European Commission

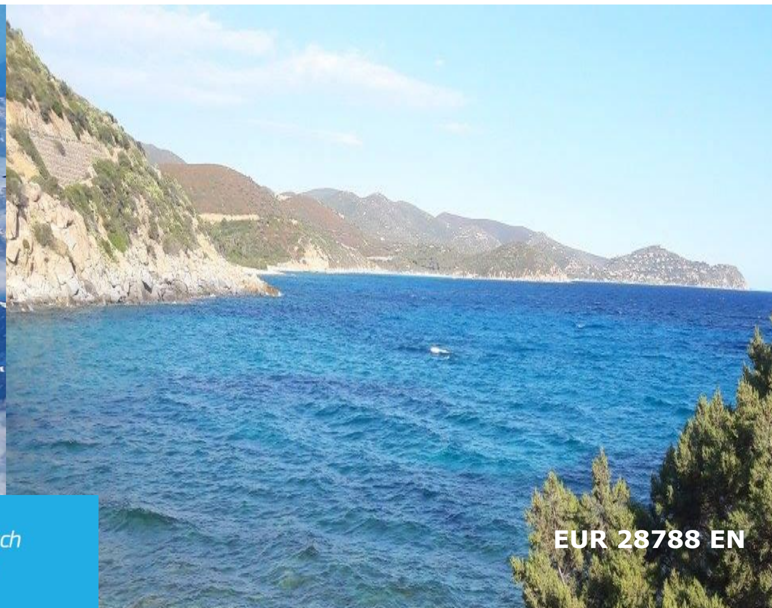
JRC SCIENCE FOR POLICY REPORT

Ex-ante assessment of air quality in EUSALP and EUSAIR macro-regions

Towards a coordinated science-based approach in support of policy development

Belis C.A., Paradiž B. and Knezević J.

2017



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JRC Science Hub
https://ec.europa.eu/jrc

JRC 107343

EUR 28788 EN

PDF	ISBN 978-92-79-73639-1	ISSN 1831-9424	doi:10.2760/701646

Luxembourg: Publications Office of the European Union, 2017

How to cite this report: Belis C.A., Paradiž B. and Knezević J., *Ex-ante assessment of air quality in EUSALP and EUSAIR macro-regions: Towards a coordinated science-based approach in support of policy development*, EUR 28788 EN, Publications Office of the European Union, Luxembourg, 2017, ISBN 978-92-79-73639-1, doi:10.2760/701646, JRC107343.

An assessment of the air quality status in EUSALP and EUSAIR macro-regions to promote a coordinated science-based approach in support of policy development

Abstract
The study focuses on the air quality issues of the EUSALP and EUSAIR macro-regions and discusses areas for improvement to be considered in the development of their future strategies.
Key areas where action is expected to be most effective, considering the particular features of the macro-regions, are those of residential heating, traffic and shipping emissions.
A strengthened collaboration at the macro-regional level, especially between EU and non-EU countries, has the potential to boost environmental policies by promoting collaboration and exchange of best practices among cities and regions that face similar challenges.

EX-ANTE ASSESSMENT OF AIR QUALITY IN

EUSALP AND EUSAIR MACRO-REGIONS

TOWARDS A COORDINATED SCIENCE-BASED APPROACH IN SUPPORT OF POLICY DEVELOPMENT

Contents

Acknowledgements

The authors would like to thank:

- Elisabetta Vignati and Julian Wilson (JRC – Directorate C, Energy, Transport and Climate)
- Miroslav Veskovic (JRC – Coordination of scientific support to macro-regional strategies)
- Marco Onida (DG REGIO - Competence Centre Macro-regions and European Territorial Cooperation) and
- Frauke Hoss (DG ENV – Clean Air Unit)

for reviewing this report and for their useful comments and suggestions.

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Executive summary

This report presents an Ex-ante assessment of the current air quality status and key environmental areas identified in the action plans of the EU Strategy for the Alpine region (EUSALP) and the EU Strategy for the Adriatic and Ionian Region (EUSAIR). The former encompasses territories in Austria, Italy, France, Germany Lichtenstein, Slovenia and Switzerland while the latter includes areas of Albania, Bosnia and Herzegovina, Croatia, Greece, Italy, Montenegro, Serbia and Slovakia. The study focuses on common and specific air quality issues of both macro-regions and discusses actions to be considered in the development of the future macro-regional strategies.

Policy context

Air quality in the EUSALP and EUSAIR macro-regions is an open issue. EU air quality standards are not fully attained in any of the Member States in either macro-region and an even less favourable situation is observed in the non-EU countries such as the Western Balkans. The picture is more critical when considering the World Health Organisation guidelines.

Exceedances of the PM_{10} and/or NO_2 levels have led to infringement procedures in almost all the EU Member States of the area and some of them have been referred to court.

The economic costs of air pollution only due to the premature deaths range from 2.5% to 33% of national annual GDP. Clean air is also relevant for economic activities, like tourism, that contribute to the economy of both macro-regions.

There are specific air quality issues in each macro-region that would require a macro-regional approach and high-level cooperation to improve air quality. Moreover, due to the transboundary nature of air pollution, addressing pollution sources at a multilevel approach (from local to international) involving EU and non-EU countries is the most cost-effective approach.

Key conclusions

Air quality is a complex and cross-cutting topic that requires comprehensive data collection and integrated analysis of economic and social implications in order to inform the development of thematic policies such as those in the areas of regional development, energy, transport and tourism, among others.

Despite the improvement due to past and on going abatement measures, air quality is still critical in many areas of both macro-regions, mainly for PM, NO_2 and ozone. The preparedness to assess and develop action still varies considerably between local authorities in the macro-regions. Consequently, strenghtened collaboration at the macro-regional level has the potential to boost environmental policies by promoting collaboration and exchange of best practices among cities and regions that face similar challenges.

Key sectors where action is expected to be most effective, considering the particular characteristics of these macro-regions, are those of residential heating, traffic and shipping emissions. Moreover, mitigation measures and long-term urban planning will be needed to deal with the predicted increases in ozone concentrations in southern Europe.

Main findings

As shown by source apportionment studies, many EUSALP and EUSAIR areas face adverse meteorological conditions that exacerbate the effect of emissions on air quality. Thermal inversions contribute to the accumulation of pollutants during winter in the valleys of mountaineous regions and basins. On the other hand, high insolation and humidity contribute to elevated ozone levels and heat waves in Mediterranean areas.

Wood has been traditionally used for residential heating in both macro-regions and there is a considerable potential to increase the use of this locally produced and potentially

carbon-neutral renewable energy source. However, wood combustion in outdated residential small combustion installations contributes substantially to elevated particulate matter levels also in urban areas. Taking into account that the residential heating contribution to air pollution is common to many areas and is often underestimated, the dimension and the possible implications of the challenge calls for coordinated action.

Because of its strategic and central position, EUSALP is heavily affected by road traffic (freight and passenger). In addition to the main pan-European routes, there are also significant local and regional transport flows. The issue of transport and air pollution has long been the subject of air pollution policies and considerable infrastructural developments are in progress. However, further improvement of air quality policies in the cities of this area is still required, including technical and non-technical measures. In this regard, information technologies are powerful tools to raise awareness and promote sustainable behaviour in the population.

In the EUSAIR macro-region there is a considerable divide in the availability of essential information about air quality. While some countries have a dense monitoring network covering many pollutants, others are lag behind with monitoring networks that do not fully meet the e-reporting requirements of the European air quality database[1]. Since reliable information on air quality is the basis for any assessment and planning urgent action is needed to fill the existing gap.

One of the features of the EUSAIR is that almost all countries have access to the sea and are, therefore, subject to national and international shipping emission regulations. Moreover, expected growth in tourism will likely lead to increased maritime traffic and consequently to rising emissions, especially in ports. However, the resulting degraded air quality could be damaging for the tourism industry. Considering that both tourism and maritime transport are by nature border-crossing activities, implementing measures to promote their sustainable development is most appropriate at the macro-regional level.

The high levels of ozone observed in southern Europe have negative effects on both human health and ecosystems and cause crop yield losses. In a future scenario with warmer climate, ozone levels are likely to rise and the increase is expected to be most pronounced in many areas of the EUSALP and EUSAIR macro-regions where the levels are already critical.

Related and future JRC work

This work has been carried out in the frame of the JRC support to the macro-regional policies (project MARREF, WPK Environment). In addition, source apportionment and integrated assessment tools to support air quality management are developed and tested within the European network for air quality modelling (FAIRMODE).

Quick guide

- The number of premature deaths due to air pollution in the EU is ten times higher than those caused by traffic accidents.
- When air pollution exceeds the limit values (Directive 2008/50/EC), competent authorities are required to draft air quality plans to abate pollution levels.
- In case of non-compliance, an infringement procedure is launched by the Commission.
- Air quality should be dealt with ‘an integrated approach’ by coordinating actions across each macro-region to take advantage of synergies between local initiatives.
- Transfer of knowledge and experience from EU Member countries regarding air pollution abatement policies would result in a faster adoption of new standards by accession countries, where pollution levels are higher than in the EU.

[1] https://www.eea.europa.eu/data-and-maps/data/airbase-the-european-air-quality-database-7

1 Introduction

An EU macro-regional strategy is an integrated framework endorsed by the European Council to address common challenges faced by Member States and third countries located in the same geographical area. They aim to promote economic, social and territorial cohesion by strengthening cooperation between relevant actors.

Four EU macro-regional strategies, covering a wide range of policy areas linked with air quality, have been adopted so far:

- EU Strategy for the Baltic Sea Region (2009)
- EU Strategy for the Danube Region (2010)
- EU Strategy for the Adriatic and Ionian Region (2014)
- EU Strategy for the Alpine Region (2015).

To achieve the objectives of each macro-regional strategy, an action plan is set and regularly updated in light of new emerging needs and changing contexts. Sustainable development is a component common to all macro-regional strategies.

Since air pollutants affect human health, ecosystems and the built environment, air quality is a key environmental status indicator. Air pollution is the single largest environmental health risk in Europe (EEA, 2016). It imposes large economic costs on society. In 2010, the annual cost of premature deaths attributed to air pollution across the countries of the WHO European Region stood at US$ 1.4 trillion, and the overall annual cost of health impacts from air pollution stood at US$ 1.6 trillion (WHO Regional Office for Europe, OECD, 2015).

Air pollution is strongly dependent on energy and transport policies because many of the sources are associated with these activities. Tourism is an important economic activity associated with transportation. Protecting natural resources is a prerequisite to promote tourism, because areas with poor air or water quality are less attractive. A sustainable development of tourism is therefore, essential for a continuous and long-term growth of this sector (European Commission, 2017). In addition, air quality is closely interlinked with climate change, as some air pollutants are also short-lived climate forcers and climate variations affects the pollutant levels (e.g. ozone). Since air pollutants and greenhouse gases are released to a great extent by the same, mainly energy related, sources, it is essential to exploit synergies among different policies as well as balance their trade-offs in order to achieve targets more efficiently.

To be effective air pollution abatement measures should cover all the relevant policy levels. Thanks to the efforts during the last decades at the international, European, national and local levels, a significant improvement in air quality in many areas of Europe has occurred. However, additional effort is required in many areas to control the adverse effects of pollutants that still reach levels harmful for human health and ecosystems.

The EU macro-regional approach represents a new opportunity for the development of strategies over large regions, with similar features, to address common challenges. Considering its transnational nature, air pollution is particularly suitable to be tackled at the macro-regional level. Due to the similar situations present across each macro-region, the coordinated development and implementation of best practices for air quality assessment, identification of sources and development of abatement measures is more efficient than independent local actions. Moreover, local or regional improvements in air quality in critical areas will help ameliorate pollution levels in the macro-region as a whole.

An analysis of air quality and related policy options in the Danube macro-region, which partially overlaps EUSALP and EUSAIR, has been recently carried out (Belis et al., 2016). The purpose of the present report is to provide elements for further developing the EUSALP and EUSAIR macro-regional strategies with a view to identify topics for future priorities. The focus is on air quality and its connection with the pillars of the macro-regional strategies with particular reference to: energy, connectivity, natural ecosystems, climate change and tourism.

This analysis is accomplished by summarising and interpreting information on:

- the status of air quality,
- the main pollution sources,
- the impact of air pollution,
- the adopted measures to abate air quality,

the final step is the discussion of actions, with added value at macro-regional level, to improve air quality.

Despite the same approach and reasoning being applied to both macro-regions in this study, their different contexts and specificities are taken into account. The EUSALP macro-region involves almost only EU countries and has a long tradition of transnational cooperation. The EUSAIR macro-region, on the other hand, is more heterogeneous, encompassing regions from EU and non-EU countries that have only recently started to cooperate. The heterogeneity of the legislative frameworks in the EUSAIR macro-region impacts on the completeness and comparability of the data. Moreover, the main territorial set up of both macro-regions differ considerably, the Alps and the flat surrounding areas being the common feature of the EUSALP regions, while in EUSAIR the pivotal element is the Eastern Mediterranean Sea.

Infringement procedures due to non-compliance with the AQD limit values.

When the Commission considers that the EU legislation has not been complied with by a Member State an infringement procedure under Article 258 of the Treaty is launched.

The existence of open infringement procedures in the EUSALP and EUSAIR macro-regions points out the relevance of the air quality topic in this area.

The first two steps of the infringement procedure are the "letter of formal notice" and the "reasoned opinion". In case of no satisfactory action by the Member State, the third step of the procedure is the referral of the Member State to the European Court of Justice.

All EUSALP EU Member States received a letter of formal notice because of exceedances of either PM_{10} or NO_2 values. The EUSAIR EU Member States (Italy and Slovenia are in both macro-regions) also underwent infringement procedures with the exception of Croatia.

At present, the Commission is pursuing infringement actions for excessive levels of PM_{10} particles against the following EUSALP/EUSAIR Member States: Germany, Greece, France, Italy, and Slovenia. Furthermore, the Commission has also initiated infringement procedures on NO_2 involving the following EUSALP/EUSAIR Member States: Austria, France, Germany, Italy and Slovakia (F. Hoss, pers. comm.).

2 Overview of the macro-regions

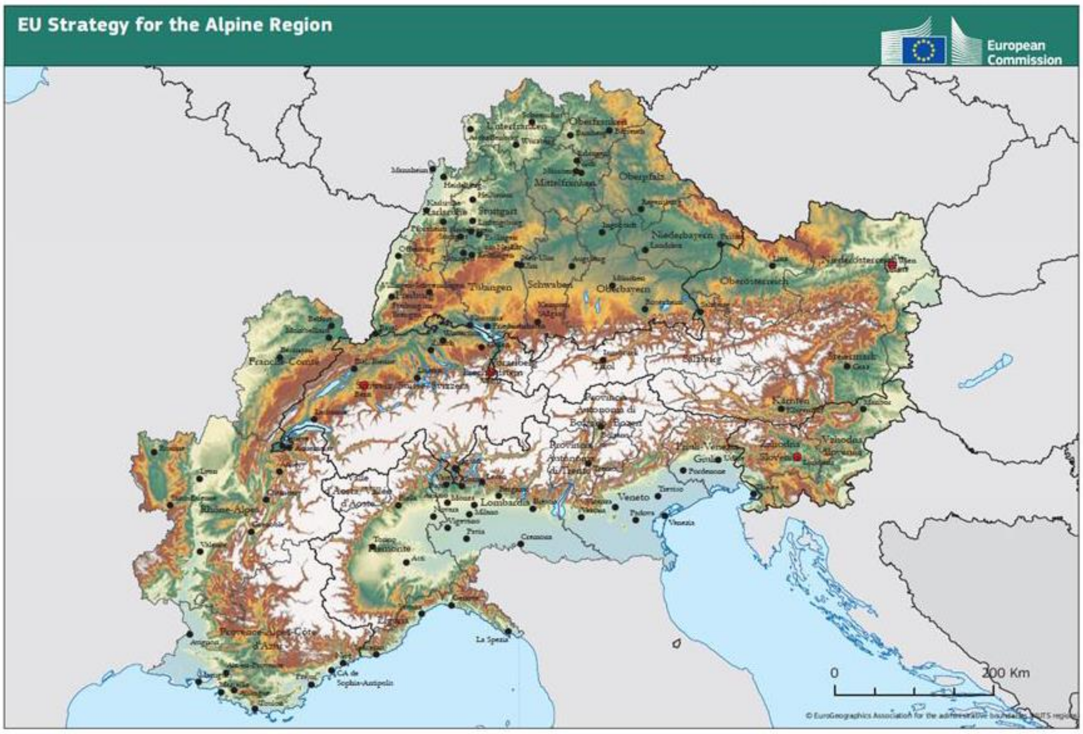
2.1 EUSALP

The EUSALP, launched in 2015 by the Commission (COM(2015)366) and endorsed by Parliament in 2016 (P8_TA(2016)0336), aims to balance development and protection to ensure a living space for people and nature as well as a field for economic and social activities in a sustainable way.

