

**STUDY ON THE HEATING  
IN THE CITY OF SKOPJE  
ANALYSIS OF POLICIES AND MEASURES  
STUGRES**



# STUDY ON THE HEATING IN THE CITY OF SKOPJE ANALYSIS OF POLICIES AND MEASURES STUGRES

Financial and  
technical support by:  
(UNDP)

Global Environment Facility  
The UN Development Program

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July, 2017

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# Introduction

## Context

This Study is prepared as a response to the raising concerns about the air pollution in the City of Skopje. There are many reasons for the poor air quality in the capital of minor importance, but the most prevailing one is the heating of the households. The Report from the Campaign for Measuring Heavy Metals and Polycyclic Aromatic Hydrocarbons in Skopje 2015 – 2016, developed under the Twinning Project implemented by the Finish Meteorological Institute and the Ministry of Environment and Physical Planning says that burning biomass is the cause for 90% of the total air pollution with PM<sub>10</sub> particles. According to the Annual Report of the Ministry of Environment and Physical Planning prepared on the basis of data on environment quality in 2015, only PM<sub>10</sub> particles on several occasions have breached the limit values during the winter period. Due to poor thermal insulation, buildings and houses require more energy for heating on one hand, and on the other hand the inefficient stoves and boilers used for heating in the households contribute to increased local pollution. Besides this, the inefficient use of energy is one of the main reasons for the increase in the GHG emissions. It is quite paradoxical, from a sociological point of view, self-harming, and it throws a light to some social weaknesses which can be corrected only with short-term, midterm and long-term policies and measures which will be based on a systematic analysis.

The Study titled "Definition of Technically and Economically Optimal and Environmentally Sustainable Heating Structure and Implementation of Centralized Supply of Sanitary Hot Water in the City of Skopje" developed by the Faculty of Mechanical Engineering - Skopje and MACEF contains an overview of the situation in relation to various air pollutants as well as an overview of current and possible ways of heating the households in Skopje in future, at the same time presenting technical and economic aspects of the possible options.

With the support of the United Nations Development Program, in January 2017, a survey<sup>1</sup> was conducted on the manner of heating the households in the Skopje valley (seventeen municipalities within the Skopje region) which also analyzes the results from a geographical and locational point of view (Figure 1 **Error! Reference source not found.**). So, from this survey we can conclude that most of the respondents, about 47% of them, use solid fuel (fuel wood, coal, pellets, briquettes) in their own combustion system, one third of households use electricity for heating and about 21% are supplied heat from the central heating system. Also, more than half of the buildings have walls without additional thermal insulation.

Although most of the citizens of the City of Skopje during winter constantly and loudly speak about the local pollution and are concerned about it, still the survey results tell as something completely different, and that is that only 1,5% of the households choose their manner of heating according to the level of pollution caused by the heating device. The data received through this survey are numerous, but still, additional processing is needed in order to extract more detailed and more in-depth conclusions.

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<sup>1</sup> More information at <http://www.skopjesezagreva.mk/>

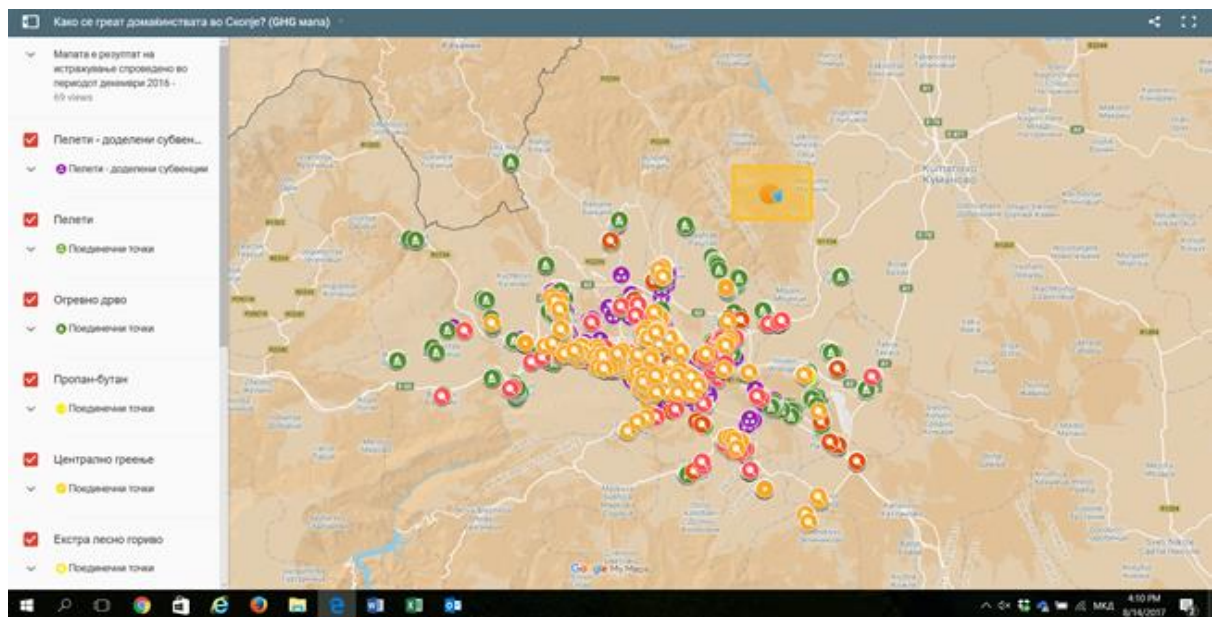


Figure 1. Heating practices in the households in Skopje– interactive map<sup>2</sup>

<sup>2</sup> See [https://www.google.com/maps/d/u/0/embed?mid=1stOPIDjxLu4sH5i5JOJ\\_q03s4o0](https://www.google.com/maps/d/u/0/embed?mid=1stOPIDjxLu4sH5i5JOJ_q03s4o0)

# The Aim of STUGRES

The main aim of this Study on the Heating in the City of Skopje - STUGRES is to determine, with as many details as possible, the impact of various heating measures on the GHG emissions (CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O), but also on the local pollution (PM<sub>2.5</sub>, PM<sub>10</sub>, CO, SO<sub>x</sub>, NO<sub>x</sub>) and air quality. For this purpose, a model is needed, which will reflect reality and will analyze different measures and policies. The model was filled with the results from the Survey on the Heating Practices in the Households in Skopje Valley. The Study investigates the effects of the following measures:

- Improving the insulation in the housing facilities
- Change of fuel and the manner of heating
- Increased acceptance of central heating (the existing or small central heating systems)

The proposed measures should reduce the consumption of energy obtained from GHG high emission energy sources and should ensure their replacement with low-carbon fuels, as well as promote the use of technologies that will have minimum effect on local pollution.

# Methodology and Data Used

The Research Center for Energy and Sustainable Development of the Macedonian Academy of Sciences and Arts (RCESD-MASA) has an established practice always to use what had been previously developed or what was part of another projects. Such was the case with this Study as well. Namely, during the preparation of the Skopje Climate Change Strategy "Resistant Skopje" a MARKAL model for the City of Skopje was developed which was also used to analyze the benefits of implementing the listed measures and policies. Although in this Study the main focus is on the households, still we analyze the situation with the general energy system in the capital.

In order to determine the total need for energy, a division by sectors was made, which are as follows:

- Manufacturing industries and construction;
- Transport;
- Residential;
- Non-specified (commercial and service sector).

Taking into consideration that this Study is prepared as part of the Second Biennial Report on Climate Change, we have harmonized the input data with the data used for modeling the measures and policies in the analysis for mitigating climate change made in the Second Biennial Report. Namely, in the model developed for the City of Skopje during the preparation of the "Resistant Skopje Strategy", we made some changes concerning the price of energy sources, the GDP, population growth etc. The model that was developed for the city of Skopje covers the period 2012-2025. The same time period is covered with this Study as well.

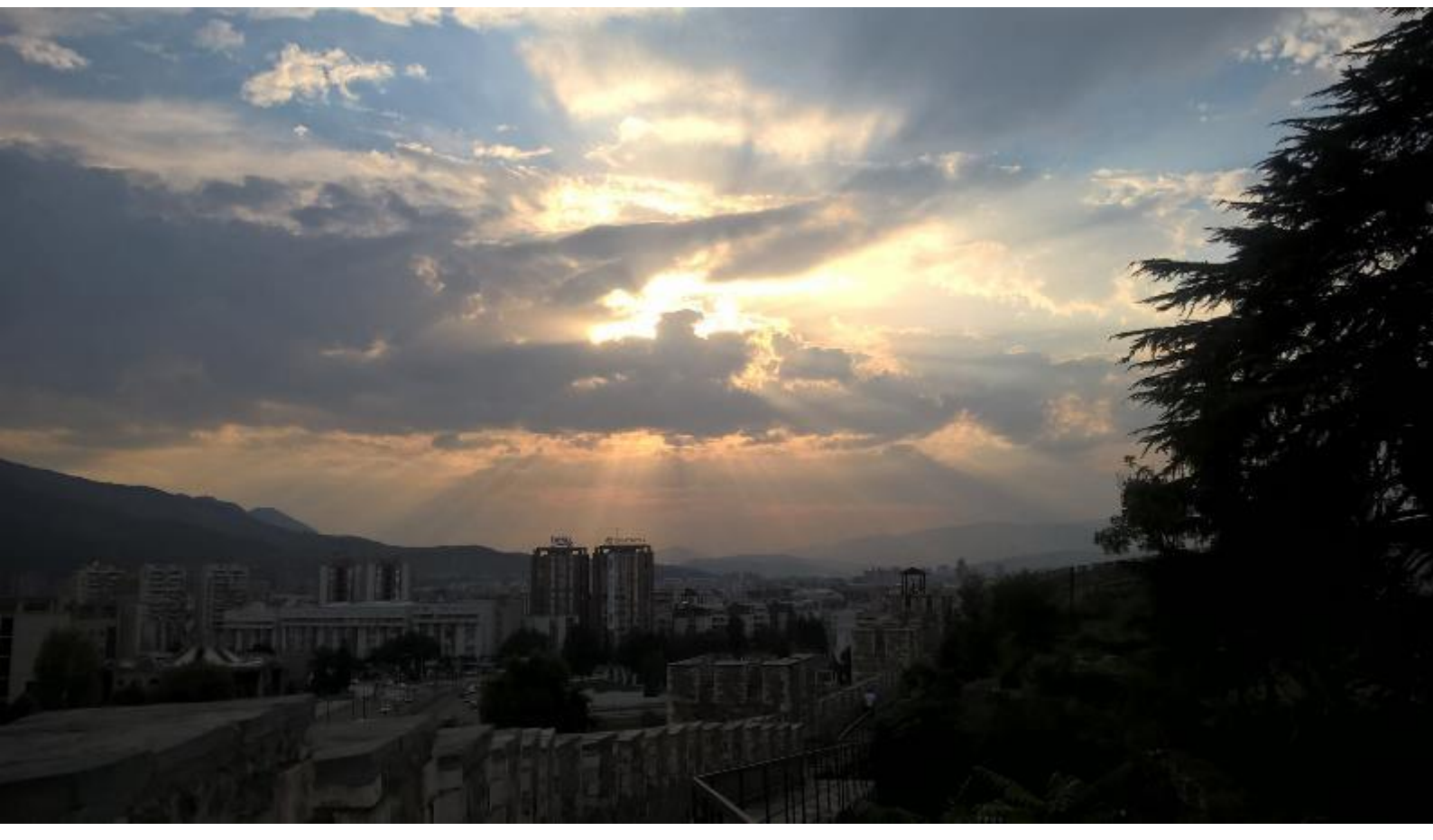
The main factors used in order to define the energy needs until 2025 are: the GDP growth in Skopje and the changes in its population, i.e. its growth. In order to determine the growth of the GDP we used data from the State Statistical Office as well as the GDP distribution in regions (available until 2014 through the MAKStat database) and the total national GDP expressed in million denars. After some additional assessments it was determined that the GDP of Skopje represents 80% of the GDP of the Skopje Region. From the analysis made, we could determine that the GDP of Skopje grows approximately with the same pace as the national GDP.

The national GDP projections for the period until 2025 are taken from the analysis on mitigating climate change made for the Second Biennial Report (SBUR). Taking into consideration that the GDP of the city of Skopje grows approximately with the same pace as the national GDP, it was assumed that this trend will continue. The average GDP growth rate is projected to be 4.16% until 2025, (Figure 2).



*Figure 2. GDP of the City of Skopje*

Concerning the changes in the population, we also analyzed the past period using the data from the State Statistical Office (available in the MAKStat database, the population in various regions (on 31.12) for the period 2006-2015). If we analyze the values per statistical regions, we can see that the biggest growth is present in the Skopje region. Taking into consideration that the Study analyzes the City of Skopje, it was assumed that 88% of the population of the Skopje region live in the municipalities of the City of Skopje (percentage that is in line with the statistical data for the period 2012-2015 if we deduct the number of the inhabitants of Sopishte). It was also projected that the City of Skopje will continue to have the biggest growth of the population, but in time the growth rate will decrease. The total number of citizens in the City of Skopje in 2025 is predicted to increase for 2.9% compared to 2012 or annually to increase in average for 0.22% (Figure 3). For the same period the average population growth in Macedonia is predicted to be 0.02%.

