DOCUMENT 3

2017-2025 Roadmap
for Reducing Local Air Pollution
Caused by Household Heating

SKOPJE IS BREATHING–
UTOPIA OR REALITY

DRAFT (for discussion)

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Since January 2017, UNDP Office in Skopje works on analysis of the local pollution and the emission of GHGs from households heating in the Skopje valley and design and testing of local actions for emissions decrease. The activities have been undertaken within three ongoing complementing projects of UNDP, generously funded by the Ministry of Finance of the Slovak Republic, the City of Skopje and the Global Environmental Facility (GEF).

This is the third document produced within this initiative and developed by the team of experts listed above.

The opinions expressed in this document are the opinions of the authors and do not present the opinions of the United Nations, including UNDP or UN member-states.

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1. Introduction

According to the World Health Organization (WHO), about 6.5 million people per year, or 18,000 per day die as a result of air pollution. It is believed that this is the fourth largest "killer" of people immediately after blood pressure, improper diet and smoking. The criteria set by the WHO concerning the permitted concentrations of harmful substances, presented in its Air Quality Guidelines, are:

- the average annual concentration of $PM_{2.5}$ (particulate matter with the size of 2,5 micrometres) should not exceed 10μg/m^3, or 24-hour concentration of 25μg/m^3;
- the average annual concentration of PM_{10} should not exceed 20μg/m^3, while the 24-hour concentration should not exceed 50μg/m^3

According to the national Law on Air Quality average annual concentrations of $PM_{2.5}$ and PM_{10} should not exceed 25 μg/m^3 for $PM_{2.5}$ and 40 μg/m^3 for PM_{10}. The 2015 Annual Report on Environmental Quality of the Ministry of Environment and Physical Planning (MoEPP) shows that the average annual concentration of $PM_{2.5}$ in 2015 for Centar Municipality was **40.14μg/m^3**, and for Karposh Municipality, it was **50.51μg/m^3**. On the other hand, the concentration of PM_{10} in these two municipalities of the City of Skopje amounted to **72.82μg/m^3** and **57.06μg/m^3**, respectively. The problem of air pollution in the City of Skopje is an old one, which is also confirmed by the MoEPP's annual reports, where for example, in 2005, an average annual concentration of 104.09μg/m^3 and 92.01μg/m^3 was registered in Centar and Karposh, respectively. So, it can be concluded that the citizens of the Skopje Valley are constantly exposed to concentrations higher than the permitted ones. It is interesting that according to the MOEPP data, rapid increase in the concentrations (up to three or four times) takes place during the heating season.

In order to start solving the issue of the City of Skopje's pollution, it is necessary to identify the biggest polluters first. For this purpose, in recent years, relevant institutions (Ministry of Environment and Physical Planning and City of Skopje) have done a series of analyses and studies to determine the time of the year when the highest concentrations of polluting substances occur. According to these studies[1], the highest peaks (maximum concentrations), when analysing the monthly or daily average concentrations, occur in the course of winter, during the heating season. These findings indicate that **heating is the largest air polluter in the Skopje Valley, whereby heating of households has the largest share therein**. These findings are also confirmed by the study conducted by the Finnish Meteorological Institute within the twinning project with the MOEPP, where it was calculated that 90% of the total emissions of PM particles come from residential heating.

Research shows high concentrations of $PM_{2.5}$, PM_{10} and volatile organic components (VOC) in regions with intensive firewood use. In many locations around the world, firewood heating is the dominant source of pollution and contributes up to 95% in PM concentrations measured in winter (Jordan et al. 2006). According to WHO, as high as 28 components in the emissions resulting from firewood burning are defined as toxic, of which 14 are carcinogenic (Smith et al., 2014). Also, non-specific particulate matter (PM) resulting from burning firewood and coal has recently been classified as carcinogenic by IARC (Loomis et al., 2013).

[1] Air Quality Improvement Plan for Skopje Agglomeration drafted in 2016 within the EU-funded project "Further institutional capacity building for effective implementation of the EU Acquis in the area of air quality"
- City of Skopje (2017): Elaborate Study on Ambient Air Pollution from Firewood Burning as a Means of Heating (prepared by Tehnolab)

Although these studies show the pollution rate and indicate what the sources of pollution are, the information and data they contain are general and as such, they are not sufficient for proper planning and implementation of successful activities at the micro level. For this reason, in January 2017, UNDP, in collaboration with the City of Skopje and the Ministry of Environment and Physical Planning, conducted a survey regarding the residential heating practices, on a representative sample of 5,044 households around the Skopje Region (all 17 municipalities). These findings were analysed and their results were presented in the report "Scientific and Research Study: How Are Households in Skopje Heated?" presented in Document 1.

Some of the measures envisaged in the Plan for Skopje Region Agglomeration Air Quality Improvement (from January 2017), together with the data gathered in the Study, are computer-modelled using the internationally used MARKAL software[2]. The model shows that through a combination of a series of measures aimed only at changing the ways of residential heating, significant emissions' reduction and air quality improvement can be achieved. Also, the very same measures combined with measures in other areas (e.g. construction, small company heating, transportation) will yield even better results in solving the problem. Below is a detailed description of the goals to be achieved and activities for their achievement aimed at changing the ways of residential heating.

2. Goal

Significant reduction of pollutant emissions resulting from household heating as the largest local air polluter in Skopje Valley, or reduction of:

- **$PM_{2.5}$** by 26% in 2020 and by **51%** in 2025 compared to 2015, or from 2.7 kt in 2015 to 2 kt and 1.32 kt in 2020 and 2025, respectively[3],
- **PM_{10}** by 26% in 2020 and by **51%** in 2025 compared to 2015, or from 2.8 kt in 2015 to 2.07 kt and 1.36 kt in 2020 and 2025, respectively,
- **CO** by 18.5% in 2020 and by **36%** in 2025 compared to 2015, or from 14.78 kt in 2015 to 12.05 kt and 9.42 kt in 2020 and 2025, respectively,
- **NO_x** by **4.2%** in 2025 compared to 2015, or from 1.98 kt in 2015 to 1.89 kt in 2025,
- **SO_x** by **5.6%** in 2020 and by 49% in 2025 compared to 2015, or from 9.45 kt in 2015 to 8.92 kt and 4.84 kt in 2020 and 2025, respectively.

	2015	2020		2025	
	Baseline scenario [kt]	%	kt	%	kt
$PM_{2.5}$	2.7	26	2.00	51	1.32
PM_{10}	2.8	26	2.07	51	1.36
CO	14.78	18.5	12.05	36	9.42
NO_x	1.98	/	/	4.2	1.89
SO_x	9.45	5.6	8.92	49	4.84

[2] For the development of the Climate Change Strategy for the City of Skopje titled "Resilient Skopje", a model has been developed in MARKAL, covering the energy sector, both on the supply and on the consumption side.

[3] In Launceston, Tasmania, for example, decrease of emissions from households who used wood burning stoves for 36% resulted in decrease of average concentrations (in winter periods) of PM_{10} for 39% or from 44 to 27 µg/m3 (Johsnton et al. 2013).

This can be achieved through the implementation of the following three measures:

- **Replacing firewood stoves with:**
  - **more efficient firewood stoves,**
  - **pellet stoves,**
  - **heat pumps (including inverter air conditioners),**
  - **central natural gas heating system.**
- **Application of energy efficiency measures in the homes**
- **Increasing the number of central heating users**

2.1. Data analysis

Success of policies and measures designed to reduce air pollution depends, among other things, on the availability of **primary data gathered from the ground** that will reflect the actual situation.

Supported by UNDP and using the innovative tool Placeformer (a tool for conducting mobile phone field studies), in January 2017, a survey was performed regarding the residential heating practices in Skopje Valley #SkopjeIsHeating. The results of the survey were analysed and summarized in a Study analysing the residential heating practices in all 17 municipalities of Skopje Valley (*How Are Households in Skopje Heated? Scientific and Research Study, UNDP, Skopje, February 2017*).

This research is **the first ever comprehensive survey** on the heating practices of such a large number of respondents **conducted in Skopje Valley**. **A total of 5,044 households** were surveyed, of which 71.2% in urban settlements, and 28.8% in rural settlements near **Skopje**. This **sample is a representative** one and enables data **analyses** at **the municipal level**, or **even at the neighbourhood level**.

In order **to calculate local emissions** resulting from heating of households and also **to identify ways of their reduction at the lowest cost**, survey results for the City of Skopje were **modelled** in the internationally accepted MARKAL software, specifically adapted for Skopje by applying the following measures:

- (re)construction of efficient buildings
- changing the way of heating (efficient technologies) and
- increased acceptance of central heating.

Further, these measures were implemented in the "Skopje Breaths" scenario. **Based on the GDP and population growth projections for the City of Skopje, projections were made regarding the energy needs in the household sector by 2025. Using the emission factors under the Tier 2 Methodology prescribed by the IPCC[4], each technology used for heating in Skopje was assigned an appropriate emission factor. According to the results obtained, modelling was done for all 17 municipalities in Skopje Region.**

These three measures, extracted from the Action Plan for air improvement in Skopje Region, were selected based on the results from the survey:

[4] IPCC Tier 2 methodology defines emission factors for each technology using fossil fuels and biomass.