This main objective is pursued through the following three Thematic Policy Areas and priorities: 1) Economic growth and innovation, 2) Mobility and connectivity, and 3) Environment and energy. In addition, the cross-cutting Thematic Policy Area: 4) Governance, including institutional capacity will improve cooperation and the coordination of action in the Alpine Region.

The EUSALP macro-region (Figure 1) encompasses the territories of Austria, Lichtenstein, Slovenia and Switzerland as well as parts of Italy (regions Piedmont, Valle D'Aosta, Liguria, Lombardy, Veneto and Friuli-Venezia-Giulia, the Autonomous Province of Bolzano and the Autonomous Province of Trento), parts of France (provinces Franche-Comté, Rhône-Alpes and Provence-Alpes-Côte D'Azur) and the German federal states of Baden-Württemberg and Bayern.

Figure 1. Map of the EUSALP macro-region.



Source: European Commission

The land area of the EUSALP macro-region is 412,520 km^2, roughly one tenth of the EU-28 surface. According to the 2011 census (Eurostat, 2011) the macro-region hosts 76.5 million inhabitants, 15% of the EU-28 population. The EUSALP population density is above the EU-28 average, however, there is a great variation between the flat and the mountainous areas.

The EUSALP macro-region encompasses the European mountain range: the Alps (an approximately 1000 km long and 250 km wide mountain chain).

In mountainous and hilly areas the atmosphere is often stratified, inhibiting vertical circulation. For these reasons, average wind speeds in valleys and even more in basins are lower than in other regions. In these locations calm periods are much more frequent, with consequent negative impacts on air quality. A particularly critical situation is present in the Po Valley a densely populated area surrounded by mountains on three sides. Though it may appear as a large plain, it has the meteorological characteristics of a basin. In the cold season, it experiences persistent periods of high atmospheric stability and low wind speed similar to inner-Alpine basins, with corresponding consequences for air pollution (Heimann D., 2007).

The average wind speed at a location is an indicator of the dispersion characteristic of the atmosphere (Vignati E. et al., 1996). The EUSALP macro-region is characterised by low wind speed particularly the southern part that may cause elevated pollutants levels in the atmosphere.

The EUSALP macro-region is characterised by GPD per capita well above the average of European NUTS (nomenclature of territorial units for statistics) level 3 regions. The economic engines of the region are urban centres in Germany, Austria and Italy (especially Munich, Vienna and Milan), while values above 25,000 purchasing power standard (PPS) characterise northern Italy, western Austria, most of Southern Germany, Central Slovenia and the departments of Rhône, Bouches-du-Rhone, Alpes-Maritimes and Savoie in France. The non-EU countries Switzerland and Lichtenstein are also among the countries with the highest GDP per capita in the world (ESPON, 2013).

Although the service sector dominates, a strong industrial sector is present in the most parts of the EUSALP. The presence, and development, of a very high number of enterprises belonging to the services sector represents a favourable situation for the improvement of the efficiency of the productive process (ESPON, 2013).

Tourism is an important activity in the EUSALP macro-region. Among the EU top 20 tourist regions at the NUTS 2 level in terms of nights spent in tourist accommodation, six (Veneto, Provence-Alpes-Côte d'Azur, Rhone-Alpes, Tirol, Lombardia and Oberbayeren) are located in the EUSALP macro region (Eurostat, 2016). A good air quality is an asset for tourism; however, touristic activities may generate additional pressure on the air quality, especially when tourists travel by road.

The EUSALP region is characterised by a high level of car ownership. The three EU NUTS 2 regions with the highest number of cars per 1000 inhabitants are in the EUSALP macro-region (Eurostat, 2016). In addition to local and regional transport flows, the EUSALP is a major European crossroads. It is crossed by traffic flows (freight and passenger) connecting southern to northern, as well as eastern to western Europe. The geomorphology of the area is a natural obstacle to circulation. Often busy road traffic corridors are in the narrow valleys where the orography intensifies the effects of air emissions and noise.

The connection between renewable energy and domestic heating is discussed in Box 1.

2.2 EUSAIR

The EU Strategy for the Adriatic and Ionian Region (EUSAIR) was endorsed by the European Council in October 2014. The main EUSAIR objective is to promote sustainable economic and social prosperity in the region through the growth and jobs creation and by improving its attractiveness, competitiveness and connectivity while preserving the environment and ensuring healthy and balanced marine and coastal ecosystems. The objectives, pillars and actions of the EUSAIR were defined in the Communication from the European Commission and related Action Plan (European Commission, 2014a). Four thematic pillars were recognised: 1. Blue growth (sustainable development in marine and maritime sectors), 2. Connecting the Region (transport and energy networks), 3. Environmental quality (both marine and terrestrial) and 4. Sustainable tourism. Actions and projects relating to each particular pillar should be coherent and mutually supportive and at the same time account for possible impacts and compatibility with other pillars.

The EUSAIR macro-region encompasses the areas of the western Balkans and eastern Italian Peninsula that surround the Adriatic and Ionian seas. It comprises eight countries with significant diversity in cultural, social and economic situations. Four of them are EU Member States: Croatia, Greece, Italy and Slovenia, while the other four are Western Balkan countries and EU membership candidates in different stages of the accession process: Albania, Bosnia and Herzegovina, Montenegro and Serbia (Figure 2). Bosnia and Herzegovina is structured in three territories: the Federation of Bosnia and Herzegovina (FBiH), the Republic of Srpska and the Brčko District, a self-governing administrative unit.

The western Adriatic Sea coast is low and includes the Delta of its main tributary: the Po river. Venice, Ancona, Bari and Trieste are the principal ports. The eastern Adriatic coast is irregular, where Koper, Rijeka, Bar and Durrës are the main ports, followed by Patras. Piraeus and Thessaloniki to the south. Coastal areas in all of the countries are popular tourist destinations, and tourism is also developing in the inland areas of the EUSAIR. Fishing is an important activity in the Adriatic Sea. The Balkan EUSAIR territory is characterised by forested mountainous ranges: the Dinaric Alps and the Pindus. The main economic activities in this part of the macro-region are agriculture and mining.

Figure 2. Map of the EUSAIR macro-region

Source: EUSAIR, http://www.adriatic-ionian.eu/

The southern and coastal areas of the macro-region present a mild Mediterranean-type climate, with a dry summer period while the northern areas show a humid subtropical and continental climate. Similarly, as in the EUSALP also valleys and basins in the mountainous and hilly terrain of the EUSAIR often experience unfavourable meteorological conditions for the dispersion of pollution, thus exacerbating the influence of local emissions.

Although these countries share the same geographic area, they have their own specific characteristics and differences related to various historical, demographic, cultural and economic development. Regional cooperation in the Adriatic and Ionian Region is fundamental for countries in the pre-accession process and for strengthening links with other EU macro-regions (EUSALP, Danube and Baltic).

Harmonisation of the legislation in the field of air quality

The EUSAIR aims to strengthen EU policies relevant to the Region. In the case of air quality the focus is on the implementation of the European Parliament directives on air quality:

- Air Quality Directives 2008/50/EC and 2004/107/EC (4th daughter directive),
- National Emission Ceilings Directive (NEC, Directive 2016/2284/EU),
- Directive on Sulphur Content of Liquid Fuels 1999/32/EC,
- Directive 2012/33/EU regarding the sulphur content of marine fuels,
- Directive 94/63/EC (NMVOCs),Directive 2009/126/EC(NMVOCs-II),
- Commission Regulation (EC) No 692/2008 on Euro 5 and Euro 6 standards of light vehicles, and
- Regulation (EC) No 595/2009 on the Euro VI standard for heavy duty vehicles.

The EUSAIR Western Balkan countries, namely, Albania, Bosnia and Herzegovina, Montenegro and Serbia have different status in the process of accession to the EU and consequently different levels of harmonisation of legislation on air quality with the one of the EU. Albania, Montenegro and Serbia are candidate countries and Bosnia and Herzegovina has a status of potential candidate country. The degree of alignment of the national legislation with the European *acquis* in the non-EU EUSAIR countries is presented in Table 1.

Table 1. The status of transposition and implementation of the main EU air quality legislation in non EU countries.

	Albania	**Bosnia and Herzegovina**	**Montenegro**	**Serbia**
Directives 1999/32/EC	Transposed	Not yet transposed	Implemented	Not yet transposed
NEC Directive	Not yet transposed	Not yet transposed	Not yet transposed	Not yet transposed
NMVOCs and NMVOCs-II	Stage I- transposed Stage II - under preparation	Not yet transposed	Transposed but not implemented	Need to finish transposing

Source: European Commission staff working documents 2016a, 2016b, 2016c, and 2016d

All candidate countries have transposed and mostly implemented Directive 2008/50/CE on ambient air quality and cleaner air for Europe and Directive 2004/107/EC on arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons in ambient air except Albania, which postponed with national law the transposition to 2018.

Although there is tendency to harmonisation, there are still differences between these countries in the level of implementation of air quality limit and target values. In both Bosnia and Herzegovina entities and the Brcko District, the limit and target values have been harmonised with the values defined in Directive 2008/50 and Directive 2004/107. However, the deadlines for when those values have to be met differ and have been postponed to dates ranging between 2018 and 2024, depending on the pollutant. The limit values were defined for other pollutants not regulated by the aforementioned Directives that may be specific for FBiH (hydrogen sulphide, mercaptan, chloro hydrogen) due to certain industrial activities present in that region (B&H, 2012)

Montenegro achieved complete harmonisation of its national regulations with EU legislation in 2015. Serbia has transposed the EU Directives for most of the pollutants in 2016, except NO_2 which is postponed to 2021. Albania will fall into line with the EU regulations by 2020 (except for PM_{10} daily and annual limit values, postponed to 2030) and Bosnia and Herzegovina aims at doing so by 2021.

As regards international agreements, there are two key instruments for preventing pollution which are of great importance in this macro-region (Table 2):

- the Convention on Long-range Transport of Air Pollution (CLRTAP) and
- the International Convention for the Prevention of Pollution from Ships (MARPOL), more precisely the Protocol 97 (Annex VI, setting limits on sulphur oxide and nitrogen oxide emissions from ship exhausts).

The CLRTAP and the Protocol on the Financing of the Co-operative Programme for Monitoring and Evaluation (EMEP) were ratified by all countries in the macro-region while the Gothenburg Protocol and NMVOC Protocol were ratified by only two EUSAIR countries.

Table 2. Status of ratification international contracts relevant for EUSAIR macro-region

Convention or Protocol	**MARPOL 97 (A VI)**	**CLRTAP**	**EMEP**	**Sulphur**	**NOx**	**NMVOC**	**Sulphur**	**HMs**	**POPs**	**Gothen-burg**
year	1997	1979	1984	1985	1988	1991	1994	1998	1998	1999
Albania		√	√	√	√					
Bosnia and Herzegovina		√	√							
Croatia	√	√	√		√	√	√	√	√	√
Italy	√	√	√	√	√	√	√		√	
Greece	√	√	√		√		√			
Montenegro	√	√	√					√	√	
Serbia	√	√	√					√	√	
Slovenia	√	√	√		√		√	√	√	√

Source: IMO, UNECE

Moreover, the Commission called for further action at the International Maritime Organization (IMO) to reduce emissions and in October 2008 an amended Annex VI was adopted lowering the maximum permissible sulphur content of marine fuels. These are the limits that were subsequently introduced in the EU legislation by Directive 2012/33/EU.

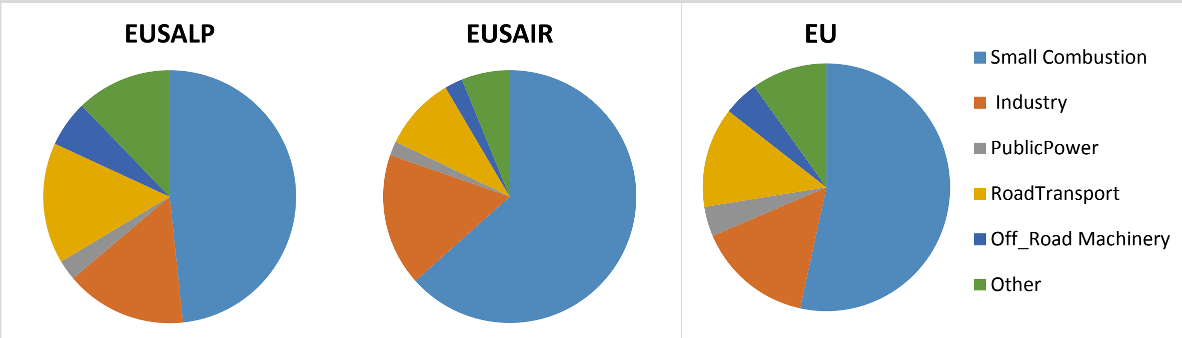
Box 1. Renewable energy sources and domestic heating

Energy production and consumption is a main source of air pollutants and greenhouse gases emissions. Considering that one of the EU main policy objectives is the transition to a low carbon society, increasing both energy efficiency and the share of renewable energy sources is required. While the increase in energy efficiency has in general synergistic effect with air quality improvement, the increased use of renewable energy sources requires more attention in the context of the air quality objectives.

The increasing use of renewable energy is one of the central pillars of EU climate and energy policies. Already ambitious, legally binding plans to reach 20 % of the renewable sources by 2020, gained new momentum with 2030 targets in line with the Paris Climate Change Agreement. The EU- wide target in this context is at least a 27% share of renewable energy consumption by 2030. Moreover, in rapidly changing and potentially unstable world, the issues of energy security are becoming more and more important. Sustainable use of renewable energy resources has also a significant job creation potential.

In both the EUSALP and EUSAIR macro-regions, particularly the mountainous areas, wood has been traditionally used for residential heating. Thermal conditioning of buildings remains the dominant renewable energy market sector in EU. In 2014, heating and cooling represented over half of the national gross final consumption of renewables in 17 Member states. Although biogas and heat pumps have the fastest annual growth rates, wood-based technologies are still dominant in the residential heating market sector in EU (EEA, 2017).

Share of $PM_{2.5}$ emissions from small domestic combustion appliances. Source: JRC, elaborated from (EMEP, 2016)



Residential heating fuelled with wood is an important source of particulate matter in EUSALP and EUSAIR. According to the JRC database of European source apportionment studies to determine the actual impact of sources on PM (including transformations in the atmosphere), direct emissions of biomass burning contribute to 10-15% of the PM while the secondary processes due to the transformation of gaseous emissions into particles represent approximately twice that figure (Belis et al., 2013).

Considering the significant potential for sustainable additional harvesting of wood in EUSALP and EUSAIR (Elbersen B., 2012) an increase in the emissions from this source cannot be excluded unless action is taken to improve efficiency of small combustion installations and abate their emissions. The development and implementation of the policies and measures integrating and balancing air quality and climate change mitigation aspects of solid biomass energy use are therefore fundamental for compliance with current PM limit values and to pave the way to gradually attain WHO air quality guidelines.