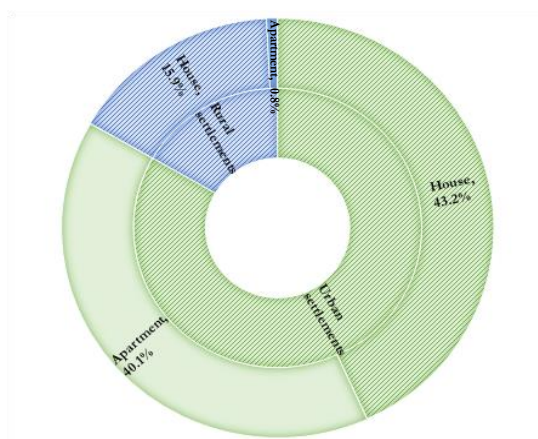




*Figure 3. Population, the City of Skopje*

For the needs of this Study we have completely revised and remodeled the residential sector. Namely, the results from the Survey on the Heating Practices in the Households in Skopje Valley prepared during the preparation of the Second Biennial Report on Climate Change were entered in the model. 5,044 households were surveyed in the Skopje valley and the modelling was made based on the data from 4,469 questionnaires, collected in the municipalities of the city of Skopje: Aerodrom, Butel, Gazi Baba, Gjorche Petrov, Saraj, Karposh, Kisela Voda, Centar, Chair and Shuto Orizari.

Figure 4 shows that 83.3% of the respondents live in urban communities. The share of households living in houses (43.2%) is slightly higher than the households living in apartments (40.1%). The rest of the households (16.7%) stated that they live in rural settlements. This is a consequence of the geographical area covered by some municipalities (Aerodrom, Butel, Gazi Baba, Gjhorche Petrov, Karposh, Kisela Voda and Saraj) which also have partially rural settlements. Most of the households in the rural settlements, or 15.9% of all surveyed households or 95.1% of the rural households live in houses.

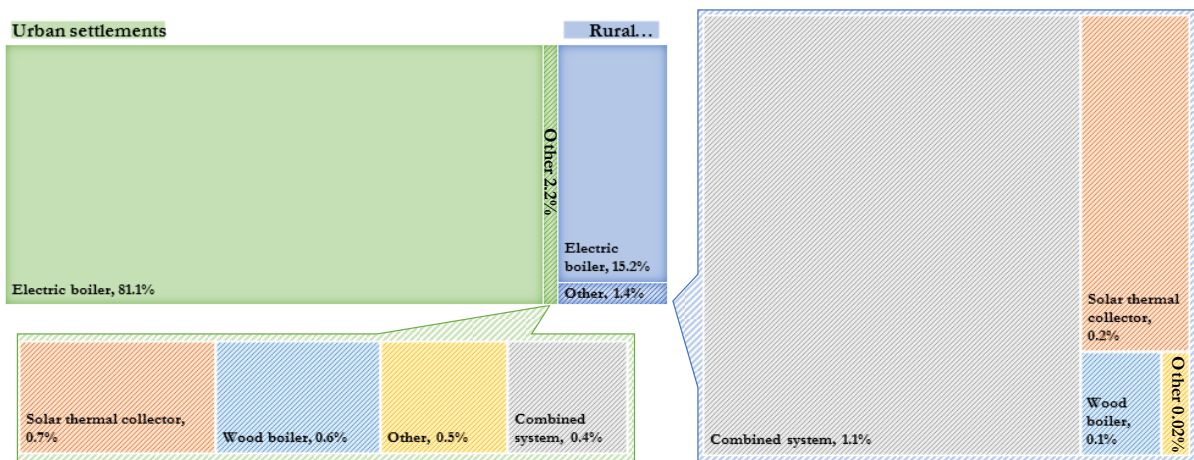


*Figure 4. Place and type of living facility*

We have used these data in the model and the residential sector was divided into apartments and houses in urban areas and also houses in rural areas.

In relation to obtaining sanitary hot water the survey confirms the expected, and that is that most of the households (96.3%) use electric boilers. If we take a closer look, this number can be divided into households in the urban community 81.1% and households in rural communities 15.2% (Figure 5). The other 3.7% of the respondents responded that they use other technologies such as solar thermal collectors, wood boilers, combined systems etc. In the rural communities

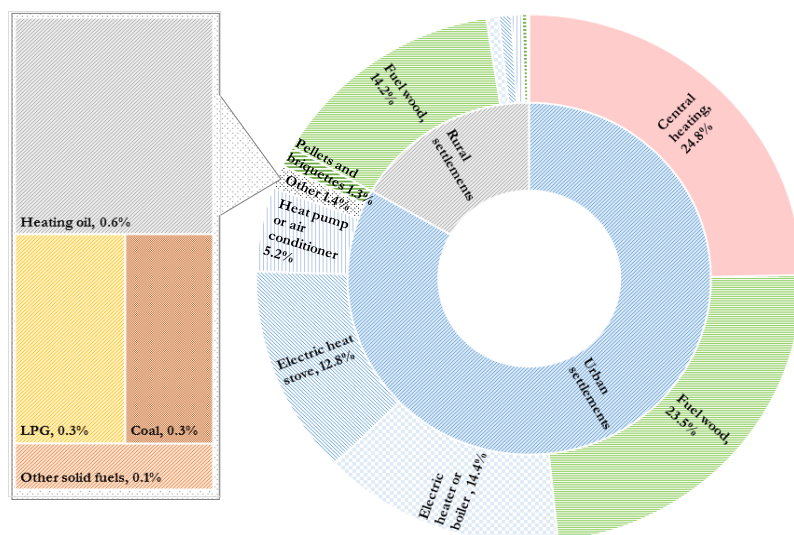
besides the presence of electrical heaters, mostly used are combined systems for hot water. Still, in urban communities the most popular alternative manner of heating sanitary hot water are the solar thermal collectors. About 0.7% of the households in urban communities have solar thermal collectors, and this percentage for the households of the rural regions is about 0.2%.



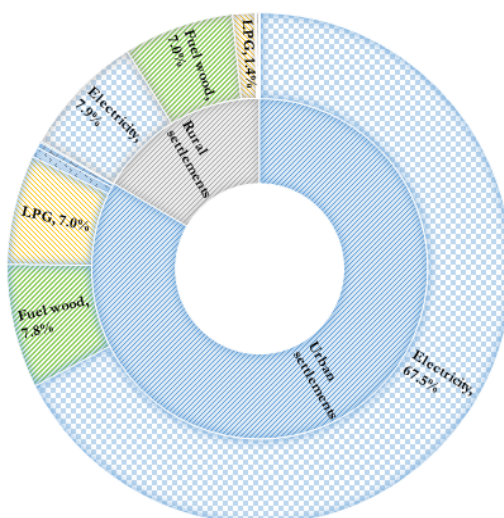
**Figure 5. Heating sanitary hot water**

Very important for this Study are the data related to the heating, that is the technologies used for heating the households (Figure 6). The Survey shows that the households in the City of Skopje mainly use fuel wood for heating (37.6%), electricity (34.4%) or central heating (24.8%). The fuel wood is mostly used by the citizens who live in houses. Having in mind the distribution of households per location and per type (Figure 4) it can be seen that almost all citizens who live in houses in rural settlements use biomass for heating. In urban communities, the situation is significantly different. Electricity is used quite often for heating the households and that is mostly done by using electric heat stove, electric heaters or boilers. Out of all surveyed households only 5.8% responded that they use heat pumps or air conditioners for heating their homes, or 5.2% in the urban and 0.6% in the rural communities. 24.8% of the households are connected to the central heating system, and all of them are located in the urban settlements. On Figure 6 we can see that part of the households use coal, heating oil, Liquefied petroleum gas (LPG) or other solid fuels. Although their share is quite small, some of these fuels significantly contribute to the GHG emissions and to local pollution.

Figure 7 shows technologies and fuels used for cooking in the households. About 75.4% of the households use electricity for cooking and of them 67.5% live in urban areas, while 7.9% live in rural areas. Next important fuel used for cooking is fuel wood, which is used in 14.8% of the surveyed households. LPG is used by 8.4% of the households, and most of them are located in the urban communities.



*Figure 6. Technologies and fuels used for heating in the households*



*Figure 7. Technologies and fuels used for cooking*

In order to verify and validate the data from this Survey we compared them with the data from the Survey made by State Statistical Office for the publication "Consumption of Energy Sources in the Households", for which 3,136 households were surveyed from different parts of the country. It was determined that there was a serious deviation in the data on consumption of fuel wood. Namely, according to the data from the Survey on Skopje valley it turns out that 44.7% of the households use biomass, while in the survey of the SSO this percentage is 32.3%. Also, it was noticed that the percentage of households which use energy sources which are not that common, such as coal for example, are also more prevailing in the survey of the SSO than in the Survey on the Skopje valley.

All these data are used in order to determine the energy balance of the city of Skopje. First in order to determine the number of households in Skopje, we have used the statistical data from the SSO where it says that in 2015 the municipalities of Gazi Baba, Gjorche Petrov, Karposh, Saraj, the rest of Skopje and Sopsishte had 544.086 inhabitants. If we deduce the number of people living in Sopsishte, and according to the Census from 2002 it is 5,656 inhabitants, we get that on the

territory of the City of Skopje currently there are 538,430 inhabitants. The Survey also shows the average number of persons per household and it is 3.73. This datum was verified by comparing it with the result obtained in the survey conducted by the SSO for the publication "Consumption of Energy Sources in the Households" where for the Skopje region it says that in one household there are in average 3.79 persons. By dividing 538,430 inhabitants with 3.73 we get the result that on the territory of the City of Skopje there are 145,192 households. According to the distribution of percentages (Figure 4), 120.961 households live in urban areas, while 24,231 are in rural.

Taking into consideration the number of households on the territory of the City of Skopje, and the distribution of percentages of the number of households and their heating sources, as well as their average consumption, we obtain the energy balance of the City of Skopje for heating. The energy balance of the City of Skopje in relation to heating of households in ktoe is presented in Table 1.

*Table 1. The energy balance of the City of Skopje in relation to heating of households (ktoe).*

| Coal | LPG  | Heating oil | Fuel wood | Briquettes, pallets | Heat derived | Electricity |
|------|------|-------------|-----------|---------------------|--------------|-------------|
| 0.43 | 0.09 | 1.111       | 71.56     | 3.08                | 32.31        | 26.84       |

Once again, we have validated the results obtained by comparing them with the energy balance of the Republic of Macedonia for 2015. It was determined that all values fit within the framework presented in the energy balance.

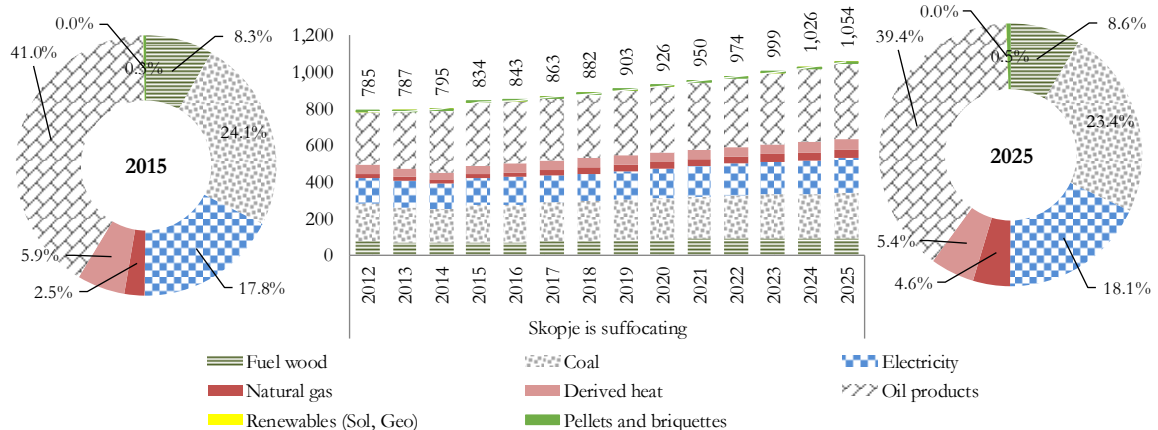
Because the MARKAL model models the total consumption of energy in the sector households and not only the energy consumed for heating, we made additional calculations in order to obtain the total energy balance for the households. The total consumption of electricity was taken from the SSO publication "Consumption of Energy Sources in the Households" where for the Skopje region it says that one household in average consumes 6,381 kWh per year. This quantity was multiplied with the number of households in the City of Skopje and thus we obtained the total consumption of electricity for the city of Skopje.

