Nr C 598
September
2021

European and Central Asian Actions on Air Quality

A regional summary of emission trends, policies, and programs to reduce air pollution

Stefan Åström, Lovisa Källmark, Katarina Yaramenka, Peringe Grennfelt

Author: Stefan Åström, Lovisa Källmark, Katarina Yaramenka, Peringe Grennfelt
Funded by: UNEP
Report number C598 , September 2021
ISBN 978-91-7883-300-9
Edition Only available as PDF for individual printing

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

This report has been reviewed and approved in accordance with IVL's audited and approved management system.

Executive Summary

The challenge with air pollution

Air pollution is the single greatest environmental risk factor for premature death globally. In response to the global threat from air pollution, the United Nations Environment Programme have since 2014 increased its engagement in air quality issues. One of the UNEP engagements on air quality is to make a re-occurring global summary of the air quality problem, its trends, and policies and instruments implemented to reduce it. The first global summary was published in 2016 and the second global summary is published in Autumn 2021. In support of the global summary, there are six regional reports (Africa, Asia-Pacific, Europe, Latin America, North America, and West Asia).

The purpose with the current European and Central Asian report is to provide detailed information on emission trends and European actions on air quality during 2016-2020, thereby providing detailed information in support to the second UNEP global summary of policies and programmes to reduce air pollution. The pollutants in focus for the report are sulphur dioxide, nitrogen oxides, non-methane volatile organic compounds, ammonia, and fine particulate matter (PM2.5). To a minor extent the report also presents an update on trends and policies for emissions of arsenic, cadmium, lead, and mercury.

Even though air pollution problems are more severe in other regions they still cause problems in the pan-European region, despite much progress since the peak pollution years of the 1970-ies and 1980-ies. In 2018, some 417,000 premature fatalities per year occurred in Europe due to fine particulate matter in ambient air (European Environmental Agency 2020). Over the last winters, some cities in South Eastern Europe even experienced the worst air quality in the world.[1]

Key sources of air pollutants in Europe

Thanks to the continued strengthening of policies developed under the UNECE Convention on Long-range Transboundary Air Pollution (in this report called the Air Convention), EU policies and legislation and national legislations, emissions of most monitored air pollutants have decreased. Since 2010, this trend has continued in Western, Central, Eastern and South Eastern Europe. Emissions are however increasing in Central Asian countries. Looking at the entire European and Central Asian region covered in this report, there is one pollutant that stands out: ammonia. Ammonia emissions have in all sub-regions increased during 2010-2017, and there is no sign of decline.

If focusing on emitting sectors instead of sub-regions, large combustion plants are the largest polluters of sulphur dioxide and heavy metals, road transport is responsible for most of the nitrogen oxides and carbon monoxide, whilst residential heating causes the highest emissions of fine particulate matter. Not surprisingly, agriculture is almost solely responsible for emissions of ammonia.

Actions taken in Europe

Several actions are taken in European countries to further improve air quality, and since 2016 there are several indications that efforts are increasing. In 2020 at least 46 of 54 surveyed countries have national air quality standards. Out of the survey respondents, one country has newly implemented

[1] https://rs.n1info.com/english/news/a582617-air-visual-belgrade-most-polluted-world-city/

standards since 2016. There are somewhat fewer countries with direct air quality management strategies (42 countries).

If considering actions aimed at industrial sources, it can be seen that 76% of the 29 respondents have clean production incentives in 2020. At least two countries have started to implement clean production incentives since 2016. For transport sources, at least 43 countries mandate specific vehicle emission standards for newly sold vehicles. Out of these, one country did not report mandatory emission standards in 2016. Four countries have put in place more strict mandates since 2016, and all respondents now report having at least Euro 4 (or equivalent) vehicle emission standards. Other measures that are commonly implemented the last five years include promotion of electric mobility and increased efforts on vehicle inspection and maintenance programmes. 38 of the surveyed countries are regulating solid waste burning, out of which 6 have enforced stricter regulations the last five years. Turning the attention to residential cooking and heating the survey indicates that 70% of the respondents have national programmes promoting use of clean energy for cooking and heating, a rate that is the same as in 2016. The most common focus in these programmes is on increased energy efficiency in buildings.

Conclusions

There are large variations with respect to how engaged countries are in their efforts to improve air quality. The EU member states and Norway, UK and Switzerland, with the largest past emission reductions, are also those with well-developed air quality monitoring and assessment infrastructure. In addition, these countries report the largest portfolio of further actions to reduce emissions in a cost-effective manner, including investments in energy efficiency improvements as well as in clean technologies.

Awareness and progress in efforts to improve air quality assessment infrastructures in Eastern and South Eastern Europe as well as Central Asia are improving, and there are several examples of knowledge-sharing initiatives and capacity building efforts. Particularly for Eastern Europe, air quality assessment infrastructure is now almost on par with those in Central and Western Europe.

To reduce the risk for an increasing air quality induced human health divide in the region, it is important to ensure reliable air quality monitoring and assessment infrastructures in all countries and to complement these with reporting of progress and establishment of prospective emission scenarios. Many Eastern and South Eastern European countries can focus on accelerating the introduction of low-emission road transport and on reducing emissions from residential heating. All countries need to increase efforts to reduce emissions of ammonia.

Table of contents

Executive Summary 3

1. Introduction 6

2. Regional Overview 7

2.1. Background 7
2.2. Countries considered in this report 10
2.3. Emission source sectors analysed in this report 11
2.4. Regional overview of air quality and trends 12
2.5. Regional overview of air pollution emissions 13
2.6. Key sectoral sources and trends in emissions of air pollutants 17
2.7. Macro-trends in policy formulation 24

3. Measuring progress towards improved air quality 26

3.1. National air quality standards and Legislation 26
3.2. In which sectors are measures taken to improve air quality? 27
3.3. Lessons learnt and policy uptake 35

4. Case studies 37

4.1. Case study 1 37
4.2. Case study 2 38
4.3. Case study 3 40
4.4. Case study 4 41

References 41

1. Introduction

In June 2014, the United Nations Environment Assembly (UNEA) adopted resolution 1/7: *Strengthening the Role of the United Nations Environment Programme in Promoting Air Quality*. This resolution came in response to the growing global threat of air pollution. In 2017, the third session of UNEA built on this commitment through UNEA resolution 3/8 requesting, inter alia, that United Nations Environmental Programme (UNEP) develops an overview of the actions taken by governments to promote better air quality. The 2016 report *Actions on Air Quality* (UNEP 2016) presented results at that time in an online catalogue of 193 countries. Since then, UNEP has developed an updated global summary of policy action using a detailed survey questionnaire of member states and built on this work with a set of 6 regional reports (Africa, Asia and the Pacific, Europe, Latin America and the Caribbean, North America and West Asia). These regional reports provide more detailed information on the status of key actions being undertaken by governments around the world to improve air quality.

For the pan-European region, the questionnaire was disseminated to 54 countries in total. 29 countries completed and three countries partially responded to the questionnaire. Due to the low answer frequency and differences in methodology, any direct comparison with the results presented in 2016 are made with caution. For some of the responding countries – and to enable regional comparisons – some complementary sources were used. The graphs over the survey responses only contain the actual responses. All methodological details of these reports are presented in Annex A of the 2021 Global report (UNEP 2021).

This pan-European regional report on action for air quality contains an overview of how emission trends of air pollutants have developed over the recent years. Following the introduction of the scientific basis and state-of-play, the report presents developments in air quality legislation, policy and action during the last five years. The report ends with presenting four case studies exemplifying current air quality and air quality governance in the pan-European region.

The report has been written by Stefan Åström, Lovisa Källmark, Katarina Yaramenka and Peringe Grennfelt, all at IVL Swedish Environmental Research Institute Ltd. The authors are grateful for active engagement by the UNEP contact Tomas Marques at UNEP Europe Office, the authors of the other UNEP regional reports, and all experts participating in the review of the draft: Kristof Doucot (Aarhus Convention Secretariat), Christer Ågren (AirClim), Richard Ballaman (Federal Office for the Environment FOEN, Switzerland), Yelyzaveta Rubach (Industrial Accidents Convention Secretariat), Eli Marie Åsen (Ministry of Climate and Environment, Norway), Rob Maas (RIVM, Netherlands), Petra Hagström (Swedish EPA), Peter Meulepas (VMM, Belgium), Victor Nthusi (UNEP), Soraya Shmaon (UNEP), Ketevan Kordzakhia (UNECE), Krzysztof Olendrzynski (UNECE), Carolin Sanz Noriega (UNECE), and several experts from the European Commission. All errors are however the authors' own.

2. Regional Overview

2.1. Background

Even though air pollution is more severe in other parts of the world it still causes problems in the pan-European region, despite much progress since the peak pollution years of the 1970's and 1980's. The World Health Organization (2014a, b) has identified that the largest health risk from environmental causes is driven by human exposure to fine particulate matter (PM2.5) in the air. PM2.5 in ambient air is mainly constituted of emissions of primary particles and of secondary particles (such as ammonium nitrates and ammonium sulphates) formed in the atmosphere and composed from emitted gases, such as non-methane volatile organic compounds (NMVOC), nitrogen oxides (NO_x), sulphur oxides (SO_2), and ammonia (NH_3). Human exposure to PM2.5 is associated with premature mortality, heart- and lung related diseases, and many other illnesses (Thurston et al. 2017). In 2018, some 417,000 premature fatalities per year occurred in Europe[2] due to PM2.5 in ambient air, of which around 379,000 – in EU28. Premature fatalities due to exposure of EU population to NO_2 the same year is estimated at 54,000, while exposure to ground-level ozone is estimated to have caused around 19,400 preterm fatalities (European Environment Agency 2020). By comparison some 25,000 EU member state citizens died in traffic accidents in 2017 (European Commission 2018). No future scenarios covering all of Europe have been reported, but the latest projections for the EU member states is that exposure to PM2.5 in the ambient air will cause some 170,000 premature fatalities per year in 2030 in EU27 (Amann et al. 2020) – this is compared to roughly 240,000 cases in 2020 estimated in the same source. Annual premature fatalities due to exposure to ground-level ozone in 2030 is projected to be around 16,000.[3]

Beside the effects on human health, emissions of the same air pollutants are associated with several types of environmental effects and damage to buildings and cultural heritage. The most well recognized non-health effects of air pollution are acidification of soils and freshwaters, eutrophication of soils and waters, damages from tropospheric ozone to crops, and corrosion damages to buildings and materials. In the European region, the evolution of these problems varies. For most of these effects the problem is in decline, but for eutrophication the progress is slow and for ozone the problem is mainly changing in nature, with a decrease in summertime peak ozone concentrations in Europe and an increase or a stabilization of hemispheric background concentrations (Maas and Grennfelt 2016).

In addition to these effects on air quality, emissions of several air pollutants are identified to have short term and regionally varied impact on climate change. In general, PM2.5 as well as coarser fractions of particulate matter contributes negatively to the radiative forcing[4] of the climate system, while some sub-fractions of PM2.5 like black carbon (BC) as well as tropospheric ozone (affected by emissions of NO_x, NMVOC, and methane (CH_4)) increase the radiative forcing.

---

[2] EEA Europe, see the geographical coverage below

[3] Estimates made by Amann et al. 2020 are somewhat lower than the numbers presented in the European Environmental Agency 2020 – this is due to methodological differences such as geographical scale and the way PM2.5 from natural sources are taken into account (Amann et al. 2020).

[4] The radiative forcing of an air pollutant or greenhouse gas basically describes its impact on the climate systems' radiative energy balance (solar energy to earth minus heat energy from earth). Radiative forcing is measured in watt per square meter of earth's surface at the tropopause. Forster, P., et al. (2007). Changes in Atmospheric Constituents and in Radiative Forcing. Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. S. Solomon, D. Qin, M. Manning et al. Cambridge, United Kingdom, Cambridge University Press.

There is no dispute on the fact that controlling carbon dioxide (CO_2) emissions is the most important policy to reduce climate change. It is however also important to consider climate effects of air pollutants to achieve effective air quality policies that are integrated with climate change policies. On a global scale, todays' atmospheric concentration of particles induces cooling, and is on average currently masking half the warming induced by anthropogenic CO_2 concentrations in the atmosphere. The global average of radiative forcing of particulates does however hide large regional variation, and the impact of the particle components vary (Myhre et al. 2013). As an example, whilst most particles are cooling, the global average direct radiative forcing of BC is warming the climate half as much as current CO_2 is, with indirect effects adding more unquantified warming (Bond et al. 2013, Myhre and Samset 2015). And emissions of ozone precursors, in particular methane, as well as ozone itself also warms the climate (Myhre et al. 2013).

The air pollutant gaining most attention recently for its impact on climate change is BC.[5] Although estimates are uncertain and dependent on when and where emissions occur, the current best estimate is that one ton BC emissions have an impact on radiative forcing equivalent to 120-3200 tons of CO_2 emissions, which might still be an underestimation (Myhre et al. 2013, Myhre and Samset 2015). Climate change impact has been identified for all the above presented air pollutants, as well as for the effect of CH_4 emissions on ozone formation (Etminan et al. 2016). Collectively, these are therefore often termed short-lived climate forcers (SLCFs).[6] Control of SLCF emissions has been shown to enable a reduction in the speed of global warming, contingent that CO_2 emissions are reduced (Shindell et al. 2012, Bowerman et al. 2013, Shoemaker et al. 2013). Several initiatives have been taken to increase our understanding of the importance of the SLCFs as well as to control emissions of those air pollutants with the largest impact on global warming. One initiative of interest is the Climate and Clean Air Coalition (CCAC).[7] CCAC is hosted by UNEP and includes about 70 countries and many intergovernmental organizations and NGOs.

The most important international air quality policy processes in Europe are those under the United Nations Economic Commission for Europe's (UNECE) 1979 Air Convention, and the European Union's (EU) clean air policy and legislation – in particular initiatives such as the *Zero Pollution Action Plan*[8] and a *European Green Deal.*[9] These form international and transnational agreements that address the pollutants mentioned in this report. Since 1979, the Air Convention has implemented eight protocols. The revised 'Multi-Pollutant, Multi-effect' (Gothenburg) protocol is together with the revised HM protocol the most recent (both protocols were revised in 2012). The Gothenburg protocol sets country-specific 2020 emission reduction targets for SO_2, NO_x, NH_3, NMVOC, and PM2.5.

In principle, all countries in the pan-European region are Parties to the Air Convention except Israel, San Marino, Andorra and the Central Asian countries Tajikistan, Turkmenistan and Uzbekistan. The Convention has throughout its entire 40 years history been a clearing house for air pollution knowledge. Through the protocols and their amendments many countries have committed themselves to far-reaching control measures.

---

[5] Black carbon is technically only the residual of a certain technique for measuring elemental carbon concentration in air but has become established nomenclature for a specific carbonaceous subfraction of PM2.5

[6] Other terms found in the literature are near-term climate forcers (NTCF) and short-lived climate pollutants (SLCP).

[7] https://ccacoalition.org/en

[8] https://ec.europa.eu/environment/strategy/zero-pollution-action-plan_sv

[9] https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en

However, there are still countries in Eastern Europe, Caucasus and South Eastern Europe, that have not yet signed or ratified the most recent Air Convention protocols. Even so, these countries have been active in the convention and many of them have taken measures to reduce emissions. The Central Asian countries have taken part in the work within the Air Convention as observers and there have been several activities (workshops, training sessions) supported by the Air Convention in order to increase awareness and national competence, e.g. on emission inventories (UNECE 2019). See also Case study 3 in this report. One conclusion from the Air Convention work is that the collaboration between countries, particularly in the scientific and technical bodies, have supported actions within the participating countries.

The EU started its efforts to control air pollutants later than the Air Convention. Nevertheless, today it regulates air pollution and air quality through several directives and other legislative acts, the most recent being the National Emission reduction Commitments (NEC) Directive from 2016 (European Union 2016). The original NEC Directive from 2001 did set emission ceilings for 2010 and onwards. The updated NEC Directive sets national emission reduction commitments to be achieved by 2020-2029 and by 2030 and onwards for the EU member states. The Directive covers the same pollutants as the Gothenburg protocol, with the same level of ambition for the period 2020-2029 but it is more ambitious than the Gothenburg Protocol as regards the period 2030-onward. To support policy makers and the achievement of the European Union environmental objectives, the European Environment Agency (EEA) compiles and presents information on the environment. The EEA has together with the subsidiary bodies of the UNECE Air Convention been important for the establishment of infrastructures for data collection and reporting in EU and non-EU countries, including several countries east of EU.

Another type of air pollution is heavy metals (HMs) such as lead, mercury, and cadmium. They differ from the classical air pollutants in terms of sources, transport behavior and regulatory context. Heavy metals are known for their toxicity in very low concentrations and have adverse effects on human health and the environment. Heavy metals are naturally present in the environment, but their levels in ecosystems have significantly increased compared to pre-industrial time because of anthropogenic activity.

Anthropogenic emissions of heavy metals have been significantly reduced in Europe since the 1990s (Maas and Grennfelt 2016). For some sectors the emission reductions have been particularly large; lead emissions from road transport disappeared with the introduction lead-free petrol, a requirement for catalytic converters in gasoline cars. Nowadays, the prevailing emission sectors of the three considered metals include industrial combustion, non-industrial combustion, metal production and electricity & heat production. However, human health and ecosystems continue to be at risk in many European countries despite important reductions of heavy metals. To safeguard human health and the environment the Air Convention Parties adopted the Aarhus protocol on heavy metals in 1998 and amended it in 2012. Also, the UNEP Minamata Convention is an important mechanism to reduce negative effects of mercury.

