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AIR POLLUTION IN KOSOVO

REPORT

Proposed measures and policy instruments to reduce pollution from key sectors

SUPPORTED BY:

NATUR VÅRDS VERKET
SWEDISH ENVIRONMENTAL PROTECTION AGENCY

Suedia
Sverige

Authors: Katarina Yaramenka, Helena Lundström, Flintull Annica Eriksson, Anders Roth, Ingrid Mawdsley, Anna Nilsson (IVL Swedish Environmental Research Institute)

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IVL Swedish Environmental Research Institute
P.O Box 210 60, S-100 31 Stockholm, Sweden
Phone: +46-(0)10-7886500 // www.ivl.se

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SHORTENINGS AND ABBREVIATIONS

AD	Activity data
CLE	Current legislation
OS1	Biomass fuels (including fuelwood)
BC	Brown coal
HC	Hard coal
HF	Heavy fuel oil
MD	Medium distillates (diesel)
LPG	Liquified petroleum gas
GAS	Natural gas
REN	Renewables: geothermal, small hydropower, solar, wind
ELE	Electricity
HT	Heat
HYD	Hydropower
DC	Derived coal (coke, briquettes)
GSL	Gasoline
ESP	Electrostatic precipitator
HED	High efficiency deduster
SNCR	Selective non-catalytic reduction
FGD	Flue gas desulphurization
HDV	Heavy duty vehicles
ELV	Emission limit values

SUMMARY

This report presents a feasibility study that provides an overview of which sectors holds the largest efficiency potential in reducing air pollutants and greenhouse gas emissions in Kosovo. The study provides Kosovo a better understanding of in which key sectors mitigation is most feasible, as well as which measures and policy instruments that could be used. The study aims to provide an analysis that can be used for creating better living conditions concerning air quality and develop policy instruments targeted to reducing greenhouse gas emissions and air pollutants.

GAINS modeling tool has been used together with insights provided by national experts in Kosovo as well as baseline data from IIASA (International Institute for Applied Systems Analysis). The analysis concludes that the three key emitting sectors that should be of main focus for Kosovo to reduce its emissions to the air are the following:

- Residential wood combustion
- Diesel road transport
- Heat and power generation

The air pollutants that are of main interest in this analysis are PM2.5, NOx, SO2 and NMVOC.
The developed scenarios indicate the state of play of Kosovo's Air Pollution in year 2030 and 2050. Four scenarios have been developed with proposed measures across the three key sectors beyond measures implied by current legislation:

a)Low (low ambition level regarding emission reductions)
b)Mid (medium ambition level regarding emission reductions)
c)MTFR (maximum technically feasible reduction) – the most ambitious scenario with technical measures only (no fuel shifts included)
d)Green – scenarios with replacement of fuel combustion with non-emissive energy sources

Emissions are expected to decline across all pollutants of focus in this study, as well as across all key sectors. The main reason is due to several technological shifts, such as better abatement technologies at lignite power plants, reconstruction plans to build a new Kosova power plant as well as gradual replacement of appliances within the residential sector and vehicles in the transport sector. An increase of costs from 132 million Euro in 2020, to 213 million Euro in 2030 is expected due to new technical equipment in Kosovo. It corresponds to an increase of 62 percent. It should be noted that these amounts do not include expenses related to structural changes such as fuel shifts.

A Low scenario implies the same abatement level in the residential sector as in the baseline but contains certain energy efficiency improvements in the sector. The Mid scenario implies higher implementation rates of new, improved and pellet stoves. Maximum Technically Feasible Reduction (MTFR) scenario implies that all technical measures are set to the maximum implementation rates. However, this is a rather unrealistic situation included in the study to assess the full emission reductions potentials in the key sectors.

The table below illustrates that by year 2030, the most expensive measures are measures within the residential wood combustion sector. It concerns the replacement of wood heating stoves with pellet stoves equipped with ESP.

Table ES1: Overview of total costs for abatement of emissions across different scenarios in 2030 (million Euro2015)

Year 2030/Sector	Type of costs	CLE (baseline)	Low	Mid	MTFR
Residential wood combustion	Technical measures	51	41	117	460
Diesel road transport	Technical measures	118	121	105	139
Heat and power generation	Technical measures, large lignite plants	35	77	97	118

Abatement costs are only estimated for measures that are included within the GAINS model.

For the key sector **Residential Wood combustion**, six measures are proposed. These measures are related to replacement of conventional stoves, retrofitting of existing stoves and right burning practices. Energy efficiency improvements in buildings, reduced burning in urban areas and replacement of fuelwood stoves with non-emissive heating technologies are also highlighted as important measures to take into account when deciding on specific measures for emission reduction in Kosovo.

Seven measures are proposed for the second key sector, **Diesel Road transport**. These measures are related to replacement of newer Euro standards, less emitting fuels, retrofitting with particle filters and/or SCR, proper inspection and maintenance, less driving by car, modal shifts by shifting travellers from cars to public transport and goods to railway and finally replacement of diesel with other fuels such as natural gas, biogas, and hydrogen.

Targeting emissions of pollutants within the third key sector, **Heat and Power**, four measures are proposed. One of the proposed measures are emission control technologies at large power plants which includes end-of-pipe measures and process modifications to reduce air pollutants. The second measure concerns the shift from lignite to gas or non-emissive energy generation technologies. The third measure within this key sector relates to energy efficiency improvements at large combustion plants, which includes special fuel preparation techniques such as the pre-drying of solid fuels, and gasification or pyrolysis of solid or liquid fuels.

The analysed measures are not always cost-effective in terms of avoided health damage due to the full implementation of these measures vs. technical costs of such implementation. For example, for some measures, technical costs are significantly higher than avoided damage (health benefits). The analysis finds that cost-effectiveness depends on the choice of the considered domain. Once inhabitants of other countries than Kosovo are included, the measures often become cost-effective. The study finds that the positive effects in Kosovo alone vary from 13 percent to 36 percent of the avoided health damage, depending on what pollutants are reduced by a specific measure (since PM2.5 are not transported the same long distances as SO2 and especially NOx). Thus, decision-making processes regarding what measures to take to reduce emissions in a country, has a large effect on the avoided health damage in neighbouring countries.

The analysis has examined damage costs of main air pollutants in Kosovo by connecting specific pollutants emitted with health problems they cause and with corresponding monetary values of health damage. These so called “external costs”, or “externalities” are estimated by comparing monetized health damage with and without implementation of a measure that mainly affects one pollutant (within this analysis, several such measures are considered). Although premature mortality depends on concentrations of secondary particles in the ambient air breathed by recipients, those concentrations are affected by emissions of SO2, NOx and primary PM2.5 that undergo chemical reactions during their path from the source of emissions to recipients.

The table below presents an overview of external costs – estimated costs of health damage resulting from emissions in Kosovo – depending on the considered domain and pollutant. These costs do not depend on measures considered, but on the structure of the population, current levels of emissions and the exposure to air pollution. Also, geographical location and meteorological conditions affecting transboundary pollution is an important aspect. The results illustrate that reducing one kilogram of PM2.5 emissions in Kosovo would bring significantly larger health benefits than reducing one kilogram of SO2 or NOx, and that for NOx and SO2, trans-boundary pollution is much more significant than for PM2.5.

Table ES2: Overview of damage costs of air pollutant emissions in Kosovo, Euro2015/kg pollutant.

Pollutant	PM2.5	SO2	NOx
Effects in Kosovo	24.8	5.0	1.0
Effects in Europe	68.4	31.1	7.0

The choice of measures needs to be decided upon priority for Kosovo. Often a wide range of measures could be implemented across different sectors. If cost-effectiveness is prioritised, instalment of High Efficiency Deduster (HED) in existing power plants is the best option. On the other hand, if avoided damage is prioritized, a switch to non-emissive technologies within heat and power generation or shifting from lignite to gas (less damaging to public health, but still emissive) is the best option. Finally, if decision-makers prioritize largest possible emission reduction for PM2.5, an extension of cogeneration of combined heat and power (CHP) within the heat and power generation sector would be the best option.

Relevant policy instruments targeting the residential wood combustion sector relate to investment support and tax reductions for energy efficiency measures in the building sector, economic support to install retrofit ESP on existing stoves, economic incentives to promote a switch into solar and heat pumps. In addition to the three policy instruments analysed for the residential wood combustion sector, regulations to prohibit coal combustion and biomass certification are instruments that are recommended to reduce environmental impact from this sector.

In the second key sector, diesel road transport, policy instruments such as low emission zones, vehicle replacement programs and subsidies/tax reductions related to import of electric and/or hybrid cars are proposed and further discussed.

For the third key sector, heat and power generation, taxes and refundable changes on emission of air pollutants, SO2 and NOX are proposed to be implemented also a carbon tax, to correct the negative externalities of carbon emissions is proposed as an option. Additionally, implementing support schemes for district heating is proposed. A specific chapter in this study provides an overview of the options available for regulating district heating.

Finally, the study briefly discussed aspects related to improved air quality from a gender and social inclusion perspective. Women are in most cases the primary users of household energy, thus suffer more from indoor particulate matter, unsafe water resources as well as sanitation. In all three key sectors, taxes are suggested as a policy instrument. The gender analysis proposes that policy and decision makers should consider three main issues when it comes to implementing an environmental tax in Kosovo:

- The gender implication of the tax measure itself
- Gender implications of the tax policy package
- The gender implications of the outcome of the tax

Improvement of stoves are likely to bring positive benefits for women, as housekeeping is still often considered a women's domain. By providing targeted support to the installation of retrofit ESP it can give positive gender aspects within the residential wood combustion sector.

Imposing a tax on fossil fuel are likely to directly affect women due to income disparities between men and their socio-economic status. One suggestion is that any low-income tax credit could be increased in line with the tax rate to offset distributional impacts during the life of the tax. Another aspect within the heat and power generation sector relates to considering how any extra revenue, such as taxes and refundable charges on emissions is reinvested, and particular may benefit women.

Subsidies or tax reductions targeted import of electric or hybrid cars needs to be well-targeted, as households and individuals with higher incomes and a good financial situation can buy an electric or hybrid car without any subsidy or tax reduction. The study proposes increased subsidies that are targeted low-income households, which are mainly represented by women.

1. INTRODUCTION

Kosovo is a potential candidate country to the European Union. In 1999, a stabilisation and Association Process (SAP) was initiated with the aim of bringing the Western Balkan closer to the EU.

Kosovo has wide range of problems related to air pollution, including poor data management, and poor conditions for implementing measures to reduce these emissions. Funded by the Swedish International Development Agency (SIDA), the Swedish Environmental Protection Agency supports Kosovo's Environmental Protection Agency (KEPA) in the areas of water, climate, air and national parks within the project 'Environmental Capacity Building on Data Use'. Kosovo has made some minor improvements in the energy sector over the years, that can be related to energy efficiency improvements as well as gradually increasing investments in renewable energy. Following the energy crisis of 2021-2022, the government has in 2022 launched a new energy strategy for the Republic of Kosovo 2022-2031. Some of the main strategical objectives are to introduce at least two new energy related schemes for vulnerable consumers by energy efficiency programs, heating solutions and solar panels as well as to implement energy awareness information campaigns on a national scale.

Kosovo, as several other Balkan countries, faces serious problems with ambient air quality resulting in negative health effects across the population, for instance cardio-vascular and respiratory diseases, and premature mortality. Selection of measures to reduce emissions require substantial scientific basis for informed decision-making such as emission inventories and projections, emission modelling results, air quality measurements, data on the status of the emission reduction equipment, and implementation rates of different measures. Effective implementation of selected measures in practice would further depend on the policy context, i.e., on existing and planned policy instruments, willingness to harmonize the country's legislation with the EU legislation, appointed responsibilities and practical mechanisms for decision implementation, and prerequisites to introduce new policy instruments.

The project Environmental Capacity Building on Data Use in Kosovo, financed by Sida and scheduled for 2021-2024, is a collaboration between Swedish EPA and Kosovo EPA (KEPA) within management of water, climate, and air. This report summarizes the results of the air-component [1] (Component 4) related to this cooperation.

1.1 Aim and objectives

The feasibility study covered in this report, Air pollution in Kosovo, supports the overall environmental capacity building programme for Kosovo, led by the Swedish Environmental Protection Agency. The project aims to present a feasibility study that provides an overview of which sectors holds the largest efficiency potential in reducing greenhouse gas emissions and air pollutants. The study will also propose which tools Kosovo may use to prioritise measures for reduction. Ultimately, this study guides Kosovo in creating better living conditions and develop policy instruments targeted to reducing greenhouse gas emissions and air pollutants.

[1] See project document Specific Objective 4: Strengthened implementation capacity for environmental quality improvement measures

The overall aim of the project Environmental Capacity Building on Data Use in Kosovo is to contribute with capacity building support to KEPA, and the Ministry of Environment and Spatial Planning (MESPI) in Kosovo. It relates to the implementation of air quality improvement measures by reducing the domestic emissions and particularly to build on the implementation of Kosovo Environment Programme. The project is supposed to facilitate Kosovo's preparedness as a future EU member state to comply with Directive 2016/2284/EU reduction of national emissions of certain atmospheric pollutants (National Emission reduction Commitments Directive, NEC). To comply with this directive a member state needs comprehensive air quality plans and tools to mitigate emissions. The more specific aim of Component 4 is supporting implementation of measures, policies, plans and routines for reduction of emissions to air by making use of analytical tools. It will provide Kosovo with a better understanding of what key sectors mitigation is most feasible and what policy instruments that could be used.

For this reason, a feasibility study has been conducted by IVL Swedish Environmental Research Institute in close cooperation with the Swedish EPA and the operative partner organisations in Kosovo (KEPA and Balkan Green Foundation (BGF)). The study includes a short analysis of in which sectors in Kosovo it is most feasible, and effective to reduce, firstly, emissions of air pollutants and, secondly, climate emissions. The study comprises a cost-benefit analysis of separate proposed measures and future scenarios, where available. The analysis is done with respect to the Kosovo policy landscape and takes into consideration a range of policy instruments that can drive and facilitate practical implementation of effective measures in the future.

1.2 Structure of the report

In Chapter 2, the study presents current and future sources of air pollution in Kosovo and select key pollutants and key emitting sectors to focus on in the further analysis. Priority air pollutants are NOX, SO2 and particles (PM2.5, PM10). Key emitting sectors are:

A.Residential wood combustion
B.Diesel road transport
C.Heat and power generation

Chapter 3 presents the results of several future scenarios for target years 2030 and 2050. Each of the scenarios includes combinations of measures analysed in Chapter 3. Baseline scenario «business and usual», or Current Legislation (CLE) reflects the development with currently approved and implemented legislation. Maximum Technically Feasible Reduction (MTFR) scenario corresponds to the hypothetical situation when all the most effective measures are implemented to the highest possible extent (it is assumed that the measures are mostly of technical character – i.e., shift to better equipment, end-of-pipe solutions, or process changes). LOW and MID reflect two ambition levels to close the gap between CLE and MTFR. Green scenario goes beyond MTFR and explores possibilities to reduce emissions via structural measures such as shift to non-emissive energy sources. For each of the scenarios, the study presents corresponding health benefits and, as much as possible, technical costs of measures.

Chapter 4 contains an outline of the analysis of proposed measures (see Box 1) available to reduce emissions in the key emitting sectors. For each of the three key emitting sectors, a general overview of available measures is presented. For a range of measures, the study also presents an assessment of the current (around year 2020) emission reduction potential as well as relevant health benefits and were available technical costs and cost-effectiveness.

Chapter 5 contains a summary of the analysis of the proposed policy instruments, that are relevant for effective implementation of measures described in the previous chapter.

Chapter 6 discusses improved air quality from a gender and social inclusion perspective.
Discussion and conclusions are displayed in Chapter 7.

Box 1: Definitions of concepts "measure", "policy instrument" and "baseline scenario" used in the report.

Hereinafter we as much as possible try to distinguish between the concepts measure and policy instrument.

Measure is related to a solution to reduce emissions from certain sources. Beside technical solutions (end-of-pipe equipment, process modification), measures can be behavioural patterns (e.g., "burning right", "avoiding areas with congestion tax when driving") or of structural character (shift from burning fossil fuels to non-emissive sources such as electricity or H2). Implementation rates of measures within certain sectors usually can be easily quantified.

Policy instrument is a driving force for practical implementation of measures, often designed as a legislative act, an economic mechanism, or an information campaign, either promoting use of certain technologies and/or behavioural patterns or banning/restricting them.

Baseline scenario or business as usual scenario (BAU) describes the development of activities under the assumption that the current legislation is implemented, and no further actions are taken to reduce emissions.

1.3 Method, tools, and data sources

The analysis in this report was done in several steps and based on several underlying data sources. First, we analysed **current and future sources of air pollution** in Kosovo using as main information sources: a) the national emission inventory, b) certain results of JICA project (as in JICA, 2021), and c) emissions modelled as outputs from the main analytical tool used within the study – integrated assessment model GAINS (see Box 2). To obtain reliable and most up-to-date results from baseline scenario, certain modelling parameters were adjusted based on online consultations with national experts from KEPA, Balkan Green Foundation, and other organisations. Additional data was also provided by national experts via e-mail. As a result of the adjustments, we developed new, **project-specific (adjusted) baseline scenario**.

Box 2: GAINS model

GAINS (Greenhouse Gas – Air Pollution Interactions and Synergies) is an integrated assessment model, an extension of the RAINS (Regional Air Pollution Information and Simulation) model, originally developed within the UNECE Convention on the Long-Range Transboundary Pollution (CLRTAP) to identify and explore cost-effective emission control strategies for air pollutants (Amann et al. 2011). Later, the possibility to analyse greenhouse gas emissions and measures was included. The model is widely used as a unified tool for scientific analysis of economic and environmental consequences of air pollution abatement strategies and climate mitigation measures. With its broad database on abatement measures, and built-in emission dispersion parameters, GAINS enables analysis of emissions, costs and health and environmental effects for relevant policy scenarios.

Details on the GAINS model methodology are given in Annex 1.

To limit the framework of the study, selected **key pollutants and three key emitting sectors** were selected and discussed together with the national experts.

Following this step, a list of possible measures was complied, which in turn was set up to target emission reductions from three identified key emitting sectors. Subsequently, this step was followed by drafting a list of policy instruments that could stimulate implementation of those measures. Technical measures available in the GAINS model database were complemented by other possible measures mentioned as relevant for the three key emission sectors in a range of articles and reports. **A short qualitative overview of available measures and policy instrument**s was later on conducted, for which both analysis of the GAINS model database and literature review were used.

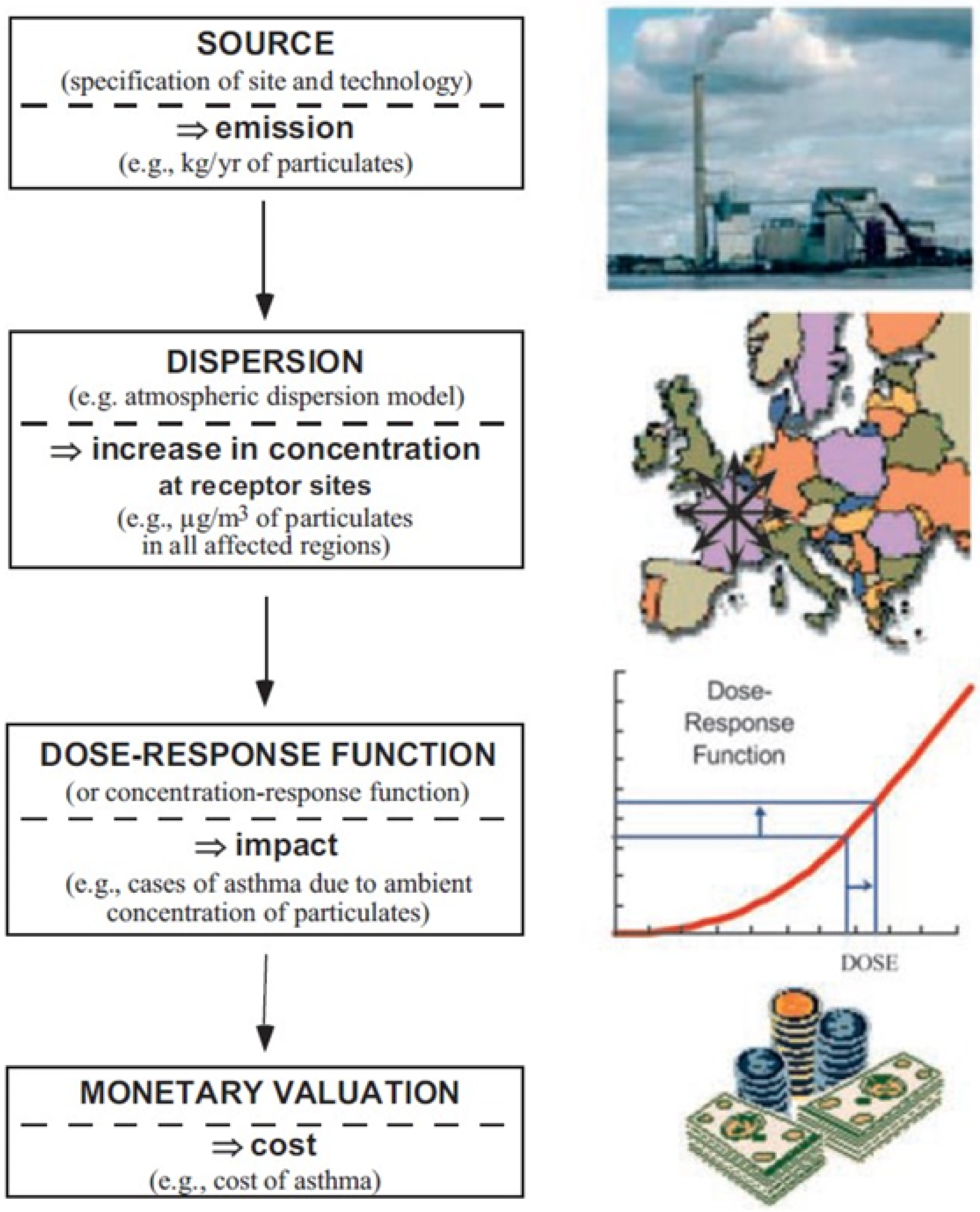


Figure 1: Overview of the Impact-pathway approach. Source: Bickel and Friedrich, 2005

Successively, **current emission reduction potentials of selected measures (in 2020)** were estimated and **related abatement costs** were calculated. Being able to calculate these costs for each measure, a maximum possible implementation rate is being used, and the difference between emissions/costs in this case and in the baseline was also calculated.

To further estimate corresponding **health benefits in monetary terms for analysed measures**, a so-called impact-pathway approach integrated into the GAINS model is used – see Figure 1. A user can define emission sources in the GAINS model; then, the model produces as outputs emissions and impacts on environment and health, as emission dispersion and resulting population-weighted concentrations of PM2.5 and ozone exposure at receptor countries are calculated with a pre-defined set of source-receptor coefficients, and a limited number of dose-response functions is also incorporated in the model.

In this study, premature mortality is used as the most significant health impact of air pollution[2]. Value of Statistical Life (VSL) is used as metric for monetary valuation of this impact. The same value is used in this analysis as in the Second Clean Air Outlook (Amann et al. 2020) – 3.6 million Euro in the currency year 2015. This value is adopted by OECD, 2012.

The described above quantitative analysis of emission reduction measures was done for each measure separately, and then we **ranked the measures** by their different characteristics (such as emission reduction efficiency, cost-effectiveness etc.) to facilitate for decision-makers in Kosovo choices based on different possible priorities.

Baseline scenario adjusted with the newest expert data was used as a starting point **to develop other scenarios for 2030 and 2050**. Four scenarios illustrating different levels of ambition to reduce air pollutant emissions were developed. Each of the scenario included a certain combination of measures analysed earlier, with different implementation rates. Measures to include in the scenarios were discussed and agreed with national experts during a workshop in Pristina during November 2022. The developed scenarios were then analysed in terms of emission reductions, technical abatement costs and health benefits – this was done in a similar way and with the same model as for separate measures.

The gender perspective analysis was conducted by IVL based upon an initial assessment made by Tripleline. Several meetings were held between KEPA, BGF, Tripleline and the Swedish Environmental Protection Agency on possible ways to include gender aspects into this study during the first half of 2022.

At all steps of the analysis, Kosovo operational partners were actively involved. KEPA and BGF provided valuable background information and references to the relevant data sources, answered questions, and clarified unclear aspects regarding the status of analysed measures and policy instruments, provided comments on the interim results during workshops, and reviewed the report draft. Swedish EPA contributed to the analysis by providing comments during monthly follow-up meetings throughout the project cycle.

[2] Premature mortality accounts for over 90% of the health impacts of air pollution (UNECE, 2022).

1.4 How to interpret these results

When reading this report, it is important to keep in mind the aims and objectives. The report provides an overview of three key sectors (residential wood combustion, diesel road transport and heat and power generation) and the reduction potential of air pollutants for each. The reduction potential is precisely that, potential, and the results presented are indicative. For each key sector, possible measures, and their potential to reduce emissions in each sector have been investigated. It should be noted that the measures and scenarios, across different levels of reduction ambitions, do not indicate the practical feasibility of implementing the proposed measures.

One measure might hold great reduction potential if implemented to 100%, but it might not be reasonable to expect implementation on that scale due to local constraints and conditions. However, knowing the full potential for each sector and measure can provide Kosovo with guidance on how to prioritise measures for reduction. The suggested measures in this report can be reviewed as a collection of alternatives in the toolbox for improving air quality and reducing emissions. It is more realistic to implement a combination of measures, instead of 100% implementation rate of one single measure.

2. DEVELOPING AN ADJUSTED BASELINE SCENARIO AND CHOOSING KEY SECTORS

This chapter is focused on the assessment of status of air pollutant emissions in Kosovo, including choice of pollutants and key sectors for further analysis.

2.1 Initial analysis of emission trends

To date, there are few studies measuring national-level emissions of air pollutants in Kosovo. The Kosovo Emission Inventory update (2021) provides quite detailed numbers for one specific year, namely 2018. The World Bank (2019) analyses historical emissions and future trends based on the GAINS modelling results obtained by IIASA (International Institute for Applied Systems Analysis). The last historical year in this report is 2015. Since then, IIASA has updated the baseline scenario assumptions. For assessment of the emission trends in the current report the study uses the latest publicly available baseline scenario developed by IIASA – Baseline from the scenario group Clean Air Outlook 2. This scenario contains data on development until the year 2050, and the closest year describing the current (2023) situation is 2020.

Air pollutants available for analysis in the GAINS model are SO2, NOx, NH3, NMVOC and PM (different fractions). Emission trends for these pollutants according to the IIASA's baseline scenario are illustrated in Figures 2 to 5, together with sectoral distribution of emissions in 2018 according to the Kosovo Emission Inventory update (2021). In the Kosovo Emission Inventory update (2021) the category 1) "industry" includes industrial processes, industrial combustion, and heat and power generation; 2) "small combustion" means residential combustion.

Most of current **PM2.5** emissions occur in the residential combustion sector. Industrial emissions as well as emissions from power and heating plants are also significant. Total emissions are expected to decrease after 2020, especially in the residential sector, see figure 2 below. The expected decrease assumes dedication from the government in implementing decided upon measures. It is important financing for this is secured in the budget, otherwise the decrease in emissions may diverge from these scenarios.
The lower panel in Figure 2 shows PM2.5 emissions according to the national emissions inventory for 2018. Thus, these indicate higher amount of PM2.5 emissions than the upper panel which is based upon IIASA's most recent public baseline.

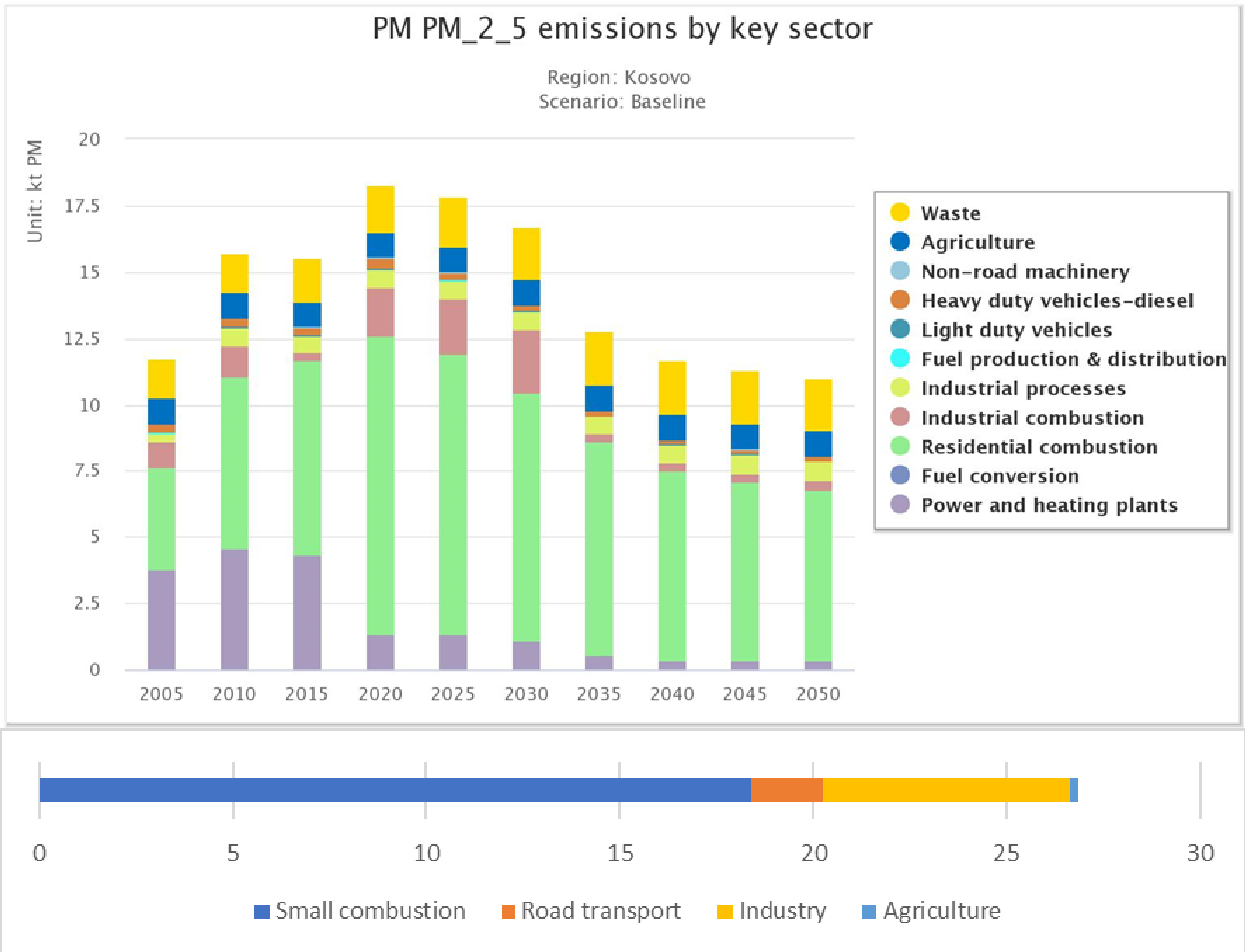


Figure 2: Baseline emissions of PM2.5 according to IIASA's most recent public baseline (upper panel), and according to the national emission inventory for 2018 (lower panel). Source: GAINS modelling

NOx emissions today mainly origin from diesel vehicles and from industries and power plants. Total emissions are expected to decrease after 2020, especially in the road transport and heat and power generation sector, while emissions from industrial processes are expected to increase, see figure 3.

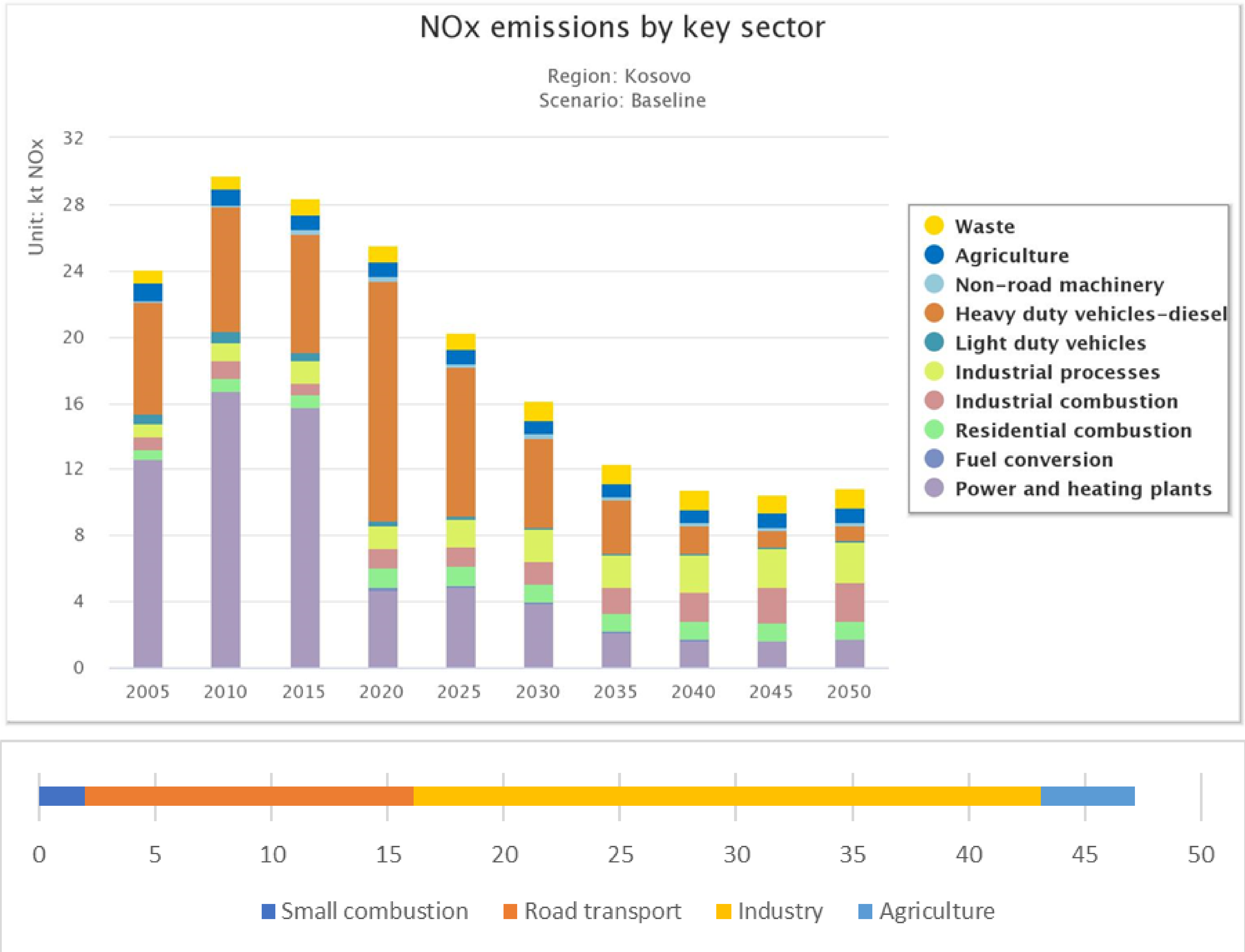


Figure 3: Baseline emissions of NOx according to IIASA's most recent public baseline (upper panel), and according to the national emission inventory for 2018 (lower panel).

Main sources of SO2 in Kosovo are power plants and industrial combustion. Viewed from a base scenario perspective it is expected that emissions could decrease between 2020 and 2035 but then increase again due to an increase in industrial combustion, see figure 4.

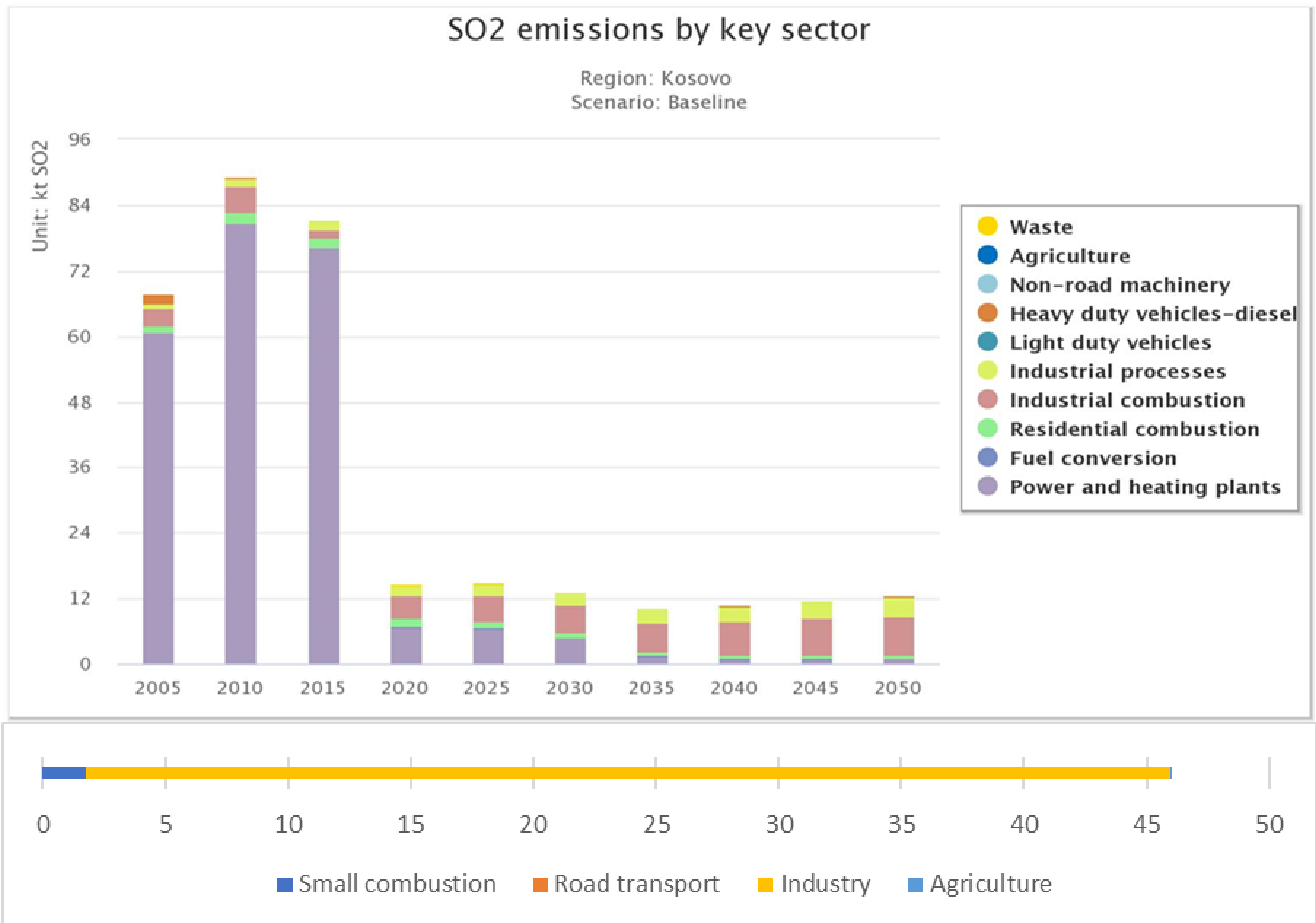


Figure 4: Baseline emissions of SO2 according to IIASA's most recent public baseline (upper panel), and according to the national emission inventory for 2018 (lower panel).

Most part of current **NMVOC** emissions occur in the residential combustion sector, followed by use of solvents and waste management. Total emissions are expected to gradually decrease after 2020, mainly due to decrease in the residential sector, see figure 5.

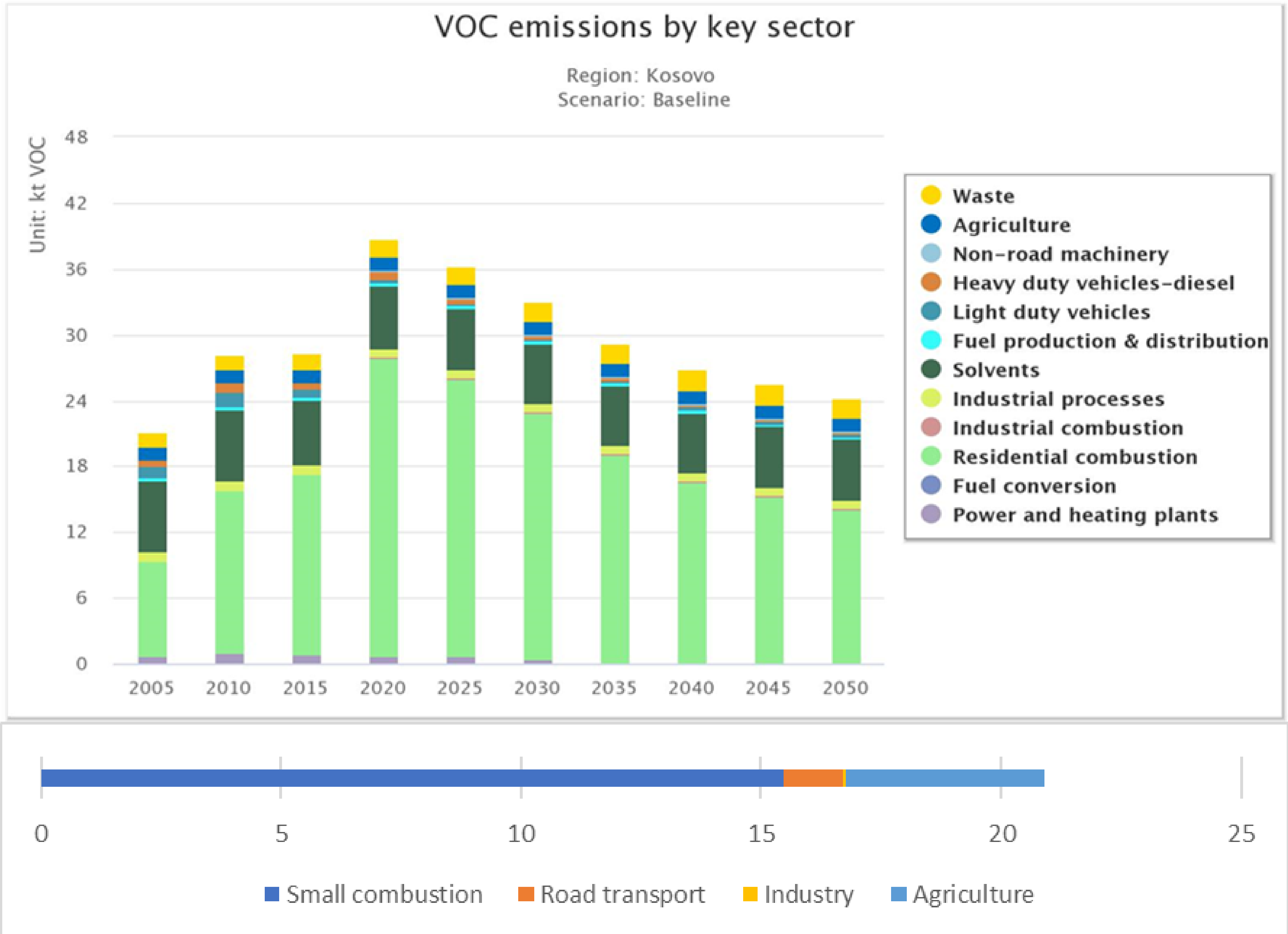


Figure 5: Baseline emissions of NMVOC according to IIASA's most recent public baseline (upper panel), and according to the national emission inventory for 2018 (lower panel).

Emissions of **NH3** origin almost entirely from agricultural sector, with small input from waste management sector. Emissions are supposed to slightly decrease by 2025 but then remain at virtually constant level, see figure 6. Kosovo Emission Inventory update (2021) does not provide values for ammonia emissions.

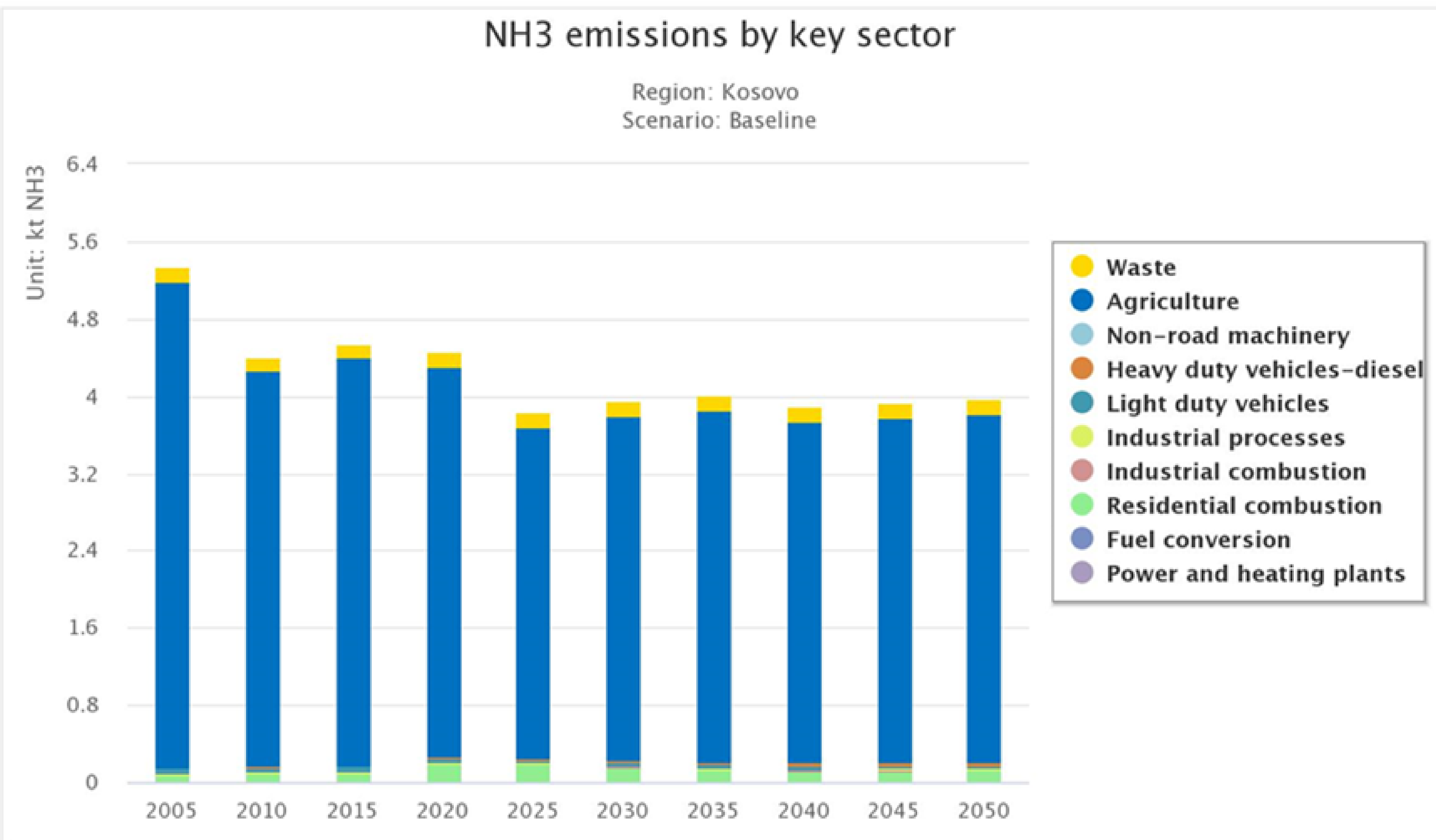


Figure 6: Baseline emissions of NH3 according to IIASA's most recent public baseline.

2.2 Key sectors and pollutants

Once the initial analysis was completed by making use of the assessment presented above across figure 2 to 6, and in cooperation with national experts, for further detailed analysis. Three key emitting sectors relevant for further analysis were selected, and is proposed by IVL Swedish Environmental Research Institute to be of main focus for Kosovo to reduce its emissions across the following key sectors:

- Residential wood combustion
- Diesel road transport
- Heat and power generation

The air pollutants that are of interest are PM2.5, NOx, SO2 and NMVOC.

Jointly with national experts, the initial IIASA's baseline was adjusted with respect to new input data provided by KEPA and Balkan Green Foundation and found in other sources such as JICA project final report (JICA, 2021) and within the Energy Balance 2020 provided by Republic of Kosovo, Ministry of Finance, Labor and Transfers (2021). The adjustments that have been made are listed in Annex 2.

The most significant discrepancies between the national data and IIASA's assumptions concern abatement and fuel use at large lignite power plants and data on the vehicle fleet (number of vehicles, fuel use, distribution of Euro standards for different vehicle categories).

Adjustments are made for the three key sectors and do not consider possible discrepancies between IIASA's and our assumptions in other sectors (e.g., industries, waste management, agriculture).

All the results from the GAINS-modelling presented below in Chapters 2.2, 3, 4 and 5 are based on the adjusted baseline scenario – **Kosovo_CL**

2.2.1 Residential wood combustion

Advancing sustainable development, thus creating a positive environmental impact in Kosovo requires that residential wood burning is being reduced, as it produces air pollutants and smoke that is harmful to the environment and for the inhabitants. In addition, continuous cutting of trees can lead to deforestation, which in turn can lead to release of carbon dioxide and other greenhouse gases.

The residential sector in Kosovo is a large source of PM2.5 and NMVOC emissions (Figure 7). In 2020, about 92 percent of the PM2.5 emissions and 94 percent of the NMVOC emissions originates from the residential sector due to wood combustion in heating stoves, according to the GAINS model. In Kosovo, this type of heating is very common.

Conventional wood stoves accounts for the largest share of wood stove types in Kosovo. In 2020, they accounted for 86 percent. Pellet stoves accounted for 9 percent and improved wood stoves with 5 percent, see figure 7 below.

One unit of Petajoule (PJ) is equivalent to almost the consumption of electricity for one domestic house. A standard domestic house consumes approximately 20,000 kWh per year, this equals 0.072 PJ (Energimarknadsbyrån, 2022; Convertunits, 2023).

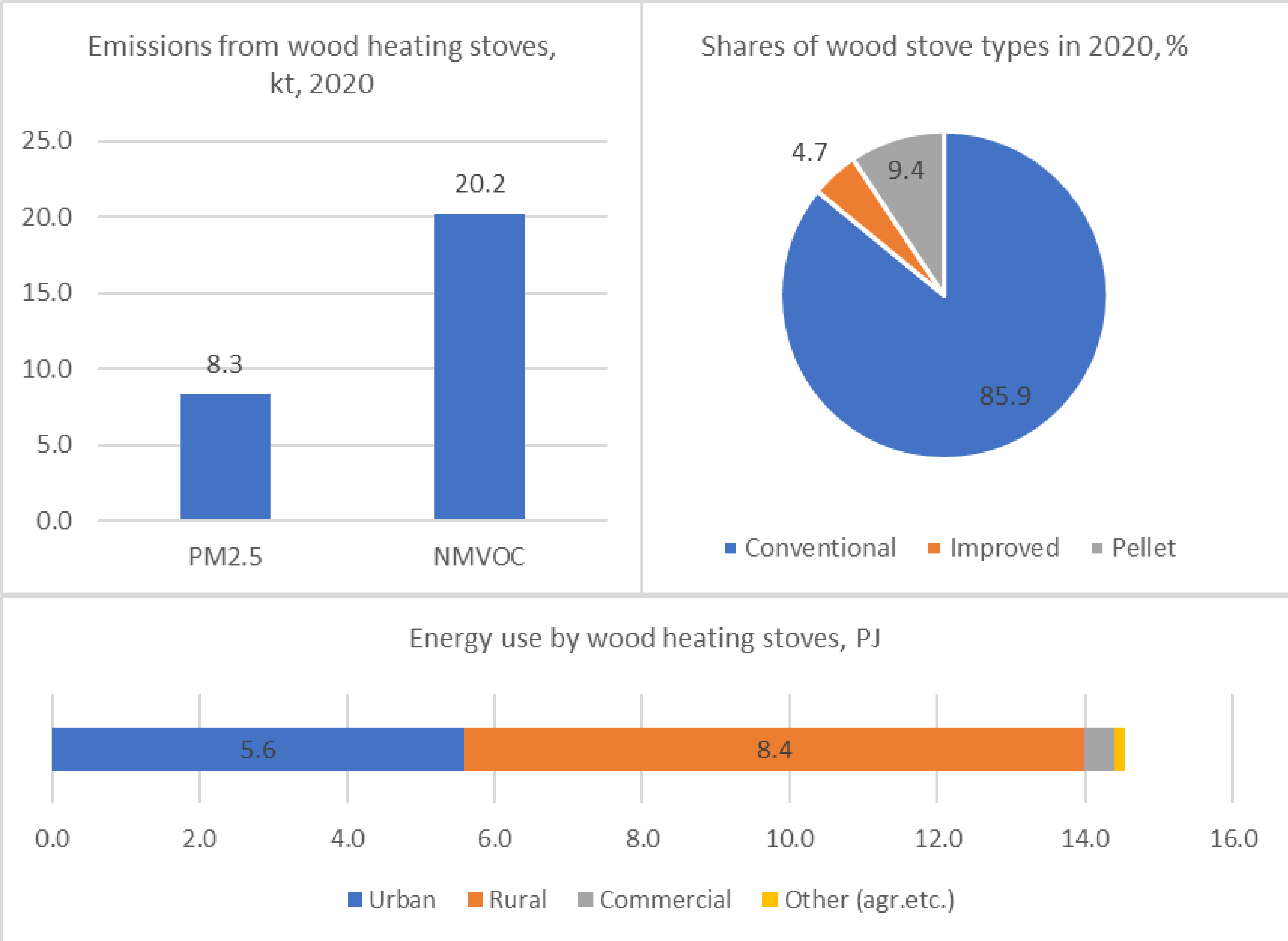


Figure 7: Use of wood heating stoves in Kosovo 2020, according to Kosovo_CLE.

According to Energy Balance Statistics compiled by Kosovo Agency of Statistics the quantity of consumed firewood in 2020 accounts for 376.93 ktoe. Compared to 2019 a decrease of 1.35 percent can be seen (Republic of Kosovo, Ministry of Finance, Labor and Transfers, 2021). Figure 7 shows that energy use by wood heating stoves in rural areas accounted for 8.4 PJ and urban areas with 5.6 PJ in 2020. Emissions from wood heating stoves (kt) have been estimated according to GAINS modelling to 8.3 Kt of PM2.5 and 20.2 Kt of NMVOC in 2020, see figure 7.

14.5 PJ of wood was combusted in the residential sector in 2020. Combustion happens mostly in the rural areas (58 percent while the contribution of urban combustion is 38 percent (Republic of Kosovo, Ministry of Finance, Labor and Transfers, 2021; Kosovo Emission Inventory update, 2021).

Most wood heating stoves are conventional, 5 percent are so called “improved” appliances (corresponding to the category “advanced” in the EMEP, 2019), and about 9 percent of the stoves are fuelled with pellets (Kosovo Emission Inventory update, 2021). There is thus significant potential for emission reductions from burning wood by gradual renewal of the appliances stock.

Shift from wood combustion to renewable energy sources (solar panels, heat pumps) and development of central heating network represent further emission reduction potential in the residential sector of Kosovo.

It should be mentioned that lignite combustion contributes to the emissions from this sector, too, and this contribution might be underestimated. It is legally forbidden for private actors to extract lignite, and no official sales statistics for the black market exist[3]. This lignite is therefore not accounted for in our (or IIASA's) baseline. With growing energy costs, however, the contribution of lignite burned at homes in the emissions can increase.

A report from 2016 (Kabashi et al 2016) indicates that central heating is fairly new in Kosovo. In Pristina an installed capacity of 140 MW is available, followed by Gjakova with a capacity of 38.6 MW, and finally in the city of Mitrovicë with a capacity of 8.3 MW. This covers only about 3 percent of the total heating demand in Kosovo.

The development plan presented measures to reconstruct and expand this district heating system. About 50 percent of Pristina heating steam plant potential is currently in use, as the infrastructure is not adequately developed to make use of its full potential (Republic of Kosovo, Energy Regulatory Office, 2022b). Gjakova heating plant is currently being reconstructed, with funding from the EU Commission and Switzerland, into a combined heat and power system fuelled by biomass instead of lignite. Mitrovica is currently closed. (International District Energy Association, 2021).