3 Air quality status

Directives 2008/50/EC and 2004/107/EC set the air quality standards expressed as thresholds not to be exceed in different averaging time intervals (Table 3).

In order to check compliance, the Member States organise monitoring networks according to specific criteria. The Ambient Air Quality Directive sets a minimum data capture of 90 % for air quality parameters. However, for assessment purposes, a more relaxed coverage of 75 % allows more stations to be taken into account without loss of representativeness (ETC/ACM, 2012). The required amount of valid data for the benzene analysis is 50 % and for toxic metals (As, Cd, Ni, Pb) and benzo(a)pyrene data it is 33 % according to the air-quality objectives for indicative measurements.

It is estimated that about 16 % of the EU28 urban population is exposed to PM_{10} above the EU daily limit value. In urban areas, circa 8 % is exposed to O_3 concentrations above the EU target value threshold (see Box 3), about 7 % of the EU28 urban population is exposed to NO_2 above the EU annual limit value and exposure to SO_2 is under 0.5 % (EEA, 2016).

Table 3. Air Quality Standards set by EU Directives 2008/50/CE and 2004/107/EC and WHO guidelines

	Air quality Directives			**WHO guidelines**	
	Concentration (μg/m^3)	Averaging interval	Allowed exceedences per year	Concentration (μg/m^3)	Observations
Fine particles ($PM_{2.5}$)		24 hours		25	99 Percentile 3 days/year
	25	1 year	n/a	10	
Fine particles (PM_{10})	50	24 hours	35	50	99 Percentile 3 days/year
	40	1 year		20	
Nitrogen dioxide (NO_2)	200	1 hour	18	200	
	40	1 year	n/a	40	
Ozone (O_3)	120	Maximum daily 8 hour mean	25 days averaged over 3 years	100	8 hour mean
Sulphur dioxide (SO_2)	350	1 hour	24	500	10 minutes
	125	24 hours	3	20	
Benzo(a) pyrene (BaP)	1 ng/m3	1 year	n/a		

Source: European Commission, WHO

When the levels of pollution exceed the limit values or target values, Member States and subsequently local authorities, shall establish air quality plans where measures are implemented to tackle the pollution sources and bring the air quality levels below those thresholds within a given term. Moreover, the WHO Air quality guidelines (WHO, 2016) provide global guidance on thresholds and limits for key air pollutants that pose health risks based on expert evaluation of current scientific evidence. The WHO guidelines are more stringent for PM than the EU Directives, while the differences are modest for the other pollutants (with the exception of the daily SO_2 limit value). In the following sections the compliance of the air quality standards are discussed taken as reference the latest year for which complete data were officially available at the start of the present study.

3.1 EUSALP

As in most parts of Europe, the levels of the sulphur dioxide and carbon monoxide are well below the air quality standards. There are some isolated hotspots contaminated with heavy metals in the EU, however no exceedances of the respective air quality standards were reported in EUSALP for 2014. The most important challenges in EUSALP are the levels of particulate matter both PM_{10} and $PM_{2.5}$, nitrogen dioxide and ozone. In certain areas, levels of benzo(a)pyrene are also a matter of concern, however is still difficult to assess the geographical pattern because of the variable data coverage between the EUSALP regions.

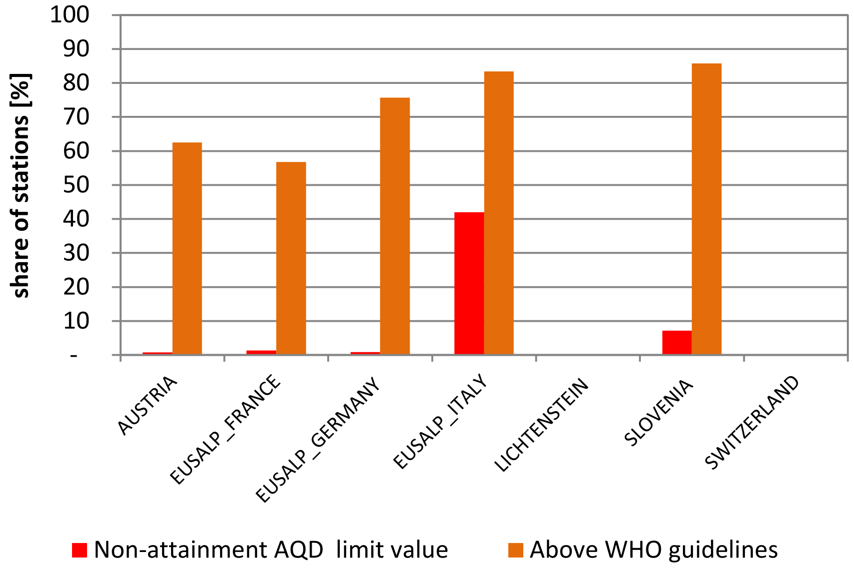
According to the EEA database, in 2014 the share of measurement sites in the EUSALP where the EU standard for the daily PM_{10} values was exceeded is circa 15% (Figure 3), which is comparable with that of the entire EU. The highest proportion of exceedances was recorded in the Italian part of the EUSALP macro-region, where nearly 40% of the monitoring sites observed non-compliances with the daily PM_{10} limit value. In Slovenia fewer than 10 % of the stations were non-compliant with such limit value, while in Austria, as well as in the German and French parts of the EUSALP there were isolated exceedances limited to only a few stations totalling approximately one percent of all stations. In Switzerland (data for 2012) and Lichtenstein, no exceedances of the EU daily limit value were reported.

The majority (> 70 %) of the EUSALP stations do not comply with the more stringent WHO guidelines for the daily PM_{10} levels (Figure 3).

It is worth mentioning that meteorological conditions favoured the dispersion of pollutants in 2014. By comparison, in 2011, there were many more exceedances of the daily limit value recorded in all countries with the exception of Lichtenstein. In that year 86 % of stations in Slovenia, 35 % in Austria, 17 % in the EUSALP part of Germany and 7% in Switzerland exceeded daily limit values. The latest available data for 2015 show that more stations did not attain the daily PM_{10} standard than in 2014 in Slovenia (ARSO, 2016), Austria (Umveltbundesamt, 2016) and the German part of the EUSALP (LUBW, 2016; LfU, 2016). The competent national and regional institutions concluded that the decrease of the PM_{10} pollution levels from 2011 onwards is attributable both to the decrease in emissions and to the annual meteorological variability, with more favourable meteorological conditions for dispersion of pollutants in recent years (ARSO, 2016; Umveltbundesamt, 2016; BAFU, 2015).

There are also differences between the countries in the types of stations where the highest levels are recorded. In the German part of EUSALP the highest number of exceedances of the daily PM values were recorded at traffic stations. In the stations with the highest 20^{th} percentile of daily PM levels in Bavaria and Baden Württemberg (22 stations) there is only one background station. Austria also has more traffic stations among the most polluted, however, there is also a substantial share of highly polluted background stations. In Italian and French part of the EUSALP as well as in Slovenia, the share of the traffic and background stations among the most polluted is comparable.

Figure 3. Share of EUSALP monitoring stations in non-attainment of the EU daily PM_{10} limit value and above the WHO guideline in 2014.

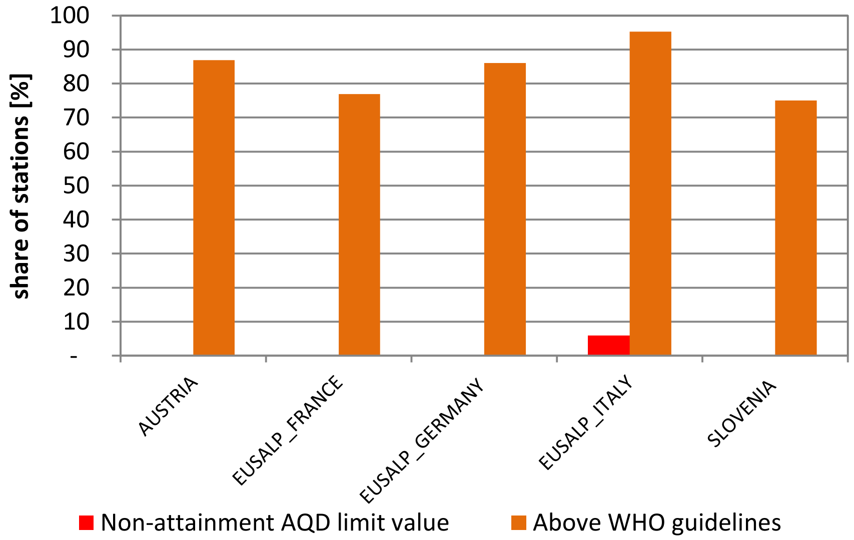


Source: data from EEA Air Quality Portal elaborated by JRC

Although some stations in the Po valley were rather close to the yearly PM_{10} limit value, in 2014 no exceedances of such threshold were reported in the EUSALP. However, exceedances of the WHO guideline for the yearly PM_{10} value were observed in more than 30% of the stations in the EUSALP part of the EU Member States.

In 2014, $PM_{2.5}$ concentrations were higher than the EU target value (annual mean, which has become the limit value for $PM_{2.5}$ from 2015 on) only in the Italian part of the EUSALP (Figure 4). The WHO guideline value is exceeded in the majority of the stations (>70%) of the EU Member States. $PM_{2.5}$ levels are not reported for Switzerland and Lichtenstein since in those two countries the limit values are defined only for PM_{10}.

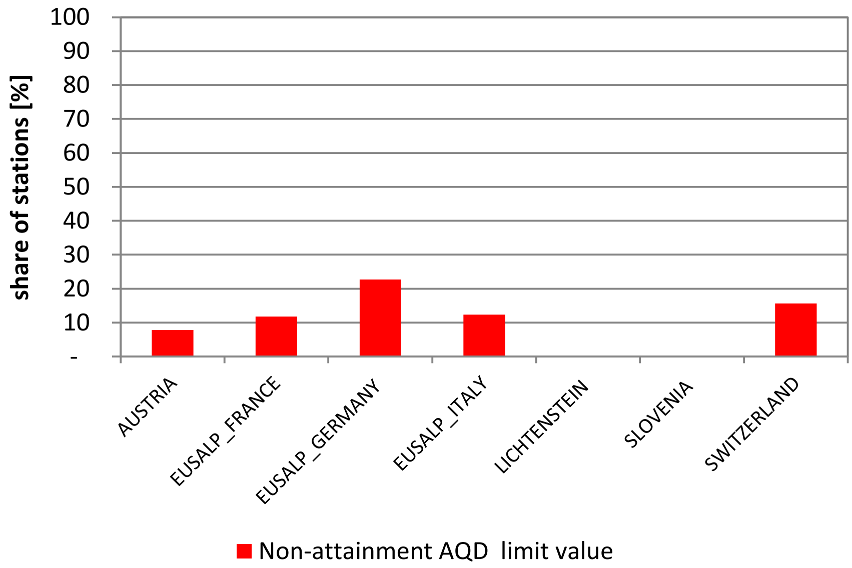
Figure 4. Share of EUSALP monitoring stations in non-attainment of the EU annual $PM_{2.5}$ target value and above the WHO guideline in 2014.



Source: data from EEA Air Quality Portal elaborated by JRC

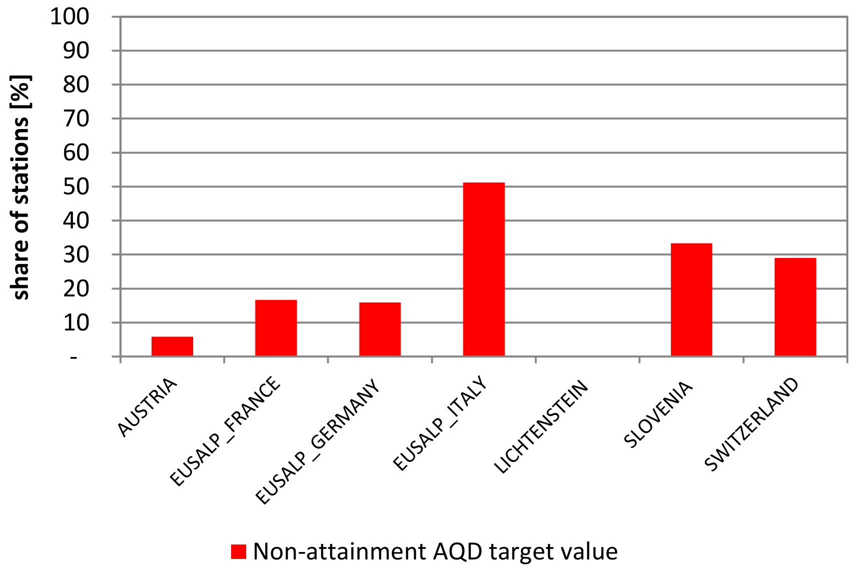
There were exceedances of the annual NO_2 limit value in all EUSALP countries, with the exception of Slovenia and Lichtenstein (Figure 5). The share of the exceedances was the highest in Germany. Exceedances were mainly observed at traffic sites in larger cities, reflecting the dominant contribution from road traffic and higher emission density in the more urbanised areas. However, in Austria the highest value was observed in the Alpine Inn valley close to a highway. Similarly in Italy one of the stations with the highest levels of NO_2 is situated in the Alpine region along the Brenner highway where the atmospheric dispersion of the pollution is limited.

Figure 5. Share of EUSALP monitoring stations in non-attainment of the EU annual NO_2 limit value in 2014.



Source: data from EEA Air Quality Portal elaborated by JRC

Figure 6. Share of EUSALP monitoring stations in non-attainment of the EU ozone 8 h daily maximum target value in 2014.



Source: data from EEA Air Quality Portal elaborated by JRC

The hourly limit value threshold for NO_2 is less stringent. Concentrations above this limit value were observed in 2014 in only 0.5 % of the EU reporting stations (EEA, 2016). No statistical evaluation at the level of the individual stations is available for this pollutant.

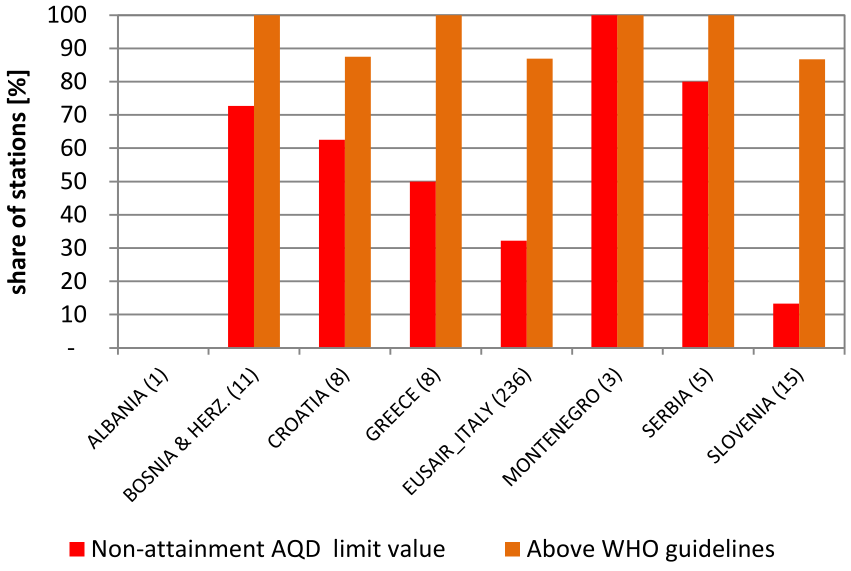
The levels of the O_3 in the EUSALP region are among the highest in Europe. 25% of the monitoring stations in the EUSALP macro-region exceed the 8-hour target value (Figure 6) which is more than twice the proportion of stations in non-attainment in the entire EU.

At the time of the preparation of this report, there were limited data on benzo(a)pyrene levels in the EEA e-reporting database. In 2014 only three stations in the Italian part of EUSALP were found to be non-compliant with the benzo(a)pyrene target value, i.e. having yearly average benzo(a)pyrene levels above 1.5 ng/m^3.