Hazardous substances may also be released into the air as a result of accidents at industrial facilities. The UNECE Convention on the Transboundary Effects of Industrial Accidents aims at protecting human beings and the environment against industrial accidents by preventing such accidents as far as possible, by reducing their frequency and severity and by mitigating their effects. The Convention presently has 41 contracting Parties, including most countries of Europe and Caucasus and one country in Central Asia.

2.2. Countries considered in this report

This report builds upon a UNEP-executed survey questionnaire as well as data from other sources such as the European Environment Agency (EEA) and the Air Convention's Centre for Emission inventories and Projections (CEIP).[10] UNEP's geographical scope includes 54 countries referred to as the pan-European region. The region is further divided into four subregions: Western and Central Europe, South Eastern Europe, Eastern Europe and the Caucasus and Central Asia (Table 1, Figure 1).

Table 1: The countries included in the UNEP pan-European region and sub-regions.

The UNEP pan-European region	
Sub-region	**Countries***
Western and Central Europe	(35 countries) **Andorra**, Austria, **Belgium**, **Bulgaria,** Croatia, Cyprus, Czech Republic, **Denmark**, **Estonia, Finland**, France, Germany, Greece, **Hungary**, Iceland, Ireland, Italy, Latvia, Liechtenstein, **Lithuania**, Luxembourg, Malta, **Monaco**, **Netherlands, Norway, Poland,** Portugal, **Romania**, San Marino, Slovakia, Slovenia, **Spain, Sweden, Switzerland,** the United Kingdom
South Eastern Europe	(7 countries) **Albania**, **Bosnia and Herzegovina**, **North Macedonia**, **Montenegro**, **Serbia**, **Turkey, Israel**
Eastern Europe and the Caucasus	(7 countries) **Armenia, Azerbaijan**, Belarus, **Georgia**, Republic of Moldova, Ukraine, **Russian Federation**
Central Asia	(5 countries) **Kazakhstan, Kyrgyzstan**, Tajikistan, Turkmenistan, Uzbekistan

*Countries that provided answers to the 2020 UNEP survey questionnaire are marked **in bold**

Figure 1: Sub-regions in the UNEP pan-European region.

The geographical scope of EEA includes the 27 member states of the EU, the United Kingdom, Iceland, Liechtenstein, Norway, Switzerland and Turkey, as well as the cooperating countries Albania, Bosnia and Herzegovina, Kosovo under United Nations Security Council Resolution 1244/99, Montenegro, North Macedonia and Serbia. When referred to in this report, these 39 countries are grouped as EEA-Europe. The countries included in the reporting of emission trends

[10] https://www.ceip.at/

constitutes a subset of the UNEP pan-European region. Since some countries in the pan-European region don't report[11] emission inventories to CEIP, the region for which there is CEIP data is referred to as CEIP-Europe (Table 2).

Table 2: The countries in the UNEP pan-European region that report emission inventories to CEIP.

CEIP-Europe	
Sub-region	**Countries**
Western and Central Europe	(33 countries) Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Liechtenstein, Lithuania, Luxembourg, Malta, Monaco, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, the United Kingdom
South Eastern Europe	(5 countries) Albania, North Macedonia, Montenegro, Serbia, Turkey
Eastern Europe and the Caucasus	(7 countries) Azerbaijan, Belarus, Georgia, Republic of Moldova, Ukraine, Russian Federation
Central Asia	(1 country) Kazakhstan

Overall level of quality (completeness, transparency, and consistency) of submitted to CEIP emission inventories differ between European countries. There might be certain gaps in submitted data; those, however, have not been explicitly analyzed. Reported emissions in all countries are associated with uncertainties regarding both activity data (e.g. fuel characteristics and amounts, number of vehicles/appliances) and emission factors used.

2.3. Emission source sectors analysed in this report

Following the structure of the questionnaire, both overview of emission trends and review of progress towards improved air quality are focused on main six source sectors:

- Electricity & heat production and Industry,
- Road transport,
- Residential cooking and heating,
- Agriculture and forestry,
- Waste management,
- Other.

Sector "Other" covers land-based emissions sources not included in the other five sectors. However, it is not implied that "other" emissions are insignificant. In particular, for emissions of NO_x from non-road traffic or NMVOC from solvent use, "other" is one of the key emission source sectors.

[11] Kyrgyzstan and Armenia have reported their emissions to CEIP for certain (including the most recent) years. However, these time series are too aggregated (providing only the national totals) or/and too short (covering very few years) to be included in the emission trends presented below for CEIP-Europe subregion together with sector-specific emissions reported by other countries for the period 2010-2017. These countries are therefore not mentioned in Table 2.

Air pollution levels in European countries are not affected solely by land-based emission sources. Shipping, especially international shipping, is whilst not attributable to any country, an important contributor to emissions of inter alia NO_x and particles in the pan-European region. International shipping, however, was not within the scope for the analysis in this report and is only covered with respect to emission trends in chapter 2.5.

2.4. Regional overview of air quality and trends

Much because of policies and legislations, the European air quality has improved since the peak emissions in the 1980-ies. However, it is not yet good enough to fully protect human health and the environment. Unfortunately for this current report, an overview of air quality is only available for EEA-Europe. In the 2020 report "Air Quality in Europe", the European Environment Agency (EEA) presents EEA-Europe status and trends for key air pollutants, with the most recent data from 2018. The report presents that concentrations of PM2.5 vary across Europe with the highest daily-average concentrations found in the South-Eastern part of EEA-Europe (European Environment Agency 2020). Even the annual mean concentrations are high and exceeds the World Health Organization (WHO) air quality guideline (AQG) values in four of the countries in the South-Eastern part of EEA-Europe. The most important sources of PM2.5-emissions are thermal power plants and household heating. In addition, emissions from neighbouring countries and transboundary transport are important for air quality even in cities (Belis et al. 2019, Colovic Daul et al. 2019).

The concentrations of particulate matter (PM10 and PM2.5) exceed the WHO AQGs in large parts of Europe. The annual average WHO AQG for PM10 was exceeded at 53% of the monitoring stations and in all the reporting countries, except Estonia, Iceland, and Ireland. The annual average WHO AQG for PM2.5 was exceeded at 70% of the stations located in all the reporting countries. Exceedances were not observed in Estonia, Finland, Iceland, and Ireland.

The PM concentrations have shown a slow downward trend between 2009 and 2018 for the EEA stations. On average, over the last decade (2009-2018) there was a reduction of 22% in annual mean concentrations of PM2.5 for all station types, with the highest reduction for those stations situated at industrial sites (Figure 2).

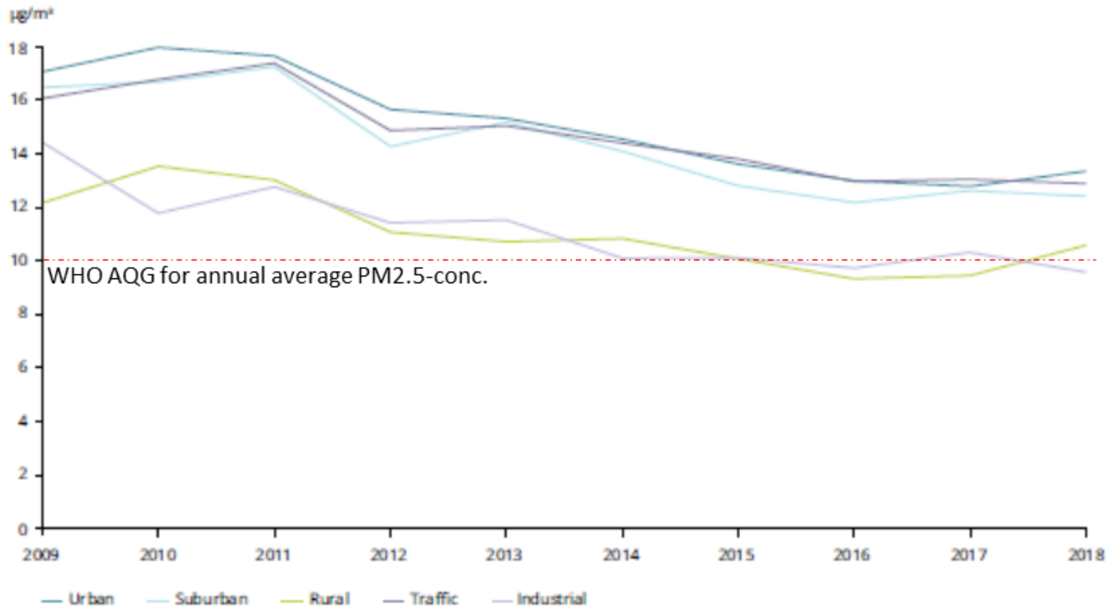

Figure 2: Average annual mean PM2.5-concentration by monitoring station type (adapted from fig. 4.8 in EEA (2020)). Red dashed line indicates the current WHO AQG for annual average concentrations of PM2.5.

For ozone the WHO AQG value was exceeded at 96% of all the reporting stations. For NO_2 and SO_2 the situation is better; annual and daily mean WHO AQG are only exceeded at 8% and 33% of the stations, respectively. The average NO_2 annual mean concentrations within the EEA network steadily decreased between 2009 and 2018. On average annual mean concentrations of NO_2 have fallen by 18% at industrial stations, by 19% in urban background stations, by 22% in suburban and rural background stations and by 23% in traffic stations. This decrease is lower than the decrease of 26% in total NO_x emissions in the same period and lower than that for road transport NO_x emissions (34%).[12]

The EEA-Europe time series for ozone shows no clear trend and a high variability from year to year over the period. This variability is mainly caused by variations in weather conditions. A trend analysis confirms that 95% of the stations have non-significant trends, while the 5% of the stations with significant trends were equally distributed between increasing and decreasing trends.

2.5. Regional overview of air pollution emissions

The significant but insufficient improvements in European air quality presented above have been driven by substantial emission reductions of most pollutants.

Trends of air pollution emissions in the pan-European region are mainly compiled based on the self-reported emission data available at CEIP. Emissions per region and per sector were summarized for the period 2010-2017. This period is chosen to enable comparability of the trends in different regions. Many of the considered countries did not report their emissions to CEIP for years before 2010; for the years 2018-2019 not all emission inventories were available yet. Thus, trends for air pollutant emissions are analysed for 2010-2017 while trends in implementation of policy measures (reviewed below) cover the period 2016-2020.

In Table 3, emission trends between 2010-2017 are distributed between the main subregions (Central Asian countries, except for Kazakhstan, are not included in the table). The overall trends in emissions between 2010 and 2017 are also indicated in the table with colours.

Table 3: CEIP-European sub-regional trend in emissions of air pollutants, % change between 2010 and 2017.

	Central and Western Europe	South Eastern Europe	Eastern Europe and the Caucasus	Central Asia (Kazakhstan)
NO_x	-21%	-17%	+7%	+19%
SO_x	-46%	-8%	-49%	+11%
PM2.5	-17%	-8%	-11%	+21%
PM10	-14%	-19%	-11%	+9%
NMVOC	-13%	+4%	-2%	+24%
CO	-22%	-37%	-7%	+34%
NH_3	+2%	+31%	+12%	+16%
Pb	-18%	-50%	-53%	+22%
As	-16%	-11%	-71%	+23%
Cd	-11%	+33%	-26%	+16%
Ni	-30%	-2%	-42%	-54%
Hg	-19%	-2%	-27%	-28%

[12] Non-EU countries in South East Europe not included.

For NO_x, which almost entirely is emitted from combustion, significant emissions occur in almost all sectors. Electricity & heat production and industry together with road transport dominates. These two sectors are making up almost 75% of the emissions with about the same share from both. There are significant differences in emission trends between the different subregions. While emissions in Western and Central Europe are reduced by 21% compared to the 2010 level, they have increased in South Eastern Europe and Eastern Europe and the Caucasus with 8% and 17%, respectively.

Most emissions of sulphur dioxide origins from combustion of fossil fuels. The dominating sector is electricity & heat production and industry (85%). A significant fraction is also coming from residential cooking and heating, indicating that fossil fuels are still used in this sector. Emissions in Western and Central Europe and Eastern Europe and the Caucasus were reduced by almost 50% over the period. However, in South Eastern Europe the downward trend was limited to 8%.

Particulate matter, the key compound for health effects, has its origin in almost all sectors. However, residential combustion is responsible for almost 50% of the fine particulate matter emissions (in total in all sub-regions) and will therefore be of high importance for local health effects. Another large source of PM-emissions is road transportation. All subregions show a decrease in PM2.5 and PM10 emissions, varying between 8- 17%.

Agriculture is the dominating source of ammonia emissions. The general trend is upwards in all sub-regions. In South Eastern Europe there is an increase in emissions by 31% between 2010 and 2017, while it is smaller (2-16%) in other regions.

For heavy metals, electricity & heat production and industry is the dominating sector contributing with 62-82% of the emissions. Heavy metals show a downward trend between 11-30% in the Western and Central Europe region. In Eastern Europe and the Caucasus, the decrease has been between 26-71%. In South Eastern Europe the downward trend is pronounced for lead (Pb), while it is upwards or neutral for the remaining three metals, cadmium (Cd), mercury (Hg) and nickel (Ni). The level of increase is notable for Cd with an increase of 33%. It should however be noted that emission inventories generally are uncertain for these compounds given that concentrations often are low and heavy metal emission inventories often are based on irregular inventory campaigns.

In **South Eastern Europe**, an increase in emissions is observed for NMVOC, ammonia and Cd, while emissions of other pollutants have been decreasing over the last years. Emission trends of main air pollutants in the Western Balkan countries[13] are shown in Figure 3.

[13] Part of the South Eastern Europe includes Albania, North Macedonia, Montenegro, Serbia and Bosnia and Herzegovina. The latter does not report emissions to CEIP.

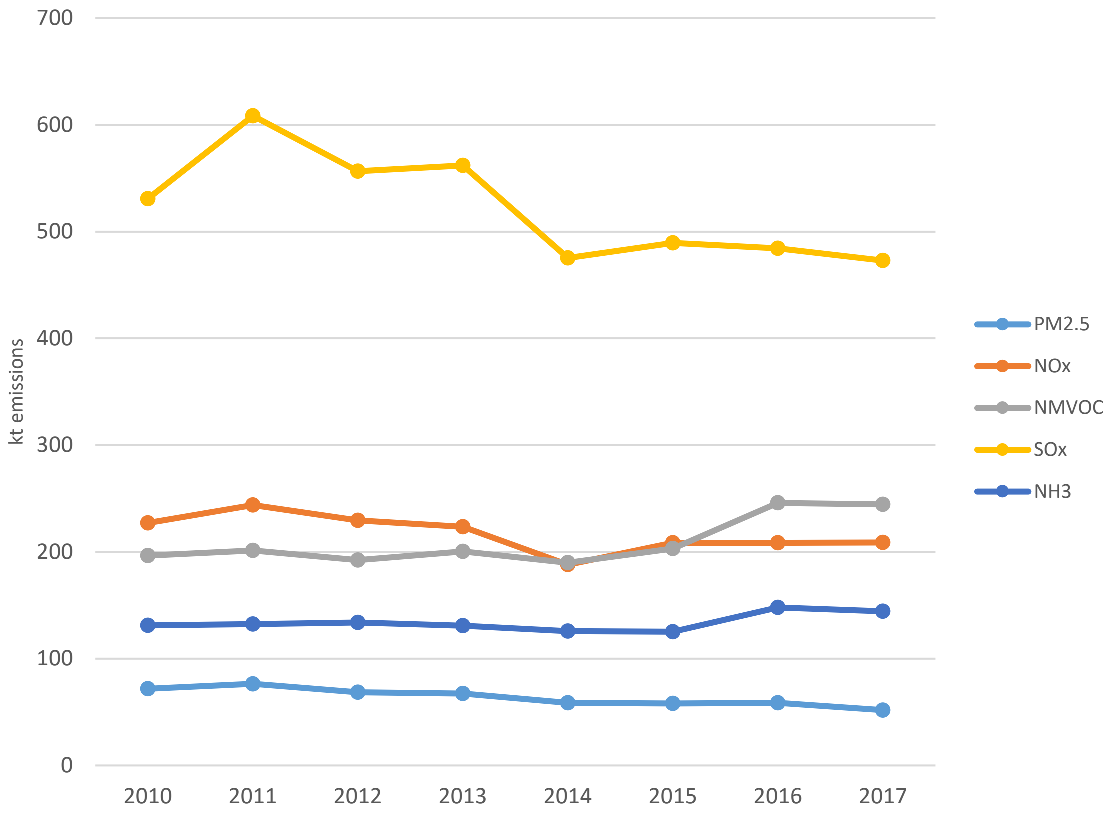

Figure 3: 2010-2017 Emission trends in the Western Balkan countries, based on CEIP data (kton emissions).