# Reference Scenario – “Skopje is Suffocating”

## Energy consumption

Taking into consideration the cost of energy sources, the price for installing new technology, the efficiency of technologies, their life cycle and the limitation that in the reference scenario “Skopje is suffocating“ we cannot use technologies newer than those existing in 2015, the MARKAL model did the calculations based on the lowest cost and at the same time taking into account the needs for energy in all sectors specifically of final energy consumption as power energy sources (Figure 8). From the calculations, we obtained the following results:

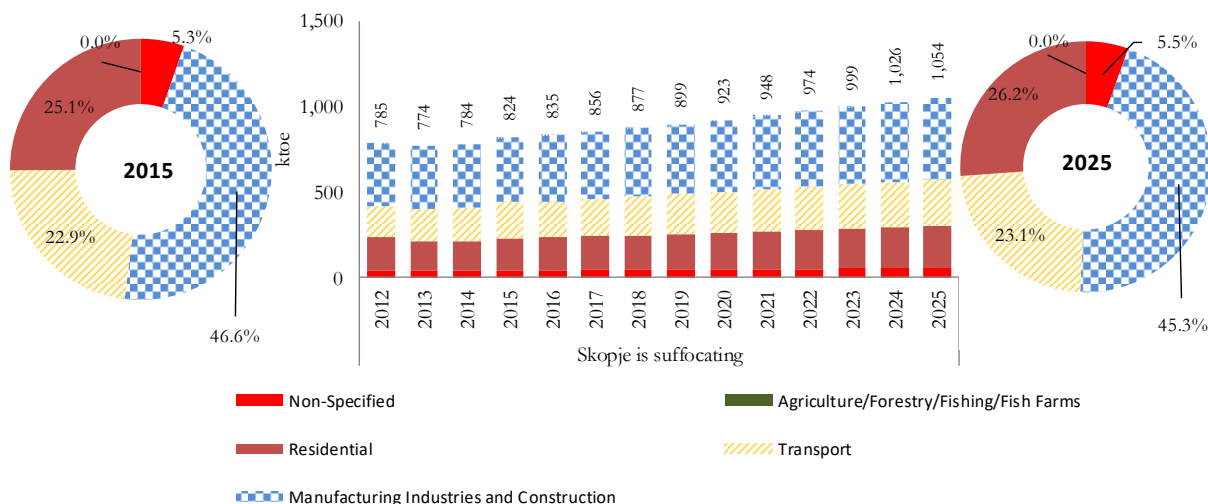
- 26.3% increase in the final consumption in 2025 compared to 2015;
- continuous dominant presence of oil products throughout the whole period of about 40%;
- the second energy source with highest share in this period are the various coals with about 24% (99% are used in the sector Manufacturing Industries and Construction) and the third energy sources is electricity with about 18%;
- from the total of renewable sources, the most present is fuel wood with about 8.5% (more than 95% is used in households) and pellets and briquettes with about 0.4% in the whole period.



**Figure 8. Final energy consumption by fuels in the scenario “Skopje is suffocating”**

The situation with the final energy consumption by sectors (Figure 9) is as follows:

- almost half of the energy consumption takes places in the sector Manufacturing Industries and Construction (45% throughout the whole period);
- The households and the transport sectors have approximately the same share in the final energy consumption, 26% and 23% respectively, in 2025 as it is in 2015.



**Figure 9. Final energy consumption by sectors in the scenario “Skopje is suffocating”**

In this Study, the household sector is of highest interest, especially the combination of energy sources used in this sector. From the results obtained we can conclude the following (Figure 10):

- the total increase in the final energy consumption is 28,8% in 2025 (243 ktoe) in relation to 2015 (189 ktoe);
- dominant is the share of electricity and fuel wood, with joint participation of about 80% throughout the period;
- the share of fuel wood is 37% throughout the whole period;
- there is slight reduction in the share of derived heat from 17% in 2015 to 15% in 2025;
- there is slight increase in the share of pellets and briquettes from 1.4% in 2015 to 2.2% in 2025.



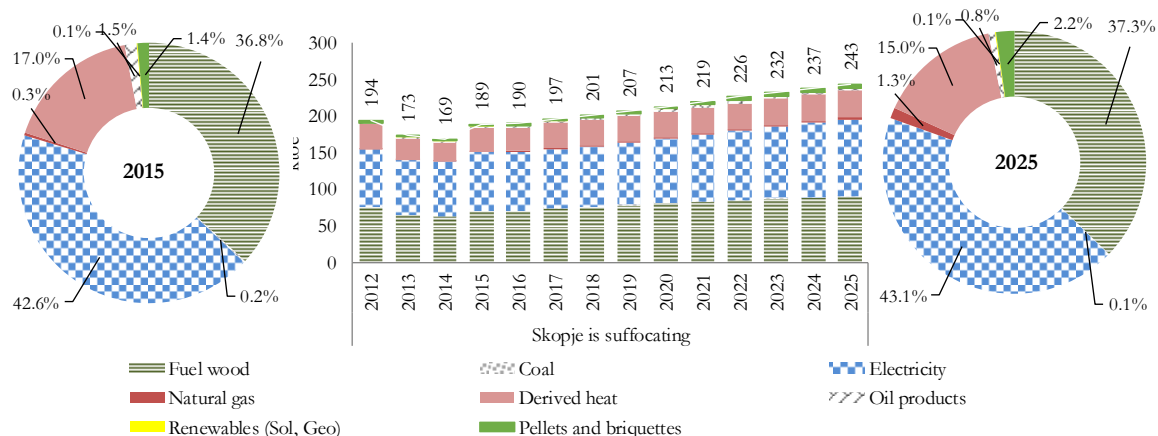


Figure 10. Final energy consumption per energy source in the household sector in the scenario “Skopje is suffocating”

## GHG emissions

Since this is the reference scenario, no measures/policies are implemented in order to reduce the GHG emissions, nor any limitations are introduced concerning their quantity in the period 2015-2025. As a result of this, the total GHG emissions continuously increase (Figure 11) and hence we can draw the following conclusions:

- 23.3% increase in 2025 (4,070 Gg CO<sub>2</sub>-eq) compared to 2015 (3,301 Gg CO<sub>2</sub>-eq);
- dominant share of CO<sub>2</sub> with 96% throughout the period;
- 2.7% share of CH<sub>4</sub> and 0.9% of N<sub>2</sub>O in 2025.

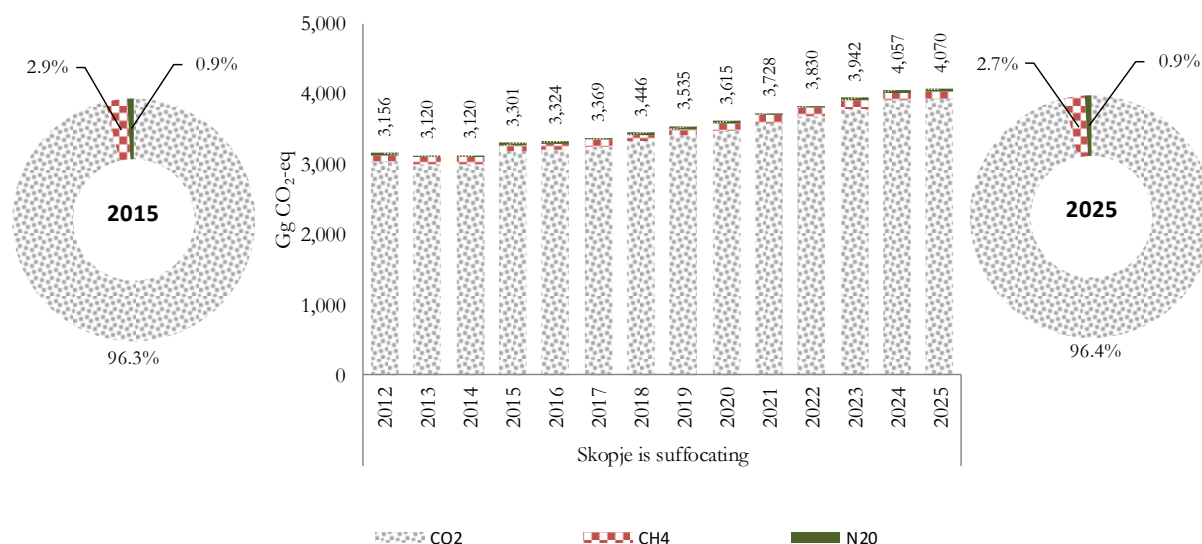


Figure 11. CO<sub>2</sub>-eq emissions per GHG in the scenario “Skopje is suffocating”

The analysis of individual GHG per sectors show the following:

- 23.5% increase in the CO<sub>2</sub> emissions in 2025 compared to 2015 and dominant participation of the sector Manufacturing Industries and Construction of about 41% throughout the whole period (Figure 12);

- the high consumption of firewood and electricity make the households sector a sector with minimum share of CO<sub>2</sub> emissions (0.3%) in 2025 (Figure 12);
- the emissions of CH<sub>4</sub> are increased for 16% in 2025 compared to 2015, and there is a dominant share of the import of electricity amounting to 73% in 2025 (Figure 13);
- second sector with the biggest share of CH<sub>4</sub> emissions is the households sector with 21.7% in 2025, above all as a result of the use of biomass (Figure 13);
- N<sub>2</sub>O emissions increase for 23.6% in 2025 compared to 2015 (Figure 14).

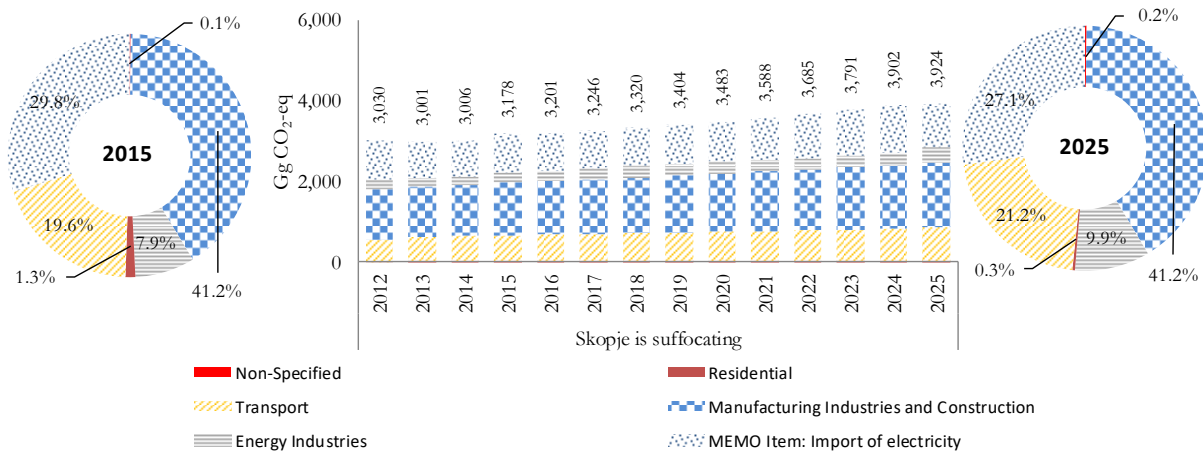


Figure 12. CO<sub>2</sub> emissions in the scenario "Skopje is suffocating"

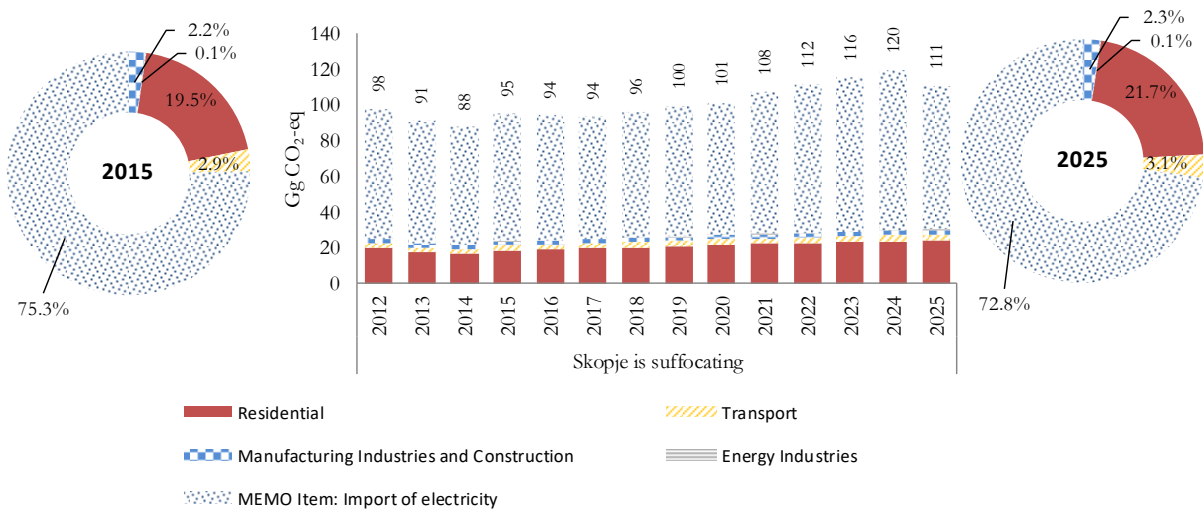


Figure 13. CH<sub>4</sub> emissions in the scenario "Skopje is suffocating"