3.2 EUSAIR

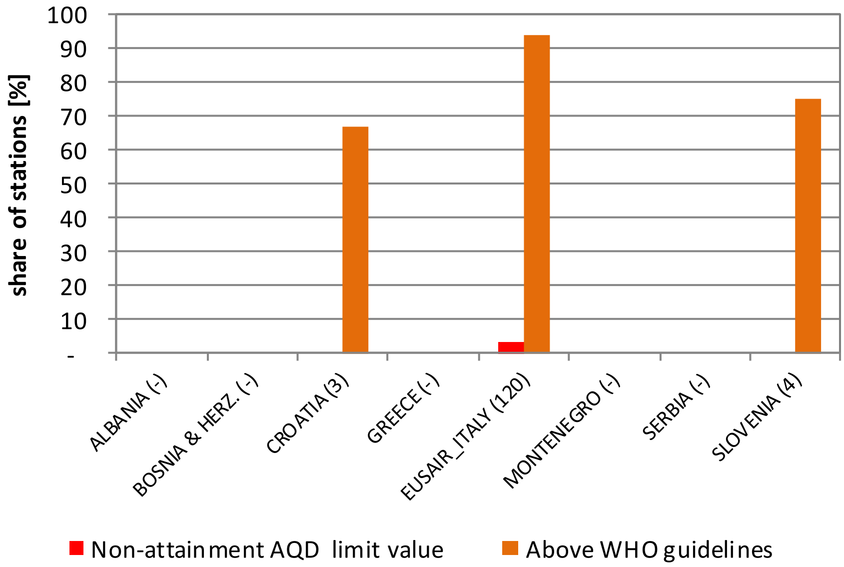
The status of air quality in the EUSAIR macro-region refers to year 2014. Due to the different level of implementation of the EU Directives in the EUSAIR countries the data presented in this section are not always available for all of them. In addition, the density of monitoring stations decreases from north to south and from west to east, with the highest density in Italy, especially in the Po Valley. Data for Bosnia and Herzegovina for 2014 were not available in the European Air Quality database, EEA (see Box 2).

Figure 7. Share of EUSAIR monitoring stations in non-attainment of the EU daily PM_{10} limit value and above the WHO guideline in 2014. Between brackets the number of available sites.



Source: data from EEA Air Quality Portal elaborated by JRC

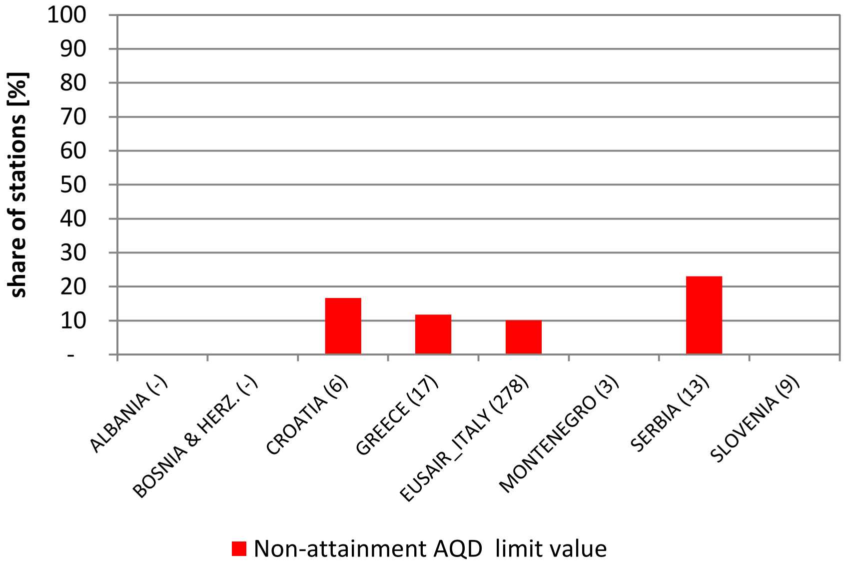
Figure 8. Share of EUSAIR monitoring stations in non-attainment of the EU annual $PM_{2.5}$ target value and above the WHO guideline in 2014. Between brackets the number of available sites.



Source: data from EEA Air Quality Portal elaborated by JRC

The largest number of stations with a percentage of valid data above 75% are those of PM_{10}. Exceedances are observed in all the EUSAIR countries with the exception of Albania (only 1 site with valid data) (Figure 7). The share of sites affected by the exceedances of the EU daily limit value is the highest in Niksic (Montenegro) and Belgrade (Serbia) where the number of daily exceedances is above 100. In the Po Valley, the highest number of daily exceedances is 88 (Meda). The share of monitoring stations exceeding the WHO guidelines is above 80% in all the countries. In 2014, the limit value for the PM_{10} annual average was exceeded in two monitoring sites in Serbia.

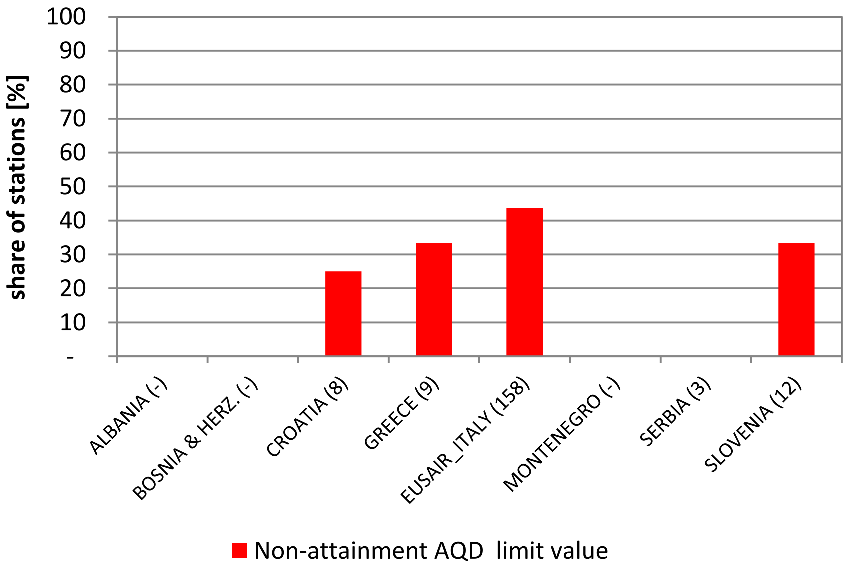
Figure 9. Share of EUSAIR monitoring stations in non-attainment of the EU annual NO_2 limit value in 2014. Between brackets the number of available sites.



Source: data from EEA Air Quality Portal elaborated by JRC

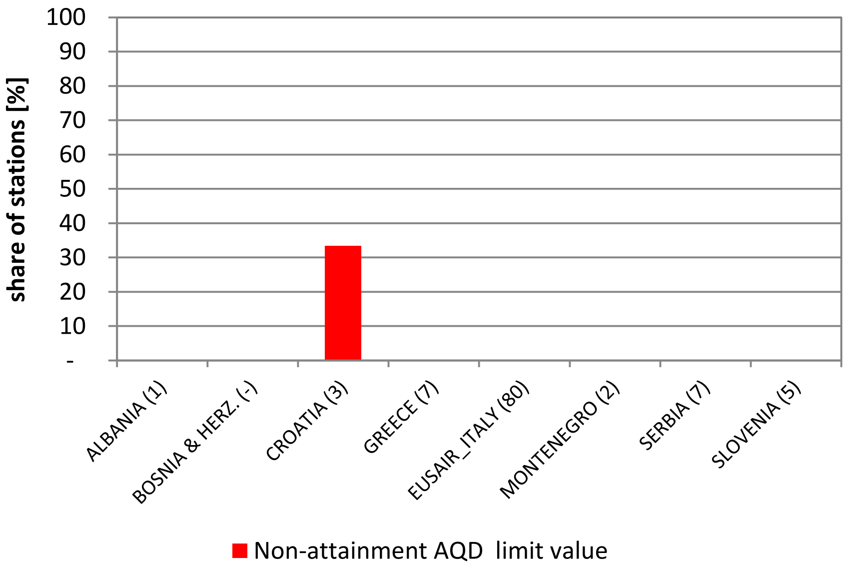
Very limited data on the $PM_{2.5}$ levels in 2014 in the eastern part of the EUSAIR area are available. Few exceedances to the target value were observed in the Po Valley while the exceedances of the WHO guidelines affect more than 60% of the monitoring stations for which data are available (Figure 8).

Figure 10. Share of EUSAIR monitoring stations in non-attainment of the EU ozone 8 h daily maximum target value in 2014. Between brackets the number of available sites.



Source: data from EEA Air Quality Portal elaborated by JRC

Figure 11. Share of EUSAIR monitoring stations in non-attainment of the EU SO_2 hourly limit value in 2014. Between brackets the number of available sites.



Source: data from EEA Air Quality Portal elaborated by JRC

The NO_2 annual limit value was exceeded in four EUSAIR countries: Serbia, Croatia, Italy and Greece in a proportion ranging between 10% and 25% of the monitoring stations with complete time series (Figure 9). The highest levels were observed in Belgrade and

Milan. Few exceedances (<6) of the NO_2 hourly limit were reported in northern Italy. Not enough data coverage is available in Albania and Bosnia and Herzegovina.

Ozone levels exceed the long-term EU objective in the majority of the EUSAIR countries for which datasets are available (Figure 10). The highest number of exceedances in 2014 was recorded in rural or remote sites, affected by emission plumes from densely populated areas, located in the Po Valley (77 days), Slovenia (58 days) and the island of Vis in Croatia (59 days).

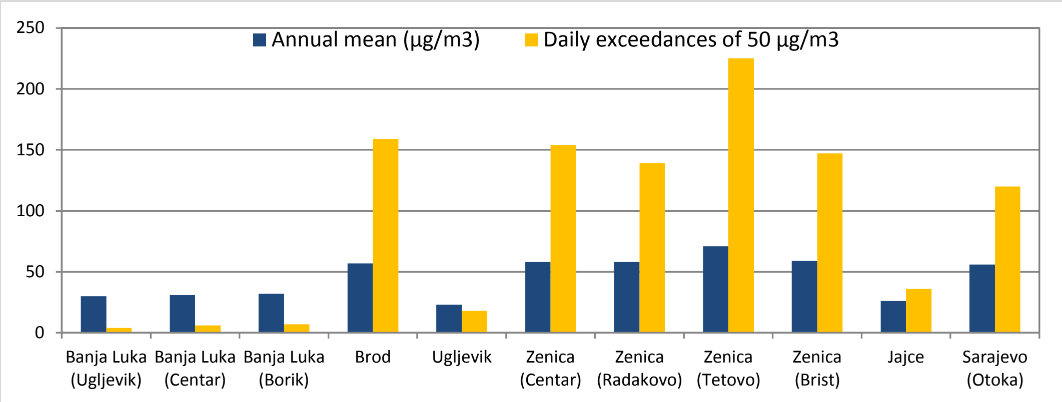
The SO_2 is measured in almost all the EUSAIR countries. In 2014 there were exceedances to the hourly limit value only in the area of Slavonski Brod in Croatia (Figure 11). The levels of this pollutant have decreased over the latest decades in Europe. However, it is still relevant for air pollution because is a precursor of PM_{10} and $PM_{2.5}$.

Validated data on benzo(a)pyrene in EUSAIR region are very scarce. The levels in 2014 are available in a limited number of stations (less than 10) which are located in Italy and Croatia where some exceedances (>1.5 μg/m^3) were observed.

Box 2. Extreme PM pollution levels in some countries of the Western Balkans

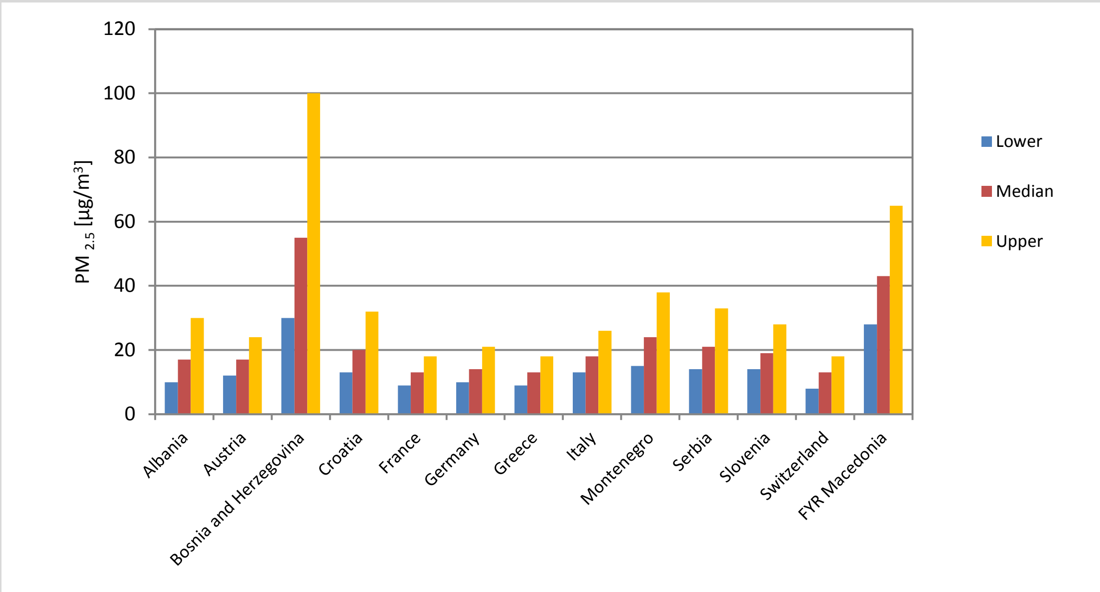
Very high levels of PM were observed in recent years in most of the Western Balkans areas where this parameter is monitored. In 2014 the average number of daily exceedances in all the six PM_{10} monitoring stations in the Federation Bosnia and Herzegovina was notably high (see figure in the box) corresponding to the highest 99.5 percent of all monitoring stations in the EU. Furthermore, the highest number of exceedances of the daily PM_{10} limit value in Bosnia and Herzegovina totalled 225, a level that is higher than the maximum number of exceedances for the same parameter and period in all the monitoring stations of the countries reporting to the EEA (> 2000).

Annual mean and number of daily exceedances in Bosnia and Herzegovina in 2014. Republic of Srpska: Banja Luka, Brod and Ugljevic; Federation Bosnia and Herzegovina: Zenica, Jajce and Sarajevo. Source: FHNI, 2015; RHMI, 2015.



The maximum daily PM_{10} values measured during pollution episodes in Sarajevo were one order of magnitude above the EU limit value. Elevated PM levels were also observed in Skopje, the capital of the FYR Macedonia, where the maximum measured hourly levels of PM_{10} reached 800 µg/m^3 (Anttila et al., 2016).

Annual median $PM_{2.5}$ population weighted concentration in urban areas of EUSALP, EUSAIR and Western Balkan countries in 2014. Lower and upper limits are also indicated. Source: WHO, 2016.