Figure 4 shows emission trends for the **Central Asian republics**. Not all countries in the Central Asian sub-region are parties to the Air Convention. Comprehensive emission data submitted to CEIP for longer time periods than 2016-2017 are only available for Kazakhstan. Figure 4 summarizes emissions for 2010-2017 as estimated by CEIP experts in separate studies (EMEP 2014, EMEP 2016a, EMEP 2016b, EMEP 2018, EMEP 2019) and used for official EMEP modelling by MSC-W (EMEP 2020). These data are different for Kazakhstan from those self-reported by Kazakhstan to CEIP in the most recent submission (as in Table 3). According to these expert estimates for the Central Asian sub-region, all emissions except SO_2 are increasing. The overall SO_2 emissions decreased by 8% between 2010 and 2017. For NO_x, there is a slightly upward trend of 13%. PM2.5 emissions show a large increase (46%) over the period. Unfortunately, the emission inventories lack distribution by sectors.

Kazakhstan is the country in Central Asia with the largest emissions for all pollutants except ammonia. For sulphur dioxide, 80-90% of the sub-region's emissions occur in Kazakhstan. For ammonia, Uzbekistan and Kazakhstan have similar emission levels, and for the entire region emissions are increasing by 19% over the period. For NMVOC and CO the downward trends are 7% and 12% respectively.

Figure 4: 2010-2017 Expert (CEIP) estimate emission trends in Central Asia (kton emissions), as used in the EMEP modelling (EMEP 2020).

Unlike the increasing emission trends in the Central Asian sub-region, **Western and Central Europe** shows a downward trend for all emissions. For this sub-region, emission trends from the EU member states cover enough parts of the region to be representative for the entire region. Overall emission trends for EU27 and the United Kingdom have been published as part of the Second EU Clean Air Outlook (European Commission 2021). The trends shown in Figure 5 reveal that since 2005 emissions for almost all pollutants have decreased with 20-40%. For SO_2 emissions have decreased by 60% while emissions of NH_3 only decreased by less than 10%.

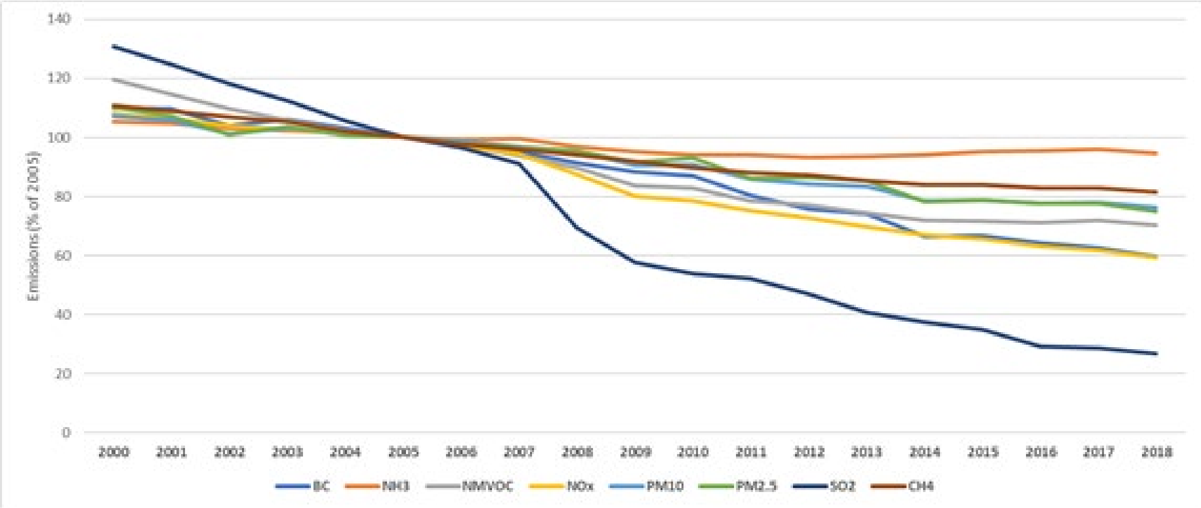

Figure 5: 2000-2018 emission trends in EU27 and the United Kingdom, % of 2005 level (European Commission 2021).

Emissions from **international shipping in the European seas** show decreasing trend for all pollutants, although with a slight increase in 2018 – see Figure 6. Compared to the 2000 level, shipping emissions in 2018 decreased by 10-45%, with the most pronounced reduction for sulphur dioxide.

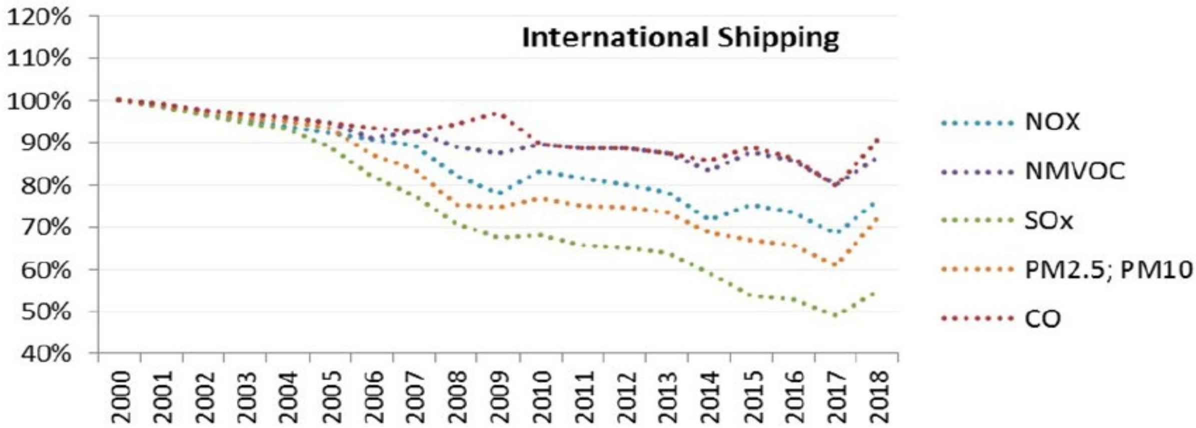

Figure 6: 2000-2018 emission trends for international shipping in the European seas, % of 2000 level (EMEP 2020).

2.6. Key sectoral sources and trends in emissions of air pollutants

Just as there are differences between regions, the emission levels and trends differ between sectors. For the entire CEIP-Europe region, Table 4 show the percent distribution of emissions between sectors for the pollutants considered in this report. The overall trends in emissions between 2010 and 2017 are indicated in the table with arrows. With respect to sectoral origin of emissions, NO_x emissions mainly originate from energy, industry, and road transport. The sector Electricity & heat production and industry is the dominating source of SO_2 and heavy metal emissions. The use of coal for production of electricity is still prominent in many parts of Europe, and emission control is not applied in some sub-regions (HEAL et al. 2019). Particle emissions mainly origins from residential cooking and heating, where the heating is most important. Correspondingly, emissions of particular matter are seasonal (Belis et al. 2019). The agricultural sector dominates NH_3 emissions. For industry, energy and transport, the trends are consistent for almost all pollutants, whilst the trend is more mixed for the other sectors. When studying the following tables and figures it is important to keep in mind that the figures are self-reported from national authorities. The data availability and collection efforts made vary substantially between countries reporting to CEIP. It is also important to remember that most of the outlier trends presented in % of 2010 emissions in Figure 7 – Figure 11 below, are for sources with very low 2010 emission levels.

Table 4: Sectoral distribution of air pollutants in the CEIP-European part of the UNEP pan-European region in 2017, % share of sectors' contribution to total emissions. The arrows indicate if emissions are increasing (red arrow) or decreasing (green arrow) during the period 2010- 2017 (CEIP database 2021)[14]

	Electricity & heat production and industry	Road transport	Residential cooking and heating	Agriculture and forestry*	Waste management	Other
NO_x	36% ↓	37%↓	8%↑	6%↑	0.4%↑	13%↓
SO_x	85%↓	1%↓	11%↓	0.02%↓	0.1%↑	3%↓
PM2.5	30%↓	10%↓	46%↓	4%↑	4%↑	7%↓
PM10	32%↓	8%↓	30%↓	20%↑	2%↑	7%↓
NMVOC	20%↓	17%↓	11%↓	19%↑	1%↑	32%↓
CO	22%↓	38%↓	30%↑	0.4%↓	2%↑	8%↑
NH_3	2%↓	1%↓	1%↑	93%↑	2%↓	1%↓
Pb	69%↓	14%↓	9%↓	0.03%↓	1%↓	7%↓
As	85%↓	2%↑	5%↓	0.04%↓	7%↓	1%↓
Cd	68%↓	3%↓	17%↑	2%↓	3%↓	7%↓
Ni	69%↓	2%↓	14%↓	0.01%↓	0.1%↓	15%↓
Hg	82%↓	2%↓	7%↓	0.3%↓	5%↓	3%↓

2.6.1. Electricity & heat production and industry

Emissions from electricity and heat production and industry are decreasing in Western and Central Europe as well as in South Eastern Europe, Eastern Europe, and the Caucasus. However, emissions in Central Asia are showing an increasing trend.

In Figure 7 the trends in emissions between 2010 and 2017 of the key sector electricity & heat production and industry are presented for four regions within the pan-European region.

For Western and Central Europe (mainly EU member states) the emission trends show consistent but small decrease, generally of the order of 20% or less. They are downward for all compounds except for NH_3. The trends represent the continuous fulfilment of the EU directives as well as commitments under the Air Convention protocols.

For Eastern Europe and the Caucasus, the trend is downwards for most compounds, in some cases of the order of 50% and more. For the key compounds NO_x, NH_3 and NMVOC, emissions are however increasing. For the key component for health effects, PM2.5, the trend is decreasing.

For South Eastern Europe the development shows a downward trend for most compounds, although for some compounds there is a tendency towards increasing emissions at the end of the period. For the key components, NO_x, NH_3 and NMVOC, the emissions show a slight increase.

[14] https://www.ceip.at/

The emission levels for the Central Asian country Kazakhstan are increasing. Although not a large source in absolute terms (according to self-reported to CEIP data), emissions of NH_3 increased with almost 150% between 2010 and 2017 in the fertilizer production industry. For the key compounds, emission trends are increasing with up to 20%.

In general, emission inventories and trends for heavy metals should be looked at with caution. The underlying data is still uncertain and there is a need for improvement, especially for the non-EEA countries.

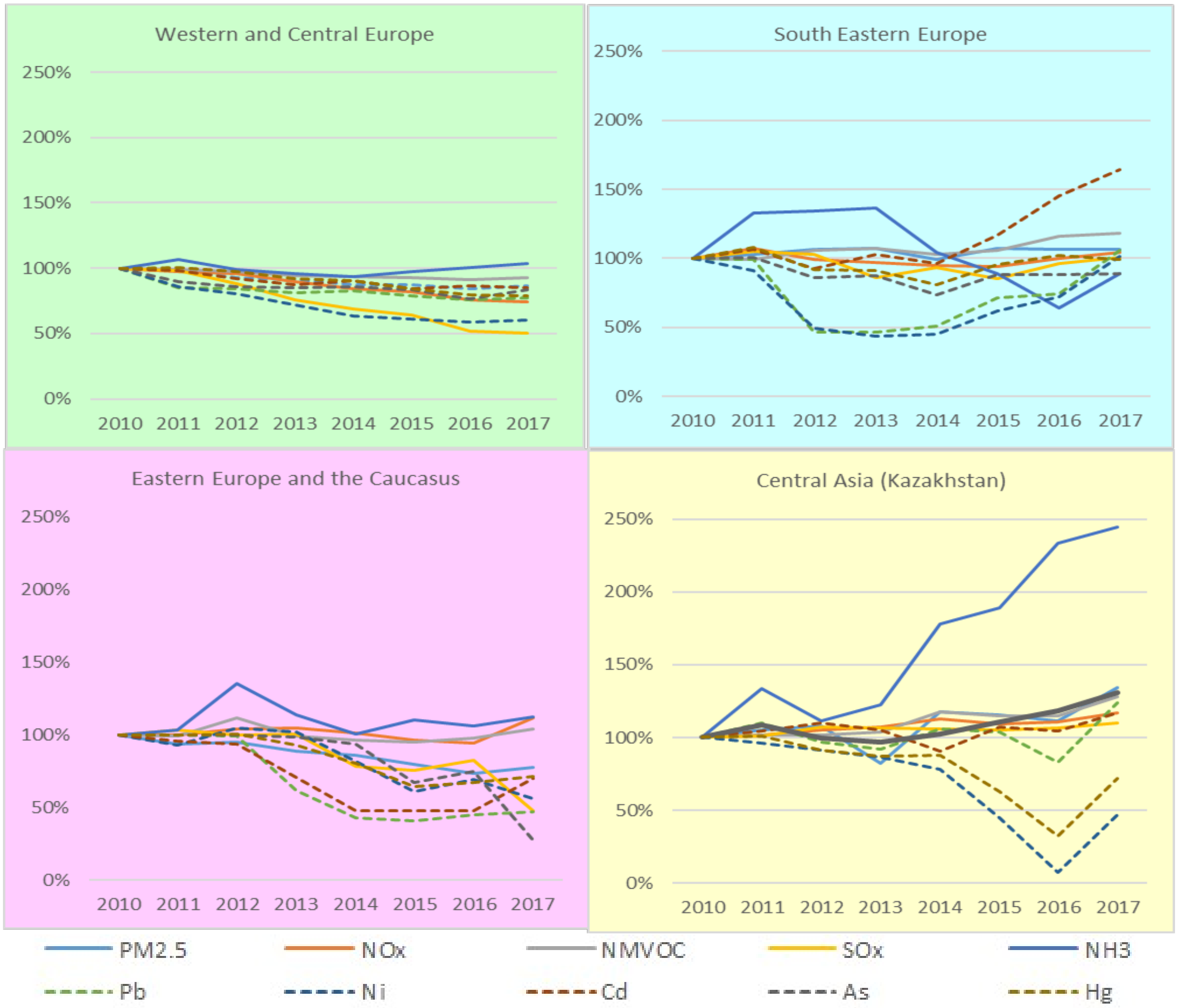

Figure 7: Self-reported and indexed 2010-2017 Emission trends within Electricity & heat production and industry per CEIP-Europe subregion.

2.6.2. Road Transport

Emissions for the key components from the road transport sector are decreasing in Western and Central Europe. The emission of NO_x, NMVOC and PM2.5 in 2017 are estimated to be 20-30% lower than in 2010. However, emission inventories indicate that emissions of heavy metals are stable or increasing.

For Eastern Europe and the Caucasus there are differing trends over the period. For PM2.5 there is a downward trend of about 20%, while there is an upward trend of 20-25% for NO_x. It is notable that emissions of Pb show significant decrease between 2010 and 2017, which may indicate a phase-out of leaded gasoline (Figure 8).

The key emissions from road traffic in South Eastern Europe are decreasing with approximately 40% over the period, consistent with introduction of stricter vehicle emission standards in the region. A similar rapid decrease in Pb emissions as reported for South Eastern Europe as well as for Eastern Europe and the Caucasus. Finally, emissions of key components in Central Asia (Kazakhstan) show an increase of up to 20%.

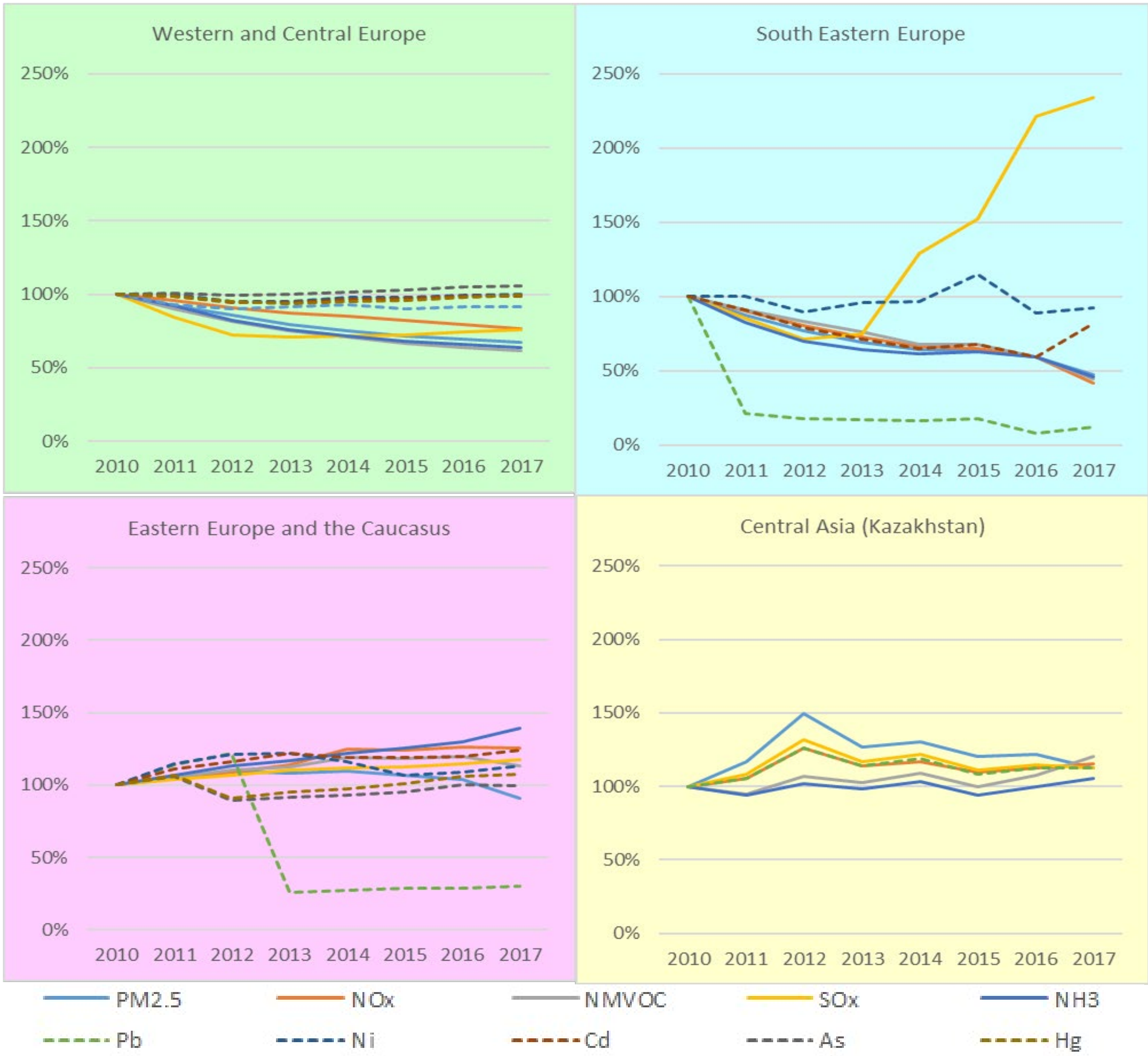

Figure 8: Self-reported and indexed 2010-2017 Emission trends from road transport per CEIP-Europe subregion.