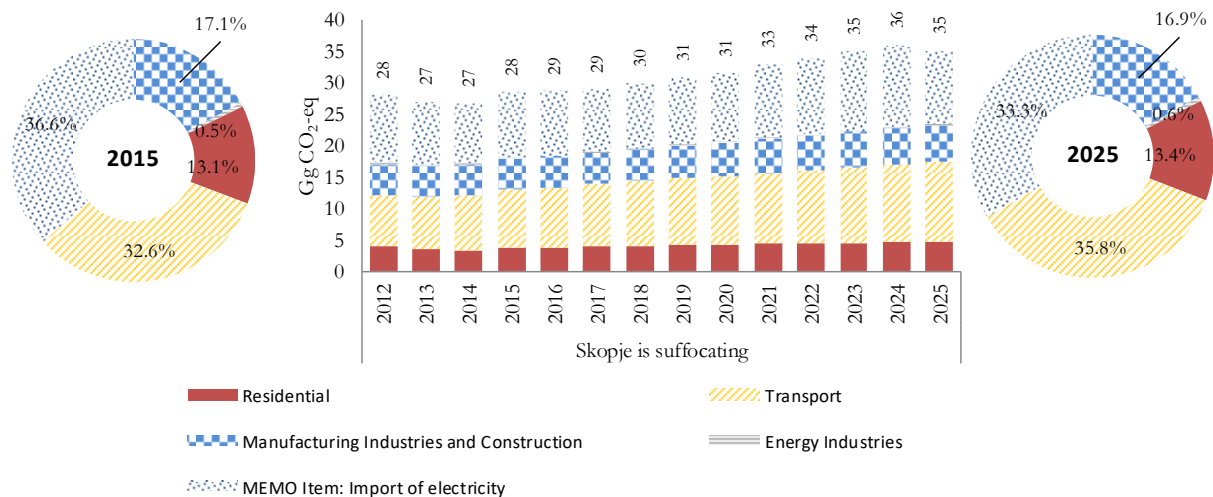


Figure 14. N<sub>2</sub>O emissions in the scenario "Skopje is suffocating"

## Local Emissions

For the needs of this Study we have adapted the MARKAL model so that it can calculate local emissions for every technology used for heating in the household sector, by using the Tier 2 methodology for emission factors prescribed by IPCC. Based on the consumption of different energy sources, and above all based on the consumption of firewood, the technologies used for heating and their efficiency, as well as the development of the household sector, we have obtained the following results (Figure 15):

- continuous increase of the local emissions;
- highest increase of PM<sub>10</sub>, PM<sub>2.5</sub> and CO for about 30.5% in 2025 compared to 2015;
- increase of the NO<sub>x</sub> for 23% in 2025 compared to 2015;
- increase of the SO<sub>x</sub> for 12.4% in 2025 compared to 2015;

The results show that firewood is the biggest local polluter. On the other hand, it is renewable energy source, and as such it is suitable to reduce the GHG emissions (CO<sub>2</sub> emissions from using firewood are not taken into consideration because it is believed that that specific tree has already absorbed the same quantity of GHG that is emitted with burning). If specific measures for reducing local pollution are not implemented, the local pollution would not decrease but it would even increase.

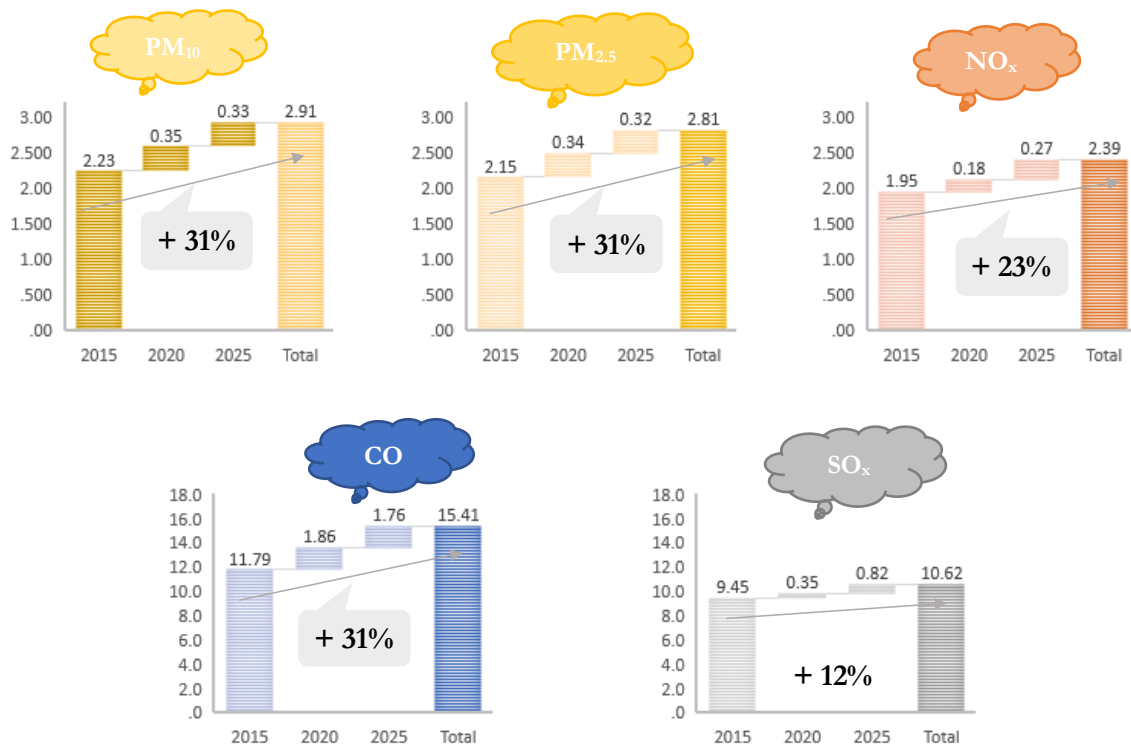


Figure 15. Local emissions in the scenario "Skopje is suffocating" [kt]

# Assessment of the Effects

## Construction of Energy Efficient Buildings

The measure Construction of Energy Efficient Buildings is the first measure which can contribute to reducing the energy consumption and thus to reducing the GHG, an even more importantly to reducing the local emissions<sup>3</sup>. This measure includes renovation of the existing buildings in the household sector according to the criteria prescribed in the Rulebook for Energy Performance of Buildings, as well as construction of passive buildings after 2020, when it is planned to start the implementation of the Directive 2010/31/EU of the European Parliament and of the Council. The problem with the inefficient buildings was underlined in the Study on the Heating Practices in the Households in the Skopje Valley (*UNDP Skopje, 2017*), where it is stated that 50.8% of the residential buildings do not have insulation at all, and 42% have insulation which is less than the prescribed.

In order to do this Study, we modelled the existing consumption of the buildings, by using the following assumptions:

- 1.5% annual renovation rate of the existing buildings, thus reducing their consumption to less than 90 kWh/m<sup>2</sup>;
- construction of new buildings consuming less than 90 kWh/m<sup>2</sup>;
- gradual construction of passive buildings after 2020, which consume less than 15 kWh/m<sup>2</sup>.

### Funds needed

Based on the assumptions about the percentage of renovations, construction of new and passive buildings, with the assistance of the MARKAL model, we calculated that in 2025 we will have 15,000 buildings and about 12% of the total number of buildings in the urban areas would meet the strictest energy efficiency requirements. On the other hand, about 2,500 buildings or about 9.8% of the total number of buildings in rural areas would be energy efficient.

In order to implement this measure, we need in total **296 million €** throughout the period from 2017 to 2025. Of this amount, for the implementation of the measure in urban areas **254 million €** will be used, and the rest, amounting to **42 million €** will be used for achieving energy efficiency in rural areas of Skopje.

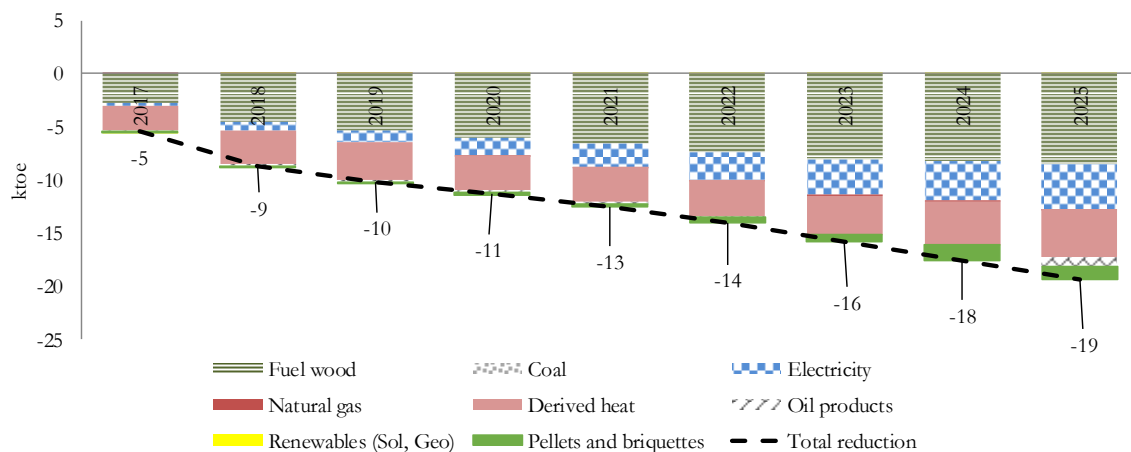
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<sup>3</sup> When we use the term buildings, we mean every housing facility (houses, collective housing apartment buildings etc.)

## Savings in Final Energy Consumption

Continuous renovation of buildings and construction of new buildings (in 2025, 11.5% of the total number of buildings in the City of Skopje will be energy efficient) shall result in the following (Figure 16):

- final energy consumption reduction in the residential sector for 8% in 2025 compared to the "Skopje is Suffocating" scenario;
- the highest reduction is related to the use of fuel wood, which is 44%;
- heat and electricity participate with 23% and 22% respectively in the total energy reduction.



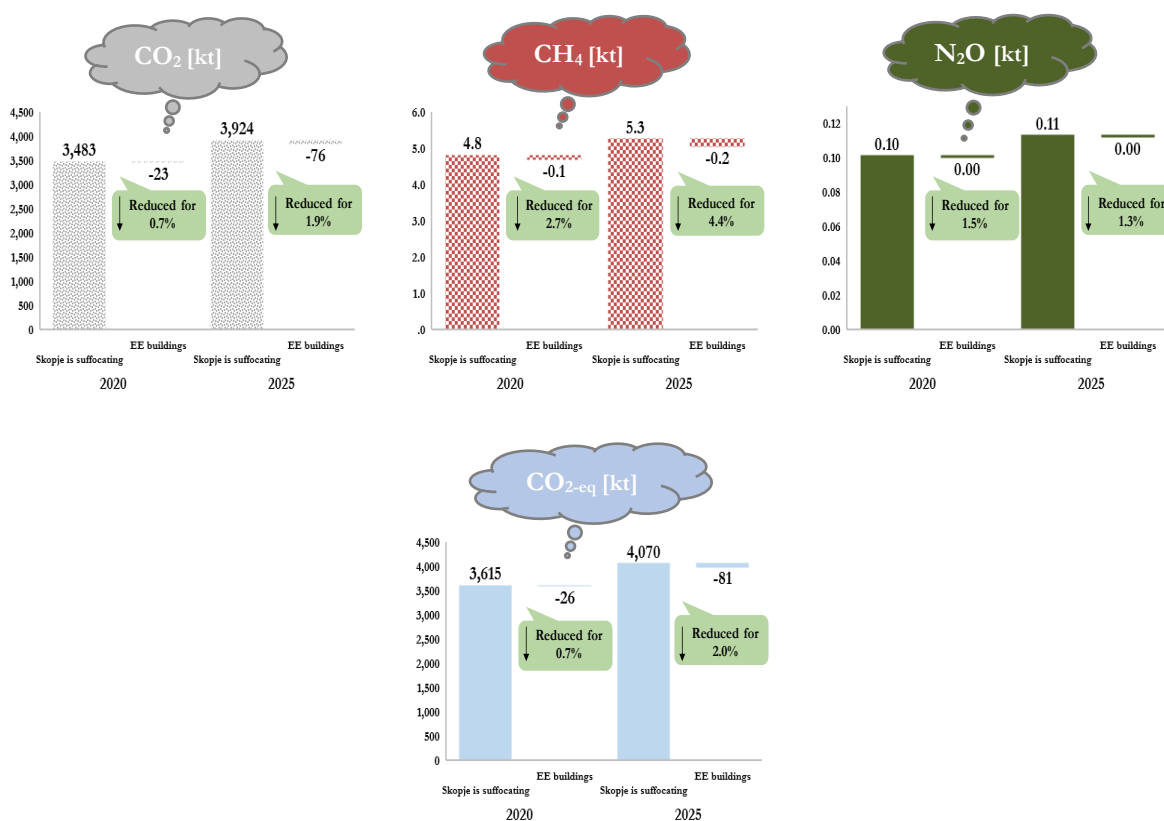
**Figure 16. Savings in the final energy consumption per energy sources from the measure Construction of Efficient Buildings compared to the scenario "Skopje is Suffocating"**



## Reduction of GHG Emissions

By implementing the measure for construction of energy efficient buildings we will directly contribute to the reduction of the GHG emissions. The results obtained from the MARKAL model show the following (Figure 17):

- biggest reduction of CH<sub>4</sub> emissions amounting to 4.4% (0.2 kt) in 2025, as a result of the reduction of the biomass consumption;
- reduction in the CO<sub>2</sub> emissions for 1.9% (75.6 kt) in 2025 compared to the “Skopje is Suffocating” scenario.