2.2.2 Diesel road transport

Kosovo's road transport is mainly fuelled by diesel with 86 percent, and gasoline accounts for 13 percent and a certain number of passenger cars running on LPG (Republic of Kosovo, Ministry of Finance, Labor and Transfers, 2021; JICA 2021). The energy balance 2020 does not consider the electrical cars that are present in the country.

Diesel road transport accounts for a large part of the country's total NOx emissions. Emissions from road transport was calculated using traffic measurements on national roads conducted by the Ministry of Infrastructure and vehicle register data. Other important air pollutants from this sector are PM2.5 and NMVOC (See figure 8).

[3] Personal communication with Balkan Green Foundation.

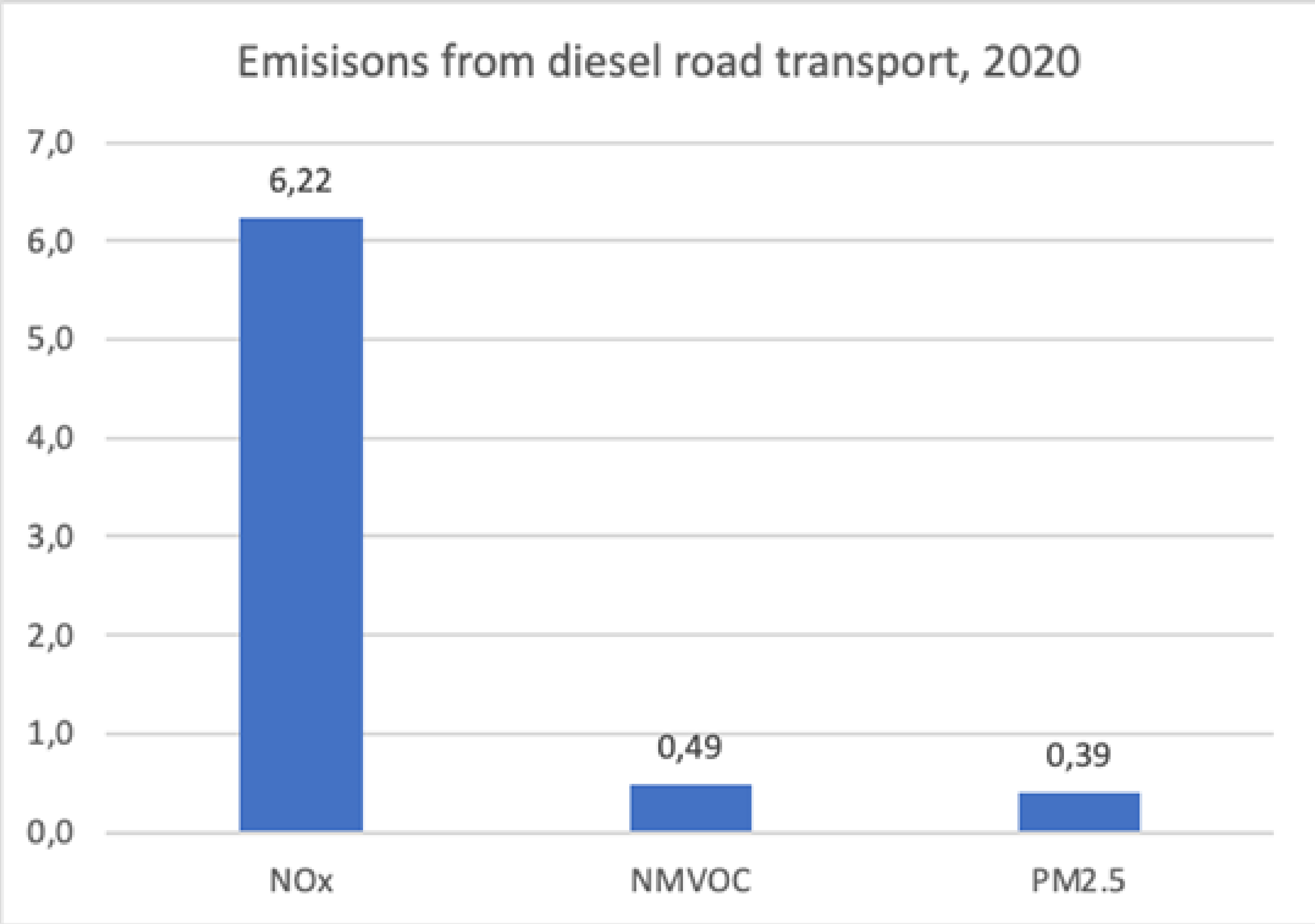


Figure 8: Estimations of emissions from diesel road transport (kt), 2020.

According to official transport statistics in Kosovo an increased share of registered motor and non-motor vehicles can be seen over the period 2011-2021. From 2020 to 2021, an increase of 11.4 percent can be seen (Kosovo Agency of Statistics, 2022). The average age of vehicles is over 18 years (Balkan Green Foundation, 2019). The inhabitants tend to buy used vehicles, as it is less costly compared to new ones. This results in a large share of vehicles with poor emission control in the Kosovo's total vehicle fleet – 14 percent of passenger cars lack control at all, and for heavy trucks this share is 26 percent. Most vehicles in both categories are of Euro 3, and the share of Euro 6 is very small – 2-3 percent (JICA, 2021; personal communication with KEPA), see figure 9 below.

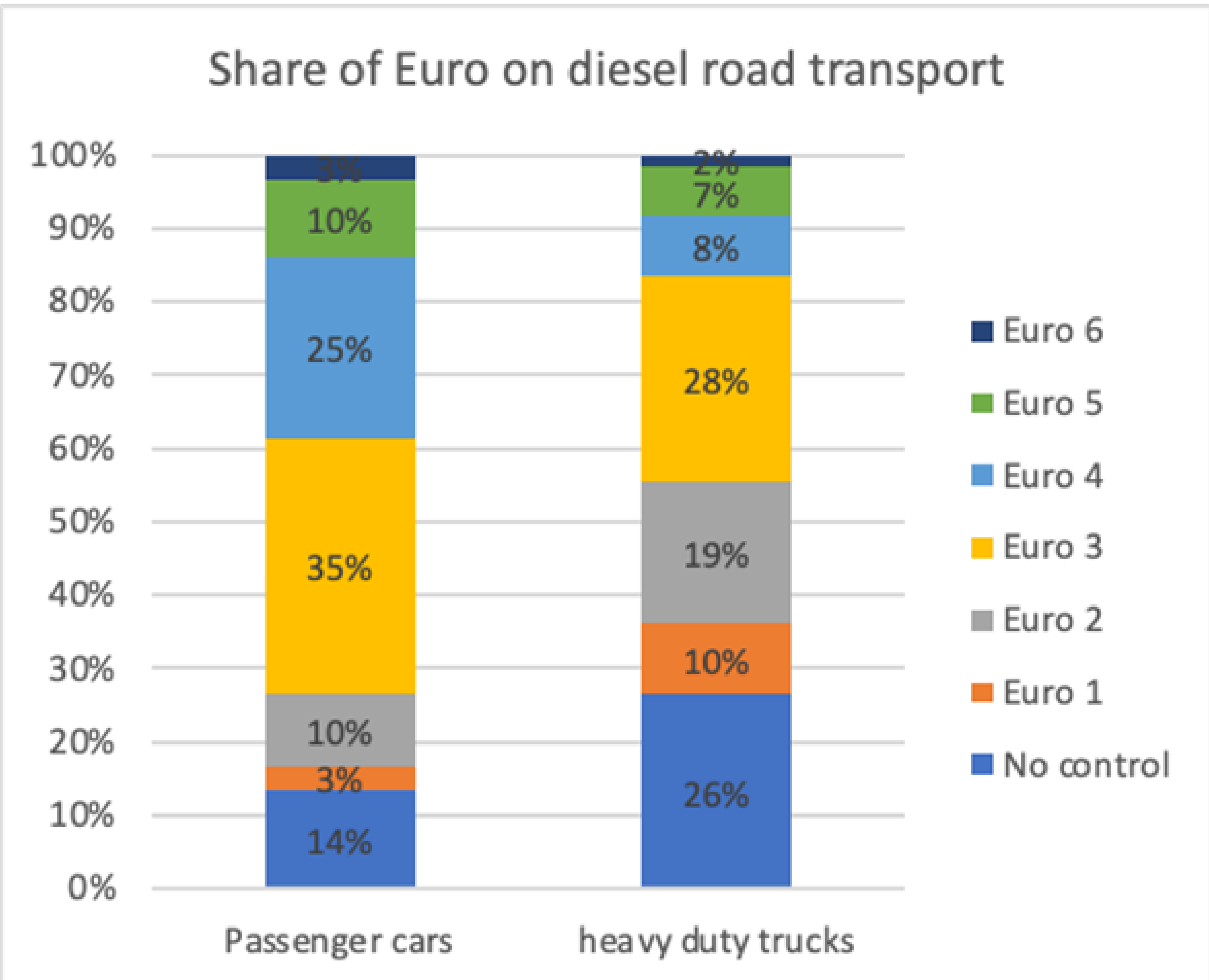


Figure 9: Share of Euro class on diesel road transport.

The traffic in Pristina and other cities was adjusted using traffic surveys conducted by JICA in Pristina. Emissions and energy use was estimated for the following vehicle categories: Passenger Cars (PC), Light commercial vehicles (LCV), Trucks – heavy duty vehicles (HDV) and Buses.

Figure 10 illustrates energy use by diesel transport (unit PJ) and here it can be seen that passenger cars accounts for 10.4 PJ, followed by heavy duty trucks with 2.4 PJ, heavy duty buses accounts for 1.3 PJ and light duty vehicles is estimated to 0.6 PJ.

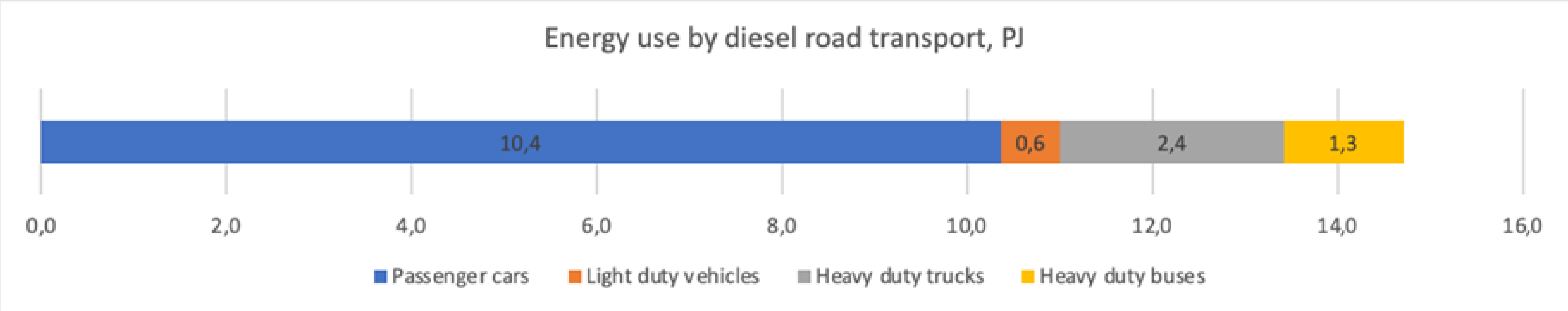


Figure 10: Energy use by diesel road transport, PJ.

A great potential can be seen by reducing the emissions from Kosovo's diesel vehicles by gradual renewal of its national vehicle fleet and shift to electric vehicles.

2.2.3 Heat and power generation

The annual energy balance (Republic of Kosovo, Ministry of Finance, Labor and Transfers, 2021) indicates that the electricity generation capacities in the country consists of three parts namely:

a)Power plants
b)Hydropower plants
c)Renewable energy resources (small HPPs, wind power plants and photovoltaic panels).

Kosovo has two coal-fired powerplants that are operated by Kosovo Energy Corporation (KEK). These two powerplants Kosova A and Kosova B are the main source for air pollutants. The corresponding emissions from both power plants are displayed in the figure 11 below. SOX accounts for 40.2 Kt, NOX with 36.8 kt and PM2.5 with 3.5 kt.

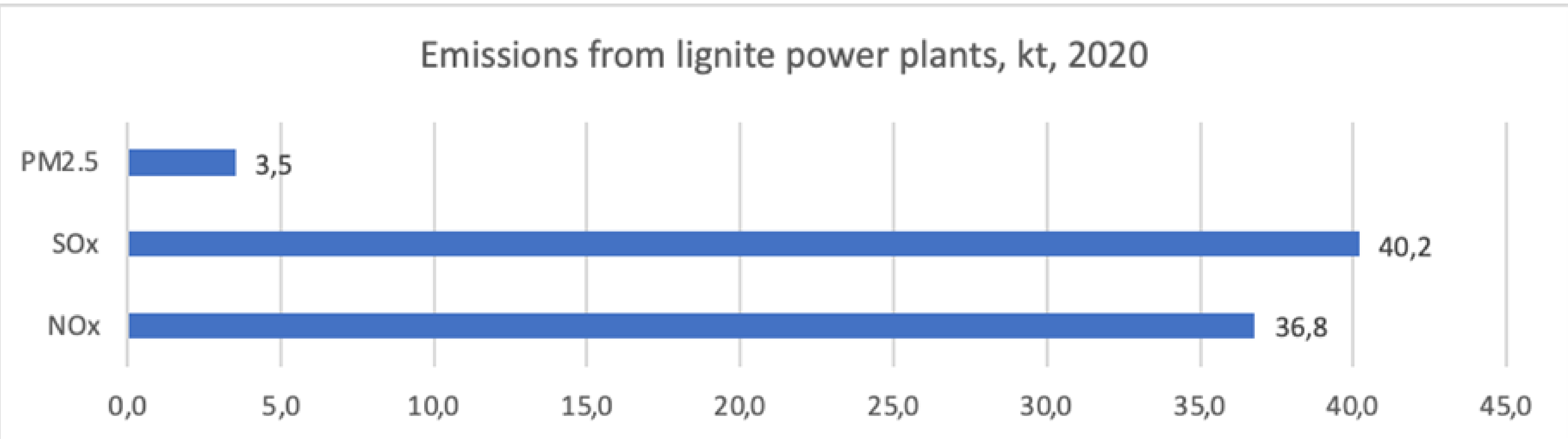


Figure 11: Emissions from lignite power plants, Kt, 2020.

In figure 12, energy use (in PJ) by lignite power plants is displayed. Kosova A used 29 PJ and Kosova B accounted for 41.3 PJ during 2020. Combined they produced approximately 25 PJ of electricity and 0.3 PJ of heat. The data includes district heating and is estimated according to GAINS modelling.

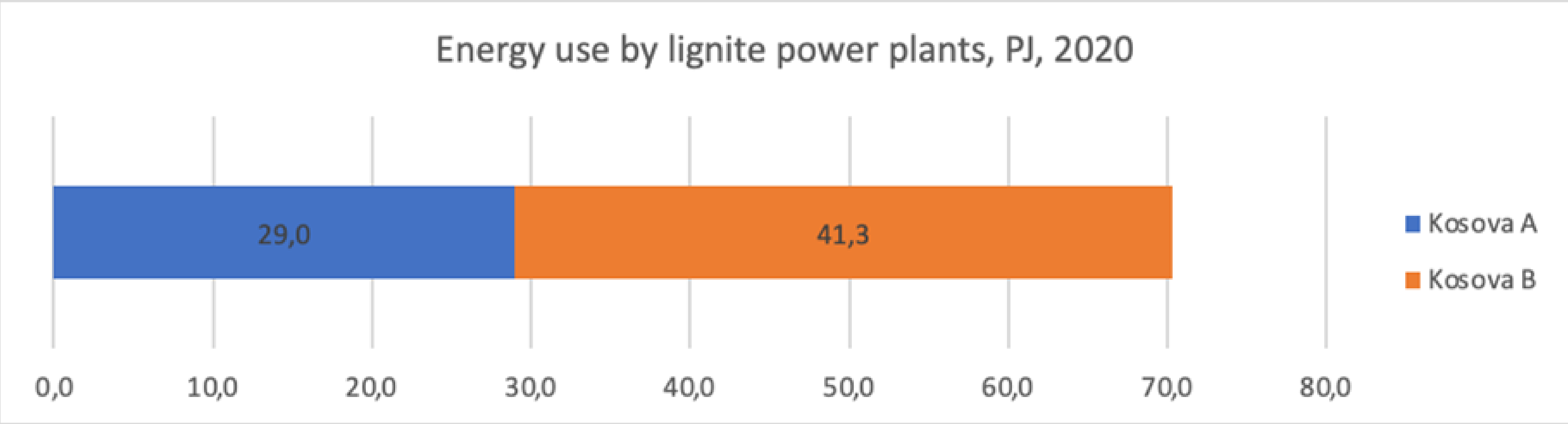


Figure 12: Energy use by lignite power plants, PJ, 2020.

According to the annual energy balance (Republic of Kosovo, Ministry of Finance, Labor and Transfers, 2021) other types of heat and power generation plants in the country include solar (0.06 PJ), wind (0.33 PJ) and hydropower (0.93 PJ), and centralized heat plants (CHP) (0.67 PJ).

2.2.3.1 Lignite power plants

Kosova A were built in the 1960s and Kosova B during in 1980s. There are reconstruction plans and power reallocation to build newer plants (World Bank, 2019).

It's expected that the new plant will have a higher efficiency than 40 percent and it will require about 40 percent less lignite coal in order to produce the current amount of electricity than Kosova A and 25 percent less than Kosova B. Estimations indicate that once the new Kosova plant is fully operational, carbon dioxide emissions, NOX and dust emissions will be reduced by 25, 3.8 and 20 times respectively, compared to the current emissions. The new plant is planned to produce both electricity and thermal energy. It will be connected to the district heating system in Pristina and enable its expansion, anticipating reaching about 20,000 consumers, in addition to the 13,500 customers that are currently supplied with heating through district heating (Yaramenka, 2022).

2.2.3.2 Renewable energy sources

As of today, the share of the renewable energy sources such as hydroelectric power, wind-generated power, photovoltaic power, etc. are still limited and are considered as only complementary energy sources to the electric power demand in Kosovo.

In 2020, hydro energy produced in hydropower plants was 22.26 ktoe. The amount of wind-generated electricity was 7.8 ktoe in the same reference year, similar amount as last year. Solar energy accounted for 0.38 ktoe in 2020.

According to survey results, households' energy consumption accounted for 0.37 ktoe in the same reference year[4].

2.2.3.3 Energy efficiency goals

Kosovo has in June 2022 in its Energy strategy 2022-2031 established a national goal of total share of renewables in the electricity consumption to 35 percent by 2031. Most part of this electricity is consumed within the residential sector (Balkan Green Energy News, 2022). The law on Energy Efficiency (see annex 8 for more details) contains goals on energy efficiency savings. The law encourages any financing schemes that contributes to the application of more energy efficient technologies.

3. SCENARIOS FOR KOSOVO 2030, 2050

By making use of baseline data from IIASA (International Institute for Applied Systems Analysis), a modelling tool by GAINS have been used to develop several scenarios in terms of the state of play of Kosovo's Air Pollution in year 2030 and 2050. Combination of proposed measures across the three key sectors are described and analysed in chapter 4.

3.1 Baseline

The baseline scenario describes the development of activities under the assumption that the current legislation is implemented, and no further actions are taken to reduce emissions – denoted as 'business as usual' scenario.

As previously described in chapter 2.2, IIASA's initial baseline scenario for 2020 was adjusted with respect to data obtained from national experts and from sources such as Kosovo' energy balance. For the scenario to remain consistent, relevant input data for year 2030 and year 2050 are adjusted as well. The main principles, assumptions, and underlying adjustments for the three key sectors are further explained in Annex 2.

The resulting **total emissions** in our baseline case (Kosovo_CLE) compared to the IIASA's initial baseline emissions are illustrated in the figure 13 below for the four major pollutants – SO2, NOx, PM2.5 and NMVOC.

The main differences can be seen for year 2020 for SO2 and NOx. The SO2 and NOx emissions are much higher in Kosovo_CLE since IIASA assumed NOx and SOx abatement at lignite power plants already by 2020, which has not been implemented.

[4] Source data: Hydropower data have been provided by KESCO, KOSTT and ERO. These data are based on the amount of electricity produced by the hydro power plants: HPP Ujmani, Cascade of Lumbardh (KELKOS), HCV in distribution network + WP + Solar, DIKANCE, Hydroline-Albaniku, RADAC, Burimi, Wind Power, HC Brod 2 "Eurokos- JH", LED LIGHT TECHNOLOGY, ONIX, Feti, HPP Brezovica.

In the baseline scenario, NOx abatement is supposed to be in place by 2030, while for SOx no abatement is assumed to be installed in the near future (by 2030). As for PM2.5 small reductions are expected in 2030 for the baseline case (Kosovo_CLE), where the trends display a reduction from 16,7 to 15,2 kt. For NMVOC, a similar trend can be seen, where the baseline case (Kosovo_CLE) in 2030 is expected to decline from 33 to 31 kt.

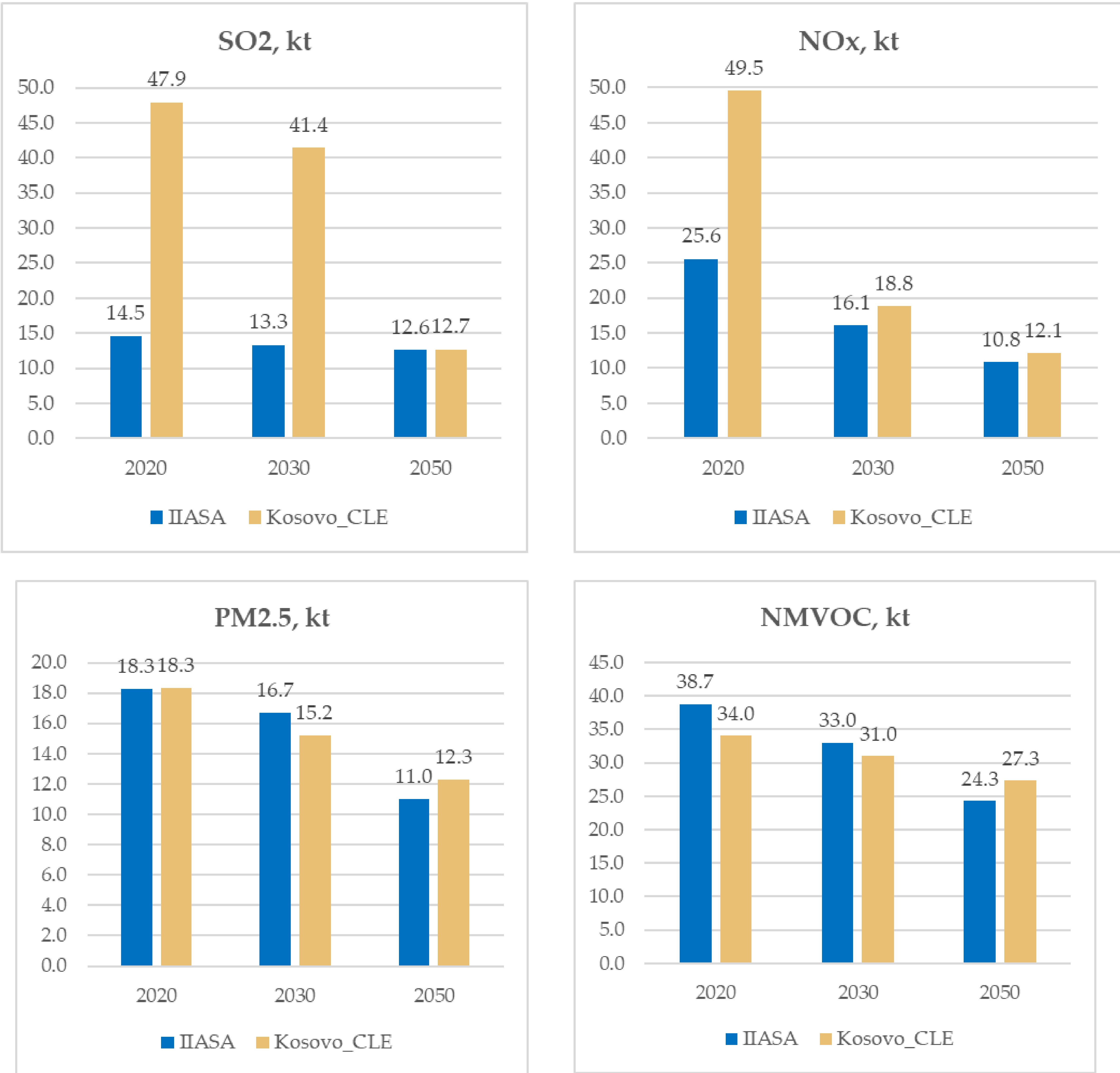
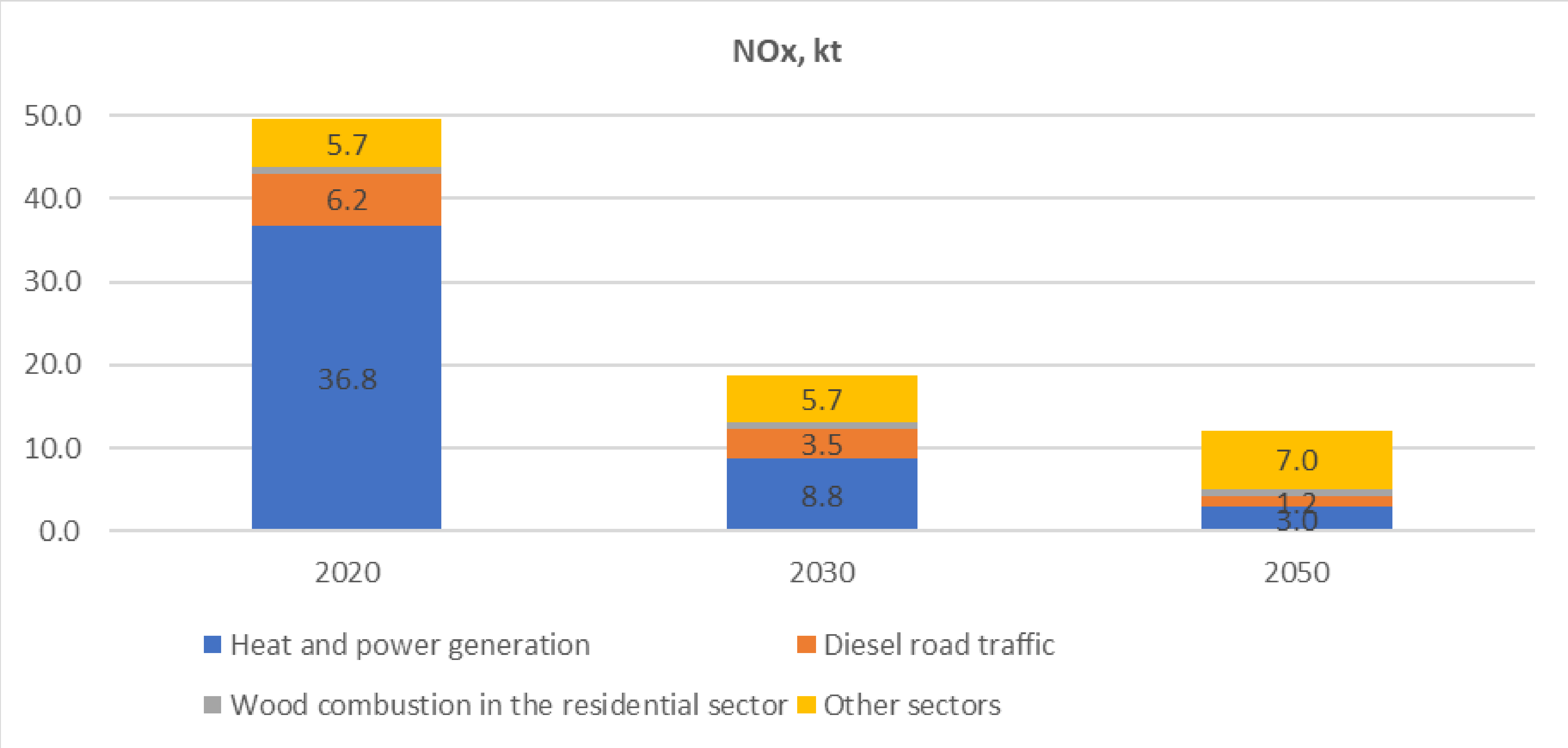
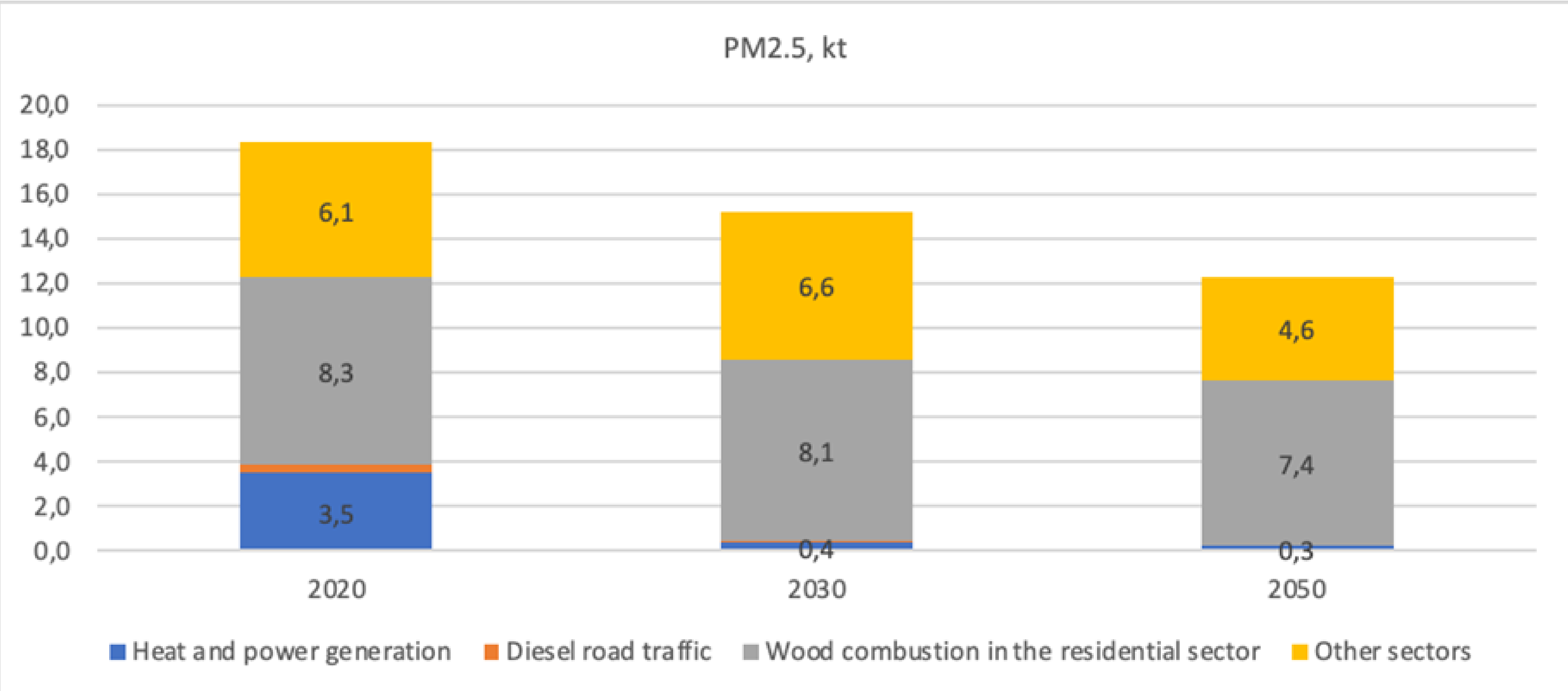


Figure 13: Baseline emissions of the main pollutants: IIASA vs. Kosovo_CLE.

The baseline emission trends across the key sectors are shown in figure 14 below. Emissions are expected to decline across all key sectors in the study, due to several technological shifts such as better abatement technologies at lignite power plants, reconstruction plans to build a new Kosova plant (see chapter 2.2.3.1 for additional details), gradual replacement of appliances in the residential sector and vehicles within the transport sector. The expected increase in other sectors, are related to an expected increase in industrial activities. However, these emissions are not of focus in this analysis.

Annual technical costs of new equipment in Kosovo are expected to increase from 132 million Euro in 2020 to 213 million Euro in 2030, corresponding to a 62 percent increase. Looking at the scenarios for year 2050, the increase is 145 percent and annual technical costs of new equipment accounts to 322 million Euro. However, these amounts do not include expenses related to structural changes such as fuel shifts.





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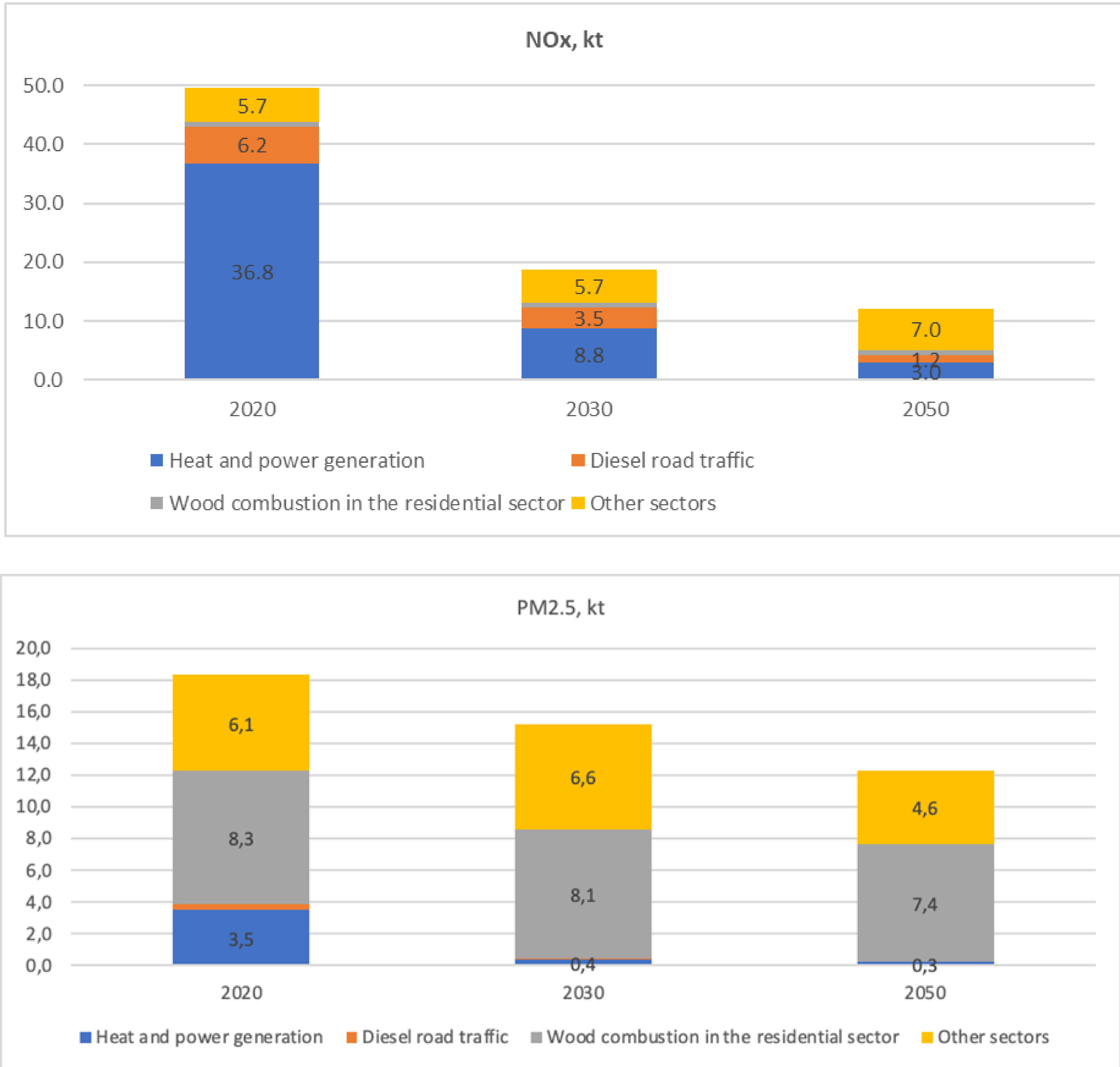
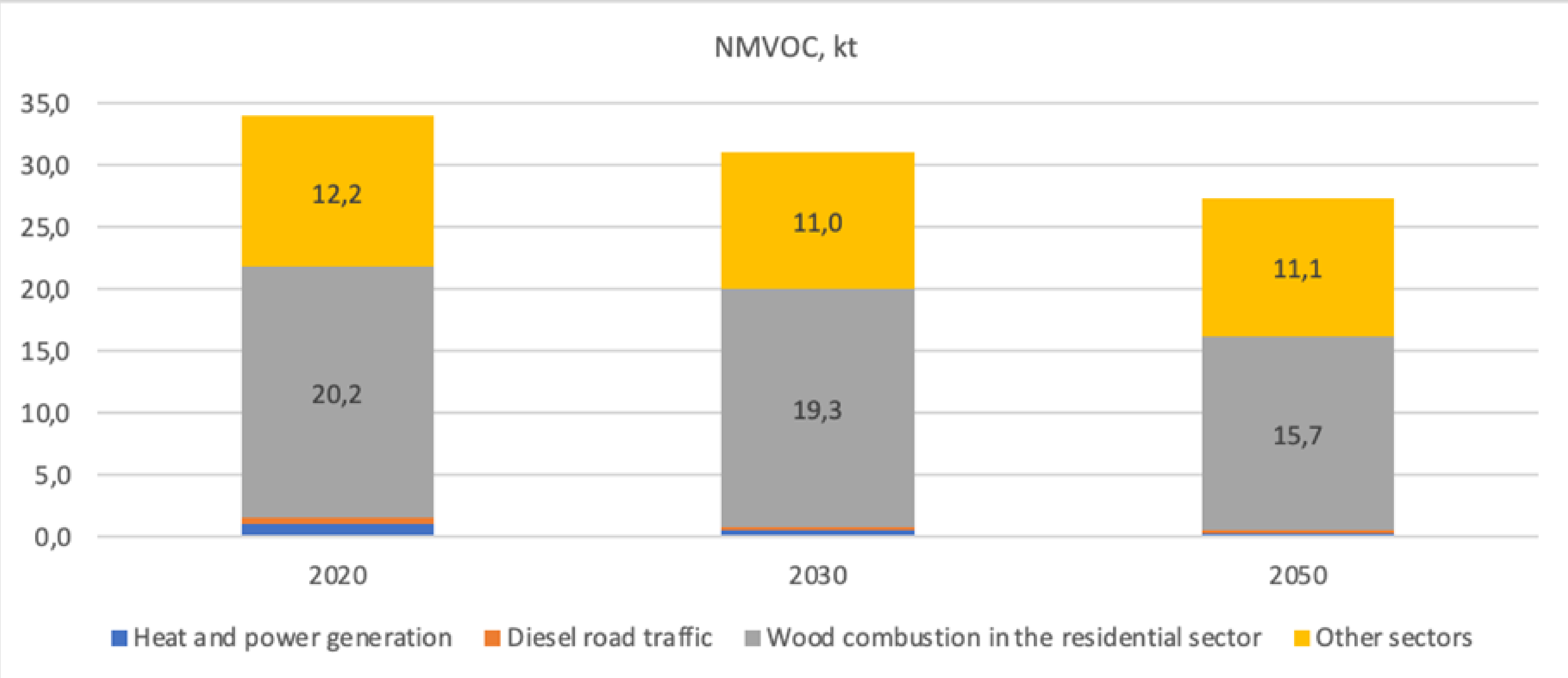


Figure 14: Baseline emissions across the key sectors in Kosovo_CLE.

Reduction of emissions implies that individuals' health will improve as well. Health related benefits (costs of avoided premature deaths) due to measures implemented between 2020 and 2030, 2050, according to the baseline scenario, are illustrated in figure 15 below. These benefits cover trans-boundary effects that are supposed to be reached by joint emission reduction efforts of all European countries.



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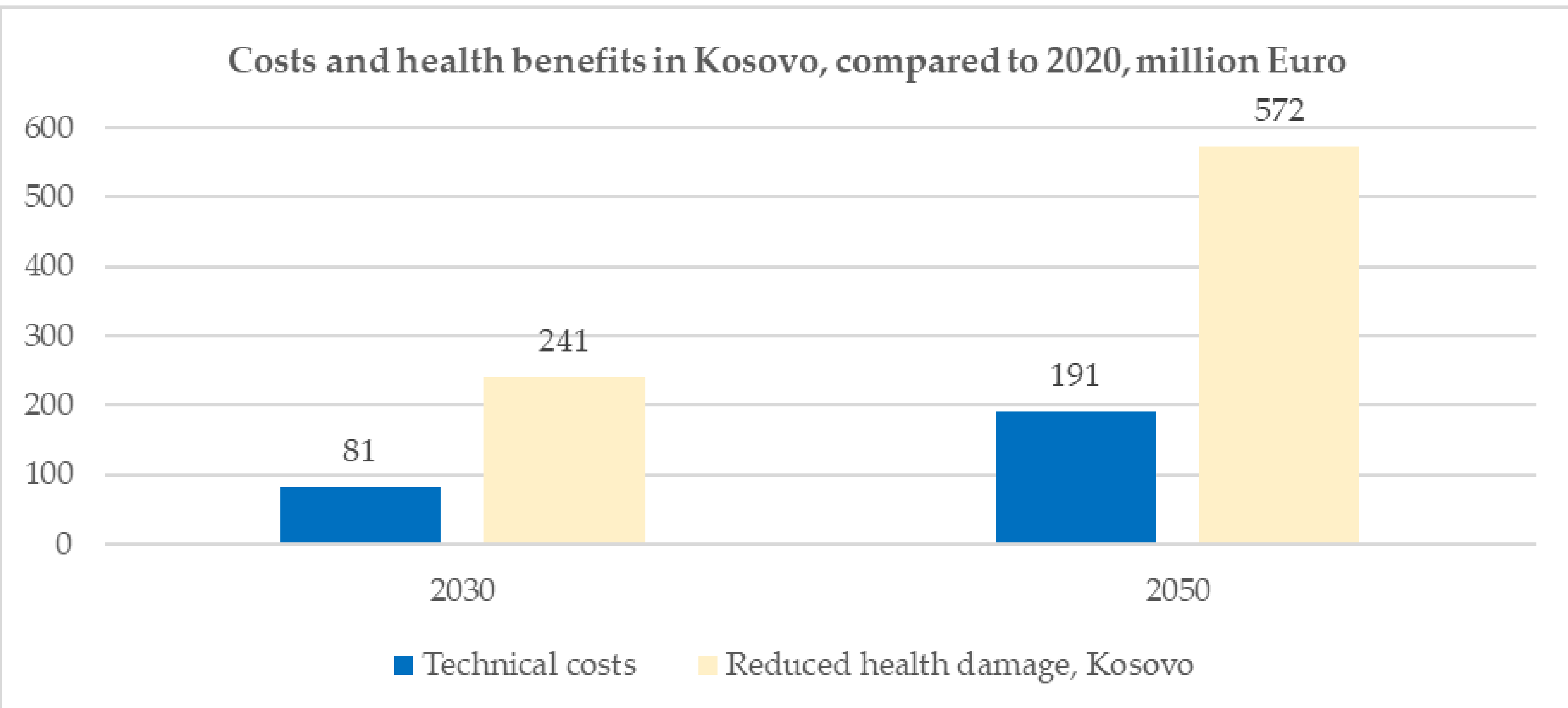


Figure 15: Costs and health benefits of air pollution measures in place in 2030 and 2050, compared to 2020, according to baseline (Kosovo_CLE).

3.2 Scenarios with additional measures

Four scenarios have been developed with proposed measures in the three key sectors beyond measures implied by current legislation:

- **Low** (low ambition level regarding emission reductions)
- **Mid** (medium ambition level regarding emission reductions)
- **MTFR** (maximum technically feasible reduction) – the most ambitious scenario with technical measures only (no fuel shifts included)
- **Green** – scenarios with replacement of fuel combustion with non-emissive energy sources

It should be noted that these four scenarios, across different levels of ambitions does not indicate the practical feasibility of implementing the proposed measures discussed in chapter 4. For example, new improved pellet stoves are further discussed in chapter 4.

All details related to the four scenarios can be seen in Annex 3. This Annex 3 illustrates how selected measures are combined with these scenarios, across various stages of implementation and year 2030 and 2050, respectively.

3.2.1 Scenario definition

Low scenario implies the same abatement level in the residential sector as in the baseline but certain energy efficiency improvements in the sector (20 percent less energy demand), low emission zones in four large cities, higher level of NOx and SO2 reductions at existing lignite power plants, and higher level of NOx and particle control at new biomass plants (CHP).

Mid scenario implies higher implementation rates of new, improved and pellet stoves. In 2030, it is also assumed that a certain share of existing heating stoves uses retrofit ESP to reduce particles. Instead of energy efficiency measures to reduce energy consumption by residential sector, this scenario assumes extension of the central heating system. For the transport sector, the scenario implies partial shift from road to railway goods transport, and higher rate of Euro 6 vehicles than in the baseline and Low scenarios. Abatement in the heat and power sector is assumed to be better than in the Low scenario but below the level of MTFR.

MTFR scenario means that all technical measures are set to the maximum implementation rates – this is rather unrealistic situation, and scenario is meant to assess the emission reductions potentials in the key sectors rather than to be used as direct guidance for relevant policy actions. In this scenario, all wood heating stoves are those on pellets with ESP, all cars are of Euro 6 already in 2030, and all power plants (including CHP) are equipped with the most effective abatement technologies for NOx, SO2 and particles.

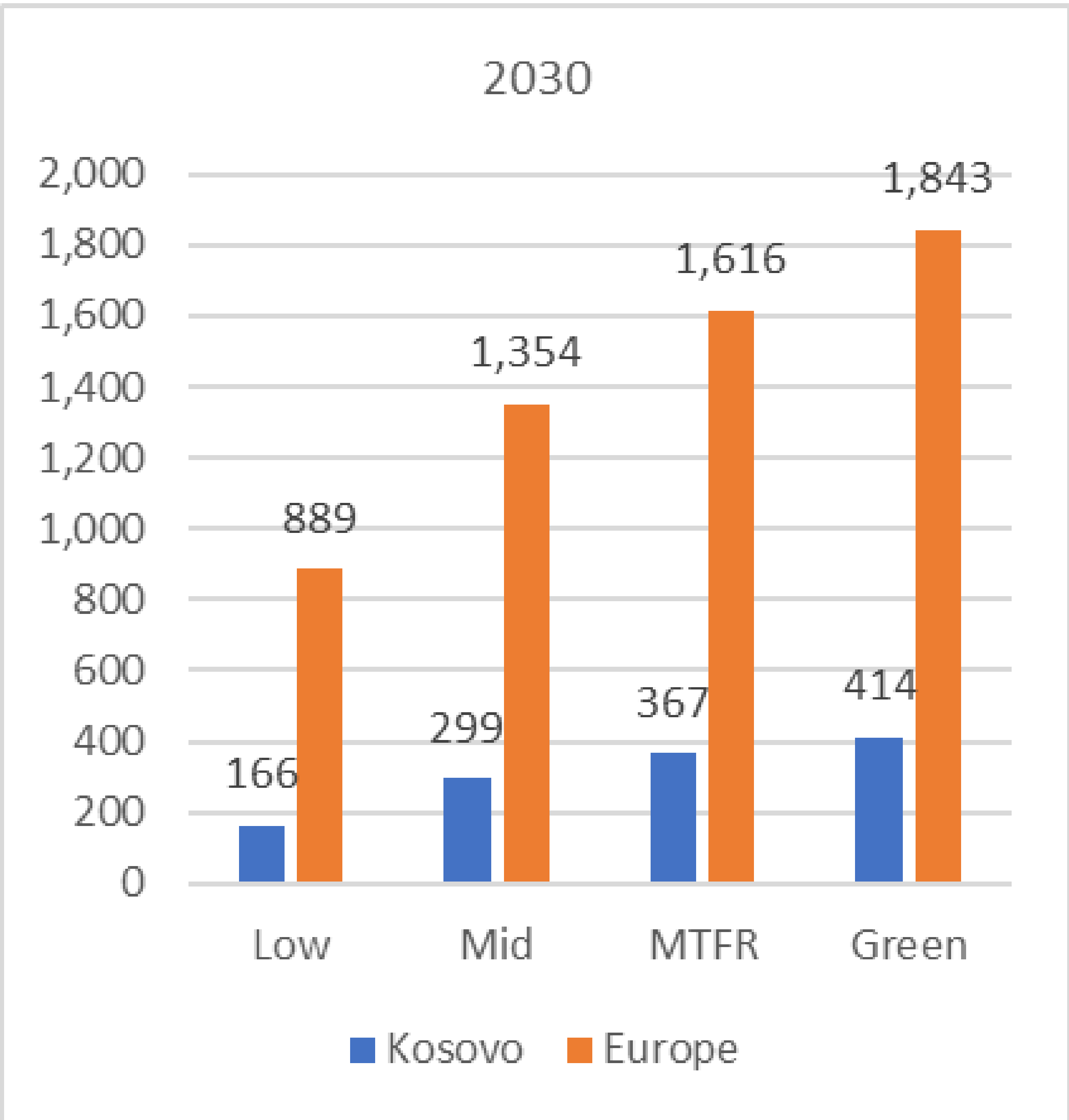
The details for Low, Mid and MTFR scenarios are presented in Annex 3.

Green scenario implies that lignite-based power plants are replaced with e.g., hydro-energy, nuclear energy, and other non-emissive sources; wood combustion in the residential sector is replaced by solar panels and heat pumps, and diesel vehicles are replaced by electric vehicles. This is also rather unrealistic scenario that, however, gives an estimate of emission reduction potential if fuel shifts are considered.

3.2.2 Emission reductions and health-related benefits

Annex 4 illustrates scenario-specific emissions in year 2030 and 2050. The potential emission reductions based upon only technical measures in year 2030 are estimated to 5.1 kt NOx (difference between baseline and MTFR emissions). For NMVOC it is 19 kt (fuelwood heating stoves) and 8.2 kt PM2.5 (fuelwood heating stoves).

Figure 16 illustrates reductions of health-related damage, compared to the baseline. The analysis shows that the benefits for Kosovo in year 2030, range between 166 million Euro with the Low scenario to 414 million Euro with the Green scenario. Once mortality figures across all of Europe is incorporated within the model, the results range from 889 million Euro to 1843 million Euro. In 2050, the comparative damage reductions in the considered scenarios are lower due to many of emission reduction measures are already included in the baseline scenario.



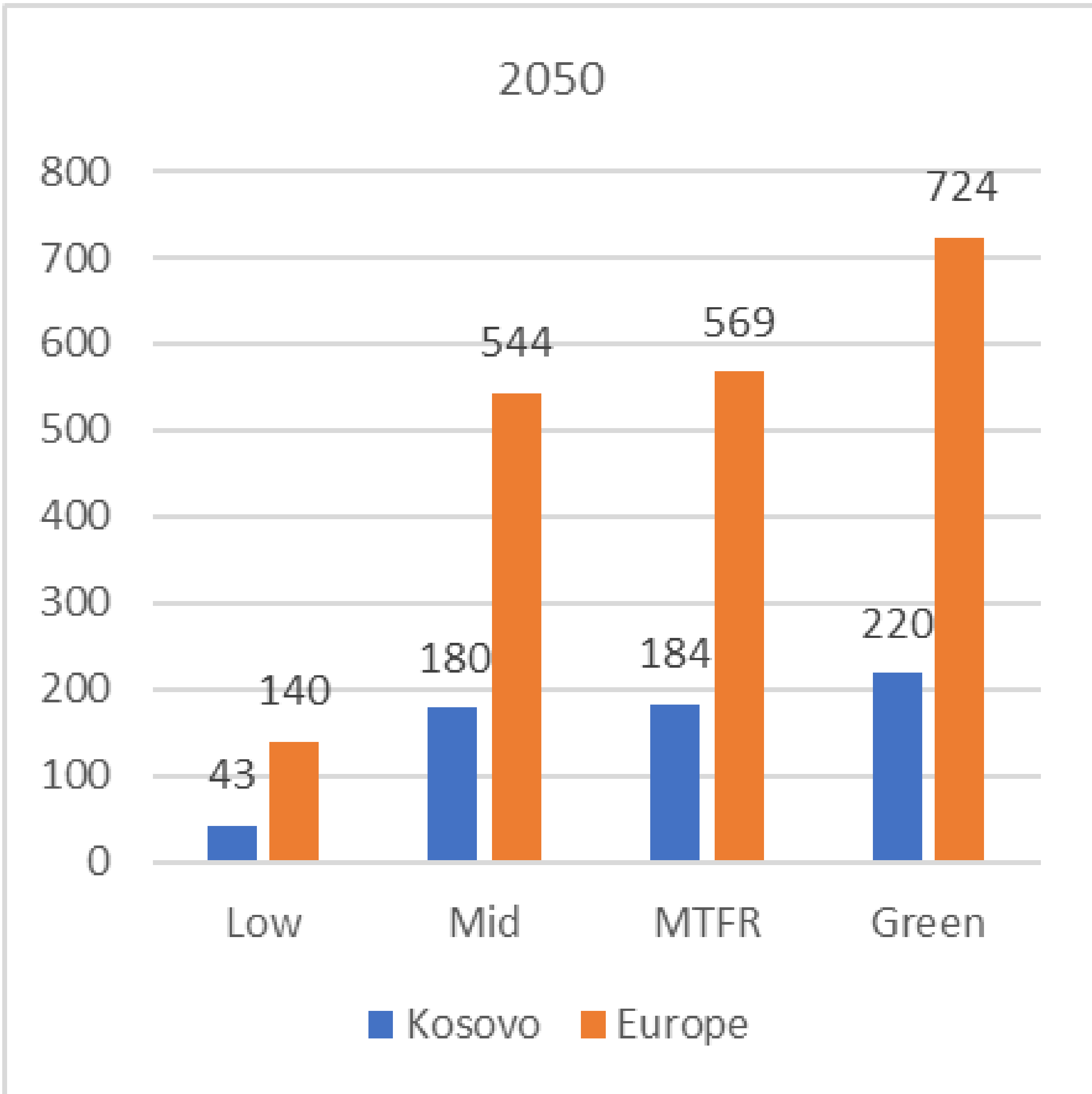


Figure 16: Scenario-specific reductions of health-related damage in Kosovo and entire Europe, million Euro2015.

3.2.3 Abatement costs

The GAINS model does not contain expenditure data related to all measures considered above and included in the scenarios. In particular, there is not enough data to calculate costs of insulation measures to improve energy efficiency in the residential sector or the costs of introduction of low-emission zones in large cities. From several developed scenarios, it is only possible and reasonable to compare costs between Baseline and MTFR scenarios as those two only differ by the implementation of abatement technologies whose costs are available in the model.

Table 1 summarises total costs for abatement of emissions with technical measures (specified in Annex 3), in million Euro2015. For other measures (italic in Annex 3) included in scenarios, costs are not directly available. The most expensive measures are measures within the residential sector – replacement of wood heating stoves with pellet stoves equipped with ESP.

Table 1: Summary of total costs for abatement of emissions across different scenarios (million Euro2015)

2030	Type of costs	CLE (baseline)	Low	Mid	MTFR
Heat and power generation	Technical measures, large lignite plants	35	77	97	118
	Technical measures, CHP	0.2	0.3	3[5]	0.5
	Other measures	-	-	Extension of central heating system (N/A)	-
Residential wood combustion	Technical measures	51	41[6]	117	460
	Other measures	-	Energy efficiency improvements (N/A)	-	-
Diesel road transport	Technical measures	118	121	105	139
	Other measures	-	Low emission zones (N/A)	Goods to railway[7] (N/A)	-
2050	**Type of costs**	**BL**	**Low**	**Mid**	**MTFR**
Heat and power generation	Technical measures, large lignite plants	30	32	39	42
	Technical measures, CHP	1	2	7	3
	Other measures	-	-	Extension of central heating system (N/A)	-

Residential wood combustion	Technical measures	104	83	85[8]	544
	Other measures	-	Energy efficiency improvements (N/A)	-	-
Diesel road transport	Technical measures	177	177	172	177

4. MEASURE INSTRUMENT TOOLBOX FOR KEY SECTORS

The results from the GAINS baseline indicated the key sectors and related pollutants to be further analysed for Kosovo were outlined in chapter 2.2. This chapter outlines proposed measures relevant for emission reduction in these three key emitting sectors in Kosovo, including quantified analysis of certain measures (Chapter 4.5) with assessments of current emission reduction potentials, technical abatement costs, and health-related benefits. See Annex 6 for additional details.

