# DEVELOPMENT OF EMISSION REDUCTION COMMITMENTS (ERCS) FOR 2020-2029 AND FOR 2030 AND BEYOND FOR THE SIX WEST BALKAN ECONOMIES

## TECHNICAL REPORT – FINAL

**EU 4 Green Recovery:**
**Support the implementation of the Green Agenda for the Western Balkans**

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# TABLE OF CONTENTS

# LIST OF FIGURES



# LIST OF TABLES

# ABBREVIATIONS

| | |
|---|---|
| ALB………….. | Albania |
| BIH………….. | Bosnia and Herzegovina |
| CLE………….. | Current Legislation scenario |
| EEA............ | European Environment Agency |
| EMEP.......... | European Monitoring and Evaluation Programme |
| EnC............ | Energy Community |
| EU ............. | European Union |
| ERC…………. | Emission Reduction Commitment of the NEC directive |
| ESP……….. | Electrostatic Precipitator |
| FAOSTAT...... | United Nations Food and Agriculture Organization Statistics |
| FGD………… | Flue Gas Desulfurization |
| GAINS ......... | Greenhouse gas - Air pollution Interactions and Synergies model |
| GHG…………. | Greenhouse gas |
| ICE………….. | Internal Combustion Engine |
| IEA.............. | International Energy Agency |
| IFASTAT....... | International Fertilizer Association statistical database |
| IIASA........... | International Institute for Applied Systems Analysis |
| IIR……………. | Informative Inventory Report |
| Kt………………. | Kilotons, $10^3$ tons |
| LRTAP.......... | Convention on Long-range Transboundary Air Pollution |
| MET Norway | Norwegian Meteorological Institute |
| MTFR………….. | Maximum Technically Feasible Reduction |
| MKD…………. | North Macedonia |
| MNE…………. | Montenegro |
| NECD.......... | National Emissions reduction Commitments (NEC) Directive |
| NFR………….. | Nomenclature for Reporting |
| $NH_3$…………. | Ammonia |
| NMVOC……. | Non-methane volatile organic compounds |
| $NO_X$…………. | Nitrogen oxides |
| uEMEP........ | urban European Monitoring and Evaluation Programme model |
| UNECE.......... | United Nations Economic Commission for Europe |
| $PM_{2.5}$.......... | Fine particles with an aerodynamic diameter of less than 2.5 µm |
| PRIMES....... | Price-Induced Market Equilibrium System - Energy Systems model |
| USGS.......... | United States Geological Survey |
| $SO_2$………….. | Sulphur dioxide |
| SRB…………. | Republic of Serbia |
| XXK………… | Republic of Kosovo |
| YOLLs.......... | Years of Life Lost |

# 1. INTRODUCTION

The EU4Green project aims to support Western Balkan economies in the implementation of the Green Agenda and the initiation of corresponding reforms, addressing decarbonization, circular economy, depollution, sustainable agriculture, and biodiversity.

Within this project the work provided by the IIASA team focused on assessment of the current and likely future development of air pollutant emissions and potential for their mitigation in the West Balkan. This activity included support for the development of improved datasets representing past emissions of air pollutants from 2005 to 2020 as well as future projections until 2050 for emissions of $SO_2$, $NO_x$, $NH_3$, NMVOC and primary $PM_{2.5}$ for six Western Balkan economies (Albania, Serbia, Kosovo[1], Montenegro, North Macedonia and Bosnia and Herzegovina). This support was provided through online consultation meetings with each of the Western Balkan economies. In these meetings, emission calculations from GAINS (Greenhouse gas - Air pollution Interactions and Synergies) model[2] were compared to the data reported by the respective economy, including reported emissions, underlying activity data, and other assumptions that were then discussed. Experts from each economy were also given an opportunity to present the status and plans for their inventory compilation and potential exchange to support both sides in the development of improved datasets was discussed.

The second part of IIASA's work made use of the improved datasets developed in the first part of the project and focused on the development of preliminary emission reduction commitments (ERCs) for $SO_2$, NOx, $NH_3$, NMVOC and $PM_{2.5}$ for 2020-2029 and for 2030 and beyond for all six economies using the GAINS model. These commitments shall ensure a reduction of 50% of the premature deaths attributable to air pollution between 2005 and 2030 for the whole West Balkan region, in line with the approach of deriving national ERCs for 2030 set under the NECD[3].

[1] This designation is without prejudice to positions on status, and it is in line with UNSCR 1244 and the ICJ Opinion on the Kosovo declaration of independence.
[2] https://gains.iiasa.ac.at/models/
[3] National Emissions reduction Commitments (NEC) Directive; https://eur-lex.europa.eu/legal-content/EN/TXT/

# 2. MODELLING FRAMEWORK

IIASA has developed and maintains the GAINS model (Amann et al., 2011) that has been used in supporting discussion, development and evaluation of air quality and climate polices by the European Commission and the UNECE LRTAP Convention's Protocols. The GAINS model allows for calculation of ambient PM2.5 and NOx concentrations, consistent with the EMEP and uEMEP models (Denby et al., 2020) developed by the Norwegian Meteorological Institute (MET Norway) that have been regularly validated against the existing monitoring network (including the whole European UNECE area where respective monitoring data is available), therefore enabling a consistent atmospheric modelling framework, including cross scale analysis.

## 2.1. Scenario description

The starting point for the development of the baseline scenario was a scenario developed within the "EUCLIMIT-9East[4]" project in 2021-2022. This project focused on energy community (EnC) countries and on different aspects of decarbonization. The scenario developed in this project created a basis for negotiations to set up climate mitigation targets[5], share of renewable energy, energy efficiency improvements, targets for transport fleet etc. These targets are defined similar to EU with often a 5-year delay. The goal for climate neutrality (net zero GHG emissions), for example, is projected to be reached in 2050. Coal will be phased out by 2040 and the natural gas infrastructure will be upgraded and further developed until 2050 to secure gas supply. In the road transport sector, it is assumed that a large-scale replacement of gasoline and diesel fuel by electricity and hydrogen by 2050 takes place, combined with assumed increases in efficiency of vehicles.

## 2.2. Updates to the modelling framework

Some general modifications of the baseline scenario were done before and after the consultation meetings to include best available information/calculation methods for certain sectors.

### 2.2.1. Agriculture

All emission factors for the calculation of $NH_3$ and NMVOC from agriculture were updated to fit the Tier 2 emission factors from the EMEP/EEA Guidebook 2023 (EMEP/EEA, 2023). Historic activity data such as livestock numbers for each livestock type were adjusted to the respective economy's statistics, NFR or IIR data if available and if differences to other sources such as FAOSTAT were not too large. If larger differences between these statistics and additional sources were found, they were presented and discussed with the respective economy's experts at the consultation meetings. Historic data on nitrogen fertilizer consumption and urea shares in nitrogen fertilizers was updated to reflect either local statistics or IFASTAT data.

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[4] Service Contract ENER/A3/SER/2019-563/SI2.840866 - ENER/2020/OP/0005; Extension of the EU Energy and Climate Modelling Capacity to include the Energy Community and its Nine Contracting Parties

[5] https://www.energy-community.org/implementation/package/CEP.html

The applicability of $NH_3$ mitigation technologies was revised and adjusted to local conditions such as farm sizes, which give an implication of the feasibility of the implementation of certain technologies by a certain time.

### 2.2.2. Transport

Total fuel consumption in GAINS by each vehicle and technology type for the historical period was taken from IEA Statistics. For the historic years, total fuel consumption was disaggregated into different vehicle categories based on assumptions of the average fuel consumption (fuel efficiency) and kilometers driven for each vehicle type. This final data on the number of each vehicle type (two-wheelers, passenger cars, buses, light duty trucks and heavy-duty trucks) in each fuel or technology category (e.g., ICE gasoline, ICE diesel, electric, hybrid, hydrogen etc.) was then compared with economy level data, where available, and altered according to the feedback given during the consultations.