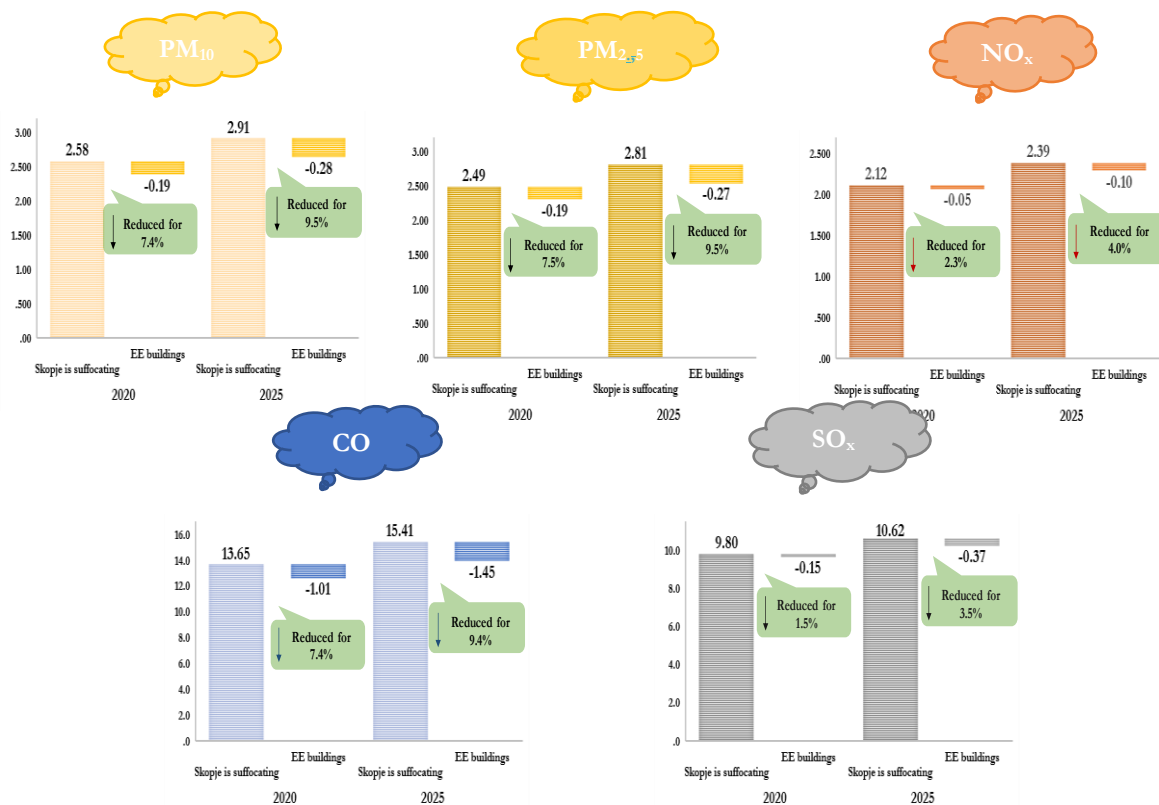


**Figure 17. Reduction of GHG emissions from the measure Construction of Energy Efficient Buildings compared to the “Skopje is Suffocating” scenario**

## Reduction of Local Emissions

The results about the local emissions show continuous reduction in parallel with the reduction of the energy consumption, especially the reduction of biomass consumption. Specifically, we can draw the following conclusions (Figure 18):

- reduction of PM<sub>10</sub>, PM<sub>2.5</sub> and CO for about 9.5% in 2025 compared to “Skopje is Suffocating” scenario;
- reduction in the SO<sub>x</sub> and NO<sub>x</sub> for 13.5% and 4.0% respectively in 2025 compared to “Skopje is Suffocating” scenario.



**Figure 18. Reduction of local emissions from the measure Construction of Efficient Buildings compared to the “Skopje is Suffocating” scenario**

## Potential for New Jobs

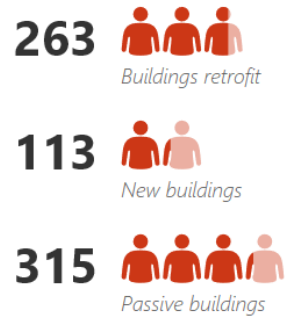
In order to determine the potential for creating new jobs we have used the methodology for calculating jobs developed for the preparation of the Report on National INDCs for Climate Change, which was also used for the preparation of the Second Biennial Update Report on Climate Change. One of the measures on which this methodology can be applied (which is not the case with the other two measures from this document) is the construction of energy efficient buildings. This measure has a huge potential for creating new "green" jobs on the territory of the City of Skopje. In 2025, it would create:

- total of 690 new jobs;
- most of them, that is 45.6% of the jobs are for the construction of passive buildings.

It is important to underline that these jobs are additional to the regular ones, and are created only due to the insulation of buildings and not for regular construction.

## JOBS -CONSTRUCTION OF EFFICIENT BUILDINGS

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*Figure 19. Number of jobs created in 2025 as a result of the measure Construction of Efficient Buildings*

# Changing the Heating Practices (Efficient Technologies)

The next measure analyzed under this Study in order to reduce energy consumption and reduce the local and global emissions is the change of the heating practices, that is using more efficient technologies and changing the energy sources used for heating. The reason for analyzing this measure is that in the Survey on the Heating Practices of Households in Skopje Valley (*UNDP, Skopje 2017*), it was presented that in the City of Skopje only 5.7% of the households use heat pumps out of 33.6% households which use electricity for heating. On the other hand, the share of pellets and briquettes stoves is only 1.6% opposite to 39.3% share of the firewood.

When modelling this measure, we have enabled the model to choose heating technologies based on lowest cost, which are more efficient compared to technologies used in 2015. Specifically, the model had the following technologies available:

- fuel wood stoves with 70-80% efficiency;
- pellets and briquettes stoves with 80-90% efficiency;
- heat pumps with average coefficient of performance (COP) of 3.2;
- natural gas heaters with 65-70% efficiency.

Concerning natural gas, it is assumed that after 2020 the households will have access to natural gas.

## Funds Needed

Based on these assumptions it was calculated that 42% of the households in the urban area until 2025 will change the manner of heating in the following way:

- 22,600 households will use more efficient stoves for fuel wood;
- 10,000 households will use pellets stoves;
- 17,400 households will use heat pumps;
- 3,000 households will use natural gas heaters;

Concerning the situation in the rural areas, the MARKAL model results show the following situation until 2025:

- 35.6% of the households will change their heating practices;
- 4,400 households will use more efficient stoves for fuel wood;
- 930 households will use pellets stoves;
- 3,450 households will use heat pumps;
- 290 households will use natural gas heaters;

It is important to underline that here we are not talking about new households that will use specific technology. For example, when we say that a specific number would use more efficient fuel wood stoves, this does not mean that besides the existing firewood stoves in 2025 there will be additional 22,600 households, but that out of the total number of households which in 2025 will use fuel wood, 22,600 will use efficient fuel wood stoves.

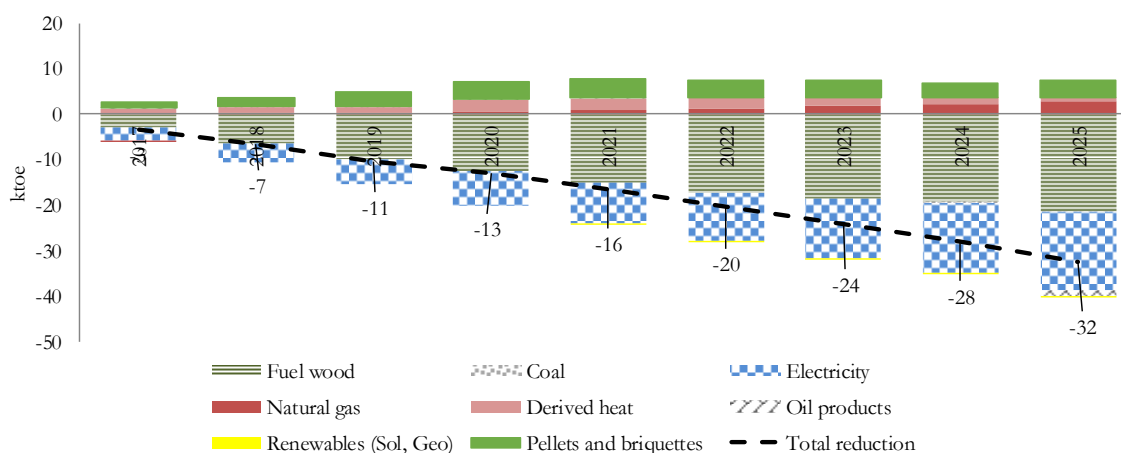
In order to implement this measure about **47.7 million €** are required, and most of them are for new heat pumps - **22.8 million €** and for fuel wood – **19.1 million €**. The pellet stoves would require **5.8 million €**, and because of the low number of households connected to the natural gas Network it will be necessary to invest additional **1 million €**.

It is important to mention that each of the above-mentioned technologies contributes to reducing the total cost, which means that every technology would return the investment for a specific period of time, which depends on the type of the technology, its efficiency and the price of fuel which changes every 3 to 7 years.

## Savings in Final Energy Consumption

The penetration of more efficient technologies would contribute to the following (Figure 20):

- reduction in the final energy consumption for 13.3% in 2025 compared to the “Skopje is Suffocating” scenario;
- the biggest reduction is taking place in fuel wood and electricity, since there we have the biggest penetration of more efficient technologies;
- increase in the pellets and briquettes consumption for 70% in 2025 compared to the “Skopje is Suffocating” scenario;
- increase in the natural gas consumption for 85% in 2025 compared to the “Skopje is Suffocating” scenario;



**Figure 20. Savings in the final energy consumption per sources of energy from the measure Efficient Technologies compared to the scenario “Skopje is Suffocating”**

## Reduction of GHG emissions.

The reduction in the final energy consumption for 13.3%, and especially of electricity will lead to the following (Figure 21):

- reduction in the non-CO<sub>2</sub> emissions for about 5%;
- significant reduction of the CH<sub>4</sub> emissions for about 15%;
- reduction of the N<sub>2</sub>O for about 5%

in 2025 compared to the “Skopje is suffocating” scenario.

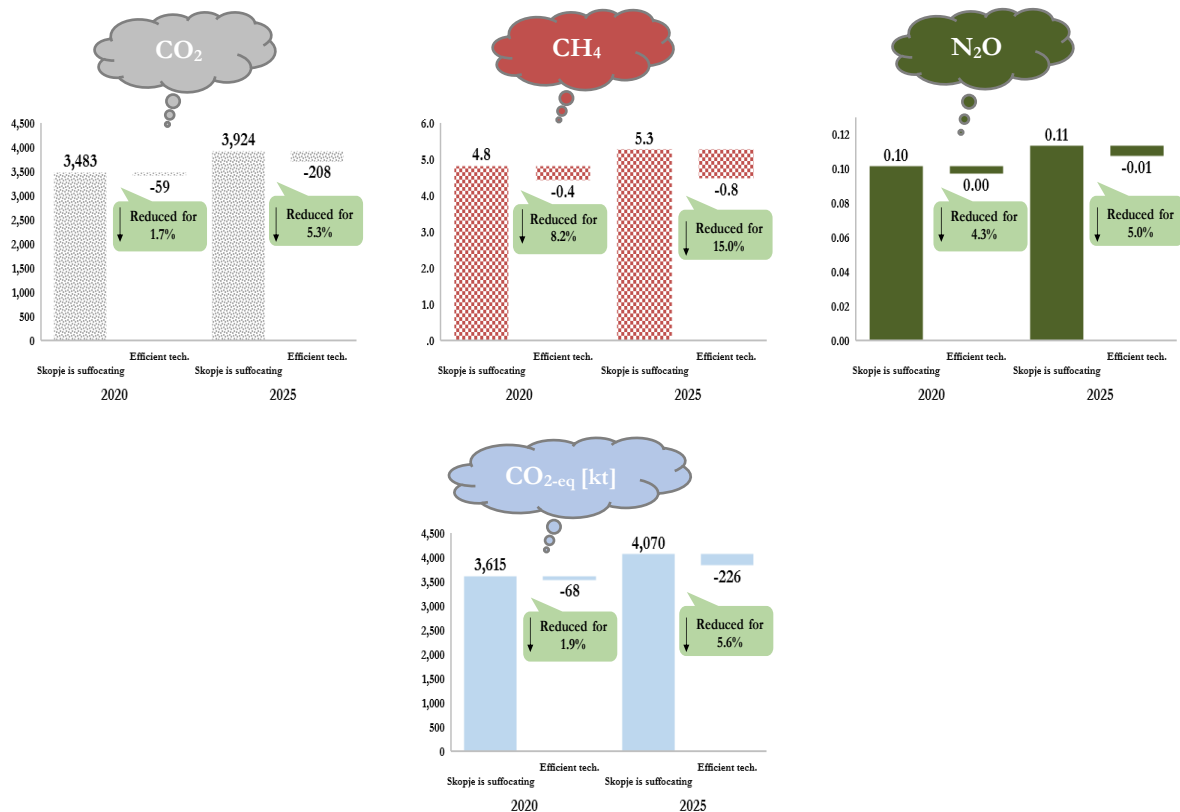


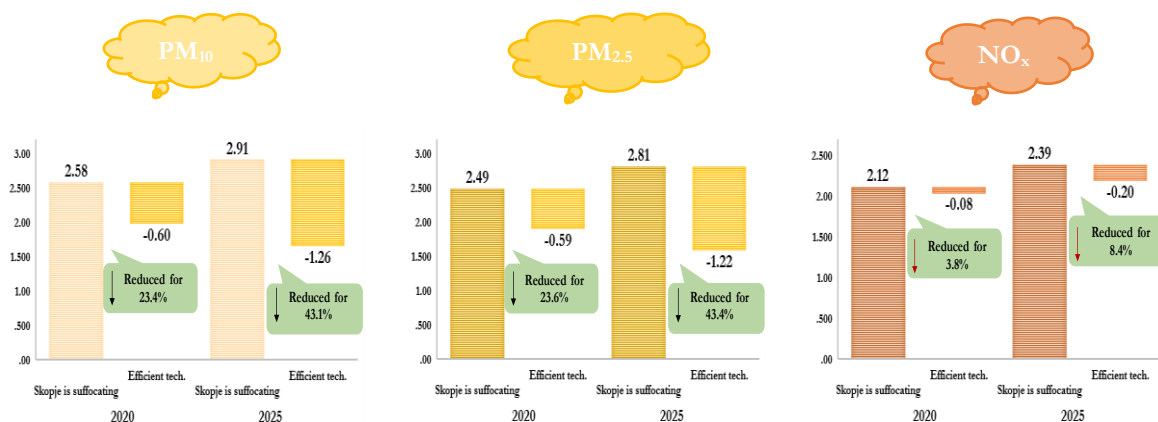
Figure 21. Reduction of GHG emissions from the measure Efficient Technologies compared to the “Skopje is Suffocating” scenario

