the reduction of emission of PM particles is possible through a proper use of stoves and respective fuels, chimney cleaning and increased inspection of the heating systems that use solid fuels. In the same document, several measures are foreseen for all sectors that are responsible for the air pollution and in the text below only those relevant to household heating are listed:

1. A ban on heating with firewood in areas with central heating from public heating plants (Measure 1)
2. Defining areas in which for all newly build objects the connection to the central heating grid will be mandatory (Measure 2)
3. Financial subsidies for replacing the old heating systems that use solid fuel with modern pellet heating systems (Measure 3)

The implementation of Measure 1 would lead to a reduction of the emission of particulate matter in the air. Although low administrative costs for monitoring and enforcing the ban are foreseen, the costs with regard to the households will be larger as they would have to invest in installing a new central heating system. Therefore, the proposed Measure 1 within the Plan for improving the air quality in Skopje region is assessed as expensive. The suggested Measure 2 is also assessed as expensive because its implementation implies upgrade and/or building of new power plants for central heating. It would result in increase of the administrative costs due to increased staff and workload. The households would have increased costs for the installations to the central heating grid. Measure 3 refers to a replacement of old heating systems (wood heating and oil heating) with new heating systems (pellet stoves) with financial subsidies from the City of Skopje. With this measure, by subsidizing the replacement of old systems that emit larger amount of harmful pollutants in the air, with new, more environmental and energy efficient heating systems the citizens are stimulated to use more environmental friendly solid fuels for heating their homes. Hence, the air quality would be improved. Regarding the costs for both, the Government and the households, this proposed measure is

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evaluated as moderately expensive. The households will be exposed to higher costs for buying the wood pellets, whereas the Government will have to allocate funds from the budget for subsiding the households and invest in new employments that will deal with the implementation of this measure.

Taking into account the health consequences, which on the other hand cause significant economic implications, the implementation of the third measure from the Air Quality Improvement Plan for the Skopje region is highly recommended for the citizens of Skopje because although it requires more investments, in the long run the increase in costs is many times smaller than the pollution caused by wood heating (Spirova & Vasiljevic-Shikaleska, 2021). Studies have shown that share of personal experience has more impact on raising awareness about air pollution and its abatement than the media or publicity campaigns (Aydin-Guc, Funda et al., 2018). Therefore, the households in Skopje were investigated in terms of the mode of heating, heated area, region of residence, household income and costs for heating per month. Additionally, the familiarization of the households with the subsides for using modern technologies that cause less air pollution was investigated. The obtained results are given in the text below.

Survey results

Socio-demographic characteristics of the sample

Socio-demographic factors are important predictors of community perception of air pollution. Therefore, information for two categories of households was gathered: households that in major use firewood for heating (Category 1) and households that use pellets for heating (Category 2). The obtained results are presented in Table 6.

It can be observed that in both categories, the age group (42-62) years occurs most frequently, with 49.23% for Category 1 and 58.93 % for Category 2. Most of the households in both categories had monthly income between 30.000 and 45.000 mkd. Furthermore, the households that use firewood are almost equally distributed (10-20%) among the analyzed municipalities except the municipality of Karposh where 32.14% of the households heat with pellets.

Table 6. Sociodemographic characteristics of the respondents

Variables	**n (%)**	
	Category 1	Category 2
	Age group	
21-41	27.69	18.75
42-62	49.23	58.93
63-83	26.15	22.32
	Monthly income	
Up to 30.000,00 mkd	26.92	7.14
30.000,00-45.000,00	46.92	52.68
Above 45.000,00	26.16	40.18
	Residence region	
Aerodrom	10.77	8.93
Gazi Baba	20.00	4.46
Karposh	7.69	32.14
Kisela Voda	17.69	26.79
Gjorche Petrov	11.54	20.54
Butel	16.92	5.36
Shuto Orizari	15.38	1.79

Source: The Authors

Survey of households that in major use firewood as primary heating source (Category 1)

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According the obtained answers most of the surveyed households live in a house (81%) and less in apartments (19%). The households use firewood as a primary source of heating (67.7%), and some of them use heating oil (15.4%) and inverter air conditioner and electric panel heaters (20.8%) (Fig. 3). Only 18% of the households heat all the area in the household, whereas 61% heat 2/3 of the available area (Fig. 4)