Households heated on:	Percent	Number of households surveyed	Estimate of the total number of households
Firewood	44.7	2,257	72,220
Electricity	31.1	1,567	50,835
Central heating	21.2	1,070	34,712
Pellets and briquettes	1.5	78	2,530
Fuel-oil	1	44	1,427
Coal	0.4	22	714
other solid fuel	0.1	6	195
		5,044	163633[5]

and in terms of buildings' thermal features:

- As many as 50.8% of the buildings have no insulation at all, and
- 42% have thermal insulation lower than that prescribed by the 2013 Regulations on New Buildings, or as shown in the following table:

Households that:	Percent	Number of households surveyed	Estimate of the total number of households
have no insulation at all	50.8	2,563	82,147
have thermal insulation lower than the prescribed one	42	2,118	68,710
have insulation under the provisions of the 2013 Regulations on Buildings' Energy Features	7.2	363	11,776
Total		5,044	163,633

Particularly interesting conclusions can be drawn from the survey conducted, if the criteria based on which citizens choose their heating technology are analysed. **Although every individual in Skopje is complaining about Skopje's pollution, only a modest 1.3% said that when choosing a heating system, they are guided by the criterion of how much such system pollutes the air. The main criterion** in the selection of a heating system among citizens is **the financial one** and it is important for 74% of the respondents. As a result, as many as **44% of the households** responded that **they would connect to central heating** if available, even if **the price were slightly higher** compared to the system they were currently using.

2.2. Skopje is suffocating: baseline scenario

In order to determine how a given policy or measure will contribute to reducing local emissions, it is necessary to create a **reference (baseline) scenario**. This scenario takes into consideration the **factual data of 2015 and the data from the analysis**. On the other hand, its

[5] Total number of households in the Skopje Region (all 17 municipalities) according to the 2002 Census. Source: National Statistical Office, www.stat.gov.mk

creation **is crucial** for being able to compare all policies and measures with the same baseline option, thus allowing to see the impact (financial, energy, environmental) from the implementation of a particular policy or measure.

The data obtained from the survey are very important in the process of creating the baseline scenario. It is important to model the data from the survey because in this way the data are verified, and it creates a basis for projections. Besides the data from the survey on energy source consumption, above all of firewood, modelling also considers heating technologies and their efficiency but also the development of the residential sector in the Skopje Valley.

The results have shown that if no measures are taken in order to reduce the local pollution, it will continuously grow leading to:

- continuous increase in local emissions;
- the highest increase in PM_{10}, $PM_{2.5}$ and CO by 28% each, in 2025 compared to 2015;
- increase in NOx by 23% in 2025 compared to 2015;
- increase in SOx by 12.4% in 2025 compared to 2015.

Figure 1. Local emissions in "Skopje is suffocating" scenario [kt]

2.3. Skopje is Breathing: Desired Scenario

Results of all of the aforementioned studies and survey show that **firewood is the largest local pollutant**. On the other hand, it is a renewable energy source, and as such, it is conducive to reducing greenhouse gas emissions and **reaching the renewable energy targets on the share of RES in the gross final energy consumption adopted by the Government and accepted by the Energy Community**. This raises the question of how to come up with **an acceptable solution that will simultaneously address these two challenges**. Therefore, this scenario considers three measures that derive from survey results and are already part of the Air Quality Improvement Plan, meeting the preceding requirements:

1. **Improve homes' energy efficiency** - survey results showed that 50.8% of the buildings have no insulation, while 42% have insulation that is not in accordance with prescribed standards;
2. **Change the way of heating** (efficient technologies) – survey results showed that 44.7% of the households use under efficient firewood stoves and efficient electricity technologies, 5.3% use heat pumps, while pellet and briquette stoves are used by only 1.5% of the households;
3. **Increased coverage by central heating** - survey results show that 44% would accept to be heated by a central system even with slightly higher costs than the system used currently.

Each measure in the model is analysed individually to see its impact. **Analyses** of the investment required, and of local and global emission reductions were performed. But if a decision is made to implement each of these measures in parallel, because of their interconnection, their impact will not be a simple sum of the parameters indicated. For this purpose, a scenario entitled "Skopje is Breathing" was created. This scenario shows that local emissions can be drastically reduced compared to 2015:

- **$PM_{2.5}$** by 26% in 2020 and by 51% in 2025,
- **PM_{10}** by 26% in 2020 and by 51% in 2025,
- **CO** by 18.5% in 2020 and by 36% in 2025,
- **NO_x** by 4.2% in 2025,
- **SO_x** by 5.6% in 2020 and by 49% in 2025.

Compared to the scenario "Skopje is Suffocating", by 2025, with this scenario, the following emissions can be reduced:

- **PM_{10} and $PM_{2.5}$ emissions by about 62%;**
- **CO and SOx emissions by about 50%, 54% respectively;**
- **NOx emissions by 22%.**

Annual emissions for both the scenarios "Skopje is Suffocating" and "Skopje is Breathing", as well as for each individual measure are shown in figures bellow (2 to 6).

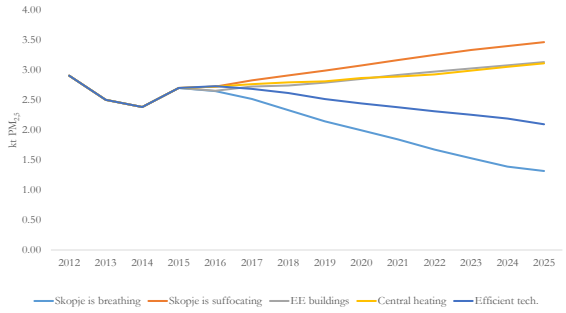


Figure 2. Comparison of $PM_{2.5}$ in the scenarios "Skopje is Suffocating" and "Skopje is Breathing" and for each individual measure

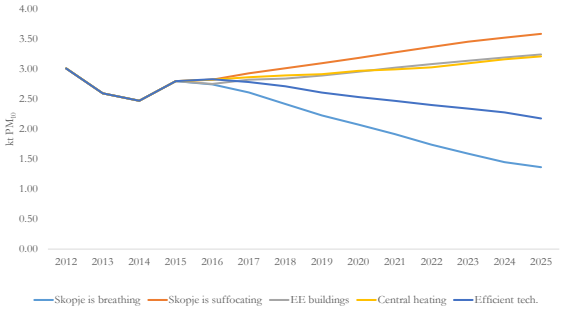


Figure 3. Comparison of PM_{10} in the scenarios "Skopje is Suffocating" and "Skopje is Breathing" and for each individual measure

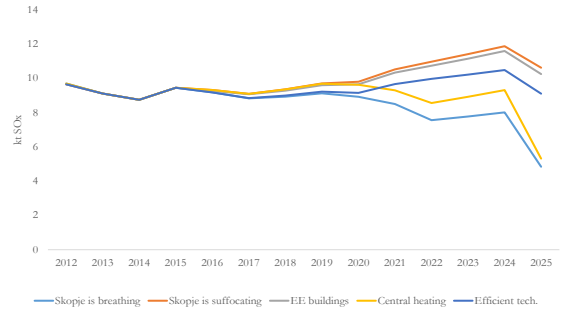


Figure 4. Comparison of SO_x in the scenarios "Skopje is Suffocating" and "Skopje is Breathing" and for each individual measure

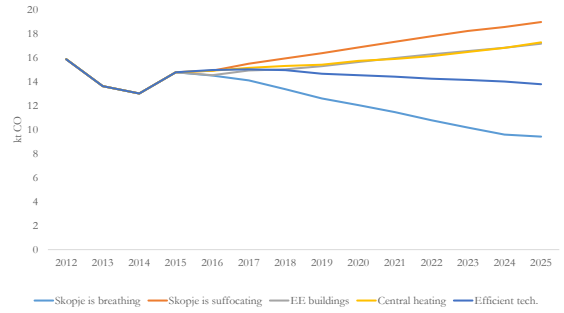


Figure 5. Comparison of CO in the scenarios "Skopje is Suffocating" and "Skopje is Breathing" and for each individual measure

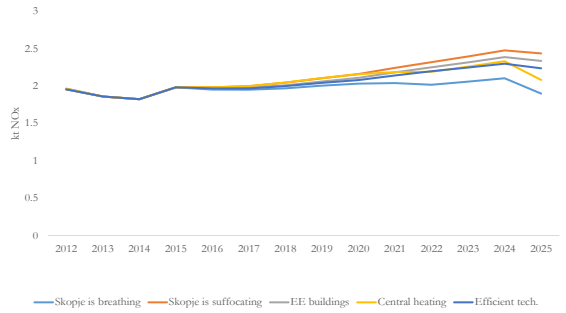


Figure 6. Comparison of NO_x in the scenarios "Skopje is Suffocating" and "Skopje is Breathing" and for each individual measure

2.4. Prudent Math - How to Achieve These Goals?

In order to reduce local residential heating pollution, i.e. in order **to implement the scenario "Skopje is Breathing"**, **55.8% of urban households and 22.2% of rural households should be covered by some of the measures by 2020** (Table 1), or **81.3% and 42%** by **2025 for urban and rural areas, respectively. It is important to note that here, it is not about new households that will use a particular technology**. For example, in terms of more efficient firewood stoves, it does not mean that in addition to the existing households which use firewood stoves there will be additional 9,000 households by 2020, but that of the total number of households using firewood in 2020, 9,000 households will use efficient firewood stoves.