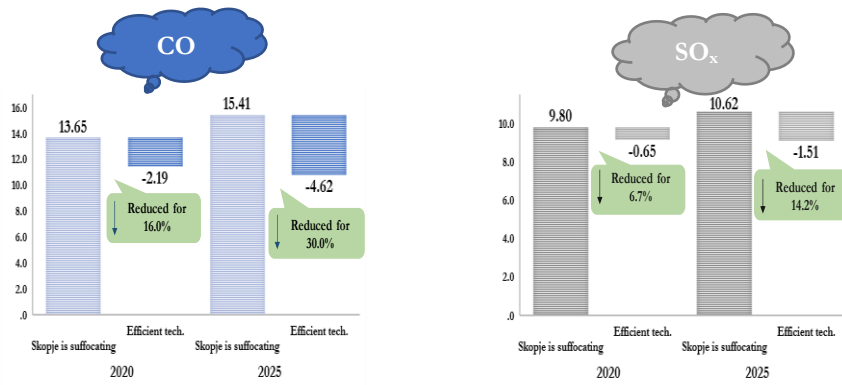
## Reduction of Local Emissions

Mainly the reduction in the consumption of firewood, which is a significant part of the final energy consumption in the households in Skopje, contributes to the following (Figure 22):

- reduction of PM<sub>10</sub> and PM<sub>2.5</sub> emissions for about 43%;
- drastic reduction of CO and SO<sub>x</sub> emissions for about 30% and 14%, respectively;
- reduction in the NO<sub>x</sub> emissions for about 8%

in 2025 compared to the “Skopje is suffocating scenario”.





**Figure 22. Reduction of local emissions from the measure *Efficient Technologies* compared to the “*Skopje is Suffocating*” scenario**

# Increased Acceptance of Central Heating

One of the ways for solving the problem with the local pollution in Skopje is to use more the existing central heating system. The results from the Survey on the Heating Practices in the Households in Skopje Valley (*UNDP Skopje, 2017*) shows that large part of the owners of residential facilities (42,5%) would opt for central heating even if the price for central heating is slightly higher. It is interesting to see that 62% of the households in the rural areas would like to join the central heating system. Because of this, the third measure which is projected for reducing the local pollution is Increased Acceptance of Central Heating.

For this measure, we have made the modelling based on the following assumptions:

- maximum utilization of the existing network;
- construction of a new network, if economically feasible;
- available to the model (provided it is economically feasible) is the construction of a cogeneration power plant of 40 MW and another one of 210 MW (cogeneration power plants with these capacities are also listed in the development plans of the energy companies in Macedonia, and are part of the scenarios contained in the draft version of the Energy Development Strategy until 2035).

## Funds Needed

The results obtained from the modelling show that the use of the central heating system with minimum increase in the price of gas from 6 €/GJ in 2017 to 6.3 €/GJ in 2025 is affordable option for the citizens who have access to the network. According to this:

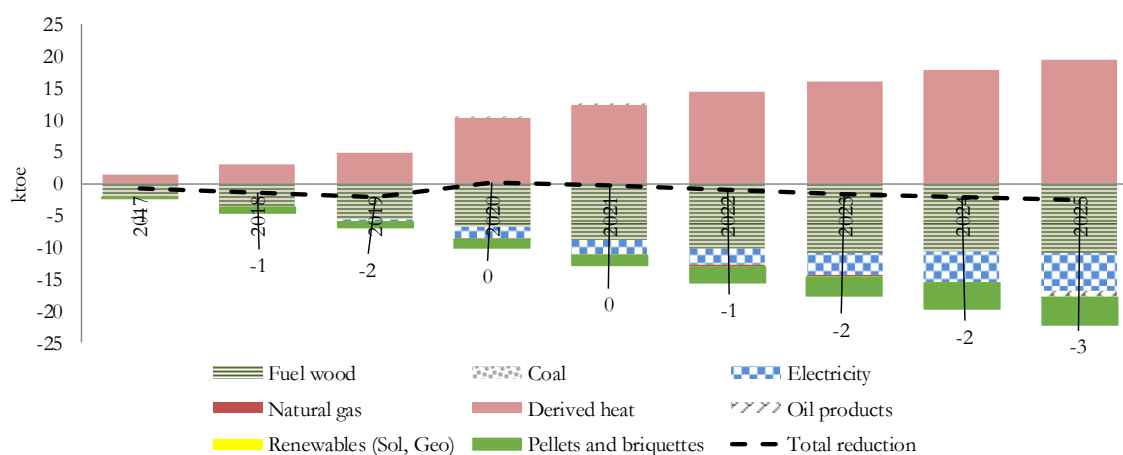


- there would be about 30% more households which would use the central heating system in 2025 compared to 2015;
- the capacity of the network would increase to 850 MW;
- the utilization of the existing cogeneration plants would be increased;
- a small cogeneration power plant would be built of 40 MW in 2021;
- one big cogeneration power plant of 210 MW would be built in 2025.

In order to implement this measure about **7 million €** are required in the period between 2017 and 2025, for new connections and extension of the network. Additionally, an investment of **262 million €** is needed for the construction of the new cogeneration power plants.

## Savings in Final Energy Consumption

The increased utilization of the central heating system reduces final energy consumption to a minimum, but on the other hand if we analyze the total energy needed, then we have a reduction of 3% in 2025 compared to the “Skopje is Suffocating” scenario. The main technologies compared to which the central heating is more affordable in the part of Skopje where the system is available are the inefficient firewood stoves and the inefficient electricity heaters. Because of this, on Figure 23 we can see a reduction in their participation (firewood for 12%, and electricity for 5.6% in 2025 compared to the situation in the “Skopje is Suffocating” scenario) because of the biggest share of central heating.



*Figure 23. Savings in the final energy consumption per sources of energy from the measure Increased Acceptance of Central Heating compared to the scenario “Skopje is Suffocating”*

## Reduction of GHG Emissions.

The replacement of the fuel wood which has zero CO<sub>2</sub> emission factor (which means it is carbon neutral) with heat energy produced from natural gas leads to mild increase in the CO<sub>2</sub> emissions in 2020 (Figure 24). The construction of the new cogeneration power plants in 2021 and 2025 will contribute for the reduction of CO<sub>2</sub> for about 7% in 2025 compared to the reference scenario. This is a result of the reduced import of electricity on the territory of the City of Skopje which has higher emission factor. On the other hand, the reduction in the consumption of firewood contributes to significant reduction of CH<sub>4</sub> emissions - for about 40% in 2025 compared to the reference scenario.

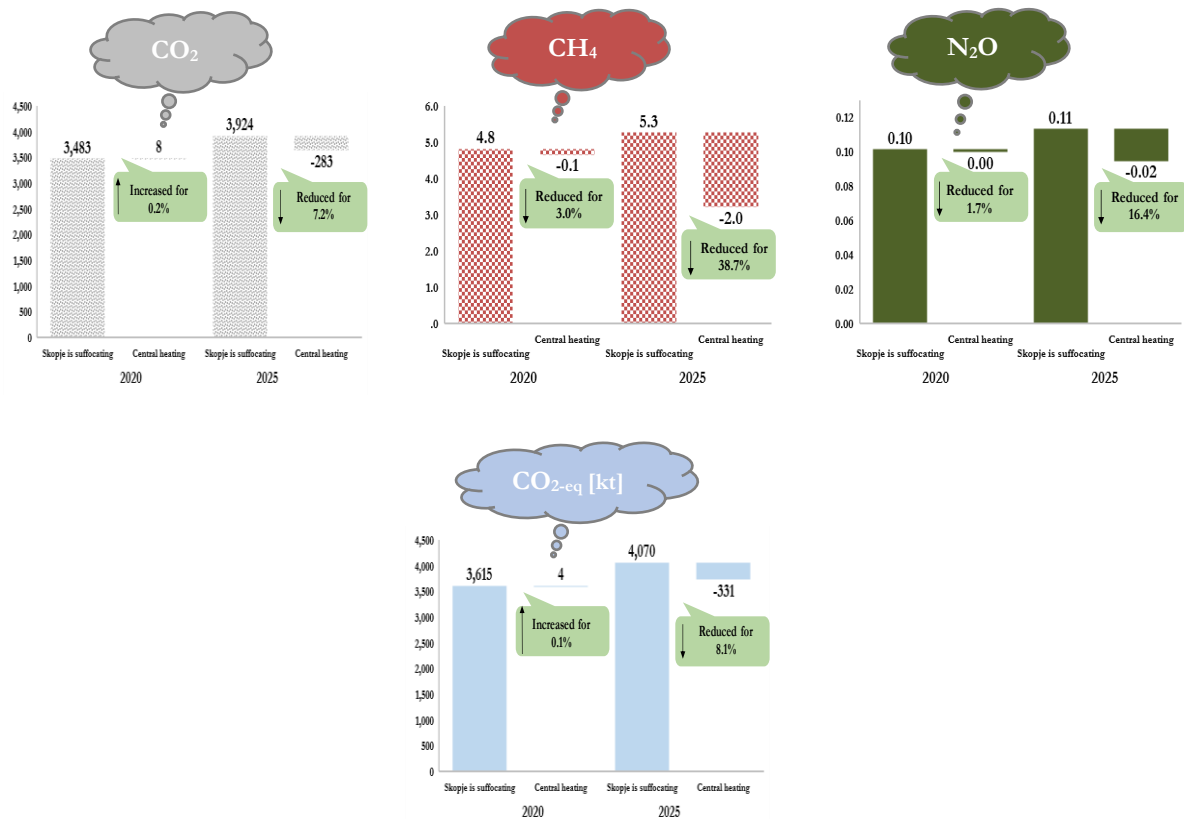
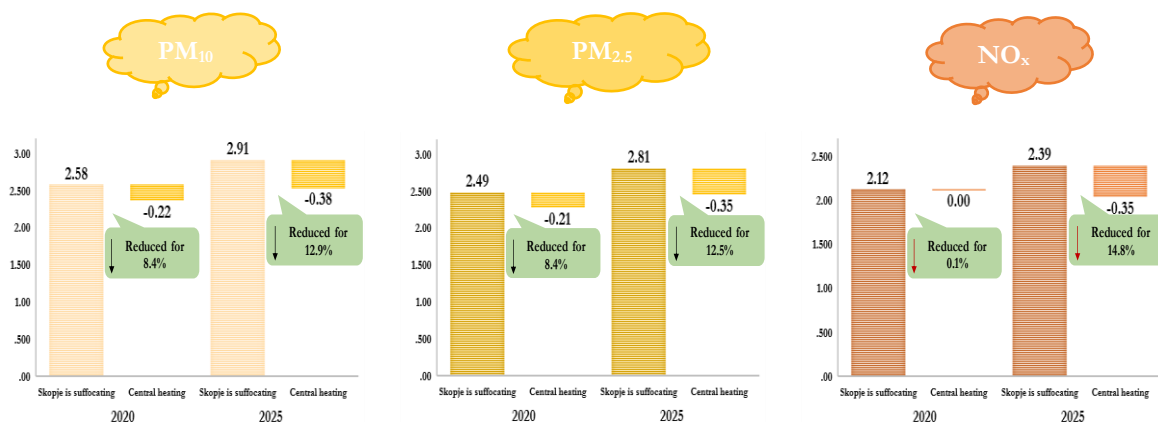
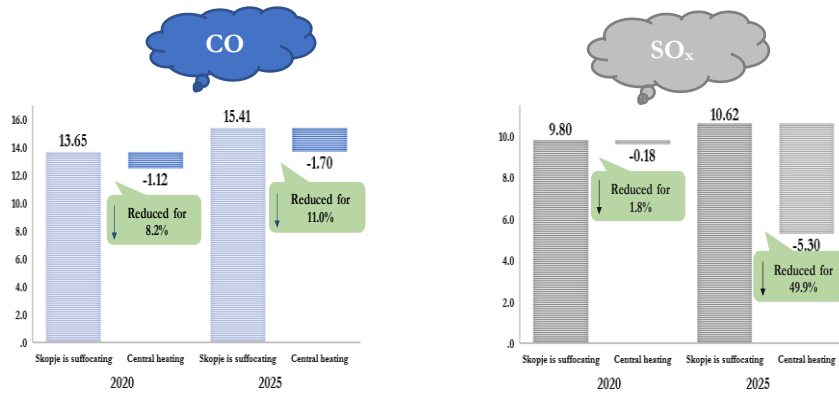


Figure 24. Reduction of GHG emissions from the measure Increased Acceptance of Central Heating compared to the “Skopje is Suffocating” scenario

## Reduction of the Local Emissions

Due to the reduction in the consumption of biomass for 12%, we have almost the same level of reduction of PM<sub>10</sub> and PM<sub>2.5</sub> in 2025 compared to the reference scenario (Figure 25). The construction of new cogeneration power plants also significantly contributes to the reduction of SO<sub>x</sub> emissions (for about 50% in 2025 compared to the reference scenario) because the import of electricity on the territory of Skopje will be reduced, which has higher emission factor.