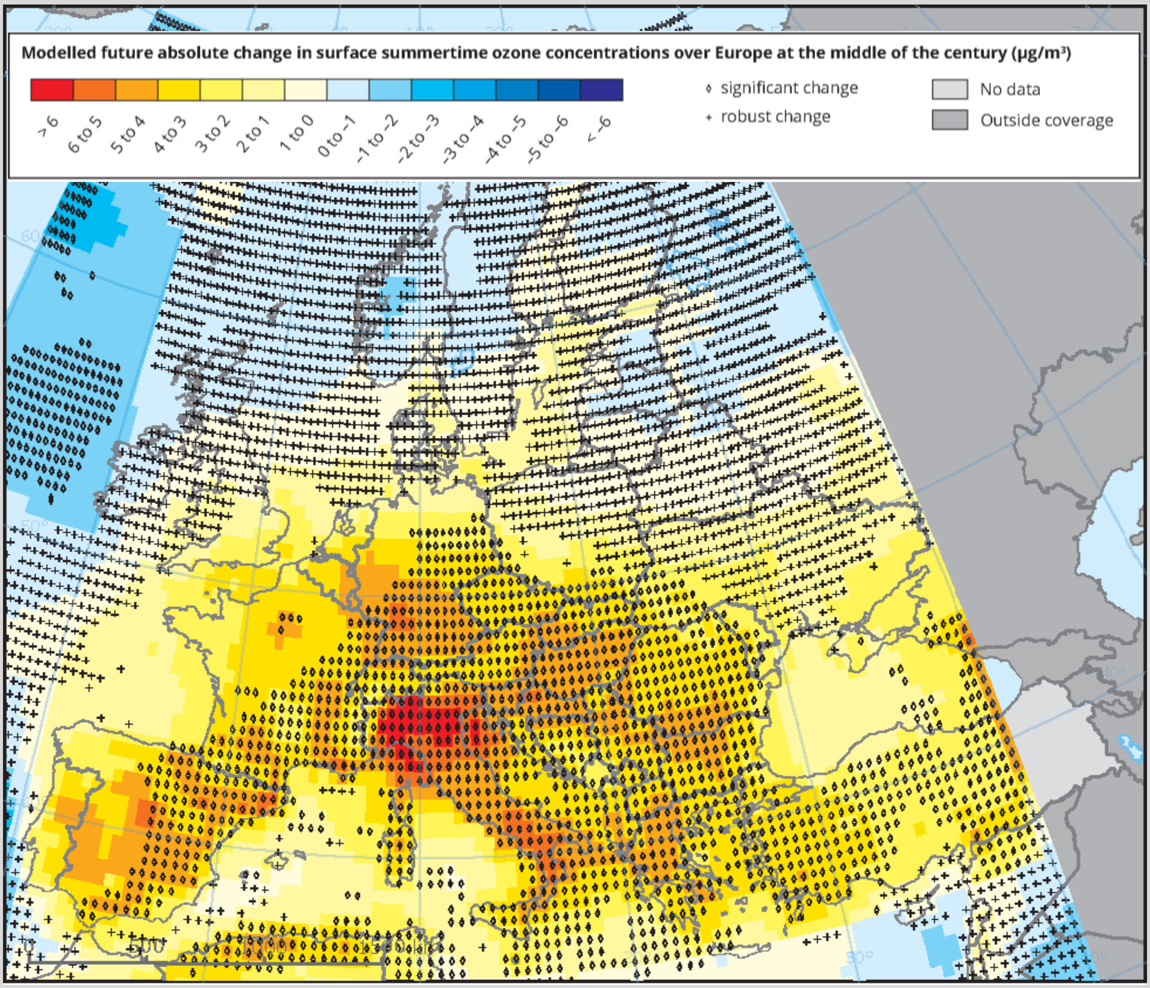


In order to compare the situation in this area with some EU countries, a combination of measures and models used in a WHO assessment of urban population exposure are synthesised in the figure above. Bosnia and Herzegovina, FYR of Macedonia and Montenegro are those with the highest exposure levels.

Box 3. The geographical pattern and future ozone levels in EUSALP and EUSAIR

The geographical distribution of ozone levels depends on the emissions of precursors (NO_X and NMVOCs) and on the physical and chemical properties of the atmosphere. In particular, the formation of ozone is influenced by the solar radiation and the temperature. Hence, in Europe ozone concentrations show a gradient increasing from north to south. Moreover, the ozone concentrations increase with altitude in the first few kilometres of the troposphere leading to higher concentrations in the mountain ranges. At the ground level, ozone is depleted by surface deposition and titration reaction with freshly emitted NO to form NO_2. Therefore, in contrast to other pollutants, ozone concentrations are the highest in rural locations and the lowest in traffic locations. High elevation Alpine monitoring stations, as for instance the Zugspitze in Germany or in Gerlitzen in Austria, are important to assess ozone impacts on ecosystems and their biodiversity.

Absolute difference between future (2041-2070) and present (1960-2010) summertime daily maxima ozone levels in a 9 model ensemble. Diamond signs indicate the change is significant and plus signs denote the change is robust across two-third of modelled years. Source: EEA, 2016.



In future, ozone levels are likely to be influenced by the ongoing climate change. The photochemical reactions that lead to the formation of ozone from precursors are influenced by the global warming. An ensemble of models was used to predict the changes in ozone levels due to climate variability and climate change (see figure). In the simulations the period 2041-2070 was taken as representative of the middle 21st century (2050). The increase in ozone concentrations in Europe (assuming no change in emissions of precursors) is expected to be most pronounced in the EUSALP and EUSAIR macro-regions, where the levels are already higher than the EU average.

4 Main pollution sources

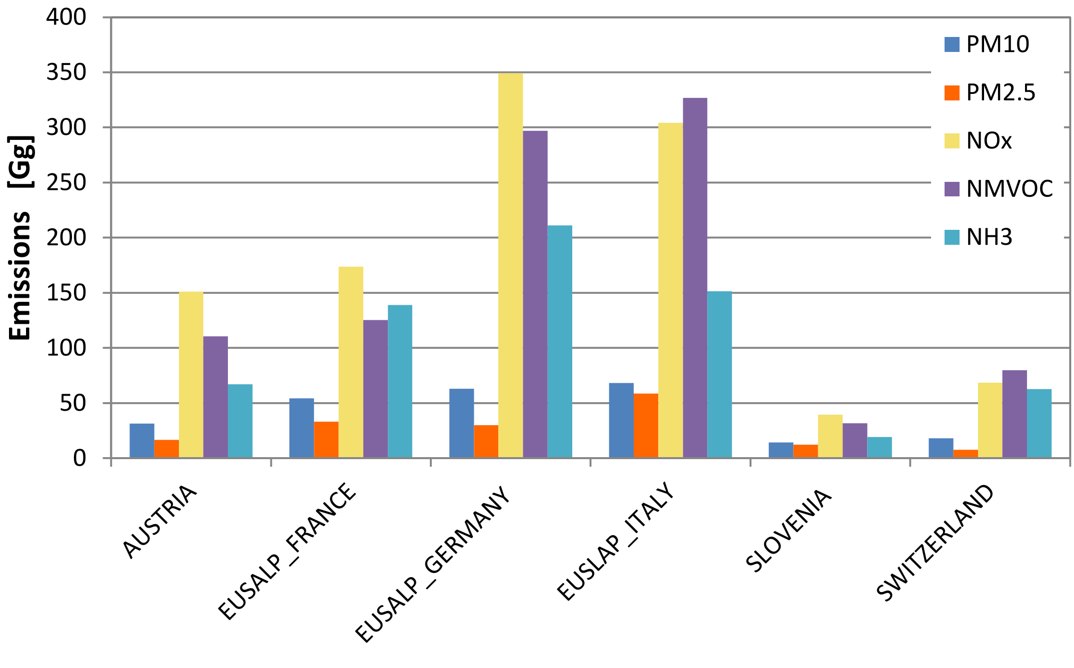
Emission inventories provide unique information to identify the emitting sources at national and often also at regional level. However, to identify the actual contribution of these sources to the concentration of pollutants in the air it is necessary to apply specific modelling techniques known as source apportionment. These techniques encompass receptor models (based on pollution measurements) and chemical transport models (based on emission inventories). The adoption of these techniques is instrumental for understanding the feasible air quality improvement that can be achieved by reducing emissions from those sources, due to the implementation of emission reduction policies for protection of the human health and environment (Air4EU, 2006).

4.1 EUSALP

A screening of the emission inventories was performed in order to analyse the main pollution sources in EUSALP macro-region. Due to the limited availability of regional/local emission inventories the national emission inventories, as they were reported to the EMEP for the year 2014 (EMEP, 2016), were used for this purpose. The emission estimations for the French, Italian and German part of the EUSALP was derived from the official national emission inventories, assuming equal per capita emissions in the EUSALP part and non –EUSALP part of the particular country. Emissions for the EU are based on the data reported by only 27 Member states because the data for Greece were not available in the EMEP database. The average emission densities were thus calculated without taking into the account the Greek population and land area. The population data used to compute per capita emission derive from the 2011 census (Eurostat, 2011).

The information on pollution sources is complemented by the analysis of the Lombardy region emission inventory and source apportionment studies highlighting the differences in the pollution sources structure in the large cities in the Po Valley and those in the Alpine area. Some emission from Lichtenstein, as for instance emissions due to use of the liquid fuels, are in included in the Swiss national emission inventory (FOEN, 2016).

Figure 12. Emissions of main pollutants and precursors in EUSALP by country.



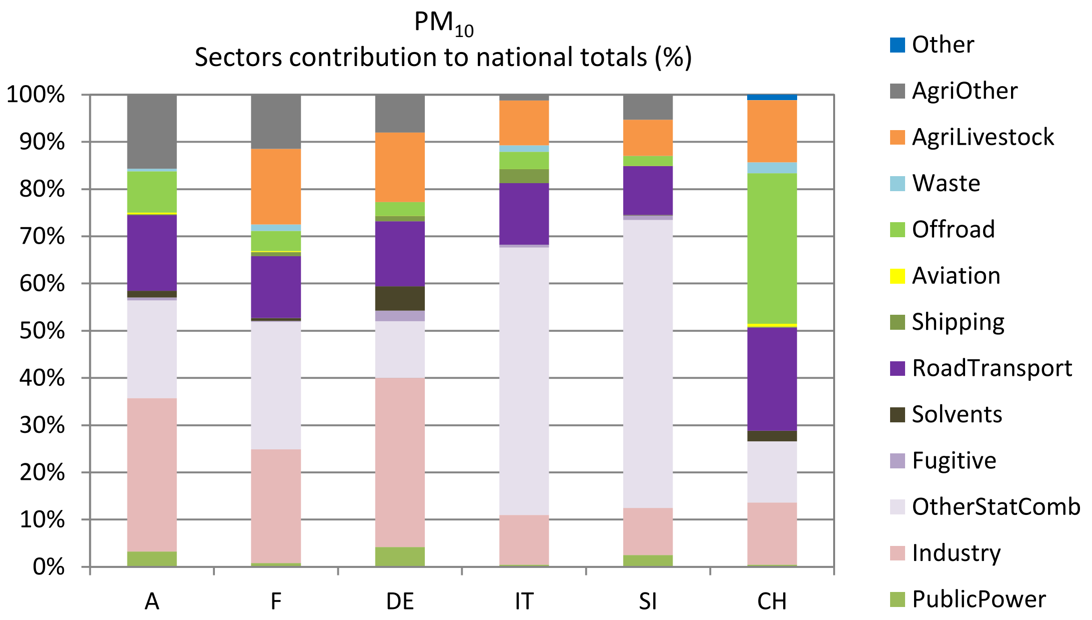
Source: data from EMEP elaborated by JRC

In this section emissions of five pollutants that are of interest either because of their direct impact (PM_{10}, $PM_{2.5}$ or NO_X) or because they are precursors of other pollutants (NMVOC, NO_X and NH_3) are discussed.

The highest absolute emissions in EUSALP are those located in the corresponding German and Italian territories (Figure 12). These countries are those with the highest share in terms of both area and population density to the macro-region. The differences between countries are more evident for the gaseous pollutants than for PM.

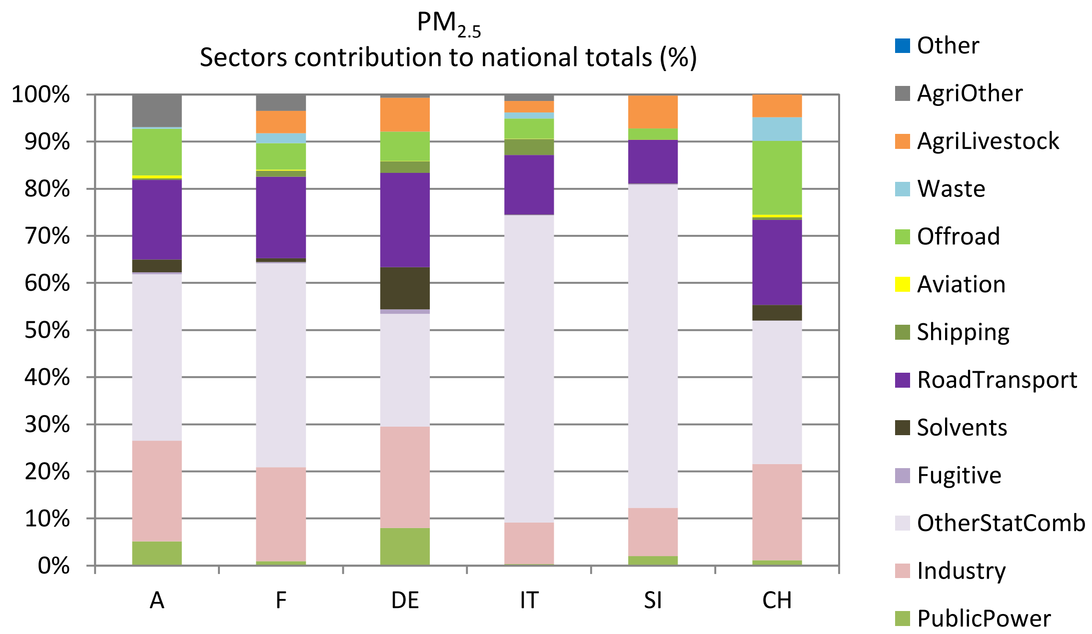
The mix of PM_{10} emissions is quite variable among the EUSALP countries (Figure 12). This likely due in part to the different country set up (technologies, use of fuels, meteorology, etc.) and also to the lack of harmonisation in the methodologies to compile the emission inventories. Small combustion installations, mainly from household sectors (OtherStatComb) are dominant in Italy and Slovenia while off-road is the most important source in Switzerland. A mixture of sources more or less equally responsible for the primary PM_{10} emissions is observed in the other countries where small combustion installations are still responsible for a considerable portion of $PM_{2.5}$ emissions (20-25%) while road transport and industry emission share are ca. 15 % each (Figure 14). On per capita basis the emissions of primary particulate matter, both PM_{10} and $PM_{2.5}$, in the EUSALP are at similar level as those in the EU.

Figure 13. PM_{10} national emissions in 2014 in EUSALP disaggregated by macrosector.



Source: data from EMEP elaborated by JRC

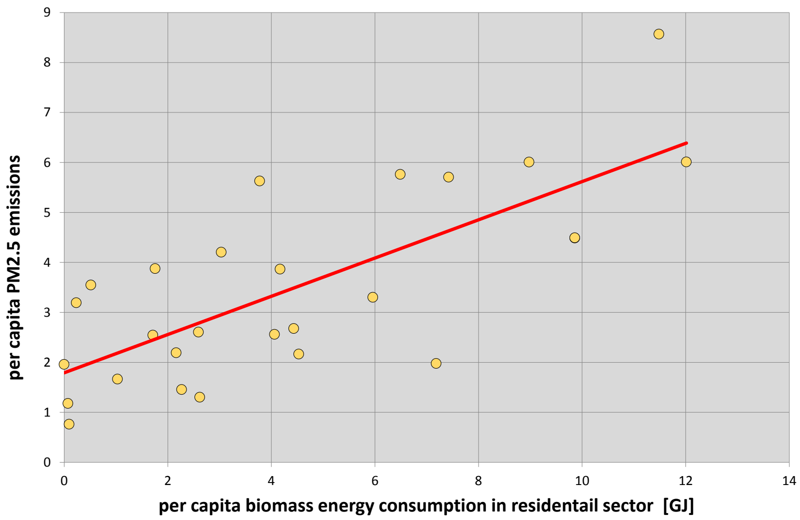
Figure 14. $PM_{2.5}$ national emissions in 2014 in EUSALP disaggregated by macrosector.