Description:	**Target by 2020**		**Target by 2025**	
	Urban areas	Rural areas	Urban areas	Rural areas
Number of households covered by either of the measures	55.8%	22.2%	81.3%	42%
- will meet the most stringent energy efficient building criteria	8,960	2,660	15,600	4,290
- will use more efficient firewood stoves	9,000	3,100	20,400	6,770
- will use pellet stoves	6,630	790	7,280	1,460
- will use heat pumps	8,140	2,770	16,280	5,390
- will use natural gas stoves	930	280	2,700	450
- Increased rate of the central heating system use	3,000	/	10,000	/

Table 1. Number of households to be covered by either of the measures planned

By this strategy, the results show that the scenario **"Skopje is Breathing"** would help **reduce** the total number of **households** using firewood and they would account for **35.4%** of the total number of households in **2025**, which means that they would go down by about **18,000 households**. On the other hand, the share of households using electricity would remain the same, while the number of households using heat pumps (most of them inverter air conditioners) would increase. The number of **households** using **pellet stoves** would **go up** by at least **8,500 households** and their share in the total number would be 6.1%.

Finally, households using coal or other solid fuels, although accounting for only 0.4% or about 650 households in 6 municipalities in the region, by **2020** should disappear, i.e. **there should be no households using coal or other solid fuels**, while the number of households being heated by fuel-oil (which is now about 1%) should be reduced to 0.

Also, the number of households connected to the **central heating system** would **increase** by **10,000 households**. The detailed plan for the heating structure of Skopje prepared by BEG envisages the following:

- Short-term plan – reconnecting all disconnected customers (about 13,500 households). The implementation has already started.
- Mid-term plan – connecting all collective and business buildings in areas with existing network infrastructure (it is assessed that these amount to 50,000 households). Period of implementation until 2020.

- Long-term plan – until 2040 and in accordance with the detailed urban plans it is planned to install a central heating infrastructure in the parts of Skopje which currently are not covered with it. With the implementation of this plan about 71% of the households in Skopje (covered by the General Urban Plan) will have an opportunity to be connected to the central heating system.

Finance

"Skopje is breathing clean air for 50 MKD per day per household"

The realization of all the measures in this scenario requires **€ 378 Mill.** for the period from 2017 to 2025, of which about **€ 325 Mill.** for refurbishment of buildings (facades, roofs, floors etc.) to meet **the highest** energy performance of buildings criteria in accordance with the relevant national regulations. This is the maximum sum of total cost, which are expected to be funded by several sources, and these would require the development of a financing plan.

In order to respond to the increased operational needs due to the higher number of connections in the central heating system, BEG will invest about **€ 200 Mill.** in order to construct new cogeneration power plant (thermal -electric power plant)[6].

In order to start the implementation of the Roadmap, the educational campaign, to initiate coordination f implementation and design and test all activities individually and in detail, at least **€1 Mill. Is needed for the period of 2.5 years**. After that it is expected the activities to continue and to be implemented with slight coordination, monitoring and guidance if and wherever it is necessary, and the additional funds required would be insignificant.

2.5. Target Groups

The very detailed analyses of micro regions were done, including the analysis of municipalities' share in local pollution caused by firewood burning. Although when viewing the data on each individual municipality, there are municipalities where biomass is predominant with over 90%, still, when observing the percentage of the total firewood consumption in Skopje, the situation is somewhat different. As an example, in the Municipality of Shuto Orizari, 91% of the respondents used firewood, but viewed in the total consumption of Skopje, Shuto Orizari Municipality accounts for only 5.4%. Regarding the other municipalities, the share of each municipality in the total firewood consumption of Skopje Valley is shown in the following table, where the other 7 municipalities outside the territorial scope of Skopje are also presented, accounting for 24% in the total firewood consumption of Skopje Region.

[6] http://beg-snabduvanje.com.mk/wp-content/uploads/2017/03/BEG-studija-MFS-MACEF.pdf

10 municipalities 76 %	7 municipalities 24 %
✓ 24 % - Gazi Baba	✓ 5.8 % - Ilinden
✓ 15.6 % - Saraj	✓ 4.6 % - Studenichani
✓ 13.4 % - Kisela Voda	✓ 4.4 % - Arachinovo
✓ 12.3 % - Gjorche Petrov	✓ 3.5 % - Chucher Sandevo
✓ 9.5 % - Butel	✓ 3.2 % - Petrovec
✓ 7.5 % - Aerodrom	✓ 1.3 % - Sopishte
✓ 5.7 % - Karposh	✓ 1.3 % - Zelenikovo
✓ 5.4 % - Shuto Orizari	
✓ 5.6 % - Chair	
✓ 1 % - Centar	

This does not mean that the municipalities that are contributing less to the pollution should work less on this issue, but it only indicates that different municipalities should prioritize measures adequate to the sources generating the biggest pollution.

For example: Although firewood in Centar Municipality accounts for 1% of the total pollution caused by firewood burning, it does not mean that Centar Municipality should not work on solving the problem, but that it should set its own specific objectives, such as:

1) There shall be no households heated on coal (according to the survey, there are about 100 such households in this municipality - especially as some of them are in the very centre of town, for example at 50-ta Divizija St., near the Clinical Centre);

2) There shall be no households in this part of the city heated on firewood, and local measures shall be created to ensure that such households will switch to central heating or other more environmentally friendly way of heating;

3) Specific measures shall be designed to reduce pollution generated by other sectors (traffic, construction), according to the results of other relevant studies or surveys.

The Survey allows to do detailed analyses for each individual municipality and create specific local measures to be implemented by each municipality in addition and complementary to the measures to be taken by the ministries and the City of Skopje.

Target groups[7] were identified on the basis of survey results, while taking into account the following factors that are intertwined or complement each other, which in economic theory are considered to have the biggest impact on the choice of the heating method:

1. Economic conditions – households' economic status as a determining factor that directly affects the choice of energy source.
2. Demographic and cultural features - household size, age structure, education level.

[7] Detailed analysis and explanation regarding the selection of each target group is shown in Document 2.

3. Insulation factors of residential buildings - ownership status, the building's year of construction and size.
4. Motivational factors - lifestyle habits of family members, their level of comfort, use of new techniques and technologies in the home, awareness and commitment to environmental protection and family members' health.

The establishment of these specific target groups is essential to defining recommendations for each target group, which in turn would enable the fulfilment of targets set for reducing local pollution. The detailed analysis of the survey results indicates that actions for addressing the issue of air pollution caused by firewood burning should focus (without excluding other citizens) on the following target groups:

1. **Households using coal - about 714 households in 6 municipalities (Centar, Gazi Baba, Chair, Karposh, Studenichani and Saraj)**

2. **Households using firewood - as many as 44.7% or 2,257** households of the 5,044 households surveyed use firewood, i.e. of a total of 161,841 households (according to the State Statistical Office's data), around 72,400 use firewood. 63.3% of the total number of households using firewood are found in 6 municipalities (Gazi Baba, Saraj, Kisela Voda, Gjorche Petrov, Butel and Shuto Orizari).

3. **Households using firewood and generating a monthly income of up to the average net salary** in the Republic of Macedonia[8] **-** this target group stands out because the analysis shows that out of the households using firewood:
    - **15%** have a monthly income of up to 12,000 MKD, or around 11,000 households;
    - **28%** have a monthly income between 12,000 and 24,000 MKD, or around 20,500 households;
    - **33% earn** more than 24.000 MKD, or around 24,000 households;
    - **24% of the respondents that use firewood** for heating did not answer this question.

4. **Households using firewood that have members with completed primary and secondary education, because:**

    - **40%** of respondents in households using firewood have completed primary education
    - **51%** have completed secondary education and
    - **9%** have a university degree

or out of a total of 163,633 households, households using firewood whose members have primary education are **29,522** and whose members have secondary education are **37,437**. The highest percentage of households using firewood that have members with primary education are found in the Municipalities of Shuto Orizari, Saraj, Studenichani, Arachinovo and Petrovec.

The last two categories are singled out because results show unusual correlations pointing to the conclusion that the use of firewood does not depend on the household's financial situation, but on household members' education level. This suggests that the focus of activities should be

[8] The criterion for monthly income analysis is the average net salary paid in MKD in the Republic of Macedonia, and in the month of May 2017, it was 22,889 MKD (State Statistical Office of the Republic of Macedonia, MAKStat base.) Survey data was grouped according to a monthly income of up to 12,000 MKD (roughly up to the amount of the minimum net salary in Macedonia), from 12,000 to 24,000 MKD (approximately up to the average net salary paid in Macedonia)

placed on non-standard "educational" individualized approaches, as opposed to subsidies, which should certainly not be excluded, but they should be properly directed to low-income households, so that the impact on emission reduction could be the greatest through the implementation of such measures.