To estimate emission standards and technology which are needed to accurately quantify tailpipe emissions from the vehicle fleet, information on vehicle age was combined with the existing legislation in each economy and EU emission standards to derive the distribution of emission standards within the vehicle fleet. Where economy level data on the age structure of the vehicle fleet was not available, information from the UNECE report '2022 Europe and North America Inland Road Transport' (UNECE, 2022) was used. It contains the average age of the vehicle fleet segregated for most economies by passenger cars, buses and trucks. Overall, the data was used to estimate the fleet structure for a recent year and then scaled back for historic years (1990-2020).

For the baseline scenario and to estimate the penetration of new vehicles into the vehicle fleet, assumptions were made on the share of new and newly registered but imported vehicles which were entering the vehicle fleet per year in each economy. For some economies, such as Montenegro and Serbia, this data was readily available. In this case, it was assumed that there would be similar infiltration rates across all West Balkan economies. Generally, in the West Balkan economies there is a very low proportion of the vehicle fleet which are new (representing < 5 % of newly registered cars). This means that a large proportion of the vehicle fleet are imported. The predominant import market is assumed to be the EU.

To develop a future scenario for the structure of emission standards in the vehicle fleet, current local legislation on emission standard limits was combined with assumptions on the turnover rate of the vehicle fleet based on the average vehicle age as well as historic EU legislation.

### 2.2.3. Residential Combustion

Data on emissions from residential combustion, especially from use of fuelwood for cooking and heating, are burdened with rather high uncertainties, also in the EU27. Key reasons include lack or poor information about actual fuelwood use, limited availability of representative emission factors and of information about the structure of combustion installations (i.e. share of stoves, fireplaces, manual and automatic boilers, pellet stoves, etc.).

GAINS model is relying on the available statistical information from IEA, Eurostat, OECD, review of several studies addressing residential and in general heating sector in West Balkan. The two key studies that were used to validate GAINS data and assumptions was the UNECE/FAO (2019)[6] study on "Wood Energy in the UNECE Region" and the IBRD/World Bank (2018)[7] study on "Biomass-Based Heating in the Western Balkans – A Roadmap for Sustainable Development". Apart from estimates of total fuel wood use, the studies allowed for specification of how much fuel is used in urbanized vs rural areas and what is the likely structure of installations. This information allowed to apply Tier II approach in GAINS.

The above information has been shared with the West Balkan economies during consultations and the assumptions made have been either confirmed by the respective economy's data or received as additional input to improve the economy's assessment. Some experts provided additional valuable inputs, e.g., North Macedonia sent detailed reports assessing activities and emissions in this sector for the period prior to 2003 and then a detailed study for 2019 where characteristic and structure of the household sector has been presented at the subnational level. This has been useful to evaluate and update the GAINS data as necessary. Also, Serbia provided comments and some additional information for this sector, recommended however use of Tier I method.

Overall, the exchange of information has led to improved understanding of this sector and better representation of its emissions in GAINS and possibly also in the future inventories. The atmospheric calculation in GAINS indicates that the estimates of residential emissions of $PM_{2.5}$ in GAINS are quite reasonable for most countries which is reflected in the acceptable match with the available measurements at several air quality monitoring stations across the region.

### 2.2.4. Power and Industry

Following comparison and discussion with the respective economy's experts, information about the activity levels, specifically fuel use in power plant and industrial boilers and furnaces and data on production/manufacturing of various commodities like iron and steel, pulp and paper, crude oil throughput, etc. were revised and updated, where necessary. In the case such information was missing or incomplete, gaps were filled to the possible extent with information from IEA and USGS statistics and PRIMES model.

Emission factors were adjusted to reflect the best available economy level information on fuel characteristics, e.g., sulphur content and heat value of used coals (lignite).

The level of application (penetration) and efficiency of emission controls was revised and updated according to the economy's information. This specifically concerned the extent of application of technologies to reduce emissions of $SO_2$, i.e., Flue Gas Desulfurization (FGDs), technologies to reduce NOx emissions like low-NOx burners, and further control of particulate matter emission by installations of electrostatic precipitator (ESPs).

[6] https://unece.org/fileadmin/DAM/timber/publications/SP-42-Interactive.pdf
[7] http://documents1.worldbank.org/curated/en/135831542022333083/pdf/Biomass-Based-Heating-in-the-Western-Balkans-A-Roadmap-for-Sustainable-Development.pdf

# 3. SUMMARY OF RESULTS FROM CONSULTATIONS

From December 2023 to January 2024, six consultation meetings (one per economy) with good attendance took place online. IIASA and economy teams communicated already before the actual consultations meetings and exchanged information about data on air quality monitoring stations, data on energy balances and information on policies affecting air pollution. As the meetings also served to identify areas where additional or more detailed information was needed, they were followed by further data exchange between the IIASA and the respective economy's experts. While IIASA provided details and background of certain GAINS calculations, the respective economy's experts provided information on national policies and more specific data on, e.g., emission factors, fuel characteristics, current and expected application of emission reduction measures. All these exchanges, combined with general adjustments of the baseline scenario to the most up-to-date information as described above, led to improvements as can be seen in Figure 1. Relative differences between the GAINS baseline and the respective economy's data for the whole West Balkan region decreased for all years and pollutants.

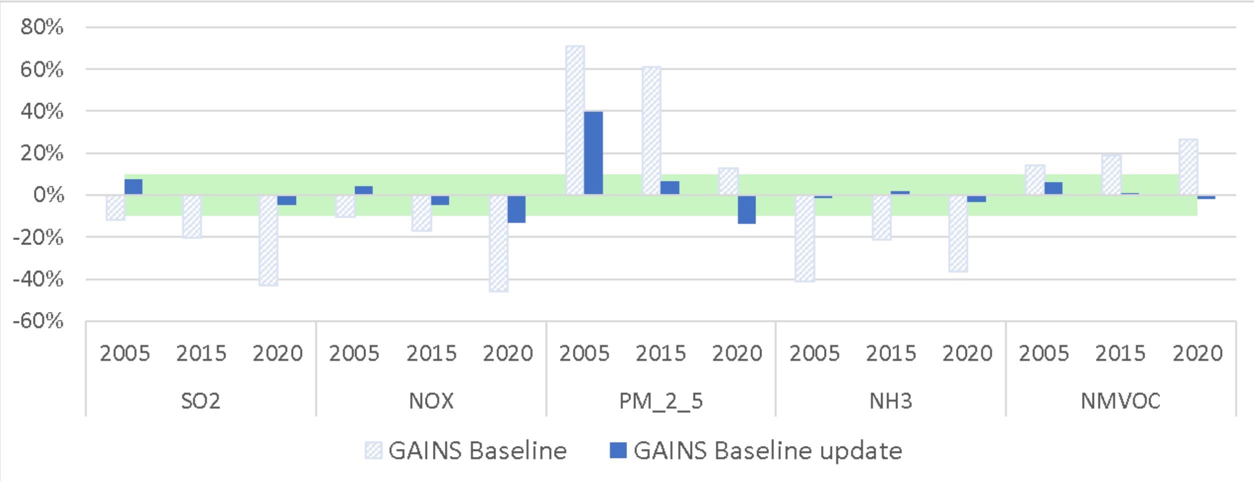


**Figure 1 Relative differences between the original GAINS baseline and the respective economy's data as well as the updated GAINS baseline and the respective economy's data for each pollutant and the whole West Balkan economy for the years 2005, 2015 and 2020.**

However, as can be seen in Figure 2, some differences between economy reporting and the GAINS baseline are higher for certain pollutants in certain economies. These differences were subject of discussion during the consultation meetings which lead to a better understanding of them.