2.6.3. Waste management

Waste management is a relatively small source of emissions in the region compared to other sectors. However, the emissions of NMVOC, PM2.5 and NO_x (Figure 9) are of some significance. In Western and Central Europe emissions of NMVOC are decreasing, while emissions of PM2.5 and NO_x show no trends. Emissions of heavy metals have been steady on the same level.

Emissions in South Eastern Europe show both significant upwards and downwards trends. While emissions are decreasing for SO_2, NO_x, NH_3 and PM2.5, they are increasing for heavy metals and NMVOC. For Eastern Europe and the Caucasus emissions of NMVOC are increasing while they are decreasing for NH_3. For the remaining compounds, reported emissions are small without any clear trends.

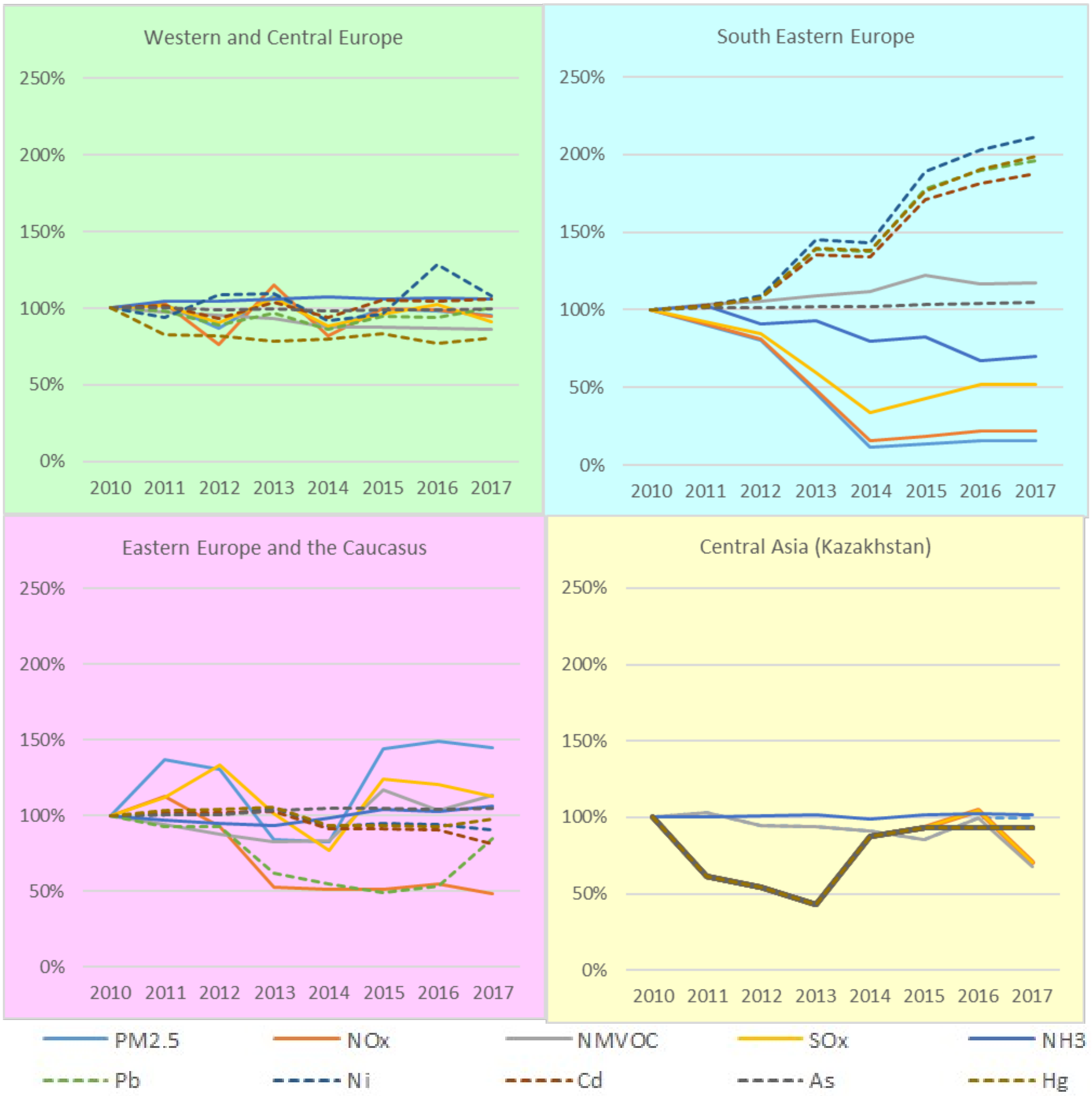

Figure 9: Self-reported and indexed 2010-2017 Emission trends from waste management per CEIP-Europe subregion.

2.6.4. Residential cooking and heating

Residential heating in Europe is the main source of air pollution while cooking plays a less significant role. The heating is often based on wood-burning (e.g. Northern and Western Europe) and in some regions on coal-burning (e.g. Eastern and South-eastern Europe). In the countries where wood and/or coal are supplementary heating sources, they still contribute significantly to emissions of inter alia fine particles from the sector. Emissions from residential heating are together with road traffic a main source of pollution exposure to humans. At the same time, these emissions are often estimated based on several assumptions, due to the lack of data regarding exact number of heating appliances of a certain type, their age distribution, fuel amounts and quality, burning techniques, etc. All of which contributes to the uncertainties of the emission estimates for this sector. Residential heating with small-scale combustion technologies is common all over Europe, and even more so in areas with low seasonal temperatures.

In Western and Central Europe, the trends for PM2.5, NO_x and NMVOC are downwards with approximately 15% over the period 2010-2017 (Figure 10). SO_2 emissions are down with 24%. In South Eastern Europe the trends are mixed. While emissions of NO_x have increased with 61%, emissions of PM2.5 are down with 9% and those of NMVOC and SO_2 are down with 40-50%.

In Eastern Europe and the Caucasus, the emissions are increasing. However, there are large variations between years and compounds. In 2017 emissions of the key components PM2.5, NO_x, NMVOC and SO_2 were between 25-47% larger than in 2010. For Central Asia (Kazakhstan) emissions of NO_x, NMVOC and SO_2 increased by 66%, 99% and 54%, respectively, between 2010 and 2017.

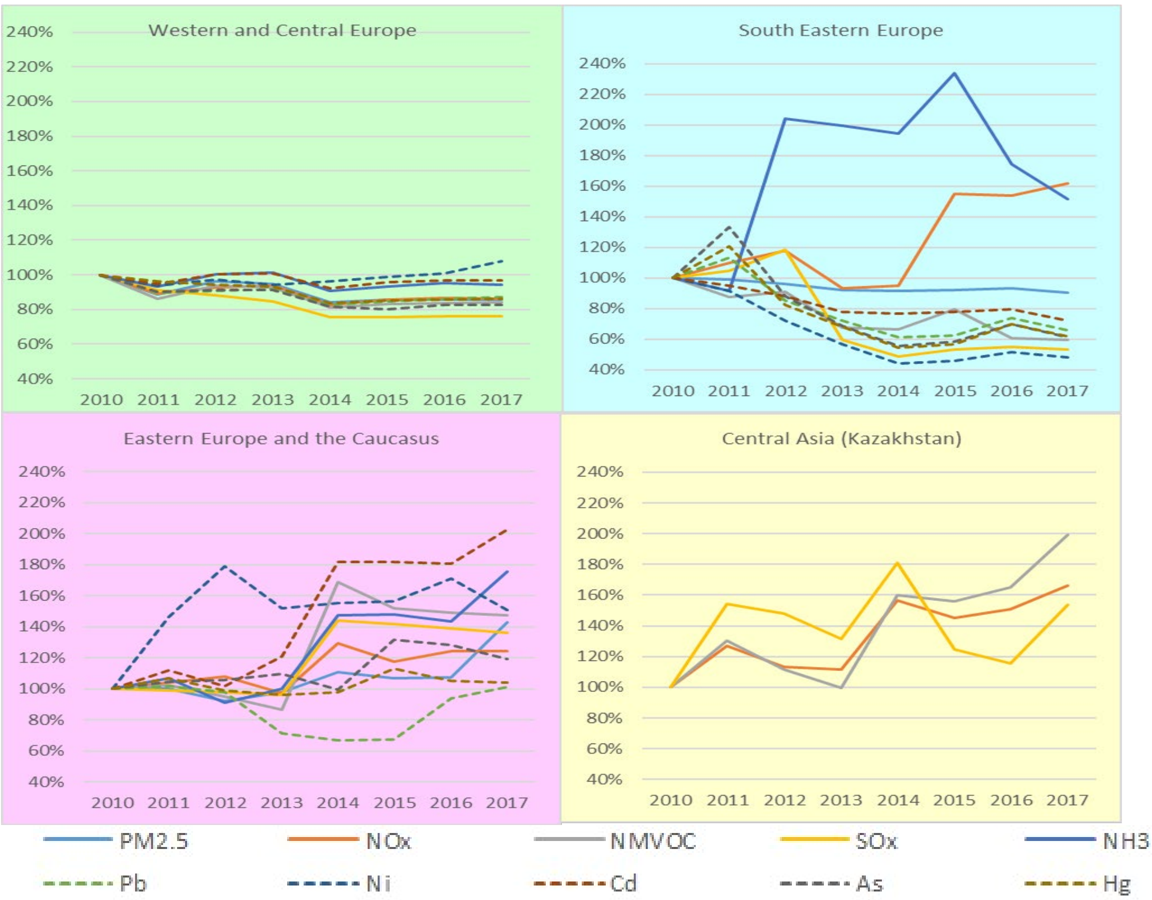

Figure 10: Self-reported and indexed 2010-2017 Emission trends from residential cooking and heating per CEIP-Europe subregion

2.6.5. Agriculture and forestry

Atmospheric emissions from the agriculture and forestry sector are mainly caused by agricultural activities. For forestry, emissions are mainly caused by various forest management machineries. Emissions of ammonia is a key problem for the agriculture sector. This sector is responsible for more than 90% of all ammonia emissions in Europe. Despite awareness of the problem and measures in many countries, there are no signs of reductions in the total emissions in the region.

In Western and Central Europe, the emissions of NH_3 are 2% higher in 2017 compared to 2010 (Figure 11). For NMVOC emissions are up with 4% and those of NO_x are up with 6%. In Eastern Europe and the Caucasus, emissions of all key components are increasing; the 2017 emissions are up with 11% for NH_3 compared to 2010 and corresponding figures for NMVOC and NO_x are 7% and 28%, respectively.

For South Eastern Europe emissions of NH_3 are up with 32% and NMVOC and NO_x emissions have increased with 27% and 36%, respectively. The emissions in Central Asia (Kazakhstan) are for all components increasing with approximately 10% over the 2010-2017 period.

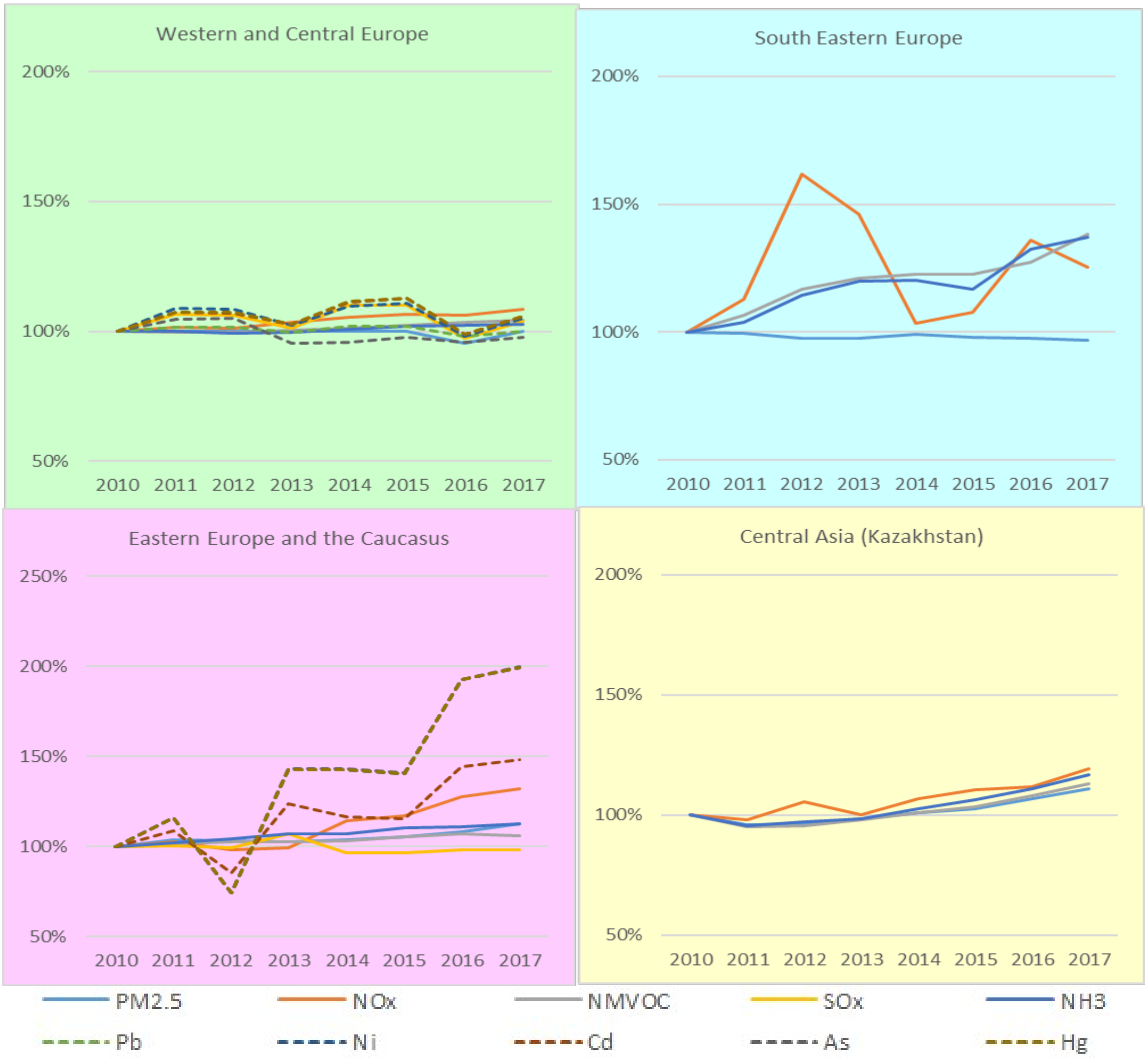

Figure 11: Self-reported and indexed 2010-2017 Emission trends from agriculture and forestry per CEIP-Europe subregion.

2.7. Macro-trends in policy formulation

International and transnational actions are of large importance for the formulation and development of air pollution control policies in Europe. The two main actors within the region are the Air Convention and the EU. The Air Convention covers almost all countries in Europe while EU covers 27 countries today. EU air pollution legislation is also affecting countries having association agreements with the EU. Furthermore, European air pollution control policy is in general developed in co-production between policymakers and scientists, involving a broad palette of various scientific interests and disciplines such as medicine, ecology, atmospheric science, environmental technology, and economy. Integrated assessment modelling (IAM) has played an important role by linking the various elements of knowledge into designing cost-effective policies. Correspondingly, European policy formulation is to a large extent influenced by scientific results.

To take stock of progress and future needs, the Air Convention published a scientific assessment report *'Towards Cleaner Air'*[15] in 2016. The report points to the progress achieved within the region in terms of improvements in emission reductions for the benefit of human health and ecosystems (Maas and Grennfelt 2016). It also points out the need for further actions if long term objectives with respect to health and ecosystems are to be achieved. The conclusions from the report formed the basis for an updated long-term strategy for the period up to 2030, which was adopted by the Executive Body of the Air Convention in 2018.[16] (The strategy will be further presented under Chapter 3).

Towards Cleaner Air – Key Conclusions

- There is a need for coordinated actions going beyond the UNECE region.
- Technical solutions are available to reach WHO guidelines for health impacts of air pollution and avoid negative impacts of air pollution on ecosystems in most parts of Europe
- Air pollution control costs are generally much lower than the damage costs of air pollution
- An integrated approach to climate change and air pollution could lead to significant co-benefits
- Actions are needed at different levels: international, national and local.