4.1 Measuring the impact of air quality in three sectors

Proposed measures or indicators of the impact of air quality and instruments to collect and analyze data have been identified for three key sectors in Kosovo:

- Residential wood combustion
- Diesel road transport
- Heat and power generation

For each of the three key sectors, possible scenarios for 2030 and 2050 were discussed in the previous chapter. Based upon these scenarios, proposed measures are discussed within this chapter.

The measures or indicators selected for further analysis are presented in the table below and are in the next chapter 5 divided into three levels of ambition: LOW – MID or GREEN. See table 2 - Matrix overview of key sector and related policy instruments.

[5] Higher than in MTFR as extension of central heating system (with shift from residential combustion to heat and power generation sector) implies higher activity data that technical abatement measures are applied to (relevant also for 2050)
[6]Lower than in CLE as energy efficiency improvements imply lower activity data that technical abatement measures are applied to (relevant also for 2050)
[7] Lower than in CLE as shift of goods from diesel trucks to railway implies lower activity data that technical abatement measures are applied to (relevant also for 2050)
[8]Lower than in CLE as extension of central heating system (with shift from residential combustion to heat and power generation sector) implies lower activity data that technical abatement measures are applied to (relevant also for 2050)

Table 2: Overview of key sectors and related measures

KEY SECTORS	MEASURES
Residential wood combustion	• Enhanced replacement of conventional stoves with advanced and new stoves, or pellet stoves • Retrofit ESP on existing stoves • "Right burning" practices • Energy efficiency improvements in buildings • Reduced burning in urban areas • Replacement of fuelwood stoves with non-emissive heating technologies
Diesel road transport	• Replacement with newer Euro standards • Less emitting fuels • Retrofitting with particle filters • Proper inspection and maintenance • Reduced diesel transport • Modal shift • Replacement of diesel with other fuels
Heat and power generation	• Emission control technologies at large power plants • Shift from lignite to gas or non-emissive energy generation technologies • Energy efficiency improvements at large combustion plants • Extension of district heating systems

4.2 Residential wood combustion

The following sub-chapter provides an overview of proposed measures targeting emissions from the residential wood combustion sector. Initially, measures related to replacement of conventional stoves, retrofitting of existing stoves and right burning practices is discussed. It is followed by a section related to energy efficiency improvements in buildings, reduced burning in urban areas, replacement of fuelwood stoves with non-emissive heating technologies.

4.2.1 Measures in the residential sector

Emissions from small-scale burning depend on several factors, including the type and quality of fuel used, the type of appliance and user practices.

Measures to reduce emissions from residential wood combustion can be divided into two categories: Reducing emissions from combustion through technological or behavioural measures and avoiding combustion. The first three measures described below belongs to the first category whereas the following three measures belongs to the second category.

4.2.1.1 Enhanced replacement of conventional stoves with advanced and new stoves, or pellet stoves

Substantial emission reductions can be achieved by replacing old, conventional stoves with more advanced stoves designed to provide better combustion, and thus prevent formation of carbonous substances. Poor combustion conditions may result in substantially increased emissions and can be the result of appliance design, as well as user practices.

Homogenous fuels, such as wood pellets, result in lower emissions than for example wood logs. Replacing stoves designed for wood, coal, or lignite combustion with pellet stoves will therefore reduce emissions. The extent of the emission reduction depends on the stove technologies and fuels in question, as well as user practices.

In the GAINS model, fuelwood stoves are divided into three types – conditional, improved, and new. While conditional stoves have simple grate-based firebox design with usually only primary air supply and no heat store components, improved stoves have secondary air supply and heat storing components in the firebox construction resulting in higher (improved) combustion performance. New stove is the most advanced stove type on the market where firebox, construction and airflow characteristics optimize combustion efficiency. New stoves can be equipped with ESP that further increases emission removal (Klimont et al., 2017).

The EU Ecodesign Directive regulates emissions from new stoves and boilers in EU member states. As old stoves are replaced with new ones, the gradually updated appliance stock results in reduced emissions.

4.2.1.2 Retrofit ESP of existing stoves

Installing ESP (electrostatic precipitator) on existing stoves removes some of the particles, including soot, from the flue gas. It is a cheaper alternative to replacing the entire appliance with an advanced or new type of stove.

The ESP is installed either in the flue gas pipe or on top of the chimney and consists of an electrode that makes flue gas particles negatively charged. These negatively charged particles are then attracted to the walls of the flue gas pipe or chimney and form larger flakes. These flakes must be removed manually or automatically. The higher the voltage of the ESP electrode the more particles are charged and deposited on the walls. However, too high voltage may result in a spark discharge (electric arc) forming between the electrode and the walls. At spark discharges, the ESP briefly switches off the current, and the removal efficiency decreases. (Janssens et al, 2020)

The emission reduction efficiency of ESPs has been studied with varying results. Brunner et al. (2017) observed >83 percent TSP reduction efficiency for wood boilers whereas Vicente et al. (2022) observed a 29 percent reduction efficiency for a wood stove. The reduction efficiency used for the GAINS modelling within this project has been set to 79 percent. Cleaning of the filter is essential for its efficiency, which indicates that automated cleaning systems are preferable.

4.2.1.3 Replacement of fuelwood stoves with non-emissive heating technologies

Introducing non-emissive heating technologies will reduce emissions from residential wood combustion. There are several possible non-emissive heating technologies. Solar energy can be harvested and used in several ways, including solar panels for electricity production to power electric radiators or heat pumps, or by active or passive solar heating. In active solar heating, energy is collected to heat air and liquid inside a pipe, which is used to heat up the interior space. Passive solar heating requires the building to be designed for this purpose. Electricity produced by solar PV is increasing rapidly globally and it is becoming more cost-effective. However, annual growth needs to average 25 percent between 2020-2050 to meet the Net Zero Emissions by 2050 Scenario.

Installing heat pumps is an established technique to heat a building. The electrically driven pump transfers heat from outdoors to inside the house, and thus heats up a house more efficiently than for example electric radiators. The IEA (2022) projects that 20 percent of the global heating needs must be met by heat pumps in 2030 to meet the Net Zero Emissions by 2050 Scenario. In the Nordic countries, heat pumps are wide-spread, and in Sweden, 29 percent of the heating demand in buildings are covered by heat pumps. Heat pumps are often the best option to meet energy performance standards in new buildings (IEA, 2020).

District heating is another heating source that does not give rise to emissions at use. District heating, however, requires accessibility to the district heating infrastructure.

Heating through electricity from the grid (directly or via heat pumps) may cause emissions at the electricity production site, depending on the energy source. District heating is generally produced at combustion plants. However, large combustion plants generally have better conditions for emission abatement and control than small-scale combustion. In addition, removing the emissions from homes reduce exposure to emissions.

4.2.1.4 “Right burning” practices

As stated above, user practices may have a large impact on emissions. Some appliances are more resilient to poor handling but in general emissions increase if there is not enough air during combustion (incomplete combustion) which may happen if the chimney damper is closed or if there are not enough air supply from the house. Lighting the fire from the top makes for a more complete combustion and thus results in lower emissions

Wet fuel also increases emissions, why it is important to store the firewood long enough to obtain sufficiently dry wood. However, also too dry wood may result in higher emissions. Wood should therefore not be stored longer than a week inside the house.

4.2.1.5 Energy efficiency improvements in buildings

Energy efficiency improvements in buildings, such as better insulated buildings, reduces the need of heating with wood stoves. Reduced firing has several benefits. In addition to reducing emissions of all combustion-related pollutants it also saves on fuel (wood).

4.2.1.6 Reduced burning in urban areas

Reduced firing may also be achieved by introducing bans on firing, which for example are effective to reduce emissions in urban areas where there is poor air quality.

4.3 Diesel Road transport

Traffic is a main contributor to the overall emissions and have a strong influence on air quality. The following sub-chapter will provide an overview of relevant measures for improving air quality by targeting emissions from road transport. Firstly, measures in the road transport sector will be presented, covering aspects such as technological standard of vehicles, inspection and maintenance, fuel quality etc. In chapter 5.2, policy instruments for road transport will be review considering the previously presented measures.

4.3.1 Measures in road transport sector

The measures for mitigating road transport emissions can be of various nature. When it comes to air quality and emissions, even small reductions help. The following measures display this diversity by targeting measures ranging from Euro standard, vehicle inspection protocols, fuel quality, emission filters, modal shift and so forth.

4.3.1.1 Replacement with newer Euro standards

One option to combat emissions originating from the vehicle fleet is to improve the standard and technical performance of the vehicles. Currently, the average age of vehicles in Kosovo is 18 years compared to the average age of cars in the European Union which is 11.8 years whereas trucks are on average 13.9 years in the EU (ACEA, 2022). Unfortunately, the situation and development in Kosovo indicate an increased average vehicle age since it is less cost intensive to acquire and use older vehicles compared to newer, more modern alternatives.

By replacing old vehicles with newer Euro standards, heavy polluting vehicles can be removed from the vehicle fleet and by extension contribute to improve air quality. Newer vehicles usually have a higher safety performance besides better emission technologies thus, a renewal of the vehicle fleet would bring benefits beyond improved air quality.

4.3.1.2 Less emitting fuels

Cleaner and less emitting fuels can contribute to reduce emissions from road traffic. As a minimum, fuels should be according to what EU legislation stipulate.

4.3.1.3 Retrofitting with particle filters and/or SCR

Diesel particulate filters (DPF) and selective catalytic reduction (SCR) are crucial in strive to mitigate the negative aspects of diesel-powered engines. DPF and SCR can contribute to reach what is required from an environmental point of view, mitigating emissions of both particles and other substances.

4.3.1.4 Proper inspection and maintenance

Vehicle inspection is an important cog in the machinery of improving air quality. With proper inspection and maintenance, the standard of vehicles will be maintained and the ones with catalysts removed, or other malfunctions will be detected and given a driving ban. If the vehicle inspection is carried out by private actors, it is vital that they also are subject to inspection.

4.3.1.5 Reduced diesel transport (less driving)

One way to reduce emission from road transport is to reduce the amount of transportation. This can be done by bringing about a shift to biking, walking, and using public transportation instead of going by car. Less driving can also be accomplished by more efficient driving, e.g. less traffic work for the same purpose. Regarding goods transportation, increased capacity utilization can likewise have an effect of less driving.

4.3.1.6 Modal shift (goods to railway, people to public transport)

Modal shift is another approach to reduce emissions from traffic. Shift travellers from cars to public transport and goods to railway. The effect of this measure is dependent on which energy is used for the railway, electrified railway transport from renewable fuel sources will have the greatest effect.

4.3.1.7 Replacement of diesel with other fuels (natural gas, biogas, hydrogen, electric/hybrid)

Replacement of diesel and petrol with other fuel sources such as natural gas, biogas and hydrogen is another fuel centred approach to mitigate emissions from road traffic. Promoting a transition of the vehicle fleet towards electric and hybrid vehicles can be one potential approach to reduce emission and pollution from diesel traffic.

4.4 Heat and power generation

The following sub-chapter provides an overview of measures targeting emissions from the heat and power generation sector – main contributor to SO2 emissions in Kosovo.

In the energy strategy for 2022-2031 four main challenges for Kosovo's energy sector were identified (Republic of Kosovo, Ministry of Economy 2022a):

1. dependence on lignite-fired electricity generation,
2. high energy consumption in relation to GDP and population,
3. high reliance on individual household heating solutions, mainly based on electricity or inefficient coal or wood burning,
4. high energy market concentration at both wholesale and retail levels. To target these challenges the energy strategy states the objectives for the energy sector in the coming years: improve system resilience, decarbonize, promote renewable energy, increase energy efficiency, strengthen the regional cooperation and market functioning and to protect and empower consumers.

Kosovo National Emissions Reduction Plan (NERP) sets the limits for nitrogen oxides (NOx), sulphur oxides (SOx) and dust (PM), but the non-compliance of lignite-fuelled power plants with the limits makes air pollution a remaining problem in Kosovo (Republic of Kosovo, Ministry of Economy 2022a). The following sections focuses on the measures and policy instruments to reduce pollution from heat and power generation.

4.4.1 Measures in the heat and power sector

The following measures within the heat and power sector are primarily targeting emissions of pollutants from heat and power plants.

4.4.1.1 Emission control technologies at large power plants

Combustion modification
In-furnace control with limestone injection
Wet Flue Gas Desulfurization (FGD), retrofitted
High Efficiency Deduster (HED)

Emissions control technologies include end-of-pipe measures and process modifications to reduce air pollution. These emission control technologies can often be used in combination to target several pollutants. The conclusions on Best Available Techniques (BAT) are the reference for setting permit conditions for installations of large combustion plants, >50 MW, within the EU (European Commission, Joint Research Centre, 2017). The technologies are mainly presented in the BAT Reference Document (BREF) for Large Combustion Plants.

Selective Catalytic Reduction (SCR) is a process where NOx molecules are chemically reduced into molecular nitrogen and water (Romero and Wang 2019) (Tillman 2018). SCR is currently the most effective method of post-combustion NOx reduction for coal-fired heat and power generation and is widely used around Europe. The capital costs of this air pollution control technology are significantly higher than other NOx controls because of the large volumes of catalysts needed, this also affects the operating costs (European Commission, Joint Research Centre 2017). The designs on large combustion units are often very site specific. The process might also result in ammonia in the waste gas stream, which in turn may impact the visibility of the plumes as well as the management of the ash.

Low NOX Burners (LNB) is a primary technique, modifying the burner and hence the combustion, to reduce the formation of NOX (European Commission, Joint Research Centre 2017). Important to note is that combustion modifications might lead to impact on the plant operations and the formation of other pollutants. To avoid this, there are several criteria's to be considered. The installation requires existing burners to be changed, at a minimum. For new installations the capital cost compared to a classical burner is negligible, for retrofits the costs are very plant specific and cannot be generalized.

Electrostatic Precipitator (ESP) are particulate control devices for the capture and disposal of fine particles such as Particulate Matter (PM10 and PM2,5) and Hazardous Air Pollutants (HAPs) (Miller 2005) (Kumar and Kumar, 2018). ESPs can be either dry or wet type, and wire-pipe or wire-plate type. ESPs can manage large air volumes, operate in different temperatures, and requires little maintenance. However, the devices are often large and have high operation expenses as well as inconsistent collection efficiencies due to sensitivity in changes in moisture and sensitivity.

The wet ESPs (WESP) are operated with water vapour and are also commonly used for gases with high moisture content, such as acid mists. The WESPs can handle a wider collection of pollutants than dry ESPs.

Fabric Filters (FF), or baghouses, have very high collection efficiencies for a broad range of particles (such as PM2.5) and can filter large volumes of flue gas (Tillman 2018). There are three basic types of FFs: reverse-gas, shake-deflate and pulse-jet. As ESP sizes and costs have increased to maintain high collection efficiencies, the interest in FFs has increased. The advantages of FFs include flexibility in design due to the availability of a broad set of cleaning methods and filter media, reasonable operating pressure drops and power requirements as well as an ability to handle various solid materials. Disadvantages with the filters are that they may require a lot of space, risks of explosions and fires if ignition sources are present and that they cannot handle materials that attract water. The capital costs of bag filters are quite low, but the maintenance costs are high as the filter material needs to be changed every 2-5 years (European Commission, Joint Research Centre, 2017).

4.4.1.2 Shift from lignite to gas or non-emissive energy generation technologies

A fuel switch is one of the general primary techniques to reduce emissions from combustion plants, but it is largely dependent on local circumstances as well as both national policy and market availability (European Commission, Joint Research Centre, 2017). The use of fuels with lower content of ash, sulfur, nitrogen, mercury etc. could be an option. Another option could be to shift from lignite to gas, which is emissive but less damaging to health, or to renewable non-emissive power generation such as hydropower, solar power, wind power etc.

There are also several techniques for the combustion that can reduce emissions thanks to a higher energy efficiency or integration into the combustion process (European Commission, Joint Research Centre, 2017). Examples are cogeneration of combined heat and power (CHP), integrated gasification combined cycle or combined-cycle combustion. Modifications could also be made to the combustion process, e.g. process control such as burner, air and fuel modifications. Co-generation requires a sufficiently high electricity price and stable local heat demand, e.g. from large industrial heat loads or heat loads in cold climates, to be competitive. However, it can be helpful to improve energy efficiency and reduce emissions compared to separate generation of heat and power. Combined-cycle power plants, such as combined-cycle gas turbines (CCGT), offers low investment costs and rapid development of the efficiencies. Despite high operating costs when natural gas is used as fuel, these are competitive.

4.4.1.3 Energy efficiency improvements at large combustion plants

Energy efficiency improvements at large combustion plants include special fuel preparation techniques such as the pre-drying of solid fuels, and gasification or pyrolysis of solid or liquid fuels, with the necessary syngas cleaning for combined-cycle applications (European Commission, Joint Research Centre, 2017).

With gasification low-value fuels and residuals can be converted into a syngas (European Commission, Joint Research Centre, 2017). The process can be applied to a variety of feedstocks and also offer product flexibility - through gas cleaning techniques corrosive ash elements can be cleaned from problematic fuels. Using syngas can be more efficient than the combustion of the original fuel as is allows for combustion at higher temperatures. Syngas also has higher concentrations of pollutants, making it easier to remove them more efficiently, offering low emissions across all pollutants. Slag and bottom ash and potentially cleaning residues from the syngas filtering are by-products to be handled.

The gasification can be integrated with the combustion process, e.g. in an integrated gasification combined cycle (IGCC) (European Commission, Joint Research Centre, 2017). For IGCC plants, particulate emissions may be close to zero, but NOX emissions can be higher than for natural-gas-fired turbines. The capital costs are also higher compared to natural gas fired combined cycles and combustion pf pulverized coal. However, IGCC combined with carbon capture and storage (CCS) is expected to be lower than combining pulverized coal with CCS. IGCC also offer higher public acceptance than for pulverized-coal-fired plants.

With pyrolysis, a thermochemical process, waste can be converted into gaseous, liquid, or solid products (European Commission, Joint Research Centre, 2019). The process operates at a high temperature and in the absence of oxygen. Pyrolysis is described in the Best Available Techniques (BAT) Reference Document for Waste (WI BREF). Some of the potential advantages of pyrolysis processes are the possibility to recover the material value of the organic fraction, e.g. as methanol, and to increase electricity generation by replacing steam boilers with gas engines or turbines.

4.4.1.4 Extension of district heating systems

There are currently four district heating systems in Kosovo and district heating is covering 3-5 percent of the total heat demand in Kosovo (Republic of Kosovo, Ministry of Economy, 2022a). In the energy strategy for 2022-2031, there is an aim to expand the district heating systems in Prishtina and Gjakova both in terms of cogeneration capacity and numbers of customers connected. The development of district heating systems in other municipalities is also being assessed.

District heating has been acknowledged as one of the keys for the decarbonization of the European energy sector as heating today is mainly fossil-fuelled (European Commission, Directorate-General for Energy, 2022). The extension of centralized heating systems, or district heating networks, can replace or complement individual heating solutions that are less efficient, e.g. individual boilers or heat pumps. As heat networks are economies of scale, the heat generation in one large heat plant can often be more efficient than production in multiple smaller ones. District heating and cooling can deliver heating, hot water, and cooling services through a network of insulated pipes, from a central point of generation to the end users.

The district energy networks are diverse and may develop and adapt to the local circumstances, e.g., by integrating local renewable and excess (i.e., waste) heat and cold sources (European Commission, Directorate-General for Energy, 2022). Through power-to-heat solutions such as heat pumps and electric boilers, combined with heat and power (CHP) plants as well as thermal storages, district heating grids offer sector coupling points with the electricity system and enables a more flexible operation of the energy systems.

Modern Fourth Generation district heating (4GDH) systems are characterized by high shares of renewables (e.g. biomass, geothermal, solar thermal), waste heat and cold (e.g. excess heat from industries), lower operating temperatures and a higher interaction between end-users and heat producers (European Commission, Directorate-General for Energy, 2022). The deployment of 4GDH is however hindered by high specific heat consumption of the buildings in many countries. Hence there is a need to apply energy efficiency measures in buildings to reduce the supply temperatures in district heating networks. Building codes, such as requirements on primary energy consumption, minimum share of renewables and primary energy factors of district energy systems, also have a strong impact on the introduction of renewable heating and cooling.

A challenge when it comes to the extension of district heating and cooling systems, are the end-users' perception and satisfaction (European Commission, Directorate-General for Energy, 2022). Common complaints in European countries are high prices and billing issues. Transparency of prices, a reliable supply of energy and good customer service are keys to ensure a good consumer perception of district energy.

4.5 Measures – Emission reduction potentials, costs, and benefits

This sub-chapter presents the results of the analysis of selected measures to reduce emissions in the three key sectors in Kosovo – residential wood combustion, diesel road transport, and heat and power generation. The study uses an impact-pathway approach, further explained in chapter 1.3. The analysis includes estimates of emission reduction potentials and related avoided health damage for the current situation (year 2020 in the GAINS model), and where available – of technical costs, net benefits, and benefit-to-cost ratios. All measures are considered separately. See Annex 7 for rankings of measures in key sectors.

Emissions are calculated on the country level, even in cases if measures are assumed to be implemented at the local level.

Emission reduction potential is estimated by extending the current implementation rate of a measure (see description of the current situation in chapter 2) to the maximum possible implementation rate – typically 100 percent[1]. Emission reduction potential is basically a gap between the current emission level and the minimum emission level reached by maximum implementation of a measure.

Reaching the emission reduction potential is usually too expensive and thus not realistic – in the real life, a combination of measures is applied rather than one measure to 100 percent. However, estimates of emission reduction potentials and costs (external as well as technical, or abatement costs) with this method give an understanding of maximum possible reduction that can be reached with each measure, and whether it is cost-effective in terms of avoided health damage.

Health benefits of each measure are calculated as difference between the current health damage and the damage in case the measure is applied to 100 percent of activity. Effects included in quantification of health damage are premature mortality due to exposure to PM2.5 and ozone; for monetary valuation of damage, we use metric called VSL assumed to equal 3.6 million Euro2015 (see Chapter 1.3). Health benefits are assessed for Kosovo and for the entire European domain[1] to include trans-boundary effects of emission reductions.

Technical (abatement) costs are only estimated for measures included in the GAINS model (see Annex 1 for details), while for other measures, technical costs are not available, and cost-benefit-assessment (CBA) is not conducted.

Resulting emissions for different measures might be presented on different aggregation levels, depending on the effect of a measure – e.g., congestion tax affects not only diesel vehicles but all personal cars in a considered area; ban on burning wood also concerns all types of appliances and not only heating stoves. **Emission aggregation** level for each measure is specified either in text or in the titles of figures illustrating emissions.

4.5.1 Residential wood combustion

For the residential wood combustion sector, the quantified analysis of measures is mainly focused on replacement and/or modernization of appliances, "right burning" techniques, reduced burning due to a ban, energy efficiency measures, and implementation of non-emissive heating technologies.

4.5.1.1 Replacement of conventional stoves with advanced and new stoves, or pellet stoves

Basic assumptions for GAINS modelling

As specified in Chapter 4.2.1.1, GAINS model database contains several types of appliances that conventional wood stoves can be replaced with – see their removal efficiencies in Table 3. Current level of application of different appliances is estimated in Chapter 2.2.

[9] This is done by changing the application rate of a measure in the GAINS model's control strategy for a considered scenario – in this case, the current legislation (CLE) scenario.
[10]See Annex 1 for the list of countries included

Table 3: Appliances to replace conventional wood stoves.

Type of appliance	Removal efficiency		Level of application in 2020
	PM2.5	NMVOC	
Improved stove	63%	85%	4.7%
New stove	80%	95 %	-
New stove with ESP	95.7%	95.1%	-
Pellet stove	95%	97.5%	9.4%
Pellet stove with ESP	99.3%	97.5%	-

For each type of appliance, replacement of conventional stoves is modelled as a separate measure. When modelling emission reduction potentials, we assume that the considered type of appliance replaces only conventional stoves – i.e., 90.6 percent of stoves used today. Pellets stoves are not supposed to be replaced by less effective equipment.

Emission reduction potential

Figure 17 summarizes emissions with and without implementation of the measures. Emission reduction potentials vary from 5.13 kt PM2.5 (improved stoves) to 8.24 kt (pellet stoves with ESP). For NMVOC, the respective lowest and highest emission reduction potentials are estimated at 17.00 kt and 19.64 kt.

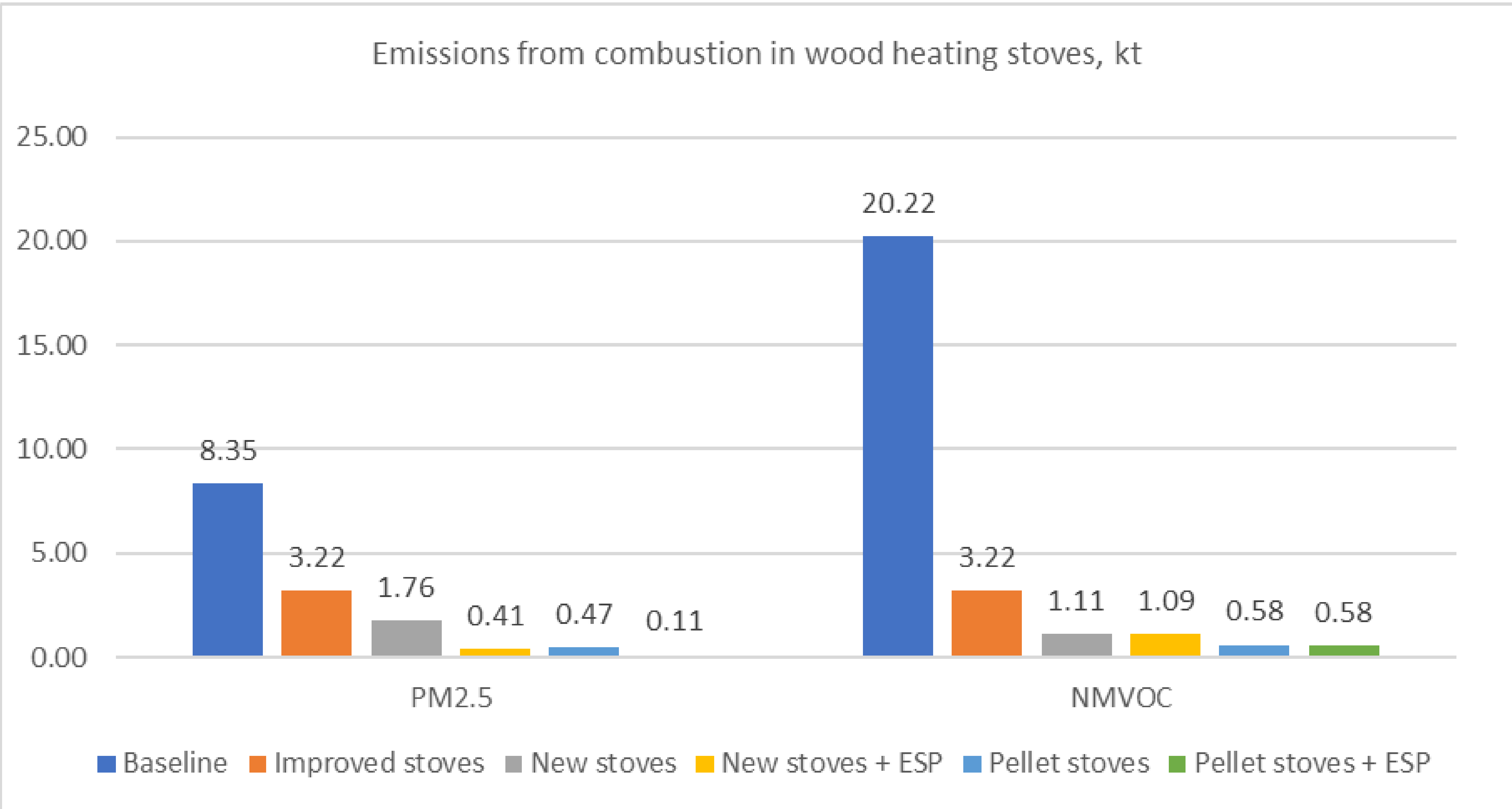


Figure 17: Replacement of conventional stoves with advanced and new stoves, or pellet stoves – emissions from fuelwood heating stoves, kt.

Health benefits

Figure 18 displays total avoided health damage in Kosovo vs. entire Europe, and average distribution of avoided damage by country. If Kosovo replaces conventional stoves with advanced and new stoves, 36 percent of the avoided health damage would be observed in Kosovo.

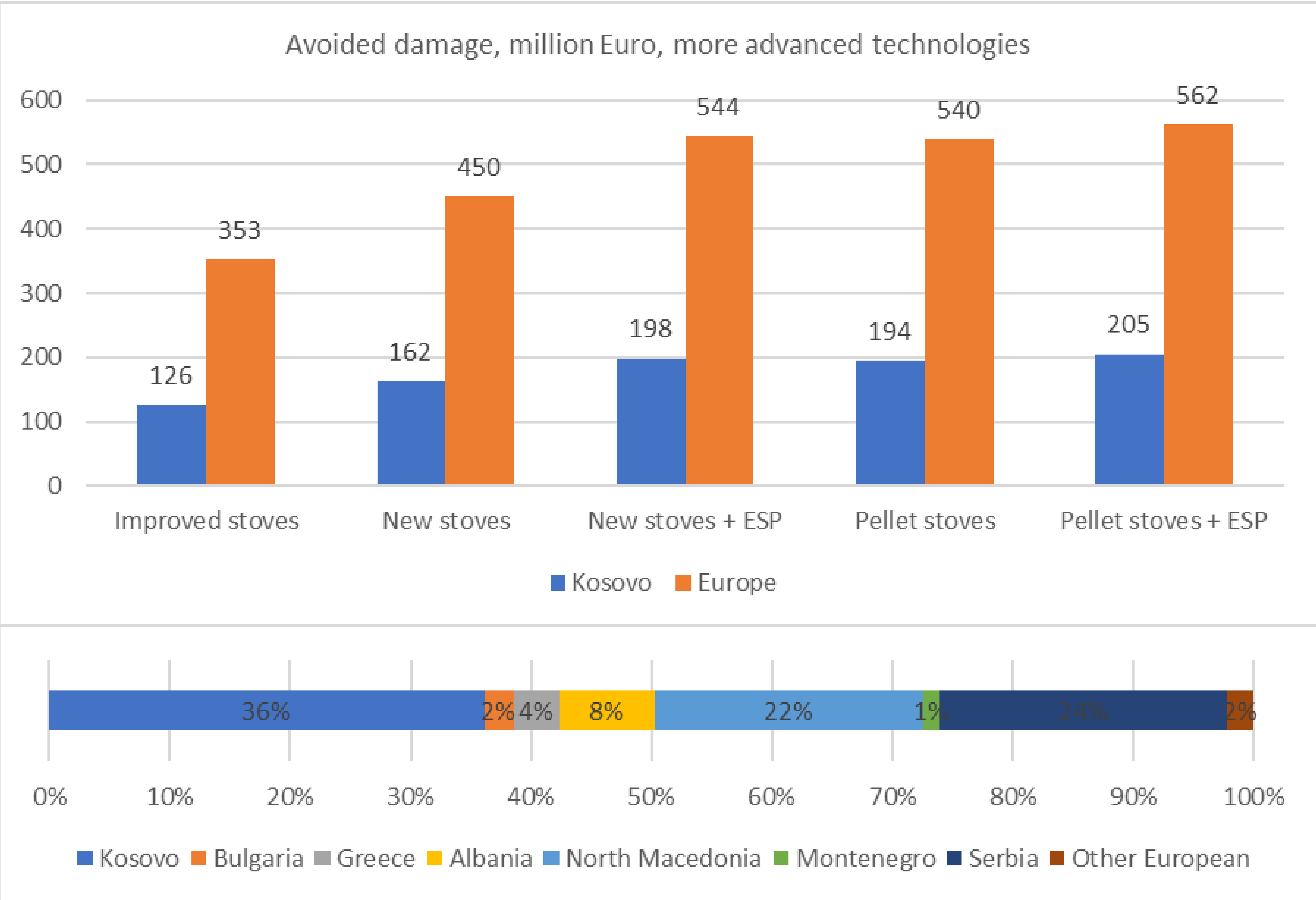


Figure 18: Replacement of conventional stoves with advanced and new stoves, or pellet stoves – total avoided damage in Kosovo and the entire European domain (upper panel) and average distribution of avoided damage by country (lower panel).

Technical costs and CBA

Table 4 presents technical costs and net health benefits from implementation of the analyzed measures, as well as benefit-to-cost ratios. Full replacement of conventional stoves with more advances appliances is too expensive to be cost-effective in terms of saves lives, if only Kosovo citizens' lives are accounted for. For the entire Europe, however, benefits from avoided premature mortality exceed the technical costs, making all considered measures cost-effective. Based upon these conclusions, the different options are further discussed in the next sub-chapters 4.5.1.2 and 4.5.1.3.

Table 4: Replacement of conventional stoves with advanced and new stoves, or pellet stoves – technical costs and CBA.

Measure	Technical costs, Million Euro	Avoided damage, Million Euro		Net benefits, Million Euro		Benefit-to-cost ratio	
		Kosovo	Europe	Kosovo	Europe	Kosovo	Europe
Improved stove	37	126	353	89	315	3.4	9.4
New stove	302	162	450	-140	148	0.5	1.5
New stove with ESP	347	198	544	-149	197	0.6	1.6
Pellet stove	328	194	540	-133	212	0.6	1.6
Pellet stove with ESP	398	205	562	-192	164	0.5	1.4

4.5.1.2 Retrofitting of existing stoves with ESP

Basic assumptions for GAINS modelling

GAINS model does not contain retrofit-ESP as a technology option to reduce emissions from residential wood combustion, which is why PM2.5[11] removal efficiency of this measure, compared to the conventional stove without ESP, is estimated based on the differences between new stoves (80 percent) and new stoves with ESP (95.7 percent). Calculated from these numbers, the removal efficiency of ESP alone is about 79 percent. This estimate is further used in GAINS modelling[12].

9.4 percent of pellets stoves are not supposed to be retrofitted with ESP. For the remaining stoves (both conventional and improved), we assume 79 percent reduction of PM2.5 due to retrofit-ESP. As activity data (TJ fuel used) affected by application of ESP is the same as in the case of replacement by new stoves, technical costs of the full implementation of this measure are assumed to correspond to the difference between the costs of new stoves and new stoves with ESP as calculated in Chapter 3.2.3, multiplied by 150 percent (conservative retrofit coefficient chosen for this analysis)[13].

Emission reduction potential

Figure 19 shows emissions with and without implementation of the measure. Emission reduction potential is 6.53 kt PM2.5.

[11] NMVOC emissions are reduced by this measure as well, however, due to some technical constraints, changes in the NMVOC emissions in GAINS model do not affect the damage results, which is why NMVOC emission reductions from certain measures (such as retrofit ESP) are not included in the analysis.
[12] EF cannot be changed directly, so adjustments via other parameters (application rates of abatement for firewood heating stoves) so that PM2.5 emissions are the same as calculated outside the model.
[13] Based on the authors' expert judgment and Parsmo et al. 2017.

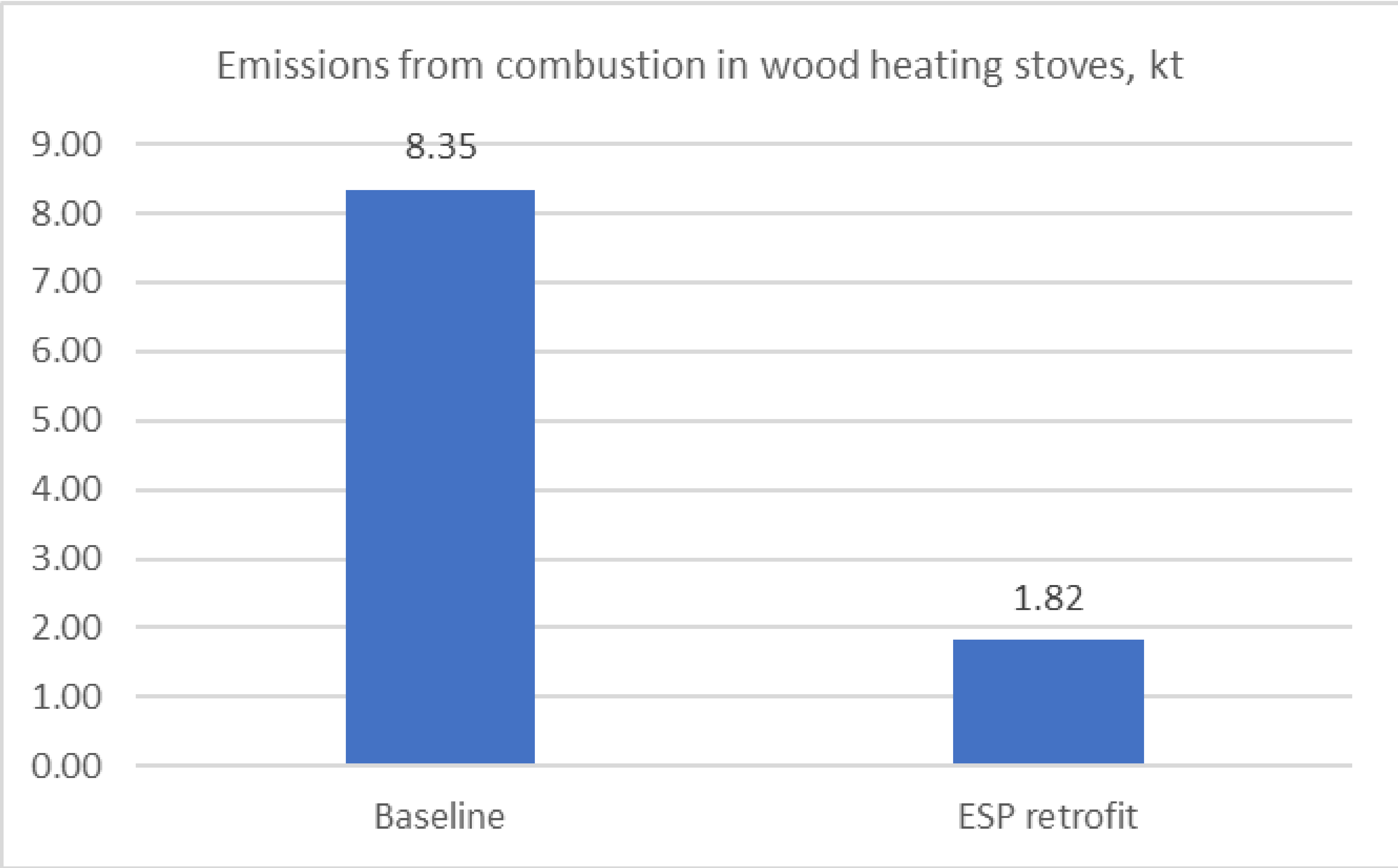
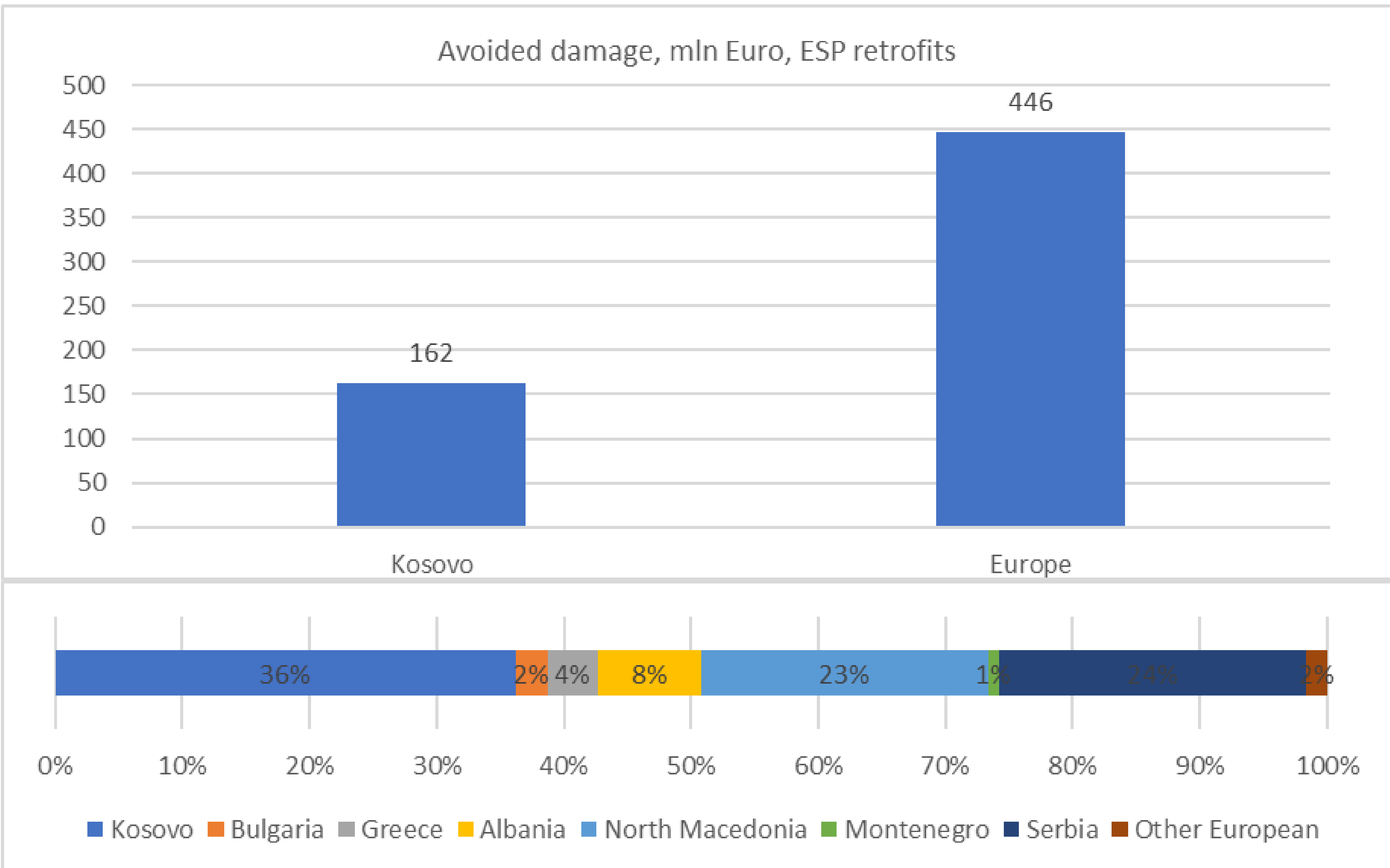


Figure 19: Retrofitting of existing stoves with ESP – emissions from fuelwood heating stoves, kt.

Health benefits

Figure 20 displays total avoided health damage in Kosovo vs. entire Europe, and distribution of avoided damage by country. If Kosovo retrofits existing stoves with ESP, 36 percent of the avoided health damage in Europe would be observed in Kosovo.

Figure 20: Retrofitting of existing stoves with ESP – total avoided damage in Kosovo and the entire European domain (upper panel) and distribution of avoided damage by country (lower panel).



Technical costs and CBA

Table 5 presents technical costs and health benefits from implementation of retrofit-ESP. The measure is cost-effective irrespective the chosen domain (Kosovo alone or the entire Europe) and results in the net health benefits (due to avoided premature morality) of 95 million Euro and 380 million Euro, respectively.

Table 5: Retrofitting of existing stoves with ESP – technical costs and CB

Technical costs, mln Euro	Avoided damage, mln Euro		Net benefits, mln Euro		Benefit-to-cost ratio	
	Kosovo	Europe	Kosovo	Europe	Kosovo	Europe
67	162	446	95	380	2.4	6.7

4.5.1.3 "Right burning" practices

Basic assumptions for GAINS modelling

"Burning right", or "good combustion" is not a technical measure and mainly considers behavioral patterns such as using dry (not wet) wood and full (not partial) loads when burning fuelwood. This measure is not included in the GAINS model database, and it is not clear from the model methodology documentation whether emission factors in the model correspond to "bad" or "good" combustion or are state-of-the-art weighted emission factors. For emission factors presented in the EMEP/EEA Guidebook 2019, this aspect is not clarified either. In this analysis, it is assumed that GAINS model emission factors are weighted emission factors, i.e., they correspond to the situation where some people use "good" combustion, and some – "bad" combustion.

Studies that estimate how much "good combustion" is spread are scarce. To roughly estimate emission reduction potential of this measure in Kosovo, we used as an indication data from a recent Swedish study – Gustafsson & Helbig, 2018 – in the absence of better estimates. Current shares of "bad" burning practices assumed in our analysis[14] are summarized as follows (ratios of "bad" and "good" emission factors, same for PM2.5 and NMVOC, are given in parenthesis):

[14] Shares of "bad combustion" are conservatively assumed to be slightly higher than in Gustafsson & Helbig, 2018

- 10 percent of conventional stoves use wet wood (EF ratio 1.5/1)
- 10 percent of conventional stoves use partial load (EF ratio 4/1)
- 10 percent of improved stoves use wet wood (EF ratio 1.5/1)
- 5 percent of pellet stoves use partial load (EF ratio 4/1)

The numbers above imply that “good combustion” practices prevail, and only a relatively small share of the population uses “bad” burning. Assuming that GAINS-model emission factors are weighted, and assuming the same ratios of bad” and “good” emission factors as in Gustafsson & Helbig, 2018, we derive “good” and “bad” GAINS emission factors from the weighted values – see Table 6 below.

Table 6: GAINS-based emission factors for different types of wood stoves and burning practices, kg/GJ.

Type of stove	GAINS EF = weighted EF, kg/GJ		EF for good combustion, kg/GJ		EF for bad combustion – wet wood, kg/GJ		EF for bad combustion – partial load, kg/GJ	
	PM2.5	NMVOC	PM2.5	NMVOC	PM2.5	NMVOC	PM2.5	NMVOC
Conventional stove	651	1600	482	1185	723	1778	1929	4741
New stove	241	240	230	229	348	346	-	-
Pellet stove	33	40	29	35	-	-	115	139

To model emission reductions in Kosovo from this measure, we simulate a case where 100% “good combustion” emission factors[15] are used, i.e., where owners of the remaining 20% of conventional stoves, 10% of improved stoves and 5% of pellets stoves also practice “good combustion”.

Emission reduction potential

Figure 21 shows emissions with and without implementation of the measure. Emission reduction potential is 2.12 kt PM2.5 and 5.20 kt NMVOC.

[15] In the GAINS model, emission factors cannot be changed directly, so adjustments are in practise made via other parameters.

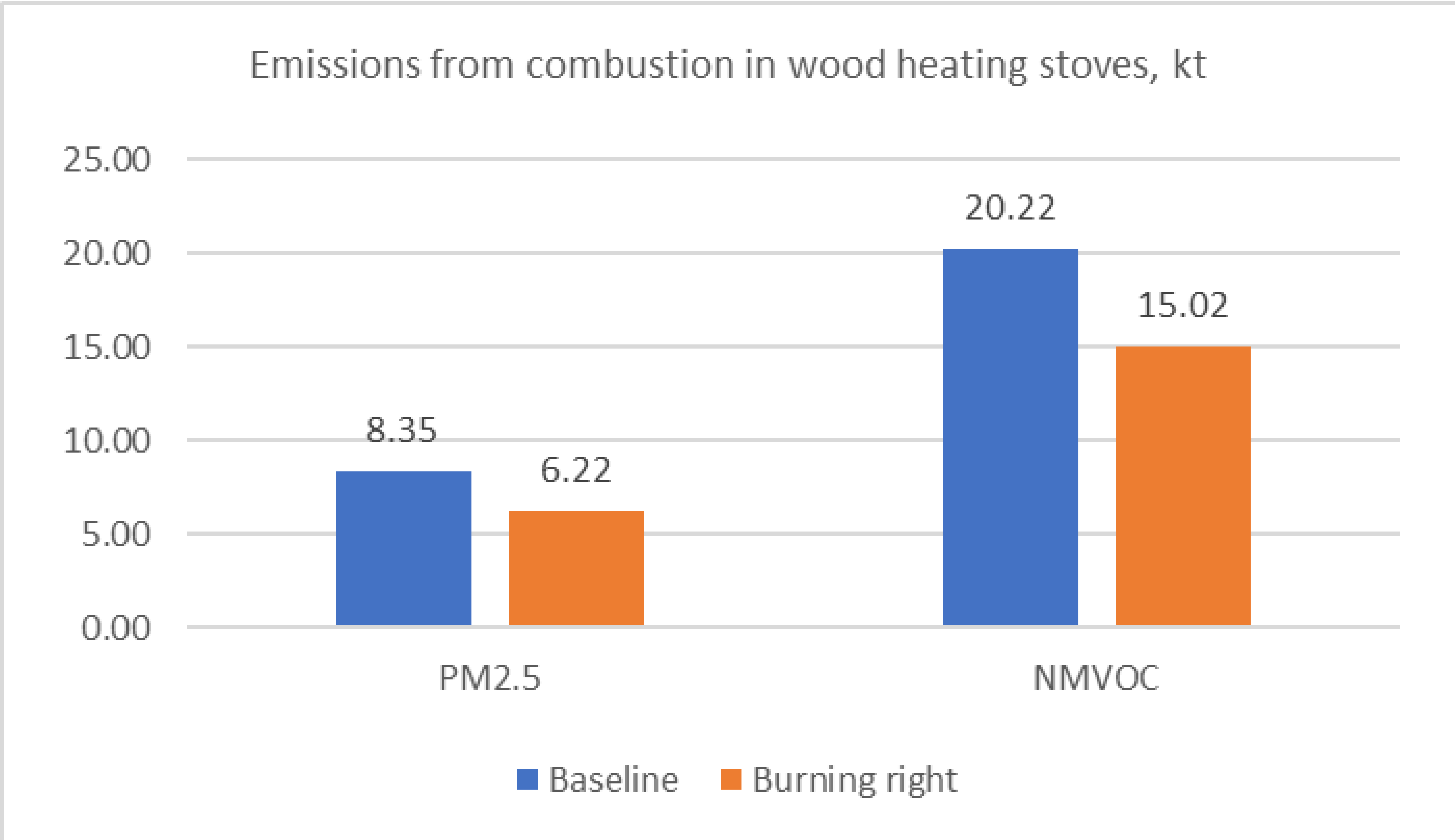


Figure 21: "right burning" – emissions from fuelwood heating stoves, kt.

Health benefits

Figure 22 displays total avoided health damage in Kosovo vs. entire Europe, and distribution of avoided damage by country. If Kosovo implemented "right burning" techniques, 36 percent of the avoided health damage in Europe would be observed in Kosovo.

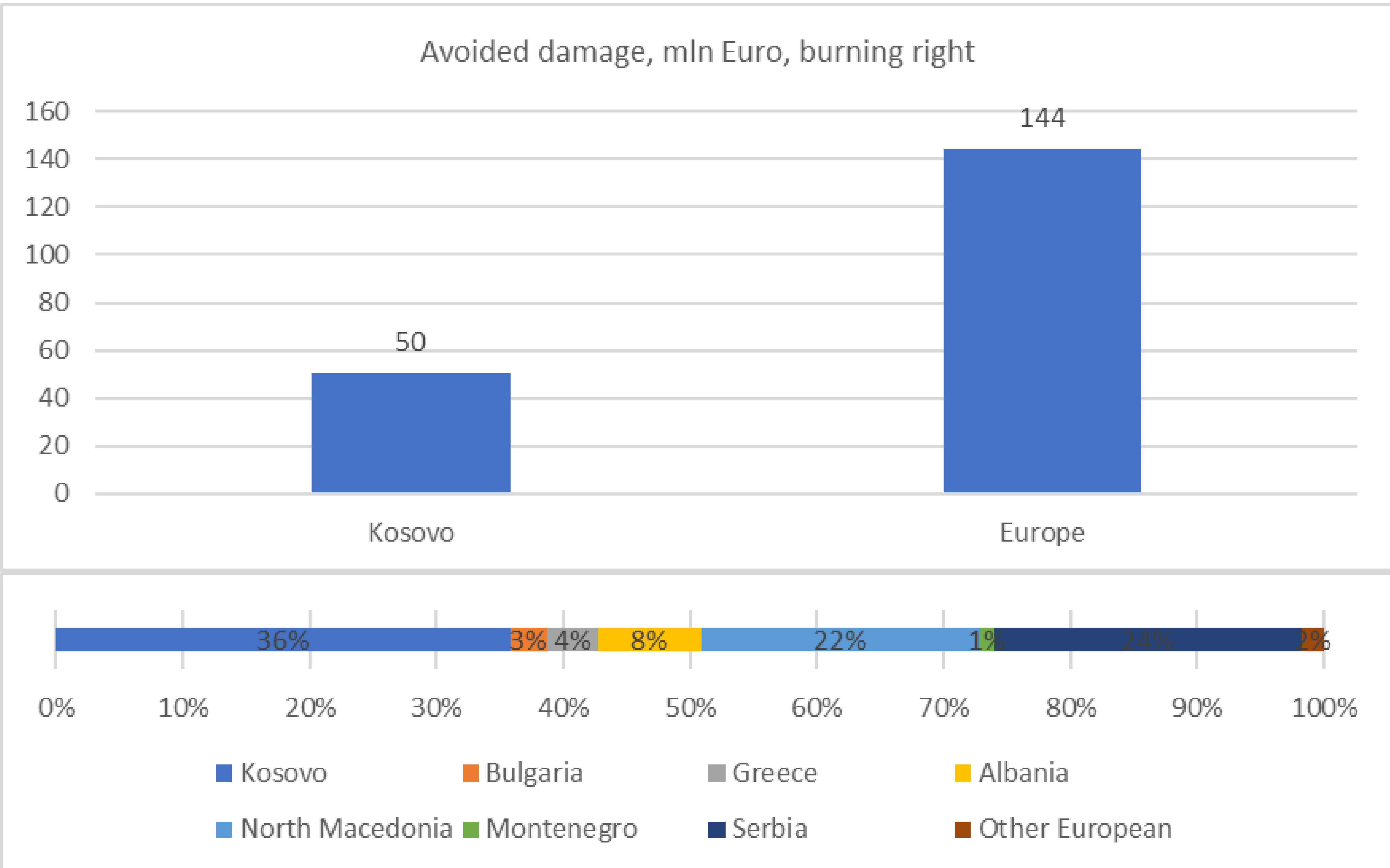


Figure 22: "Burning right" – total avoided damage in Kosovo and the entire European domain (upper panel) and distribution of avoided damage by country (lower panel).

Technical costs and CBA

This measure does not imply additional technical costs. Administrative costs of introduction of the relevant policy instruments are not covered by this analysis.

4.5.1.4 Energy efficiency improvements in buildings

Basic assumptions for GAINS modelling

GAINS model does not contain energy efficiency improvements as an option to reduce emissions from residential wood combustion. Energy efficiency in the residential sector is estimated as use of fuels (wood, coal, oil etc.) and other types of energy (solar, geothermal, electricity, etc.) for fulfilling certain demand for heating, cooling, and use of appliances. Energy efficiency improvements in buildings (by e.g., better insulation) without changes in heating and cooling demand would imply reduction of TJ energy used for heating in the sector.

In the assessment of the emission reduction potential of this measure we assume that all types of fuels and heat energy consumed in domestic sector are reduced by 35 percent – the number is based on the World Bank 2007 study, also cited in newer sources (e.g., in Kosovo Climate Change Strategy 2019-2028). For electricity, it is assumed that certain share is used for other purposes (cooling, appliances). This share (~3 percent is calculated based on the assumption that electricity covers about 40 percent of heat demand in the residential sector (Ministry of Economic Development, Republic of Kosovo, 2011).