5. **Households using firewood with children under 18 - 50.2%** of households are using firewood (2,257 households). According to the estimates of the total number of households in Skopje Region, there are 36,756 households using firewood with children under 18 out of a total of 72,220 households. Most of these households or about 23,458 are located in 7 municipalities - Shuto Orizari, Saraj, Chair, Studenichani, Butel, Chucher Sandevo and Arachinovo)

6. **Single-parent households using firewood with children younger than 18** – or by approximation, about 1,764 households[9] are single-parented with children younger than 18 and using firewood in Skopje Region. This category stands out as the method of heating differs from the total distribution, and differences are noted in the ways of heating in families with a female breadwinner and a male breadwinner of single-parented families. This category may be of interest to the respective institutions or NGOs working with vulnerable groups of citizens.

7. **Households with energy inefficient facade of the building - 49.3%** of the total number of responses received[10] include walls that are not additionally thermally insulated. **35.8%** are under-insulated. Only **7.8%** have buildings that meet the prescribed insulation standards, while **7.1%** do not know whether their residential building has any thermal insulation.

8. **Households with energy inefficient roof of the home - 52.3%** answered that their building had no thermally insulated roof. Insulation of 5 cm and 10 cm can be found in **24.1%**, while house roof insulation of 15 cm and above is found in **6.7%** of the total number of responses. **16.8%** do not know if there is any roof insulation and what it is like, if any.

9. **Households that have been disconnected from the central heating system** – households that once used a central heating system, but due to certain reasons, have given up this way of heating, or households that do have access, but have never connected.

3. The Path to the Desired Scenario

"The road to success begins with the first step"

Skopje's pollution problem cannot be resolved within one or two years. It is a process where everybody, primarily citizens and institutions at both local and central levels, have to work hard, and this has to be supported by the private sector. This is a process in which the blame should not be shifted from one to another, where everyone should start from themselves and change their own behaviour to be able to legitimately request change from other stakeholders in society.

[9] Of the total number of respondents, 1,133 households are with children under 18 that use firewood, of which 4.8% are single-parented or 51 households. Hence, the number of 1,764 households is obtained by approximation.

[10] Questions of the questionnaire relating to the insulation of the home (main structure, facade and roof) have multiple-choice answers, so we made the calculations according to the total number of responses received, and not according to the number of households surveyed.

Decisions made at the central level should be initiated as a result of local issues, and each decision should be based on previous thorough analyses. The implementation of measures should be gradual. Quick implementation of measures may cause an increase in market prices, both in terms of technology and energy sources, but also of labour when it comes to insulation. Recently, there have been cases of lack of pellets and firewood as a result of increased demand.

To meet the targets for reducing local emissions defined in this document related to 2020 and 2025, a Roadmap was developed that should be followed and observed. Activities recommended in this Roadmap (a series of recommendations) follow up onto the Plan for Air improvement (mentioned at the beginning of this document), by providing detailed guidance on how to implement the 3 measures elaborated.

To achieve the best results within a short time period with no greater investment required, it is necessary to direct the preliminary activities towards the target group "Households that have been disconnected from the central heating system". In fact, the analysis of financial implications from these measures' implementation showed that the least investment was required for the implementation of this measure, and quick results can be achieved already in this heating season, when most of the other measures could not be implemented fully. On the other hand, institutions have a good partner for this measure, because BEG alone has already started such a campaign and has significantly reduced the cost of heating energy (e.g. in the 2012-2017 period, the price of heating energy per kWh was reduced by about 45%, i.e. 31,3% for households, 65,7% for educational institutions and 52% for the others[11]) which makes this heating method much more affordable (just for comparison the cost for central heating is lowest compared to other types of heating i.e. central heating is 2,9 MKD/ kWh, firewood with 50% efficiency of the stove is about 3,94 MKD/ kWh and the mean tariff for EE is about 4,5 MKD/ kWh) .

The modelling showed that most investments are needed for the measure: construction of energy efficient buildings, which means that activities towards the target groups of households with energy inefficient facades of their homes and households with energy inefficient house roofs will include a lot of hard work, but should also be priority activities, because they will be implemented throughout the period up to 2025. The recommendations and measures to be undertaken for this target group should include buildings that have no insulation on their facades and roofs or have insulation that does not meet the prescribed thermal insulation standards. The activities should include a combination of educating (because there are many households that have insulated their facades using up to 2 cm, 5 cm or 10 cm insulation of Styrofoam, fiberglass or mineral wool on their walls, which is not enough), subsidizing and usage of innovative approaches - such is design of affordable packages available from private construction and other renovation companies, or crowdfunding[12].

To achieve greater impact in reducing local emissions, it is necessary to direct initial activities towards the target group of households using coal and firewood, and they should primarily be directed towards the municipalities whose share in firewood consumption is the largest, such as: Municipalities of Centar, Gazi Baba, Saraj, Kisela Voda, Gjorche Petrov, Butel, but also the Municipalities of the City of Skopje where firewood is almost the only fuel used to heat homes (Shuto Orizari, Saraj) and all other municipalities in Skopje Region that are not part of the city.

[11] http://www.erc.org.mk/odluki/2017.07.28_Soopstenie%20za%20regulirani%20ceni%20i%20tarifi%20na%20toplinska%20energija%20za%202017%20godina.pdf

[12] Crowdfunding is a is the practice of funding a project or action by raising monetary contributions from large number of people. Crowdfunding is a form of crowdsourcing and of alternative finance.

For households heated on firewood or coal, and also included in the target group with low monthly income, it is necessary to allocate funds and assist in changing of the heating technology or house insulation.

Measures towards households with children under 18 should be framed towards explaining the health implications for children. Namely, care for children and their health is the highest priority for any parent. Research[13] confirms that families with children, who are directly acquainted with the air pollution conditions and are informed about its harmful effects on their children's health and physical and psychological development, change their behaviour. Thus, this target group would much more easily decide to change their most air-polluting method of heating, if they were presented the air pollution indicators and how much wood as fuel contributes thereto, then data regarding the air pollution impact and development of lung disease in children, development of chronic diseases (asthma), growth in the number of malignant diseases of airways and lungs, data on children suffering from such diseases within the territory of Skopje, rather than approach them with financial incentives for change.

In order to implement the three measures a plan has been prepared covering 14 activities, grouped in the following categories:

- Educating the citizens and changing the habits related to household heating (for example offering them a way to calculate what is the cheapest and environment friendly manner of heating, using educational videos concerning the harmfulness of pollution in closed premises and personal exposure, how to protect ourselves etc.)
- Legal changes and preparing by-laws which will provide for the implementation of some of the measures requiring regulations
- Encouraging and developing partnership with the private sector.
- Financial incentives targeting groups which cannot be covered with other activities or exemptions (e.g. tax exemptions) for expedited implementation of some measures
- Recommendation for preparing a Source Apportionment Study, a methodology and a system for predicting and timely designing of measures

And of course, establishing a monitoring system (in real time) of the results from the implementation of the activities, which in timely manner would point out to the necessary changes or amendments in the Roadmap.

Some of the proposed activities include introduction of new types of activities which have not been implemented so far in our country. For example, cooperation with the private sector – in this group of activities is recommended to enable (including educating private companies) and creation of partnerships which will aim at helping the companies to create offers/packages/ campaigns which will stimulate increased consumption of environmentally friendly devices and heating materials. The measures for incentivizing market mechanisms are extremely important in order to reduce the pressure on the national budget for subsidizing, because they give positive results when the decisions made by households do not depend directly on the monthly income but on the low level of awareness of the citizens as it is the case in Skopje. The experience in other countries in the neighborhood show that it is the private sector that succeeds in initiating positive changes and achieve significant results in the areas subject of analysis in this report, contrary to

[13] Omar, I Asensio, and Magali A. Delmas, Nonprice incentives and energy conservation, Proceedings of the National Academy of Science of USA, Vol. 112, 6.2. 2015;
The World Bank and Institute for Health Metrics and Evaluation University of Washington, Seattle, The Cost of Air Pollution – Strengthening the Economic Case for Action, 2016;
The World Bank Group, FYRMacedonia green growth country assessment, March 2014

long-lasting and independent attempts of institutions to do achieve significant step forward through campaigns.

In this group of activities, an **assessment of the interest and potential for introducing alternative methods of funding the** air pollution reduction activities.

Concerning the mechanisms for financial incentives, it is proposed before making the decision on the subsidies to analyze the newest global trends and models of funding provided by public institutions which have greater social impact or are better known as social impact investments.

Here above all we refer to the possibilities for: 1) concluding the so called social impact bond, and 2) establishing a fund (there are various models of social impact funds), and 3) designing programs for subsidizing (according to pay per performance models), or in cooperation with the private sector and individual investors: 4) appropriate forms of investing by the private sector (various models are known of impact investment as the most recent and modern forms of social corporate management), 5) Crowdfunding and other models.