Source: data from EMEP elaborated by JRC

The very high PM emission factors, for older solid fuel-fired appliances in particular and their abundance, explain the significant share of the small combustion installations to the total emissions of primary PM observed in EUSALP compared and in the rest of the EU. These small combustion installations are mainly used for heating and the preparation of hot sanitary water in households.

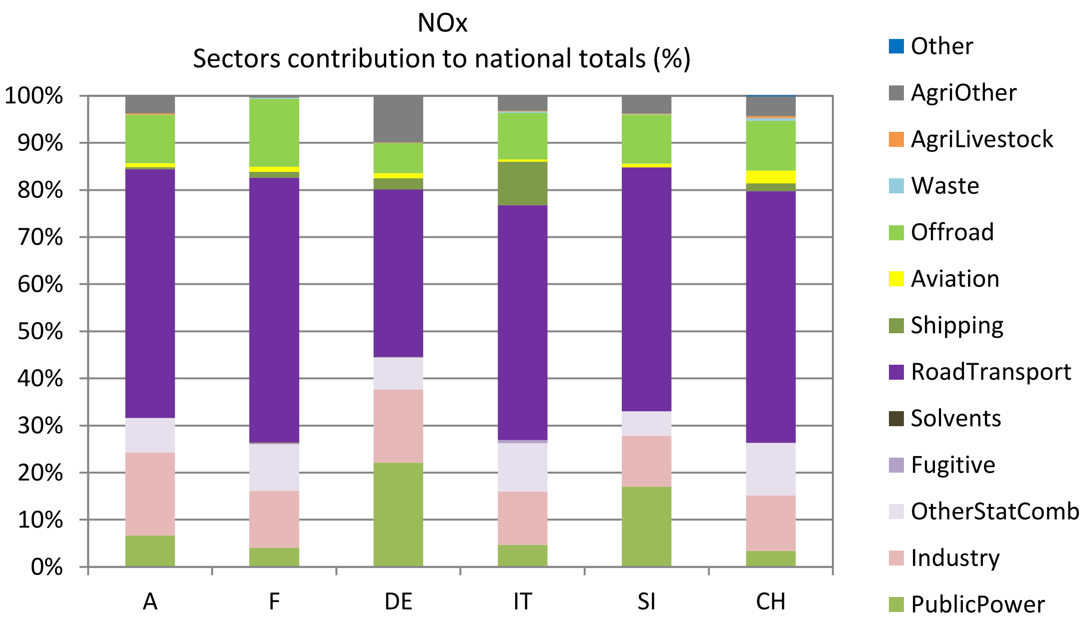
Figure 15. Per capita $PM_{2.5}$ emissions compared with per capita biomass consumption in residential sector in EU Member States.



Source: JRC

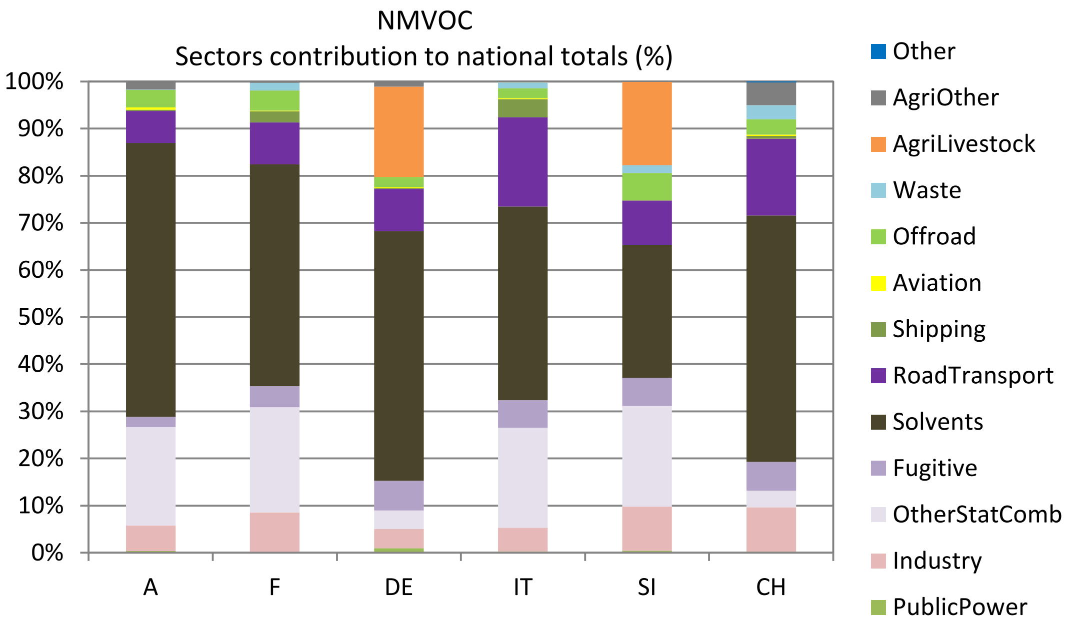
The correlation between PM emissions and biomass consumption at the EU level (Figure 15) reflects the high share of the small combustion installations on the total PM emissions in Europe and the high emission factors of those fired with solid fuels. Some deviations are explained by the greater share of coal consumption in the residential sector, as for instance in Poland. Lower ratios of PM emissions to biomass consumption in residential sector in Finland, Austria and Switzerland are associated with more advanced small combustion installations that have lower emission factors in those countries. Due to major gaps in emission inventories regarding the actual amount of fuel consumed, the range of emission factors and the entity of the emissions condensable fraction, a thorough understanding of this category of sources is still to come (European Topic Centre on Air Pollution and Climate Change Mitigation, 2016).

Figure 16. NO_x national emissions in 2014 in EUSALP disaggregated by macrosector.



Source: data from EMEP elaborated by JRC

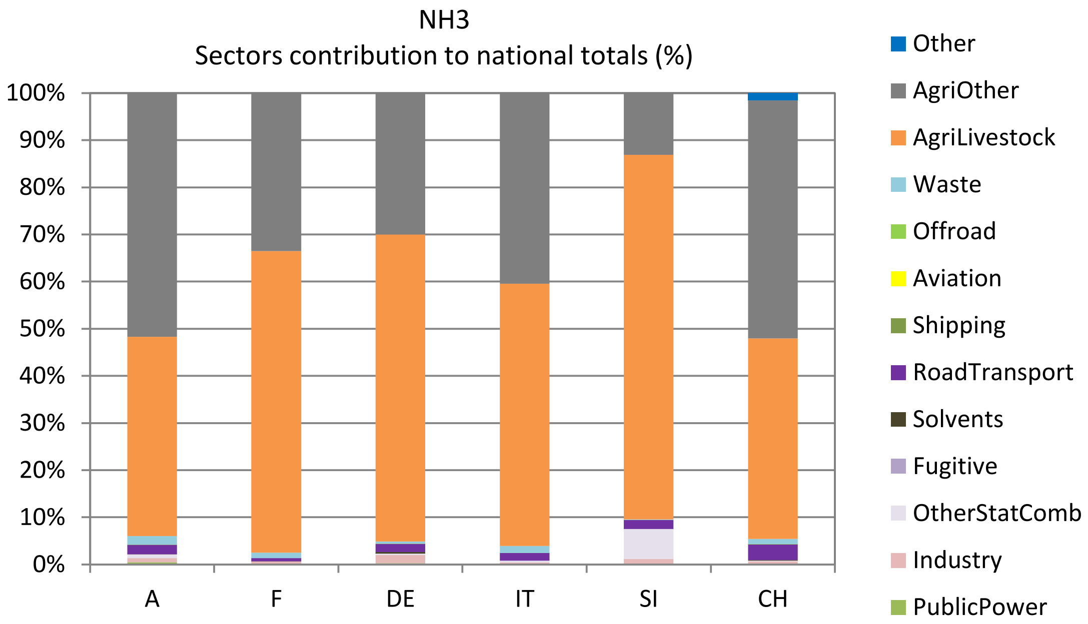
Figure 17. NMVOC national emissions in 2014 in EUSALP disaggregated by macrosector.



Source: data from EMEP elaborated by JRC

Despite differences in total emissions of NH_3, NMVOC and NO_x among EUSALP countries (Figure 12), their per capita emissions and the mix of sources (Figure 16) do not differ much. Road transport is a dominant sector for NO_x emissions and there is a variable share from the public power sector. When compared with the rest of the EU, the share of NO_X emissions from the road transport sector in EUSALP is higher and that from the public power sector is lower.

Figure 18. NH_3 national emissions in 2014 in EUSALP disaggregated by macrosector.



Source: data from EMEP elaborated by JRC

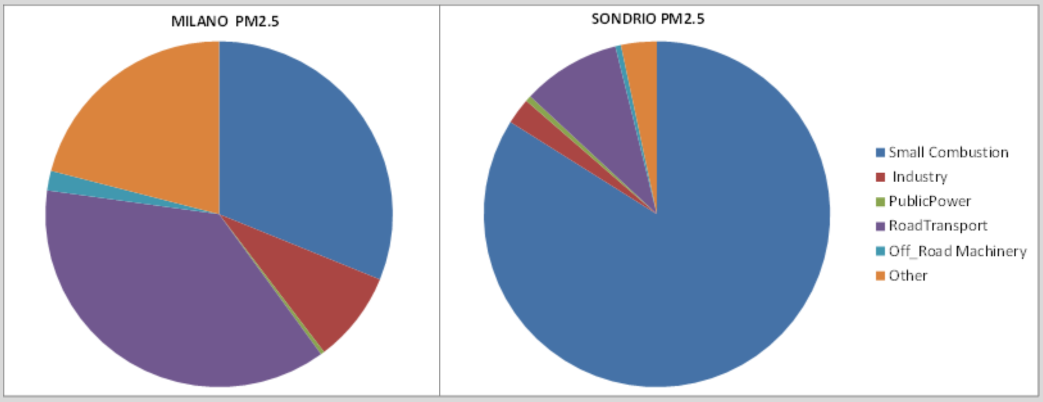
NMVOC and NOx are precursors in the processes that lead to ozone formation. The use of solvents accounts for approximately half of the total anthropogenic NMVOC emissions. The remainder is mainly attributed to small combustion installations and road transport (Figure 17). NH_3 is a precursor of secondary PM formation, together with SO_2 and NO_x. Almost all the NH_3 emissions derive from agriculture (Figure 18).

Box 4. Emissions at the regional level: the case of Lombardy - Po Valley

Lombardy is, with 10 million inhabitants and a population density of more than 400 inhabitants per km^2, one of the most economically developed regions of the EU. It is also very heterogeneous, ranging from the Po lowland to the Alpine mountainous area. The regional emission inventory INEMAR was used for a comparative analysis of some emission sectors in this region (ARPA Lombardia, 2017).

Two areas of the region with different emissions and geographical characteristics were selected for analysis. The province of Milan has more than 3 million inhabitants and a population density of 2000 inh./km^2. On the other hand, the Alpine province of Sondrio is a mountainous area in the north of the Lombardy region (Valtellina) where the population density is only 50 inh./km^2.

$PM_{2.5}$ emissions in Milan and Sondrio Source: INEMAR, 2017.



The dominant emission source of NO_x in both Sondrio and Milan is road transport, accounting for more than two thirds of the emissions. The overall share of road transport in NO_x emissions in Lombardy is lower, although still above half of the total emissions.

The residential heating in Lombardy as a whole produces one half of the total primary $PM_{2.5}$ emissions, however, the mix of emissions in the region is less uniform than those deriving from road transport. According to INEMAR, in the highly urbanised Milan province the residential heating contribution, mainly from wood-fired appliances, and road transport have a similar share of $PM_{2.5}$ emissions (see figure in the box). On the other hand, in Sondrio province residential heating share is more than 80% of the total $PM_{2.5}$ emissions. This is reflected also in the actual contributions from this source to $PM_{2.5}$ concentrations estimated with source apportionment techniques. In Sondrio city biomass burning reach 30% of the primary $PM_{2.5}$ and approximately 20% of the secondary fraction (Piazzalunga et al., 2011; Larsen et al., 2012). In this small city the residential sector is also the main contributor to the levels of benzo(a)pyrene (Belis et al., 2011). The much higher prevalence of residential heating in small settlements located near forested areas was also reported in Switzerland (Lanz, 2010), Austria (AQUELLA, 2007) and Germany (Umweltbundesamt, 2016).

Despite the much lower population density in the mountainous areas compared with the most populated lowlands, the spatial density of $PM_{2.5}$ emissions due to residential heating is comparable or higher in the former. It follows that managing the emissions from the residential heating is essential for the improvement of air quality, in particular in settlements of the Alpine valleys and those in other mountainous ranges of EUSALP and EUSAIR.

4.2 EUSAIR

Although all the EUSAIR countries have ratified the Convention on Long-range Transboundary Air Pollution (CLRTAP), data on national annual emissions are not available for all of them. Bosnia and Herzegovina has not submitted emission data at all and Montenegro has only reported until 2011 (Table 4). Albania submitted a report to CLRTAP in February 2017 in the framework of the project "Technical assistance for institution building" of the Ministry of the Environment to enforce environmental and climate *aquis* (European Commission, 2014). Greece reported a subset of gaseous pollutants.

Table 4. Status of reporting to CLRTAP

Country	2007	2008	2009	2010	2011	2012	2013	2014
Albania	√	√	√	√	√	√	√	√
Bosnia & Herzegovina								
Croatia	√	√	√	√	√	√	√	√
Greece	√	√	√	√	√	√	√	√
Italy	√	√	√	√	√	√	√	√
Montenegro	√	√	√	√	√			
Serbia	√	√	√	√	√	√	√	√
Slovenia	√	√	√	√	√	√	√	√

Source: EMEP-CEIP

In this section, the EMEP Centre on Emission Inventories and Projections (CEIP) data are used to assess air pollution sources in the EUSAIR area. The CEIP database contains officially reported data.

EMEP inventory data for the reference year 2014 for sectors that have a dominant influence on the emissions of SO_x, NO_x, PM_{10} and $PM_{2.5}$ are discussed below, apart from Montenegro whose analysis is for 2011, the latest available year in the emission inventory.

The highest NO_x emissions are from Greece and Italy which are also the countries with the largest land areas and populations in the macro-region (Figure 19). Italy is also the largest source of PM, both PM_{10} and $PM_{2.5}$ however, no info about these pollutants is available for Greece. Serbia is the main SO_X emitter followed by Italy and Greece.

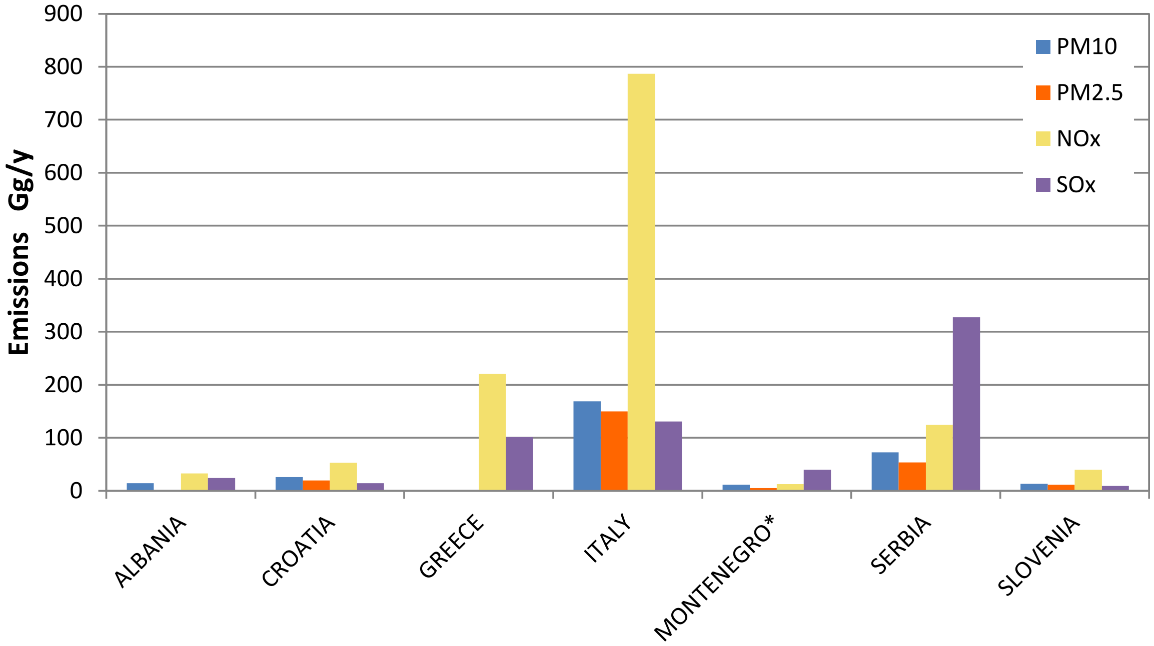
The main PM_{10} source in the majority of the EUSAIR countries is domestic combustion, apart from Serbia and Montenegro where there is a significant share from industry and public power plants, respectively (Figure 20). According to the emission inventories, primary emissions of PM_{10} from the road transport are quite limited.