We furthermore assume that electricity production is adjusted to the reduced demand in the residential sector, i.e., that power generation and fuel use at power plants would reduce accordingly. Once fuel efficiency at power plants (35 percent) and transmission losses (12 percent for electricity and 20 percent for heat) is taken into consideration. Combined with the share of produced electricity used for heating in the residential sector (>50 percent). We calculated the reduction of fuel use at power plants at about 20 percent. In the study, it is assumed that all fuels combusted at power plants are reduced equally in percentage.

Emission reduction potential

With this measure emission reductions would take place in both the residential sector and in the heat and power generation sector. In the residential sector we consider all emissions, not only those from the wood heating stoves, as we assume that energy efficiency improvements would result in equal (in percentage) reductions of all fuels and other energy types used for heating of buildings.

Figure 23 summarises emissions with and without implementation of the measure in the residential sector (upper panel) and in the heat and power generation sector (lower panel). Emission reduction potentials in the residential sector are mainly related to PM2.5 and NMVOC. For the heat and power generation sector emission reduction potentials are estimated for NOx and SOx.

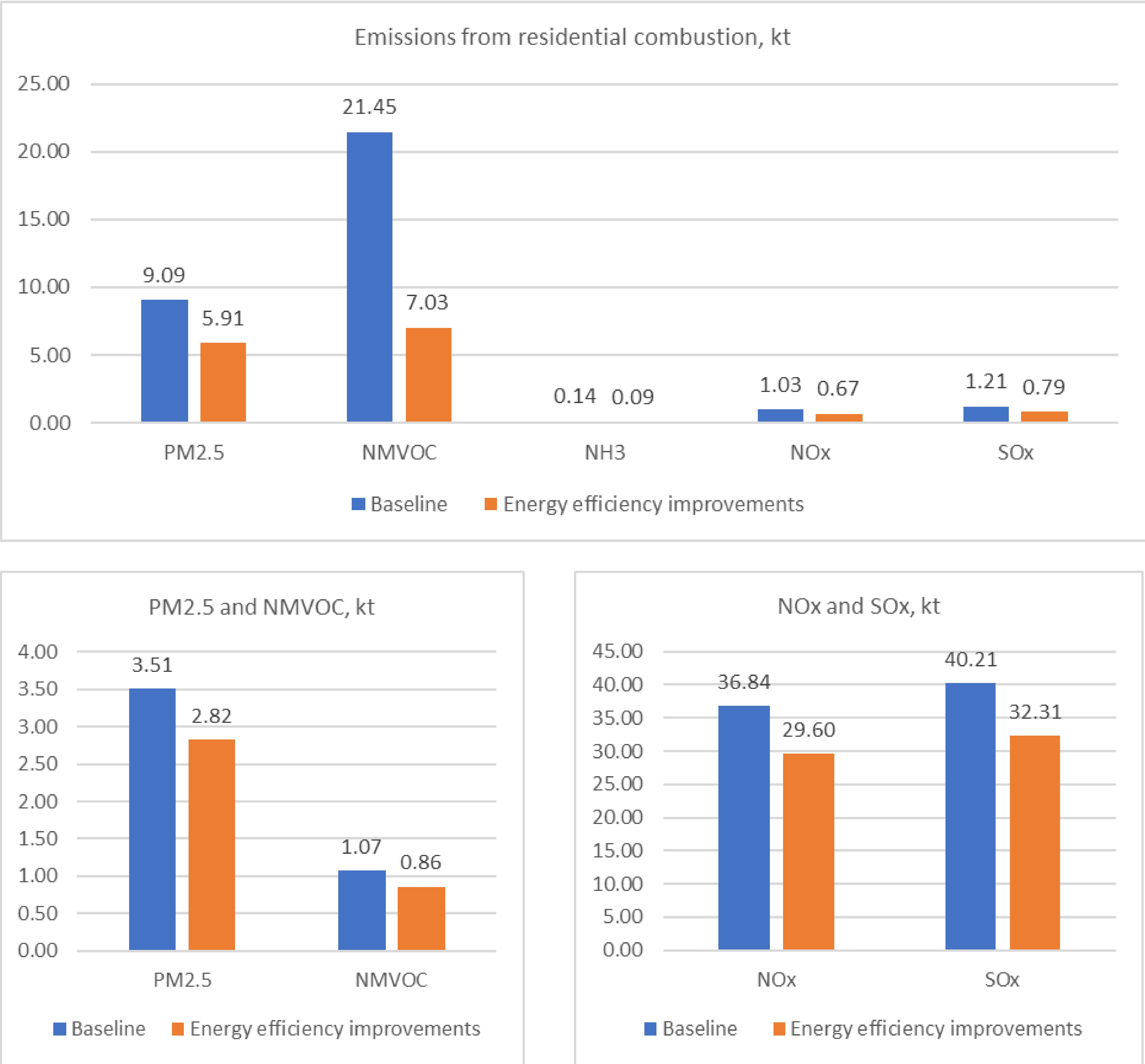


Figure 23: Energy efficiency improvements in buildings – emissions from all fuel combustion in the residential sector (upper panel) and all fuel combustion in the heat and power generation sector (lower panel), kt.

Health benefits

Figure 24 displays total avoided health damage in Kosovo vs. entire Europe, and distribution of avoided damage by country. If Kosovo made energy efficiency improvements in buildings, 25 percent of the avoided health damage would be observed in Kosovo.

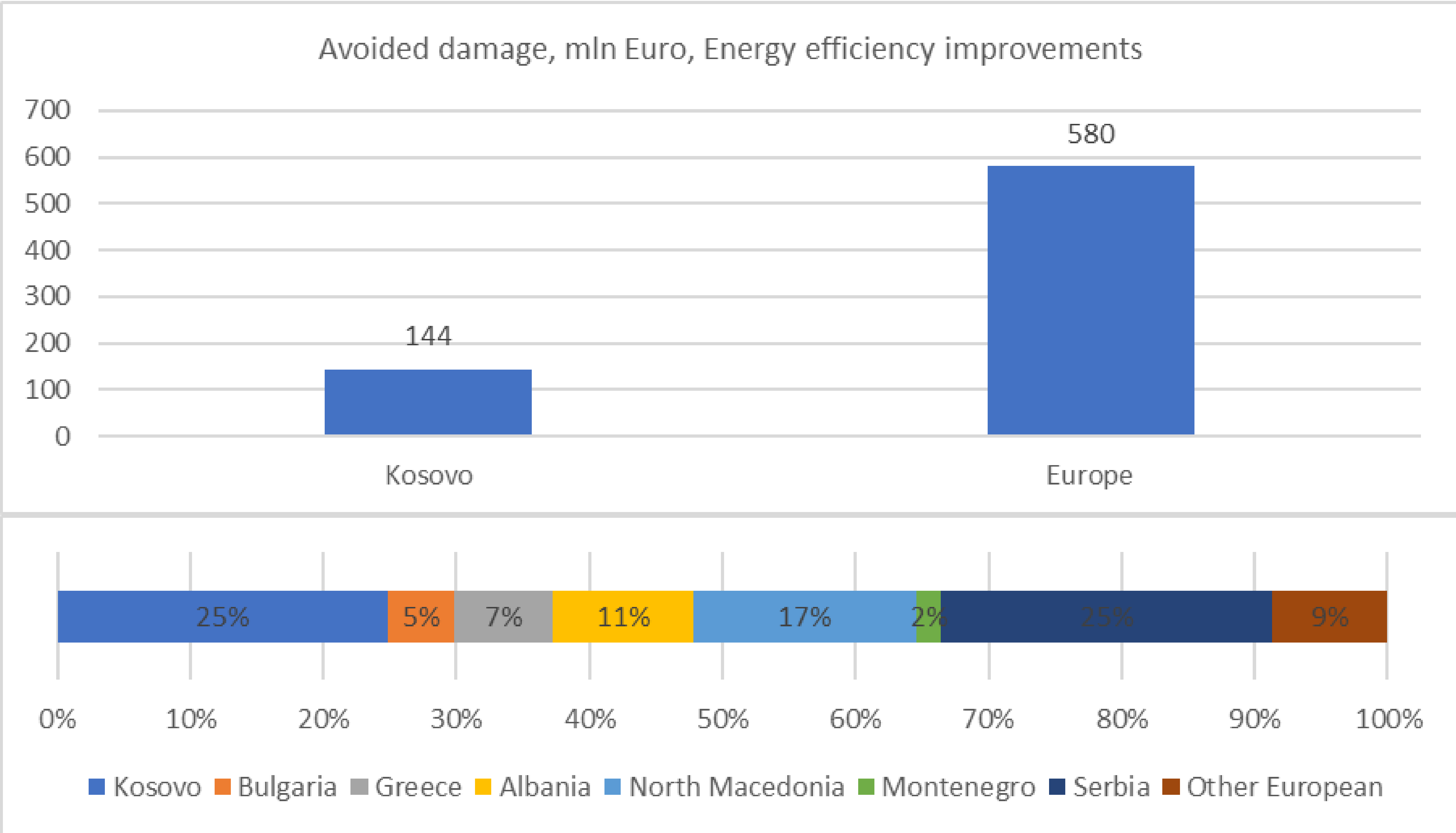


Figure 24: Energy efficiency improvements in buildings – total avoided damage in Kosovo and the entire European domain (upper panel) and distribution of avoided damage by country (lower panel).

The damage reduction is a combined effect of emission reductions in the residential sector and in the heat and power generation sector. Also, it is a combined effect of secondary particles formed from different primary pollutants (such as NOx, SOx), not mainly primary PM2.5. Energy efficiency improvements reduce significant amounts of SOx and NOx from heat and power generation sector. Differences in pollution transfer for NOx, SOx vs. particles (primary particles are transferred on shorter distances) results in different ratio of damage in Europe vs. damage in Kosovo for this measure, compared to measures that do not affect NOx and SOx (see Figures 23, 24).

Technical costs and CBA

Technical costs of this measure are not available in the GAINS model. To conduct a CBA, the following cost-related data are needed:

- Investment and installation costs of energy efficiency measures – e.g., insulation and double-glassed windows.
- Lifetime of energy efficiency measures, i.e., number of years with these measures in place and being effective.

4.5.1.5 Reduced burning in urban areas

Basic assumptions for GAINS modelling

A Ban on residential burning in urban areas (policy instrument of command-and-control character) and a subsequently reduced burning by population (measure) are not included in the GAINS model database. In the assessment of the emission reduction potential of this measure, we assume that residential fuelwood combustion is banned in the urban areas during all the days when concentration of PM10 exceeds the set concentration limits. The annual number of days per year with such exceedances is assumed to be 73 – maximum of the values provided in the literature (INDEP 2019, UN Environment Programme 2021, Annual Report on the State of Air in Kosovo 2019 by Kosovo Environmental Protection Agency). We also assumed that fuelwood is only used for heating during the cold period, which we for simplicity assume to be 365/2 = 182.5 days. With these assumptions, TJ fuelwood combustion in heating stoves in the urban areas (which in the baseline accounts for 38 percent of the total fuelwood residential combustion) is reduced by 40 percent (73/182.5). For simplicity, we assume that this energy is not replaced or replaced with non-emissive sources or imported electricity – i.e., that no additional emissions occur somewhere else in Kosovo due to this measure.

Emission reduction potential

Figure 25 below shows emissions with and without implementation of the measure. Emission reduction potential is 2.08 kt PM2.5 and 5.08 kt NMVOC.

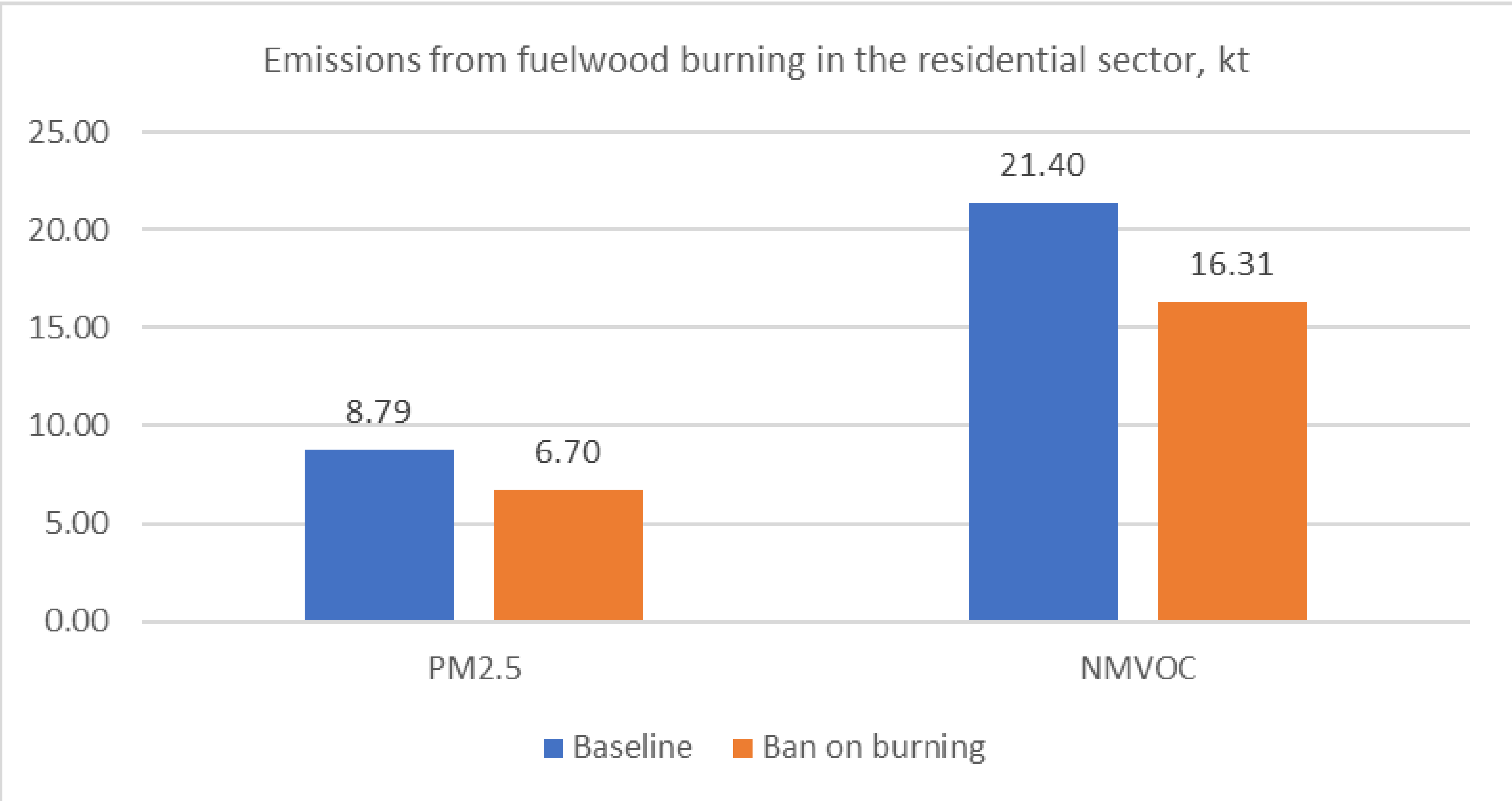


Figure 25: Reduced burning in urban areas due to a ban – emissions from fuelwood burning in the residential sector, kt.

Health benefits

Figure 26 displays total avoided health damage in Kosovo vs. entire Europe, and distribution of avoided damage by country. If Kosovo implemented a ban on reduced burning in urban areas, 34 percent of the avoided health damage in Europe would be observed in Kosovo.

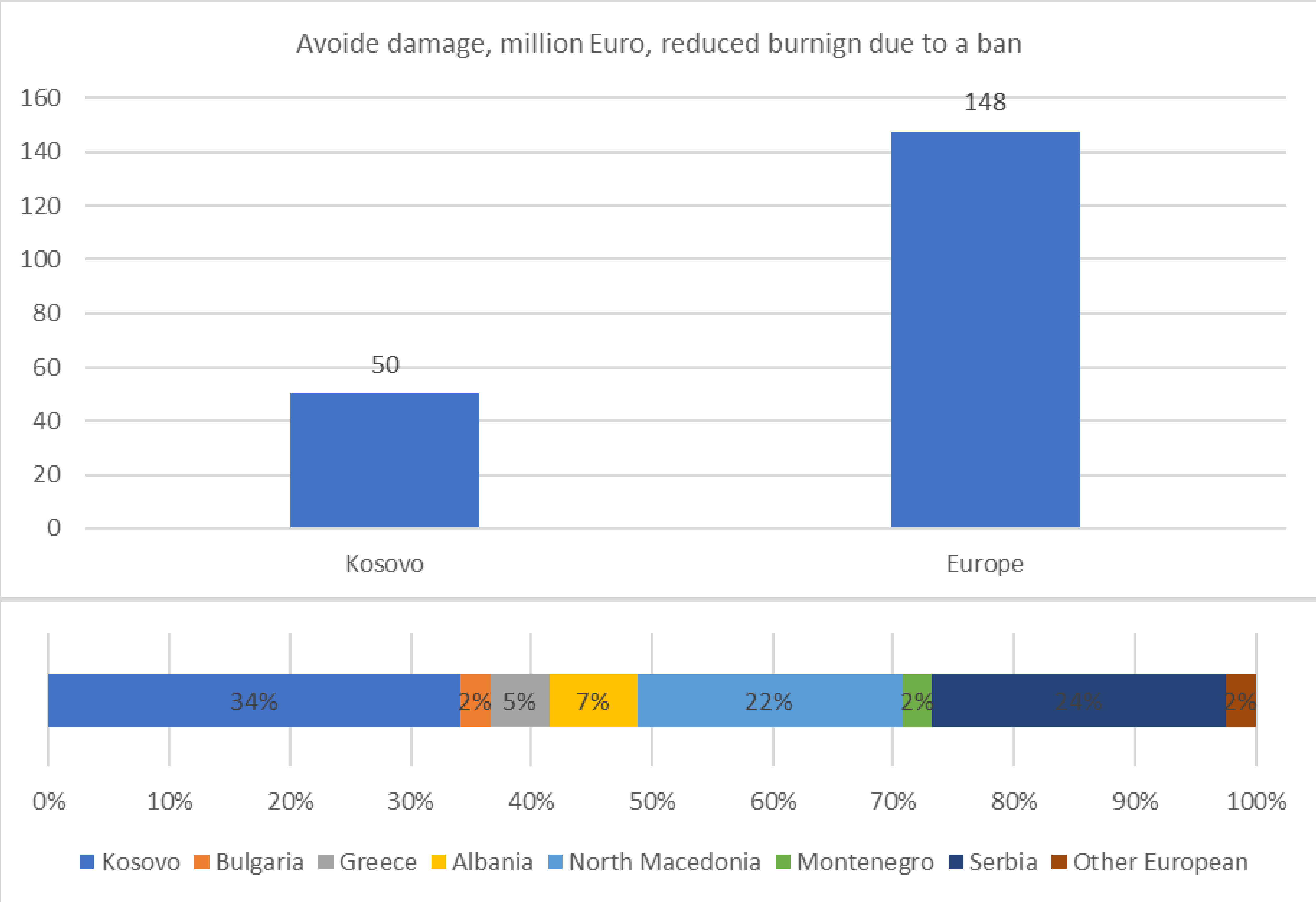


Figure 26: Reduced burning in urban areas due to a ban – total avoided damage in Kosovo and the entire European domain (upper panel) and distribution of avoided damage by country (lower panel).

Technical costs and CBA

This measure does not imply additional technical costs.

4.5.1.6 Replacement of fuelwood stoves with non-emissive heating technologies

Basic assumptions for GAINS modelling

Non-emissive heating technologies are not included in the GAINS model database, as other structural measures implying fuel/energy shift. The main assumption in the assessment of the emission reduction potential is zero activity data, i.e., zero TJ fuelwood combustion in heating stoves.

Emission reduction potential

Emission reduction potentials for this measure are equal to emissions from fuelwood heating stoves – 8.35 kt PM2.5 and 20.22 kt NMVOC.

Health benefits

Figure 27 displays total avoided health damage in Kosovo vs. entire Europe, and distribution of avoided damage by country. If Kosovo replaced its current technologies with non-emissive heating technologies, 35 percent of the avoided health damage in Europe would be observed in Kosovo.

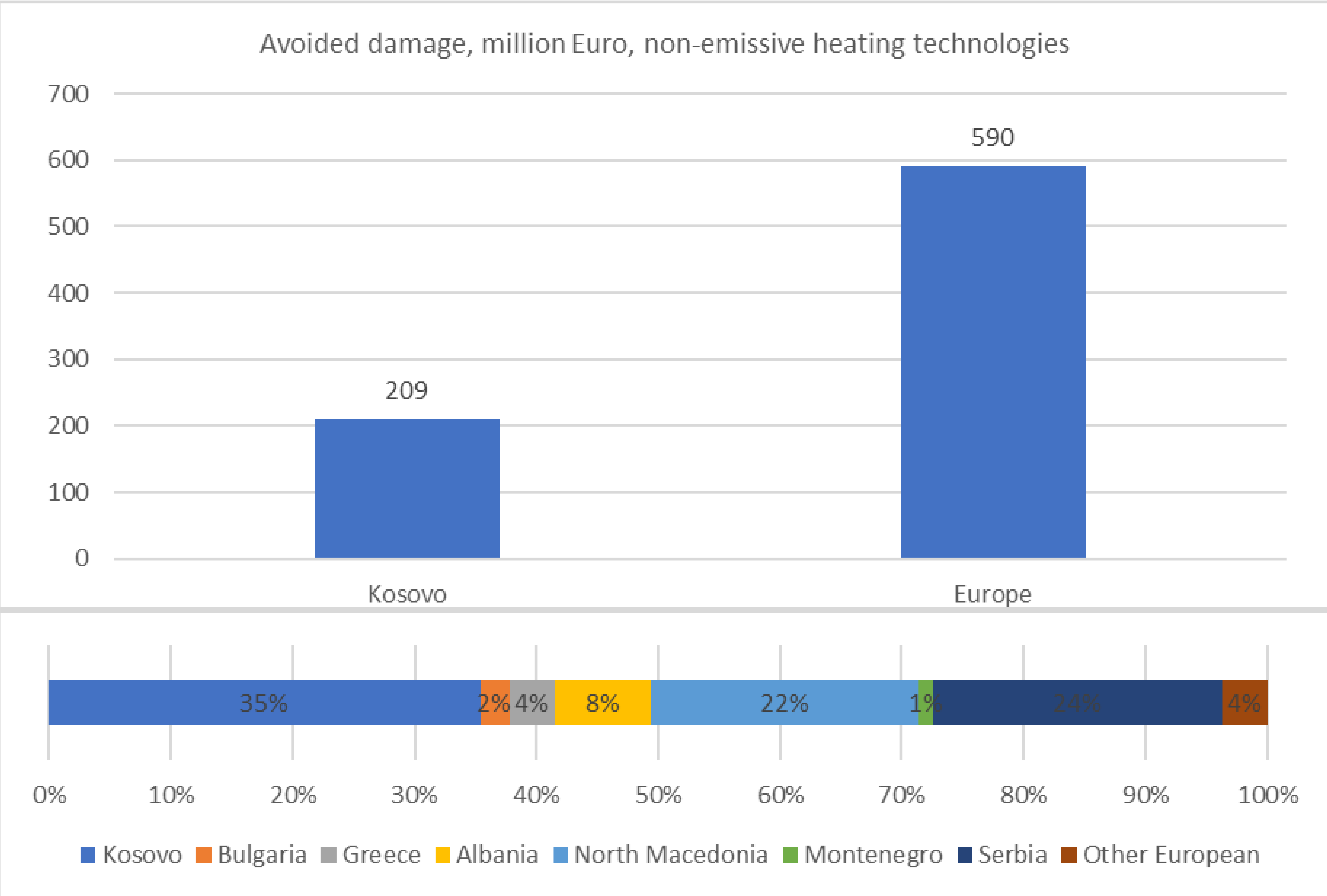


Figure 27: Replacement with non-emissive heating technologies – total avoided damage in Kosovo and the entire European domain (upper panel) and distribution of avoided damage by country (lower panel).

Technical costs and CBA

Technical costs of this measure are not available in the GAINS model. To conduct a CBA, the following cost-related data are needed:

- Investment and installation costs of non-emissive heating technologies – e.g., heat pumps, solar panels, imported electricity etc. – and conventional wood heating stoves.
- Operation and management costs of non-emissive heating technologies and conventional wood heating stoves.
- Lifetime of equipment.

4.5.2 Diesel road transport

For diesel road transport, it is sometimes especially difficult to separately analyse measures and instruments to reduce emissions. The quantified analysis of measures is partly focused on emission control technologies to fulfil Euro 6 standard. Other considered measures are shift to non-emissive energy sources (electric vehicles) and shift of goods transportation to electric trains. Also, reduced driving and/or shift to other transport means – measures of a behavioural character – are analysed as responses to certain local-scale policy instruments such as introduction of congestion taxes or transport zones.

4.5.2.1 Emission control technologies – Euro 6

Basic assumptions for GAINS modelling

Replacing existing vehicles with vehicle of higher Euro standards is one of the emission reduction technologies available in the GAINS model. In this analysis, we consider several cases where Euro 6 standard is applied for 100 percent of vehicles in the following categories running on diesel:

- Passenger cars,
- Buses,
- Heavy trucks,
- Light trucks,

Also, the case when Euro 6 is applied in all the above-mentioned categories (all road traffic on diesel) is included in the analysis.

Emission reduction potential

Figure 28 summarizes emissions with and without implementation of Euro 6 for considered transport categories. Emission reduction potentials for NOx vary from 0.18 kt (light trucks) to 2.44 kt (passenger cars), and in case Euro 6 is applied in all road traffic constitutes 5.24 kt. Emission reduction potentials for PM2.5 vary from 0.02 kt (light trucks) to 0.27 kt (passenger cars), and for “all road traffic” case is 0.38 kt. For NMVOC, emission reduction potentials are from 0.01 kt (light trucks) to 0.13 kt (passenger cars), and for “all road traffic” case 0.34 kt.

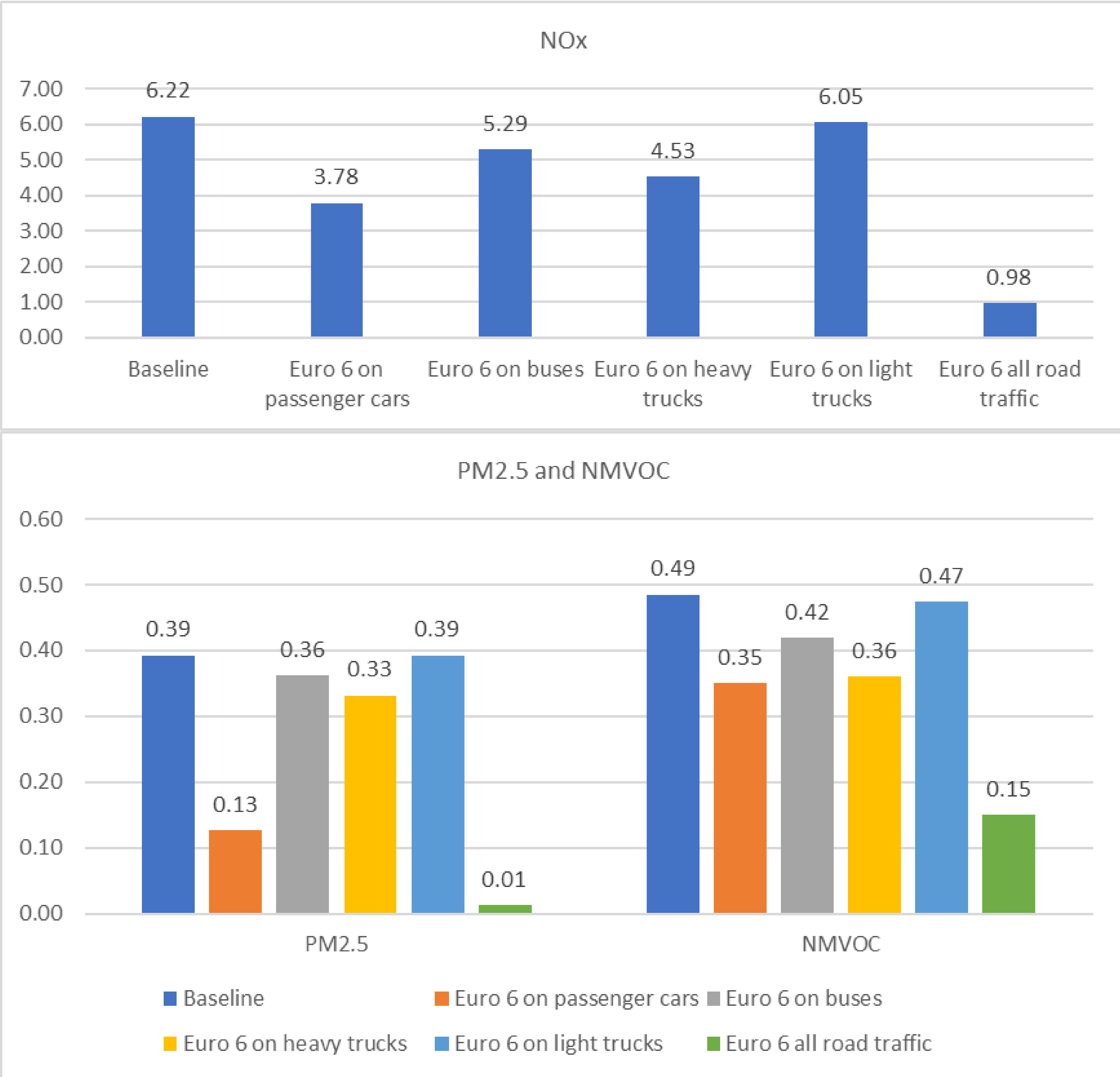


Figure 28: Euro 6 on diesel road transport – emissions from diesel road traffic, kt.

Health benefits

Figure 29 displays total avoided health damage in Kosovo vs. entire Europe, and average distribution of avoided damage by country. If Kosovo implemented Euro 6 for specific transport categories, 23 percent of the avoided health damage in Europe would be observed in Kosovo.

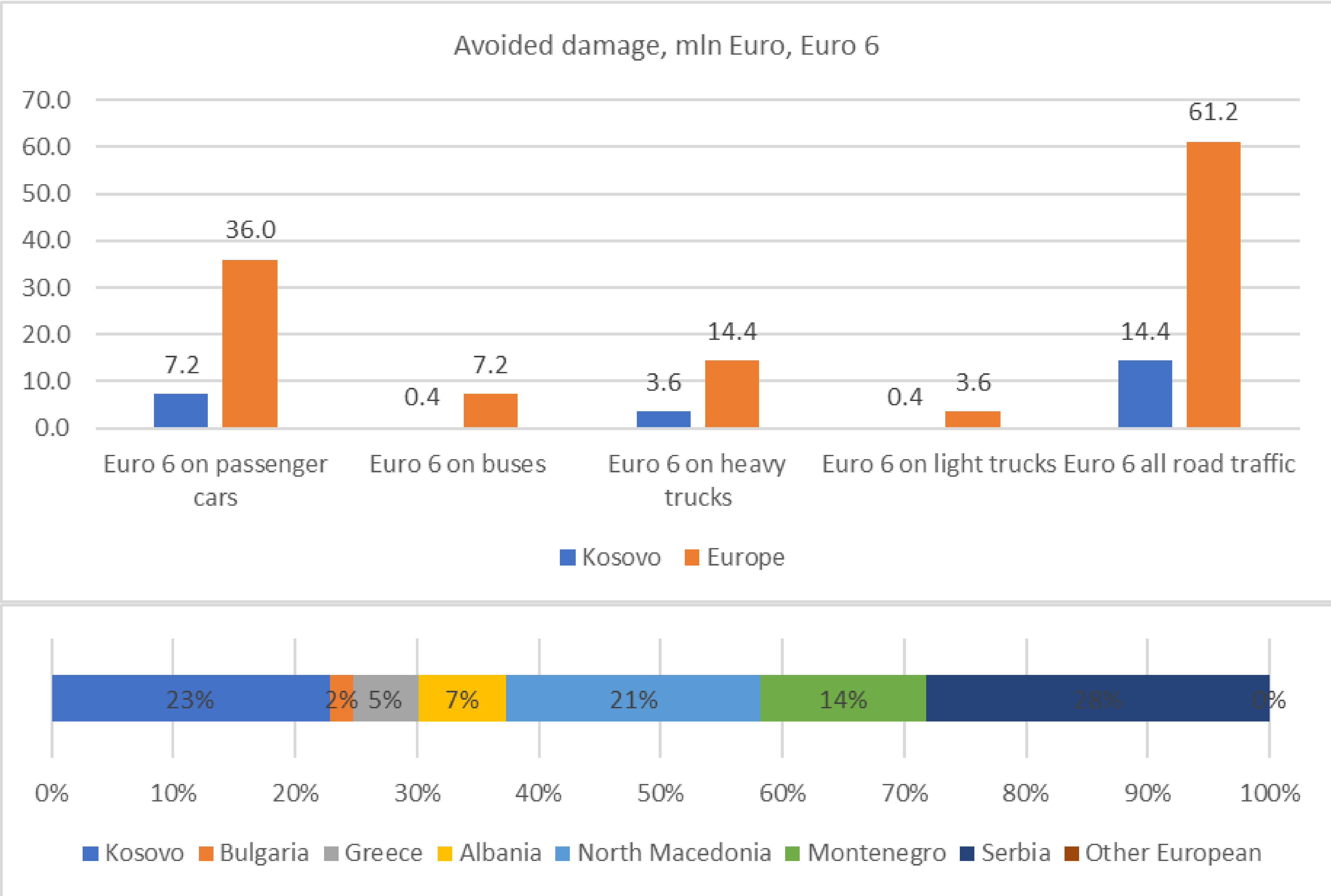


Figure 29: Euro 6 on diesel road transport – total avoided damage in Kosovo and the entire European domain (upper panel) and distribution of avoided damage by country (lower panel).

Technical costs and CBA

Table 7 presents technical costs and net health benefits from implementation of Euro 6 on different diesel vehicle categories. For all considered cases, full replacement with Euro 6 is not cost-effective in terms of saved lives in Kosovo, due to very high technical costs. For the categories 'buses' and 'light trucks', the avoided damage is so small that it cannot even be quantified with the GAINS model. For the entire Europe, however, benefits from avoided premature mortality are higher than technical costs for all cases except for the heavy trucks case. The largest net benefits in Europe can be expected if Euro 6 are applied on all diesel passenger cars in Kosovo, but also for buses, the net benefits are large.

Table 7: Euro 6 on diesel road transport – technical costs and CBA.

Table 7: Euro 6 on diesel road transport – technical costs and CBA.

Transport category/case	Technical costs, mln Euro	Avoided damage, mln Euro		Net benefits, mln Euro		Benefit-to-cost ratio	
		Kosovo	Europe	Kosovo	Europe	Kosovo	Europe
Passenger cars	29	7.2	36	-22	7.3	0.25	1.25
Buses	3.2	n.a.*	7.2	n.a.*	4.0	n.a.*	2.28
Heavy trucks	26	3.6	14	-22	-11	0.14	0.56
Light trucks	3.58	n.a.*	3.60	n.a.*	0.02	n.a.*	1.005
All road transport	61	14.4	61	-47	1.4	0.24	1.07

*Avoided damage is too small to be quantified with the GAINS model, considered insignificant.

4.5.2.2 Low emission zones

Basic assumptions for GAINS modelling

Low emission zone is a local-scale policy instrument rather than a measure; it affects people's behaviour by e.g., making them drive less or replace their vehicles with those with higher Euro standard to comply with the specific zone requirements. In the analysis, we assume that in the low-emission zones, vehicles that do not comply with Euro 3 or higher (i.e., vehicles of Euro standards 0 to 2) are not allowed (banned). People can either replace the old vehicles with newer vehicles to be able to drive within the zones or choose other modes of transport e.g., public transport or bicycles thus reduce traffic. In our analysis, we consider the case of vehicle substitution. We assume that vehicles of Euro standards 0 to 2 are replaced with vehicles of Euro 6 – in the model it means no changes in TJ fuel used by transport but only changes in control technologies.

We assume that local emission zones are introduced in three big cities in Kosovo – Prishtina, Prizren, and Mitrovica. The total population of those cities' accounts to 60 percent of the country population – see Table 8 below. In the absence of more accurate information, we assume that road transport in Kosovo is distributed similarly between the cities. Thus, assuming that low emission zones would cover about 60 percent of the road transport.

Table 8: Population in Kosovo cities in 2020[16].

City	Population in 2020, people	Share of Kosovo's total population
Prishtina	497 400	28%
Prizren	349 900	19%
Mitrovica	224 100	12%
Kosovo, total	1 789 200	

[16] https://www.citypopulation.de/en/kosovo/cities/

Emission reduction potential

Figure 30 summarises emissions with and without implementation of the measure. Emission reduction potentials for NOx is 1.45 kt, for PM2.5 – 0.15 kt, and for NMVOC – 0.18 kt.

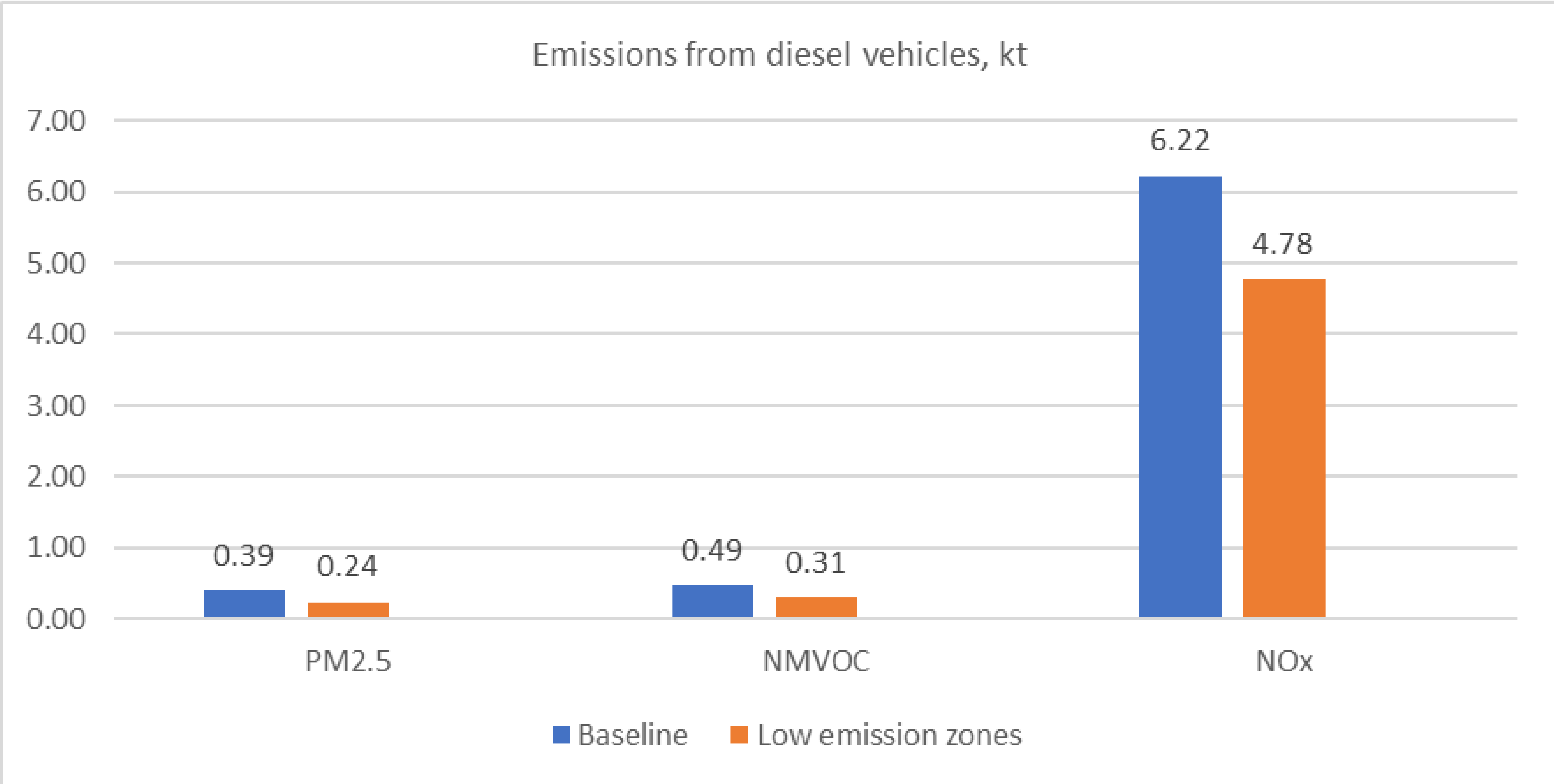


Figure 30: Low emission zones – emissions from diesel road traffic, kt.

Figure 31 displays total avoided health damage in Kosovo vs. entire Europe, and distribution of avoided damage by country. If Kosovo introduced local emission zones, 17 percent of the avoided health damage in Europe would be observed in Kosovo.

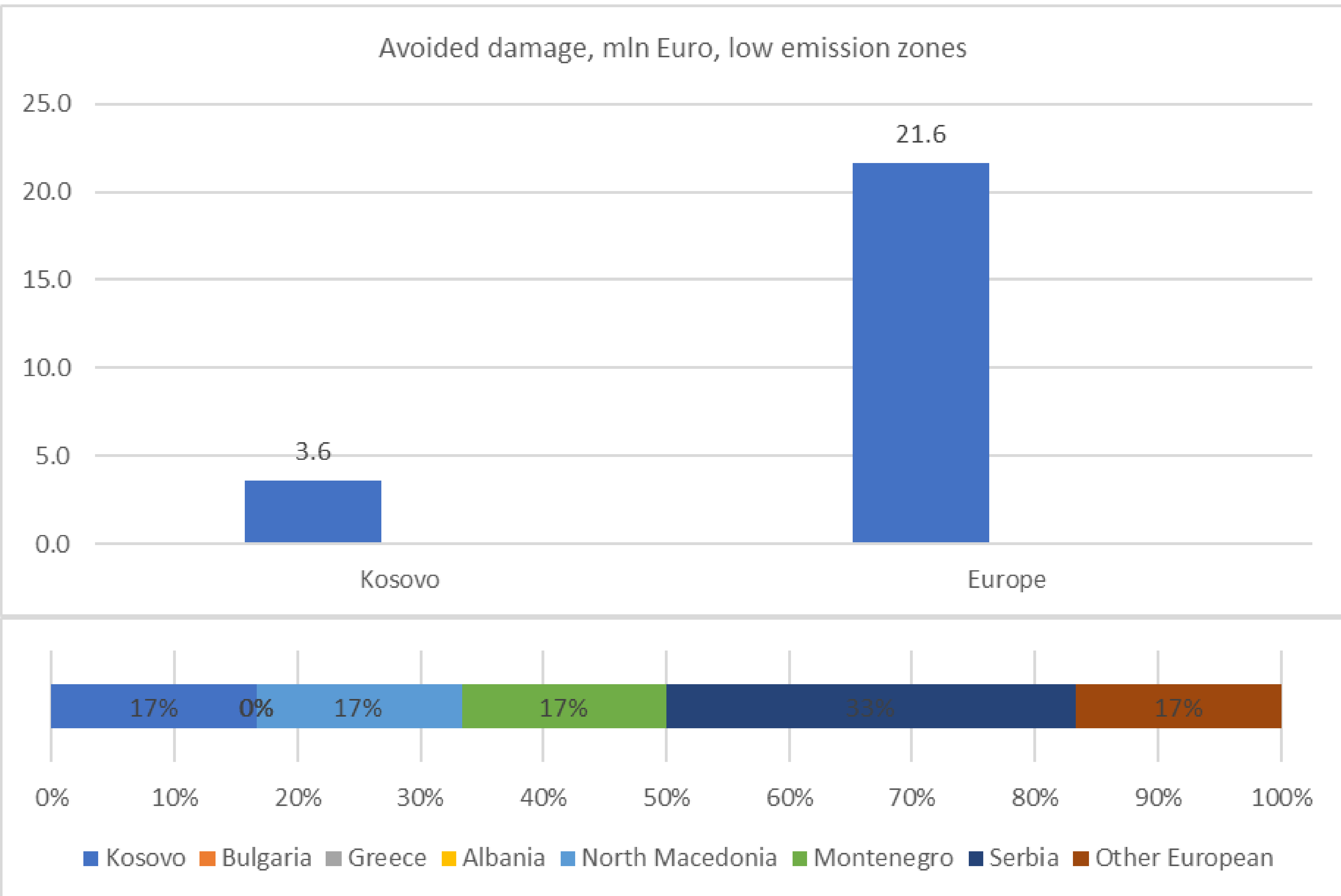


Figure 31: Low emission zones – total avoided damage in Kosovo and the entire European domain (upper panel) and distribution of avoided damage by country (lower panel).

Technical costs and CBA

Table 9 presents technical costs and health benefits from implementation of low emission zones assuming vehicle replacement to comply with the zone requirements. The measure is cost-effective considering the entire Europe. However, if only Kosovo citizens' lives are accounted for, high technical costs exceed the health benefits.

Table 9: Low emission zones – technical costs and CBA.

Technical costs, mln Euro	Avoided damage, mln Euro		Net benefits, mln Euro		Benefit-to-cost ratio	
	Kosovo	Europe	Kosovo	Europe	Kosovo	Europe
20	3.6	22	-17	1.4	0.2	1.1

4.5.2.3 Congestion tax

Congestion charges is a way of using traffic fees to regulate traffic. In a pure congestion charge system, the fee levels are set to regulate traffic flows and avoid congestion. The fee is mainly dependent on time since the aim is to mitigate congestion which typically occur during certain hours of the day. However, if one of the goals with the congestion charges is to improve air quality, emission class of the vehicles, fuel technology, time period and type of vehicle can be parameters influencing the price level (Roth et al. 2021a).

In Sweden, the purpose of congestion charges is twofold. Firstly, to reduce congestion and emissions and secondly to provide financing for new infrastructure such as roads and railways (Trafikverket, 2020). There are currently two cities in Sweden with a congestion charge set up, Stockholm and Gothenburg.

According to an estimation, fossil carbon dioxide emissions decreased by approximately 8 percent between year 2006 and 2008 when congestion charges were implemented in the inner city of Stockholm (SLB Analys, 2008). Other significant changes were also seen in decreased emissions of carbon monoxide and hydrocarbons. Between 2006-2008 hydrocarbons and carbon monoxide were reduced by approximately 1/3 due to an increase of zero-emission vehicles on the roads. Nitrogen oxide emissions decreased by 13 percent. The smaller reduction of nitrogen oxide is attributed to an increase of diesel vehicles.

In Gothenburg, congestion charges were implemented in 2013 with the aim of improving passability and the city environment. The revenues from the congestion charges were also earmarked to provide financing for infrastructural projects (Riksdagen, 2010). A lesson to learned from Gothenburg is how to go about the implementation process. There was a large public discontent when the congestion charges were implemented eventually leading to a referendum 18 months after implementation. In general, it was not the congestion charge itself that was the main cause of discontent but the overall political process and how it all was handled. Despite the referendum showing a majority against the congestion charge system, the politicians chose to keep it (Hultgren, V, 2021).

Basic assumptions for GAINS modelling

Like low emission zone, congestion tax is a local-scale policy instrument rather than a measure; it affects people's behaviour by e.g., making them drive less to avoid paying the tax. In the analysis, we make the following assumption:

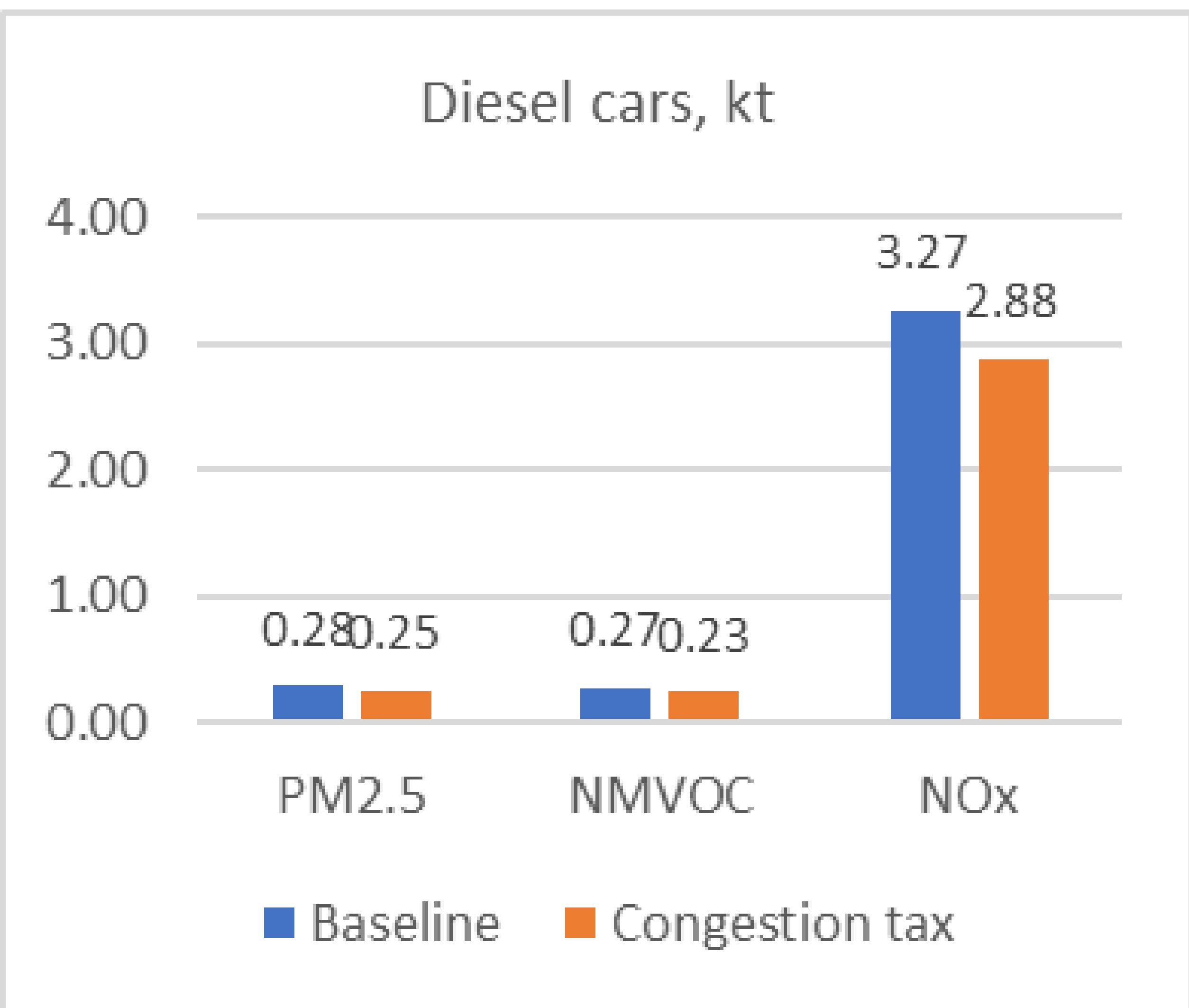
- The tax affects not only diesel vehicles but also other vehicles (on gasoline and LPG).
- The tax mainly affects passenger cars only, while trucks and buses are not reduced.
- The tax results in 20 percent less traffic in the areas where it is introduced. This assumption is based on the results of the Swedish study of congestion tax in Stockholm and Gothenburg (Börjesson, 2018).

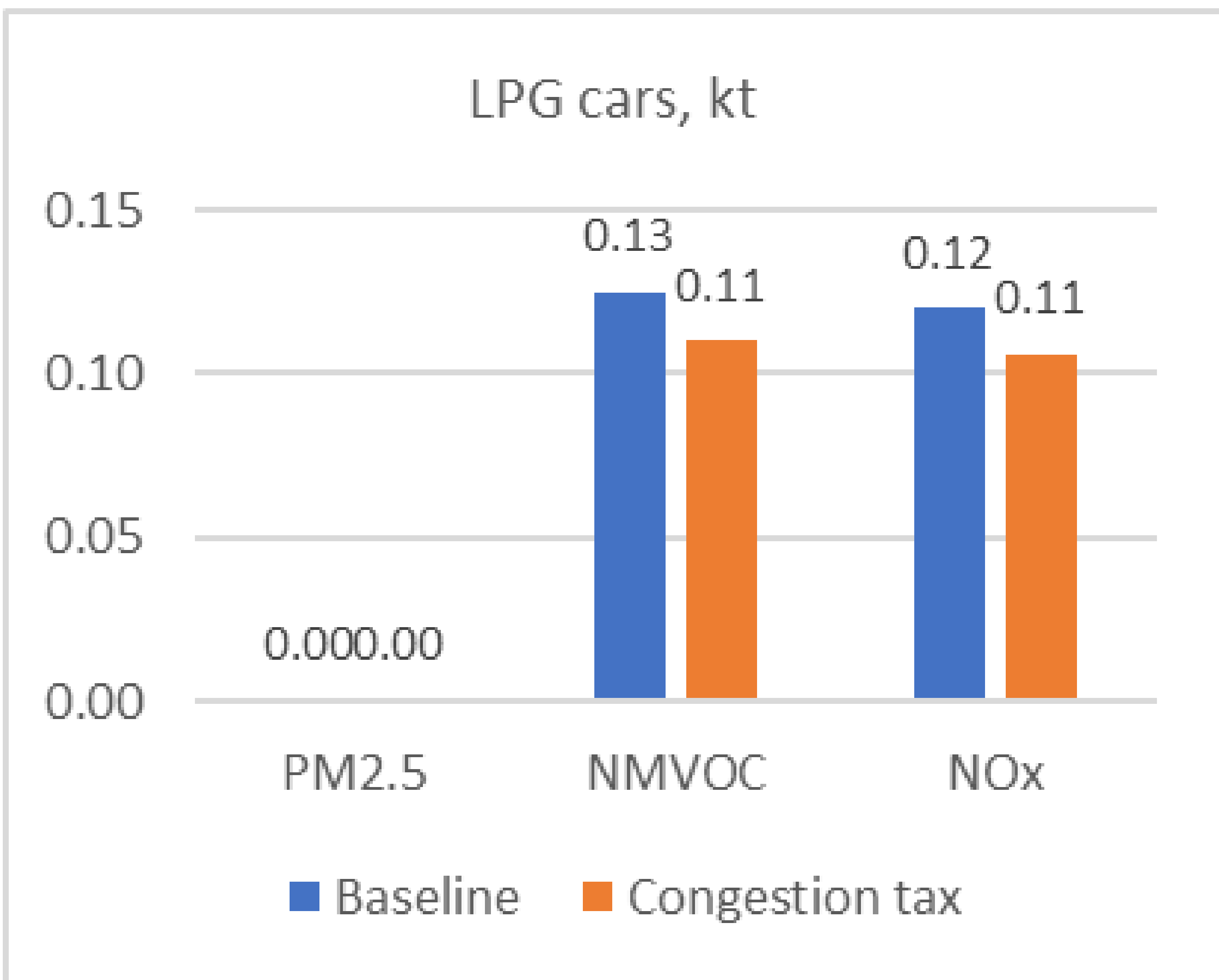
Reduced traffic activity means that not only the exhaust emissions decrease but even particle emissions from road, tire, and break wear. However, due to the complexity of including this aspect into modelling, we do not consider this change in calculations assuming that non-exhaust emissions are not affected. The emission reductions due to the measure and the resulting positive health effects are thus underestimated.

We assume that congestion tax is introduced in the three big cities in Kosovo – Pristina, Prizren, and Mitrovica, and that, as for the low emission zones, population can be used as proxy for traffic in the cities.

Emission reduction potential

Figure 32 summarises emissions with and without implementation of the measure. Considering diesel cars only, emission reduction potentials for NOx is 0.39 kt, for PM2.5 – 0.03 kt, and for NMVOC – 0.03 kt. Although emission reduction potentials are highest for diesel cars, emission reductions also occur in gasoline and LPG cars so that the total emission reduction potentials are 0.46 kt for NOx, 0.03 kt for PM2.5 and 0.14 kt for NMVOC.