**Figure 25. Reduction of local emissions from the measure Increased Acceptance of Central Heating compared to the “Skopje is Suffocating” scenario**

In order to determine more precisely the penetration of this measure as well as its cost-effectiveness it is necessary to map in detail the need for heating and its distribution throughout the city. This is also an obligation stipulated in the EE Directive. That is why one of the recommendations of this Study is to make a detailed mapping of the need for heating in Skopje in a future project.

# Skopje is Breathing

There is a strong connection between the three measures which were analyzed in the previous chapters (Assessment of the Effects) and because of this if all three measures are implemented their effect will not only be a simple sum of the effects of all three and of the parameters that were already analyzed. Because of this, we have developed a new scenario “Skopje is Breathing” which includes these three measures and in which we analyzed the impact of their combined implementation. The assumptions which are valid for each of the measures individually, are valid for this scenario as well.

## Funds Needed

Because the measure Construction of Efficient Buildings largely overlaps with the other two measures, the effects of these measures on number of households affected are reduced. This scenario predicts that in 2025 in the urban areas:

- 81.3% of the households will be covered with one of the measures;
- 15,000 households will meet the strictest criteria for energy efficient buildings;
- 20,400 households will use more efficient stoves for fuel wood;
- 7,280 households will use pellets stoves;
- 16,280 households will use heat pumps;
- 2,700 households will use natural gas heaters;
- there would be about 14% more households using the central heating system in 2025 compared to 2015;

The following is foreseen for the rural areas:

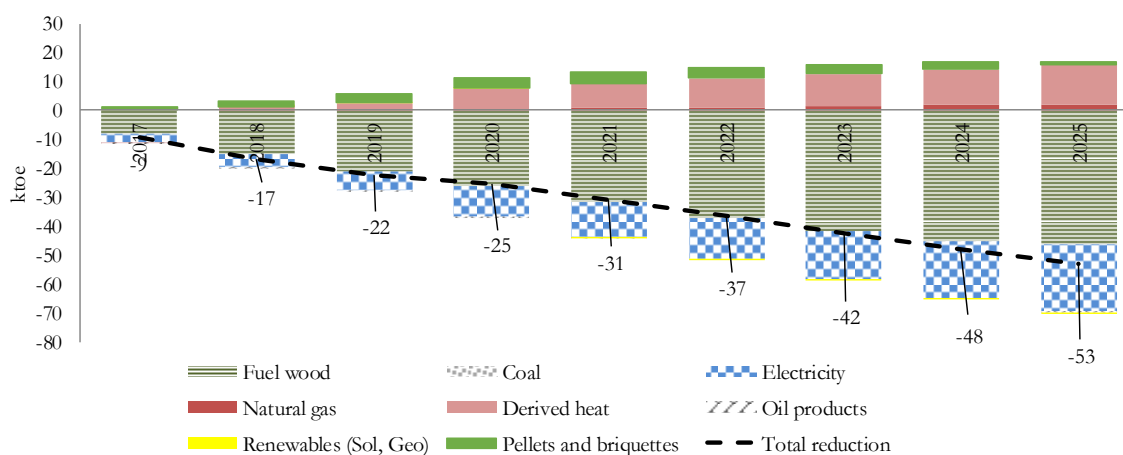
- 42% of the households will be covered with one of the measures;
- 2,500 households will meet the strictest criteria for energy efficient buildings;
- 3,900 households will use more efficient stoves for fuel wood;
- 850 households will use pellets stoves;
- 3,100 households will use heat pumps;
- 260 households will use natural gas heaters;

**356 million €** are needed for the implementation of this scenario in the period from 2017 to 2025. Additionally, **212 million €** are needed for the construction of new cogeneration power plants. The difference between this scenario and the scenario in which only the measure Increased Acceptance of Central Heating is implemented, is that here in 2025 a cogeneration plant of 170 MW is built, instead of a cogeneration plant of 210 MW.

## Savings in Final Energy Consumption

The implementation of all measures would lead to significant reduction of final energy consumption in the household sector, which in 2025 would be 22% compared to the reference scenario “Skopje is Suffocating” (Figure 26). The other results show the following:

- 50% reduction in the use of fuel wood, which is the biggest reduction;
- 45% reduction in the use of electricity;
- 37% increase in the use of heat energy;
- 70% increase in the use of natural gas.



**Figure 26. Savings in the final energy consumption per sources of energy in the “Skopje is Breathing” scenario compared to the scenario “Skopje is Suffocating”**



## Reduction in GHG emissions.

The reduction in the final consumption (especially of firewood) and the opening of the new cogeneration power plants will contribute to:

- reduction in the CO<sub>2</sub> emissions for about 11%;
- significant reduction of the CH<sub>4</sub> emissions for about 50%;
- reduction of the N<sub>2</sub>O for about 21%

in 2025 compared to the “Skopje is Suffocating”.

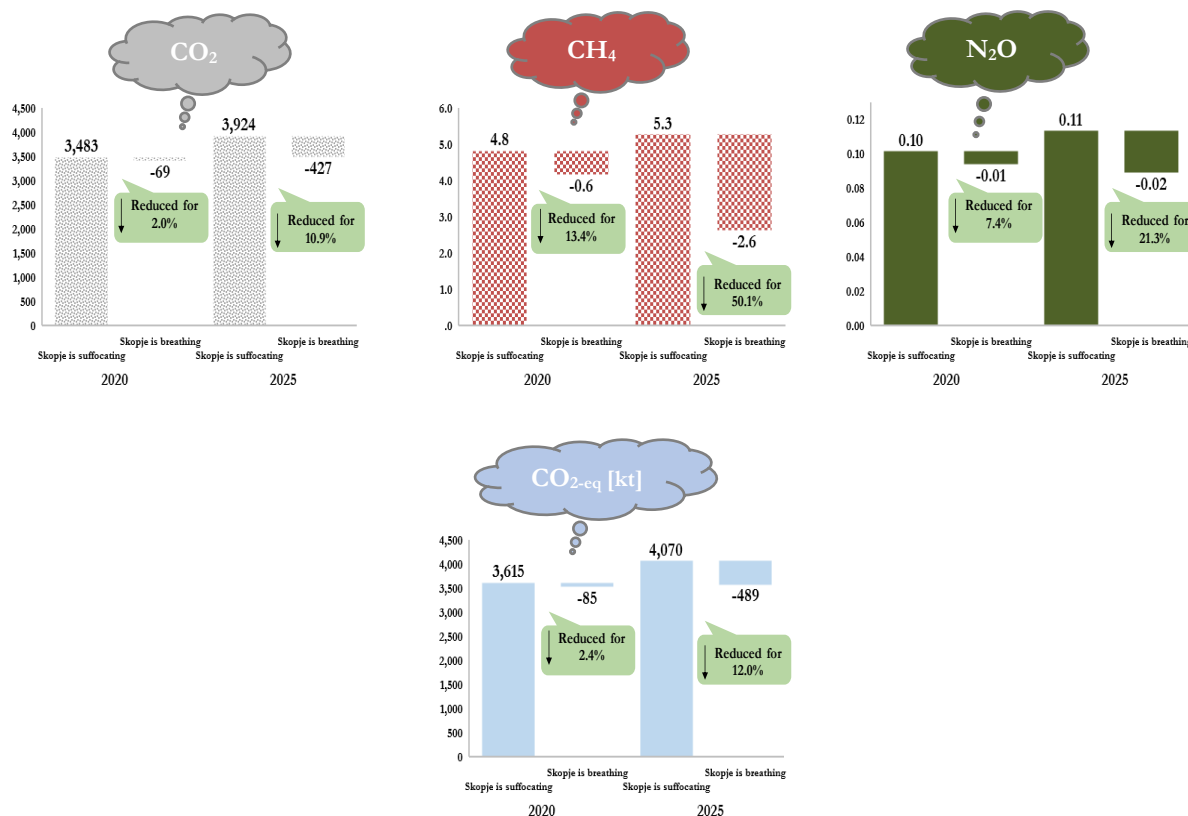


Figure 27. Reduction of GHG emissions in the “Skopje is Breathing” scenario compared to the “Skopje is Suffocating” scenario

## Reduction of Local Emissions

The name of the scenario “Skopje is Breathing” can be best explained and justified with the assistance of Figure 28. Namely, in this scenario we have:

- enormous reduction of PM<sub>10</sub> and PM<sub>2,5</sub> emissions for about 70%;
- drastic reduction of CO and SO<sub>x</sub> emissions for about 55%;
- reduction of NO<sub>x</sub> emissions for about 22%

in 2025 compared to the “Skopje is suffocating”.



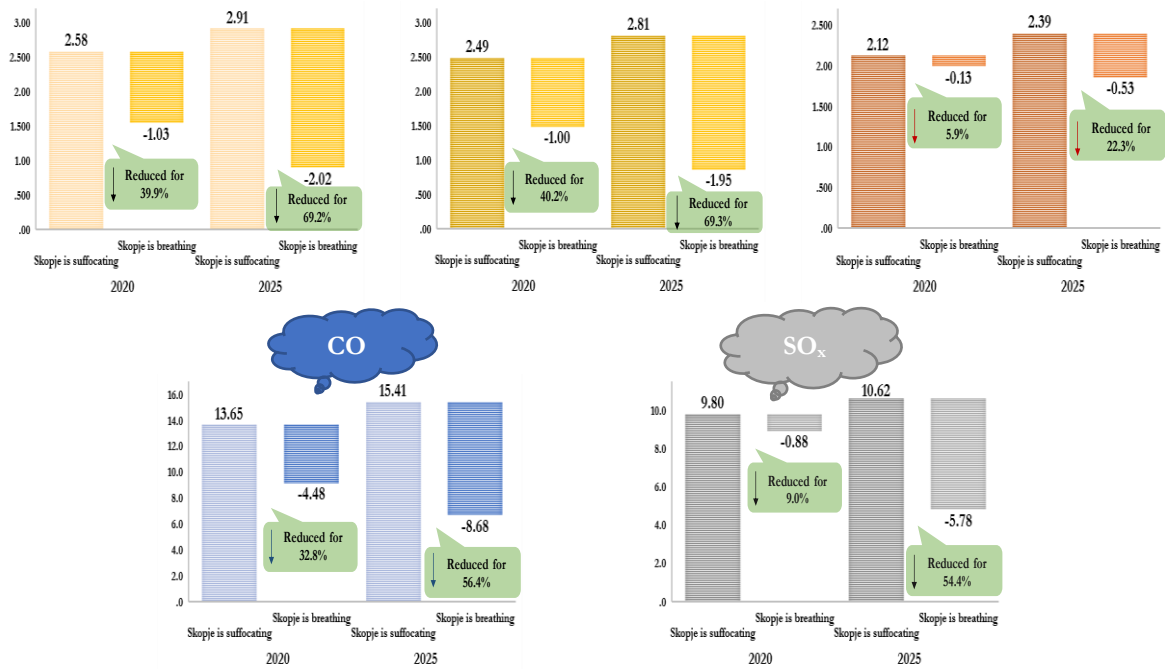


Figure 28. Reduction of local emissions in the “Skopje is Breathing” scenario compared to the “Skopje is Suffocating” scenario

Continuous reduction of PM<sub>2.5</sub> emissions as one of the most harmful particles is additionally presented in Figure 29 and it is clearly visible that in relation to these particles and in comparison to 2015, there is a reduction of 60 %. Additionally, the figure presents the local emissions from all three measures individually.