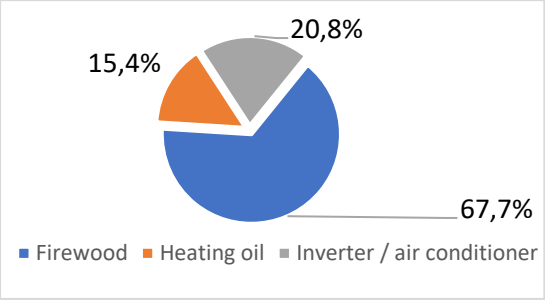

Figure 3. Primary source of heating
Source: The Authors

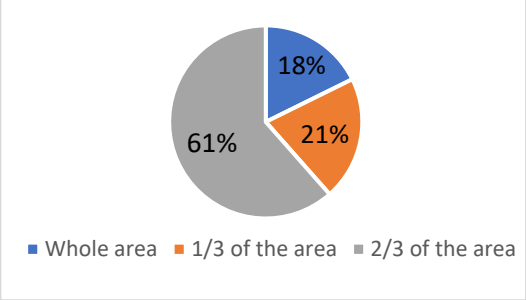

Figure 4. Total area heated in the households
Source: The Authors

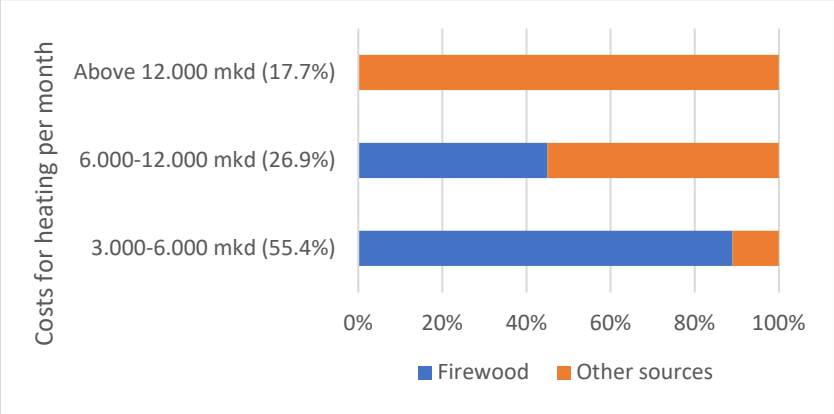

Figure 5. Average monthly costs for heating with firewood
Source: The Authors

With regard to the monthly costs for heating during the winter season it was observed that most households (55.4%) pay from 3000 to 6000 mkd per month for heating. Of them, 89% use only firewood as primary source for heating, where as 11% use additional sources as previously mentioned. 26.9% of the households have a monthly expenses of 9000 to 12000 mkd, in which 45% use only firewood as primary source for heating, and the remaining also use additional heating modes. Only about 17.7% of households have higher monthly costs (above 12000 mkd) and none of these heats the home with firewood. The comparison of results given in Table 6 and Figure 5 indicate that most of the households that have monthly income up to 45.000 mkd, (about 73.84%) have chosen to heat the household using firewood because of its lower monthly costs (up to 6000 mkd).

Concerning the awareness about air pollution, measures and legislative in North Macedonia for reducing the emission of harmful particles in the air the respondents gave the following answers:

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Table 7. Awareness about air pollution and measures for air pollution abatement in North Macedonia

	Aware about the possibility of heating with pellet stoves	Aware about the governmental subsidies for air pollution abatement	Aware about the costs of using pellet stoves	Aware about the environmental benefit of using pellet stoves	Aware about the legislation regarding the air pollution
Yes	61.54 %	37.69 %	54.62 %	55.38 %	25.38 %
No	38.46 %	62.31 %	45.38 %	44.62 %	74.62 %

Source: The Authors

According to the results presented in Table 7, the households that use firewood as a primary source for heating are not well informed about the existing legislative (plans, strategic programs and measures) for reducing air pollution, as well as for the possibility of being subsidized to replace the existing firewood heating system with wood pellets, but they are familiar with the possibility of using pellets instead of firewood and with the costs and usefulness of the same. Despite all, the majority of households (60%) are not willing to use pellet stoves (Fig. 6) because they think that the existing way of heating is more cost effective (65.38%) (Fig. 7). The obtained results imply that the choice of heating with firewood is more due to the lower monthly household income and rational cost planning, and less to lack of information that there is still another way of heating that is more efficient and environmentally acceptable.