The amended Gothenburg Protocol from 2012 include national reduction commitments for SO_2, NO_x, NMVOC, NH_3, and is the first international agreement setting reduction targets for PM2.5. The protocol entered into force in 2019 and is currently under review.

The clean air policy of the European Union rests on three pillars. The first pillar comprises the ambient air quality standards set out in the Ambient Air Quality Directives for ground-level ozone, particulate matter, nitrogen oxides, heavy metals, and several other pollutants.[17] If the set limit values are exceeded, Member States are required to adopt air quality plans specifying measures to keep the exceedance period as short as possible.

The second pillar consists of national emission reduction obligations set by the National Emission reduction Commitments Directive (NEC Directive)[18] for SO_2, NO_x, NMVOC, NH_3 and PM2.5.

[15] https://unece.org/environment-policy/publications/towards-cleaner-air-scientific-assessment-report-2016

[16] Long-term strategy for the Convention on Long-range Transboundary Air Pollution for 2020–2030 and beyond. https://unece.org/fileadmin/DAM/env/documents/2018/Air/EB/correct_numbering_Decision_2018_5.pdf

[17] Directives 2004/107/EC (https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32004L0107) and 2008/50/EC (https://eur-lex.europa.eu/legal-content/en/ALL/?uri=CELEX:32008L0050)

[18] Directive (EU) 2016/2284 on the reduction of national emissions of certain atmospheric pollutants ('NEC Directive')

Member States had, for the first time in 2019 and at least every 4 years thereafter, to develop and report national air pollution control programmes (NAPCPs) presenting the measures they will put in place to comply with their emission reduction commitments. The NEC Directive emission reduction commitments are set in two steps, for 2020-2029 and for 2030 and beyond.

Lastly, the third pillar consists of source-based control legislation, comprising inter alia emission standards for key sources of pollution, from vehicle and ship emissions to energy and industry. These standards are set out at EU level in dedicated legislation.

Several European countries are also partnering in the international work to reduce emissions of black carbon. When the Arctic Council met in Fairbanks in 2017, the members set a joint aspirational goal to collectively reduce their black carbon emissions to 25-33% below 2013 levels by 2025.[19]

In the eastern part of the pan-European region, a recent policy development that deserves consideration is the Clean Air 2020-2024 Programme in the Russian Federation,[20] which is a part of the national Ecology Plan launched in 2018. The aim is a substantial reduction of air pollution by reducing emissions in 12 large industrial cities. The target is set to reduce emissions with 22% between 2017 and 2024. The target is supposed to be reached by investments in cleaner technologies, especially in the transport and energy sectors, and in improved air pollution monitoring. Russia currently accelerates renewal of its transport fleet in the appointed 12 cities together with a development of the network of reference air quality monitoring stations.[21] In 2020, it was suggested to expand the programme to 48 cities[22] – according to the proposed amendments in the federal law, dedicated emission reduction activities in the extended programme domain should start in 2022.

The Batumi Action for Cleaner Air (BACA)[23] – an initiative launched in 2016 – supports countries' efforts in improving air quality and welcomes voluntary commitments from countries and organizations. Several countries in the Eastern Europe and the Caucasus have submitted commitments on policy actions – e.g. Armenia committed[24] to revise the law on air protection that should reflect modern approaches to air protection such as control of air pollution via best available technologies (BATs). Commitments of Azerbaijan[25] include updating National Action Plan on Air Quality; Georgia committed[26] to improve air quality standards, Uzbekistan[27] – to improve national legislation on the protection of atmospheric air. Policy developments in Eastern Europe and the Caucasus are also enhanced by Association Agreements with the EU — as an example, within the activities pursuing the Agreement, Georgia is planning to transpose relevant parts of the EU legislation into the national law (UNECE 2019).

---

[19] https://oaarchive.arctic-council.org/bitstream/handle/11374/1910/EDOCS-4072-v5-ACMMUS10_FAIRBANKS_2017_Fairbanks_Declaration-2017.pdf?sequence=9&isAllowed=y

[20] https://rpn.gov.ru/activity/fresh-air/info/ (Federal Supervisory Natural Resources Management Service)

[21] https://www.envea.global/russia-envea-equips-air-quality-monitoring-stations-as-part-of-clean-air-program/

[22] https://www.rbc.ru/business/27/11/2020/5f884b339a794735d8d6caef

[23] https://unece.org/baca

[24] https://unece.org/DAM/env/efe/Batumi/Armenia.BACA.e.pdf

[25] https://unece.org/DAM/env/efe/Batumi/Azerbaijan.BACA.e.pdf

[26] https://unece.org/DAM/env/efe/Batumi/Georgia.BACA.e.pdf

[27] https://unece.org/DAM/env/efe/Batumi/Uzbekistan.BACA.e.pdf

3. Measuring progress towards improved air quality

The UNEP survey gives insights into the instruments used by countries to reduce emissions and what actions that have been taken the last five years. As indicated earlier the response rate does not allow for solid conclusions from the survey, and methodological differences impedes direct comparisons with the UNEP 2016 report. The information from the survey is therefore complemented with information from other sources. Half of the countries are members of the European Union and some additional countries are through the Schengen agreement or accession agreements connected to EU's legislation and reporting systems. Here it is only assumed that all the EU and Schengen countries apply EU law. This assumption implies that when the survey questionnaire relates to EU law it is considered that all EU and Schengen states adheres to the law. The figures presented below contain information from the survey, while the complementary information is provided in adjacent text.

3.1. National air quality standards and Legislation

The survey responses show that almost all the respondents have ambient air quality standards (Figure 12). Only 14 out of the 28 positive responses are from EU and Schengen states. Given that the EU Ambient Air Quality Directive (Directive 2008/50/EC) is in effect in all EU and Schengen states it is reasonable to add all EU member states as positive responses. With this the indication is that at least 46 countries in Europe have national ambient air quality standards. Out of the survey respondents, one country has newly implemented standards since 2016.

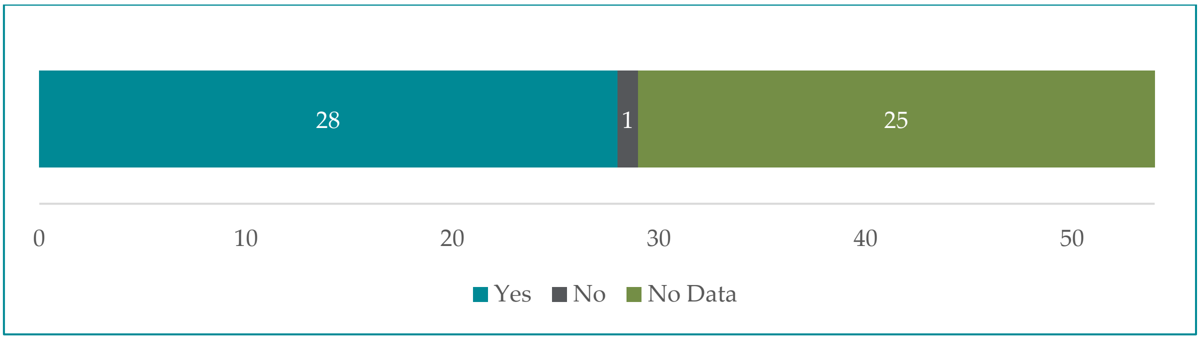

Figure 12: Does your country have national ambient air quality standards?

All the respondents with ambient air quality standards are regulating PM10, ozone, NO_x and SO_2, and 93% are regulating PM2.5, which has the greatest chronic effects on public health (Figure 13). Furthermore, 72% of the countries state that they regulate for NMVOC and 90% regulate Pb. Over 85% state that the above regulations are legally enforced. Air quality monitoring includes PM10, SO_2, NO_x, O_3 in all cases and PM2.5 in almost all cases.

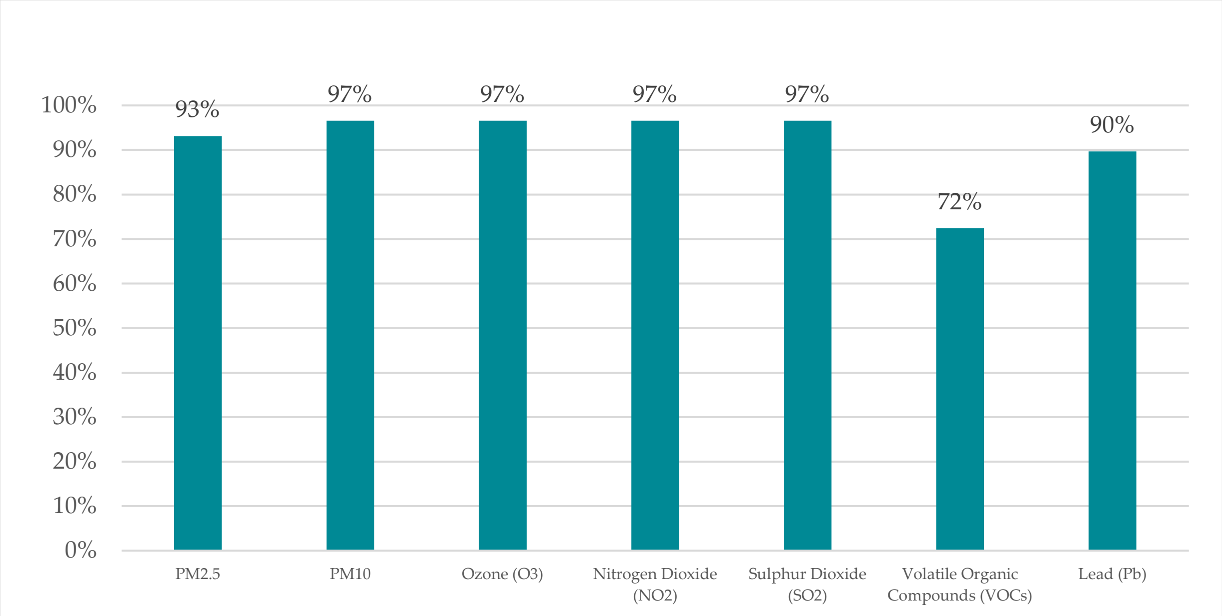

Figure 13: Which ambient air pollutants are regulated? % of responding countries that regulate for each pollutant.

Within the region, 24 countries (13 EU) (83%) state that they have a national air quality management strategy (Figure 14). Again, all EU and Schengen states fall under the Ambient Air Quality Directive and therefore need to have a strategy if they don't reach limit values for air quality. At least 42 countries therefore have air quality management strategies. In addition to the national air quality framework, 69% of the countries state that they have a clean air action plan at subnational level. The subnational levels are either on regional or city levels. These plans are often associated with large urban and industrial regions. Some countries, e.g. Belgium, Switzerland and the Netherlands have regional air quality plans for all regions in the country, while others have plans for one or several specific areas, e.g. Spain, Serbia and Finland.

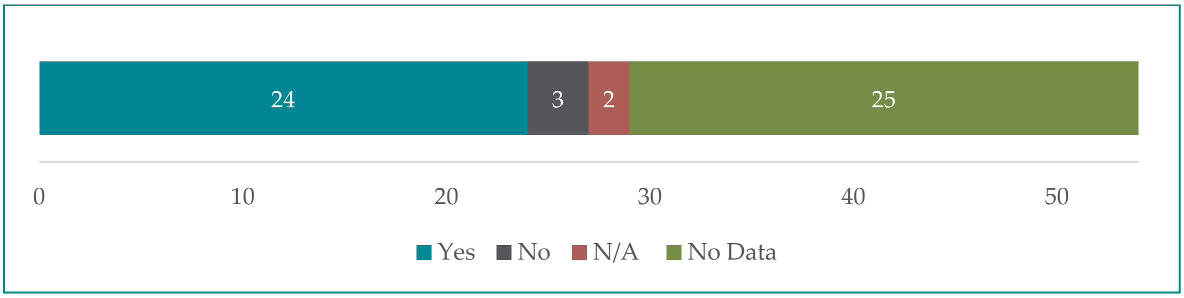

Figure 14: Is there a national air quality management strategy/framework/plan of action in the country?

3.2. In which sectors are measures taken to improve air quality?

As mentioned earlier in this report, most countries in the pan-European region have a long history in controlling air quality and emissions of air pollutants and heavy metals. The instruments used are all the instruments you can find in a policy instrument textbook. Command-and-control technology specifications, emission standards, integrated planning tools, environmental quality conditions in operational permits, emission taxes and fees, investment support schemes and information campaigns. This has encouraged an array of actions, and the primary means of emission reduction has for most air pollutants been fuel shifts and end-of-pipe emission controls. Shifts in operations as well as improved resource and energy efficiency within the industry have also been of importance.

The survey respondents indicate that over the past five years the largest increase in efforts to reduce emissions from electricity & heat production and industry has been in promotion of renewable energy and energy efficiency and in increasing the use of environmental impact assessments as support for investment and operational decisions. Interestingly the last five years have seen an increase in the usage of vehicle inspections to control emissions from road transport, but also the increased focus on electrical mobility has been important. To reduce emissions from waste treatment, the approach has been more focused on management plans and management regulations, while new efforts to reduce emissions from residential combustion mainly come in shape of increased focus on energy efficiency and green technologies for heating. Finally, emissions from agriculture are mainly controlled through construction of facilities such as closed-roof manure storage and methane capture for energy use. Although the survey responses indicate new efforts in all sectors, there are indications that initiatives to control emissions from waste management are evolving slower than for other sectors (7% had no new measures last five years). Control efforts within the agricultural sector have also been less successful.

3.2.1. Electricity & heat production and Industry

To abate emissions of air pollutants and heavy metals from electricity & heat production as well as from industrial production, the survey respondents are engaged in a variety of actions. The responses indicate that 76% have incentives and/or policies to promote cleaner production, energy efficiency and pollution abatement for industries (Figure 15), at least two more than in 2016. Some countries, including Norway and Sweden, use economic instruments such as environmental taxes, fees, and subsidies to control emissions. Examples in Sweden are sulphur taxes and refundable NO_x charges. Norway has an excise duty on emissions of NO_x from production of energy and offers exemption from payment for emission sources that are voluntarily affiliated with an agreement with the government committing themselves to fulfilling specific environmental protection objectives.

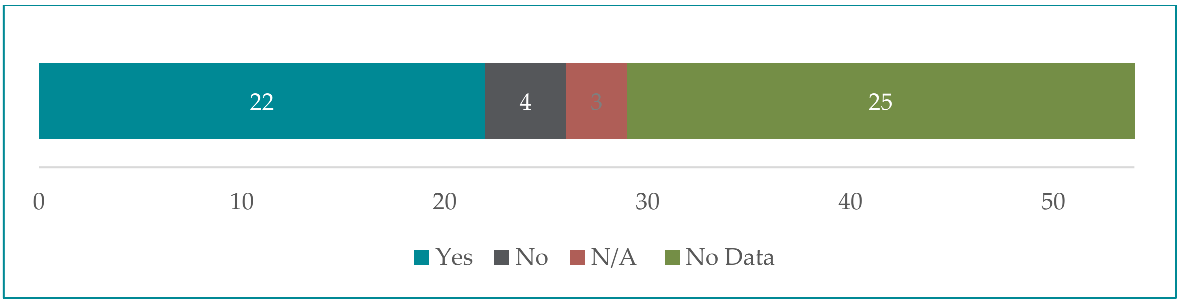

Figure 15: Are there incentives and/or policies in your country to promote cleaner production, energy efficiency and pollution abatement for industries?

A majority (66%) of the respondents report that they have national emission standard laws or regulations (Figure 16). Of these, 13 are EU or Schengen countries subject to EU legislation. Given the EU Industrial Emissions Directive (Directive 2010/75/EU), which sets emission standards for industries by law, at least 38 European countries have national emission standards for industries contained in legislation.

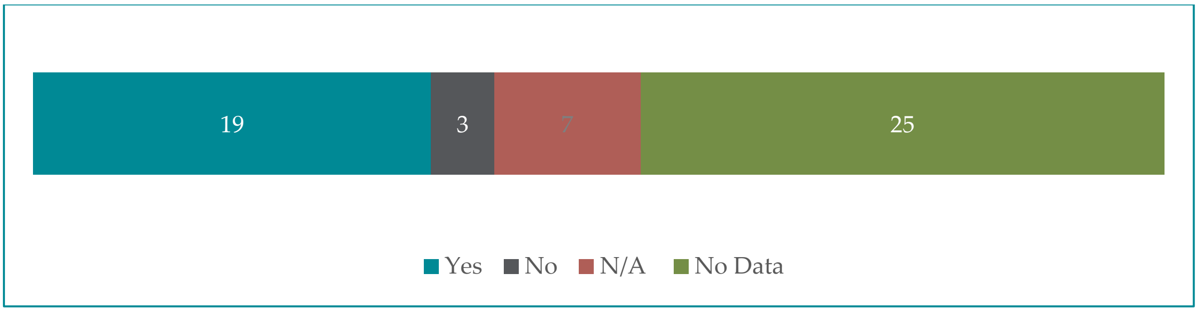

Figure 16: Are national emission standards for industries contained in laws or regulations?

During the last five years, a variety of measures are used to reduce emissions from the energy and industry sectors, including: (i) investment in renewable energy or energy efficiency, (ii) policies on efficient resource use, (iii) policies and legal structures to promote cleaner production, and (iv) use of environmental impact assessments to regulate industries (Figure 17). In general, these actions are leading to a decrease in emissions of both greenhouse gases and atmospheric pollutants. The legal instruments, e.g. emission standards, are generally the most important for regulating emissions of air pollutants.