Across all economies we could identify several common reasons for discrepancies but also agreements in the data:

- There was a good agreement on fuel consumption in **residential combustion** for all economies. However, differences in the structure of installations such as boilers and stoves in the residential sector led to differences, especially for $PM_{2.5}$ and sometimes

NMVOC emissions as can be seen for North Macedonia in 2005 and 2020 and Montenegro in 2005 (Figure 2). Assumptions on structure of installations are mostly relevant when Tier II[8] method is used, as in GAINS, while less important (or neglected) when Tier I methods are used – as it is the case in most of the economies' inventories – where the emission factor reflects the type of fuel used only and ignores at large the diversity in actual emissions from various residential combustion installations. This difference in calculation method and often limited data about structure of combustion installations are the main reasons for the remaining differences in $PM_{2.5}$ emissions.

- In the **power sector**, activity data on fuel consumption is consistent with the respective economy's data for most economies but there is a general difference in emission factors as well as the extent of implementation of abatement technologies and their efficiencies. This difference in emission factors due to a difference in the calculation methodology (Tier) also leads to differences in emissions from the industrial sector. Such differences lead to higher discrepancies in $NO_X$ emissions as can be seen for North Macedonia and Montenegro as a Tier I emission factor is used in economy reporting and a Tier II emission factor is used in GAINS.
- In the **transport sector**, GAINS fuel consumption is mostly consistent with the respective economy's data but in most economies data on off-road transport is not available, leading to higher discrepancies in total $NO_X$ emissions since it is included in GAINS.
- For the **agricultural sector**, activity data such as livestock numbers and fertilizer application are mostly consistent with economy reporting. There are differences in emission factors due to a difference in Tier method used to calculate these emission factors leading to discrepancies in $NH_3$ and NMVOC emissions from agriculture. Furthermore, estimates for open burning of agricultural residues vary between GAINS and the respective economy's data owing to different methods used to assess actual amount of biomass burned. In some cases, these emissions are ignored all together in the economies' inventories, since there are laws prohibiting open burning. In GAINS, however, a consistent method is used for all economies, relying on the remote sensing data used in the FINN inventory of open biomass burning[9].
- For **NMVOCs**, information on solvents is often missing or not documented in economy data. Additionally, there are differences in emissions from coal mining which link to different assumptions/interpretation for emission factors, i.e., deep versus open mining. The mining emission factors for NMVOC are based on the measurements done for methane, however, there is no clear guideline how to apply those to open and deep mining operations, which leads to high uncertainties.

[8] Different Tier methods refer to a difference in the methodological complexity of the respective calculations. Tier I describes the basic method, often relying emission factors to the type of fuel, while Tier II describes a more complex calculation method, typically requiring information about the technologies and defines technology-specific emission factors, which is considered more accurate,

[9] https://www2.acom.ucar.edu/modeling/finn-fire-inventory-ncar

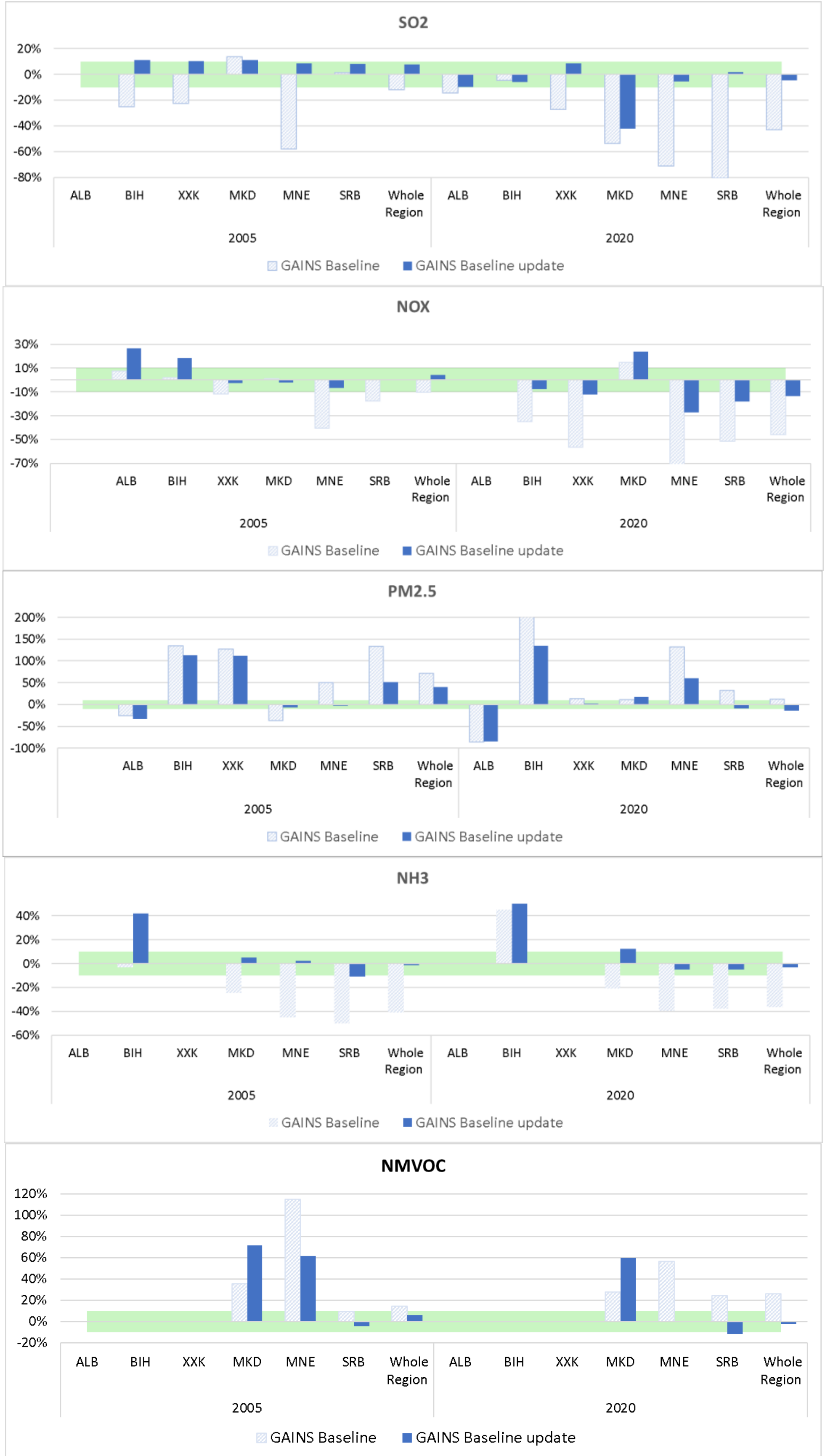


**Figure 2 Relative differences between the original GAINS baseline and economy data as well as the updated GAINS baseline and economy data for each pollutant and each West Balkan economy for the years 2005 and 2020.**

For some economies, a comparison between their own and GAINS data proved to be difficult:

- For Albania, two different reporting formats, both excluding some sectors, were used from 2005 to 2020. This exclusion of certain sectors in the economy's inventory, which are included in the GAINS modelling, made the comparison between GAINS and economy data more difficult as some pollutants could not be directly compared. This is the reason why there is no comparison for $NH_3$ and NMVOC emissions for Albania for either year in Figure 2. There is no comparison for $NO_X$ emissions for Albania in 2020 due to the transport sector being excluded from the economy's reporting and no comparison for $SO_2$ emissions in 2005 as power sector and most of industrial emissions were not included in the economy's reporting. An additional complication was that the air pollutant emission inventory was prepared by external experts before the year 2008. As these experts did not take part in the consultation meeting, information and data exchange on calculations prior to 2008 was not possible. Hence, also the increased difference in $NO_X$ emissions in 2005, after updating GAINS data on fuel use, vehicle fleet structure and emission standards to best available data, could not be analyzed.
- Bosnia and Herzegovina does not yet have an air emission inventory and GAINS data could only be compared to the UNECE Environmental Performance review for Bosnia and Herzegovina 2018 (UNECE, 2018) with data for 2020 being based on a prognosis. As the solvent sector was missing from NMVOC emissions in this report, NMVOC emissions are excluded from the comparison. Due to the UNECE report not including details on the emission calculation, an analysis of discrepancies could not be done.
- Kosovo provided an air emission inventory to the EEA Central Data Repository. However, as emissions from agriculture were excluded from reported $NH_3$ emissions and the solvent sector was missing from reported NMVOC emissions, a comparison between GAINS and Kosovo's data for these sectors was not possible.

# 4. VALIDATION OF ATMOSPHERIC CALCULATIONS

GAINS calculates ambient PM2.5 concentrations at a resolution of 0.1°×0.1° (approximately 8km × 11km). To represent local increments, a downscaling approach is applied based on high-resolution output generated with the uEMEP model at 100×100m resolution. In order to establish credibility of the calculations, modelled concentrations need to be compared against monitoring data. Ambient concentrations modelled for 2015 are shown in Figure 3 overlaid with observations for 2014-2016; modelled $PM_{2.5}$ for 2020 overlaid with observations 2019-2021 is shown in Figure 4.

Monitoring data have been collected from internationally available sources (EEA AirBase, US Embassies) as well as local monitoring networks. When comparing modelled concentrations from GAINS to observations, two things need to be kept in mind, both of which are related to the purpose of GAINS to represent long-term average population exposure to $PM_{2.5}$:

1) GAINS uses five-year average meteorology from the years 2016-2020 so for any individual monitoring year there can be deviations due to inter-annual variations in meteorological conditions, and
2) GAINS is supposed to represent average population exposure within each grid cell, but not the concentrations at any given location. If there are strong local variations, for example due to solid fuel use in residential heating, the grid average, even when considering the exposure increment included in GAINS, can be off.

Furthermore, the quality of ambient $PM_{2.5}$ calculations relies largely on the spatial distribution of precursor emissions. For the West Balkan economies, the emission distributions were produced by IIASA based on the best information available, but in several cases such information was not available.

A scatter plot of model versus observations in the whole region is shown in Figure 5. Given all the limitations mentioned above, the model performs well in comparison to observed $PM_{2.5}$ concentrations. Most stations are well within the factor 2 margins indicated by dashed lines. The bias between model and observations depends on the economy.

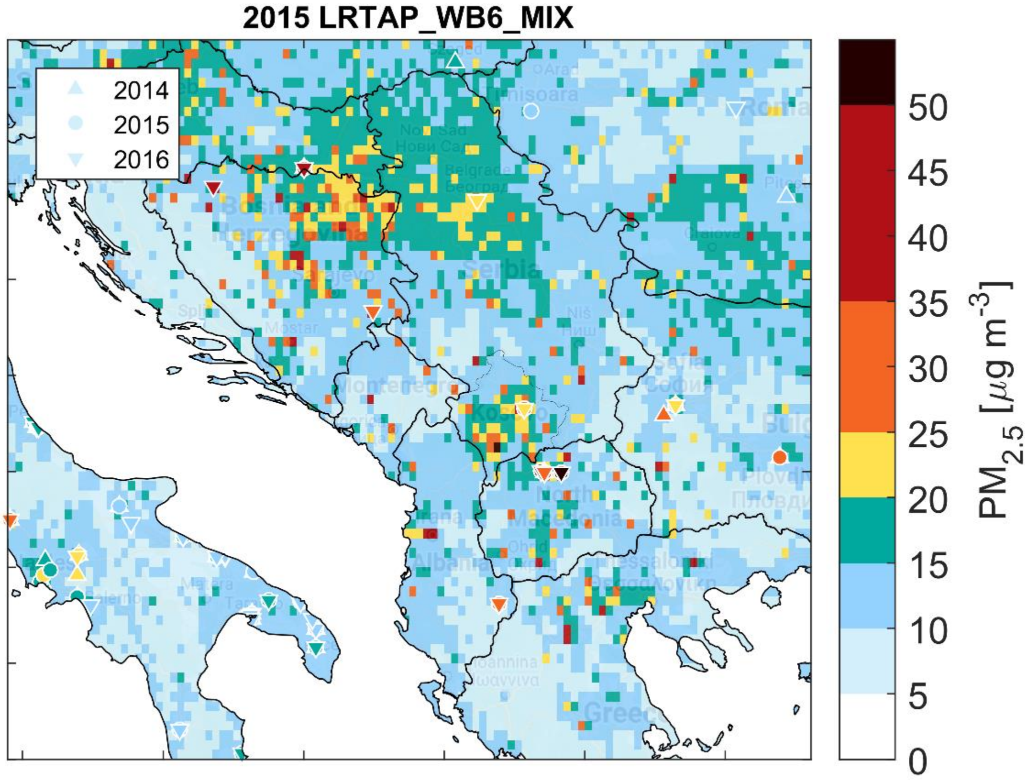


**Figure 3. Ambient $PM_{2.5}$ concentrations modelled with GAINS for 2015, overlaid with monitoring data for the years 2014-2016.**

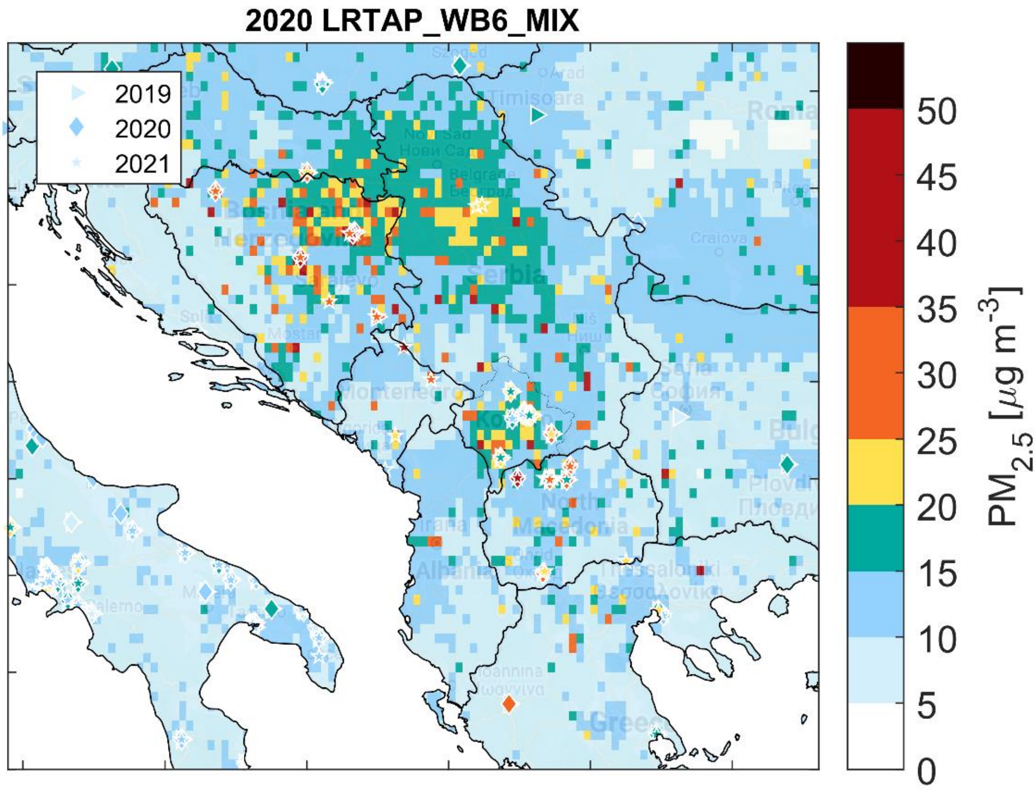


**Figure 4. Ambient $PM_{2.5}$ concentrations modelled with GAINS for 2020, overlaid with monitoring data for the years 2019-2021.**