List of suggested activities (this is just to start with, the list should be developed and evolving over time, based on evidence collected from the field, and the ongoing activities by other stakeholders):

3.1. Changing the Heating Practices by Knowledge Sharing

3.1.1. A Good Heating Choice Requires Knowledge

Activity 1:

Single #SkopjeIsHeating web portal with tools and methods for different target groups, including: - **Visual monitoring of the fulfilment of "Skopje is Breathing" objectives** - **Learning from the best (Gamification[14] of the campaign on social media)**	
Target group	All citizens living in the Skopje Valley or work in Skopje and have access to the Internet (different tools will be aimed at different target groups) Target: 500,000 persons
Goal	Changing citizens' behaviour/habits in relation to heating and habits causing pollution
Which measure it refers to	All measures
How it should be implemented	- **#SkopjeIsHeating** - developing and regularly maintaining a website, which will serve as a single portal for information, advice and recommendations related to air pollution in Skopje Valley - **"For Skopje to breathe, it further needs..."** (#SkopjeNow) – developing a visual dashboard for monitoring the implementation of the "Skopje is Breathing" scenario

[14] Gamification is one of the latest trends in learning, but also a strategy for achieving certain targets by using game elements - competition, awarding, ranking lists, etc. In recent years, it has been used by government institutions in the world to: 1) collect information from citizens and 2) more easily and rapidly implement new policies or actions. General definition of the term: https://en.wikipedia.org/wiki/Gamification

	- **"From the forefront of Skopje is breathing"** - developing a game to stimulate citizens through social (neighbours', relatives') pressure/influence (including a module where citizens could develop scenarios, i.e. propose measures and on such basis, get predictions of the effects). For example, if 500 stoves were bought, by how much the pollution would be reduced, what % of the budget of municipalities or companies it would present. (How much is the value of 500 stoves as percent of the budget of Alkaloid or Tikvesh...something that would encourage thinking, educating and gaining grounds to come up with measures to be proposed to certain stakeholders...) - **"I want to know, too" (Custom made for you)** - developing a tool that will be uploaded on the website and would introduce the household to every type of heating, how much it is polluting or would pollute the air, as well as calculate the investment and monthly cost of converting to another type of heating - **"The path of $PM_{2.5}$ particles"** - developing a video animation about the harmfulness of $PM_{2.5}$ particles - Integrating #SkopjeIsHeating web portal with the official MEPP's website on air, My Air application, and other existing pages on this topic - - Primary and secondary schools' contests on the topic - *The list will be regularly updated with ideas from partners and citizens*
Responsible entity	- Ministry of Environment and Physical Planning - City of Skopje and all 17 municipalities in Skopje Region - Ministry of Education and Science - Ministry of Information Society - Civil society organizations for environment protection
Time-frame	- Continuously until 2025, with most intensive activities in the first year until the beginning of other activities - Throughout the year, and most intensively in the May-June period, when households usually buy firewood for the following year, and in August and September (before the start of the heating season)
Prioritization	The implementation of these activities should start immediately
Estimated budget	Ideally, the budget for this activity would amount to not less than 150,000 for the period from October 2017 until December 2019 (for the development of quality tools and 2-year coverage on social media) The intensity of the promotion activities will depend on the budget available
Funding	- Ministry of Environment and Physical Planning, - Funds from the State Budget of the Republic of Macedonia allocated to measures for reducing unemployment and creating green jobs, - City of Skopje, - Municipalities, - Alternative funding through civil society, donors and private sector
Potential partners	- UNDP - Technical colleges - Private companies and tech start-ups - Advertising agencies - NGOs
Risks	Real time data collection from the private sector
Effects	- Creating a moral sense of responsibility for air pollution in Skopje - Changing the heating methods in the households - Active citizens' participation in the design of measures for pollution reduction - Creating development opportunities and opening new jobs - Strengthening the cooperation between the public and civil sector

Activity 2:

I can contribute for Skopje to breathe	
Target group	Households with senior members who use firewood, coal, oil, and do not use the internet or have poor digital literacy Target: 20,000 persons
Goal	Raise awareness among citizens in terms of their personal contribution to air pollution in Skopje and change the method of heating
Which measure it refers to	Change the heating practices, improve insulation of homes
How it should be implemented	- Visits to senior people's homes - Group meetings/events including direct contact with citizens through associations of pensioners, women's organizations and other groups, in the presence of medical staff - Organizing workshops and training - Organizing talk-shows with experts on TV and radio - Announcing the results of air pollution from different fuels on both test air purification billboards to be installed in October 2017 - Distribute information leaflets to persons with respiratory problems in hospitals, clinics and pharmacies - Organizing workshops and debates in primary and secondary schools in order to introduce the schoolchildren to the impact of heating on air pollution
Responsible entity	- Ministry of Environment and Physical Planning - Ministry of Health - Ministry of Education and Science - City of Skopje - All municipalities in Skopje Region - Civil society organizations for environment protection
Time-frame	November 2017 - October 2018
Prioritization	These activities should be implemented immediately
Estimated budget	No more than 30,000 euros
Funding	- Funds from the State Budget of the Republic of Macedonia allocated to measures for reducing unemployment and creating green jobs (Ministry of Environment and Physical Planning and Ministry of Health) - Additional funding from donors, including the civil society in the implementation
Potential partners	- Philosophy and Mechanical Engineering Faculties - UNDP - Non-governmental organizations (associations of pensioners, women's organizations, informal groups, etc.) - Hospitals and pharmacies in Skopje
Risks	- - Implementation control.
Effects	Citizens will change their opinion and heating methods in order to prevent air pollution and will contribute to the realization of targets set for 2020 and 2025.

3.1.2. Influencing the Behaviour of Citizens through Personal Experiences

Activity 3:

The method of heating and air quality in my home	
Target group	Households using firewood for heating/cooking
Goal	Raise public awareness of the importance of the method of heating and possible adverse health effects
Which measure it refers to	Changing the heating method (and indirectly to the measure for increasing the number of central heating users and for improving insulation of homes)
How it should be implemented	Determine the quality of air (ambient conditions; PM 1, 2.5, 4, 10, CO; CO_2; NO_2, benzene and formaldehyde) in homes with different methods of heating. At least five groups should be defined, including: - wood stoves (old ones), - wood stoves (modern ones), - systems with pellets, - electric/central heating, - other ways (sawdust, used oil, wood waste, plastic...) For each of these categories, an adequate number of homes with: 1) good insulation and 2) insufficient or no insulation will be selected. This activity will be implemented through a **participatory monitoring** (equipment will be placed in homes, while participants will be trained to read the results and to keep a diary of activities) so that each participant will be able to share their experience. The program will be implemented within one heating season, for no longer than 45 to 60 days. Results will be summarized and presented (in videos and talk show appearances on television) by participants as their real experiences.
Responsible entity	- City of Skopje - Ministry of Environment and Physical Planning - NGOs
Time-frame	November 2017 - June 2018 (heating season) with a possibility of expanding the scope and time-frame
Prioritization	These activities should be implemented immediately
Estimated budget	25,000 euros
Funding	- Alternative funding/donors
Potential partners	- Technical faculties, accredited laboratories - UNDP - NGOs
Risks	Indifference of citizens to participate, destroying the equipment
Effects	Citizens will understand the risks of using wood for heating/cooking and the benefits of converting to another heating method, which less pollutes the air in the home and will contribute to the realization of 2020 and 2025 targets

Activity 4:

How to protect ourselves from pollution (which procedures the population can use to reduce its exposure to high concentrations of harmful substances in the air)	
Target group	All citizens
Goal	Minimize the level of personal exposure, thus eliminating the health effects associated with high exposure to ambient dust
Which measure it refers to	Actions to reduce personal exposure
How it should be implemented	Phase 1: Test specific devices in real terms or conditions contributing to reduced exposure such as various air purification devices (air-conditioners performing filtration, HEPA filters ...), level of exposure in various types of vehicles (car, bus...) etc.; define the efficiency of individual systems and make recommendations for optimal use; draft a leaflet with the results. Each system requires at least 5 tests in real terms (or sufficient measurements for minimum statistical analysis). Phase 2: Test realistic scenarios of behaviours at high pollution (use of devices indoors, use of different means of transport) by using participatory monitoring, e.g. by defining 3 scenarios of movement and use of systems in one's home: - travel by bus to and from work for an average of 1 hour, outdoors, - travel by car to and from work for an average of 1 hour, outdoors, - walk to and from work for an average of 2 hours, outdoors,.... The same conditions at home and at work shall be defined for all scenarios in order to avoid side effects and define the average levels of exposure. At least 5 participants in each scenario. The results obtained will be systematized, including participants' actual experiences, and in addition, a statistical analysis and a leaflet with scientifically sound facts and figures shall be developed in support of information campaigns.
Responsible entity	- City of Skopje and municipalities in Skopje Region - Ministry of Environment and Physical Planning
Time-frame	November 2017 - June 2018 (heating season) with a possibility of expanding the scope and time-frame
Prioritization	It is recommended that this activity be implemented immediately
Estimated budget	- Technical faculties, accredited laboratories - UNDP - NGOs
Funding	20,000 to 25,000 euros
Potential partners	Alternative funding/donors
Risks	There are no risks
Effects	Reducing the level of personal exposure

Activity 5:

Let us protect our loved ones/most sensitive ones from pollution (monitoring and control systems in kindergartens, schools and hospitals)	
Target group	Children and staff in kindergartens, schools, hospitals
Goal	Monitor pollution levels in and around sensitive facilities and activate protection measures if needed, better information, increased public awareness
Which measure it refers to	Actions to reduce exposure
How it should be implemented	Develop a monitoring network around sensitive buildings, including small (and cheaper) monitoring systems that will provide information to authorities and feed a database for future analysis. These systems must be simple and have low-cost maintenance. Buildings may be equipped with at least one portable device for determining the quality of air and ambient conditions on the premises (temperature, relative humidity, pressure and CO_2) and dust (fractions PM 2.5 and 10), so that screening can be performed in a period of high external concentrations. Upon detection of high pollution, measures shall be taken such as ventilation (natural or forced), if it is cleaner outside, or air cleaners shall be turned on, if it is more polluted outside. This would be tested on one or two pilot facilities (one kindergarten and one school) and if proven successful, it would be expanded if adequate results were obtained. (These systems shall be maintained and implemented with great care; they will require adequate training and implementation control).
Responsible entity	- City of Skopje (secondary schools) and municipalities in Skopje Region, - Ministry of Labour and Social Policy, - Ministry of Health, - Ministry of Education and Science
Time-frame	Establishment of the system at the beginning of 2018 and regular monitoring afterwards
Prioritization	Immediately
Estimated budget	Pilot project of at least 1year, direct budget for monitoring equipment (indoors and outdoors) - 15,000 to 20,000 euros, air purification equipment for a facility with 50 rooms - 10,000 euros. Training, implementation control and report - 2,000 euros (or a total of 47,000 to 52,000 euros)
Funding	Alternative funding/donors
Risks	There are no risks
Effects	Reducing the level of personal exposure

3.2. Legislative Changes

Activity 6:

Development of a Regulation and introduction of an environmental tax (polluter pays)	
Target group	All households
Goal	Reduce the number of households using polluting heating materials (mostly firewood and coal) or other solid fuel through an increase in the price of firewood and coal and allocation of these funds for subsidizing more efficient firewood or pellet stoves.
Which measure it refers to	Changing the heating practices
How it should be implemented	- Establish a working group consisting of all competent institutions - Define the procedures for collecting the environmental tax, where the funds will be collected, the management, the manner of allocation and spending, transparency and decision-making etc. (an excellent example of this process in Montenegro at www.budiodgovoran.me) - Develop Regulations for the introduction of the environmental tax
Responsible entity	- Ministry of Finance - Ministry of Environment and Physical Planning - Ministry of Economy - Ministry of Labour and Social Policy - City of Skopje and municipalities in Skopje Region
Time-frame	Development and adoption of Regulations shall be completed by June 2018, tax shall start being collected as of 1 January 2019
Prioritization	Immediately
Estimated budget needed	The time of the employees participating in the development of the documents
Funding	This activity does not require additional funds other than the time of employees participating in the activity
Risks	Changes in legislation, non-acceptance of the proposal by competent institutions
Effects	Reduction of air pollution in the City of Skopje

Activity 7:

Development of a package of Regulations to remove part of the legal obstacles to taking action regarding pollution reduction in Skopje Valley	
Target group	All households
Goal	Remove most of the legal barriers to reducing pollution in Skopje Valley
Which measure it refers to	- Construction of efficient buildings - Changing the method of heating (efficient technologies) and - Increased acceptance of central heating.

How it should be implemented	- Establish working groups from relevant institutions for the development of Regulations - Transpose the Energy Efficiency Directive into the Macedonian legislation - Develop **Rulebook for labelling of solid fuel heating stoves** - Develop **Rulebook on solid fuels** - Amend the **Rulebook for defining the content for obtaining Construction Permit** (this amendment will oblige investors in the parts of town where there is central heating to connect the building to the central heating system) - Change the **Rulebook of the City of Skopje defining the heating means, and approximated with the Housing Law** (this Regulation shall prescribe the manners of using and obtaining heating energy permitted in different parts of the city, in various communities) - Develop **Rulebook on indoors ambient air**
Responsible entity	- Ministry of Economy - Ministry of Environment and Physical Planning - Ministry of Finance - Ministry of Labour and Social Policy - City of Skopje and municipalities in Skopje Region - Energy Regulatory Commission
Time-frame	2018-2019
Prioritization	These activities should begin immediately, since they are prerequisites for the implementation of most of the other activities envisaged
Assessed budget	The time of the employees participating in the development of the documents
Funding	- The development of Regulations will include employees of competent institutions - UNDP, USAID, GIZ, other donors and international organizations
Risks	Changes in legislation, non-acceptance of the proposal by competent institutions
Effects	Reduction of air pollution in the City of Skopje

3.3. Partnerships with Private Companies

The set of recommendations below refers to creating enabling environment partnerships aiming to help companies make offers/packages/campaigns that will stimulate increased sales of environmentally friendly appliances and heating materials. Measures for incentivizing market mechanisms are especially important to reduce the pressure on the State Budget for subsidies, because they yield positive results when households' decisions do not depend directly on monthly incomes but are related to the low level of awareness among citizens, as is the case in Skopje. The experience collected so far in other countries show that it is the private sector which manages to initiate positive changes and to achieve significant success in the areas of concern, contrary to the long lasting independent attempts of the institutions to create progress via campaigns.

Within this group of activities, **interest and potential will be assessed to create alternative ways of financing the activities for air pollution reduction**.

Activity 8:

Free (re)connection to the central heating system	
Target group	Households disconnected from the central heating system or which live in a new building that has central heating, but they are not connected to it
Goal	Increase the number of households that use the central heating system
Which measure it refers to	Increased central heating acceptance
How it should be implemented	- Train BEG teams by psychologists and sociologists regarding the approach to this activity - Select homes to be visited - focus on households with children and homes with insufficient insulation - Prepare materials including financial calculations for all possible scenarios (or use the tool - financial calculator, which is recommended to be developed in the first recommendation) - Door-to-door discussions directly with citizens - Informing the citizens via the mobile app regarding the benefits of fuel change
Responsible entity	BEG
Time-frame	Continuously until 2020 - with aggressive campaigns before the heating season's start
Prioritization	Immediately (BEG has started the implementation independently)
Assessed Budget	The budget of BEG (for this activity BEG has established a unit and has budget allocated for a campaign). The total assessed budget for implementing the strategy for expansion of the central heating system (which besides covering disconnected households also foresees connecting all collective and business buildings in zones where there is existing network, and in the long run extension to new parts of the city) of BEG amounts to about 11 million Euros, or 57 million Euros investments in portable and secondary lines and 40 million Euros for connecting parts of Skopje without a network (investments in infrastructure). The budget needed for constructing the new cogeneration power plants amounts to 200 million Euros.
Funding	- BEG or the households, if they have removed their radiators
Risks	All risks are on the side of BEG

Activity 9:

Encouraging increased interest in buildings' energy audits among citizens	
Target group	Households with insufficient or no insulation of their homes
Goal	Increase citizens' interest in improving the insulation of their buildings
Which measure it refers to	- Changing the way of heating - Improving the insulation of homes
How it should be implemented	- Examinations for energy auditors shall take place on actual buildings in the category of households to be subsidized - Inform citizens about the importance of good insulation of buildings by using a financial calculator (to be developed under Activity 1), to show savings from improved insulation and time of return on investment

	- Create partnerships with certified energy auditors, and authorized firms and construction companies, which will offer energy audit as a free service *(This approach was suggested following the example of certain marketing strategies that have operated successfully for many years in our country - like those of Zepter, Kirby etc.)* - *The next step is presented in the following activity, where private companies appear as implementing parties* - *Identifying interested companies to be included in the implementation of the measure*
Responsible entity	- Energy Agency - Ministry of Economy - Companies employing certified energy auditors - Construction companies - City of Skopje and its municipalities - The other municipalities in Skopje Region - City of Skopje's Innovation Centre - Skopje Lab (activity design)
Time-frame	Continuously until 2025, with greater intensity in the period to 2020
Prioritization	This activity shall start during this 2017/2018 heating season, when households can measure their heating energy consumption costs and energy audits shall be made, so that in the summer months, during the construction season, the first homes shall be renovated and measure the results and savings in the following heating season already.
If it applies to citizens	Energy audits make it possible to assess the measures required for each individual building in terms of improving its insulation or selecting the appropriate method of heating that will pollute less. Not always will what the neighbour/friend has done be good for us, too.
Estimated budget	Not more than 10,000 Euros for initiating the process and then every company shall factor in this cost in the offers for refurbishing the buildings
Funding	This activity does not require a direct budget except staff time for detailed activity elaboration and presentation of this proposal to the relevant companies
Risks	Insufficient interest among companies, slow attraction of businesses and citizens
Effects	Increased number of adequately insulated homes; popularization of Energy Auditor profession; creating green jobs

Activity 10:

Increasing the intensity of existing facades' renovation and construction of thermally insulated facades in accordance with the Energy Efficiency Regulation	
Target group	Households with energy inefficient facades on their houses, households with energy inefficient house roofs
Goal	Reduce the amount of energy required for residential heating
Which measure it refers to	Improving the insulation of homes
How it should be implemented	- (Continue) preparing 3-year municipal energy efficiency strategies and annual plans, which serve as a framework for support of municipalities in this area, and which will also foresee additional and new ways of cooperation with the private sector - Create partnerships with interested private construction companies - Create offer packages for the renovation of households' buildings accepting free energy audits (and other interested households) - Work with banks to design financial packages "custom made for the citizens" - Opportunity for all companies joining the initiative to get their own space on #SkopjeIsHeating portal, where they will promote their offers