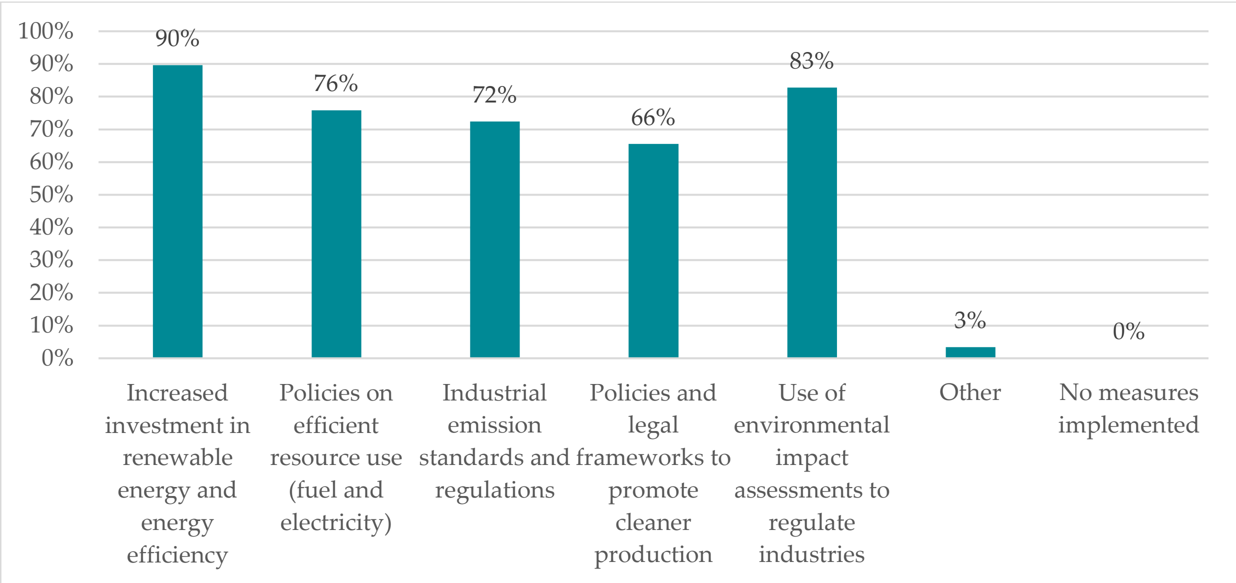

Figure 17: Which of the following measures have been implemented in the past 5 years (2015 – 2019)?

To ensure cost-effective action, it is important to check and evaluate the effectiveness of the actions. For electricity & heat production and industry, there is a wide variety of assessment methods in place. Most common is continuous air quality monitoring, followed by national emission inventories and air quality modelling and scenario analysis (Figure 18).

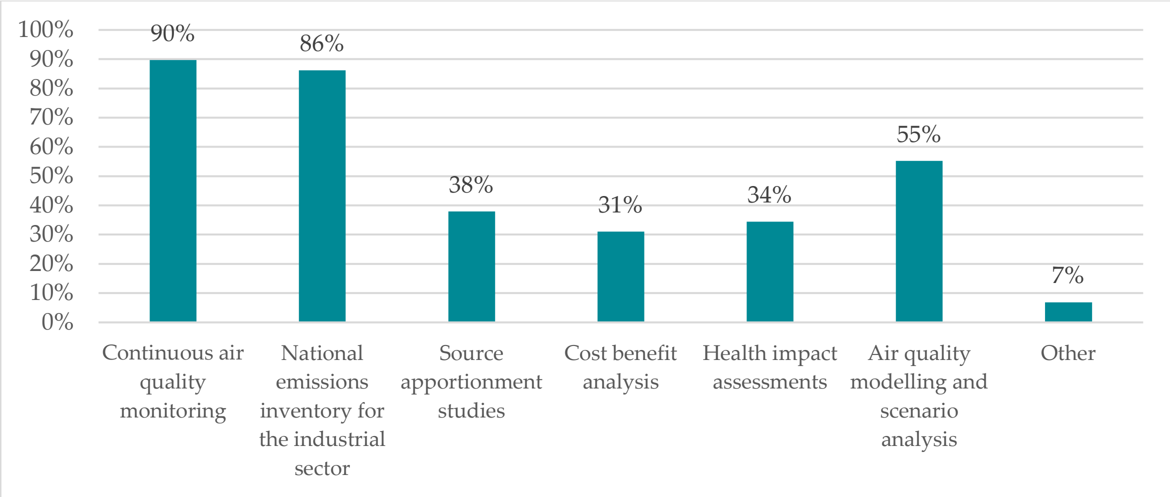

Figure 18: How is the impact of the measures measured?

3.2.2. Transport

Transportation, including road traffic, represent an important source of air pollution, especially in urban areas where the high density of emissions and high population density significantly enhance human exposure (Apte et al. 2012, Karagulian et al. 2015). Thus, policies to reduce vehicle emissions are of high priority. In many European countries, including EU members, the use of low sulphur fuels and engine exhaust treatment systems has been in place since the early 90-ies. The EU emission standards are graded into different classes, so-called Euro-classes, corresponding to increasing requirements on emission control with increasing class number. There have been continuous problems with achieving the required emission reduction in real-world driving conditions. This is partly due to imperfect exhaust gas test procedures, and partly due to some car manufacturers deliberately manipulating the performance of diesel cars' emissions control systems, a practice revealed in the infamous Dieselgate.[28]

Of the respondents to the UNEP questionnaire, only one country specified that no vehicle emission standards are used (Figure 19). In the same way as for electricity & heat production there is EU legislation in place mandating which vehicle emission standards to apply in EU. Correspondingly there are at least 43 countries in Europe with vehicle emission standards, out of which four have implemented stricter standards than in 2016.

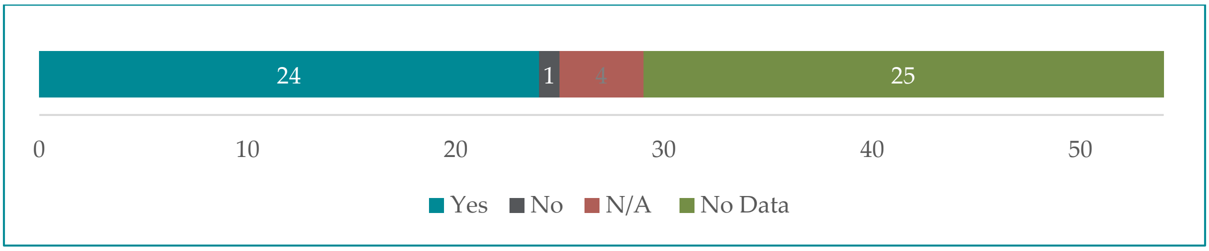

Figure 19: Are there national vehicle emission standards in your country?

[28] https://www.cleanenergywire.org/factsheets/dieselgate-timeline-car-emissions-fraud-scandal-germany

Out of the 24 countries that responded to the survey question on vehicle emission standard, 59% specify that they have standards higher than Euro 4 equivalent (Figure 20). These include the EU member states and Andorra, Monaco, North Macedonia, the Russian Federation and Serbia.

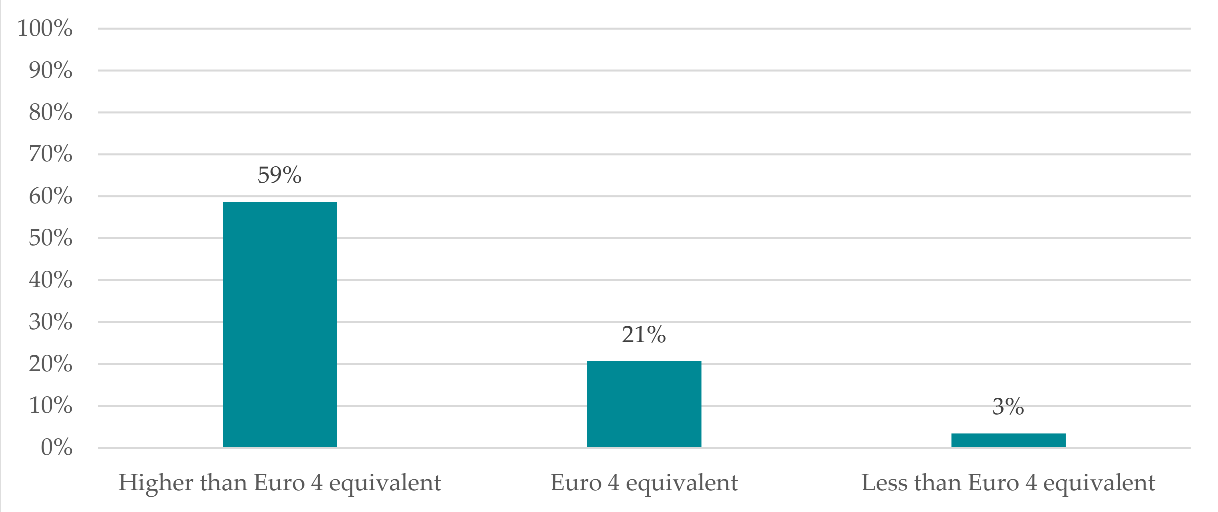

Figure 20: Type of vehicle emission standard currently in force.

Most countries are also setting standards for low or even ultra-low (<10 ppm) levels of sulphur in fuel (Table 5). Interestingly, the reason for having low-sulphur fuels have partly changed over the years following the introduction of more advanced vehicle engine exhaust technologies. What used to be motivated by environmental concern is now also being motivated by requirements for exhaust technologies to function.

Table 5: What is the maximum allowable sulphur level in petrol, by law?

What is the maximum allowable sulphur level in petrol, by law?		
	Diesel	Petrol
0 – 50 parts per million (ppm)	76%	76%
51 – 500 ppm	3%	3%

During the last five years these traditional ways to reduce emissions from road transport were not the most prominent according to the survey responses. Of increasing importance is instead the increased efforts on promoting electric mobility and launching vehicle inspection and maintenance programmes (Figure 21). Increased efforts to introduce stricter vehicle standards and improving public transport are also important though.

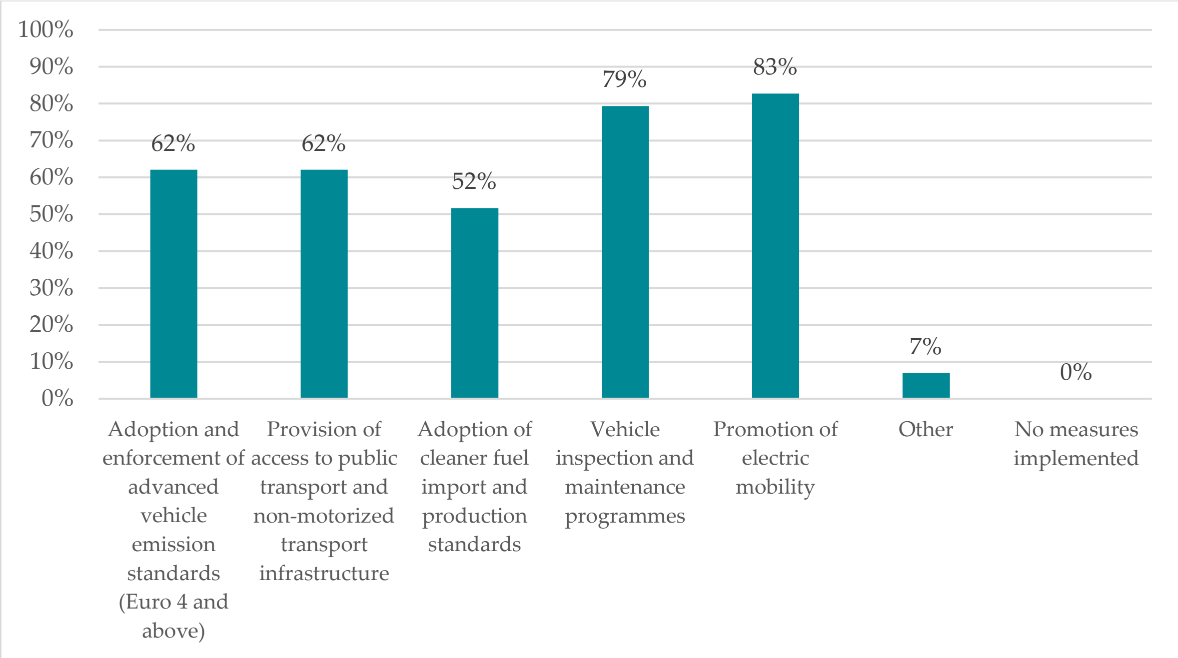

Figure 21: Which of the following measures have been implemented in the past 5 years (2015 – 2019)?

3.2.3. Waste management

The survey results indicate that waste management practices are varying across the European region. What is considered here is open burning of waste from several different types of activities such as agriculture, municipal (household) waste and other types of solid waste. Only 17 of the countries (11 EU member states) indicated that open burning of waste is strictly regulated, whilst 8 countries indicated that open burning is regulated but practiced (3 EU member states) (Figure 22). The EU member states are subject to regulations of agricultural waste burning in the NEC Directive and the Common Agricultural Policy (CAP), as well as in the EU Waste Framework Directive (Directive 2008/98/EC). The existence of EU regulations implies that at least 38 European countries have strict (but somewhat flexible) bans, corresponding to six more countries than in 2016. Nevertheless, open burning of waste is still practiced in several European countries.

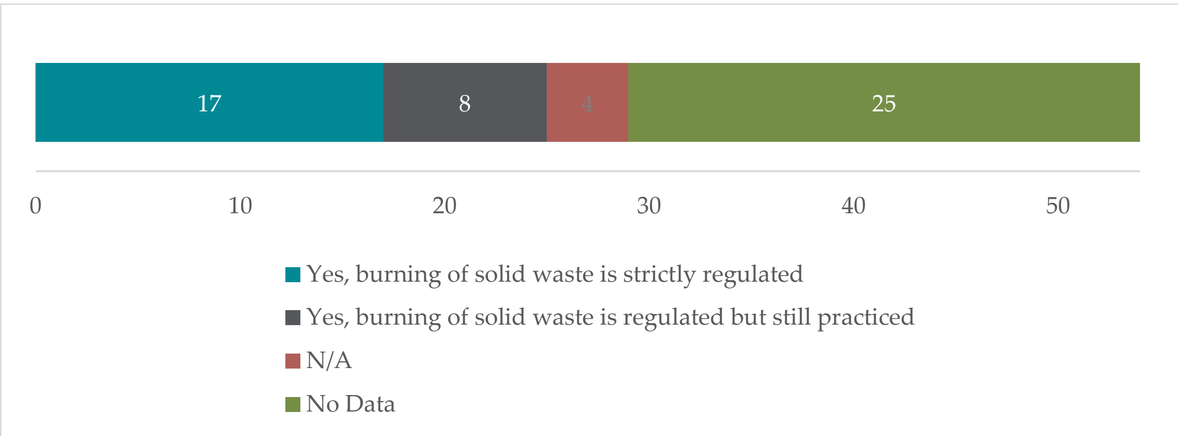

Figure 22: Is open burning of agricultural, municipal and/or other forms of solid waste prohibited by law or provisions?

To improve waste management practices, the survey results indicate a relatively large variety of actions in the European countries. During the last five years, actions such as improved management plans, strengthened general regulations and regulation of open waste burning have been implemented. But there has also been focus on improving technical practices such as recovery of landfill gas, improved waste fraction separation, collecting and recycling waste. Even campaigns for behavioural change have been common (Figure 23).

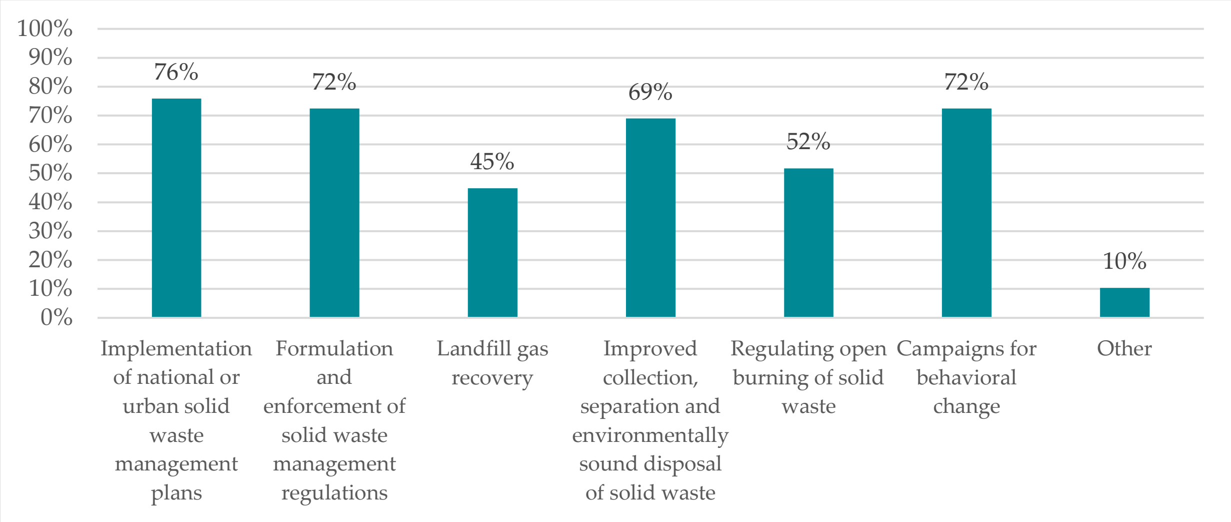

Figure 23: Which of the following measures have been implemented in the past 5 years (2015 – 2019)?