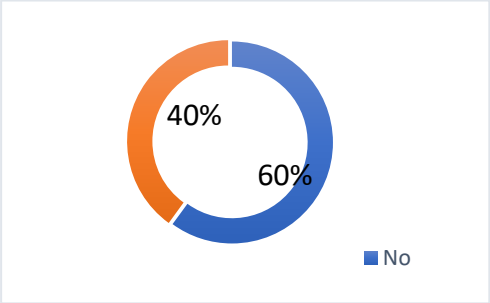

Figure 6. Willingness of changing the heating system from firewood to pellets

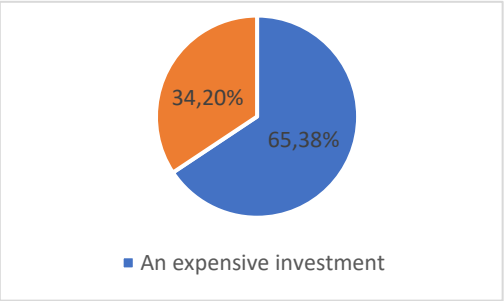

Figure 7. Reasons for not changing the heating system from firewood to pellets

Source: The Authors

Survey of households that have changed the heating system to wood pellets as primary source for heating (Category 2)

The results shown below refer to the surveyed households that have made a shift towards using a heating system with wood pellets. It was noticed that before using the pellets and pellet stoves, more than a half of the respondents (67.86%) were heating their homes with electric appliances (heating panels and air conditioners), whereas the remaining were using firewood (32.14%) (Tab. 8). The most significant decrease of the costs for heating (up to 10% per month) was observed for the households that have previously used panel heaters, whereas for the ones that were previously heating with firewood the costs per month were increased, mostly about 10- 15% per month (Fig. 8).

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Table 8. Information for the households that have changed the heating system to wood pellets as primary source for heating

Heating system used before the use of pellet stove	
Firewood	32.14 %
Panel heaters	42.86 %
Air conditioners	25 %
Procurement of pellet stoves	
With subsidies	7.15 %
Self-financing	92.85 %
By using pellets instead of firewood I contribute positively to reducing air pollution	
Yes	57.14 %
No	9.82 %
No opinion	33.04 %

Source: The Authors

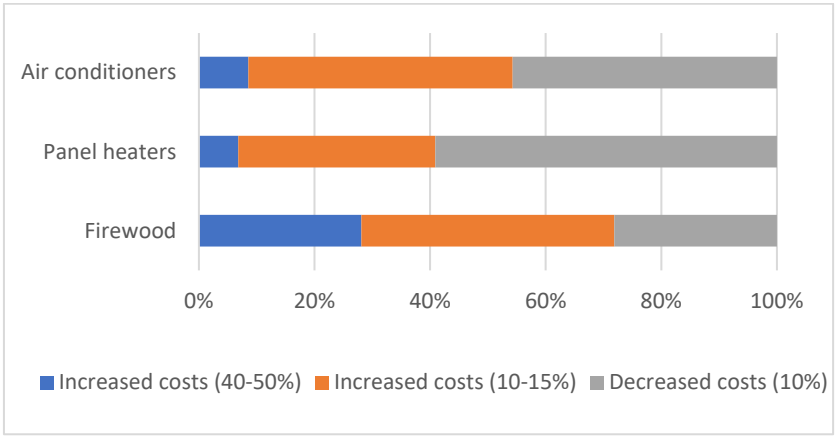

Figure 8. Comparison of the expenses for previous modes of heating with heating with pellet stoves
Source: The Authors

The results obtained for the monthly expenses of the households before and after they have changed the heating system to pellet/pellet stove indicate that the average monthly costs have shifted towards the higher amounts i.g. from average monthly costs of 4.500,00 mkd (most frequent observation on Fig. 5) to 10.500,00 mkd (most frequent observation on Fig. 9). For 35% of households, these monthly costs remained unchanged (Fig. 9).