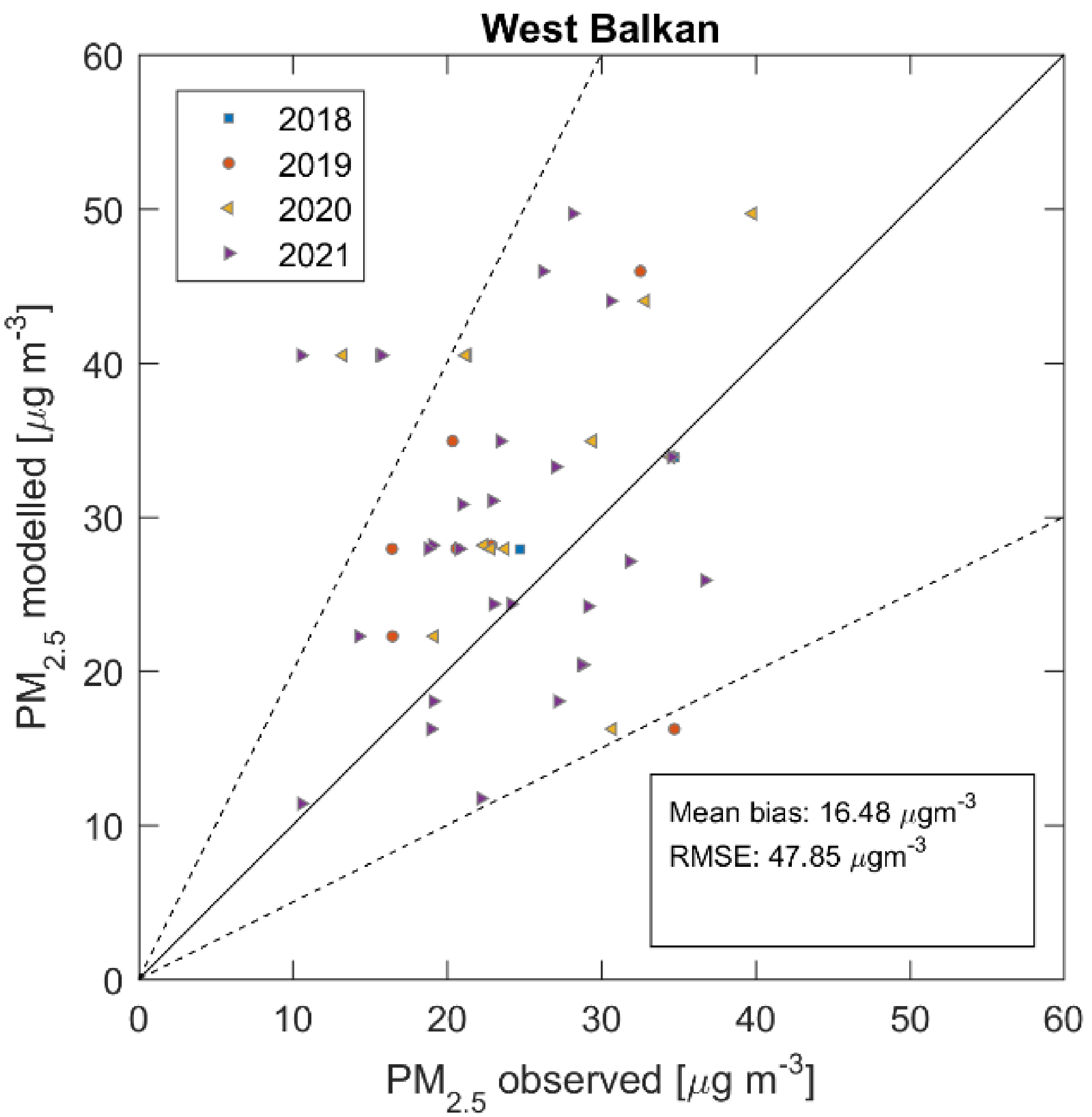


**Figure 5. Comparison of annual mean modelled against measured $PM_{2.5}$ at monitoring sites across the West Balkan region. Modelled $PM_{2.5}$ is for 2020, measurements for different years are distinguished by symbols. Each dot represents one station.**

# 5. SCENARIO RESULTS WITH DEVELOPED ERCS

After the consultation process, the baseline data and the validated atmospheric calculations in the GAINS model were used as the starting point for the derivation of a set of cost-effective emission reduction commitments (ERCs). The approach taken is consistent with the one that the EU Commission had taken for the derivation of national emission reduction commitments for 2030 for the pollutants $SO_2$, NOx, $PM_{2.5}$, $NH_3$ and NMVOCs for EU Member States, whereby the preferred option from the impact assessment underpinning the NEC Directive was consistent with a 52% reduction in 2030 of the health burden as compared to 2005, across the EU27.

That is, the ERCs are considered a means to an end, namely, to reach a certain health objective in the most cost-effective way for the aggregate region, rather than for individual countries. In the same vein, the GAINS model is used to identify cost-effective emission reduction strategies/commitments that would lead to a 50% reduction in premature deaths from $PM_{2.5}$ exposure by the year 2030, relative to the year 2005, in the aggregate of the six West Balkan economies.