3.2.4. Residential cooking and heating

The survey results suggest that natural gas and LNG are the most used source of energy for cooking and heating among the responding countries, closely followed by biomass and charcoal, and electricity a distant third. It is also encouraging to see 70% of the respondents presenting national programmes for clean energy in households (Figure 24), the same rate as in 2016.

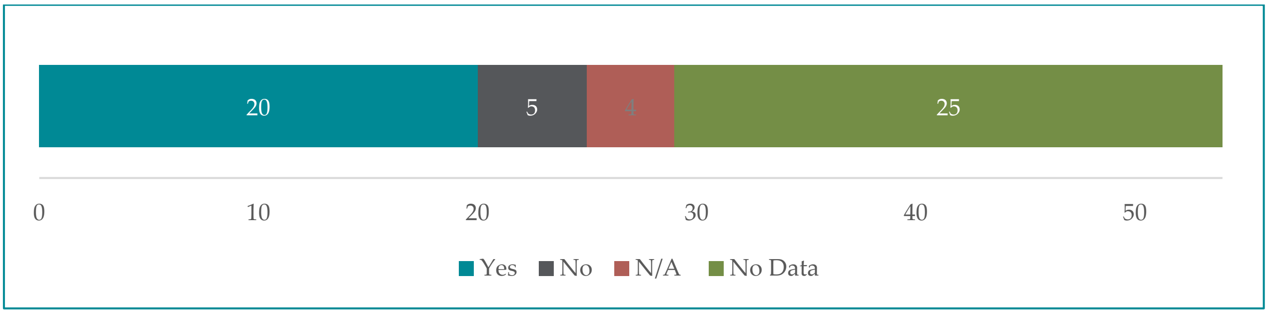

Figure 24: Are there national programmes that promote use of clean energy in households for cooking and heating?

Solid fuel combustion has become one of the most important sources of PM2.5 emissions in Europe. Using low emission cooking stoves for combustion of wood and charcoal is therefore often considered a key solution to reduce emissions from cooking and heating, but the survey results indicate that focus for action lies more on encouraging clean technologies and energy efficiency (Figure 25). Emission-reducing actions aimed at households are also the most diverse compared to actions in other sectors. Several interesting examples are worth mentioning. Monaco is introducing bans on certain fuels by 2022 as well as new energy regulation for buildings. Norway is phasing out the use of oil boilers for heating in larger buildings by banning them from 2020. In Poland there are anti-smog resolutions implementable in separate subnational regions/agglomerations. More examples are given in case study 2.

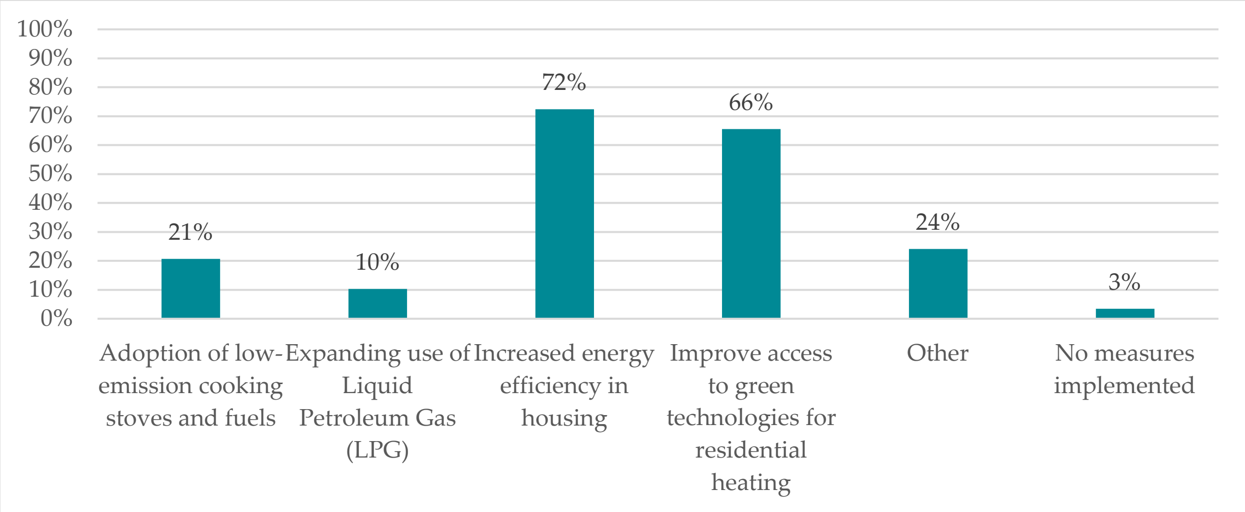

Figure 25: Which of the following measures have been implemented in the past 5 years (2015 – 2019)?

3.2.5. Agriculture and Forestry

Agricultural emissions of ammonia are in all parts of Europe still increasing or remaining stable, despite being regulated both under the UNECE Air Convention and through the EU NEC Directive. Controlling agricultural emissions are more difficult than other sources, much due to the large areas over which much of the emissions occur. Nevertheless, 75% of the respondents are promoting sustainable agricultural practices (Figure 26).

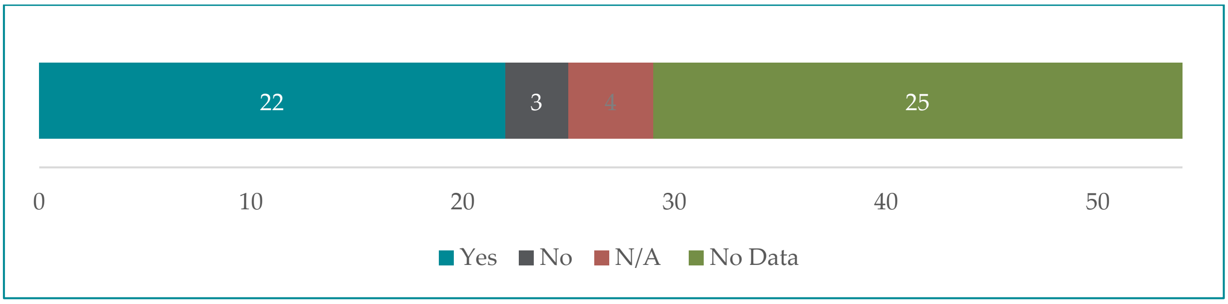

Figure 26: Does your country have incentives to promote sustainable agriculture?

During the last five years, actions have been taken to reduce emissions of PM2.5, NH_3 and methane within the agricultural sector. Like for residential cooking and heating, the actions in agriculture have been quite diverse, ranging from encouraging changes in practice with respect to open burning of agricultural waste, technological solutions to improve manure management and capture of methane gas, as well as food processing changes to reduced food waste (Figure 27). Just as for emissions from electricity & heat production and industry, progress of the actions is mainly monitored through air quality measurements and emission inventories.

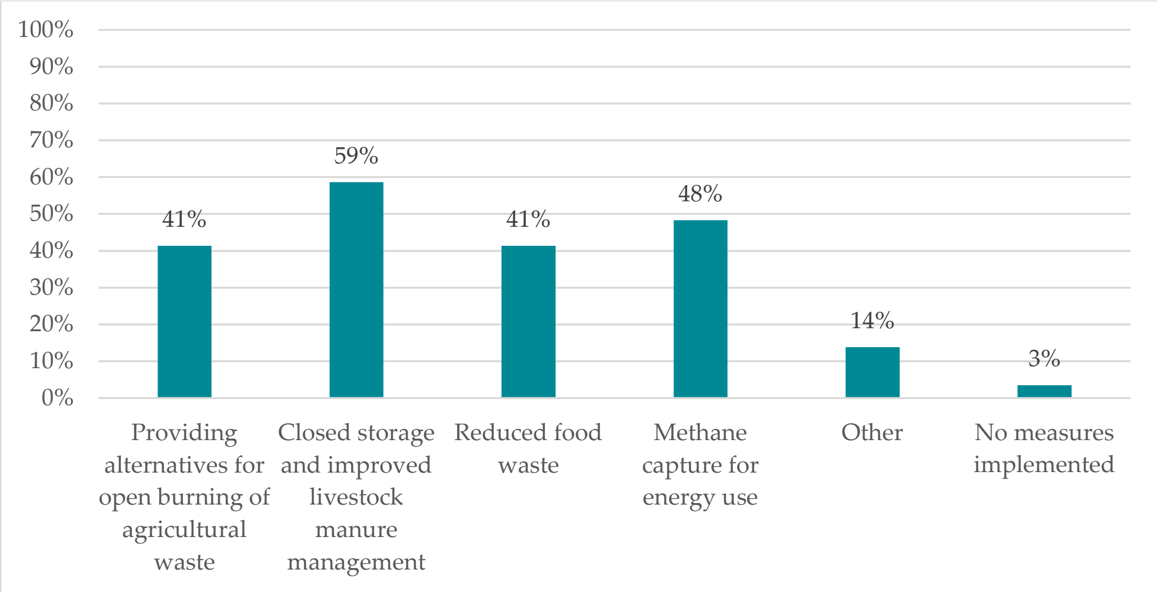

Figure 27: Which of the following measures have been implemented in the past 5 years (2015 – 2019)?

3.2.6. Common integrated approaches to curb climate change and improve air quality

The survey responses also show that countries are well aware of the existing large co-benefits between air pollution and climate change control. In fact, most of the top actions during the last five years are all co-beneficial actions such as focus on energy efficiency, electrification, and renewable energy. It deserves to be stressed yet again though, that not all renewable energy sources are co-beneficial in their nature. The absolute best option, in addition to energy efficiency options, is production of electricity and heat without the combustion of fuel, such as solar and wind power. To what extent the co-benefit potential of renewable energy investments has been captured is unfortunately not possible to extract from the survey responses.

3.3. Lessons learnt and policy uptake

Overall, for Europe and Central Asia, statistics over emission trends, the responses to the UNEP survey questionnaire and other complementary information provides some interesting lessons to bring forward. Countries within the European region are in general aware of the air pollution problem and particularly its importance for health effects. The maturity of scientific understanding and taking actions are however varying. Western and Central Europe have a well-developed system of key activities including emission inventories, air quality monitoring, data reporting and auditing, standards, and implementation activities. To some extent these activities are supported by assessments, analyses of cost-effectiveness and cost-benefit, and scenario development.

The situation is however quite different in parts of South Eastern Europe, Eastern Europe and the Caucasus, and Central Asia. In many countries, activities related to air quality assessment and control are limited, even if progress is seen. The awareness is high in all countries and most countries report that they are promoting actions in terms of investments in renewable energy and energy efficiency as well as road vehicle fuel and emissions standards. For some countries, particularly those in Eastern Europe (including Ukraine, Belarus, and Russia), emission inventories and air quality monitoring networks are approaching standards that are common in Western and Central Europe.

There are also some observations of relevance for all European countries. Officially reported emission data on heavy metals often lack in consistency and there is a need for improvements, particularly for non-EEA countries. To support effective policy, it is also important for all European countries to complement the established air quality monitoring and emission inventory systems with prospective emission scenarios, in which the different scales in air pollution distribution and control are assessed together with regulation options, including their costs and benefits.

For many of the key emission sectors, there has been an active engagement in taking action to reduce emissions. The survey results indicate, however, that it is necessary to increase the efforts to reduce emissions from domestic solid fuel burning, waste management and most importantly to reduce ammonia emissions from the agricultural industry.

4. Case studies

4.1. Case study 1

Eurocities - the leading network of major European cities working together to ensure a good quality of life for all

Eurocities is a network of 190 cities in 39 countries, representing 130 million people. Through joint work, knowledge-sharing and coordinated Europe-wide activity, it ensures that cities and their people are heard in Europe and the EU, with the aim to create a better future characterized by inclusive societies, prosperity, an healthy environment, vibrant and open public spaces, and city governments fit to address global challenges and the future.

The environment is the one of the most heavily regulated area in Europe. Despite this, the concentration of air pollutants in our cities is leading to thousands of premature deaths each year. Urban air pollution can only be tackled effectively through coordinated action across local, national and EU levels, and across sectors including transport, agriculture, shipping and electricity & heat production. Better collaboration and dialogue among all stakeholders and levels of government is essential as well as more coherent EU legislation that aligns the goals of the air quality with the goals of EU source legislation.

Eurocities member cities gather together in thematic forums (Environment, Mobility, Social Affairs, Economic development) and working groups (on air quality, noise, sustainable mobility planning, smart and connected mobility, etc.), which support cities in their efforts to bring about a better environment and work towards achieving sustainable development, sharing knowledge and expertise.

Eurocities has been advocating for years for aligning EU air quality standards with scientific evidence, better implementation of EU air quality legislation at all levels, and to urge the EU institutions to remove provisions that allow car manufacturers to exceed the legal limits. Among other publications, in 2020 the network produced a policy paper on the revision of the alternative fuels infrastructure directive.

Cities that are members of the Eurocities network are committed to deliver better air for their citizens, and they are taking bold action to fight pollution using all instruments in their powers: they are promoting cleaner and quieter vehicles, encouraging a shift to alternative modes of transport, engaging and communicating with citizens on good practices.

London, for example, has created an Ultra Low Emission Zone (ULEZ), in which charges are paid by more polluting vehicles, that has nearly halved NO_2 pollution in central London. The ULEZ will expand to cover all of inner London from October 2021, improving air quality for millions of people. Since 2016 emissions from London's 9,000-strong bus fleet have been reduced by an average of 90%, there are now nearly 4,000 zero emission capable taxis and nearly 6,000 charge points for electric vehicles.

Berlin has been using socio-spatial distribution maps of air pollutants for urban planning and design of air quality measures to account for social equity in air pollution exposure and related health effects, promoting e-mobility, and built green infrastructures to create connectivity across the city.

The city of Paris supports sustainable development initiatives and prioritises environmentally friendly and sustainable mobility projects. One example is the development of an ambitious soft mobility plan, which includes an additional 50 kilometres of bike lanes aimed for residents and tourists.

Gothenburg is launching a cutting-edge innovation project on clean mobility. Sweden's second largest city, and home to the biggest port in the Nordic region, is establishing a "Green Zone", where fully climate-neutral and zero-emissions transportation systems will be deployed and tested, with the aim of bringing the Gothenburg region closer to its aim of achieving 100% emission-free transport by 2030.

Furthermore, Eurocities members are implementing a series of projects and initiatives with its members, to pilot innovative solutions that reduce congestion in urban areas, boost e-mobility market take-up, foster the deployment of zero-emission logistics, mobilise local governments and citizens around sustainable mobility through the European Mobility Week, and help to end exceedances of EU air quality standards as soon as possible through the Green City Accord.

4.2. Case study 2

In the wider Western Balkans region, problems are growing but solutions are on the horizon

Air pollution is directly responsible for up to one in five premature deaths in 19 Western Balkan cities, meaning they experience some of the worst air quality in Europe.

As for most of Europe, fine particulate matter (PM2.5) is most responsible for health impacts such as cardiovascular and respiratory diseases. The economic effects of air pollution in the Western Balkans are also notable. By some estimates, air pollution eats over 21.5% of Bosnia and Herzegovina's GDP through lost work and school days, healthcare and fuel costs.

Thermal power plants and individual heating (both public and residential) represent the main emitters of particulate matter. Given its low cost and abundancy, low quality lignite is the major energy source in the region. A recent study has shown that 16 outdated coal power plants from the Western Balkan are costing health systems and economies a total of EUR 6.1-11.5 billion each year, of which the EU bears EUR 3.1-5.8 billion, compared to the economic burden on the Western Balkan countries estimated to be EUR 1.9-3.6 billion.

Large urban areas such as Sarajevo (Bosnia and Herzegovina), Belgrade (Serbia), Skopje (North Macedonia) and Sofia (Bulgaria) are particularly affected by poor air quality. During winter, when solid fuels are commonly burned to heat homes, these cities are among the worst polluted cities in the world. The situation becomes further aggravated by the fact that energy poverty – a condition generally recognized to exist when people spend a disproportionate share of their income on fuel to heat their homes – is widespread in the region[1]. Indeed, more than 60% of people living in the Western Balkans use solid fuels such as coal and firewood to heat their homes, with only 12% of buildings connected to district heating systems. Other important contributing factors to the problem are aging vehicle fleets and pollution from industry.

As a result, on average city dwellers in the Western Balkans lose up to 13–16 months of life to air pollution, and the total number of premature deaths directly attributable to air pollution in the region is nearly 5,000 per year[1].

Even though air quality monitoring systems are in place, the lack of financing for maintaining stations and the absence of both certified calibration laboratories and air quality modelling is evident throughout the region. As a result, inconsistency and data gaps limit the possibilities of conducting thorough analyses and compromise the ability to monitor long-term health impacts and formulate targeted policy responses[1].