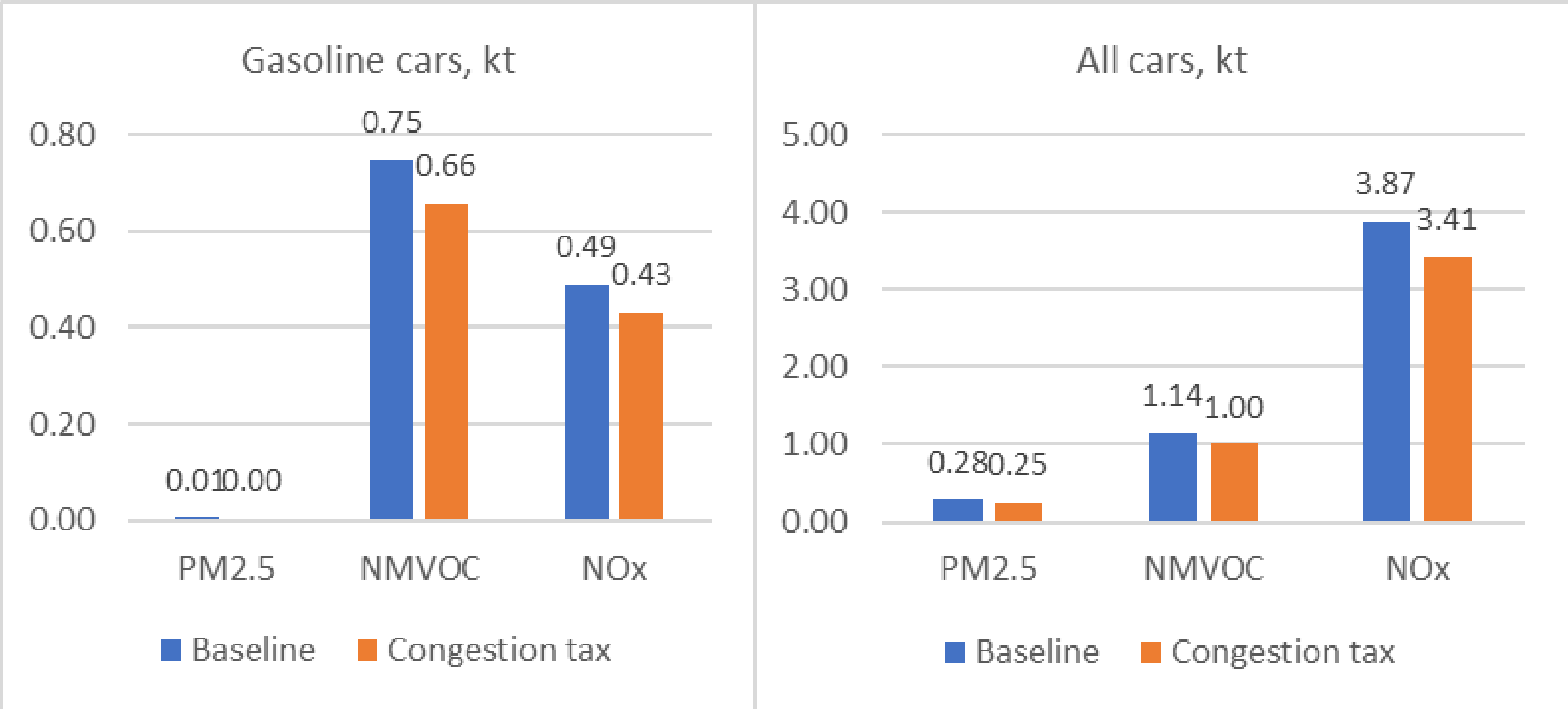


Figure 32: Congestion tax – emissions from passenger cars, kt.

Health benefits

Avoided health damage in Kosovo due to this measure is so small that it cannot be quantified with the GAINS model. Avoided health damage in entire Europe is estimated at about 7 million Euro.

Technical costs and CBA

This measure does not imply additional technical costs. Administrative costs of introduction of the relevant policy instruments are not covered by this analysis.

4.5.2.4 Modal shift, goods transportation to railway

Basic assumptions for GAINS modelling

GAINS model does not contain reallocation of traffic between different transport means as an option to reduce emissions in the transport sector. This measure is thus modelled by setting all activity corresponding to heavy diesel trucks to zero. As it is assumed that the trains are electrical, no additional emissions from the railway would appear. However, the boundary of this scenario excludes upstream emissions associated to power production.

Emission reduction potential

Figure 33 summarises emissions with and without implementation of the measure. Emission reduction potentials for NOx is 1.74 kt, for PM2.5 – 0.06 kt, and for NMVOC – 0.13 kt.

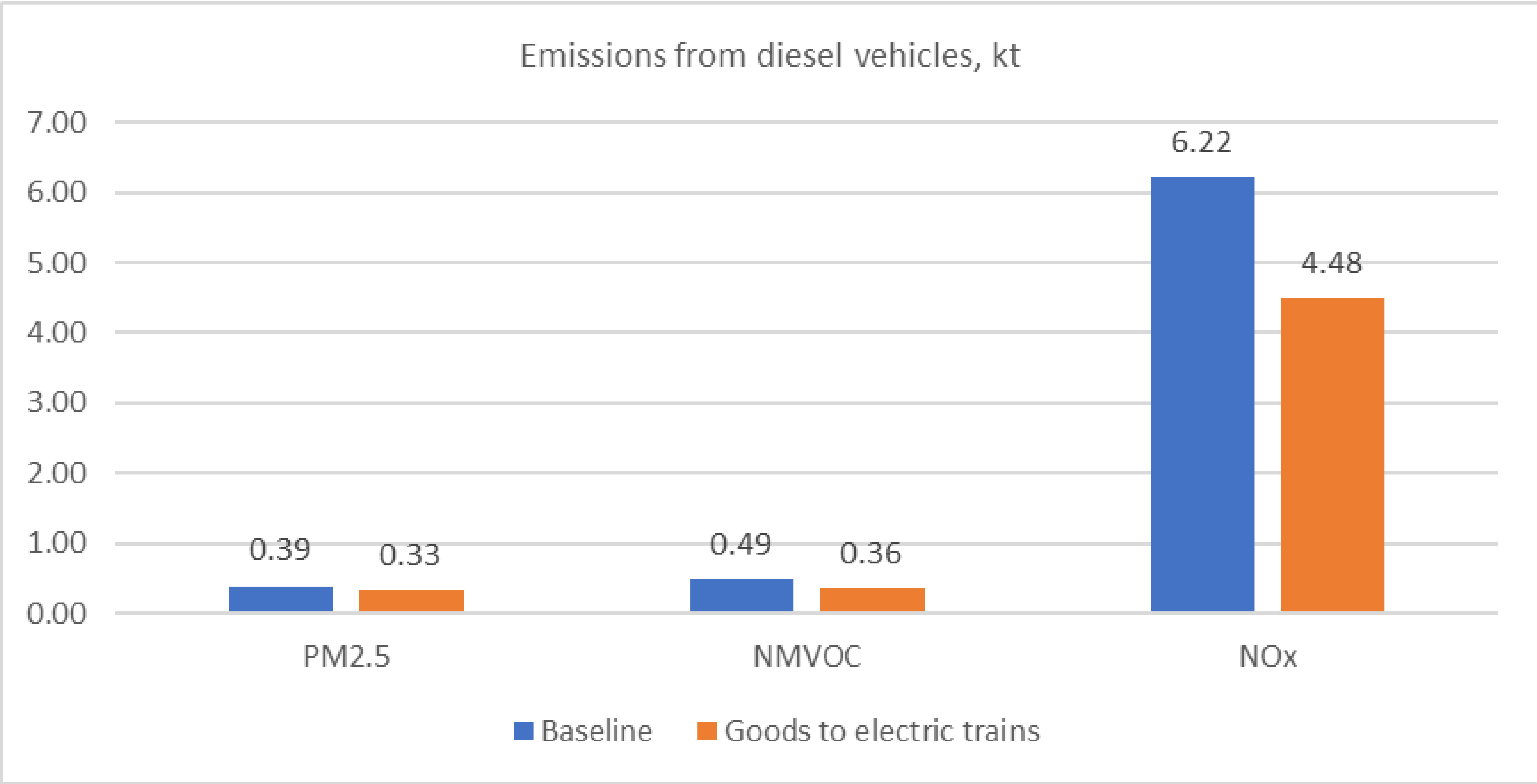


Figure 33: Shift of goods to railway – emissions from diesel road traffic, kt.

Health benefits

Figure 34 displays total avoided health damage in Kosovo vs. entire Europe, and distribution of avoided damage by country. If Kosovo implemented a shift of goods to railway, 25 percent of the avoided health damage in Europe would be observed in Kosovo.

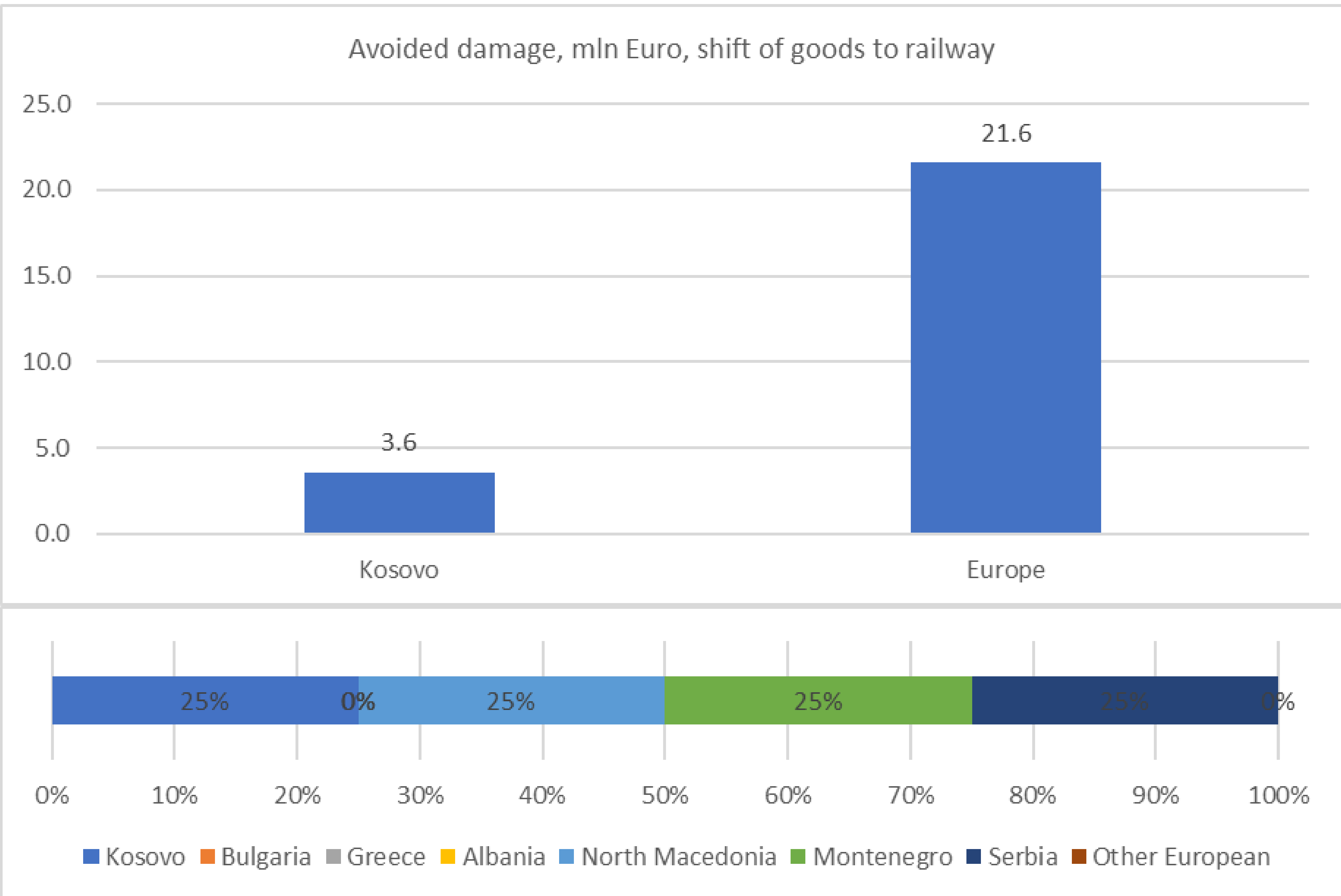


Figure 34: Shift of goods to railway – total avoided damage in Kosovo and the entire European domain (upper panel) and distribution of avoided damage by country (lower panel).

4.5.2.5 Shift from diesel to electric vehicles

Shift diesel-fueled to electric vehicles is not included in the GAINS model database. The main assumption in the assessment of the emission reduction potential is setting TJ diesel used in the transport sector to zero.

Emission reduction potential

Emission reduction potentials for shift to non-emissive sources are equal to emissions from road diesel transport – 6.22 kt NOx, 0.49 kt NMVOC and 0.39 kt PM2.5.

Health benefits

Figure 35 displays total avoided health damage in Kosovo vs. entire Europe, and distribution of avoided damage by country. If Kosovo shifted from diesel to electric vehicles, 20 percent of the avoided health damage in Europe would be observed in Kosovo.

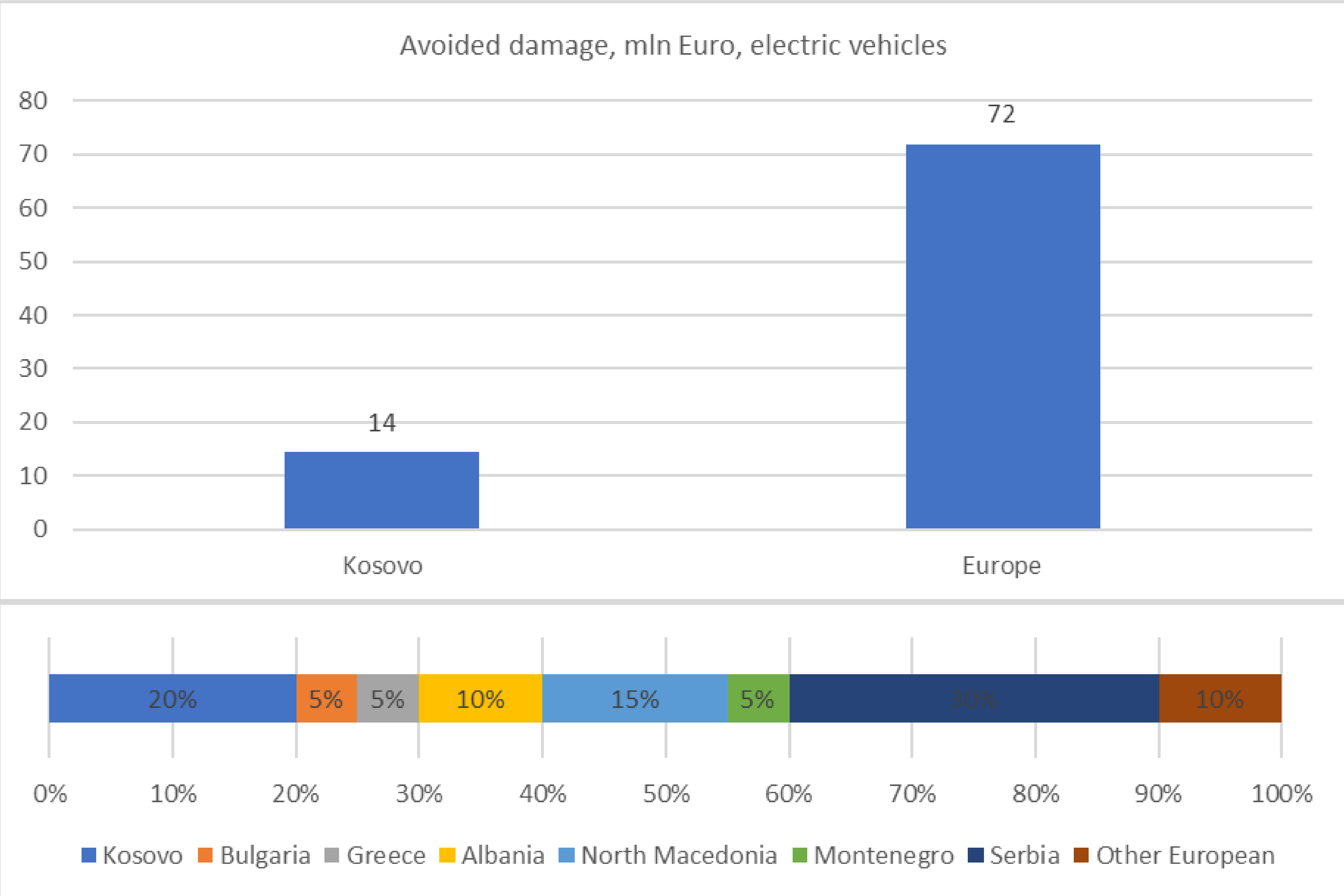


Figure 35: Shift to electric vehicles – total avoided damage in Kosovo and the entire European domain (upper panel) and distribution of avoided damage by country (lower panel).

Technical costs and CBA

Technical costs of this measure are not available in the GAINS model. To conduct a CBA, the following cost-related data are needed:

- Investment costs of electric and conventional diesel vehicles of all types (passenger car, heavy truck, light truck, bus).
- Operation and management costs of electric and conventional diesel vehicles.
- Lifetime of electric and conventional diesel vehicles.

4.5.3 Heat and power generation

For heat and power generation sector, quantified analysis of measures is mainly focused on emission control technologies such as end-of-pipe emission reduction equipment's and process modifications, wider implementation of centralized heating networks (to replace residential combustion), replacement of lignite with gas, and shift to non-emissive energy sources.

4.5.3.1 Emission control technologies at large power plants

Basic assumptions for GAINS modelling

GAINS model database contains several types of emission control technologies for existing large lignite heat and power plants – see Table 10. Current level of application of these technologies are estimated in Chapter 2.2.

Table 10: Emission control technologies for existing large heat and power plants on lignite.

Control technology	Removal efficiency			Level of application in 2020
	PM2.5	NOx	SO2	
Combustion modification	-	65%	-	-
Combustion modification + Selective Catalytic Reduction (SCR)	-	80%	-	-
In-furnace control with limestone injection	-	-	60%	-
Wet Flue Gas Desulfurization (FGD), retrofitted	-	-	90%	-
2-fields Electrostatic Precipitator (ESP)	96%	-	-	100%
High Efficiency Deduster (HED)	99.5%	-	-	-

Implementation of each type of technology to cover 100 percent of the activity is modelled as a separate measure. 2-field ESP is not included in the analysis since this technology is already implemented to 100 percent. Less effective technologies for particle control (1-field ESP, wet scrubber) available in the GAINS model are not included either.

Emission reduction potential

Figure 36 summarises emissions with and without implementation of the measures. Emission reduction potentials for NOx measures are 23.9 kt (combustion modification) and 29.4 kt (combustion modification + SCR). For SO2 measures, emission reduction potentials are 24.1 kt (limestone injection) and 36.2 kt (wet FGD). Emission reduction potential of HED as the most effective measure for PM2.5, is 3.08 kt.

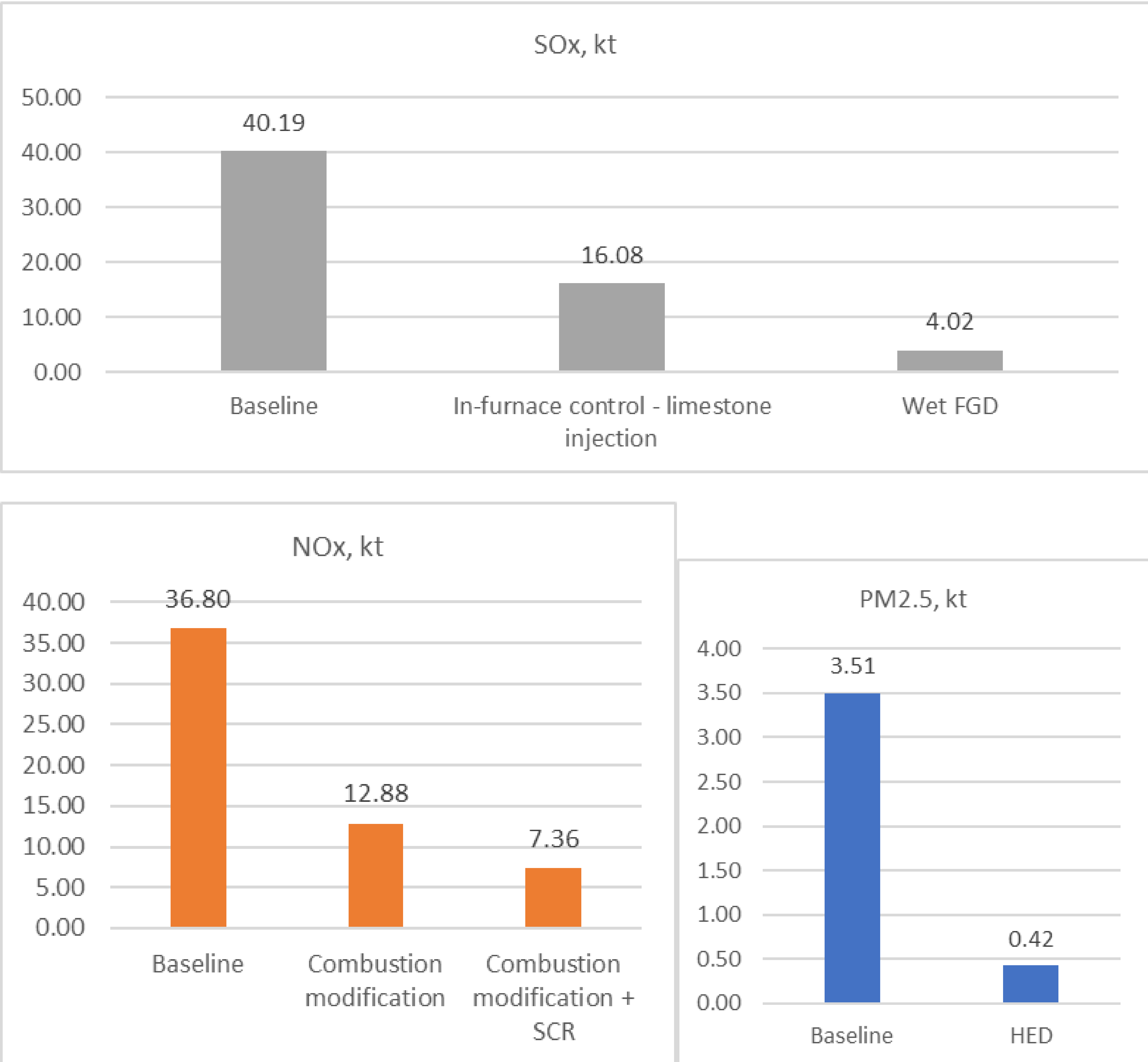


Figure 36: Emission control technologies – emissions from large lignite power plants, kt.

Health benefits

Figure 37 displays total avoided health damage in Kosovo vs. entire Europe, and distribution of avoided damage by country. If Kosovo implemented emission control technologies for existing large lignite heat and power plants, the major part (60 percent) of the avoided health damage in Europe would be observed in Kosovo.

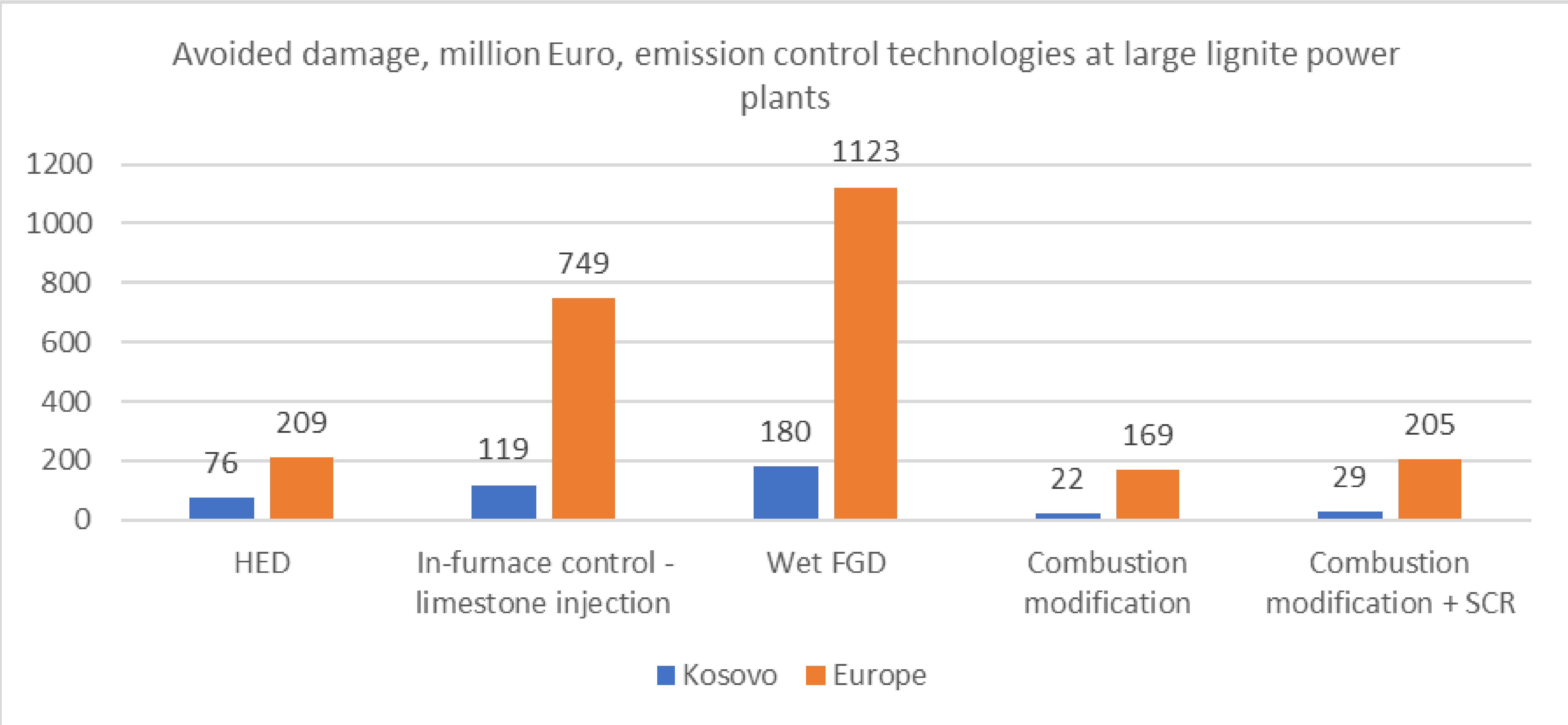


Figure 37: Emission control technologies at large lignite power plants – total avoided damage in Kosovo and the entire European domain.

Technical costs and CBA

Table 11 below presents technical costs and net health benefits from implementation of the analysed measures, as well as benefit-to-cost ratios. Full replacement of all considered technologies except for the combination of combustion modification in combination with SCR – high technical costs of this technology make it not cost-effective in terms of saving lives in Kosovo. For the entire Europe, however, benefits from avoided premature mortality are 7 times higher than technical costs.

Table 11: Emission control technologies at large lignite power plants – technical costs and CBA.

Table 11: Emission control technologies at large lignite power plants – technical costs and CBA.

Measure	Technical costs, million Euro	Avoided damage, million Euro		Net benefits, million Euro		Benefit-to-cost ratio	
		Kosovo	Europe	Kosovo	Europe	Kosovo	Europe
In-furnace control with limestone injection	60	119	749	59	689	2.0	12
Wet Flue Gas Desulfurization (FGD)	80	180	1123	100	1043	2.2	14
Combustion modification	3.7	22	169	18	165	5.8	45
Combustion modification + Selective Catalytic Reduction (SCR)	29	29	205	-0.5	176	0.98	7.0
High Efficiency Deduster (HED)	1.8	76	209	74	207	42	116

4.5.3.2 Shift from lignite to gas or non-emissive heat and power generation technologies

Basic assumptions for GAINS modelling

Shift from lignite plants to plants on gas or non-emissive heat and power generation technologies (e.g., hydro-energy) is not included in the GAINS model database. The main assumption in the assessment of the emission reduction potential is zero TJ lignite combustion at existing large power plants and, in the case of shift to gas, introduction of the same amount of TJ gas combustion for the same type of plants.

Emission reduction potential

Emission reduction potentials for shift to non-emissive sources is equal to emissions from large lignite power plants – 37 kt NOx, 40 kt SOx, 1.06 kt NMVOC and 3.51 kt PM2.5. For shift to gas (see Figure 38), the emission reduction potentials are 33 kt NOx, 40 kt SOx, 0.99 kt NMVOC and 3.50 kt PM2.5.

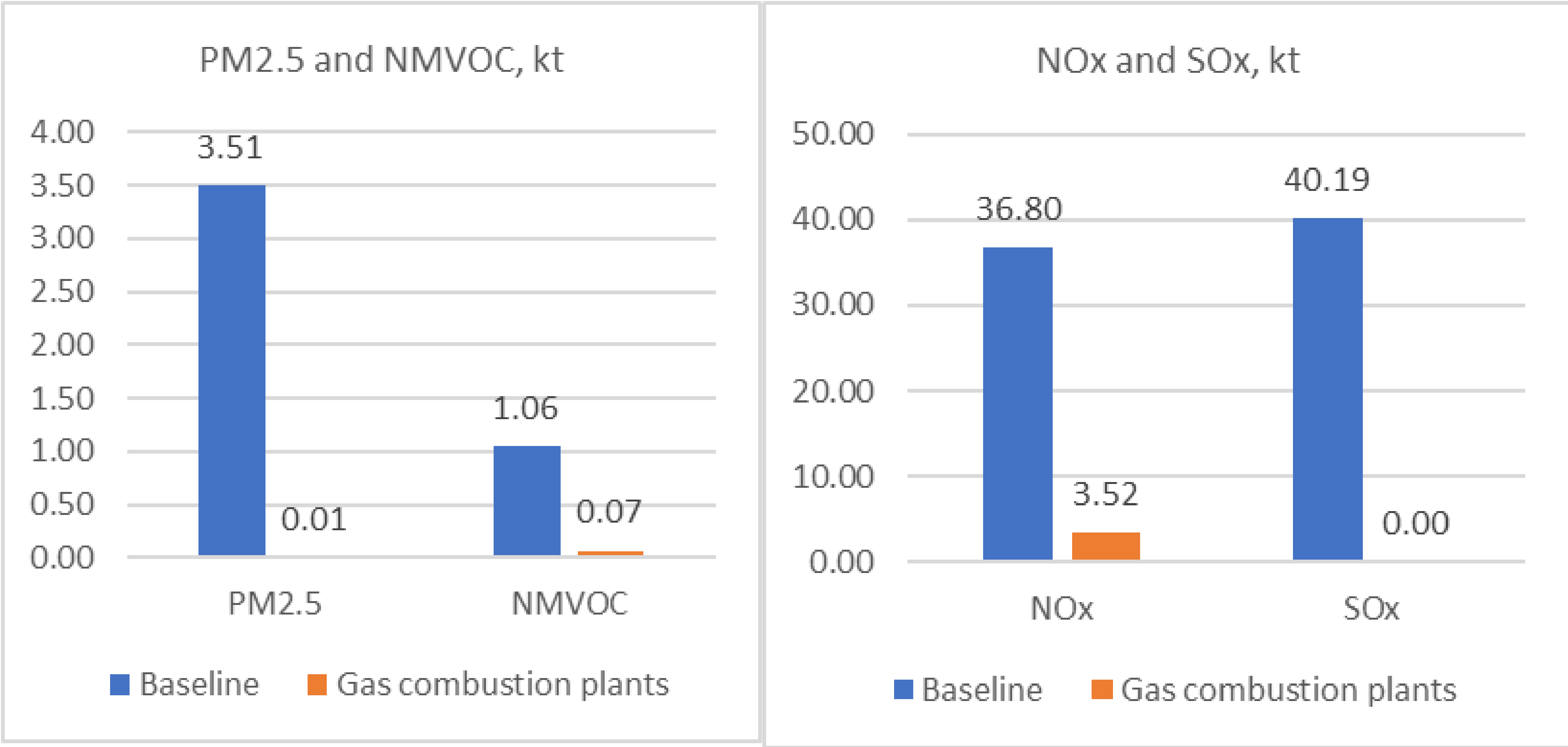


Figure 38: Shift to gas or non-emissive technologies – emissions from large lignite power plants, kt.

Health benefits

Figure 39 displays total avoided health damage in Kosovo vs. entire Europe, and average distribution of avoided damage by country. If Kosovo shifted from lignite plants to plants running on gas or non-emissive heat and power generation technologies, 19 percent of the avoided health damage in Europe would be observed in Kosovo.

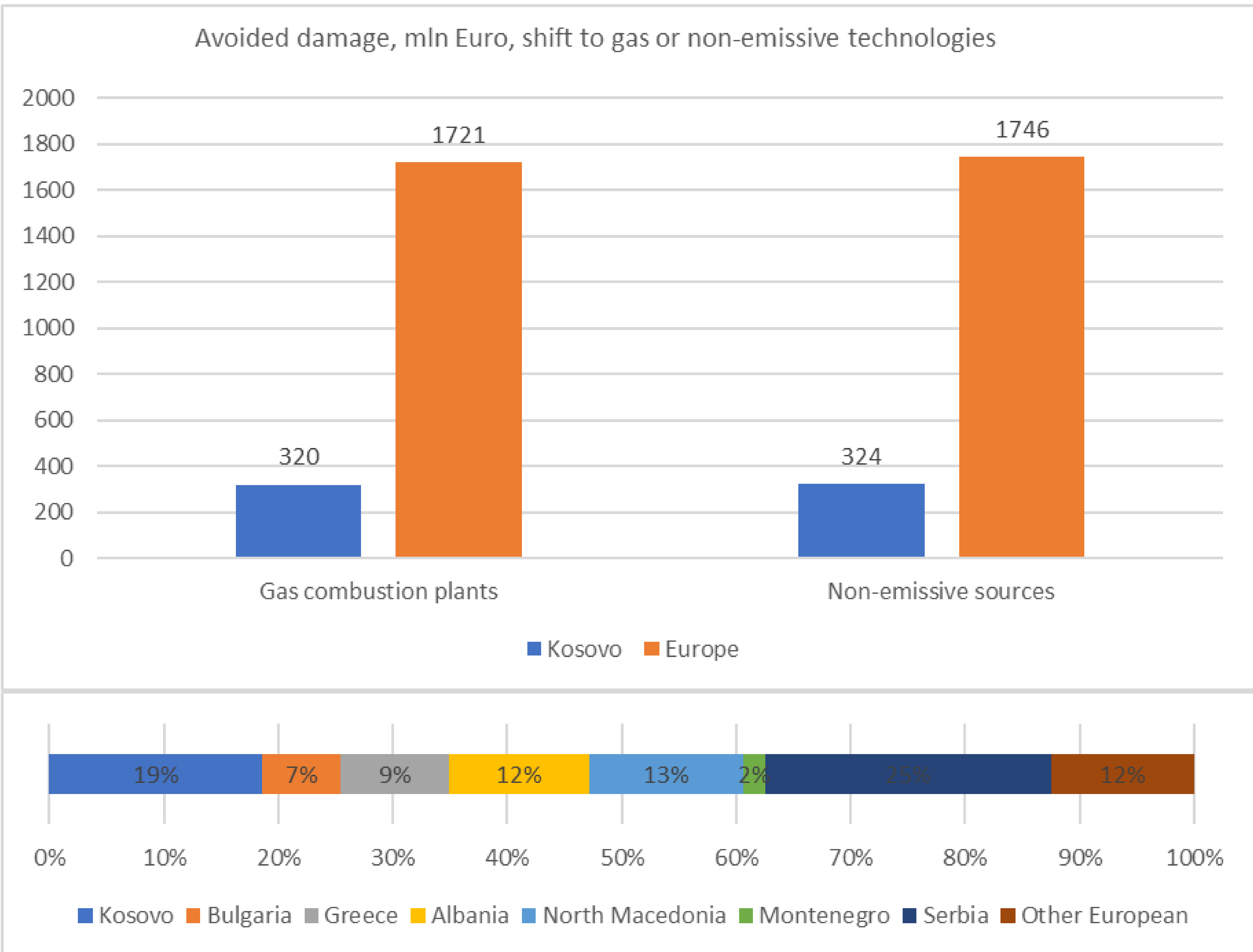


Figure 39: Shift to gas or non-emissive technologies – total avoided damage in Kosovo and the entire European domain (upper panel) and average distribution of avoided damage by country (lower panel).

Technical costs and CBA

Technical costs of this measure are not available in the GAINS model. To conduct a CBA, the following cost-related data are needed:

- Investment and installation costs of non-emissive heat and power generation technologies – e.g., hydropower, nuclear energy, etc., or gas combustion plants – and conventional lignite power plants.
- Operation and management costs of non-emissive heat and power generation technologies and conventional lignite power plants.
- Lifetime of equipment at non-emissive heat and power generation plants and conventional lignite power plants.

4.5.3.3 Extension of centralized heating system

Basic assumptions for GAINS modelling

Heat and power can be generated not only at large lignite power plants. Centralized heating plants, currently accounting for very small amount of generated heat energy, have potential to fulfill significant part of the heat demand in the residential sector. Extension of centralized heating system in Kosovo is a measure affecting both heat and power generation sector and residential sector.

The measure is not included in the GAINS model database. In the assessment of the emission reduction potential of this measure we assume that all wood combustion in the residential sector is replaced by combustion at centralized heat plants (CHP) – a part of the heat and power generation sector. Amount of fuel combusted at CHP is assumed to be higher than amount of wood in the residential sector because of the losses during heat transport. Based on the numbers in Termokos 2022-2031 (for average losses at heat transfer from Kosova B), we assume 11 percent heat losses in the analysis.

We analyze three cases of potential fuel re-allocation from residential sector to CHP:

1. CHP is fuelled with wood; emission control technologies are the same as in the baseline scenario (50 percent of 1- field ESP and 50 percent of 2-fields ESP for particles, no NOx control).
2. CHP is fuelled with wood; emission control technologies are set at the maximum possible level (100 of HED for particle control, 100 percent of Selective Non-Catalytic Reduction (SNCR) for NOx).
3. CHP is fuelled with waste; emission control technologies are set at the maximum possible level (100 of HED for particle control, 100 percent of SNCR for NOx, 100 percent of wet FGD for SO_2).

Emission reduction potential

With this measure, emissions in the heat and power generation sector increase due to fuel reallocation (Figure 40) while emissions in the residential sector decrease (Figure 41). Because of much better combustion conditions at CHP and much lower emission factors, the total emissions from the same (in fact, slightly higher due to losses) amount of combusted fuel becomes lower than emissions in case if all this fuel is burnt in the residential sector (the baseline case).

Total emission reduction potentials (in sum in both sectors) are as follows:

1. Wood-based central heating, current emission control – 8.60 kt PM2.5, 20.95 kt NMVOC.
2. Wood-based central heating, maximum emission control – 8.77 kt PM2.5, 20.95 kt NMVOC.
3. Waste-based central heating, maximum emission control – 8.79 kt PM2.5, 21.23 kt NMVOC.

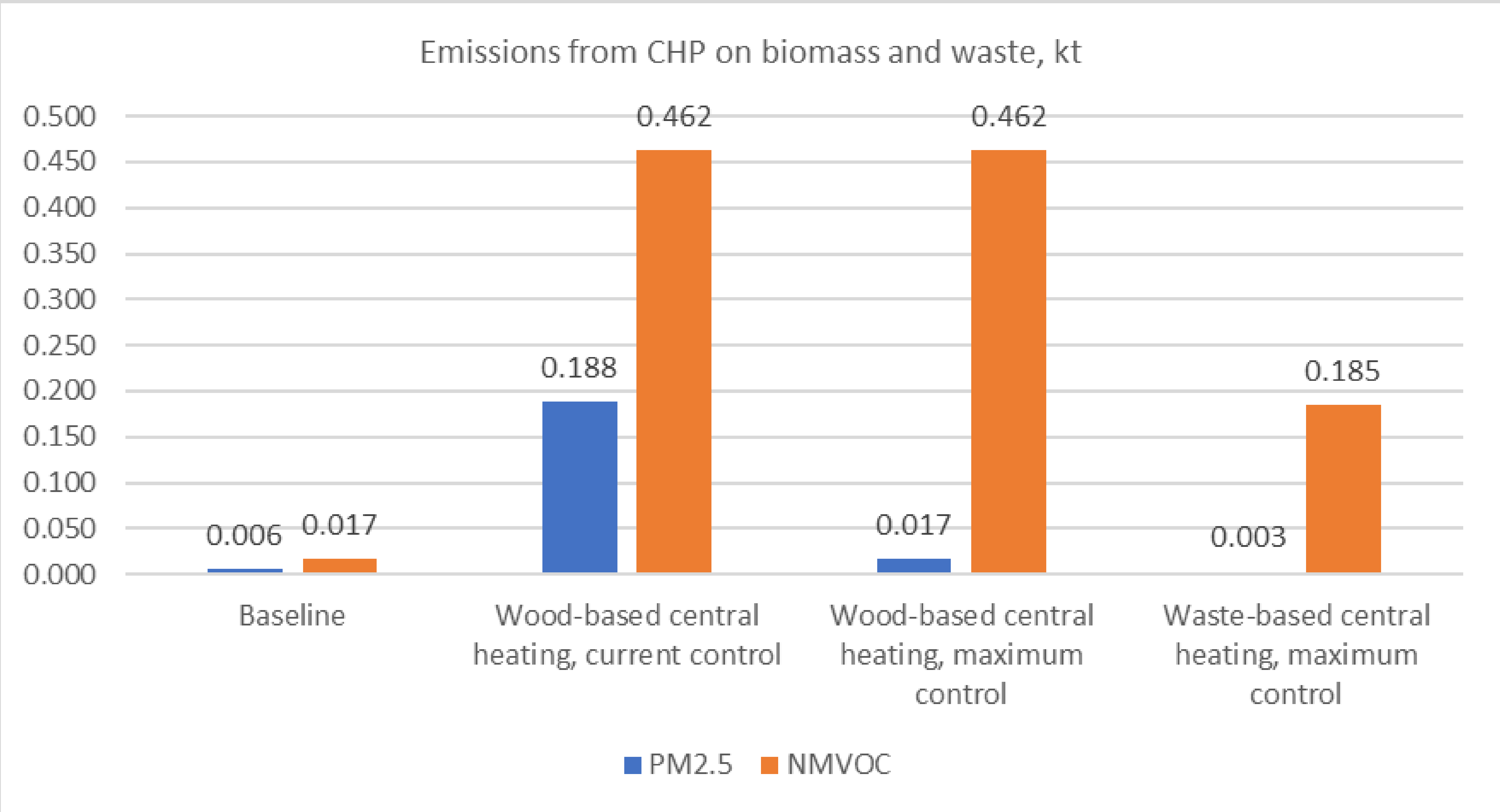


Figure 40: Extension of centralized heating system – emissions from CHP on biomass and waste, kt. Emissions of NOx, NH3 and SO2 are very low and considered insignificant.

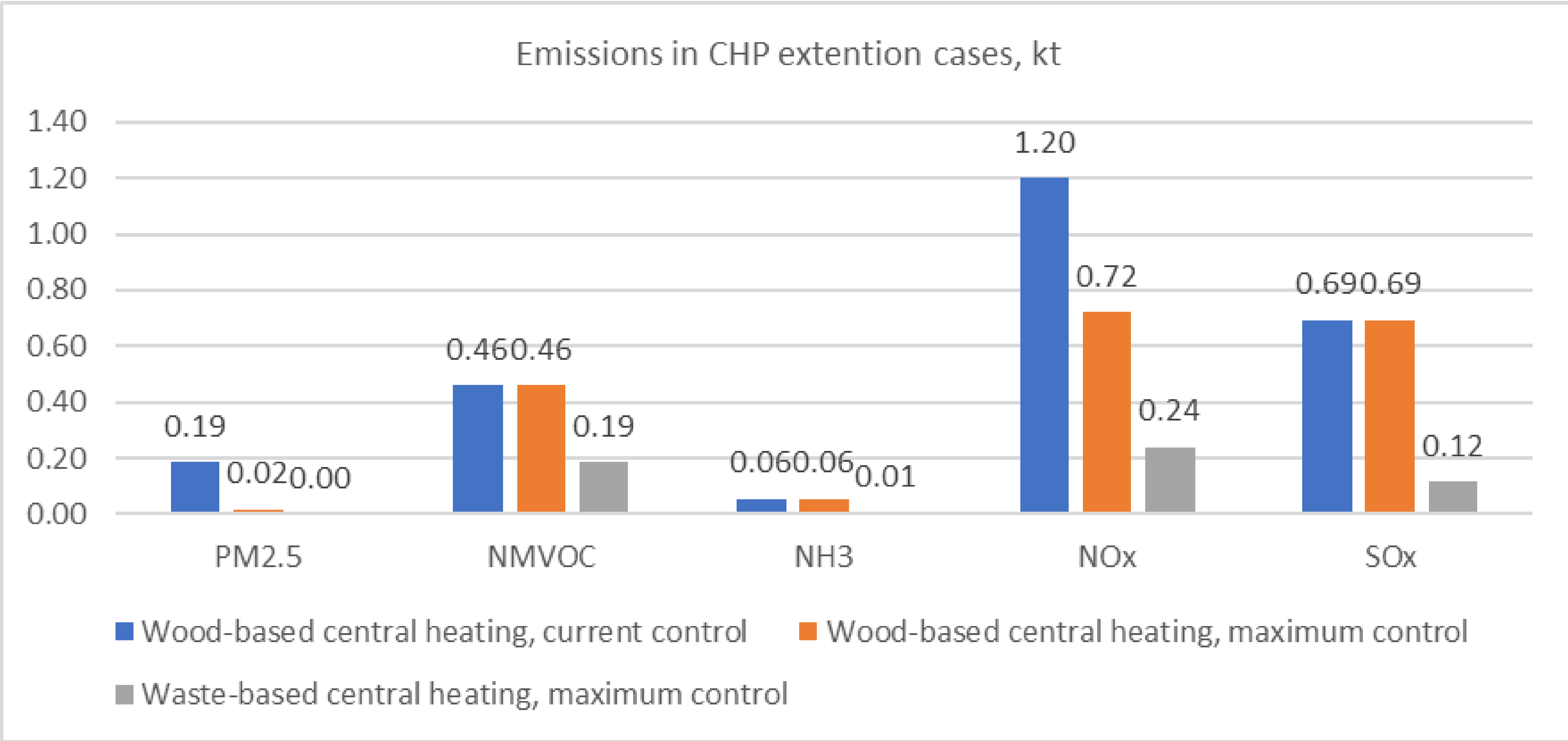


Figure 41: Extension of centralized heating system – total emissions from wood combustion in the residential sector and CHP on biomass and waste in the baseline case.

Health benefits

Figure 42 displays total avoided health damage in Kosovo vs. entire Europe, and average distribution of avoided damage by country. If Kosovo, extended its centralized heating system, 36 percent of the avoided health damage in Europe would be observed in Kosovo.

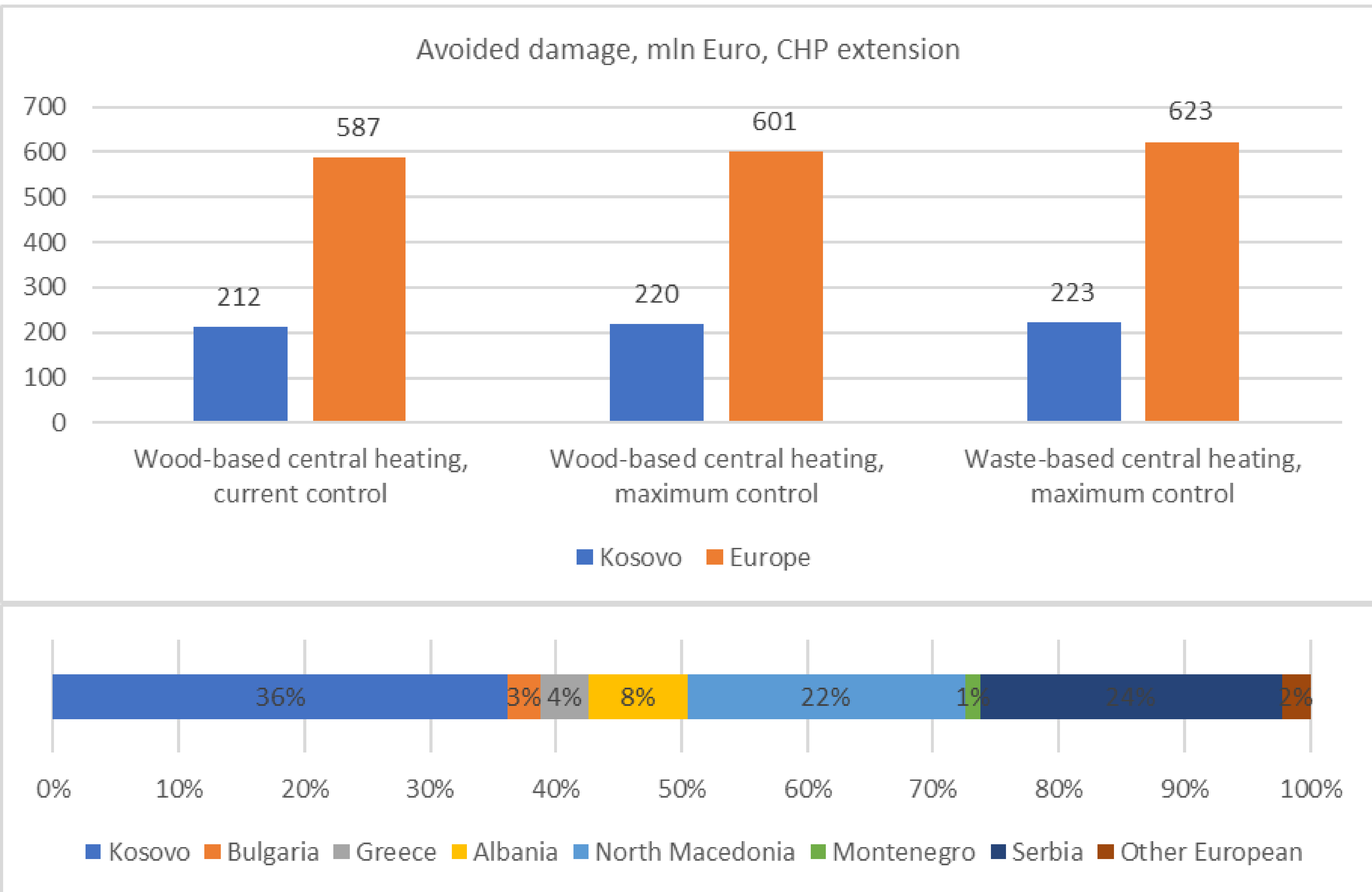


Figure 42: Extension of centralized heating system – total avoided damage in Kosovo and the entire European domain (upper panel) and average distribution of avoided damage by country (lower panel).

Technical costs and CBA

Technical costs of this measure are not available in the GAINS model. To conduct a CBA, the following cost-related data are needed:

- Investment and installation costs of equipment/ facilities needed to extend the centralized heating system.
- Operation and management costs of equipment/ facilities.
- Lifetime of equipment/facilities.

4.5.4 Summary of quantified analysis of measures

Annex 5 summarises avoided health damage due to the full implementation of the analysed measures, and if available – also technical abatement costs, net benefits, and benefit-to-cost ratios. Not all considered measures seems to be cost-effective: for some measures, technical costs are significantly higher than avoided damage (health benefits) making them not cost-effective. However, cost-effectiveness, depends on the choice of the considered domain. Considering the lives of the inhabitants not only in Kosovo, but also in neighboring countries often makes measures cost-effective. Thus, the avoided damage in Kosovo is still lower than technical costs and benefit-to-cost ratio is below 1.

Health effects of measures depend on whether we consider only Kosovo in the assessment, or the entire European domain. Positive effects in Kosovo alone vary from 13 percent to 36 percent of the avoided health damage – this depends on what pollutants are reduced by a measure. PM2.5 are not transported to the same long distances as SO2 and especially NOx, which is why for measures only affecting PM2.5 (such as replacement of appliances in the domestic sector), the share of avoided damage in Kosovo is higher (about 36 percent , see Figure 22) while for measures aimed specifically to reduction of NOx and SO2 (wet FGD, SNCR), this share is significantly lower because premature mortality from NOx and SO2 emissions occur to higher extent in countries around Kosovo (see for instance Figure 18). In decision-making processes regarding what measures to take to reduce emissions in a country, avoided health damage in other countries is often iniquitously neglected.

In certain cases, health problems due to air pollution can be tracked back to specific pollutants emitted so that unit costs (damage costs per ton pollutant) can be calculated. The GAINS model makes it possible to measure only reductions when one pollutant is affecting the premature mortality. In this analysis, several such measures are considered. Table 12 presents an overview of external costs – estimated costs of health damage resulting from emissions in Kosovo – depending on the considered domain and pollutant. These costs do not depend on measures considered, but on the structure of the population, current levels of emissions and exposure to air pollution, as well as on geographical location and meteorological conditions affecting transboundary pollution. The results illustrate that reducing one kilogram of PM2.5 emissions in Kosovo would bring significantly larger health benefits than reducing one kilogram of SO2 or NOx, and that for NOx and SO2, trans-boundary pollution is much more significant than for PM2.5.

Table 12: Overview of damage costs of air pollutant emissions in Kosovo, Euro2015/kg pollutant.

Pollutant	PM2.5	SO2	NOx
Effects in Kosovo	24.8	5.0	1.0
Effects in Europe	68.4	31.1	7.0

The results of the presented above analysis are not meant to provide an answer to what measure or combination of measures to choose to reduce certain emissions. The choice would depend on the priorities of the decision-making bodies. However, it can be facilitated by providing decision-makers with rankings of different measures by various parameters of interest – emission reduction potentials, reduction efficiencies, avoided damage, benefit-to-cost ratio. Such rankings can be found in Annex 6.

Annex 6 illustrates that depending on the parameter of priority, different measures would be chosen – e.g., extension of CHP if decision-makers prioritise emission reduction potential for PM2.5, switch to non-emissive technologies in heat and power generation if avoided damage should be maximized and installing HED in existing power plants – if cost-effectiveness is prioritized[17]. Most often, a set of measures in different sectors is taken for implementation – this set, together with activity data, defines a certain development scenario. Relevant scenarios for Kosovo were discussed in the previous chapter 3.

5. POLICY INSTRUMENTS RELEVANT FOR SCENARIOS

As previously described in chapter 1.2, this report distinguishes between proposed measures and policy instruments and consider policy instruments as driving forcers to implement measures. In Annex 5, measures, and instruments relevant for the key sectors are presented as matrixes illustrating a ‘measure-instrument toolbox’ for each key sector, where each measure is linked to one or several policy instruments and vice versa.

[17] With regard to the limited number of measures for which technical cost data are available in the GAINS model.

Several of relevant policy instruments are of legal character. Kosovo's national environmental legislation is currently not in full compliance with the relevant EU legislation. The status of harmonization of Kosovo's legislation for the three key sectors with relevant EU Directives is summarized in Annex 8. Possible solutions might be better harmonization with the EU legislation by drafting enforcement legislative acts and appointing responsibilities.

Jointly with discussions with KEPA, and Balkan Green Foundation (BGF) and other national experts, nine policy instruments, across three key sectors have been selected for further, more detailed analysis. Table 13 below show one policy instrument per key sector and per options LOW – MID or GREEN.

The previous chapters included a Maximum technically feasible reduction (MTFR) scenario. The MTFR scenario corresponds to a hypothetical situation. It implies that all technical measures are set to maximum implementation rates, which is a rather unrealistic scenario. Hence, it cannot be used for guidance on specific policy recommendations. Therefore, the recommended policy actions listed in this chapter has excluded the MTFR scenario.