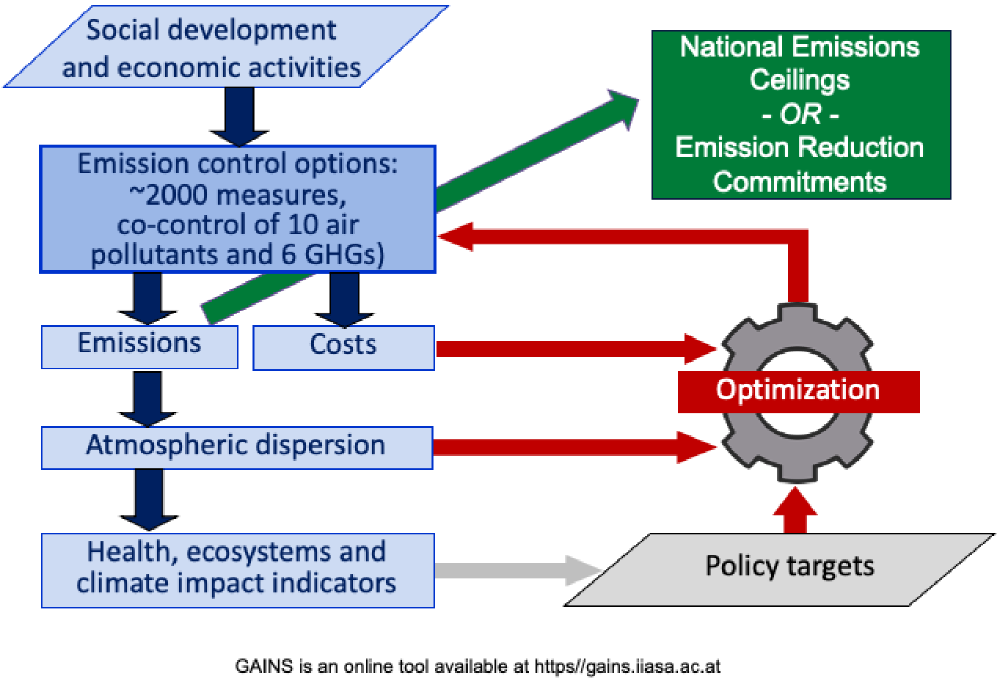


**Figure 6 The GAINS modeling framework as used here to derive cost-effective Emission Reduction Commitments (ERCs)**

Figure 6 and Figure 7 illustrate the overall approach. The implied impact relative to 2005 calculated for the TSAP is used as an overall ambition level. After checking its technical and economic feasibility, a policy scenario is calculated that reaches the target level at least cost. This policy scenario thus implies cost-effective ERCs that would lead to achieving the target on mortality related to $PM_{2.5}$ concentrations. The 50% reduction target is set for the West Balkan region as a whole and the GAINS optimization method identifies measures in each economy that together achieve the target in the most cost-effective way. The optimization calculation takes also into account the unit costs and removal efficiencies of each technical measure represented in the GAINS database, as well the atmospheric transport of pollution (see above), and the country-specific information on vulnerabilities and baseline mortalities. The resulting set of ERCs are the aggregated effect of all such cost-effective measures for each economy and each pollutant.

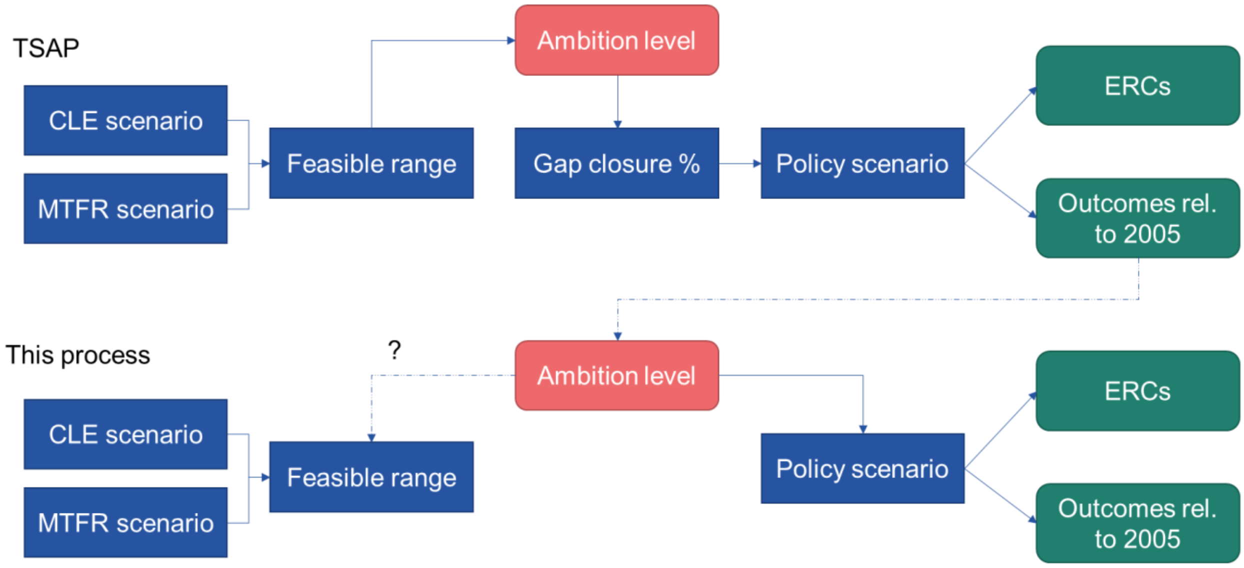


**Figure 7 Comparison of the approaches to calculate a policy scenario and associated ERCs between the Thematic Strategy of the EU in 2013 and the approach taken for the West Balkan region now.**

As a preliminary step of the analysis the GAINS model was used to confirm that such a target is technically feasible. Figure 8 illustrates that in all six economies, the mortality related to $PM_{2.5}$ exposure is expected to decline between 2005 and 2030 in the current legislation scenario (CLE, light orange). The dark orange bar represents the maximum technically feasible reduction scenario (MTFR). The 50% reduction relative to 2005 is technically feasible for the West Balkan region as a whole, as can be seen from the fact that the dark orange bar in the last set of bars, "Whole domain", crosses the red dotted line, i.e., the target lies between the CLE and the MTFR scenario. Hence a technically feasible set of ERCs for each country can be found that reaches the aggregate target. However, a 50% reduction in premature deaths cannot be achieved in each economy assessed individually (see the maximum technically feasible scenarios, MTFR, dark orange bars per economy: not all of them cross the red dotted target line). For example, in Kosovo, the maximum reduction in premature deaths that can be reached technically, is only around 27% relative to 2005.

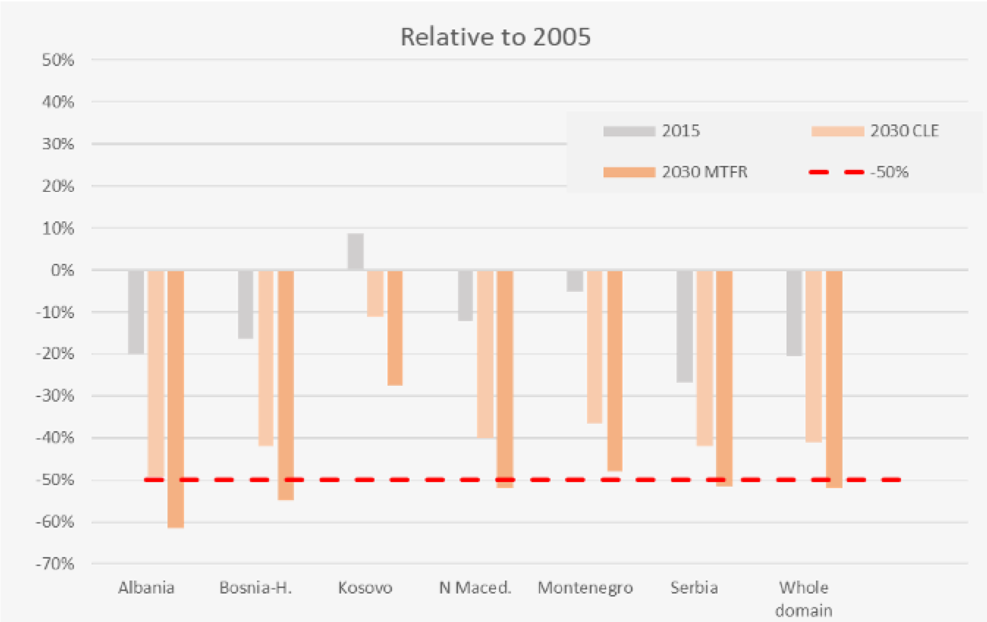


**Figure 8 Premature deaths from $PM_{2.5}$ in 2030 in the six West Balkan economies and the region as a whole**

In a next step, a whole series of scenarios (a cost curve) was generated to offer context for the specific policy scenario that was further analyzed.