	- Implement the Resilient Skopje recommendations regarding urban heat islands (a recommendation for the roof colour to be white); green roofs etc.
Responsible entity	- Private companies (interested in cooperation) - construction companies and certified energy auditors - City of Skopje and municipalities in Skopje Region - Ministry of Economy - Chamber of Civil Engineers and Architects - City of Skopje's Innovation Centre - Skopje Lab (activity design)
Time-frame	Continuously by 2025
Prioritization	It is recommended to start this activity in early 2018 and to focus on older buildings
If it applies to citizens	By implementing the Rulebook on Energy Performance of Buildings and the Rulebook on Energy Audits every new building should have an energy passport (obtained after the audit is done), every apartment sold should have energy passport, and at every bigger refurbishment of the building energy audit should be done etc. By implementing this measure, the process will be simplified, and the citizens will be given an opportunity to reduce these costs.
Estimated budget	About 325 million Euros in total for all 19,890 households or 280 million Euros funded by the households themselves, 45 million obtained with subsidies from the Ministry of Economy
Funding	- Households, - Energy Agency/Ministry of Economy - Construction companies -
Risks	It is recommended this activity to be developed gradually and carefully (new in Macedonia, but in the world, it is a regular marketing strategy for companies). It is an approach of involving the private sector in complex activities which aim at generating positive social changes
Effects	Reducing air pollution in Skopje through the construction of energy efficient buildings

Activity 11:

Increasing the interest in replacing the non-environmentally-friendly methods of heating (inefficient wood stoves) with efficient wood stoves, pellet stoves and heat pumps	
Target group	Households that can afford to cover their investment costs and regular energy supply
Goal	Increase interest in changing the method of heating by market mechanisms, and reduce the pressure on institutions to subsidize
Which measure it refers to	Changing the heating method
How it should be implemented	- Establish partnerships with all major manufacturers or importers of efficient and environmentally friendly heating appliances - Create packages with favourable stove purchase offers (including marketing strategies, ways of presentation, etc.) - Work with banks to design financial offers "custom made for the citizens" - Targeted promotions on social media - Opportunity for all companies involved in the initiative to get their own space on #SkopjeIsHeating portal, where they will promote their offers
Responsible entity	- Private companies (interested in cooperation) - City of Skopje and municipalities in Skopje Region - Ministry of Environment - City of Skopje's Innovation Centre - Skopje Lab (activity design)
Time-frame	- Design of the measure by the end of this year; implementing it with a continuous intensity by 2025.

Prioritization	It is recommended that this activity start immediately. *Preparatory activities have already been initiated.*
Estimated budget	- Не повеќе од 20,000 евра за отпочнување за дизајнирање на механизмите и мобилизирање и ангажирање на приватните компании The estimated cost is about 28 million Euros which need to be covered by the households which will change the heating technology in their homes. Having in mind that these investments will be returned in a specific period of time, and after that point every household will generate savings, this should be seen only as a one-off cost of the households, and activities should be focused on attracting and educating the households and identifying the most suitable payment methods (delayed payment, low interest loans etc.).
Funding	- Households - Private companies (in addition to the investments required to promote the packages, it is expected that private companies involved in the initiative will reinvest a small part of their increased revenues in Activity 1 or Activity 14)
Risks	Low interest of companies to engage in the initiative
Effects	Reducing the subsidizing cost; increased interest in changing the heating methods

The following activity (12) is directly proposed by the private sector representatives. It is recommended to review carefully this activity and to be further improved so that the business community and the Ministry of Finance could participate. If the initial analysis shows that the implementation is time consuming and strenuous it should to be modified or deleted from the Roadmap.

Activity 12:

Temporary introduction of "social good tax" from 2018 to 2025 (we all pollute, we all pay to reduce it) – target fund of 400 million Euro (50 million Euro per year)	
Target group	All employees located in Skopje region (in the pilot phase of the first two years, then at the territory of the whole country, in order to address the pollution in other places as well)
Goal	Reduce the financial burden for the implementation of the activities leading to less pollution
Which measure it refers to	All measures
Actions	- Establishment of a working group composed of representatives from relevant ministries, private companies and employees - Design of the taxation model and mechanism, as well as the process for funds management (transparency, equal access to financing, etc) - Depending of the type of the mechanism, draft and adopt changes in legislation
Responsible entity	- Ministry of Finance - Chambers of commerce - Private companies
Time-frame	2018-2025
Prioritization	It is recommended to design the taxation model soonest possible to enable its implementation as of 2018. This will provide sustainable financing of the roadmap implementation
If it applies to citizens	Employees at the territory of Skopje Region

Funding	The proposal might not be accepted by relevant authorities, resistance of the private companies, resistance of the employees
Effects	Sustainable financing of the roadmap without additional financial obligations for each family

3.4. Subsidy Measures

It is proposed that newest global trends and models of funding are reviewed before making the decision which subsidy measures to implement. This should include public institutions funding projects of high social impact, or better known as social impact investments models.

Here, above all, we refer to the following: 1) issuing social impact bonds, and 2) establishing a fund (various models of social impact funds), and 3) appropriate models of direct subsidizing (according to pay per performance models), or in cooperation with the private sector and individual investors: 4) appropriate forms of investing from the private sector (different models of impact investment are available as newest and most progressive forms of social corporate management), 5) Models for crowdfunding etc.

Activity 13:

Subsidizing target groups that cannot be covered by another activity or (tax) incentives for accelerated implementation of specific measures: - Extension and further improvement of measures for subsidizing the purchase of **pellet stoves and pellet reserves**, - Introduction of subsidies for the **purchase of more efficient firewood stoves**, - Introduction of subsidies for **part of the value of investment in a heat pump** and internal distribution installation (for an air/air or air/water heat pump), - Introduction of subsidies for **chimney cleaning** before the start of the heating season, - Extension and further improvement of measures to **subsidize conversion of buildings into energy efficient facilities**.	
Target group	Households with low monthly incomes that cannot afford to fully bear the brunt of the investment or monthly energy supply costs: - Households using firewood and coal - Households with low monthly incomes - Households with senior members (pensioners living alone) - Single-parent households with children younger than 18 - Households with under-insulated walls and roofs
Goal	Reduce the number of households using firewood
Which measure it refers to	- Changing the way of heating - Improving energy efficiency of homes
Actions	- Draft Guidelines on subsidy grants and award criteria (where households of the target groups listed above shall be prioritized) based on citizens' needs - Allocate subsidy funds - Inform and familiarize citizens with the subsidizing method

	- Sharing information on the web site on the benefits of changing the method of heating and chimney cleaning before the heating season for all households that have been refused to get subsidies or have been late submitting the documents for the public call for subsidies
Responsible entity	- Ministry of Environment and Physical Planning - Ministry of Labour and Social Policy - - Ministry of Finance - Ministry of Economy - City of Skopje and municipalities in Skopje Region
Partners	UNDP City of Skopje's Innovation Centre - Skopje Lab (measure design coordination) Companies whose main business is chimneys - production, operation, repairs and maintenance Private companies manufacturing or importing efficient wood stoves, pellet stoves or heat pumps Private construction companies and energy auditors
Time-frame	Continuously by 2025, with an increased intensity within the period by 2020, and tendency to reduce the number of subsidies by 2025
Prioritization	It is recommended this activity to be initiated immediately, by designing each of the subsidy measures and starting their implementation during the summer of 2018.
If it applies to citizens	If a 55% efficiency firewood stove is replaced by an 80% efficiency firewood stove through an investment of 35,000 MKD, and covered by subsidies of 17,500 MKD, it will take 2.8 years to return the investment. Without subsidies, the period of return on investment is 5.6 years. If a 55% efficiency firewood stove is replaced by a heat pump with a coefficient of performance (COP) of 3.2 through an investment of 60,000 MKD, and covered by subsidies of 30,000 MKD, it will take 7 years to return the investment, while without subsidies, this period will be 14 years.
Estimated budget	- About 200,000 Euros for designing and piloting the 5 subsidy measures - About 5 million Euros for subsidizing 30% of the households in the Skopje Valley which use inefficient /environmentally harmful methods (firewood, coal, fuel oil).
Funding	- Households - City of Skopje and its municipalities, Skopje Region municipalities, by subsidizing 50% of the investment (up to MKD 30,000) - Funds from the State Budget of the Republic of Macedonia - The cost of companies performing the service of chimney cleaning for households that have been refused subsidies or were late submitting the documents for the public call regarding subsidies for the purchase of pellet stoves or more efficient firewood stoves, shall be covered by municipalities
Risks	Not directing the funds to respective target groups, double subsidies, control households if they indeed changed the method of heating, abuse of the system by both companies and households. Strengthened control shall be required.
Effects	Reducing air pollution in Skopje

3.5. Establishment of a System for Monitoring the Measures' Implementation

Activity 14:

System for monitoring the implementation of measures	
Target group	City of Skopje, line ministries, donors, the public
Goal	Check the efficiency of measures applied, define a trend/direction of change
Which measure it refers to	All
Actions	Establish an indicative monitoring program in the city of Skopje, in order to determine the levels of polluting components associated with emissions from firewood and coal, which shall include: Identification of concentrations of $PM_{2.5}$ and PM_{10} and Ni, As, Cd, Ca, K, Pb, S in ambient air, in at least 2 locations, for 14 days continuously at each location, in each season (winter, spring, summer and autumn). Locations shall be selected as representative of background pollution levels.
Responsible entity	- City of Skopje, MOEPP
Time-frame	Early winter 2017, and continuously until 2025
Prioritization	It is necessary that this activity is initiated immediately, and it should be implemented in parallel with the activities, so that progress can be regularly measured
Potential partners	- Technical faculties, accredited laboratories - UNDP
Estimated budget	- For 1 year (4 sessions of 14 days per year) around 25,000 euros or 200,000 Euros for all 8 years - Additionally, for improving the monitoring system and development of a source appointment study according to EU recommendations and development and preparation of computer modelling and projecting (IoT and big-data) about 300,000 Euros are required.
Funding	- Ministry of Environment and Physical Planning - Alternative funding/donors
Risks	There are no risks
Effects	Better management of project activities, assessment of trends, informing the public, predicting the expected pollution and timely implementation of prevention and mitigation measures to reduce the exposure of citizens and reducing the pollution

3.6. The Recommendations through Examples

According to WHO (2015), pollution of homes with PM2.5 because of heating/cooking on firewood is associated with an estimated 3.5 million deaths annually. In addition, the use of firewood for heating contributes to approximately 12% of ambient PM2.5 pollution globally (with a much higher share in some regions), which is directly associated with about 370,000 premature deaths annually (Chafe et al., 2014).

The impact of firewood stoves on local pollution can best be seen through examples. The following examples present how much one family is polluting compared to a car. Also, investments for replacement of firewood stoves with another technology, and all financial benefits are presented.

Example 1. According to the survey data, a family in Skopje Valley spends 8.38m^3 of firewood during one heating season. Such a family lives in the Municipality of Gjorche Petrov. The firewood they use has a humidity of about 20% (acceptable humidity). Thus, the family emits about 41 kg of $PM_{2.5}$ i.e. 42.5kg of PM_{10} in the atmosphere during the heating season. To see how much this household pollutes the air, a comparison with emissions from a vehicle was made. One member of this family living in Gjorche Petrov goes to work to Aerodrom and passes 20 km both ways per day. The family has a pretty old diesel car manufactured in 2000 and running on EURO 3 standard fuel emitting 0.05g/km of PM (cars running on gasoline make no PM emissions). During the heating season, this family passes 3,600km by its car, and thus emits only 0.18kg of PM during the entire heating season. So, it can be concluded that a family using firewood emits as much PM in the atmosphere as 230 cars running every day and passing 20 km a day each. If this family decided to switch to a pellet stove to heat the same area, it would emit around 1.6kg of PM_{10}, which equals the same amount emitted by 10 cars passing 20km a day. If the family decided to replace its vehicle with a new one running on EURO 5 or EURO 6 standard (0.005g/km) then, during the heating season, it would emit 0.018kg of PM.

Figure 7. PM emissions during one heating season from firewood stoves, pellet stoves and diesel cars running on EURO 3 and EURO 5/6 standard

Example 2. Adults live on the first floor of a family house which has an area of 50m^2, where they spend 15 hours a day during the heating season and constantly maintain a temperature of 23^{0}C in the home. They use a firewood stove with an efficiency of 50% and over the average heating season, they need 12.8m^3 of firewood. The price at which they purchase their firewood is 2,700 MKD and for one heating season, they need 34,600 MKD. Having heard on the news about how much they pollute the air, they start thinking to change their old and completely worn out firewood stove that served its purpose, but which has emotional value for them. They go to an appliance shop, where they encounter a good salesman (who has in the meantime installed the app for financial savings calculation) and start inquiring him what to choose to replace their old stove.

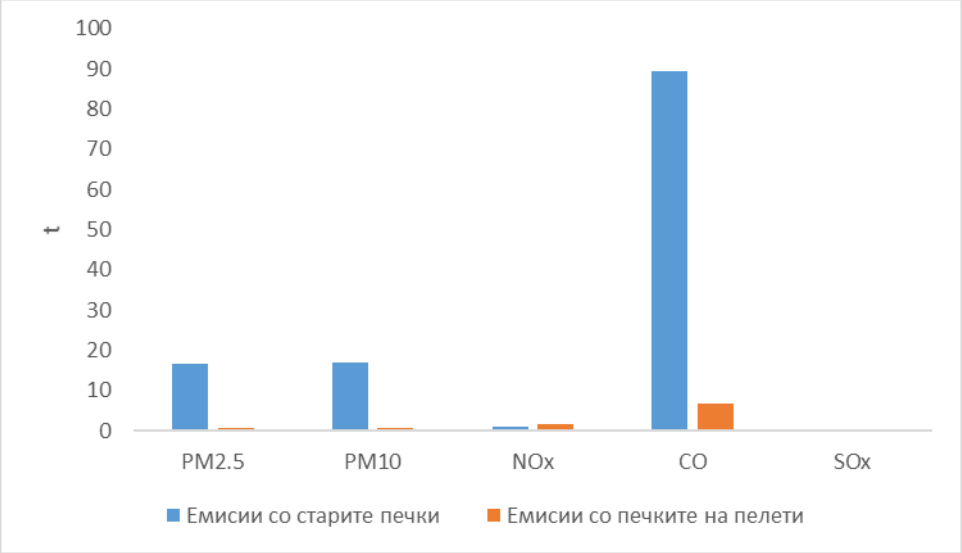
1. The first option is a more efficient firewood stove with an efficiency of 80% whose price is 25,000 MKD. If they replace their old stove with this one, the investment will be returned within less than 2 years.
2. The next option presented to them is an air-air heat pump whose price is 50,000 MKD, with a COP of 3.5. If they replace their stove with this pump, the investment will be returned within less than 5 years, not using any subsidies.

Since they were well paid throughout their lives and have secured solid pensions for themselves, they decide to buy the heat pump because they know that in this way they will reduce their pollution to zero and somehow pay their debt to society for having polluted the air throughout their lives by using their stove.

Example 3. A low-income household with children under 18 lives in an uninsulated building. This family lives in a part of town where the pollution is enormous. Due to the work commitments of the parents who go to work in the first shift, and of the children who also go to school in the morning shift, they spend an average of 9 hours at home every day, i.e. they maintain a temperature of 22^{0}C for this number of hours. They purchase their firewood at a price of 2,200 MKD per m^3 and spend 21,900 MKD annually. From a presentation at school, the children find out about the existence of the "Skopje is Breathing" web-site, visit it and see that there is a call for subsidizing pellet stoves, firewood stoves and heat pumps. Simultaneously, they install the application about the benefits of a particular technology replacement and local pollution reduction on their phones and tell their parents that if they replace their old firewood stove with a new one whose efficiency is 80% and costs 25,000 MKD, they will save more than 8,000 MKD a year and return their investment within three years. Additionally, if they managed to get the subsidies for their investment (50% of the firewood stove price), they would return their investment within 1.5 years.

Example 4. Apartment owners in Aerodrom sell their apartment to a young married couple. At the time when most of Skopje citizens disconnected their flats from the central heating system, the owners of this apartment did the same. The building also had chimneys, so they installed a firewood stove with an efficiency of 65%. The young married couple is informed about the air quality in the Municipality of Aerodrom and wants to help solve the problem as fast as possible. They go to BEG and make a calculation. The calculation is as follows. If they spend an average of 11 hours at home and heat their apartment to 23^{0}C, they will need 10.5m^3 of firewood. If they purchase it at a price of 2,500 MKD, they will need 26,300 MKD a year. If they join the central heating system and are exempt from a new connection fee payment, they would pay 11,000 MKD for the same amount of heat they would receive from firewood. Because the central heating system works more than 11 hours, their bill would amount to about 19,000 MKD. This means that they would spare 7,000 MKD per year and produce 0 greenhouse gases.

Example 5. City of Skopje granted subsidies for procurement of pellet stoves. Based on recommendations given in "Resilient Skopje", City of Skopje in 2016 and 2017 awarded 404 pellet stoves to households which previously used coal or firewood, in accordance with the requirements and conditions prescribed in the public call. In accordance with the calculations in relation to reducing PM10 and PM2,5 emissions, it was determined that the emissions of these polluting substances were reduced by 96% for every household having received the subsidy.



At the end, we believe everyone would ask how this related to the opening paragraph from the document: Will the implementation of this Roadmap contribute to decrease the average annual concentrations of $PM_{2.5}$ and PM_{10} to below maximum levels?

The answer to this question is not straight forward. What can surely be said, is that the highest concentrations of $PM_{2.5}$ and PM_{10} will decrease (both in absolute values and number of days), which will certainly lead to decrease of the annual averages. It is also certain that the air will be healthier, because the firewood burning emitted harmful particles are most dangerous for human health.

There are still going to be days of high pollution, especially in the next few years (with expectation of this year being very similar to the previous one), but with the implementation of the Roadmap, the number of these high pollution episodes should be reduced, both in terms of values and frequency.

Regular monitoring and measurement will show the impact of the Roadmap implementation and will indicate if any changes of course of actions are needed.

If we start reducing the most critical polluter, good results should be expected from the very beginning.

WE STARTED ACTING – HOW ABOUT YOU?