Table 13: Matrix overview of key sector and related policy instruments

	LOW	MID	GREEN
Key sector	**Policy instrument**	**Policy instrument**	**Policy instrument**
Small-scale wood combustion	Investment support and tax reductions for energy efficiency measures in the building sector	Financial support to install retrofit ESP on existing stoves	Economic incentives for switch to solar panels and heat pumps
Heat and power generation	Taxes and refundable charges on emissions of air pollutants (SO_2, NOx)	District heating policy instruments	Tax on fossil fuels
Diesel road transport	Low emission zones in 4 large cities	Vehicle replacement programs	Subsidies/tax reduction for import of electric/hybrid cars

5.1 Policy instruments - Residential wood combustion

This section gives an overview of proposed policy instruments targeting the emissions of air pollutants within the residential wood combustion sector.

5.1.1 Investment support and tax reductions for energy efficiency measures in the building sector

All energy efficiency measures have multiple benefits to the environment, including avoided use of energy resources, as well as avoided emissions from energy combustion. Energy efficiency measures in buildings that lead to reduced residential wood combustion will directly impact air quality in residential areas.

There are several choices of financial instruments to improve energy efficiency in buildings: Grants and subsidies, loans, and tax incentives (Cialani & Perman, 2014). Tax reductions and low-interest loans are important instruments to increase investments in energy efficiency projects. In addition, stricter energy efficiency standards, training and awareness programmes, improved legislation and governmental support programmes for investments, are important factors to increase investments. Globally and in the UNECE region, self-financing is the most widely used financing method for energy efficiency projects, followed by direct financing from public budgets and debt financing. (UNECE, 2017). Generally, national authorities provide the most support for developing and implementing energy efficiency projects, compared to authorities at regional- or local level (UNECE, 2017).

Barriers to financing energy efficiency measures include low awareness of the multiple benefits of energy efficiency projects, lack of understanding of energy efficiency project financing by banks and other financial institutions as well as bureaucracy and low energy prices (UNECE, 2017). When designing policies for energy efficiency measures, it is important to achieve acceptance for the policy through communication and information, and to raise awareness of the multiple benefits of energy efficiency projects. Another important aspect is to consider the needs of the local communities (Cialani &Perman, 2014).

A strong regulatory framework has been shown to promote strong support for investments related to energy efficiency, whereas a weak regulatory framework provides little support to investments (UNECE, 2017). To increase energy efficiency measures in Kosovo, it is therefore important to implement and strengthen regulatory policy instruments. Below, two such policy instruments are discussed in relation to Kosovo's legislation.

Energy efficiency for buildings and labelling

In Kosovo, energy efficiency goals and building renovation goals (NEEAP) are set within the Law on energy efficiency, which was legally transposed in 2018. The Kosovo Energy Efficiency Fund (KEEF) was established by this law as an independent, autonomous, and sustainable non-profit legal entity, at the service of the public interest, with full legal personality and an independent legal identity.

Energy certification of buildings

In the EU, energy efficiency targets and measures, including those for the building sector, are regulated through the EU Energy Efficiency Directive (2012/27/EU), which recently have been strengthened. The Energy Performance of Buildings Directive (2010/31/EU) regulates the energy performance of buildings. In addition to the reduced need of heating, as buildings become better insulated, the incentives to avoid chimneys have become stronger as the Energy Performance of Buildings Directive is implemented within national energy acts. This is because chimneys are exposed to heat losses when not in use. Without a chimney, installing wood stoves or boilers is difficult and more expensive (IEA Bioenergy, 2022).

In Kosovo, the law on energy efficiency defines the obligations and the procedures for the certification of the energy performance of buildings. However, due to the absence of certified energy auditors and functioning software, energy certifications of buildings have not been achieved. (See Annex 8 for more details). Currently, the Kosovo Agency for Energy Efficiency/Ministry of Environment and MESPI are working on the initiation of the training and certification of auditors with support from the University of Pristina and Centre for Energy and Sustainability (Yaramenka, 2022).

5.1.2 Financial support to install retrofit ESP on existing stoves

The EU Commission eco-design directive has requirements for energy efficiency and emission levels of new stoves and boilers. This directive has not yet been legally transposed in Kosovo. See Annex 8 for more details. As a less costly alternative to replacing stoves and boilers with new models, existing appliances can be retrofitted with ESP to reduce particle emissions.

Financial support to install retrofit ESP on existing stoves may cover the entire cost or part of it. Seen from a homeowner's point of view, there are no other direct benefits (apart from better air quality) by installing ESP. Therefore, a full cost cover is most likely needed to reach the best possible outcome. For instance, a combination of a fire ban using appliances not meeting the emission criteria and a support scheme for retrofit ESP could give stronger incentives to install ESP. However, in Kosovo financial support to install retrofit ESP on existing stoves does not exists as of today.

During 2018, the European Bank for Reconstruction and Development (EBRD) launched a new programme which aims to provide loans for households to install high-efficiency appliances (GEFF, 2018). Subsides are provided to families and companies, which can apply for a cost recovery of 20 percent of the total investment costs (Yaramenka, 2022).

In Switzerland, there are regional subsidies for installing retrofit ESP in residential wood appliances. To be eligible for the subsidy, typically a removal efficiency of 60 percent is required.

In Germany, there has been a subsidy for retrofit ESP in wood boilers. For wood stoves, there have been short-term local subsidies to install retrofit ESP (IEA Bioenergy, 2022).

Advantages of retrofit ESP include reduced particle emissions without the need of replacing the entire stove, at a significantly lower cost. Even if emission criteria according to the EU Ecodesign directive is implemented in Kosovo at this date, these would only cover new installations. Thus, emission reductions would be achieved gradually, as the current appliance stock is replaced with new appliances. A policy that promotes retrofit ESP would on the other hand have immediate effects on air emissions.

One disadvantage of retrofit ESP is the need of regular maintenance (cleaning of the ESP and chimney) for the ESP to maintain its removal efficiency. This may be an obstacle in Kosovo, as there are no chimney sweeping regulations and chimney sweeping is done very seldom, usually ordered at private companies.

Other disadvantages include the still relatively high cost of installing ESP and the fact that other pollutants than particles and soot are not reduced with ESP. In addition, retrofitting existing appliances does not reduce the energy need, which a replacement with a new, more efficient stove, will contribute to.

5.1.3 Economic incentives for switch to solar panels and heat pumps

Heat pumps are, as discussed previously in chapter 4.2.1.6, an efficient measure to heat buildings. If the electricity needed to power the heat pump is generated by building-integrated solar panels, it also becomes a non-emissive heating solution, and independent of national electricity production off the traditional electric grid.

One factor determining the total life-cycle cost of heat pumps using external electricity as a power source, relates to the electricity price. Combining a heat pump with solar panels, is likely to lower the running costs substantially, as the solar panels and heat pump load profiles match well all year-round (SolarPowerEurope, 2023).

Heat pumps as a replacement for existing heating systems are rather rare, due to high cost and lack of information and knowledge. To promote installation of heat pumps, several countries use economic incentives or education programmes to raise awareness on the benefits of heat pumps. (IEA, 2022).

The cost of installing solar panels and a heat pump is fairly high although running costs can be low. Access to low-interest loans, supported by the government, is an option to make this solution more affordable, as well as to reduce payback times. It is highlighted by a European trade association 'Solar Power Europe' as an important economic instrument for EU member states.

Other economic instruments that can increase installation of solar panels and heat pumps are fixed subsidies for installation of solar panels. Heat pumps would cover some of the material and installation costs, or a percentage of the investment cost. Tax deductions for homeowners installing solar panels and heat pumps, based on investment costs, is yet another way to reduce the cost for the homeowner (SolarPowerEurope, 2023).

Many countries offer some sort of economic incentive for installing solar PV or heat pumps. Italy is applying a 'superbonus' scheme, where a homeowner can claim a 110 percent tax deduction on installation costs, and Germany offers up to 40 percent financial support for heat pumps (SolarPowerEurope, 2023). The Swedish government offers financial support to promote the installation of solar panels, as well as tax reduction on green technology installation.

Current status in Kosovo is that economic incentives are only financed by donors and private banks, the government does not provide any support for solar and heat pumps (Yaramenka, 2022).

5.1.4 Regulations on fuel for residential combustion

In addition to the three policy instruments analysed for the residential wood combustion sector, regulations to prohibit coal combustion and biomass certification are instruments that are recommended to reduce environmental impact from this sector.

In Kosovo, in addition to wood, coal and lignite are used to a small extent for residential combustion. Compared to wood combustion, combustion of coal and lignite are worse from a health perspective. Preventing, for example by prohibiting, the use of coal and lignite for residential heating would thus improve air quality. Although it is still allowed to use coal as fuel in domestic homes, it is illegal to extract coal and sell on the market. Lignite is not as expensive, but the ash content is high, and the energy content is low.

To address the consequences of air pollution from small-scale coal combustion, the Government of Kosovo has in January 2019 approved requests from the Ministry of Environment and Spatial Planning (MESP) not to use coal as heating in public institutions. Further actions have been highlighted as necessary, such a program that totally prohibits the use of coal for heating in Kosovo (Balkan Green Foundation, 2019). Public resistance is likely to be expected if introducing a general prohibition on coal combustion, as alternative heating sources are much more expensive (Yaramenka, 2022).

Biomass certification that provides assurance that the wood biomass is sourced legally and in a sustainable manner does not exist in Kosovo as of today (Yaramenka, 2022). The study recommends that a national certification of biomass is implemented in Kosovo.

5.2 Policy instruments - Diesel road transport

For key sector Diesel road transport the following policy instruments have been selected for further analysis:

- Low emission zones
- Vehicle replacement programs
- Subsidies and tax reduction for import of electric and/or hybrid cars

5.2.1 Low emission zone

A low emission zone is a defined geographical area within a city where vehicles are excluded based on emissions, access is denied for vehicles with emissions above a specific limit and in doing so, excluding the most polluting vehicles. Emission control technologies improve over time, and it is therefore common to base the exclusion of vehicles on the current, highest Euro-emission standards. This is a way of targeting the most emission intensive vehicles and reducing the pollution from these whilst only affecting a limited number of vehicles (Roth et al. 2021a, Dieselnet, 2019a, b).

The primal objective of low emission zones is to improve air quality, not to decrease traffic or car use. The design of the zone can be adapted to fit certain conditions and the regulations can be applied during specific hours, certain days, or situations (Roth et al. 2021a).
Improvement of air quality is a continuous endeavor and nothing that can be managed during one term of office. Thus, implementation of a low emission zone must secure support that holds successive governments. It is therefore important for countries and cities with short terms of office and frequent elections to consider how to ensure long-term political support for a low emission zone.

Morton et al. (2021) argues that implementing a policy that will restrict the mobility of the citizens is usually viewed as a controversial topic. Furthermore, lack of proper political endorsement and public acceptance have been shown to prevent and hinder the introduction of Urban Vehicle Access Regulations, indicating the outmost importance of having public and political acceptance for having implementation success.

The cost for the introduction and operation of a LEZ are aspects that must be considered. Relevant matters of expense are communication, personnel costs, enforcement, traffic signs, traffic measurements and preparations etc. However, these costs are generally rather modest. For Stockholm, the introduction of the low emission zone targeting light vehicles cost approximately 175 000 EUR. The cost covered the following: time for personnel (53 500 EUR), traffic measurements (35 000 EUR) and communication measures (87 000 EUR) (City of Stockholm, 2021). Though, it must be highlighted that these costs are marginal costs. The Stockholm case presupposes that personnel and relevant competences are available. Without this knowledge foundation, more resources are needed to build the necessary competence.

The potential effects of a low emission zone are strongly dependent on the design of the zone. A strict zone only allowing the highest Euro standards will have a stronger impact compared to a zone with more light restrictions. The size of the zone must also be considered. A smaller zone will have less impact than a larger zone since a large zone will affect more people and their vehicles. A large zone creates stronger incentives for more people to switch to a vehicle complying with the zone regulations. Emission zones encompassing both light and heavy-duty vehicles are considered as efficient measures to improve air quality by reducing emissions of particles and nitrogen oxides (Stockholm Stad, 2018).

In 2015, Gothenburg performed a study to investigate the effects on air quality if the current low emission zone for heavy duty vehicles were to also include light duty vehicles. The study showed that inclusion of light duty vehicles has the potential of reducing nitrogen oxides by 4-12 percent and one percent for PM10 by 2020 compared to the emission levels 2015. For particle emissions the predicted development suggests a reduction by 10 percent for 2025 and four percent by 2030 (Koucky & Partner, 2015).

The future effects of low emission zone for heavy duty vehicles in Gothenburg was investigated and found significant effects on air quality compared to a base case with no regulations. Calculations showed a reduction in nitrogen oxides of 28 percent in 2020, 10 percent 2025 and four percent in 2030 compared to the levels of 2015. For reduction of particles, PM10, the calculated values are two percent, one percent, and zero percent for the same scenario as above. The findings from this study implies that the greatest effect of the low emission zone is seen directly after implementation and then the effect decreases over time due to a natural shift in vehicle fleet towards less polluting vehicles. Furthermore, the results indicate that heavy-duty vehicles and a low emission zone for those vehicles can have significant impact on air pollution (Koucky & Partner, 2015).

The status in Kosovo regarding low emission zones is that there are currently no zones in place however it might be part of mobility measures at the municipal level developed in large cities.

5.2.2 Vehicle replacement programs

Through a scrapping program, owners of older vehicles can become more inclined to dispose of their old vehicles. When an old vehicle is scrapped it is most common to replace that vehicle with one of better technical standard which would contribute to a renewal of the vehicle fleet.

Currently, there is no vehicle replacement program in place on national level in Kosovo. However, there are plans at the municipal level, e.g., for renewal of bus fleet in Pristhina (SUMP Prishtina, 2019).

However, replacement of old vehicles with newer has many sides. If the focus is on climate gases, phasing out existing petrol and diesel cars should be done as quickly as possible. It would reduce emissions of environmentally and health-hazardous exhaust gases and a faster vehicle turn over can contribute to reduced risk of traffic accidents. At the same time, resource use would increase following the demand for new vehicles (Larsson et al., 2023).

According to calculation in a study by Larsson et al. (2023) emissions of PM2.5 are on such levels from production of vehicles that scrapping of vehicles can increase the total amounts of these emissions. Important to this is that it can be a difference in effect of emission from cars and emissions from industry facilities. Exhaust particles from cars are very small and not comparable from a health damage perspective to larger particles. However, there are benefits from reducing these emissions in environments with a lot of people and it can be both an environmental and health benefit to limit exposure. There is much evidence that prematurely scrapping combustion engine cars can be an environmental gain in terms of exhaust particles.
In Sweden, up until 2007, it was possible to get up to SEK 50 000 when scrapping your old car. However, today it is up to municipalities and individual car scrappers to decide how much they want to give.

By the end of 2008, car owners in France were offered 1 000 EUR for scrapping passenger cars with carbon dioxide emissions above 160 gram per kilometer. The offer was extended until the end of 2009 but with a lower compensation. In Germany, car owners were offered 2 500 EUR for scrapping cars nine years or above. Within a few weeks the 1.5 billion EUR the government had allocated for this was gone. The additional five billion EUR lasted less than six months and the registration of new cars increased by 23 percent (Teknikens värld, 2020).

If decision makers decide to implement vehicle replacement programs and create incentives for people to scrap their old cars, they must also consider the increased amount of waste generated from this (Naturvårdsverket, 2004).

5.2.3 Subsidies/tax reduction for import of electric/hybrid cars

To promote a transition of the vehicle fleet subsidies and exemptions can be used. By exempting favorable vehicles from VAT etc., those vehicles become more attractive for buyers and vehicle owners. There are currently government subsidies for electric cars in several European countries and the following four are the main incentives (Panion, 2023):

- Tax breaks on registration
- Vehicle tax reductions for private car owners
- Tax reductions for company cars
- Purchase incentives

Norway is world leading when it comes to electric vehicles and charging infrastructure. The VAT is usually 25 percent for cars which makes the Norwegian VAT-exemption very attractive for vehicle owners. Furthermore, electric vehicles have more advantages in traffic since they are also exempted from road tolls on national roads, lower price to take the car on a ferry, free or heavily subsidized parking fees. In some places, electric vehicles are allowed in the designated bus lanes (Recharge, 2022). Additionally, Norway has a well-developed infrastructure for electric vehicles with a solid network of charging points. Combined, this has enabled Norway to have the most electric cars per inhabitant in the world.

In the AP Progress report from 2019 a recommendation is put forward to remove VAT from electric and hybrid cars to encourage those vehicle categories (Balkan Green Foundation, 2019). As has been seen in Norway, this can be one approach to stimulate the transition of the vehicle fleet. Though, when doing this one should bear in mind that the subsidy should not be permanent and since electric vehicles are rather cost intensive, this type of subsidy will benefit socioeconomic strong groups. The Norwegian parliament have started to investigate the incentives for electric vehicles and will most likely start to reduce the VAT-subsidy.

Subsidies/tax reduction for import of vehicles of electric cars does not currently exist in Kosovo but are being discussed (BGF personal communication). It is important to consider the source of the money in this type of policy instrument. Which group will benefit from the subsidy, rich or poor people? There must also be a plan for the long-term perspective of the subsidy. In general, it is easier to introduce a subsidy but harder to remove once it has been introduced (Sterner T, Coria J. 2012)

5.2.4 Additional recommendations and complementary measures

A general recommendation when working with traffic and transport measures and instruments is to work with packages of measures. If it gets more difficult for people to use their cars as they are used to, perhaps by restricting access for certain vehicle standards in zones in the cities, it is important to offer alternatives e.g., improve public transport and conditions for biking and walking. Thus, implementation of e.g., a low emission can advantageously be combined with investments and improvements of trams and buses as well as development of secure and of high standard bike lanes.

To improve air quality in urban areas and decrease emissions from traffic it is often needed to work with carrot and stick, a combination of subsides and creating incentives for people, making sustainable alternatives the most attractive alternative and to decrease the attractiveness of the less sustainable alternatives e.g., by making it more expensive.

Promotion campaigns and development of necessary infrastructure is one way to improve conditions for walking, biking, and public transport. With promotion campaigns citizens are encouraged to initiate behavioral changes and chose walking, biking, and public transport in favor of traveling by private car. Bear in mind that behavioral changes take time and improvements for the alternatives must be in place.

- Reliable and extended timetable for public transport
- Bike lanes and sidewalks
- Bicycle racks

In Gothenburg, as a complementary measure to the implementation of congestion charges, several investments to support sustainable travel were made.

Bus lanes and commuter station platforms were built along with purchases of new commuter trains and buses. Outside of the city, in connection to the commuter platforms carparks were built to accommodate 2 500 cars and 2 700 bicycles. This was done to enable and encourage travelers to combine different transportation modes instead of taking the car for the entire trip (Trafikverket, 2020b).

Furthermore, Gothenburg has adopted a bicycle program with a goal of tripling cycling by year of 2025. The program encircles four main areas that combined can contribute to increase the attractiveness of cycling and help achieve the goal of tripling cycling and become an attractive and safe city to travel by bike in.

The basis for a safe, simple, and passable biking in city environments is a well-designed bicycle infrastructure. Cycle paths must avoid having incomprehensive interruptions and furthermore, it must be possible to reach all important destinations by bike. The road network for bicycles must keep a high level of standard regardless time of year, this requires a high level of operation and maintenance. Support and services are another area of potential including both digital aids and physical services, e.g., applications for mobile phones and systems for loan of bicycles (Trafikkontoret, 2015).

Parking is an important policy instrument with great potential of reducing traffic and decrease emissions. Several aspects of parking can be relevant and in this report the focus lies on the cost of parking and parking spaces. First and foremost, parking measures cannot increase the attractiveness of other modes of transportation but rather make it less appealing to travel by car. However, the relative attractiveness of other modes of transport such as walking, biking, and public transport can increase if it becomes less advantageous to go by car.

The cost for parking is an efficient tool to control traffic and can be a strong influence on the choice of transportation mode. Parking costs is said to be comparable to congestion charges in terms of effects (Koucky & Partner, 2015). One of the most effective ways to convert car travelers to other modes of transport have been shown to be price increases or other impairments (Trafikverket, 2012).

Parking benefits can be used to promote and benefit certain vehicles that are desired to constitute a larger share of the vehicle fleet. For example, several Nordic cities have provided parking benefits to zero-emission vehicles to encourage the transformation of the vehicle fleet. These benefits can be discounts on parking fees, free parking, discounted charging for electric vehicles etc.

If not already in place, a parking strategy is a good way to start working with parking measures. A parking strategy can include, but is not limited to:

- Parking regulations, e.g., time limitations. For how long should it be allowed to stay in the same parking space?
- Parking costs. Higher prices for parking contribute to reduce the demand.
- Parking enforcement, an important variable to ensure compliance.
- Location of parking. Limit parking areas to garages and multistorey car parks, avoid parking on squares etc.

- Reduce parking space. Convert parking spaces to green areas or dedicate them for walking, biking, and public transport.
- Flexible parking numbers

Gothenburg apply flexible parking numbers. This means that it is the location of a building and the surrounding conditions that helps determine the appropriate space for parking, not the number of apartments or residents. In exchange for mobility services to reduce car ownership, housing developers in the city can build residential houses with even lower parking number (Boverket, 2018).

Speed limitation can be used both as a measure to reduce emissions and to increase other modes of transport. The opinions on the effectiveness of speed limitations on reducing emissions are divided and some studies question whether speed limitations are effective measures (Folgerø et. al, 2020). The effect is dependent on the current conditions such as state of the vehicle fleet, previous speed limit, level of congestion etc. (Gressai et al,. 2021). However, by significantly limit the speed in urban areas, the attractiveness of travelling by car is reduced not to mention the safety benefits connected to lower speed.

When driving in urban areas, vehicle speed is subordinated a smooth driving pattern in terms of effect on fuel consumption and generated emissions. Though, in urban areas it can be difficult to maintain a smooth driving pattern due to traffic lights, stop signs, crossings, queues and so forth. These types of situations entail stops and braking followed by accelerations in order to return to speed. A lower speed limit would therefore reduce the need to accelerate back. Consequently, a lower speed limitation in urban areas will result in less of speed variations and a smoother driving pattern. Streets and roads with many stops would therefore benefit from a lower speed limitation. (Trafikanalys, 2017)

Idling implies that you let the engine of your car or vehicle run even though you are not driving it. This results in a reduced fuel economy and creates unnecessary pollution. The vehicles of today do not suffer any damage by being turned on and off since development of batteries and starters have led to more durable components than in the past. By idling for more than ten seconds more fuel will be consumed and more pollution produced than by stopping and restarting your vehicle (Clean cities, 2015.)

It can be difficult to avoid idling in urban driving and certain traffic situations such as waiting at a stop sign. However, those periods of idling are usually rather limited. A source of greater concern is long-period idling of heavy duty diesel vehicles lacking auxiliary power units. According to a paper on Dieselnet (2017), long-haul trucks which recurringly idle overnight to provide heating or air conditioning are suspected to constitute a major contribution to the idle related emissions and unnecessary fuel consumption. Even if the conditions do not require climate control, truckers can motivate idling to power other truck accessories (lights, radio, television, refrigerators etc.)

According to a paper from 2009 (Carrico et al., 2009) investigating the situation idling in America concluded that as much as 1.6 percent of America’s total greenhouse gas emissions can be attributed to idling vehicles. Many cities have laws against idling, but the compliance and enforcement are lacking (Bloomberg, 2021).

5.3 Policy instruments - Heat and power sector

This section gives an overview of proposed policy instruments targeting the emissions of air pollutants such as SO2 and NOx, greenhouse gas emissions as well as the promotion of district heating as an alternative to individual heating and cooling alternatives.

5.3.1 Taxes and refundable charges on emissions of air pollutants (SO2 and NOx)

Taxes are economic incentives that follows the “polluter pays principle” (Naturvårdsverket, 2006). A tax can be imposed on either the emissions or, for diffuse sources, the feedstock causing the emission, e.g., a tax on a certain fuel. As long as the geographical location of a source of emissions is not impacting the level of emissions, taxes are a cost-efficient policy incentivizing abatement investments and development. However, taxes are depending on changes in the economy, i.e., more emissions during economic growth. There might also be a lack of information on abatement costs, meaning that the tax is set too low or high.

In 1991, Sweden introduced a tax on sulphur dioxide (SO2) (Naturvårdsverket, 2006). Throughout the period 1990 to 2020, the tax levels remained constant, e.g., at €3.0/kg SO2 in solid and gaseous fuels and for liquid gasoline it is €2.7 per cubic meter for every tenth of a percent sulfur content in the fuel. The tax on ‘SO2 has led to a reduction in the emissions, reaching very low levels by international standards (Sterner and Isaksson Höglund, 2006). The tax has also led to a lower sulfur content in fuel oils, as certain levels were exempted from the tax (Naturvårdsverket, 2006). Refunded emissions payments (REP) are an economic instrument, in which polluters pay a charge or tax on pollution and the revenues can be returned to the same collective of polluters as refunds in proportion to either output (out-put based refunding, OBR) or expenditures (expenditure-based refunding, EBR) (Hagem et al 2020). REP could be a viable option in cases where the emissions largely depend on the technology used, as an alternative to taxing the fuel (Sterner and Isaksson Höglund, 2006).There is often a resistance to taxes from polluters, as the taxes both imply abatement and tax costs, hence refunded emissions payments can be more politically feasible to introduce.

REP is different from a traditional subsidy, as it is not benefiting an industry as a whole but rather specific companies (Sterner and Isaksson Höglund 2006). There are also two main advantages with this policy instrument: it provides a flexibility in the sense that each firm can choose both the extent and timing of abatement investments and it encourages technical development even after an emission reduction target has been reached. In addition to this the REP is budget neutral, meaning that the state does not have to pay for large abatement costs. But there are also some limitations with REP schemes: it is challenging to set the optimal payment level, it requires a common measure that all companies agree on (e.g. energy output) and in industries with few companies or oligopolies the abatement incentive would be weakened by the refund.

Both OBR and EBR requires measurable emissions, but this is nothing different from a regular tax (Hagem et al 2020). In addition, OBR requires a measurable output, e.g. the physical heat and energy output of boilers. For EBR it is necessary to an objective way identify and measure the costs of purchasing and utilizing abatement technology. Compared to a tax both the EBR and OBR can lead to lower emission reductions than an ideal standard tax, if it is assumed that the tax is politically feasible. But because of the political resistance to high taxes, EBR or OBR could be a viable option. A challenge with OBR is that it can generate an output subsidy, giving incentives for excess production. This is harmful in a competitive environment but can increase welfare in circumstances where the competition is imperfect, i.e., where the output is suboptimal.

There can be combinations of OBR and EBR, e.g., large polluters have a larger probability of getting their abatement or research projects funded by the collected fees (Hagem et al 2020). This has been applied in many developing countries where environmental fees are put into funds with large polluters sitting on the boards. In France, fees on NOx, SO2, HCl and VOC:s are used to cover administrative costs and for subsidizing abatement. The system resembles EBR but have some OBR features.

In 1992, Sweden implemented a tax on nitrogen oxides (NOX), but as the emissions reductions were harder to attain for NOX compared to SO2, the tax came with an economic incentive, i.e. refunded emissions payments (Naturvårdsverket, 2006). Sweden has applied OBR for nitrogen oxides (NOx) and fees are refunded to the polluters strictly in proportion to output, in this case the heat output at the furnace level was considered fair and objective (Hagem et al 2020). The Swedish OBR has provided an incentive for investments in SCR units and for technology development within catalytic conversion (Hagem et al 2020) (European Commission, Joint Research Centre 2017) and has been considered a successful instrument for abatement of NOX from large stationary sources in Sweden (Sterner and Isaksson Höglund, 2006). Compared to a permit, such as emissions trading systems (ETS), it has also been considered less costly when it comes to administration.

One of the reasons that Sweden chose to use an OBR instead of a standard tax was the challenge to put a sufficiently high price on the emissions to motivate emissions control measures and at the same time tackle a strong industry opposition to a tax (Hagem et al 2020). With the OBR the Swedish regulator wanted to target some large plants, and only applying a tax would have given an incentive to invest in small plants and some industries could have considered to move abroad. A key message from the Swedish OBR was that real measurements of emissions were essential for plant operators to know which parameters reduced emissions and which abatement technology to prioritize.

Current status in Kosovo, is that taxes and refundable charges on air emissions does not exist (Yaramenka, 2022).

5.3.2 Tax on fossil fuels

A taxation on fossil fuels, or carbon-intensive fuels, can also be referred to as a carbon tax. Carbon taxation is an economic policy instrument which tries to correct the negative externalities of carbon emissions.

There are currently no charges on emissions from large combustion plants in Kosovo, but the country plans to introduce a national emissions trading scheme which can be integrated with the EU ETS in the long run (Republic of Kosovo, Ministry of Economy 2022a). All heat generation plants with more than 20 MW capacity are covered by the EU ETS (Billerbreck et al, 2023). The inclusion in the EU ETS does however not hinder the taxation of fossil fuels - some of the countries participating in also have carbon taxes. The design of the carbon taxes can result in even higher costs for fossil fuel use in power plants than what the ETS would have led to. Denmark has also implemented a carbon tax, but all operators included in the EU ETS are excluded from the tax – except for district heating operators.

In Sweden, there is a tax on carbon-intensive fuels, but there is an exemption from the carbon tax applied to industry, CHP:s and district heating that are covered by EU ETS (Government Offices of Sweden, Ministry of Finance 2023). The carbon tax in Sweden is among the highest in the world (Dolphin et al 2020) and aproximately 95 percent of the fossil emissions in Sweden are covered by either EU ETS or the carbon tax (Government Offices of Sweden, Ministry of Finance 2023). All fossil fuels, e.g. gasoline, fuel oil, LPG, fossil gas, coal and coke, are directly subject to carbon taxation no matter their final use (Skatteverket, 2022). There are also a number of fuels that get taxed depending on their final use, such as fuels that contains hydrocarbons and are intended to be used for heating. The carbon tax on motor fuels and heating fuels is calculated based on the average fossil carbon content of the fuels, and the tax rate is expressed in weight or volume units (Government Offices of Sweden, Ministry of Finance 2023).

The Swedish carbon tax was introduced in 1991 and the tax rate has gradually been increased since (Government Offices of Sweden, 2023). The stepwise increase of the tax level has given households and business time to adapt, which has improved the political feasibility of the increases. For the industry and CHP:s outside of EU ETS there has been a stepwise increase of the carbon tax, while lowering the energy tax (Government Offices of Sweden, Ministry of Finance, 2023). Until 2018, industries outside the EU ETS had a lower tax rate but this was changed, and all industries now pay the same rate (Government Offices of Sweden, 2023). The taxation generates considerable revenues for the general state budget, but the tax revenues from the carbon tax are not dedicated for specific purposes. When introduced in 1991, the tax rate was high for motor fuels and heating fuels in households while low for heating fuels in industry. In 2018, the levels converged to 106 EUR/tonne. In 2023, the carbon tax was 122 EUR/tonne.

As a result of the carbon tax in Sweden, there have been some distributional effects on households, e.g. on general welfare and social transfers (Government Offices of Sweden, Ministry of Finance, 2023). Since 1990, fossil heating fuels has dropped by more than 90 percent and fossil-fired, individual heating solutions have been replaced by district heating, wood pellets burners and heat pumps.

To support the transition, there has been temporary aid schemes for a conversion to renewable heating. For motor fuels, not covered in detail here, there is still a major challenge to transition to a fossil free transport sector. In Sweden as well as in the other Nordic countries, the revenues from environmental taxes, such as the carbon tax is used to finance environmental and climate action initiatives. The households pay the largest share of the carbon tax and energy tax (Statistics Sweden, 2022).

The main take aways from the Swedish carbon tax has been that a taxation is offering low administrative costs compared with the ETS (Government Offices of Sweden, Ministry of Finance 2023). It also raises revenues that may be used to make options for fossil fuels available (such as biofuels, district heating, energy efficiency measures etc.), which is very important to make households and companies adapt to the tax. A step-by-step approach combined with some tax exemptions and reductions for certain areas have also helped to make the tax politically feasible.

Current status in Kosovo, is that a tax on fossil fuel combustion does not exist (Yaramenka, 2022).

5.3.3 District heating policy instruments

The European Commission obliges its member states to increase the share of renewables and waste heat in the district heating systems, or to grant access to district heating grids to third party renewable or waste heat generators (Renewable Energy Directive, 2018/2001, RED II). However, the national policy framework for district heating in Europe is diverse. As district heating and cooling networks are natural monopolies, these are subject to a more or less extensive regulatory framework (European Commission, Directorate-General for Energy, 2022). Regulations may exist on price mechanisms (e.g. ex-post price control or regulated prices) and Third Party Access (TPA). This section provides an overview of the options for district heating regulation.

Most of the European district heating networks are operated by vertically integrated companies, either owned by the municipality directly or by companies where the municipality is the majority owner (Billerbreck et al, 2023). There is also some sort of authorisation process in most of the countries, such as a licence, permit, concession, or a simple registration. An overview of the main options for ownership and operation of district heating is provided in Figure 43.

Parameter	Elements			
Main form of regulation	No specific regulation of ownership	Requirements for registration for operators	Authorization, i.e. license, permit or concession	
Authorisation process	No specific procedure defined	Standard forms and processes	Tender organized by authority	
Scope of authorisation	Authorisation for construction of DH grid	Authorisation for construction of generation plants	Authorisation for operation of DH grid	Authorisation for operation of generation plants
Timing of authorisation	Authorisation by initial operation	Authorisation for specific changes, e.g. new plants or pipes	Authorisation for each change	
Size of addressed networks	Only big DH networks or networks with large generation plants	Only small DH networks	All sizes	
Ownership of addressed networks	Only public networks	Only private networks	All ownership models	

Figure 43: Morphological box for the regulation of ownership and operation of district heating. Source: Billerbreck et al 2023, based on Bacquet et al. 2022.

The European Union regulation on energy price transparency is not covering district heating prices, but there is price regulation in most countries, e.g. price caps or price adjustment clauses (Billerbreck et al, 2023). In Norway the district heating price is not allowed to be higher than the alternative cost of other heating alternatives in a specific area. In Germany the prices are based mainly on gas and coal prices. In Denmark there is a non-profit rule, i.e. the district heating prices can only cover the necessary costs for the company. In Sweden a self-regulation platform, the "Price Dialogue", has been formed as an alternative to price regulation (Abrahamsson and Schrammel, 2016). District heating and real estate companies meet voluntarily to discuss future prices. An overview of the regulation of district heating prices within the European union is provided in Figure 44.

Parameter	Elements			
General approach (who sets the price)	Freely formed prices, i.e. no specific regulation	Price is defined by operator according to regulation	Price is defined or set by regulator	
Form of pricing (price calculation rule)	(Fix) Price cap	Price adjustment clauses with indicators for adjustment (e.g. gas price)	Defined method for calculation, e.g. list of price components or specified model	Non-profit rule
Terms of prices	No terms defined	Transparency and information requirements	Equality regulation, i.e. same price for all consumers	
Price control	Ex-post control, i.e. prices can be controlled even if already applied	Ex-ante control, i.e. prices must be approved before applied (similar to price setting by the regulator)		
Timing of price control	Only on request	Mandatory on regular occasions	Mandatory each time of price change	
Addressed networks	Only specific networks (e.g. large networks or public networks)	All networks		

Figure 44: Morphological box for the regulation of DH prices. Source: Billerbreck et al 2023, based on Bacquet et al. 2022

Regulation on metering of heat consumption is of importance in order to create transparency in pricing and to improve billing, factors which in turn strongly influence the end-user satisfaction with district heating (European Commission, Directorate-General for Energy 2022). Most EU member states only refer to the European Energy Efficiency Directive (2018/2002, EED) which regulates metering and requires that the end-users must be provided with meters that accurately reflect their heat consumption, e.g. real metering of consumed heat clauses (Billerbreck et al, 2023). There are some countries, e.g. Bulgaria, Lithuania and Estonia, that also have more detailed regulation on metering, Figure 45 gives an overview of how this regulation may look like.

<table>
<tr><th>Parameter</th><th colspan="12">Elements</th></tr>
<tr><td>Main form of (national) regulation</td><td colspan="4">No regulation on metering DH</td><td colspan="4">Regulations for heat meters following EU legislation</td><td colspan="4">Regulation going further than EU legislation for smart heat meters and remote control</td></tr>
<tr><td>Installation</td><td colspan="4">No mandatory installations of meters</td><td colspan="4">Mandatory installations of meters</td><td colspan="4">Mandatory installation of smart heat meters and remote control</td></tr>
<tr><td>Type of meter</td><td colspan="4">No standards or regulations for the type of meter</td><td colspan="4">Regulation of type of meters, e.g. standards</td><td colspan="4">Regulation of type of smart meter</td></tr>
<tr><td>Frequency of providing meter data (and billing)</td><td colspan="3">No frequency defined</td><td colspan="3">Yearly</td><td colspan="3">Monthly</td><td colspan="3">Daily</td></tr>
<tr><td>Individualised metering</td><td colspan="6">No regulation on individualised metering</td><td colspan="6">Regulation on individualised metering in a multi-apartment / multi-use building</td></tr>
<tr><td>Allocation rules</td><td colspan="6">No heat cost allocation rules</td><td colspan="6">Heat cost allocation rules for metering in a multi-apartment / multi-use building</td></tr>
</table>

Figure 45: Morphological box for regulation of metering of DH. Source: Billerbreck et al 2023, based on Bacquet et al. 2022

For many district heating networks, the lack of motivation for end-users to connect to the systems is a challenge for district heating competitiveness (Billerbreck et al, 2023). As a result, some countries have introduced mandatory grid connection which is applied under certain conditions. In France, imposing a mandatory connection and usage requires that the district heating network is classified by a local authority, that it is economically balanced, has 50 percent of renewables or waste heat and that all heat supplied by the system is metered. All new and renovated buildings within the area then must be connected to the heating grid. In Denmark, municipalities were until 2019 allowed to impose a mandatory connection if district heating is proved to be the most cost-efficient heating alternative. This legislation has been removed, but the existing obligations affect half of the Danish district heating customers. In Germany, municipalities can stipulate that every building within a certain distance from the district heating grid needs to be connected. In many other countries, there is no mandatory grid connection, but the connection process can still be regulated to some extent. Figure 46 show an overview of the grid connection and usage regulation pathways.

<table>
<tr><th>Parameter</th><th colspan="6">Elements</th></tr>
<tr><td>Regulation of grid connection for consumer</td><td colspan="2">No specific regulation, i.e. voluntary connection with no further regulations</td><td colspan="2">Voluntary connection but legislation for the connection process, i.e. technical standards or for connection fees</td><td colspan="2">Mandatory grid connection for consumers (under certain conditions, i.e. zoning)</td></tr>
<tr><td>Regulation of grid usage for consumers</td><td colspan="2">No specific regulation, i.e. voluntary usage and individual contracts</td><td colspan="2">Regulation regarding delivery contracts</td><td colspan="2">Obligation to use DH</td></tr>
<tr><td>(Pre-)conditions for mandatory connection and usage</td><td>No condition</td><td colspan="2">Only if DH is the most cost-efficient heating solution</td><td colspan="2">Only if the DH network is authorized/classified</td><td>Further criteria, i.e. definition of carbon emission level</td></tr>
<tr><td>Regulation for DH operator</td><td colspan="3">No obligation for DH provider defined in legislation</td><td colspan="3">Obligations to connect consumers, e.g. under non-discriminatory conditions</td></tr>
<tr><td>Addressed networks (or areas)</td><td colspan="3">Only specific networks (e.g. large, public, or classified networks)</td><td colspan="3">All areas / networks</td></tr>
<tr><td>Addressed buildings</td><td colspan="3">Only renovated and new buildings</td><td colspan="3">All buildings</td></tr>
</table>

Figure 46: Morphological box for regulation of DH consumer grid connection and usage. Source: Billerbreck et al 2023, based on Bacquet et al. 2022.

EU legislation does not demand an unbundling of district heating generation and distribution (Billerbreck et al 2023). This means that in most EU member states, district heating companies both generate the heat, operate the local district heating grid, and sell heat. The access to the district heating market for independent producers of heat is very limited. The Renewable Energy Directive, 2018/2001, RED II is however stipulating that third party access (TPA) could be one option to increase the share of renewables and waste heat and cold. Under the current revision of RED, TPA is also being discussed. There is some national regulation on TPA. In Latvia for example, district heating operators are obliged to buy heat from third parties if certain conditions are met, e.g. if the heat price is lower than the price of the operator, there is a sufficient heat demand and that the independent producer can meet certain technical requirements. Figure 47 illustrates possible regulation of TPA.

Parameter	Elements			
Regulation of grid access for independent producers	No regulation, i.e. voluntary network access	Regulated TPA with an obligation to enable grid access for renewable or waste heat producers	Regulated TPA with an obligation to enable grid access for all heat generators	
(Pre-)conditions for grid access	No conditions	Technical conditions, i.e. security of supply	Economic conditions, i.e. low price	Environmental and quality requirements
Models for grid usage	Single buyer model	Extended producer market	Network access models	
Purchase regulations	No priority purchase	Priority purchase for renewable heat		
Contracts	No regulation of contracts	Regulated contracts, i.e. fair conditions in contracts, equal terms		
Addressed networks	Only specific networks (e.g. large or public networks)	All networks		

Figure 47: Morphological box for the regulation of TPA. Source: Billerbreck et al 2023, based on Bacquet et al., 2022; Bürger et al., 2019; Söderholm and Wårell, 2011.

In addition to the regulations affecting existing district heating networks, several European countries have implemented support schemes for district heating (Billerbreck et al, 2023). Most EU member states have subsidies and financial incentives for grid infrastructure and for renewable and efficient district heating generation, e.g. financing grants, premiums, low-interest loans or tax exemptions. As an example, in Germany provides financial support for district heating grid with high shares of renewables, e.g. funding for feasibility studies and subsidies of expenditures for the implementation of networks. To increase the connection rates, German district heating companies can also be granted support for customer information measures. Figure 48 illustrates the main support systems for district heating.

Parameter	Elements						
Addressed area of DH	Grid infrastructure	Renewable and efficient generation	Research, technology development, demonstration projects	Connecting end-consumers			
General type of support scheme	Funding /grants	Feed-in-tariffs	Feed-in-premiums	Low interest rate loans	Tax exemptions	Taxes on non-RES, i.e. carbon tax	Quota systems
Addressed costs	CAPEX	OPEX					
Type of payment	Based on generation	Based on capacity	Based on consumption, i.e. taxes				
Frequency of payment	Once	Regularly					
Determination of the support level	Administrative	Competitive (e.g. auction)					
Technology specification	Multi-technology	Technology specific					
Beneficiaries	DHC operator	DH generation plant	End-consumer				

Figure 48: Morphological box for district heating support measures. Source: Billerbreck et al 2023, based on Bacquet et al., 2022 and Winkler et al., 2016.

6. IMPROVED AIR QUALITY FROM A GENDER AND SOCIAL INCLUSION PERSPECTIVE

There is now robust evidence that demonstrates different health impacts of poor air quality by gender. Men, women, girls, and boys are all affected but in different ways. Generally, men suffer higher mortality rates from ambient (outdoor) and occupational air pollution and occupational carcinogens, while women suffer more from residential particulate matter (indoor) and unsafe water sources and sanitation (OECD, 2020). As women still are the likely primary users of household energy, their roles, needs, capacities, perceptions, and power within households must be considered in the design of any intervention (Haddad Z. et al, 2021).

Therefore, measures or indicators for the impact of air quality and instruments to collect and analyze data must consider gender as well as other factors such as age, location, and occupation.

	LOW	MID	GREEN
Key sector	**Policy instrument**	**Policy instrument**	**Policy instrument**
Residential wood combustion	Investment support and tax reductions for energy efficiency measures in the building sector	Financial support to install retrofit ESP on existing stoves	Economic incentives for switch to solar panels and heat pumps
Heat and power generation	Taxes and refundable charges on emissions of air pollutants (SO_2, NOx)	District heating policy instruments	Tax on fossil fuels
Diesel road transport	Low emission zones in 4 large cities	Vehicle replacement programs	Subsidies/tax reduction for import of electric/hybrid cars

Before proceeding with a policy instrument, it is important to consider gender aspects and identify if any of the chosen instruments also have an impact on different genders.

In all three key sectors, taxes are suggested as policy instruments. Analysis of an environmental tax policy must include an examination of not only the tax but also of any complementary policies (that is, income tax deductions) and decisions pertaining to the use of the revenue generated by the tax.

In terms of a gender analysis, policy and decision makers should consider:

1. What are the gender implications of the tax measure itself? (Income and non-income impacts)

- What are the distributional impacts of the tax? Are these shared equally by women and men?
- Does the tax impact differently upon women because of their socio-economic roles and status? E.g. women's socio-economic roles may create conditions that make it more difficult to cope with additional costs or less flexible to change their behavior around energy consumption.

2. What are the gender implications of the tax policy package (including any mitigation policies and/or policies pertaining to the use of revenue generated from the tax)?

- How does the choice about revenue use impact women?
- If the revenue will be used for tax and/or direct expenditures, how are the expenditures allocated between women and men (gender-disaggregated public expenditure incidence analysis)?

·Do the plans for spending carbon tax revenue match women's needs and priorities (gender-disaggregated beneficiary assessments)?

3. What are the gender implications of the outcome of the tax?

- Are there gender differences in how women and men respond to the tax? Women and men may respond differently to a carbon tax. For instance, if women are in general more risk averse, they may be more willing to change their behavior to reduce GHG emissions. That said, if they are more constrained by lower average incomes and reduced flexibility due to socio-economic roles, they may be less able to change their behavior accordingly.

6.1 Residential wood combustion

Starting out with residential wood combustion and investment support and tax reductions for energy efficiency measures in the building sector. Since this measure targets the building sector, which is typically dominated by a male work force, investments stimulating the building sector can benefit men more than women in terms of work opportunities and increased income. The same goes for financial support to install retrofit ESP on existing stoves. Installations is still a male dominated working field in many parts of the world thus men will benefit by income quintiles from this measure. However, women are especially harmed by inefficient household energy because cooking is often considered a woman's domain. Thus, improvements of stoves can bring benefits to women due to improved indoor air. Furthermore, it is also important to consider who makes spending decisions within households, there may be need for a targeted support to ensure that the decision of installation is not solely made by the person with the highest income in the household.

Additionally, decision makers must be aware of the possibility of "stove stacking", where households with access to clean fuel/technologies often continue to use polluting fuels in tandem, e.g., for heating or lightning. There is a difference between access to and exclusive use of clean household energy.

Economic incentives for switch to solar panels and heat pumps. The economic incentives must be designed in such a way to ensure that both men and women have equal opportunities to switch to solar panels and heat pumps. As for the other measures, it is important to consider who makes spending decisions within the household and how it can affect men and women.

6.2 Diesel road transport

Low emission zones target behaviors and exclude certain vehicles from the zone area. The air quality improves mostly within the zone but also in other areas. Since women usually tend to walk, bike, and use public transport to a larger extent compared to men, improvements in the public street are usually a benefit for those who walk and bike. However, purchasing a vehicle to comply with the zone regulations is cost intensive and certain socio-economic groups will not be able to do that.

Subsidies/tax reduction for import of electric/hybrid cars. Regarding subsidies, they need to be well-targeted since household and individuals with high income and good finances can arguably buy an electric vehicle without any subsidies. One possible way is to provide increased subsidies for lower-income household (mostly represented by women) and not as many tax credits to richer households.

6.3 Heat and power generation

Taxes and refundable charges on emissions. Women are usually disproportionally represented in the informal economy (often work in low-skilled jobs where they lack information about their rights to health and safety, etc.) so taxes on emissions can have a gendered effect - as costs imposed on employers may be borne by their workers. It is important to consider how any extra revenue may be reinvested (as women benefit particularly from the public spending that tax can be used to finance), i.e., will it go to support low-income households to mitigate any distributional impact of the tax?

Tax on fossil fuels. Policy makers must be aware of the burden of increased prices created by carbon taxes as women as a group may bear a disproportionate burden due to income disparities with men and their socio-economic status. Perhaps it could be considered if any low-income tax credit can be increased in line with the tax rate to offset distributional impacts during the life of the tax. For the long-term perspective a gender budgeting assessment is something to consider.

7. DISCUSSION AND CONCLUSIONS

The analysis finds that the three key emitting source areas are related to diesel road transport, wood heating stoves in the residential sector, and large lignite power plants. These sources are responsible for major part of NOx, PM, SO2 and NMVOC.

In year 2020 and 2030, emission reduction potential in Kosovo seems to be high. By replacing technical measures such as end-of-pipe NOx and SOx abatement technologies at power plants, newer Euro standards and replacement of stoves – substantial emission reductions can be obtained in the near future.

This study has developed three scenarios that describe different levels of ambition in terms of reaching the entire "technical" emission reduction potential (Low, Mid, and MTFR scenarios). Additionally, there is one scenario going beyond MTFR and considering shifts from fuel combustion to non-emissive energy sources in the key emitting sectors (Green scenario). The total emission reduction potentials and corresponding health-related benefits in year 2030 are summarised in Table 14.

Table 14: Emission reduction potentials and health-related benefits in Kosovo in different development scenarios, compared to baseline, year 2030.

Scenario	Emission reduction potential, kt				Health-related benefits, million Euro2015	
	NOx	SOx	NMVOC	PM2.5	Kosovo	Europe
Low	2.2	23	4.2	1.8	166	889
Mid	3.1	27	15	6.4	299	1354
MTFR	5.1	31	19	8.2	367	1616
Green	13	34	21	9.1	414	1843

The aforementioned emission reduction potentials in the key areas can be reached by a combination of different measures and policy instruments. The analysis concludes that the measures with the highest emission reduction potential is related to switching to:

- Non-emissive sources
- Extension of central heating system combined with CHP improvements
- SO2 end-of-pipe and process control at power plants

However, effectiveness is not the only factor that needs to be considered when planning emission reduction measures; other important aspects are e.g., costs and cost-effectiveness in terms of benefit-to-cost ratios. Reaching the entire emission reduction potential, on the other hand, would require high abatement costs that in some cases exceed the health benefits obtained.

The same measure proposed to be implemented in Kosovo, might appear cost-effective or not depending on whether benefit assessment includes positive health effects on the entire European population, or only on the inhabitants in Kosovo. The analysis shows that only up to about one third of the total positive effects from measures taken in Kosovo, occurs within the country. The remaining effects can be observed in neighbouring countries – this is due to the trans-boundary effects of emissions. Similarly, measures in other European countries, especially those bordering Kosovo, would affect the inhabitants of the Kosovo.

To enhance implementation of emission reduction measures in the key emitting sectors in Kosovo, a range of policy instruments can be used. The study proposes nine different policy instruments to target Kosovo's emissions of air pollutants. Several of relevant policy instruments are of legal character.

This study concludes that Kosovo's national environmental legislation is currently not in full compliance with the relevant EU legislation. Possible solutions might be better harmonization with the EU legislation by drafting enforcement legislative acts and appointing responsibilities.

Within the sector for residential wood combustion, the policy instrument analysis proposes instruments that relates to investment support and tax reductions for energy efficiency measures in the building sector, economic support to install retrofit ESP on existing stoves, economic incentives to promote a switch into solar and heat pumps. Moreover, regulations to prohibit coal combustion and biomass certification are instruments that are recommended to reduce environmental impact from the same sector.

In the second key sector, diesel road transport – policy instruments such as low emission zones, vehicle replacement programs and subsidies/tax reductions related to import of electric and/or hybrid cars are proposed. All three proposed measures have been successfully implemented in other European cities with good effects on traffic and emissions, but it is important to note that it is vital, especially when it comes to transport, to work with supporting measures to enable successful implementation. Furthermore, it is also important to consider legal aspects of implementation. Experiences from other cases have shown the need for updated jurisdiction before implementation.

For the third key sector, heat and power generation; taxes and refundable changes on emission of air pollutants, SO2 and NOX are proposed to be implemented also a carbon tax, to correct the negative externalities of carbon emissions is proposed as an option. Many of EU's member states have subsidies and financial incentives for grid infrastructure, as well as for renewables, which provides an efficient district heating generation. Examples for several EU countries are discussed and highlighted as good examples, which Kosovo could follow when implementing support schemes such as financing grants, premiums, low-interest loans, or tax exemptions for district heating.

This study briefly discusses aspects related to improved air quality from a gender and social inclusion perspective. Women are in most cases the primary users of household energy, thus suffer more from indoor particulate matter, unsafe water resources as well as sanitation. In all three key sectors, taxes are suggested as a policy instrument. The gender analysis proposes that policy and decision makers should consider three main issues when it comes to implementing an environmental tax in Kosovo:

- The gender implication of the tax measure itself
- Gender implications of the tax policy package
- The gender implications of the outcome of the tax

Improvement of stoves is likely to bring positive benefits for women, as cooking is often considered a women's domain. By providing targeted support to the installation of retrofit ESP it can give positive gender aspects within the residential wood combustion sector.

Imposing a tax on fossil fuel are likely to directly affect women due to income disparities between men and their socio-economic status. One suggestion is that any low-income tax credit could be increased in line with the tax rate to offset distributional impacts during the life of the tax. Another aspect within the heat and power generation sector relates to considering how any extra revenue, such as taxes and refundable charges on emissions is reinvested, and particular may benefit women.

Subsidies or tax reductions targeted the import of electric or hybrid cars need to be well-targeted, as households and individuals with higher incomes and a good financial situation can buy an electric or hybrid car without any subsidy or tax reduction. The study proposes increased subsidies targeting low-income households, which are mainly represented by women. To avoid negative and unwanted externalities, the report also suggests and encourages policy and decision-makers to thoroughly consider gender aspects before proceeding with measures and policy instruments.

The status of harmonization of Kosovo legislation for the key sectors with EU legislation is shown in Annex 8. The information here displays several national legislations that have not yet been transposed according to various EU legislations such as eco-design directive, renewable energy directive, etc.

Lastly, Kosovo is facing many challenges in terms of air quality. However, many good initiatives and efforts are going on and improvements are being made. An overall key recommendation is related to the fact that this study shows that Kosovo can significantly improve its air quality by implementing its current legislation. Combined with further implementation of technical measures related to Kosovo's current plans. The hope is for this report and study to provide inspiration and guidance for Kosovo in their endeavour to improve air quality.

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Annex 1 – GAINS model methodology detail

Sources: Klimont et al (2002); Åström et al. (2019), https://gains.iiasa.ac.at/models/https://gains.iiasa.ac.at/models/

GAINS model is an integrated assessment model (IAM) that explores cost-effective emission control strategies that simultaneously tackle local air quality and greenhouse gases to maximize benefits at all scales.

Scenario-specific inputs to the model are:

- Activity data: amounts of fuel combusted and rates of emission-generating human activities (e.g., industrial production, waste management, use of manure in the agricultural sector).
- Activity data: other country-specific and common parameters used in calculations, such as wages, electricity prices, distribution of appliances in the residential sector by size, investment costs for abatement equipment, lifetime of equipment, and similar.
- Emission factors.
- Control strategies: set of measures to reduce emissions, together with their removal efficiencies and year-specific implementation rates.
- Scenario-specific outputs from the model are:
- Emissions of main air pollutants from human activities.
- Air quality and resulting health and environmental impacts.
- Costs of emission control technologies.

Scenario-specific outputs from the model are:

- Emissions of main air pollutants from human activities.
- Air quality and resulting health and environmental impacts.
- Costs of emission control technologies.

Emissions

Emissions are calculated in the model for each economic sector/activity with Equation X1:

$$E_i = \sum_{j,k,m} E_{i,j,k,m} = \sum_{j,k,m} A_{i,j,k} * ef_{i,j,k} * (1 - eff_m) * x_{i,j,k,m} \quad \text{(X1)}$$

where i, j, k, m = country or sea region, sector, activity type, control measure; Ei = emissions in country in [ktonne]; A = activity in a given sector [PJ fuel or other units corresponding to the activity driving emissions]; ef = emission factor when not using any control measure [ktonne/unit of emission- driving activity], or “raw gas” emission factor; eff = emission reduction efficiency of measure m [%]; x = implementation rate of the considered control measure m [%].

If no emission controls are applied, the emission reduction efficiency equals zero (eff = 0) and the implementation rate is 100 %. In that case, the emission calculation is reduced to simple multiplication of activity rate by the “raw gas” emission factor.