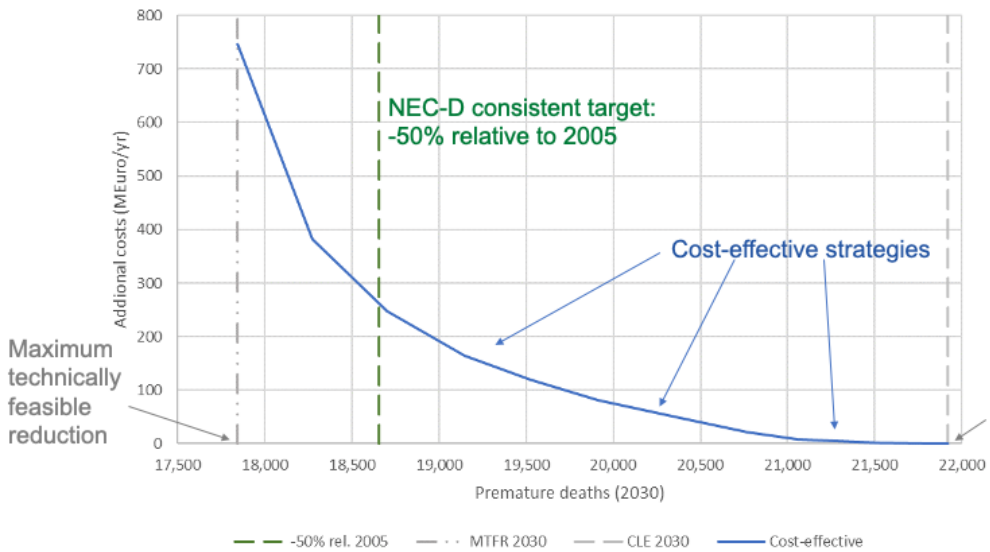


**Figure 9 Cost curve for reducing $PM_{2.5}$ mortality.**

Figure 9 illustrates that the 50% reduction target can be achieved at a cost of approx. 250 million Euros/year for the whole region. From this particular solution, economy specific information can be extracted, in particular the cost-effective ERCs and sets of technical measures that would achieve these ERCs. **Table 1** shows the ERCs both in absolute terms as well as in comparison to 2005 and 2020, and it shows the corresponding reduction in 2030 in the policy scenario compared to the 2030 emission levels under current legislation (CLE).

## Table 1 Calculated ERCs for 2030 from the modeling exercise

### Albania

| Item | unit | SO2 | NOx | PM2.5 | NH3 | VOCs |
|---|---|---|---|---|---|---|
| Absolute target | kt | 2,41 | 31,47 | 4,62 | 27,02 | 23,72 |
| | | | | | | |
| Reduction rel. 2005 | kt | -15,82 | -3,33 | -4,28 | -1,38 | -15,24 |
| | % | -87% | -10% | -48% | -5% | -39% |
| Reduction rel. 2020 | kt | -5,46 | 3,27 | -1,48 | 2,82 | -2,00 |
| | % | -69% | 12% | -24% | 12% | -8% |
| Reduction rel. 2030 (CLE) | kt | -7,33 | -3,33 | -1,58 | -0,78 | -1,83 |
| | % | -75% | -10% | -25% | -3% | -7% |

### Bosnia and Herzegovina

| Item | unit | SO2 | NOx | PM2.5 | NH3 | VOCs |
|---|---|---|---|---|---|---|
| Absolute target | kt | 21,31 | 39,00 | 18,86 | 23,18 | 48,33 |
| | | | | | | |
| Reduction rel. 2005 | kt | -311,98 | -23,30 | -23,84 | -2,42 | -27,21 |
| | % | -94% | -37% | -56% | -9% | -36% |
| Reduction rel. 2020 | kt | -380,65 | -12,60 | -14,04 | -3,12 | -16,34 |
| | % | -95% | -24% | -43% | -12% | -25% |
| Reduction rel. 2030 (CLE) | kt | -110,98 | -4,50 | -6,74 | -4,12 | -5,42 |
| | % | -84% | -10% | -26% | -15% | -10% |

### Kosovo

| Item | unit | SO2 | NOx | PM2.5 | NH3 | VOCs |
|---|---|---|---|---|---|---|
| Absolute target | kt | 7,20 | 15,15 | 7,40 | 5,76 | 20,85 |
| | | | | | | |
| Reduction rel. 2005 | kt | -88,85 | -8,15 | -3,20 | -2,04 | -2,60 |
| | % | -93% | -35% | -30% | -26% | -11% |
| Reduction rel. 2020 | kt | -110,66 | -14,15 | -4,80 | -0,94 | -5,74 |
| | % | -94% | -48% | -39% | -14% | -22% |
| Reduction rel. 2030 (CLE) | kt | -39,37 | -1,45 | -3,20 | -0,84 | -2,11 |
| | % | -85% | -9% | -30% | -13% | -9% |

### North Macedonia

| Item | unit | SO2 | NOx | PM2.5 | NH3 | VOCs |
|---|---|---|---|---|---|---|
| Absolute target | kt | 2,29 | 22,29 | 7,39 | 8,93 | 30,30 |
| | | | | | | |
| Reduction rel. 2005 | kt | -103,12 | -13,51 | -15,21 | -2,87 | -9,21 |
| | % | -98% | -38% | -67% | -24% | -23% |
| Reduction rel. 2020 | kt | -51,76 | -3,71 | -3,01 | -0,87 | -2,00 |
| | % | -96% | -14% | -29% | -9% | -6% |
| Reduction rel. 2030 (CLE) | kt | -1,66 | -3,01 | -1,81 | -1,37 | -1,20 |
| | % | -42% | -12% | -20% | -13% | -4% |

### Montenegro

| Item | unit | SO2 | NOx | PM2.5 | NH3 | VOCs |
|---|---|---|---|---|---|---|
| Absolute target | kt | 0,56 | 6,00 | 2,30 | 3,46 | 7,56 |
| | | | | | | |
| Reduction rel. 2005 | kt | -48,43 | -4,40 | -3,40 | -0,94 | -4,95 |
| | % | -99% | -42% | -60% | -21% | -40% |
| Reduction rel. 2020 | kt | -61,91 | -6,40 | -1,10 | 0,26 | -1,64 |
| | % | -99% | -52% | -32% | 8% | -18% |
| Reduction rel. 2030 (CLE) | kt | -0,33 | -0,60 | -0,70 | -0,14 | -0,84 |
| | % | -37% | -9% | -23% | -4% | -10% |

### Serbia

| Item | unit | SO2 | NOx | PM2.5 | NH3 | VOCs |
|---|---|---|---|---|---|---|
| Absolute target | kt | 47,68 | 86,33 | 36,03 | 56,21 | 93,12 |
| | | | | | | |
| Reduction rel. 2005 | kt | -432,17 | -84,37 | -24,17 | -39,19 | -44,14 |
| | % | -90% | -49% | -40% | -41% | -32% |
| Reduction rel. 2020 | kt | -377,82 | -64,37 | -16,67 | -19,49 | -26,46 |
| | % | -89% | -43% | -32% | -26% | -22% |
| Reduction rel. 2030 (CLE) | kt | -25,19 | -9,27 | -12,57 | -12,99 | -16,60 |
| | % | -35% | -10% | -26% | -19% | -15% |

Finally, Figure 10 illustrates for primary $PM_{2.5}$ and West Balkan as a whole, and by aggregated sectors, the baseline development of emissions (current legislation) relative to 2020, the additional reduction potential (maximum technically feasible reduction, MTFR) and the cost-effective measures in the proposed 50% reduction target case.