The mix of sources is quite similar for $PM_{2.5}$ with the difference that the share of domestic combustion is higher than for PM_{10} and the shares of industrial and power plant emissions are lower (Figure 21).

NO_x emissions are dominated by the road transport sector in many countries (Figure 22). However, in Montenegro, Serbia and Greece the main emitters for this pollutant is the public power generation sector.

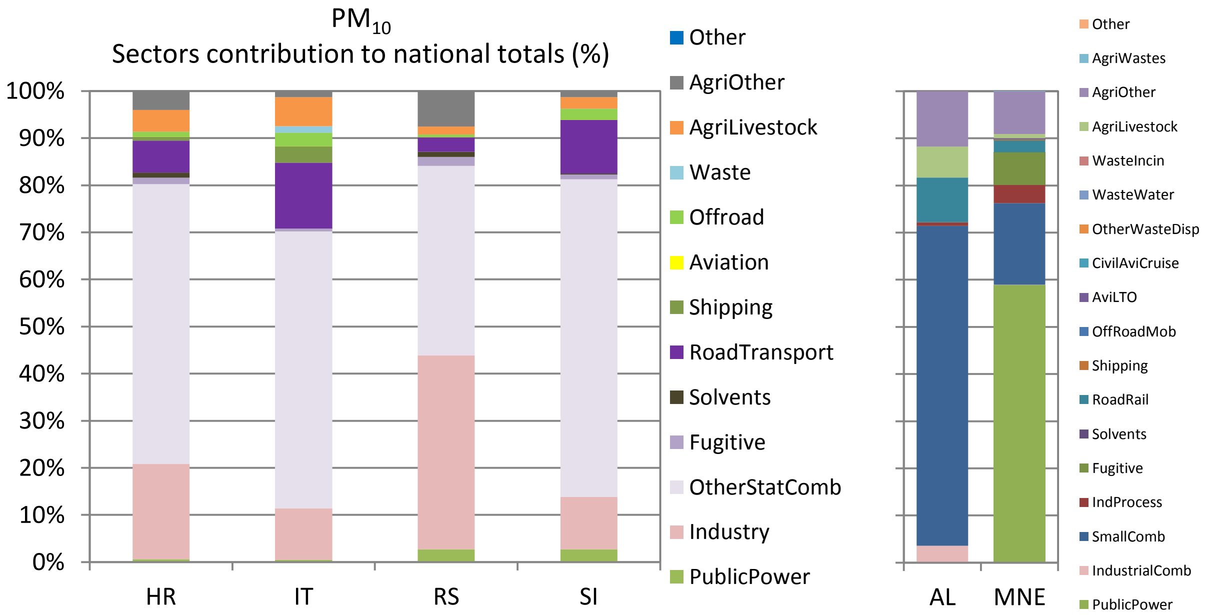
Similarly SO_x in Serbia, Greece Slovenia and Montenegro derive from the power generation sector (Figure 23). These figures are particularly important for the first two countries which are among the main emitters in the region. In Italy and Croatia the main emissions derive from industry followed by fugitive emissions and power generation sectors, while in Albania industry is the main source followed by off-road mobile sources.

Figure 19. Emissions of main pollutants and precursors in 2014 in EUSAIR by country.



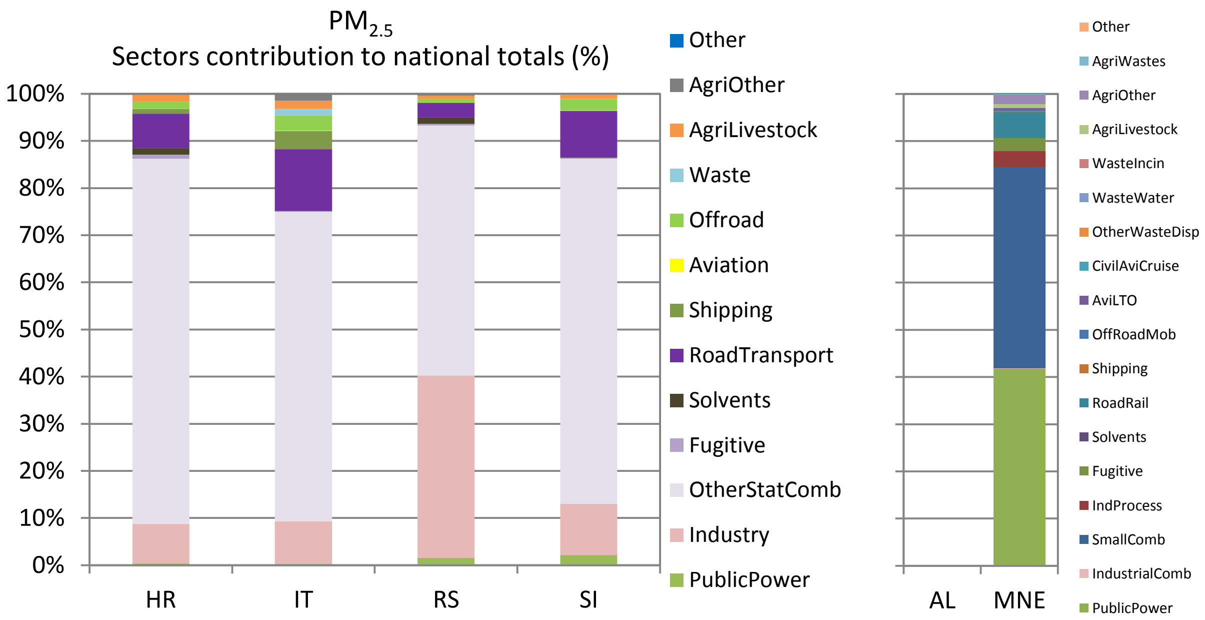
Source: data from EMEP elaborated by JRC. * emission ref. year 2011.

Figure 20. PM_{10} national emissions in 2014 in EUSAIR disaggregated by macro-sector.



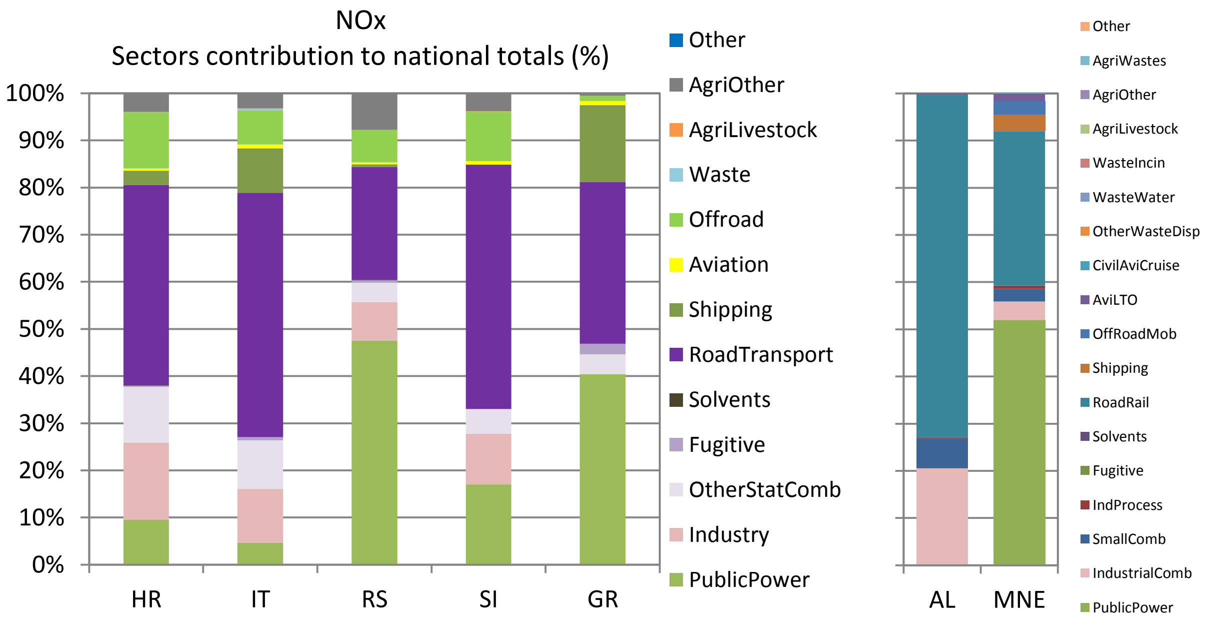
MNE emission ref. year 2011. AL and MNE have different macro-sector split than the rest of the countries
Source: data from EMEP elaborated by JRC

Figure 21. $PM_{2.5}$ national emissions in 2014 in EUSAIR disaggregated by macro-sector.



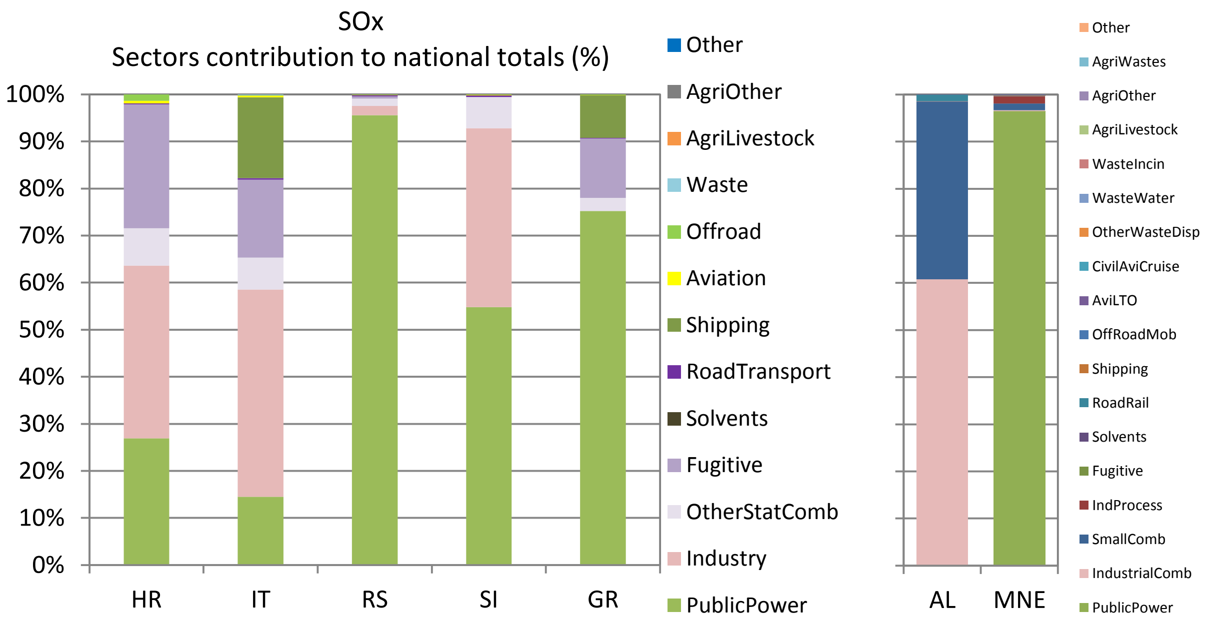
MNE emission ref. year 2011. AL and MNE have different macro-sector split than the rest of the countries
Source: data from EMEP elaborated by JRC

Figure 22. NO_X national emissions in 2014 in EUSAIR disaggregated by macro-sector.



MNE emission ref. year 2011. AL and MNE have different macro-sector split than the rest of the countries
Source: data from EMEP elaborated by JRC

Figure 23. SO_X national emissions in 2014 in EUSAIR disaggregated by macrosector.



MNE emission ref. year 2011. AL and MNE have different macro-sector split than the rest of the countries
Source: data from EMEP elaborated by JRC.

Key activity sectors for atmospheric pollution

The **public power** generation sector is the most important SO_x source for many countries of the Balkan peninsula. It is almost the sole source of this pollutant in Montenegro and Serbia, while in Greece and Slovenia it is responsible for more than 50% of the national total. On the contrary, no emissions from this sector are reported for Albania, where power production relies mainly on hydropower. The public power sector significantly contributes to NO_x emissions in Montenegro, Serbia and Greece.

Industry is the most important SO_x source in Croatia and Italy while modest fugitive SO_x emissions are reported only in these two countries and Greece.

Road transport is the most important source of NO_x in Croatia, Slovenia and Italy. It is an important contributor also in Serbia, Montenegro and Greece.

Small/other stationary combustion is the main emitter of PM_{10} in Croatia, Slovenia, Albania and Italy. The same source is main responsible for $PM_{2.5}$ in Croatia, Serbia, Slovenia, Montenegro and Italy (more details in Box 5).

The **shipping** sector is acknowledged as a significant source of SO_x and NO_x only in Italy and in Greece. However, emissions from this sector are also reported for Slovenia and Montenegro (more details in Box 6).

Box 5. Biomass burning in households

In EUSALP and EUSAIR, like in many other parts of the Europe, biomass burning (BB) has traditionally been used for residential heating. Emissions of $PM_{2.5}$, black carbon and benzo(a)pyrene in the EUSALPS and EUSAIR macro-region are mainly associated with the domestic combustion of biomass for heating purposes (Muntean et al., in prep.). Due to the high emission factors from this source, high levels of PM_{10} and $PM_{2.5}$ during winter and consequently frequent exceedences of air quality limit values are observed in the non-EU countries of the EUSAIR macro-region. The AIRUSE LIFE+ project conducted field campaigns encompassing different PM_{10} and $PM_{2.5}$ monitoring sites in Southern Europe with the aim of producing comparable results on source apportionment of these two PM fractions. Two cities of the EUSALP- EUSAIR area, Milan and Athens (AIRUSE, 2016), are among the sites studied.

In Italy the extensive use of wood in residential combustion appliances contributes significantly to the observed levels of PM. In the urban background of Milan, besides traffic, biomass burning is the most important source of $PM_{2.5}$ (24%). The average biomass burning contribution during the days with concentrations above 35 $\mu g/m^3$ accounted for 26% of $PM_{2.5}$ (AIRUSE, 2016).

Biomass burning has been recognised as a main source of atmospheric pollution in many regions of Southern Europe (e.g. Giannini et al., 2012; Paglione et al., 2014) and in many other sites around the world (e.g. Moon et al., 2008; Wang et al., 2013; Yatkin et al., 2008, Karagulian et al., 2015). However, in certain Southern European areas the biomass burning contribution has been quantified as relatively low, for example 2.5% of $PM_{2.5}$ mass in Barcelona on an annual basis (Reche et al., 2012). Thus, the scenario may vary widely across Southern Europe depending, among other, on the climate-related heating demand (AIRUSE, 2016).