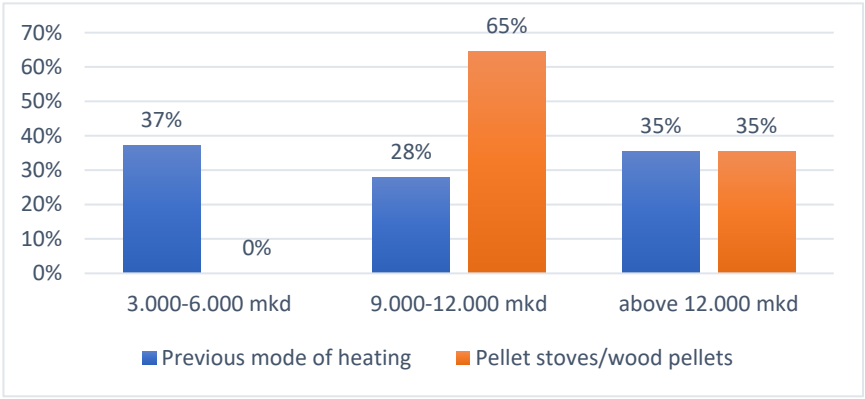

Figure 9. Monthly costs for heating the households using different heating modes
Source: The Authors

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Only 7.15% of the surveyed households used the governmental subsidies (Tab. 8). However, even though the costs were increased, most of the respondents (61.54% of the households that were previously using firewood, 88.89% that were previously heating with panel heaters and 91.89% of those ones heating with air conditioners) have stated that they still recommend the use of pellet stoves for heating the household (Fig. 10) because of its advantages like the maintenance, cleanliness and, above all, higher heating efficiency and less air pollution. They have also stated that by using more environment friendly fuels for heating all of us contribute towards much less polluted air and a more sustainable environment as a whole (from environmental, economic and primarily sociological aspect). The latest should serve as a basis for encouraging the respondents that have no particular opinion about this issue (about 33% of the households that were using firewood for heating-Tab. 8) in terms of more effective exploitation the existing subsidy measures, since it is supposed that it is particularly this group of respondents that have lower monthly incomes.

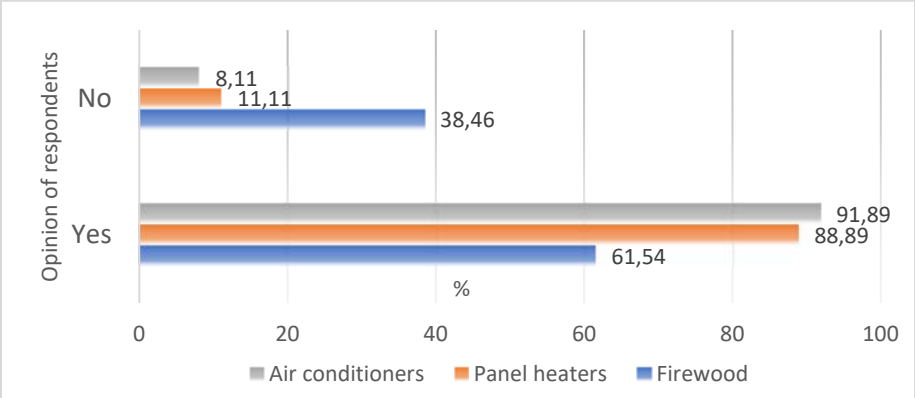

Figure 10. Recommendation (by the households) for using heating system with wood pellets compared to the previous way of heating
Source: The Authors

CONCLUDING REMARKS

The air pollution in Skopje exceeds the air quality limits particularly during the winter period with the residential heating, the industry and the electricity and heat production sector being the biggest emitters of air pollutants. The presence of harmful gasses and particulate matter in the air pose a serious health risk and cause significant economic consequences.

The aim of this research was to study the air pollution in Skopje caused by the households heating, the implementation of the governmental measures for reducing the air pollution in the city and the awareness of the households for using more environmental modes of heating.

Based on the findings it can be concluded that most of the households are aware about the emission of harmful particles into air when combusting firewood in old traditional stoves. They are also familiar with the possibility for using wood pellets, as more environmentally heating mode but there is a lack of information regarding the governmental measures for subsiding the shift from using firewood, burned in old traditional stoves to usage of pellets, with modernized pellet system where the process of burning controlled and is more environmental. As a result, only few of the households (about 7%) have made the shift towards usage of modernized, but above all, environmentally safer pellet heating systems. Although they have increased monthly costs (up to 15%) they still recommend the use of pellet heating system due to the efficiency of heating, maintenance, cleanliness, and less pollution of air on the long run.

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The major part of the households continued to use the firewood as it is the cheapest mode of heating. As expected, the monthly costs for the heating prevail over the usage of more efficient and environmentally friendly heating systems. Therefore, additional subsiding or other kind of support should be provided to the lower-income households so they would be financially sound to change the heating system to a more environmentally one.

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