Impacts

After country-specific emissions for each target year are estimated, they are introduced as input data into the GAINS model. In the GAINS model, a set of country-to-cell **source-receptor matrices**, calculated in the EMEP[18] model, are used for the air pollutants dispersion simulations. Linear form emission dispersion pattern is illustrated in Equation X2 showing an example for calculation of PM2.5 concentrations in the receptor country:

$$PM_i = \sum_i pm_i * P_{i,r} + \sum_i s_i * S_{i,r} + \sum_i a_i * A_{i,r} + \sum_i n_i * N_{i,r} + \sum_i v_i * V_{i,r} + k_{0,r} \quad \text{(X2)}$$

where r = receptor region; PMr = concentration of PM2.5 in receptor region r [μg/m3]; pmi = emissions of primary PM2.5 in country i [ktonne]; si = emissions of SO2 in country i [ktonne]; ni = emissions of NOx in country i [ktonne]; vi = emissions of NMVOC in country i [ktonne]; k0,r = background concentration constant in region r [μg/m3]; P, S, A, N, V = transfer coefficients between source region i and receptor region r [μg/m3/ktonne], for the different pollutants PM, SO2, NH3, NOx, and NMVOC.

[18] The EMEP MSC-W model is a 3-dimensional Eulerian model that calculates emissions, transport, chemistry and loss processes of pollutants. The model's main purpose is to support governments in their efforts to design effective emission control strategies. The model simulates air concentrations of gaseous (including SO2, NO2 and ozone) and particulate pollutants, as well as acidifying and eutrophying depositions on ecosystems.

The results of the simulations are the following impacts currently available in the model:

- Concentrations of fine particulate matter
- Health impacts attributable to PM2.5 exposure
- Population exposure to ground level ozone
- Health impacts from ground level ozone
- Nitrogen and sulfur deposition
- Ecosystem impacts: Exceedance of critical loads for acidification and eutrophication

Control costs

The expenditures on emission controls are differentiated into:
·Investments,
·Fixed operating costs, and
·Variable operating costs.
Investment costs include, e.g., delivery of the installation, construction, civil works, air ducting, and similar. Investments Ian are annualized over the technical lifetime of the plant lt [years] by using the real interest rate q [%/100], see Equation X3:

$$I^{an} = I * \frac{(1+q)^{lt} * q}{(1+q)^{lt} - 1}$$

(X3)

The annual fixed operating costs OMfix cover the costs of repairs, maintenance and administrative overhead. These cost items are not related to the actual use of the plant. As a rough estimate for annual fixed expenditures, a standard percentage f of the total investments is used (Equation X4):

$$OMfix = I*f \qquad (X4)$$

The variable operating costs OMvar are related to the actual operation of the plant and consider:

- additional labor demand,
- increased energy demand for operating the device (e.g., for the fans and pumps), and
- waste disposal.

These cost items are calculated with the specific demand λx of a certain control technology and its (country-specific) price cx, see Equation X5.

$$OM^{var} = \lfloor^{l}*c^{l}/pf + \lfloor^{e}*c^{e} + ef_{TSP} * \eta_{TSP} * \lfloor^{d}c^{d} \qquad (X5)$$

Where:

ηTSP — dust (TSP) removal efficiency,
λl — labor demand (per thermal capacity unit),
λe — additional electricity demand (per unit of fuel used),
λd — demand for waste disposal (per unit of dust reduced),
cl — labor cost,
ce — electricity price,
cd — waste disposal cost,
pf — plant factor (annual operating hours at full load),
efTSP — unabated TSP emission factor.

Geographical scope

The model generates results for 45 countries in the European modelling domain:		
Austria	Latvia	Belarus
Belgium	Lithuania	Bosnia and Herzegovina
Bulgaria	Luxembourg	Georgia

Croatia	Malta	Iceland
Cyprus	Netherlands	Kosovo
Czech Republic	Poland	North Macedonia
Denmark	Portugal	Republic of Moldova
Estonia	Romania	Montenegro
Finland	Slovak Republic	Norway
France	Slovenia	Russia European part
Germany	Spain	Serbia
Greece	Sweden	Switzerland
Hungary	Albania	Turkey
Ireland	Armenia	Ukraine
Italy	Azerbaijan	United Kingdom

Annex 2: Summary of baseline adjustments for key sectors in GAINS

Summary of main adjustments for 2020

ROAD TRANSPORT

- Total fuel use by road transport and use per type of fuel (diesel, gasoline, LPG) – as in the Energy Balance 2020. No use of electric vehicles, gas-fuelled, or hydrogen-fuelled vehicles is assumed.
- Distribution by vehicle types – as assumed in JICA project (Table 3-27 in the final report).
- Number of vehicles per type of fuel and type of vehicle – data from KEPA for diesel; for other fuels – as assumed in JICA project (Table 3-27 in the final report).
- Traffic work is recalculated with the assumption of constant traffic work (in vehicle-km) per PJ fuel use.
- Distribution by Euro classes for each vehicle type and fuel – data from KEPA for diesel; for other fuels – as assumed in JICA project (Table 3-27 in the final report).

RESIDENTIAL COMBUSTION

·Total energy use by residential sector and use per type of energy (fuelwood, oil, heat etc.) – as in the Energy Balance 2020.
·Distribution by stove types (conventional, improved, pellet) – calculated from numbers in the Kosovo Emission Inventory update 2021.

HEAT AND POWER GENERATION

- Total lignite use by power plants – as provided by KEPA. No hard coal use assumed based on the Energy Balance 2020. All fuel is used by existing (not new) plants.

- No SOx or NOx abatement. For particle abatement, 2-fields ESP is assumed to be used, based on the JICA final project report.

- Unabated emission factors (UEF) for NOx and SOx are adjusted to be in line with the measurement-based results in JICA project. NOx UEF is higher than UEF used on IIASA while SOx UEF is lower, which is explained by lower sulphur content in lignite than average sulphur content in the region.

- Energy production at CHP – with respect to recent changes (renovation at Gjakova, wood instead of oil, no boilers on oil). Fuelwood consumption - as in in the Energy Balance 2020, moved from existing to new plants.

- Energy production by hydropower and thermal solar panels – as in the Energy Balance 2020. No geothermal energy use assumed (no data in the Energy Balance 2020).

Summary of main adjustments for 2030, 2050

ROAD TRANSPORT

- Activity data: Same relative change (in %) in energy (PJ) consumed in the road transport sector between 2020 and 2030/2050, with further adjustments in distribution between fuels and non-emissive sources for road transport.
- Activity data: Total mileage in veh-km is calculated via energy consumed and fuel efficiency (PJ/veh-km) under the assumption that fuel efficiency in 2030 and 2050 is the same as IIASA's and decreasing with time. Number of vehicles in each category is assumed to change in proportion to the total mileage (implying that unit mileage in km per vehicle is assumed to be the same).
- Activity data: Natural gas is assumed not to be used in the transport sector in Kosovo.
- Activity data: Electric passenger cars are assumed to appear by 2030, we use the same PJ as assumed by IIASA. For other transport categories, no electrification is assumed.
- Control strategy: Same Euro standards' distribution as assumed by IIASA.

RESIDENTIAL COMBUSTION

- Activity data: Same relative change (in %) in energy consumed in the residential sector between 2020 and 2030/2050, with further adjustments in distribution between fuels and non-emissive sources.
- Activity data: Natural gas is assumed not to be used in the residential sector in Kosovo.
- Control strategy: Same percentage of pellet stoves as in 2020 assumed, otherwise same numbers as in IIASA's baseline scenario.

HEAT AND POWER GENERATION

- Activity data: Same relative change (in %) in energy consumed for production of heat and electricity between 2020 and 2030/2050 as in IIASA’s baseline, with further adjustments in distribution between fuels and non-emissive sources.
- Activity data: Distribution of fuel use between new and existing plants in 2030 – according to data provided by national experts: 42% of new (corresponds to a new plant \to be set in operation by 2030) and 58% of existing (old Kosova plant). In 2050, only new plants are assumed to be in operation.
- Activity data: Same relative change (in %) in heat and electricity produced between 2020 and 2030/2050 as in IIASA’s baseline.
- Activity data: Natural gas and hard coal are assumed not to be used at Kosovo power plants.
- Control strategy: from 2030 - stricter control of PM and NOx than assumed by IIASA.
- Emission factors: Same emission factors for NOx and SOx as in 2020.

For introduction of renewable energy such as electrical cars, hydro energy for electricity production and similar, we made more conservative assumptions than IIASA based on the national data on the current situation in Kosovo.

All adjustments made to the IIASA's initial baseline scenario

Data type	Sector	Sub-sector	Fuel	Parameter	Unit	Value 2020		Value 2030		Value 2050	
						Initial	Adjusted	Initial	Adjusted	Initial	Adjusted
AD	Road transport	Personal cars	Gasoline	Fuel use	PJ	2.63	2.02	2.88	2.21	2.81	2.19
AD	Road transport	Personal cars	Diesel	Fuel use	PJ	0.27	10.36	0.27	10.76	0.10	12.29
AD	Road transport	Personal cars	LPG	Fuel use	PJ	0.00	0.23	0.00	0.001	0.00	0.002
AD	Road transport	Personal cars	Electric	Fuel use	PJ	0.01	0.00	0.06	0.061	0.26	0.258
AD	Road transport	Light trucks	Gasoline	Fuel use	PJ	0.02	0.10	0.03	0.11	0.08	0.01
AD	Road transport	Light trucks	Diesel	Fuel use	PJ	0.26	0.65	0.21	0.67	0.19	0.77
AD	Road transport	Buses	Diesel	Fuel use	PJ	0.02	1.29	0.005	1.34	0.01	1.53
AD	Road transport	Heavy trucks	Diesel	Fuel use	PJ	38.95	2.41	39.76	2.50	44.18	2.86
AD	Road transport	all	Gas	Fuel use	PJ		0.00	0.68	0.00	1.63	0.00
AD	Road transport	Personal cars	Gasoline	Veh no	1000	111.68	66.2	132.13	81.22	161.97	110.93
AD	Road transport	Personal cars	Diesel	Veh no	1000	10.16	292.9	10.52	316.50	4.58	456.20
AD	Road transport	Personal cars	LPG	Veh no	1000	0.00	2.3	0.00	0.01	0.00	0.02
AD	Road transport	Personal cars	Electric	Veh no	1000	0.38	0.0	3.03	3.03	11.29	11.29
AD	Road transport	Light trucks	Gasoline	Veh no	1000	0.71	1.3	1.12	0.00	4.89	0.28
AD	Road transport	Light trucks	Diesel	Veh no	1000	10.48	35.7	9.66	44.52	11.80	74.33
AD	Road transport	Buses	Diesel	Veh no	1000	0.18	1.8	0.06	3.16	0.13	5.00
AD	Road transport	Heavy trucks	Diesel	Veh no	1000	104.42	19.1	142.33	27.12	211.11	44.74
AD	Road transport	Personal cars	Gasoline	Traffic work	Gveh-km	1.04	0.80	1.28	1.34	1.72	1.34
AD	Road transport	Personal cars	Diesel	Traffic work	Gveh-km	0.13	4.94	0.13	7.70	0.06	7.70
AD	Road transport	Personal cars	LPG	Traffic work	Gveh-km	0.00	0.10	0.00	0.00	0.00	0.00
AD	Road transport	Personal cars	Electric	Traffic work	Gveh-km	0.00	0.00	0.03	0.03	0.10	0.10
AD	Road transport	Light trucks	Gasoline	Traffic work	Gveh-km	0.01	0.03	0.01	0.01	0.04	0.01
AD	Road transport	Light trucks	Diesel	Traffic work	Gveh-km	0.08	0.20	0.08	0.42	0.10	0.42
AD	Road transport	Buses	Diesel	Traffic work	Gveh-km	0.002	0.12	0.001	0.34	0.002	0.34
AD	Road transport	Heavy trucks	Diesel	Traffic work	Gveh-km	1.80	0.11	2.52	0.26	4.04	0.26
CS	Road transport	Personal cars	Gasoline	No control	%	0.00	29.96	0.00	0.00	0.00	0.00
CS	Road transport	Personal cars	Gasoline	EURO I	%	12.84	7.27	0.00	0.00	0.00	0.00

Data type	Sector	Sub-sector	Fuel	Parameter	Unit	Value 2020		Value 2030		Value 2050	
						Initial	Adjusted	Initial	Adjusted	Initial	Adjusted
CS	Road transport	Personal cars	Gasoline	EURO II	%	12.88	19.41	0.62	0.62	0.00	0.00
CS	Road transport	Personal cars	Gasoline	EURO III	%	19.23	25.53	3.78	3.78	0.00	0.00
CS	Road transport	Personal cars	Gasoline	EURO IV	%	37.54	10.73	22.79	22.79	0.00	0.00
CS	Road transport	Personal cars	Gasoline	EURO V	%	11.54	4.38	18.53	18.53	0.00	0.00
CS	Road transport	Personal cars	Gasoline	EURO VI	%	4.28	2.72	54.27	54.27	100.00	100.00
CS	Road transport	Personal cars	Diesel	No control	%	0.00	13.59	0.00	0.00	0.00	0.00
CS	Road transport	Personal cars	Diesel	EURO I	%	3.01	3.00	0.00	0.00	0.00	0.00
CS	Road transport	Personal cars	Diesel	EURO II	%	23.77	10.12	3.88	3.88	0.00	0.00
CS	Road transport	Personal cars	Diesel	EURO III	%	26.72	34.58	16.61	16.61	0.00	0.00
CS	Road transport	Personal cars	Diesel	EURO IV	%	20.02	24.97	13.95	13.95	0.00	0.00
CS	Road transport	Personal cars	Diesel	EURO V	%	20.03	10.27	16.31	16.31	0.00	0.00
CS	Road transport	Personal cars	Diesel	EURO VI	%	6.22	3.46	49.26	49.26	100.00	100.00
CS	Road transport	Personal cars	LPG	No control	%	0.00	48.22	0.00	0.00	0.00	0.00
CS	Road transport	Personal cars	LPG	EURO I	%	12.84	12.80	0.00	0.00	0.00	0.00
CS	Road transport	Personal cars	LPG	EURO II	%	12.88	16.58	0.62	0.62	0.00	0.00
CS	Road transport	Personal cars	LPG	EURO III	%	19.23	15.64	3.78	3.78	0.00	0.00
CS	Road transport	Personal cars	LPG	EURO IV	%	37.54	5.20	22.79	22.79	0.00	0.00
CS	Road transport	Personal cars	LPG	EURO V	%	11.54	1.56	18.53	18.53	0.00	0.00
CS	Road transport	Personal cars	LPG	EURO VI	%	4.28	0.00	54.27	54.27	100.00	100.00
CS	Road transport	Light trucks	Gasoline	No control	%	0.00	21.41	0.00	0.00	0.00	0.00
CS	Road transport	Light trucks	Gasoline	EURO I	%	2.54	14.20	0.00	0.00	0.00	0.00
CS	Road transport	Light trucks	Gasoline	EURO II	%	55.30	29.68	31.42	31.42	0.00	0.00
CS	Road transport	Light trucks	Gasoline	EURO III	%	14.51	21.26	14.19	14.19	0.00	0.00
CS	Road transport	Light trucks	Gasoline	EURO IV	%	16.31	9.99	16.89	16.89	0.00	0.00
CS	Road transport	Light trucks	Gasoline	EURO V	%	8.79	2.93	11.26	11.26	0.00	0.00
CS	Road transport	Light trucks	Gasoline	EURO VI	%	1.69	0.53	26.24	26.24	100.00	100.00
CS	Road transport	Light trucks	Diesel	No control	%	0.00	12.96	0.00	0.00	0.00	0.00
CS	Road transport	Light trucks	Diesel	EURO I	%	30.18	10.77	10.14	10.14	0.00	0.00
CS	Road transport	Light trucks	Diesel	EURO II	%	20.66	25.75	10.08	10.08	0.00	0.00

Data type	Sector	Sub-sector	Fuel	Parameter	Unit	Value 2020		Value 2030		Value 2050	
						Initial	Adjusted	Initial	Adjusted	Initial	Adjusted
CS	Road transport	Light trucks	Diesel	EURO III	%	14.39	28.94	7.23	7.23	0.00	0.00
CS	Road transport	Light trucks	Diesel	EURO IV	%	10.08	15.82	6.89	6.89	0.00	0.00
CS	Road transport	Light trucks	Diesel	EURO V	%	15.18	4.69	13.15	13.15	0.00	0.00
CS	Road transport	Light trucks	Diesel	EURO VI	%	3.32	1.07	52.51	52.51	100.00	100.00
CS	Road transport	Buses	Diesel	No control	%	0.00	13.71	0.00	0.00	0.00	0.00
CS	Road transport	Buses	Diesel	EURO I	%	8.99	13.27	0.00	0.00	0.00	0.00
CS	Road transport	Buses	Diesel	EURO II	%	17.55	35.28	10.11	10.11	0.00	0.00
CS	Road transport	Buses	Diesel	EURO III	%	26.07	25.64	20.94	20.94	0.00	0.00
CS	Road transport	Buses	Diesel	EURO IV	%	5.87	6.08	5.59	5.59	0.00	0.00
CS	Road transport	Buses	Diesel	EURO V	%	12.58	3.85	13.00	13.00	0.00	0.00
CS	Road transport	Buses	Diesel	EURO VI	%	12.56	2.17	50.36	50.36	100.00	100.00
CS	Road transport	Heavy trucks	Diesel	No control	%	0.00	26.49	0.00	0.00	0.00	0.00
CS	Road transport	Heavy trucks	Diesel	EURO I	%	0.45	9.66	0.00	0.00	0.00	0.00
CS	Road transport	Heavy trucks	Diesel	EURO II	%	8.10	19.48	1.56	1.56	0.00	0.00
CS	Road transport	Heavy trucks	Diesel	EURO III	%	16.07	28.0	6.93	6.93	0.00	0.00
CS	Road transport	Heavy trucks	Diesel	EURO IV	%	11.44	8.0	5.61	5.61	0.00	0.00
CS	Road transport	Heavy trucks	Diesel	EURO V	%	26.19	6.7	13.50	13.50	0.00	0.00
CS	Road transport	Heavy trucks	Diesel	EURO VI	%	30.87	1.6	72.39	72.39	100.00	100.00
AD	Residential	Urban	Lignite	Fuel use	TJ	0.11	0.05	0.03	0.01	0.001	0.0004
AD	Residential	Rural	Lignite	Fuel use	TJ	0.16	0.07	0.04	0.02	0.001	0.001
AD	Residential	Commercial	Lignite	Fuel use	TJ	0.08	0.33	0.02	0.08	0.001	0.003
AD	Residential	Other	Lignite	Fuel use	TJ	0.00	0.03	0.00	0.01	0.000	0.0003
AD	Residential	Urban	Heavy oil	Fuel use	TJ	0.00	0.00	0.00	0.00	0.00	0.00
AD	Residential	Rural	Heavy oil	Fuel use	TJ	0.00	0.00	0.00	0.00	0.00	0.00
AD	Residential	Commercial	Heavy oil	Fuel use	TJ	0.53	0.16	0.14	0.04	0.02	0.01
AD	Residential	Other	Heavy oil	Fuel use	TJ	0.00	0.00	0.00	0.00	0.00	0.00
AD	Residential	Urban	Diesel	Fuel use	TJ	0.09	0.06	0.03	0.02	0.005	0.005
AD	Residential	Rural	Diesel	Fuel use	TJ	0.13	0.09	0.04	0.03	0.01	0.01
AD	Residential	Commercial	Diesel	Fuel use	TJ	0.91	1.17	0.33	0.41	0.08	0.09

Data type	Sector	Sub-sector	Fuel	Parameter	Unit	Value 2020		Value 2030		Value 2050	
						Initial	Adjusted	Initial	Adjusted	Initial	Adjusted
AD	Residential	Other	Diesel	Fuel use	TJ	0.00	0.90	0.00	0.32	0.00	0.07
AD	Residential	Urban	Gasoline	Fuel use	TJ	0.00	0.02	0.00	0.02	0.00	0.02
AD	Residential	Rural	Gasoline	Fuel use	TJ	0.00	0.02	0.00	0.02	0.00	0.02
AD	Residential	Commercial	Gasoline	Fuel use	TJ	0.00	0.00	0.00	0.00	0.00	0.00
AD	Residential	Other	Gasoline	Fuel use	TJ	0.00	0.03	0.00	0.03	0.00	0.03
AD	Residential	Urban	Gas	Fuel use	TJ	0.0000002	0.00	0.81	0.00	2.39	0.00
AD	Residential	Rural	Gas	Fuel use	TJ	0.0000003	0.00	1.17	0.00	3.44	0.00
AD	Residential	Commercial	Gas	Fuel use	TJ	0.002	0.00	0.34	0.00	0.87	0.00
AD	Residential	Other	Gas	Fuel use	TJ	0.001	0.00	0.0004	0.00	0.0005	0.00
AD	Residential	Urban	LPG	Fuel use	TJ	0.004	0.10	0.001	0.03	0.0003	0.01
AD	Residential	Rural	LPG	Fuel use	TJ	0.01	0.14	0.002	0.05	0.0004	0.01
AD	Residential	Commercial	LPG	Fuel use	TJ	0.60	0.35	0.19	0.11	0.04	0.02
AD	Residential	Other	LPG	Fuel use	TJ	0.0001	0.00	0.0001	0.00	0.0001	0.00
AD	Residential	Urban	Electricity	Fuel use	TJ	4.34	4.00	4.71	4.66	5.80	5.33
AD	Residential	Rural	Electricity	Fuel use	TJ	6.24	6.00	6.78	6.99	8.35	8.00
AD	Residential	Commercial	Electricity	Fuel use	TJ	4.16	3.36	5.65	3.91	5.41	4.47
AD	Residential	Other	Electricity	Fuel use	TJ	0.19	0.40	0.25	0.47	0.34	0.54
AD	Residential	Urban	Heat	Fuel use	TJ	0.27	0.20	0.95	0.52	1.03	0.57
AD	Residential	Rural	Heat	Fuel use	TJ	0.39	0.30	1.36	0.78	1.48	0.85
AD	Residential	Commercial	Heat	Fuel use	TJ	0.41	0.27	0.46	0.70	0.49	0.75
AD	Residential	Other	Heat	Fuel use	TJ	0.000000	0.00	0.00	0.00	0.00	0.00
AD	Residential	Urban	Fuelwood	Fuel use	TJ	0.00	6.10	0.00	6.35	0.00	7.51
AD	Residential	Rural	Fuelwood	Fuel use	TJ	16.37	9.14	14.88	9.52	12.57	11.26
AD	Residential	Commercial	Fuelwood	Fuel use	TJ	3.06	0.46	1.55	0.48	0.69	0.57
AD	Residential	Other	Fuelwood	Fuel use	TJ	1.00	0.16	1.10	0.16	1.30	0.19
AD	Residential	Urban	Solar	Fuel use	TJ	0.01	0.002	0.03	0.01	0.08	0.08
AD	Residential	Rural	Solar	Fuel use	TJ	0.02	0.004	0.05	0.02	0.12	0.12
AD	Residential	Commercial	Solar	Fuel use	TJ	0.05	0.013	0.41	0.08	2.76	0.47
AD	Residential	Other	Solar	Fuel use	TJ	0.0002	0.000	0.001	0.00	0.002	0.00

Data type	Sector	Sub-sector	Fuel	Parameter	Unit	Value 2020		Value 2030		Value 2050	
						Initial	Adjusted	Initial	Adjusted	Initial	Adjusted
CS	Residential	all	Fuelwood	No control	%	98.00	85.95	87.00	77.63	59.00	49.63
CS	Residential	all	Fuelwood	New stove with ESP	%	0.00	0.00	3.00	3.00	11.00	11.00
CS	Residential	all	Fuelwood	Improved stove	%	2.00	4.68	10.00	10.00	30.00	30.00
CS	Residential	all	Fuelwood	New stove	%	0.00	0.00	0.00	0.00	0.00	0.00
CS	Residential	all	Fuelwood	Pellet stove	%	0.00	9.37	0.00	9.37	0.00	9.37
CS	Residential	all	Fuelwood	Pellet stove with ESP	%	0.00	0.00	0.00	0.00	0.00	0.00
AD	Heat and power	Existing large	Lignite	Fuel use	TJ	52.30	70.3	31.95	33.68	0.00	0.00
AD	Heat and power	New large	Lignite	Fuel use	TJ	6.20	0.0	16.01	23.99	17.19	20.65
AD	Heat and power	New large	Hard coal	Fuel use	TJ	0.31	0.0	0.87	0.00	0.56	0.00
AD	Heat and power	New large	Gas	Fuel use	TJ	0.00	0.0	0.00	0.00	6.65	0.00
AD	Heat and power	New CHP	Heavy oil	Fuel use	TJ	0.06	0.0	0.02	0.00	0.02	0.00
AD	Heat and power	New CHP	Fuelwood	Fuel use	TJ	0.00	0.67	0.14	2.35	0.52	12.21
AD	Heat and power	Existing CHP	Heavy oil	Fuel use	TJ	0.02	0.0	0.00	0.00	0.00	0.00
AD	Heat and power	Existing CHP	Fuelwood	Fuel use	TJ	0.01	0.0	0.11	0.00	0.00	0.00
CS	Heat and power	Existing large, NOx	Lignite	No control	%	0	100	0	0	0	0
CS	Heat and power	Existing large, NOx	Lignite	Combustion modification	%	65	0	65	100	65	100
CS	Heat and power	Existing large, NOx	Lignite	Combustion modification + SCR	%	35	0	35	0	35	0
CS	Heat and power	New large, NOx	Lignite	No control	%	0	0	0	0	0	0
CS	Heat and power	New large, NOx	Lignite	SCR	%	0	0	25	100	25	100
CS	Heat and power	Large, SOx	Lignite	No control	%	0	100	100	0	0	0
CS	Heat and power	Large, SOx	Lignite	Limestone injection	%	0	0	0	0	0	0

Data type	Sector	Sub-sector	Fuel	Parameter	Unit	Value 2020		Value 2030		Value 2050	
						Initial	Adjusted	Initial	Adjusted	Initial	Adjusted
CS	Heat and power	Large, SOx	Lignite	Wet FGD (retrofitted)	%	100	0	0	100	100	100
CS	Heat and power	Large, SOx	Lignite	Wet FGD	%	0	0	0	0	0	0
CS	Heat and power	Large, PM	Lignite	No control	%	0	0	0	0	0	0
CS	Heat and power	Large, PM	Lignite	ESP 1 field	%	0	0	0	0	0	0
CS	Heat and power	Large, PM	Lignite	ESP 2 fields	%	37	100	37	0	37	0
CS	Heat and power	Large, PM	Lignite	HED	%	63	0	63	100	63	100
CS	Heat and power	Large, PM	Lignite	Wet scrubber	%	0	0	0	0	0	0
EF	Heat and power	Large, NOx	Lignite	Unabated emission factor	kg/GJ	270	523	270	523	270	523
EF	Heat and power	Large, SOx	Lignite	Unabated emission factor	kg/GJ	1200	571	1200	571	1200	571
AD	Heat and power	Hydro	-	Energy use	TJ	2.70	0.93	2.94	1.01	3.14	1.08
AD	Heat and power	Wind	-	Energy use	TJ	0.43	0.33	0.48	0.43	0.95	0.85
AD	Heat and power	Solar	-	Energy use	TJ	0.00	0.06	0.87	0.77	3.60	3.21
AD	Heat and power	All	-	Energy output: production +import-export		-32.40	-25.01	-39.96	-30.85	-49.78	-38.43

Annex 3: Definition of scenarios for Kosovo 2030, 2050

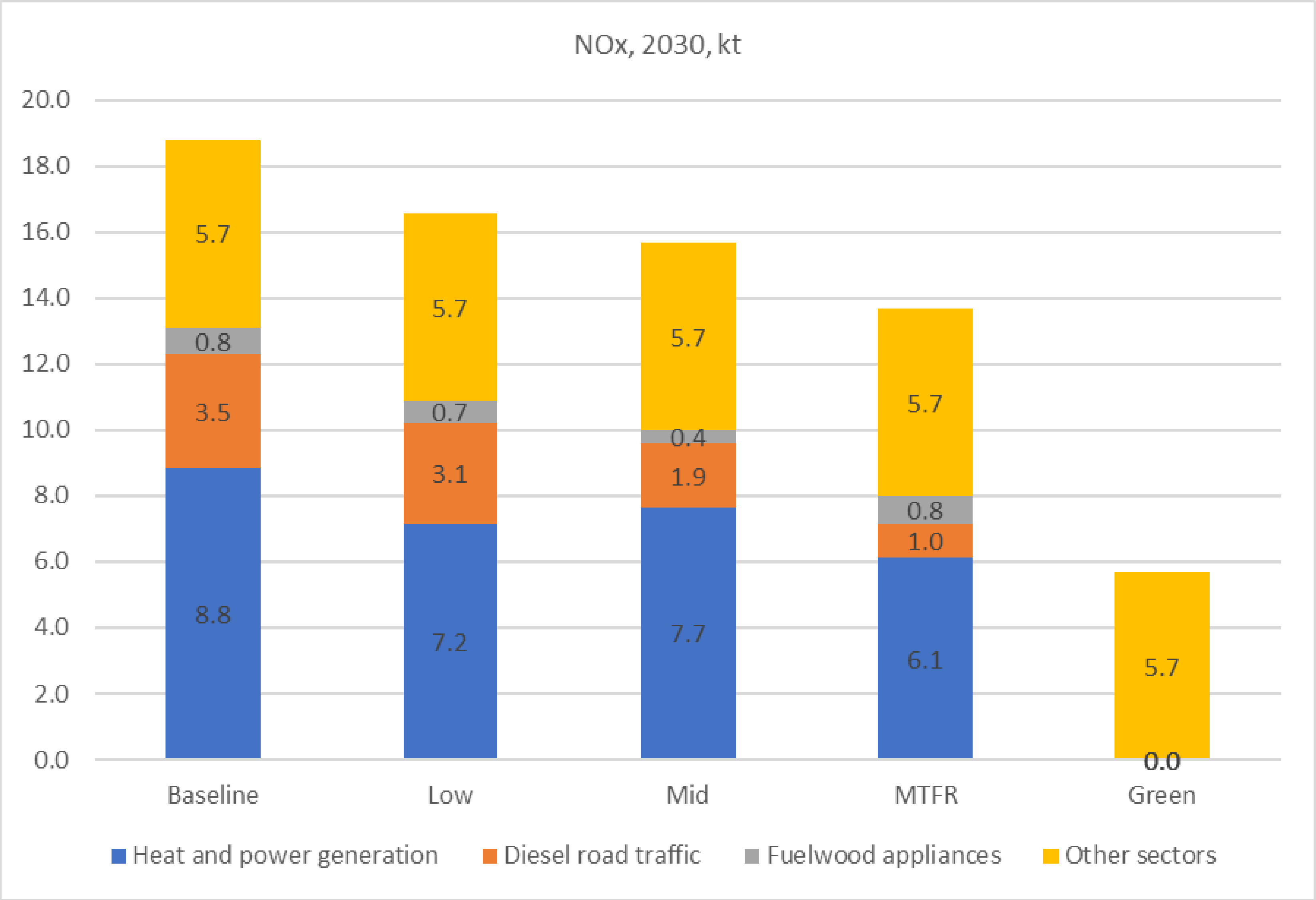
Year 2030

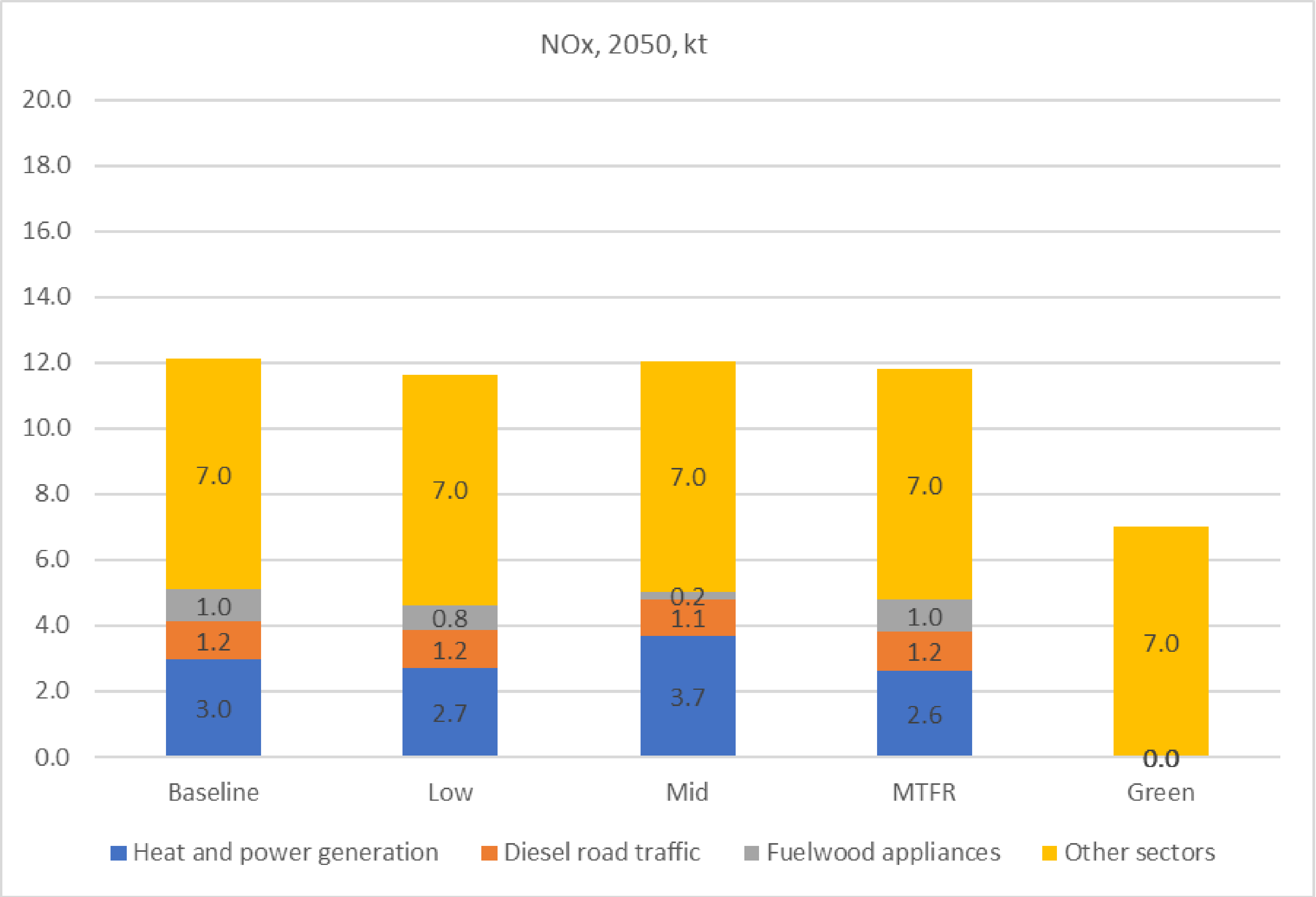
Sector	Baseline (CLE)	Low	Mid	MTFR
Residential combustion	Heating stoves: 10% improved, 3% new, 9% pellets	Heating stoves: 10% improved, 3% new, 9% pellets Energy efficiency improvements – 20% less energy demand (10% less fuel use at power plants)	Heating stoves: 25% improved, 25% new, 25% pellets, 25% conventional with retrofit ESP	Heating stoves: 100% pellet with ESP
Diesel road transport	50-70% of Euro 3	Low emission zones in 4 large cities	50% goods from road to railway 80% Euro 6 on diesel vehicles	100% Euro 6
Heat and power generation: existing lignite power plants	100% combustion modification 100% HED No SO2 control	50% combustion modification, 50% combustion modification + SCR 100% HED 100% limestone injection	20% combustion modification, 80% combustion modification + SCR 100% HED 50% limestone injection, 50% wet FGD	100% combustion modification + SCR 100% HED 100% wet FGD
Heat and power generation: new lignite power plants	100% SCR 100% HED No SO2 control	100% SCR 100% HED 100% limestone injection	100% SCR 100% HED 100% wet FGD	100% SCR 100% HED 100% high efficiency wet FGD
Heat and power generation: new biomass plants (CHP)	No NOx control 50% ESP1, 50% ESP2 SO2 control not relevant	80% no NOx control, 20% SNCR 20% ESP1, 80% ESP2 SO2 control not relevant	50% no NOx control, 50% SNCR 50% ESP2, 50% HED SO2 control not relevant Extension of central heating system: 50% of wood in the residential sector replaced by heat from CHP (with emission control specified above)	100% SNCR 100% HED SO2 control not relevant

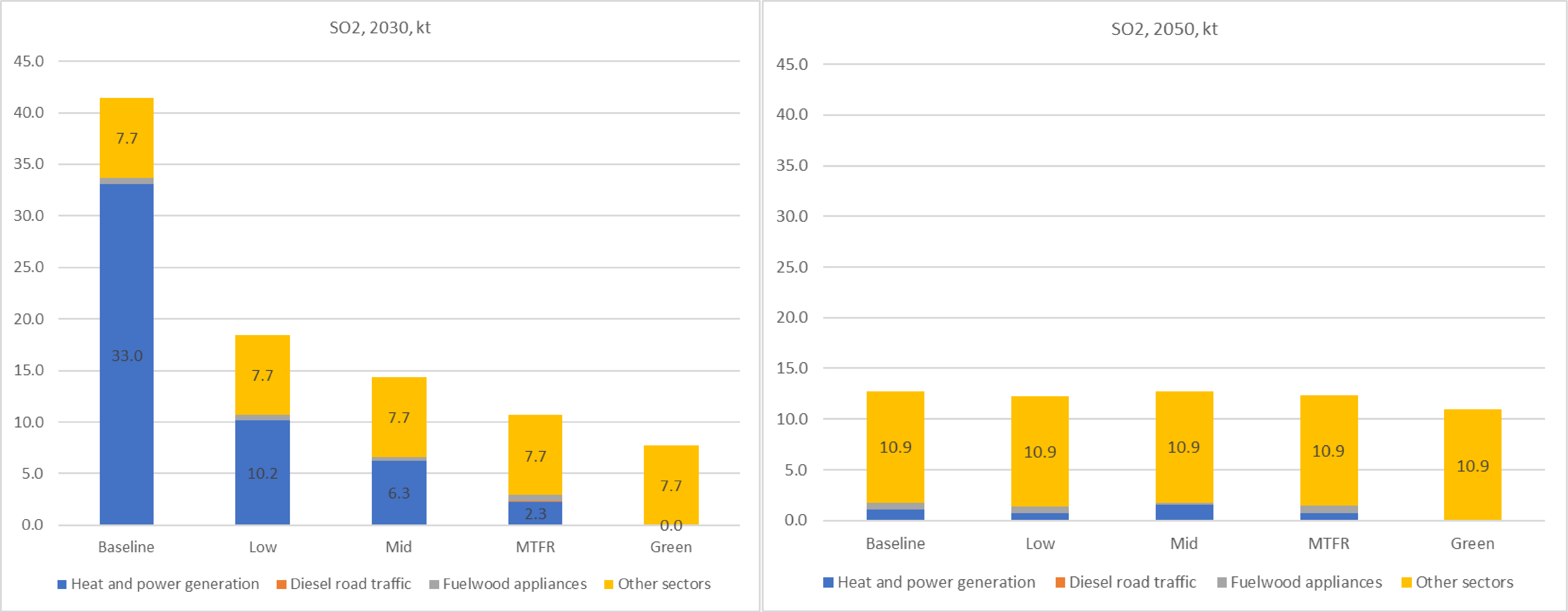
Year 2050

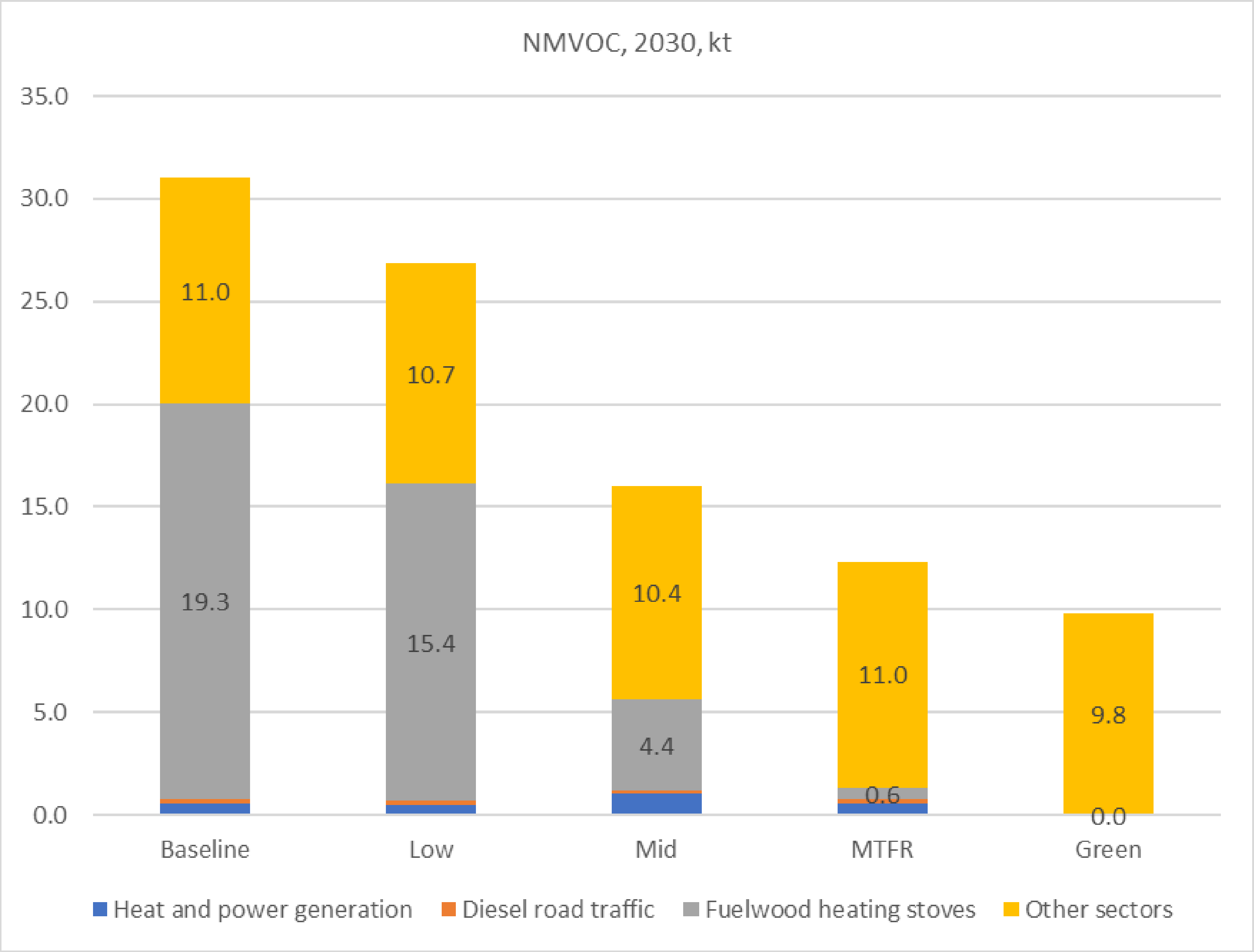
Sector	Baseline (CLE)	Low	Mid	MTFR
Residential combustion	Heating stoves: 30% improved, 11% new, 9% pellets	Heating stoves: 30% improved, 11% new, 9% pellets Energy efficiency improvements – 20% less energy demand (10% less fuel use at power plants)	Heating stoves: 25% improved, 35% new, 40% pellets	Heating stoves: 100% pellet with ESP
Diesel road transport	100% Euro 6	100% Euro 6	100% Euro 6 75% goods from road to railway	100% Euro 6
Heat and power generation: existing lignite power plants	- (no existing plants, only new)	- (no existing plants, only new)	- (no existing plants, only new)	- (no existing plants, only new)
Heat and power generation: new lignite power plants	100% SCR 100% HED 100% wet FGD	100% SCR 100% HED 50% wet FGD, 50% high efficiency wet FGD	100% SCR 100% HED 20% wet FGD, 80% high efficiency wet FGD	100% SCR 100% HED 100% high efficiency wet FGD
Heat and power generation: new biomass plants (CHP)	No NOx control 50% ESP1, 50% ESP2 SO2 control not relevant	50% no NOx control, 50% SNCR 100% ESP2 SO2 control not relevant	20% no NOx control, 80% SNCR 20% ESP2, 80% HED SO2 control not relevant Extension of central heating system: 75% of wood in the residential sector replaced by heat from CHP (with emission control specified above)	100% SNCR 100% HED SO2 control not relevant

Annex 4: Scenario-specific sectoral distribution of emissions in Kosovo






SO2, 2030, kt
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
7.7
33.0
7.7
10.2
7.7
6.3
7.7
2.3
7.7
0.0
Baseline
Low
Mid
MTFR
Green
Heat and power generation
Diesel road traffic
Fuelwood appliances
Other sectors
SO2, 2050, kt
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
10.9
10.9
10.9
10.9
10.9
Baseline
Low
Mid
MTFR
Green
Heat and power generation
Diesel road traffic
Fuelwood appliances
Other sectors


NMVOC, 2030, kt
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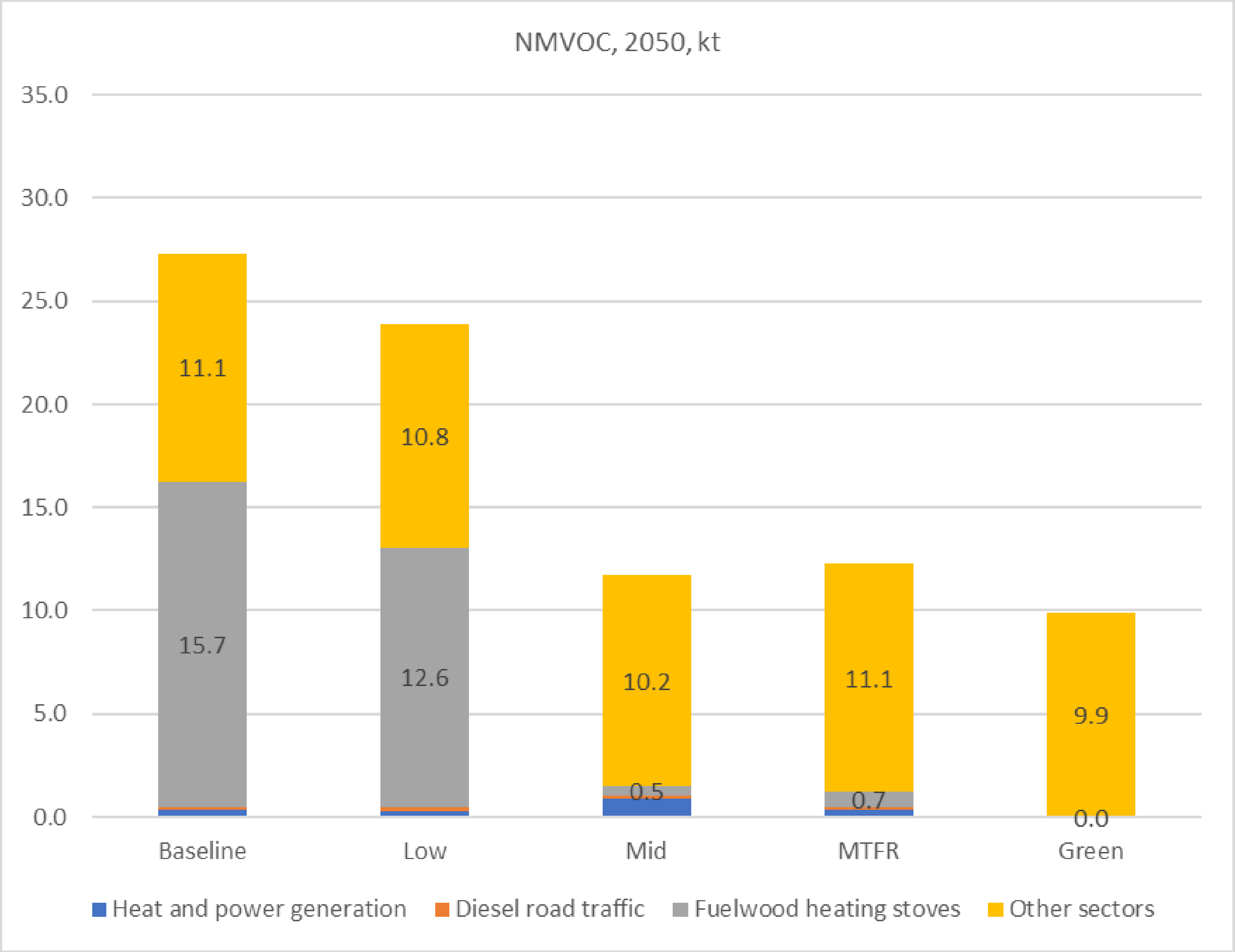
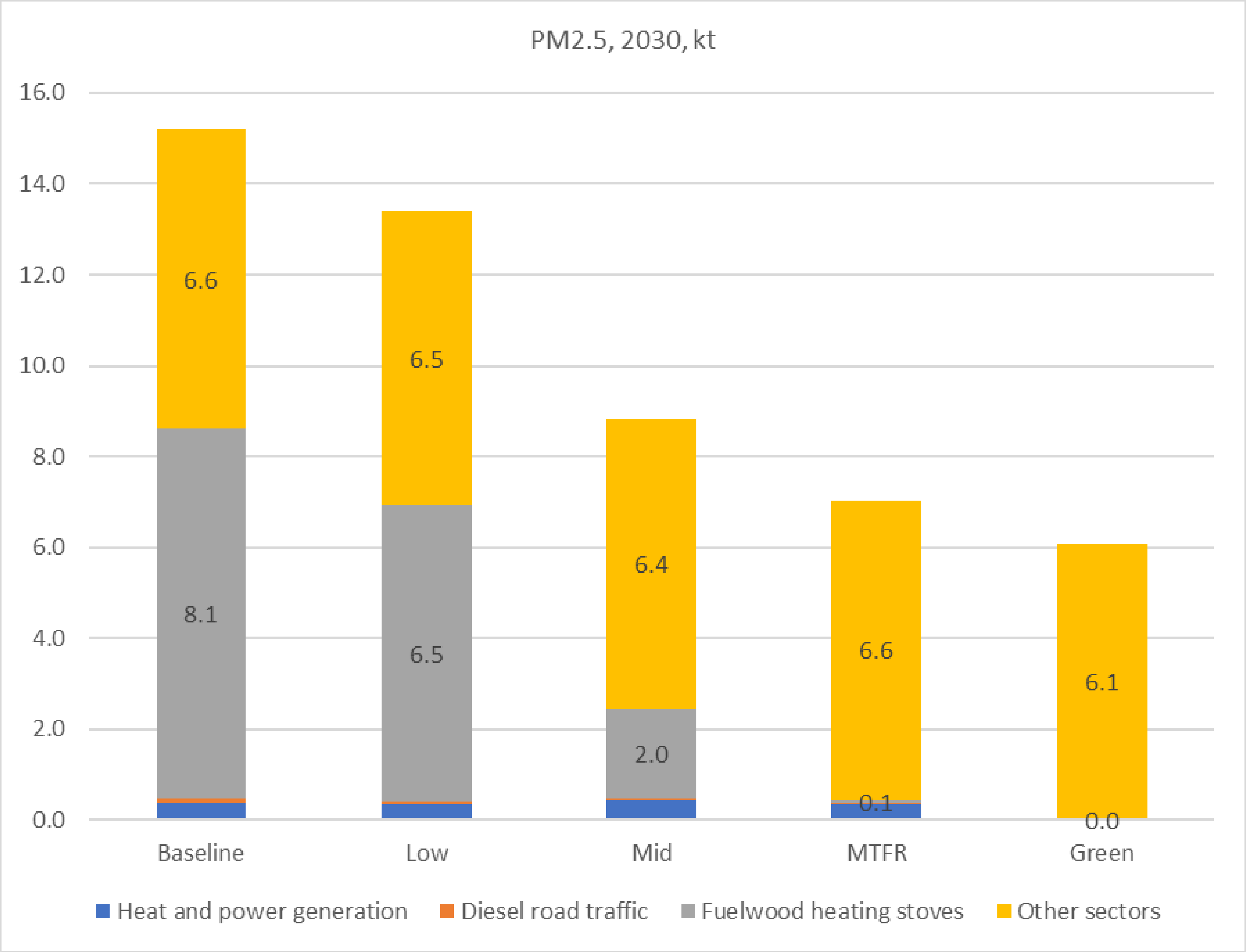
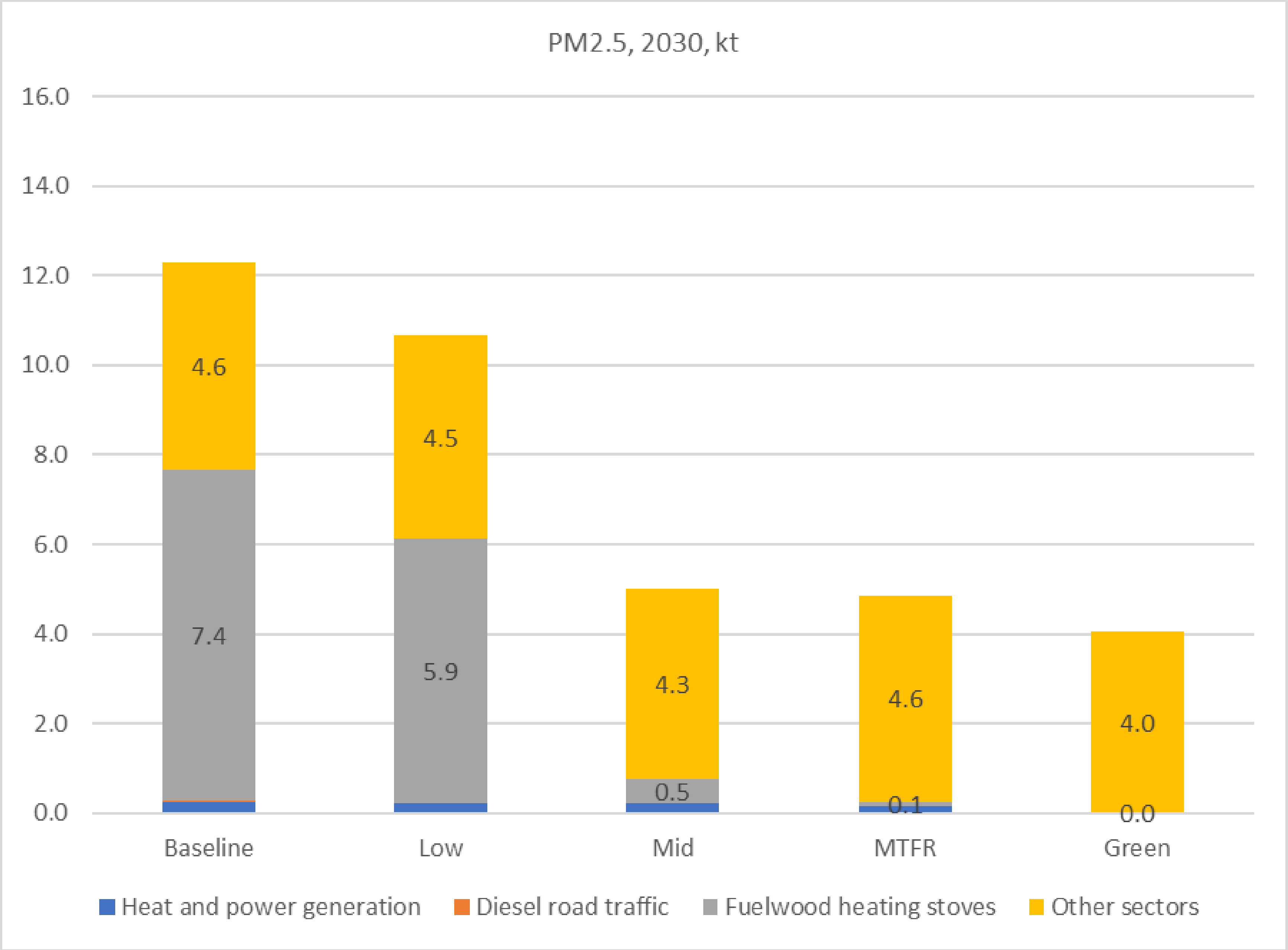
30.0
25.0
20.0
15.0
10.0
5.0
0.0
11.0
19.3
10.7
15.4
10.4
4.4
11.0
0.6
9.8
0.0
Baseline
Low
Mid
MTFR
Green
Heat and power generation
Diesel road traffic
Fuelwood heating stoves
Other sectors


NMVOC, 2050, kt
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
11.1
15.7
10.8
12.6
10.2
0.5
11.1
0.7
9.9
0.0
Baseline
Low
Mid
MTFR
Green
Heat and power generation
Diesel road traffic
Fuelwood heating stoves
Other sectors


PM2.5, 2030, kt
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
6.6
8.1
6.5
6.5
6.4
2.0
6.6
0.1
6.1
0.0
Baseline
Low
Mid
MTFR
Green
Heat and power generation
Diesel road traffic
Fuelwood heating stoves
Other sectors


PM2.5, 2030, kt
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
4.6
7.4
4.5
5.9
4.3
0.5
4.6
0.1
4.0
0.0
Baseline
Low
Mid
MTFR
Green
Heat and power generation
Diesel road traffic
Fuelwood heating stoves
Other sectors

Annex 5: Measure-instrument toolbox for key sectors

Diesel road transport

Measures → / **Instruments ↓**	Enhanced Euro 6 implementation	Switch to electric vehicles[19]	Reduced traffic (less driving)	Switch to gas (e.g., buses on biogas)	Shift of goods to railways + electrification	Proper vehicle inspection
Requirements on emissions from new vehicles	x					
Vehicle replacement programmes	x	x				
Vehicle tax (based on fuel, efficiency, age)	x	x				
Subsidies/tax reduction for import of vehicles of Euro 6 standard or electric cars	x	x				
Ban on using existing vehicles that don't meet emission criteria	x	x	x	x		
Regulations on vehicle inspection						x
Low emission zones (e.g., ban on Euro 0-2)	x		x	x		
Congestion tax			x			
Promotion of public transport and non-motorized transport (bikes, scooters)			x			
Municipal mobility plans	x	x	x	x		
National goals on share of renewables		x			x	
Developing infrastructure for electrification		x				

[19] Hydrogen-fuelled vehicles could be seen as a next step; currently, shift to electric vehicles seems as a more realistic option in Kosovo.