Nevertheless, solutions to these problems are being sought and several country-wide and local initiatives to promote and achieve cleaner air are ongoing in the region:

- Six Bulgarian municipalities are working together to improve air quality in the EU integrated project LIFE IP CLEAN AIR. One of the main project aims is to develop and test a new demonstration scheme to replace heating installations in 500 households and apply this scheme in around 10,000 households in the 6 municipalities. The scheme envisages replacing wood and coal to pellets, gas or use of the district heating network. The project is underway and has started in Sofia. This year, after an information campaign, the first 140 candidates will be included in the demonstration phase. In April 2021 candidates will continue to be recruited until the 5,000 households in Sofia municipality are reached.
- **Sarajevo Canton's Strategy for Restricting the Use of Coal and Other Solid Fuels** in Sarajevo Canton for 2021-2031, is the first tangible decarbonization plan in Bosnia and Herzegovina. The strategy has been developed in cooperation with the UNDP country office in Bosnia and Herzegovina with support through UNDP's Green Economic Development project. The Sarajevo Canton has started to work on an action plan for its implementation. One example is that the Strategy will include a gradual ban on the use of coal in houses and in multi-apartment buildings, as well as in buildings owned by companies and the public sector. This is an important step to improve air quality. UNDP is also working with the Cantonal government on a subsidy scheme for the replacement of coal furnaces in households with more efficient heating systems.

- Bosnia and Herzegovina has considerably improved its air quality monitoring capacity and a national air quality index has been created. The UN Environment Programme has helped by procuring and maintaining monitoring stations and has contributed to the creation of the index. "Six or seven years ago, we could only monitor two types of data per day. Today, on an hourly basis, we have 60 different results", said Enis Omerčić, air quality specialist at the Federal Hydro-Meteorological Institute, in Sarajevo, in 2019.
- One factor behind the increasing attention to air quality in the North-Macedonian capital of Skopje has been the AirCare monitoring app. The app provides comprehensive, easily understandable graphics and has spurred many citizens to call for action from local authorities and policymakers to deal with the issue.
- Another example from Skopje is an investment subsidy scheme to replace old wood stoves and oil boilers with inverter air conditioners. The scheme was in place during 2020 and there were more than 4000 applications made for the <1000 EUR subsidy.
- Since 2015, the City of Užice, one of the most polluted cities in Serbia, has co-financed application of energy efficiency measures in 609 individual residential buildings, aiming to reduce harmful emissions by switching to environmentally friendly fuels, achieve energy savings by better insulation of buildings and increase awareness of citizens to rationally use energy for heating in family homes. In addition to these efforts, the city invested in a significant number of energy efficiency studies targeting public buildings, awaiting opportunities for co-financing of energy efficiency projects including thermal rehabilitation and conversion of heating systems.

Environment ministers from South East and Southern Europe have acknowledged that air pollution is a recurring environmental emergency causing severe environmental damage, threatening countries' safety, security, and sustainable development, and taking a severe toll on human health. In response, and in order to support countries in accelerating and upscaling initiatives addressing pollution, the United Nations Environment Programme (UNEP) initiated the establishment of the **South East European Platform to Beat Pollution (SEEPP),** a regionally-owned institutional platform to catalyse action and facilitate regional coordination.

4.3. Case study 3

Eastern Europe, Central Asia and the Caucasus – joint efforts and capacity building on the way to clean air

The need for more active participation of the countries in Eastern Europe, Central Asia and the Caucasus (EECCA region) in the work of the UNECE Air Convention was recognized years ago. In 2010, the Coordinating Group on promotion of actions towards implementation of the Air Convention in countries of Eastern Europe, Caucasus and Central Asia (EECCA Coordinating group) was established. Led by the Russian Federation, the Coordinating group focuses on broad information exchange and capacity building and efforts to facilitate ratification processes in the EECCA countries, which have similar problems and barriers on the way. By making efforts to formulate one joint standpoint, which as much as possible reflects concerns of all countries across the EECCA region, the Coordinating group strengthens the position of the EECCA countries in negotiations under the Convention and lowers ratification thresholds. In the latest amendment (2012) of the Gothenburg protocol to Abate Acidification, Eutrophication and Ground-level Ozone, ratification requirements for the EECCA countries are more flexible than for other Parties - this is due to the active position of the EECCA Coordinating group.

The work of the Coordinating group has been actively supported by the Convention's secretariat, which further enhanced joint efforts of the EECCA countries to ratify Air Convention protocols by commencing a comprehensive capacity-building programme in 2014. EECCA Coordinating Group was actively involved in organization of several capacity-building activities within the programme, which are still on-going. The programme, implemented in close cooperation with several Air Convention bodies, resulted in notable progress in the countries' involvement in the Convention work:

- **Analysis of national legislation and development of national action plans enhances progress towards ratification.** By now, almost all EECCA countries have introduced relevant changes in the national legislation and/or developed designated national action plans on ratification of the Convention and its protocols – many of these national action plans are developed recently within the programme.

- **The quality and completeness of submitted emission inventories improves.** Apart from workshops on emission inventories organized by the Secretariat, special sessions for participants from the region were held at the annual meetings of the Task Force on Emission Inventories and Projections (TFEIP) in 2015, 2017 and 2018. In 2013, five countries submitted their emission inventories, from which one country also submitted the Informative Inventory Report (IIR) describing the inventory methodology. In 2018, the number of countries that submitted their inventories and IIRs was seven and five, respectively (Figure 28).

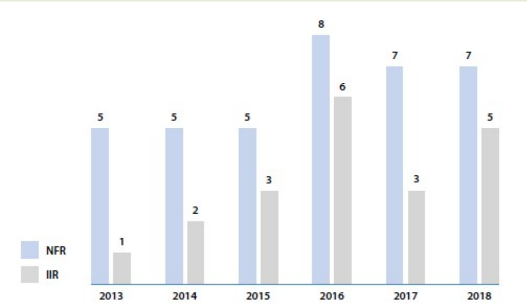

Figure 28: Number of EECCA countries that submitted air pollutant emission inventories (NFR) and Informative Inventory Reports (IIR), copied from On the Way to Clean Air

- **Understanding and implementation of Best Available Techniques (BATs) are facilitated by information exchange.** Implementation of BATs is a requirement for ratification of the most recent Air Convention protocols (as amended), which makes understanding of BATs and the ways to implement them in practice crucial for the Parties. In 2016 – 2019, the Task Force on Techno-Economic Issues (TFTEI) under the Convention organized BAT-workshops for EECCA countries, where experts shared information on existing approaches to implementation of BATs.

- **Air Convention participation and awareness rises.** The programme enhanced participation of delegates from EECCA countries in the meetings and activities under the Convention, resulting in more active exchange of information on challenges and progress in implementation. The programme events and publications continue to draw attention to main sources and effects of air pollution in the EECCA region and to highlight the benefits of joining the Convention and its protocols.

4.4. Case study 4

Central Asia - public awareness on air quality. Power of citizen knowledge.

While air quality management has improved in many places around the world, progress has been uneven. In Central Asia emission levels are increasing, and some Central Asian cities are frequently ranked among the most polluted in the world during the winter heating period, largely due to burning of coals and poor quality fuels for wintertime heating needs, emissions from coal-powered electricity generation, increase in numbers of private vehicles, and rapid and unregulated urban development compounded by local meteorological conditions and thermal inversion events.

Public awareness around air quality issues has been relatively low among the countries in Central Asia until recently, although it is increasing in certain key polluted cities, notably Almaty (Kazakhstan) and in Bishkek (Kyrgyzstan), the later frequently ranked among the world's cities with the worst air pollution during the winters 2019-20 and 2020-21 on IQAir. While the understanding of the negative effects of poor air quality and the need for action is increasing among Central Asian countries, continuing efforts to improve public awareness around air quality is crucial to driving action to reduce the negative effects of air pollution and ensure positive environment and health outcomes.

Signs of positive developments around public awareness have been seen in some Central Asian countries. For example, in Kazakhstan's largest city Almaty, a citizen-led network has set up air quality monitors around the city. After having certified 10 of these devices in the city, Kazakhstan's national hydrometeorological agency, Kazhydromet, now uses the data along with the official data it collects through the national air quality monitoring network. Kazhydromet also launched an app for the public (AirKz) displaying data from the citizen-led network in real time. City air quality data is also displayed on LED screens around the city to inform the public. The aim of this is to raise Almaty residents' awareness of the air quality in their urban environment and empower citizen action. While some action has been promoted by national and local authorities, more action is needed to mitigate the effects of poor air quality.

UNEP, UNDP, the World Bank and the US State Department are active in the region to support national efforts towards improving air quality. Several projects are being developed or are currently being implemented by international and national actors, notably in Kazakhstan, Kyrgyzstan and Uzbekistan. The focus of most of these projects is to strengthen regulatory and monitoring capacity of government actors and expand public awareness of air quality issues. The examples are:

- Automation of air pollution monitoring in Uzbekistan. The project is implemented by Zamin International Public Foundation in collaboration with Uzhydromet and technical and institutional support from UNEP. The project includes an open access platform and mobile app 'AirUz' to display monitoring results, making air quality monitoring data and recommendations depending on air quality publicly available for the very first time in Uzbekistan. Moreover, for the first time two automatic air quality monitoring stations have been installed, providing data on air quality online on a half-hour basis (including data on PM2.5 and PM10). On the basis of this pilot project, work is underway to deploy automatic monitoring stations in all regions of the country.
- Joint UNEP Europe Office-UNDP Country Office for Kyrgyzstan's Assessment of Air Pollution and its impacts on Human Health in the Kyrgyz Republic. This project includes identification of emission sources, analysis of health impacts in collaboration with the World Health Organization (WHO), and the formulation of recommendations for air quality improvement measures for the country's capital Bishkek.
- Building Air Quality Management Capacity in the Kyrgyz Republic and Kazakhstan and supporting action on air pollution in Central Asia. This US State Department-funded project is led by MoveGreen Public Foundation (Kyrgyzstan) in partnership with KyrgyzHydroment and Kazhydromet, Association of Practicing Ecologists (Nur-Sultan) and ArzKaz (Almaty) with the expert support of UNEP and UNDP. The project aims to strengthen the regulatory and monitoring capacity of government actors and expand awareness of air quality issues among decision makers and the general public in the Kyrgyz Republic and Kazakhstan. It also aims to promote broader regional collaboration on air quality among civil society actors and decision-makers in Central Asia, supported by UNEP and in coordination with the BreathLife campaign. One of the key objectives of this project is to enhance capacity of government agencies to monitor air quality through deployment of low-cost PM2.5 and other sensors, building upon results of similar citizen-led initiatives in both countries, notably the https://airkaz.org/ network in Kazakhstan and the sensors deployed by MoveGreen in Kyrgyzstan in 2017 which comprised at that time the first PM2.5 monitoring network with real-time data available in the country.

References

Amann, M., et al. (2020). Support to the development of the Second Clean Air Outlook, https://ec.europa.eu/environment/air/pdf/CAO2-MAIN-final-21Dec20.pdf

Apte, J. S., et al. (2012). "Global intraurban intake fractions for primary air pollutants from vehicles and other distributed sources." Environ Sci Technol **46**(6): 3415-3423 10.1021/es204021h.

Belis, C. A., et al. (2019). "Urban pollution in the Danube and Western Balkans regions: The impact of major PM2.5 sources." Environ Int **133**(Pt A): 105158 10.1016/j.envint.2019.105158.

Bond, T. C., et al. (2013). "Bounding the role of black carbon in the climate system: A scientific assessment." Journal of Geophysical Research: Atmospheres **118**: 5380-5552 DOI: 10.1002/jgrd.50171.

Bowerman, N. H. A., et al. (2013). "The role of short-lived climate pollutants in meeting temperature goals." Nature Climate Change **3**(12): 1021-1024 DOI: 10.1038/nclimate2034.

Colovic Daul, M., et al. (2019). Air Pollution and Human Health: The Case of the Western Balkans, https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwjrpYnVrsHvAhUlxosKHZ0ZDbUQFjADegQIAxAD&url=https%3A%2F%2Fwww.developmentaid.org%2Fapi%2Ffrontend%2Fcms%2Ffile%2F2019%2F06%2FAir-Quality-and-Human-Health-Report_Case-of-Western-Balkans_preliminary_results.pdf&usg=AOvVaw1mEnan6RmehHdvVJ0nDQTJ

EMEP (2014). Transboundary air pollution by main pollutants (S, N, O3) and PM – Turkmenistan, https://emep.int/mscw/mscw_publications.html#2014

EMEP (2016). Transboundary air pollution by main pollutants (S, N, O3) and PM – Kazakhstan in the extended EMEP domain, https://www.emep.int/publ/reports/2016/Country_Reports/report_KZT.pdf

EMEP (2016). Transboundary air pollution by main pollutants (S, N, O3) and PM – Uzbekistan, https://emep.int/publ/reports/2016/Country_Reports/report_UZT.pdf

EMEP (2018). Transboundary air pollution by main pollutants (S, N, O3) and PM – Tajikistan, https://www.emep.int/publ/reports/2018/Country_Reports/report_TJ.pdf

EMEP (2019). Transboundary air pollution by main pollutants (S, N, O3) and PM in 2017 – Kyrgyzstan, https://www.emep.int/publ/reports/2019/Country_Reports/report_KG.pdf

EMEP (2020). Transboundary particulate matter, photo-oxidants, acidifying and eutrophying components, https://emep.int/publ/reports/2020/EMEP_Status_Report_1_2020.pdf

Etminan, M., et al. (2016). "Radiative forcing of carbon dioxide, methane, and nitrous oxide: A significant revision of the methane radiative forcing." Geophysical Research Letters **43**(24): 12,614-612,623 DOI: 10.1002/2016gl071930.

European Commission (2018). 2017 road safety statistics: What is behind the figures? Brussels, europa.eu/rapid/press-release_MEMO-18-2762_en.pdf

European Commission (2021). Report from the commission to the european parliament, the council, the european economic and social committee and the committee of the regions - the second clean air outlook, https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52021DC0003&from=EN

European Environment Agency (2020). Air quality in Europe — 2020 report, https://www.eea.europa.eu/publications/air-quality-in-europe-2020-report

European Union (2016). Directive (EU) 2016/2284 Of The European Parliament And Of The Council of 14 December 2016 on the reduction of national emissions of certain atmospheric pollutants, amending Directive 2003/35/EC and repealing Directive 2001/81/EC, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv%3AOJ.L_.2016.344.01.0001.01.ENG

Forster, P., et al. (2007). Changes in Atmospheric Constituents and in Radiative Forcing. Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. S. Solomon, D. Qin, M. Manning et al. Cambridge, United Kingdom, Cambridge University Press.

HEAL, et al. (2019). Chronic coal pollution - EU action on the Western Balkans will improve health and economies across Europe, https://www.researchgate.net/publication/331487746_Chronic_coal_pollution_-_EU_action_on_the_Western_Balkans_will_improve_health_and_economies_across_Europe

Karagulian, F., et al. (2015). "Contributions to cities' ambient particulate matter (PM): A systematic review of local source contributions at global level." Atmospheric Environment **120** 10.1016/j.atmosenv.2015.08.087.

Maas, R. and P. Grennfelt (2016). Towards Cleaner Air - Scientific Assessment Report 2016. R. Maas and P. Grennfelt. Oslo, EMEP Steering Body and Working Group on Effects of the Convention on Long-Range Transboundary Air Pollution, http://www.unece.org/fileadmin/DAM/env/lrtap/ExecutiveBody/35th_session/CLRTAP_Scientific_Assessment_Report_-_Final_20-5-2016.pdf

Myhre, G. and B. H. Samset (2015). "Standard climate models radiation codes underestimate black carbon radiative forcing." Atmospheric Chemistry and Physics **15**(5): 2883-2888 DOI: 10.5194/acp-15-2883-2015.

Myhre, G., et al. (2013). Anthropogenic and Natural Radiative Forcing. Climate Change 2013: The Physical Science Basis. Contribution of working group I to the fifth assessment report of the Intergovernmental Panel on Climate Change. T. F. Stocker, D. Qin, G.-K. Plattner et al. Cambridge United Kingdom and New York USA, Cambridge University Press.

Shindell, D., et al. (2012). "Simultaneously Mitigating Near-Term Climate Change and Improving Human Health and Food Security." Science **335**: 183-189 DOI: 10.1126/science.1210026.

Shoemaker, J. K., et al. (2013). "What role for Short-Lived Climate Pollutants in Mitigation Policy." Science **342**(13 December 2013): 1323-1324,

Thurston, G. D., et al. (2017). "A joint ERS/ATS policy statement: what constitutes an adverse health effect of air pollution? An analytical framework." Eur Respir J **49**(1) DOI: 10.1183/13993003.00419-2016.

UNECE (2019). On the Way to Clean Air - The Capacity-Building Programme under the Convention on Long-range Transboundary Air Pollution in Eastern Europe, the Caucasus and Central Asia, https://unece.org/DAM/env/lrtap/Publications/20191003-CAPACITY-BUILDING-DIGITAL-PAGE-EN.pdf

UNEP (2016). ACTIONS ON AIR QUALITY - Policies & Programmes for Improving Air Quality Around the World,

UNEP (2021). Actions on Air Quality: A Global Summary of Policies and Programs to Reduce Air Pollution

World Health Organization (2014). 7 million premature deaths annually linked to air pollution. Geneva, World Health Organisation, http://www.who.int/mediacentre/news/releases/2014/air-pollution/en/

World Health Organization (2014). Burden of disease from Ambient Air Pollution for 2012, https://www.who.int/airpollution/data/AAP_BoD_results_March2014.pdf

UN environment programme

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