This type of illustrations shows the change in emissions (in absolute terms – kt of pollutant) from the emissions in 2020 discriminating key measures and for THREE scenarios which are shown in three columns for each sector:

- ➔ in the first column (BLACK bar, 'Current legislation' in legend) the change in emissions in this sector between 2020 and 2030 Baseline is shown. This can be zero (no black bar appears), an increase (above 0) or decrease shown as reduction in negative numbers,
- ➔ the second column (COLOURS, 'cost-effective emission reductions') shows for each sector the necessary reductions in emissions of a given pollutant to achieve the set target for health and ecosystem protection. These changes (reductions) are always shown in relation to the BLACK BAR and so start at its 'end' which represents the Baseline 2030. The values can be either zero and so there is 'no change shown' or no second bar or show a bar which can have several colours reflecting different type of measures and the sum of all of them cannot be larger than the length of the third column bar.
- ➔ the third column (hatched, 'MTFR') illustrates the maximum mitigation potential calculated in GAINS (MTFR) and it shows the impact of implementing ALL defined measures in GAINS, to the extent that is technically feasible.[10] The reductions are shown as a stacked bar starting at the Baseline 2030, and so at the 'end' of the black bar, just like the second column, and are typically longer than the second column illustrating that the potential for mitigation is larger than emission reductions needed to attain the set health target.

Figure 11 shows the same for the emissions of $SO_2$.

[10] In the GAINS model the maximum use of a particular emission reduction technology may be constrained to a share of less than 100% of the total underlying activity, either for technical, pragmatic or other reasons. This maximum share may change over time. For example, it is not possible to equip the whole vehicle fleet with the highest EURO standard. The share of the fleet that can be equipped with a given emission standard depends on the year in which the standard is adopted, the vehicle stock turnover rate and the year under consideration. Thus, in a future year (2030) typically only for a small share of the fleet the emission standard is still undetermined and could be modified from a CLE assumption to a more ambitious level. This small share is bounded by the maximum application rate, a value that is stored in the GAINS database and can be reviewed. Not all technologies are bounded by maximum application rates.

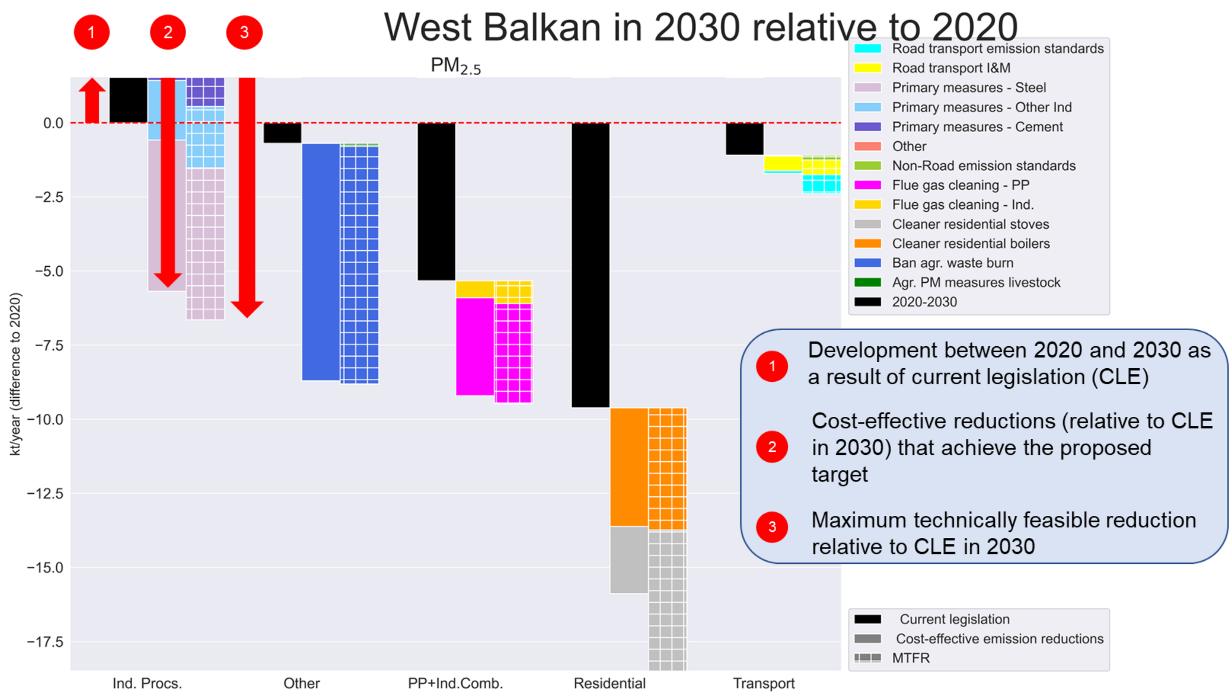


**Figure 10 Primary $PM_{2.5}$ emissions: Baseline development, additional potential and cost-effective measures for reaching a 50% reduction in mortality from $PM_{2.5}$ in West-Balkan. For details see text.**

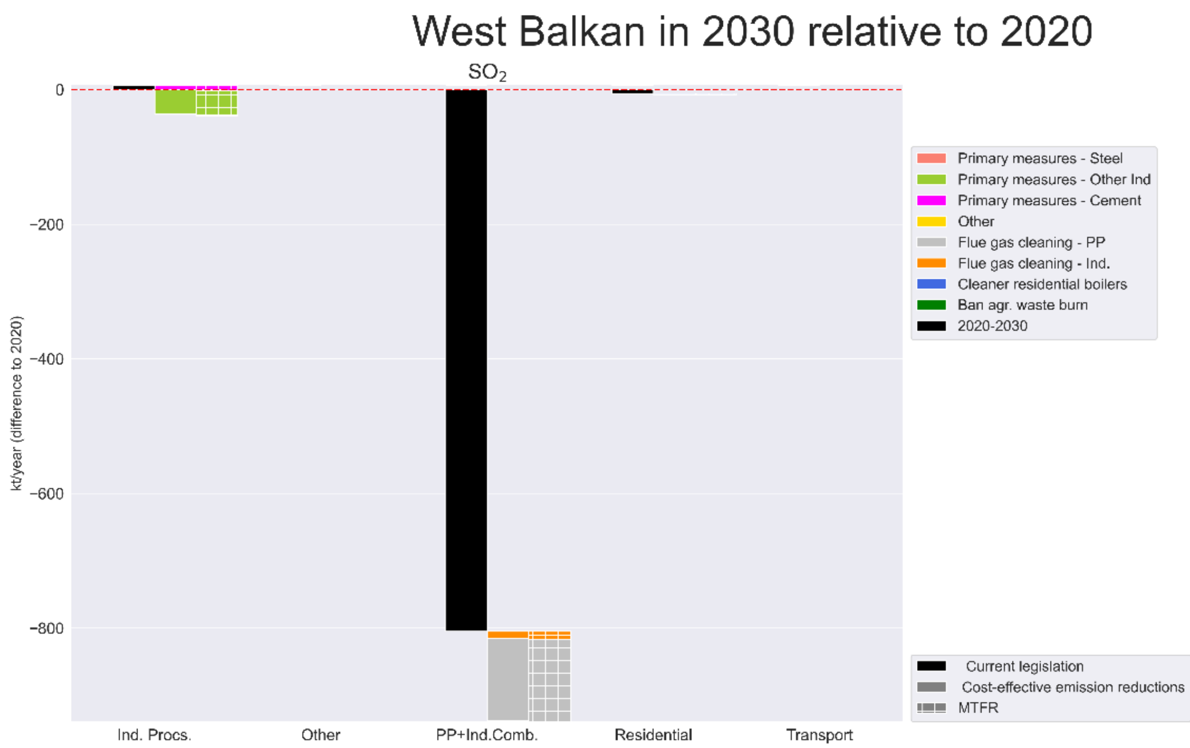


**Figure 11 $SO_2$ emissions: Baseline development, additional potential and cost-effective measures for reaching a 50% reduction in mortality from $PM_{2.5}$ in West-Balkan. For details see text.**

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