Residential wood combustion

Measures →	Enhanced replacement with improved, new and pellet stoves	Burning right practice	Retrofit ESP on existing stoves	Switch to non-emissive energy sources	Reduced residential burning of wood	Energy efficiency improvements in buildings	Proper planning and installation of appliances	Proper maintenance and inspection of appliances
Instruments ↓	x							
Appliance replacement programmes	x							
Subsidies/tax reduction for import of new, energy efficient appliances and pellet stoves	x							
Financial support to install retrofit ESP on existing stoves			x					
Ban on using existing appliances that don't meet emission criteria	x		x	x				
Certification systems for appliances	x							
Mandatory labelling (of energy efficiency)	x							
Information on effects and practices of wood burning at homes	x	x	x	x	x		x	
Certification of biomass fuels	x							
Ban on using of certain types of fuels	x							
Energy efficiency requirements for buildings						x		
Energy certification of buildings						x		
Subsidies and info-support for energy audits						x		
Investment support and tax reduction for energy efficiency audits and measures						x		
Energy efficiency goals						x		
National renovation strategy						x		
Dissemination of energy project results						x		
Economic incentives for switch to solar panels and heat pumps				x				
National goals on share of renewables				x				
Temporary bans on residential burning					x			
Regulations on planning and installation							x	
Chimney sweeping regulations								x
Requirements on indoor air quality	x	x	x	x	x		x	

Heat and power generation

Measures →	End-of-pipe and process control equipment (particle filters, FGD, SNCR etc.)	Switch to non-emissive energy sources (solar, wind, geothermal, nuclear) or imported energy	Switch to gas	Broader and more effective central heating network	Energy efficiency measures at power plants	Lower energy consumption by final users
Instruments ↓				x		
Subsidies for fuel shift at CH plants (from oil to biomass, waste, gas, steam (co-generation))				x		
Mandatory analysis of energy efficiency and renovation plans for CH boilers				x		
Requirements on energy efficiency and emissions for CH boilers				x		
Infrastructure for flexibility of CH systems				x		
National goals on share of renewables		x				
Requirements on emission levels for plants	x	x	x		x	
Eco-labelling of equipment at new plants					x	
Taxes and refundable charges on emissions	x	x	x		x	
Tax on fossil fuels		x			x	
Regional integration of electricity markets		x				
Support schemes for renewable energy production		x				x
Differentiated tariffs to discourage high energy consumption by final users						x
Mandatory energy efficiency audits					x	
Subsidies and info-support for energy audits					x	
Investment support and tax reduction for energy efficiency audits and measures					x	
BAT requirements for energy efficiency integrated in the permit issuing system					x	
National energy and climate plan		x			x	
Instruments for improved energy efficiency listed under residential wood combustion						x

Annex 6: Summary of measures in the key sectors

The following tables provides an overview and summary of different measures for each key sector. The tables contribute by presenting an overview of costs of implementation, reduction potential and avoided health damage, in Kosovo and Europe. This information can be of assistance to decision-makers who need rankings of different measures by various parameters of interest – emission reduction potentials, reduction efficiencies, avoided damage, benefit-to-cost ratio.

Residential wood combustion

Measure	Costs, mln Euro	Avoided damage		Net benefits		Benefit-to-cost	
		Kosovo	Europe	Kosovo	Europe	Kosovo	Europe
Replacement with improved stoves	37	126	353	89	315	3.4	9.4
Replacement with new stoves	302	162	450	-140	148	0.5	1.5
Replacement with new stoves + ESP	347	198	544	-149	197	0.6	1.6
Replacement with pellet stoves	328	194	540	-133	212	0.6	1.6
Replacement with pellet stoves + ESP	398	205	562	-192	164	0.6	1.4
Burning right techniques	0	50	144	50	144	high	high
Switch to non-emissive technologies	n.a.	209	590	n.a.	n.a.	n.a.	n.a.
Retrofit ESP on existing heating stoves	67	162	446	95	380	2.4	6.7
Ban of burning in urban areas	n.a.	50	148	n.a.	n.a.	n.a.	n.a.
Energy efficiency improvements in buildings	n.a.	144	580	n.a.	n.a.	n.a.	n.a.

Heat and power generation

Measure	Reduction potential, kt	Technical costs, mln Euro	Costs, Euro/kg pollutant	Avoided damage		Net benefits		Benefit-to-cost	
				Kosovo	Europe	Kosovo	Europe	Kosovo	Europe
SOx: Furnace control (limestone injection)	SOx: 24	60	2.5	119	749	59	689	2.0	12
SOx: Wet flue gas desulfurization	SOx: 36	80	2.2	180	1123	100	1043	2.2	14
NOX: Combustion modification	NOx: 24	3.7	0.2	22	169	18	165	5.8	45
NOX: Combustion modification + SCR	NOx: 29	29	1.0	29	205	-0.5	17	0.98	7.0
$PM_{2.5}$: High-efficiency deduster	$PM_{2.5}$: 3.1	1.8	0.6	76	209	74	207	42	116
Switch to non-emissive technologies	NOx: 37	n.a.	n.a.	324	1746	n.a.	n.a.	n.a.	n.a.
Switch from lignite to gas	NOx: 33	n.a.	n.a.	320	1721	n.a.	n.a.	n.a.	n.a.
Extension of central heating: wood, current control	$PM_{2.5}$: 8.6	n.a.	n.a.	212	587	n.a.	n.a.	n.a.	n.a.
Extension of central heating: wood, maximum control	$PM_{2.5}$: 8.77	n.a.	n.a.	220	601	n.a.	n.a.	n.a.	n.a.
Extension of central heating: waste, maximum control	$PM_{2.5}$: 8.79	n.a.	n.a.	223	623	n.a.	n.a.	n.a.	n.a.

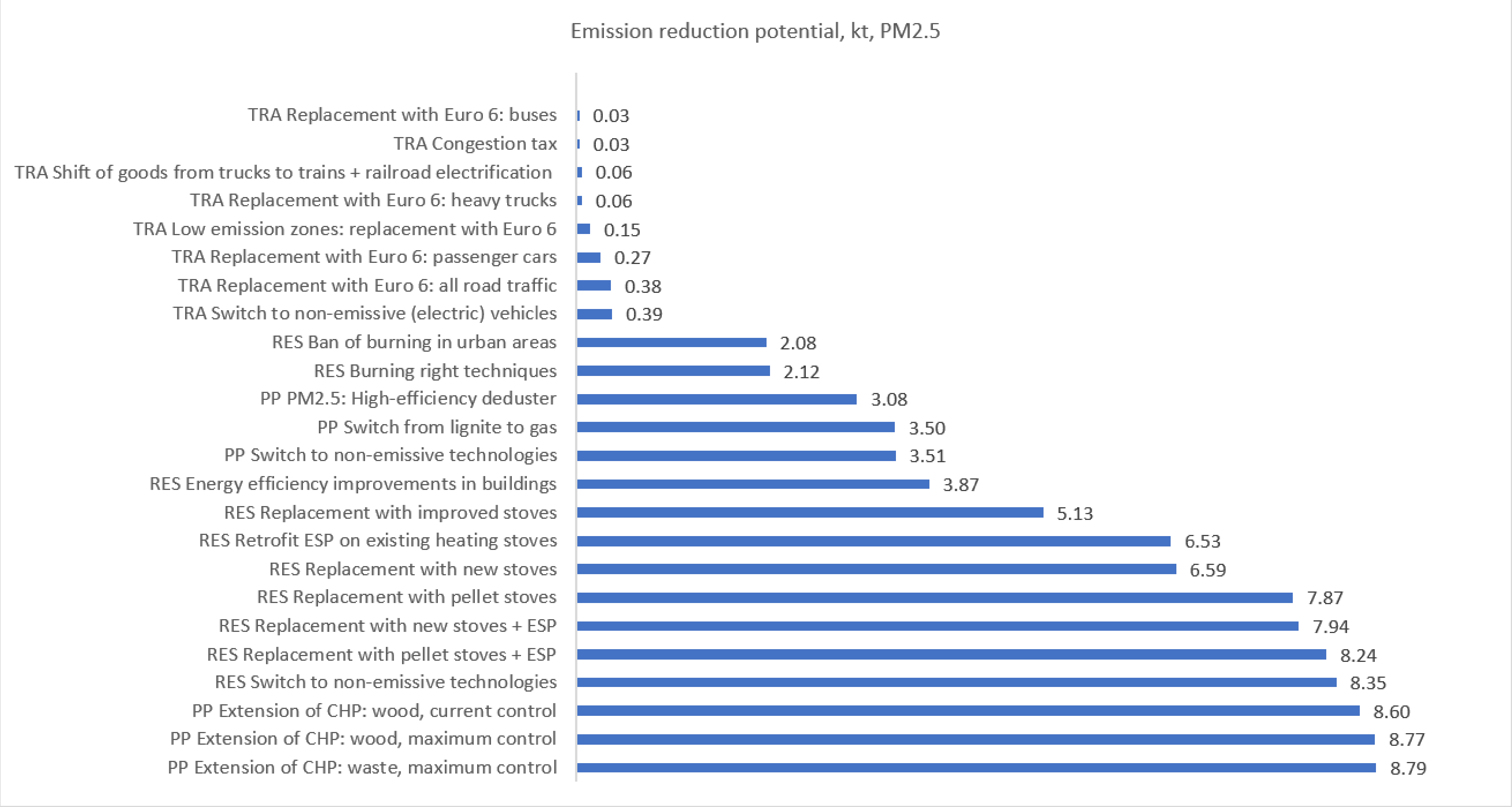
Diesel road transport

Measure.2	Technical costs, mln Euro	Avoided damage		Net benefits		Benefit-to-cost	
		Kosovo	Europe	Kosovo	Europe	Kosovo	Europe
Replacement with Euro 6: passenger cars	29	7.2	36	-22	7	0.3	1.3
Replacement with Euro 6: buses	3.2	n.a.	7	n.a.	4	low	2.3
Replacement with Euro 6: heavy trucks	26	3.6	14	-22	-11	0.1	0.6
Replacement with Euro 6: light trucks	3.58	n.a.	3.60	n.a.	0.02	low	1.005
Replacement with Euro 6: all road traffic	61	14.4	61	-47	0.1	0.2	1.07
Low emission zones	20	3.6	22	-17	1.4	0.2	1.1
Switch to non-emissive (electric) vehicles	n.a.	14.0	72	n.a.	n.a.	n.a.	n.a.
Shift of goods transport from trucks to trains + railroad electrification	n.a.	3.6	22	n.a.	n.a.	n.a.	n.a.
Congestion tax	n.a.	n.a.	7	n.a.	n.a.	n.a.	n.a.

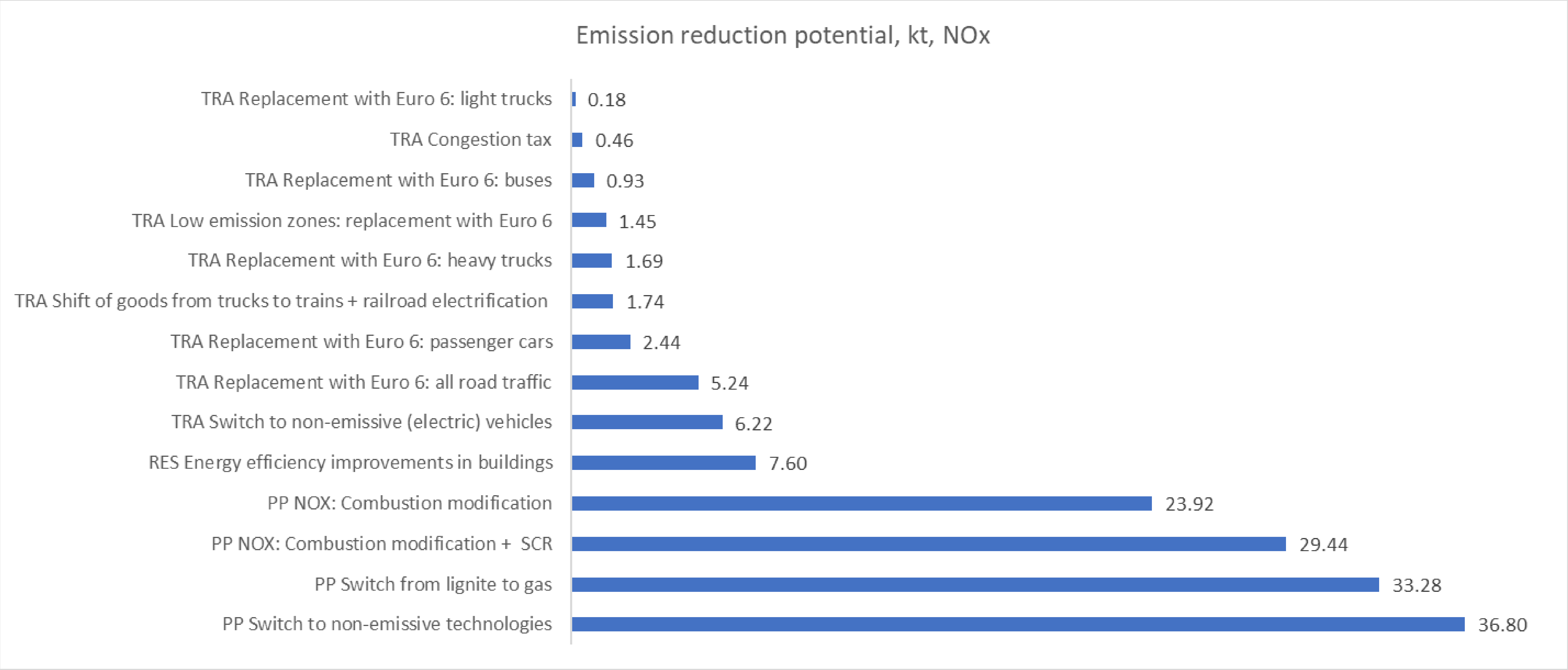
Annex 7: Rankings of measures in the key sectors

The following tables listed here in Annex 7 provide an overview of all the investigated measures for the different key sectors. Emission reduction potential, emission reduction efficiency, avoided damage, technical cost and benefit-to-cost ratio are presented for all measures and ranked from lowest to highest. The tables contribute by guiding the reader to which measures holds the greatest potential depending on what effect or potential result is most valued by the reader. E.g., if the reduction potential of PM2.5 is most valued, PP Extension of CHP: waste, maximum control holds the greatest reduction potential.

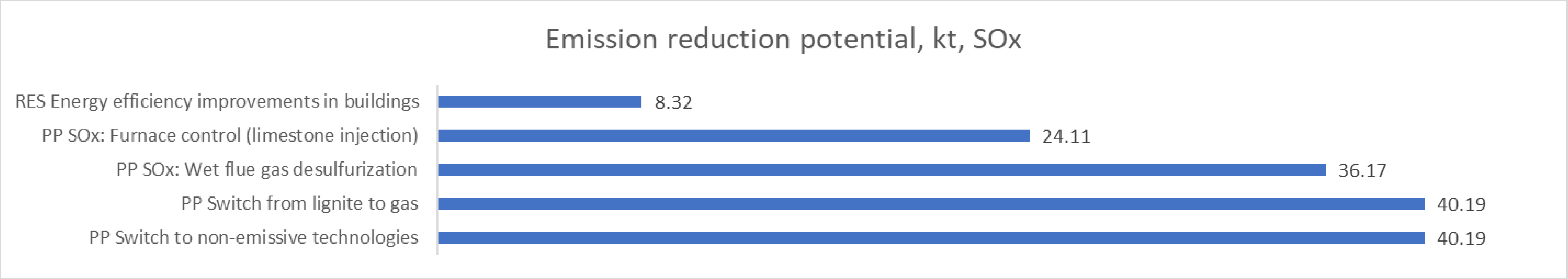
Emission reduction potential for PM2.5 (kt)



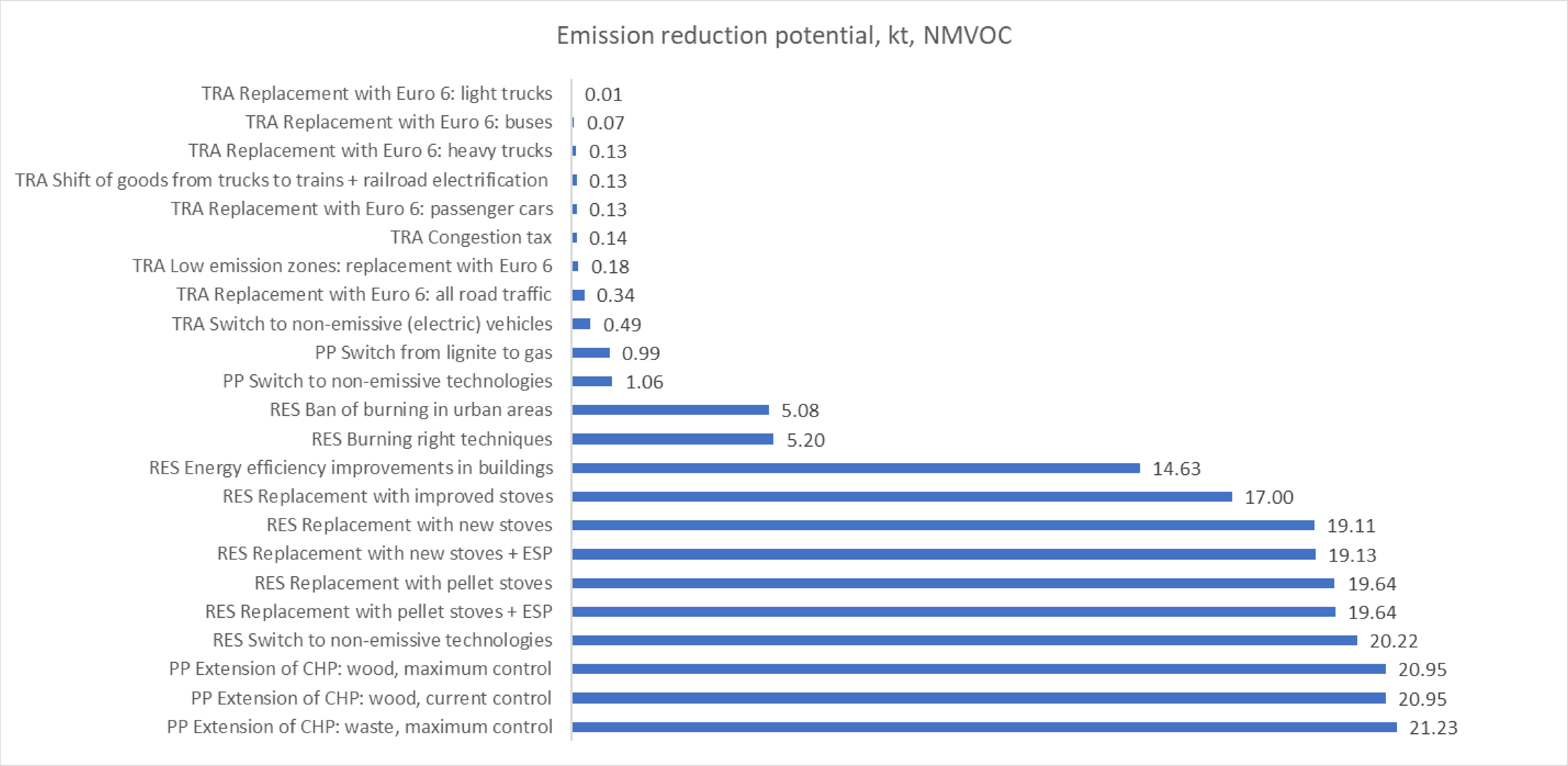
Emission reduction potential for NOx (kt)



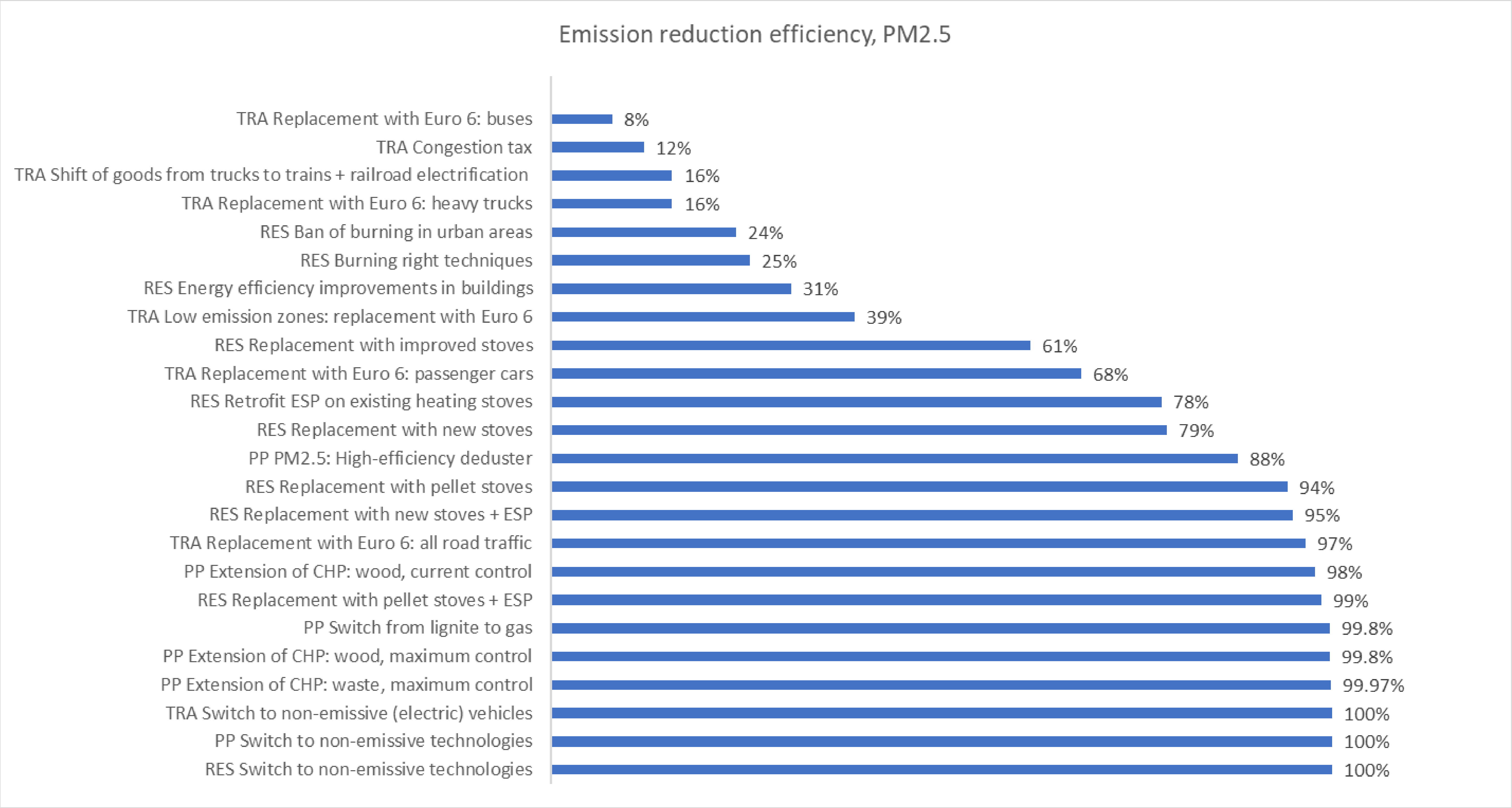
Emission reduction potential for SO2 (kt)



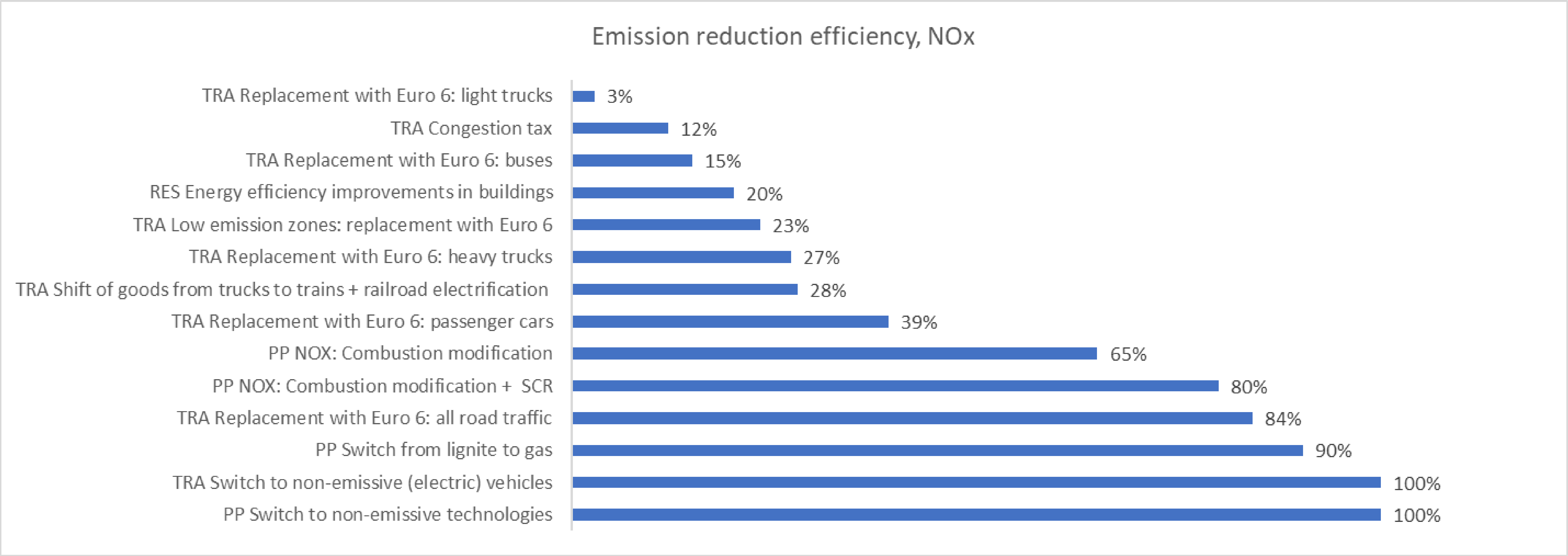
Emission reduction potential for NMVOC (kt)



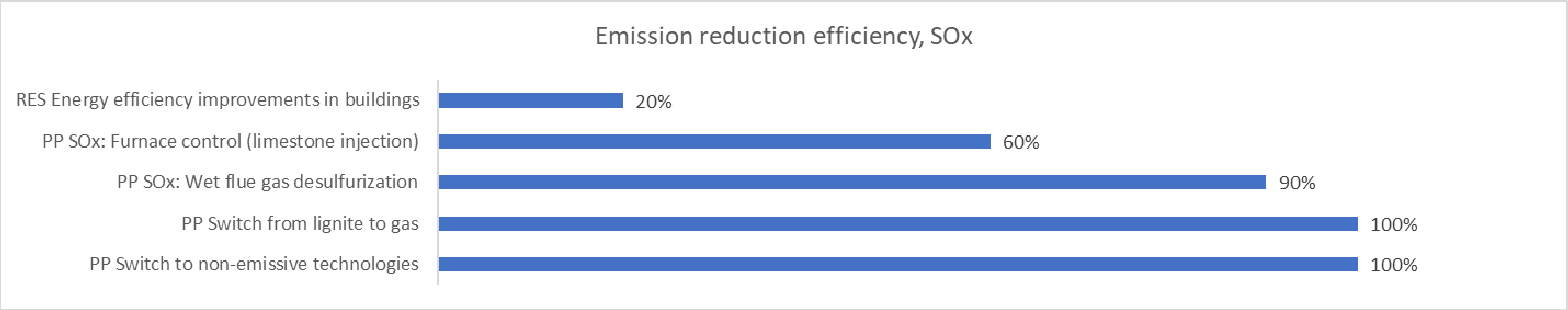
Emission reduction efficiency, measures for PM2.5 (%)



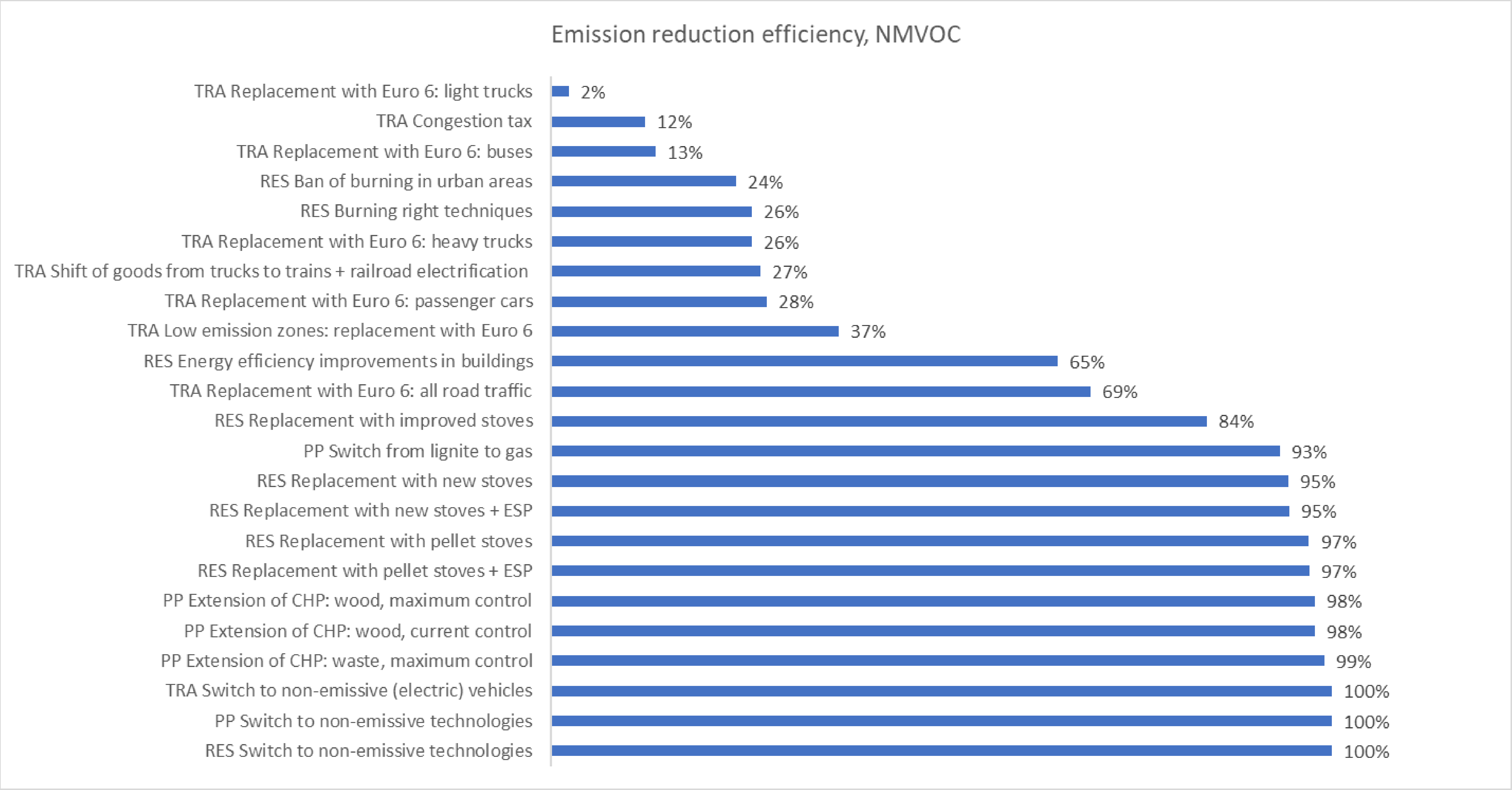
Emission reduction efficiency, measures for NOx (%)



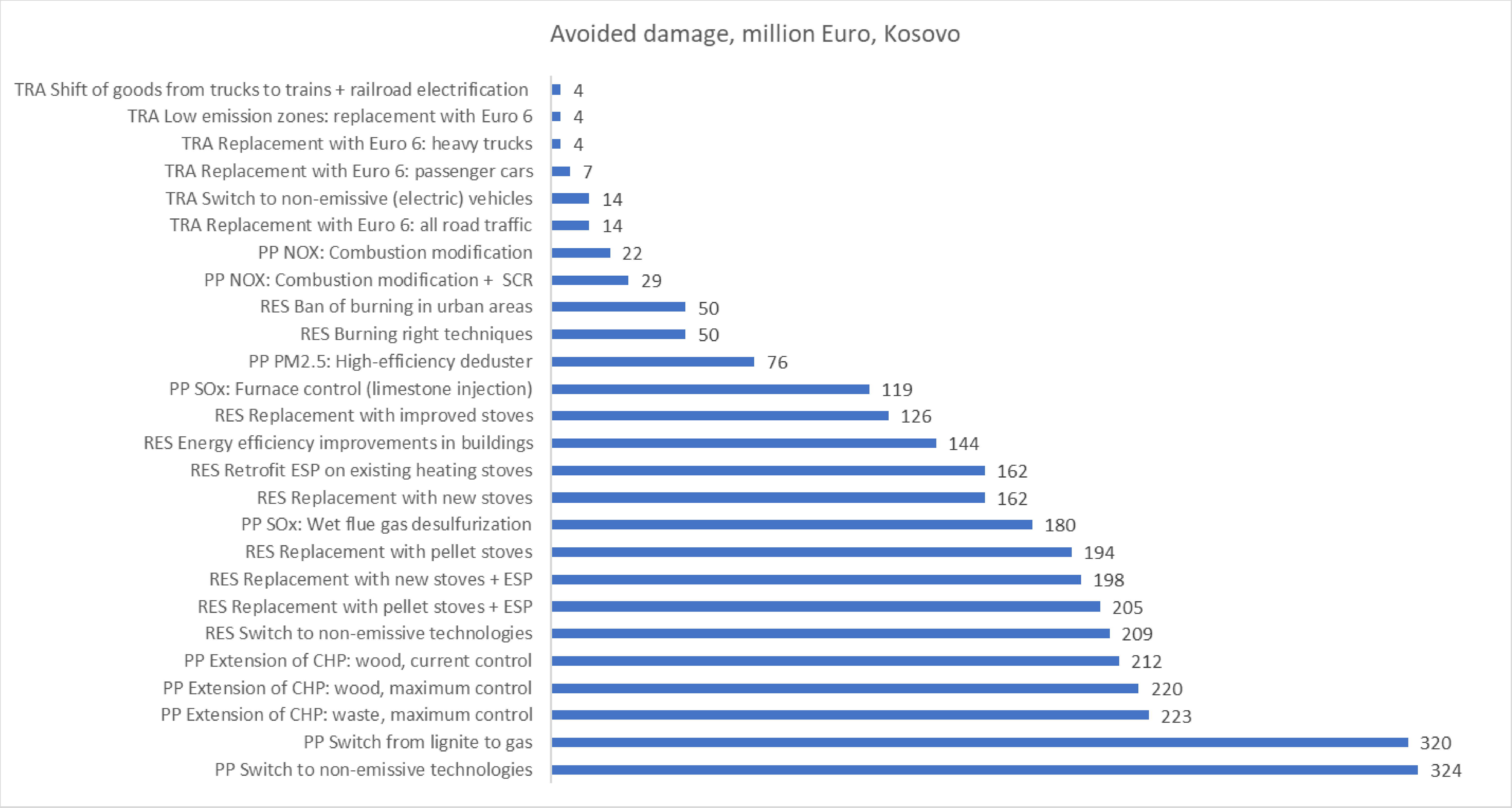
Emission reduction efficiency, measures for SO2 (%)



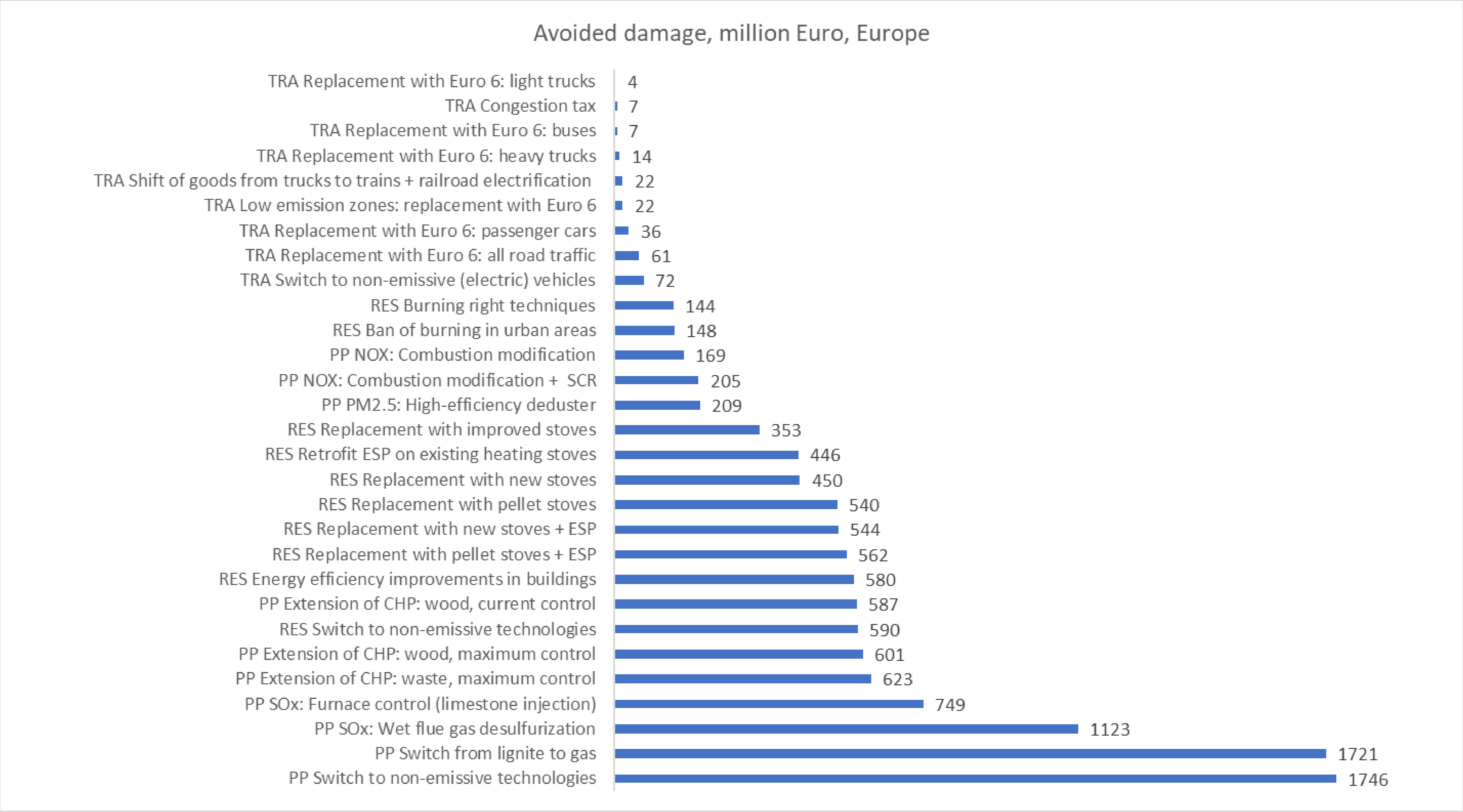
Emission reduction efficiency, measures for NMVOC (%)



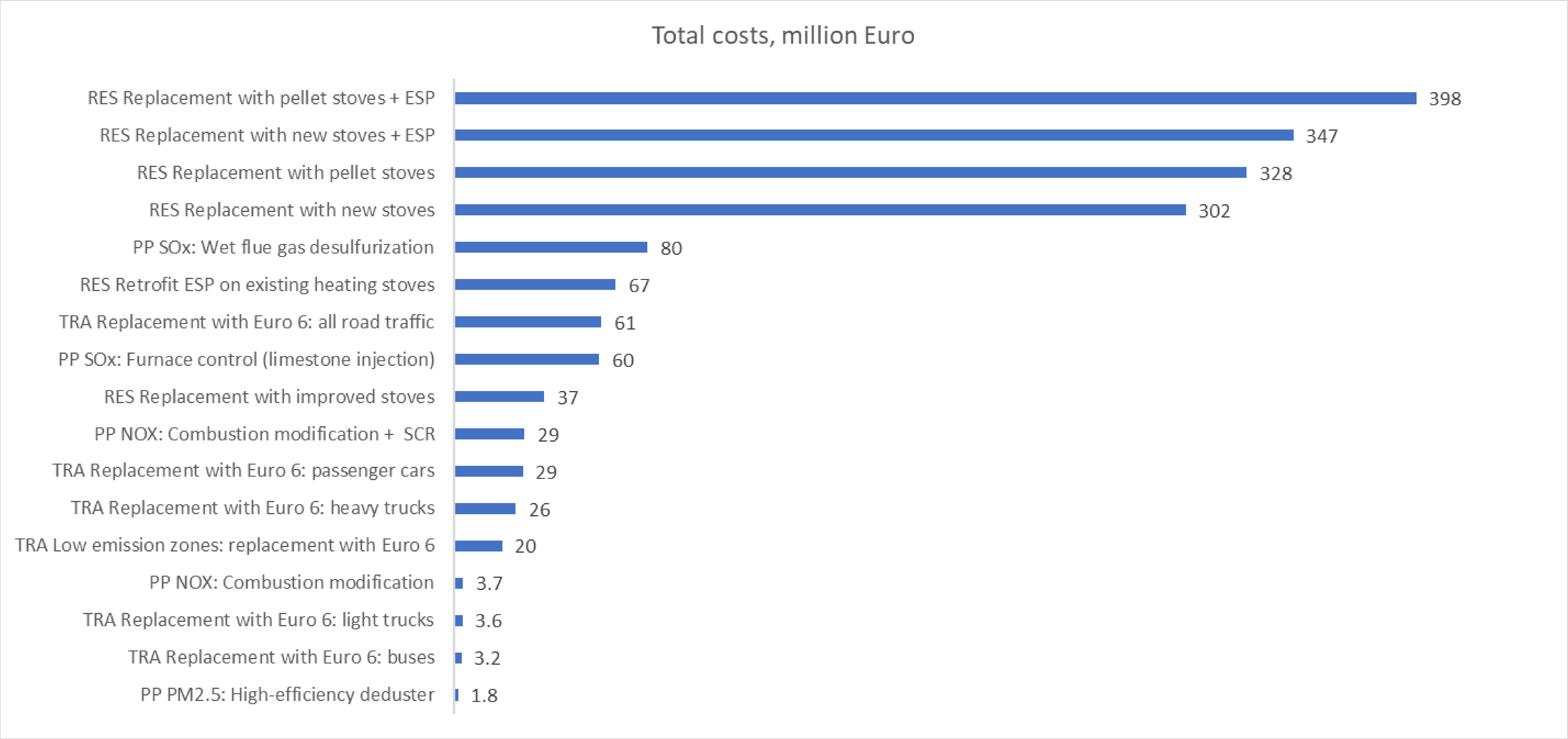
Avoided damage in Kosovo



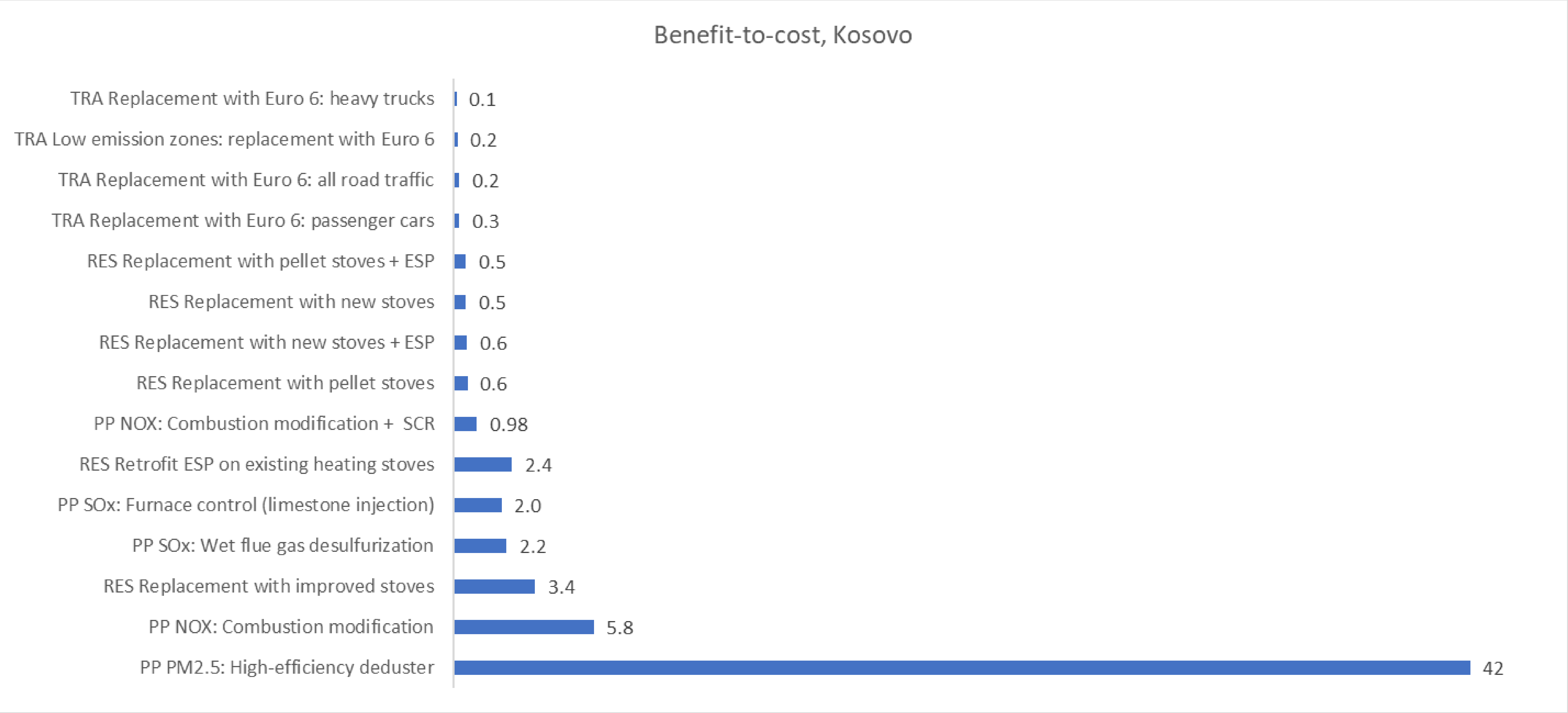
Avoided damage in Europe



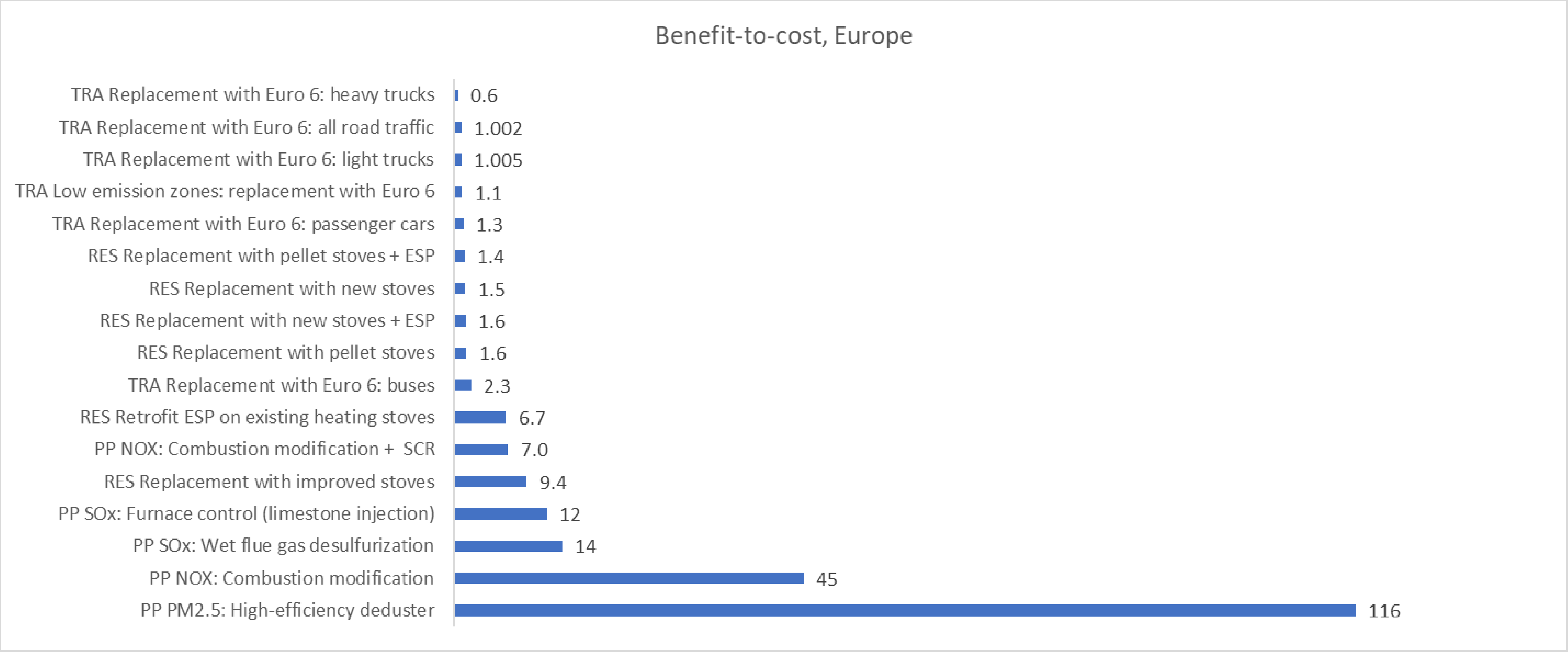
Technical costs



Benefit-to-cost ration, considering damage in Kosovo



Benefit-to-cost ration, considering damage in Europe



Annex 8: Status of harmonization of Kosovo legislation for the key sectors with EU legislation

EU legislation	Requirements	National legislation where EU legislation requirements are transposed.	If transposed - Are there secondary legislation/ administrative acts enabling practical implementation?
Eco-design directive (2009/125/EC) sets requirements to emissions and energy efficiency of boilers (2015/1189) and local space heaters (2015/1185, 2015/1188)	Energy efficiency and emission levels of new stoves and boilers	No, as of April 2023	No, as of April 2023
Energy labelling directive (2017/1369+ 2015/1186, 2015/1187)	Mandatory labelling: information on energy efficiency of stoves and boilers	Law on energy efficiency 2018.	No, as of April 2023
Energy Performance of Buildings Directive (2010/31/EU), Energy Efficiency Directive (2012/27/EU), both amended by 2018/844/EU	Energy efficiency requirements for buildings & energy certification of buildings	Law no. 05/l-101 on Energy Performance of Buildings (https://gzk.rks-gov.net/ActDetail.aspx?ActID=13176)	Energy certification of buildings has not been implemented, as of May 2023. Regulation (MESPI) no. 02/18 on national calculation methodology for integrated energy performance of buildings (https://gzk.rks-gov.net/ActDocumentDetail.aspx?ActID=18295) Regulation (MESPI) no.03/18 of the procedures on energy performance certification of building (https://gzk.rks-gov.net/ActDetail.aspx?ActID=18296)

EU legislation	Requirements	National legislation where EU legislation requirements are transposed.	If transposed - Are there secondary legislation/ administrative acts enabling practical implementation?
			Regulation (MESPI) no. 04/18 for minimum requirements for the energy performance of buildings (https://gzk.rks-gov.net/ActDocumentDetail.aspx?ActID=18297) Regulation (MESPI) no. 01/2018 for inspection of heating and air-conditioning system (https://gzk.rks-gov.net/ActDetail.aspx?ActID=16142)
Renewable energy directive (2018/2001)	EU-overall (32% in 2030) and national targets on total share of renewables	Residential and power sector: Energy strategy 2022-2031 (draft). Transport sector: Transport strategy (under development) Will be transposed in the Law on Renewable Energy Sources. (Request on Access to Information sent to MoE, Pr. No. 02/1995/14, 23.08.2022).	No, as of April 2023
Euro standards	Requirements for emissions from new vehicles	Law no. 03/l-160 on Air Protection from Pollution (https://gzk.rks-gov.net/ActDocumentDetail.aspx?ActID=2669)	Administrative Instruction (GRK) no. 08/2016 for the allowed norms of discharges in air from mobile sources (https://gzk.rks-gov.net/ActDocumentDetail.aspx?ActID=15113) Administrative Instruction (mi) no.01/2017 on amandine and supplementing the administrative instruction no. 04/2016 on periodical technical inspection of vehicles (https://gzk.rks-gov.net/ActDocumentDetail.aspx?ActID=13550)

EU legislation	Requirements	National legislation where EU legislation requirements are transposed.	If transposed - Are there secondary legislation/ administrative acts enabling practical implementation?
EU Car labelling Directive 1999/94/EC	Mandatory labelling: information on fuel economy of vehicles	Law on energy efficiency 2018. Does labelling requirement apply to vehicles? Law no. 05/l-132 on vehicles (https://gzk.rks-gov.net/ActDetail.aspx?ActID=14671)	Administrative Instruction (MESPI) No.09/2022 on the conditions of participation of vehicles on the road (https://gzk.rks-gov.net/ActDocumentDetail.aspx?ActID=68515)
EU Directive on fuel quality 2009/30/EC	Requirements to quality of diesel and petrol, including content of certain substances (e.g., sulfur)	Law no. 08/l-018 on trade with petroleum products and renewable fuels (https://gzk.rks-gov.net/ActDetail.aspx?ActID=55139)	Administrative instruction (MTI) no. 09/2020 on the control and quality of petroleum-derived liquid fuels (https://gzk.rks-gov.net/ActDocumentDetail.aspx?ActID=33921) Administrative instruction (me) no. 04/2021 for amending and supplementing the administrative instruction (med) no. 03/2019 on energy content of selected fuels for end use
Industrial Emission Directive (2010/75/EU)	Emission requirements for LCP	Law on Integrated Prevention Pollution and Control (https://gzk.rks-gov.net/ActDocumentDetail.aspx?ActID=2635) National Emission Reduction Plan 2018	Administrative Instruction no. 07/2021 on the rules and standards of the discharges on air the stationary sources of pollution.