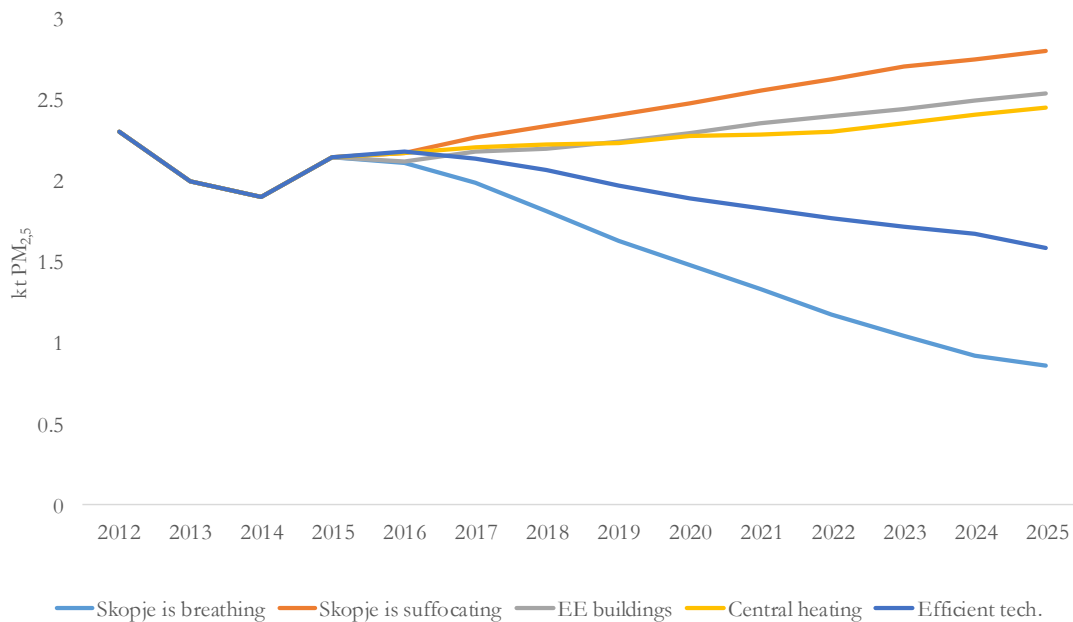
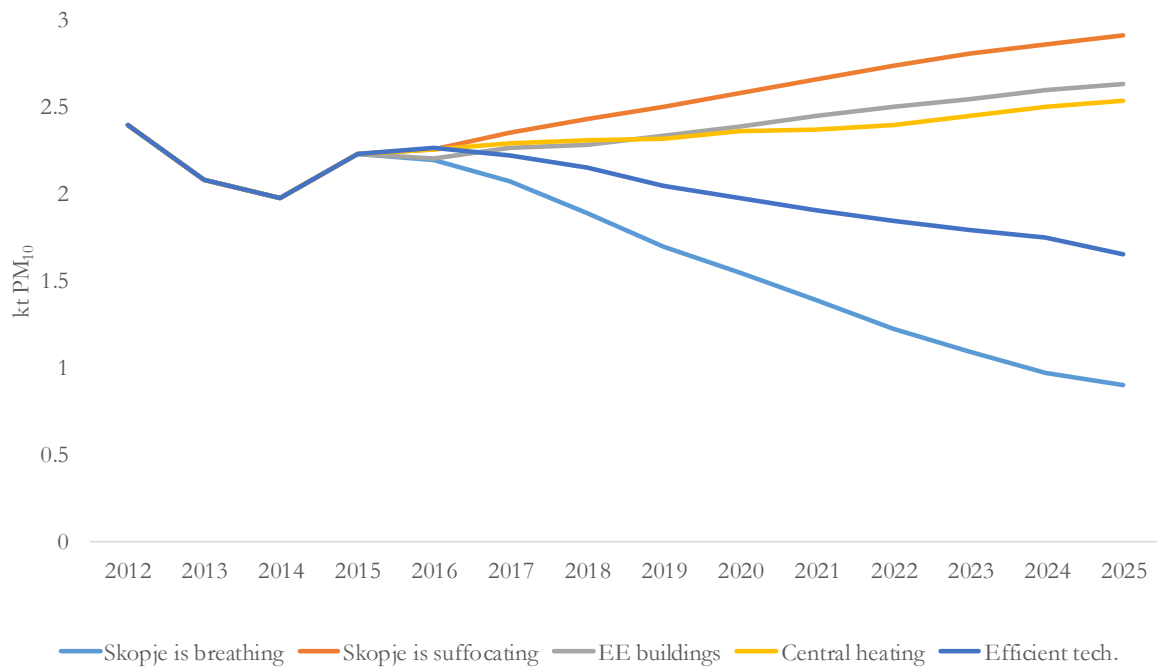
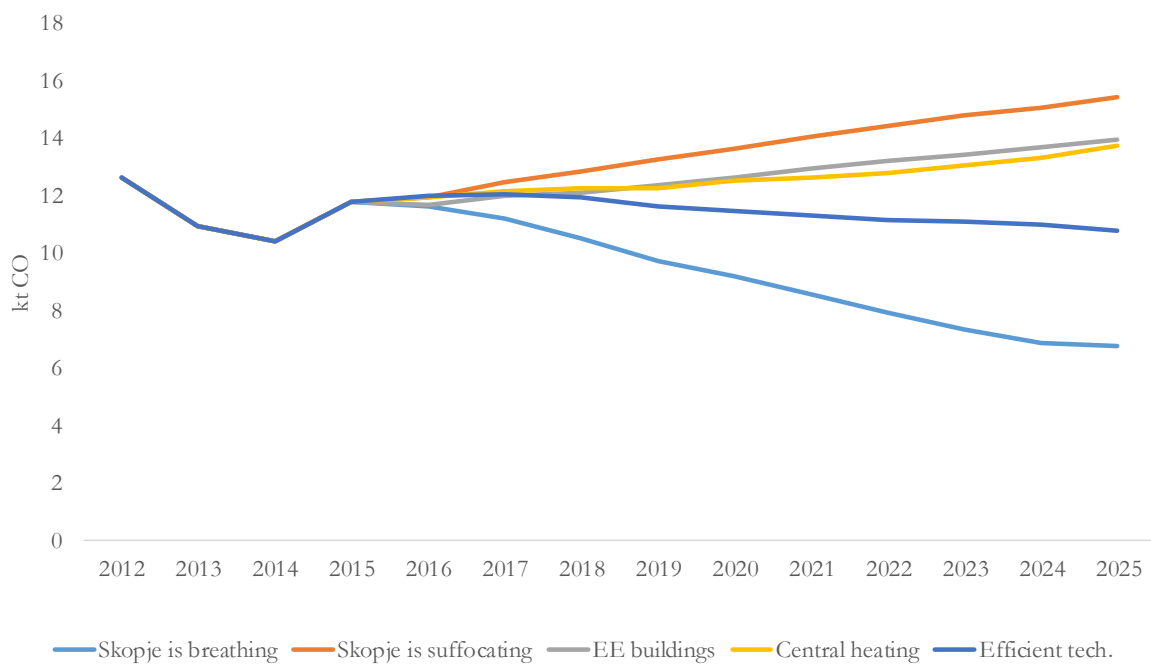


Figure 29. Comparing PM<sub>2.5</sub> emissions in the scenarios “Skopje is Suffocating” and “Skopje is Breathing” and for each measure individually

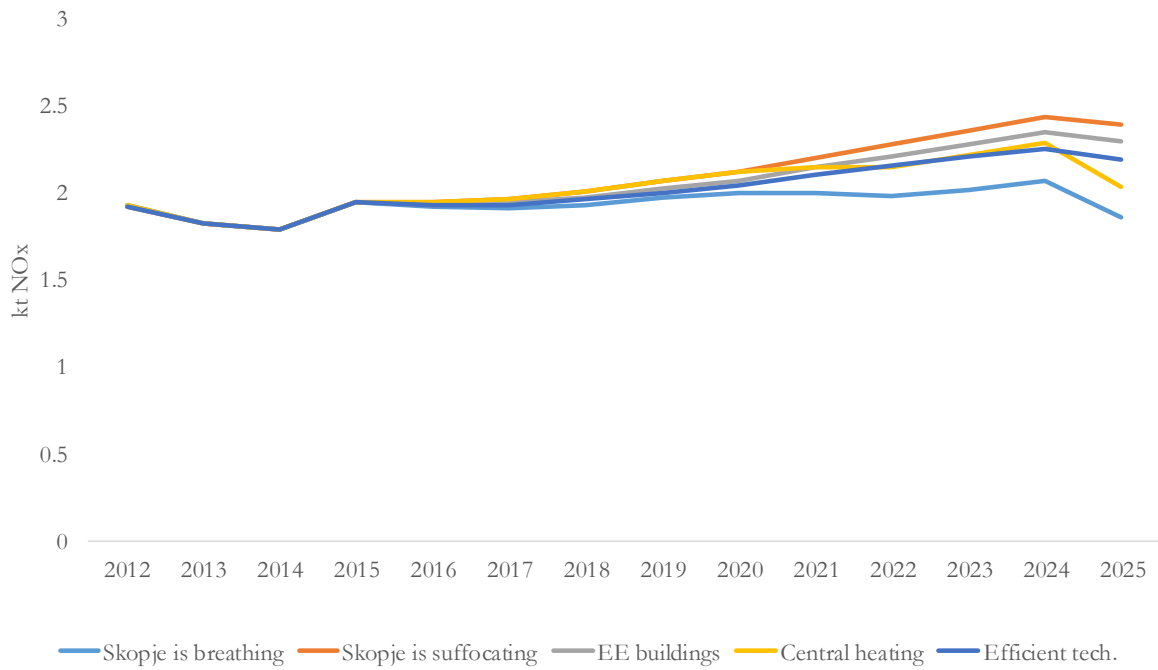
In comparison to 2015, PM<sub>10</sub> will be reduced for 60% (Figure 30), CO for 43% (Figure 31), NO<sub>x</sub> for 4,4% (Figure 32) and SO<sub>x</sub> for 50% (Figure 33) in 2025.



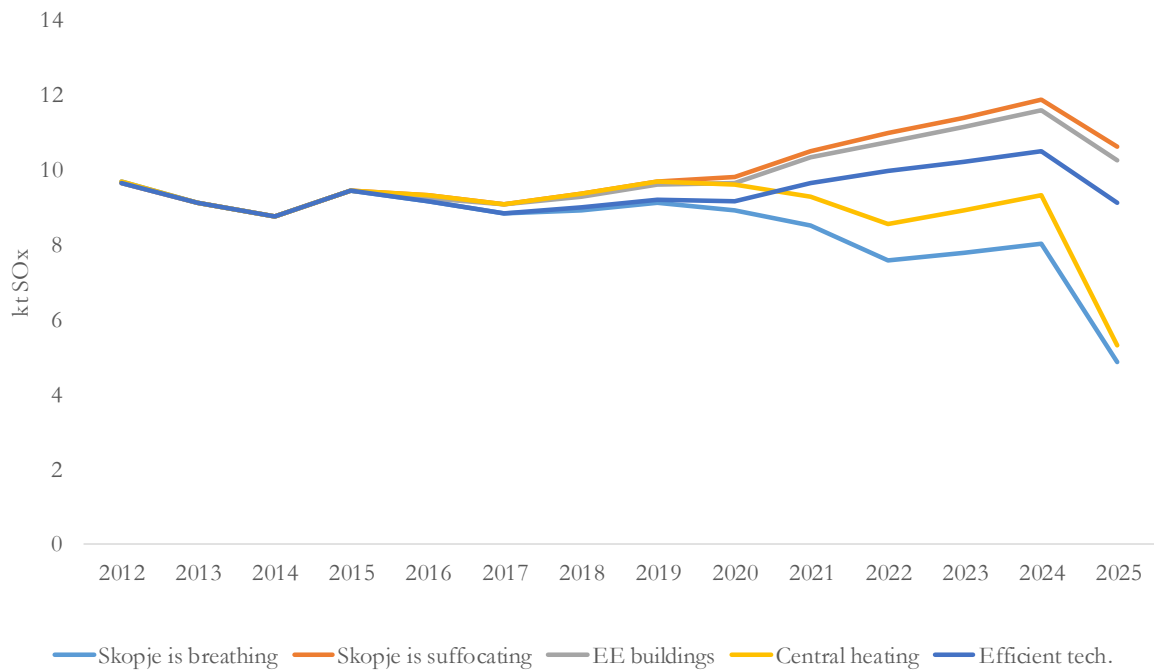
**Figure 30. Comparing  $PM_{10}$  emissions in the scenarios "Skopje is Suffocating" and "Skopje is Breathing" and for each measure individually**



**Figure 31. Comparing CO emissions in the scenarios "Skopje is Suffocating" and "Skopje is Breathing" and for each measure individually**



**Figure 32. Comparing NO<sub>x</sub> emissions in the scenarios “Skopje is Suffocating” and “Skopje is Breathing” and for each measure individually**



**Figure 33. Comparing SO<sub>x</sub> emissions in the scenarios “Skopje is Suffocating” and “Skopje is Breathing” and for each measure individually**



# Conclusions:

The main conclusions from this Study on the emissions from heating in the household sectors are as follows:

- An individual measure that mostly contributes to reduction of PM<sub>10</sub> and PM<sub>2.5</sub> is the measure for Changing Heating Practices (efficient technologies);
- Concerning CO<sub>2</sub> emissions, the biggest impact is achieved by implementing the measure Increased Acceptance of Central Heating, if implemented as an individual measure;
- By implementing the “Skopje is Breathing” scenario (combined implementation of all three measures), we can achieve almost 70% reduction of PM<sub>10</sub> and PM<sub>2.5</sub> and about 11% reduction of CO<sub>2</sub> emissions in 2025 in comparison to the reference scenario “Skopje is Suffocating”.
- The total funds needed to implement the “Skopje is Breathing” scenario are 356 million Euros in the period from 2017 to 2025.
- Additional 212 million € are needed for the construction of new cogeneration power plants.
- The measure Construction of Energy Efficient Buildings will create 690 new jobs.