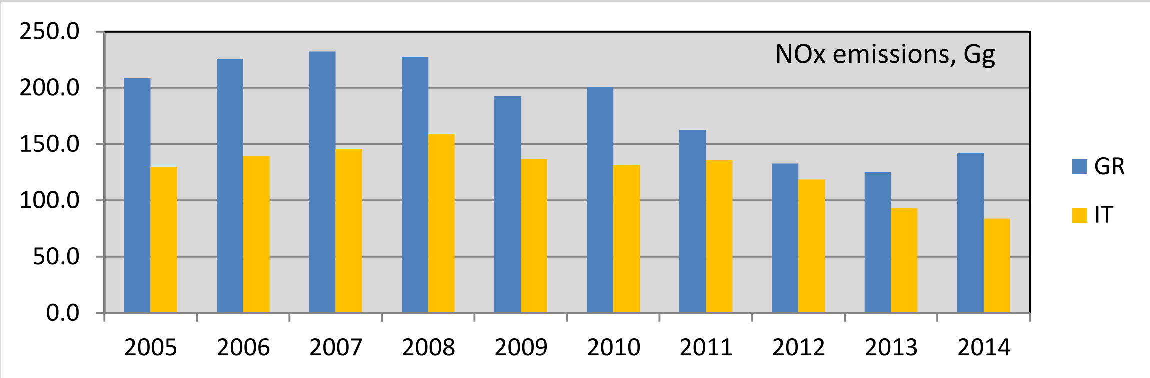
Also economic factors and local legislation may affect the mix of fuels used for heating purposes. The biomass burning contribution to PM is relatively low in Greece. In Athens, for instance, the source apportionment indicates that biomass burning is the third largest contributor to observed $PM_{2.5}$. This source accounted for 7% and 12% of the PM_{10} and $PM_{2.5}$ levels, respectively. Although biomass burning accounts for 17% of the overall energy consumed for space heating in the residential sector, the Greek biomass market is not considered to be widely developed. Consumers have only few choices when it comes to biomass suppliers and biomass boiler installers. A crucial reason for the little development of the biomass market is a barrier that exists in the Greek legislation. According to a Ministerial Decree of 1993 (MD 103/1993/B-369), biomass boilers are not allowed to be installed in the two major cities of Greece, Athens and Thessaloniki. Due to this restriction, biomass as energy source for space heating is not a choice for a large share of the Greek population. The associated Joint Ministerial Decision (JMD D3/A/11346 FEK 963/B/15-7-2003) requires since 2004 newly constructed buildings in some big cities (e.g. Athens, Thessaloniki) to have natural gas installations as standard equipment (Giakoumi and Iatridis, 2009).

Air quality in the Greek city of Thessaloniki has worsened during the recent economic crisis because residents burn more wood and other types of biomass for heating purposes. Saffari et al. (2013) report a 30% increase in the concentration of $PM_{2.5}$ emissions associated with residential wood combustion (RWC) in 2012 and 2013. Evening samples had a higher proportion of organic matter (74%) compared with the morning samples (58%), again suggesting more wood and biomass were used for heating in the evening.

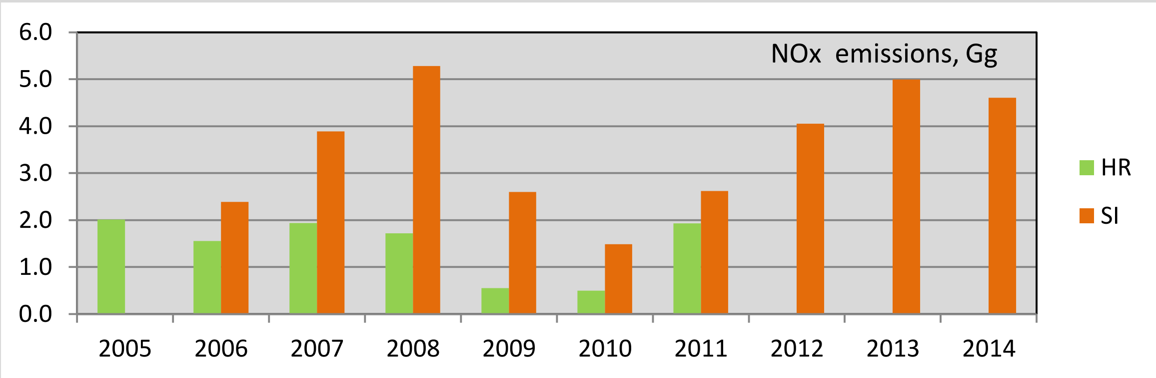
Box 6. Maritime transportation in the EUSAIR

Maritime transportation is the backbone of international trade because it is a cost-efficient mode of transport for both goods and passengers. According to EUROSTAT, Italy and Greece registered the highest number of port of calls and the largest gross tonnage of vessels making port of calls in 2015. In this year these two countries that lead the maritime passenger transportation had a combined share of about one third of the total number of seaborne passengers embarking and disembarking in the EU countries. Their geographical positions enable good connections with the ports outside the EU, increasing the quantity of goods and the number of passengers in their ports.

International maritime navigation as a source of NO_x in Italy and Greece (a) and Slovenia and Croatia (b) Source: data from EMEP elaborated by JRC



a)



b)

Due to the strategic importance of maritime transportation in the EUSAIR macro-region, it is essential to assess its emissions and impacts, with a view to promote a sustainable development of this sector. The navigation (shipping) source category covers all water-borne transportation. Emissions from maritime transport are included in the international maritime navigation category under CLRTAP. Italy and Greece report international maritime shipping emissions as do Croatia, Slovenia and Montenegro (until 2011) (see figure in the box)

For tourism to develop, adequate transportation services using a variety of vessels to cover trips ranging from short to long-range distances are necessary. Among these, cruise vessels are the most fuel demanding, because of their high energy requirements, for both propulsion and passenger services, that impose a constant need of ancillary power for lighting and ventilation at sea and in port.

A number of methodologies are used for the estimation of emissions, typically based on fuel statistics. Depending on the method, emission estimates may vary up to a factor 2 for NO_x and by factor 2.5 for SO_2 (EEA, 2013). It is considered that international shipping in European waters contributes 10-20% of NO_x, 10-25 % of SO_2 emissions and 15–25 % of primary $PM_{2.5}$ emissions (EEA, 2013).

Harbours are directly influenced by ship emissions, as well as the cities around them. Source apportionment studies have been carried out to assess the contribution of shipping emissions to annual mean concentrations in those areas. According to source apportionment studies, contribution of shipping emissions to ambient air concentrations are in the range: 1–7 % and 1–14 % for PM_{10} and $PM_{2.5}$, respectively and 7-24% for NO_2 in European coastal areas (Viana et al., 2014).

There is a typically summertime maximum in cruise traffic intensity. The increased traffic intensity causes congestion at ports and increases fuel consumption and gas emissions.

An impact assessment study was conducted at selected urban monitoring stations in the city of Taranto, a Mediterranean harbour with sizeable industrial facilities. In this city, 9% of SO_2 and NO_x average source contributions are estimated to derive from harbour activities, while 87% and 41% respectively of total concentrations are attributed to industrial origin (Gariazzo et al., 2007).

The influence of ship traffic on levels of PM_{10} and $PM_{2.5}$ was also estimated in the urban area of Venice, Italy. The results have shown a direct contribution of ship emissions to PM_{10} and $PM_{2.5}$ ranging between 1% and 8% (Contini et al., 2011).

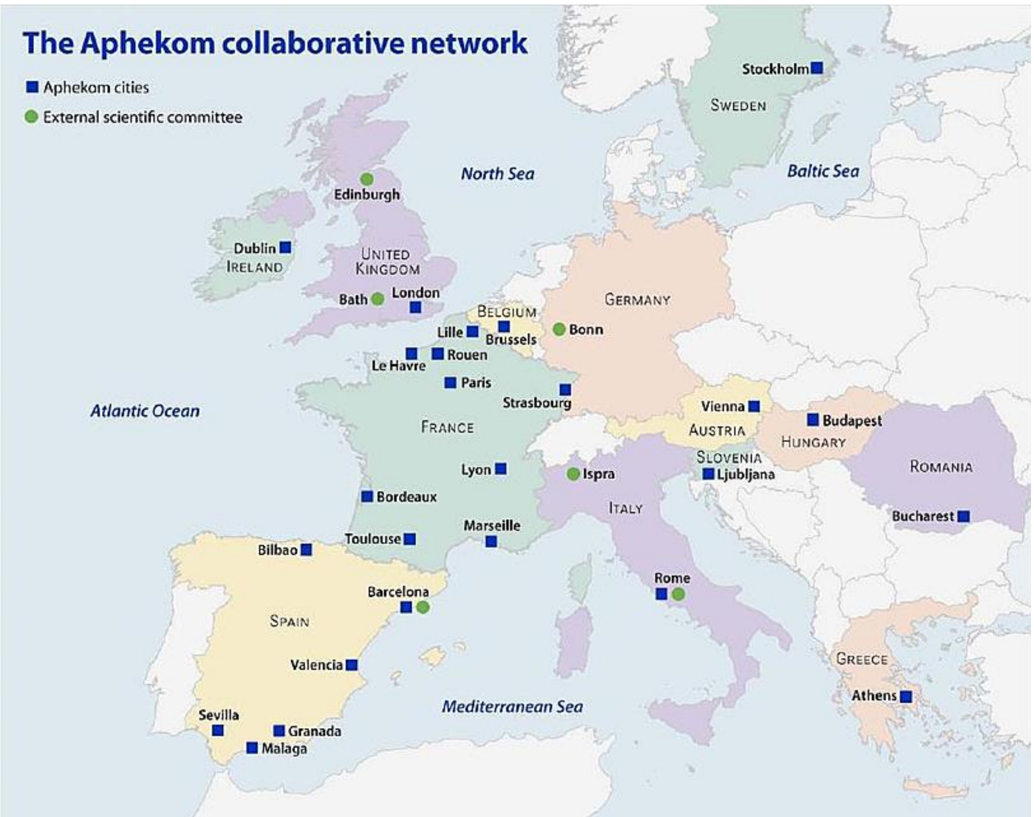
5 Air pollution impacts

5.1 Health effects

Air pollution is the single largest environmental health risk in Europe (EEA, 2016). By reducing air pollution levels, countries can reduce the burden of disease from stroke, heart disease, lung cancer, and both chronic and acute respiratory diseases, including asthma. Lowering the levels of air pollution would result in an improvement of the cardiovascular and respiratory health of the population in both the short- and long-term. A 2013 assessment by WHO's International Agency for Research on Cancer (IARC) concluded that outdoor air pollution is carcinogenic for humans, with the particulate matter component of air pollution most closely associated with increased cancer incidence, particularly lung cancer. An association between outdoor air pollution and increase in cancer of the urinary tract/bladder has also been observed (WHO, 2016).

The adverse effects on health of particulate matter (PM) are well documented. There is no evidence of a safe level of exposure or a threshold below which no adverse health effects occur. Pollution from PM creates a substantial burden of disease, reducing life expectancy by almost 9 months on average in Europe. Since even at relatively low concentrations the burden of air pollution on health is significant, effective management of air quality with the aim of achieving the WHO Air Quality Guidelines levels is necessary to reduce health risks to a minimum (WHO, 2013).

Figure 24. Cities involved in the Aphekom study



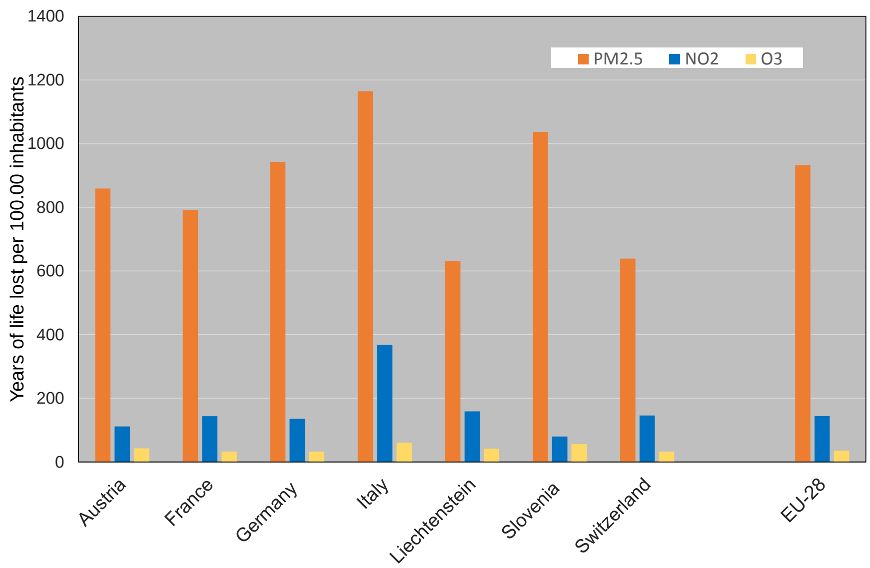
Source: Pascal et al., 2013

Several multinational projects focused on health risk and health effects observation due to the air pollution in Europe. The Aphekom project, carried out between 2008 and 2011, used traditional health impact assessment (HIA) methods to assess the impact of air pollution on health in 25 European cities (Figure 24) with nearly 39 million inhabitants in 12 countries across Europe including areas of the EUSALP and EUSAIR (M. Pascal at al., 2013 and references therein). This and other recent projects, together with a body of consistent epidemiological findings from different cities, periods and study designs, have indicated both short- and long-term exposure to elevated air pollution, especially atmospheric particulate matter and ozone concentrations, as the factors associated with specific health outcomes like respiratory and cardiovascular mortality (WHO, 2013).

EUSALP

A harmonised estimation of premature deaths and years of life lost for the year 2013 in 41 European countries due to air pollution exposure was performed by the European Topic Centre on Air Pollution and Climate Change Mitigation of the EEA (EEA, 2016). The population weighted levels of pollutants were derived from measurement results, air quality modelling and population density. The data are available at the country level only, so details for the EUSALP parts of France, Germany and Italy are not available. According to this study, PM induced morbidity is main cause of mortality in the EUSALP countries due to air pollution (Figure 25). The mortality due to NO_2 levels is on average less than one fifth and the one due to ozone less than one twentieth of the mortality associated to PM.

Figure 25. Years of the life lost due to air pollution with $PM_{2.5}$, NO_2 and O_3 in EUSALP countries in comparison with the average EU values.



Source: JRC elaboration from (EEA, 2016)

In general, the health impact of air pollution in EUSALP is comparable to that of the EU 28. Among the EUSALP countries, Switzerland (and Liechtenstein) stand out for their low population weighted PM levels and consequently relatively low morbidity due to air pollution.

The economic costs of air pollution are considerable. The costs of premature deaths from air pollution, as a percentage of the annual GDP per country in the EU, varies from 0.7 % in Finland to 29.5 % in Bulgaria. In EUSALP it ranges from 2.5 % in Switzerland to 5.7 % in Slovenia (WHO Regional Office for Europe, OECD, 2015).

In many areas of the EUSALP health impacts assessments of the air pollution were performed at different levels, as described in national or regional air quality reports (Spangl W., 2010, ARSO, 2015, Felber Dietrich D., 2014, Kallweit D., 2013, Préfet de la Haute-Savoie, 2012). The results are similar to those presented in the abovementioned EEA report. However, a direct comparison of the results is not possible, due to differences in the methodologies used to derive the population exposures. Such assessments are also important for the awareness rising of the population.

EUSAIR

A 2002 study on the eight largest Italian cities (Bologna, Florence, Genoa, Milan, Naples, Palermo, Rome and Turin), showed that deaths, hospital admissions, cases of bronchitis and other respiratory conditions were in excess of predicted rates. PM_{10} was used as an indicator of air quality, given its importance as a health determinant but other urban pollutants are suspected to have additional impact on health (Martuzzi et al., 2002). This study describes the air quality in relation with sources of pollution, evaluates the burden of atmospheric pollutants on human health and assesses the economic costs related to air pollution. In 2006, a second study, concerning 13 Italian cities, focused on the health effects of both PM_{10} and ozone (Martuzzi et al., 2006) This study used an updated and extended set of data; it considered 25 adverse health outcomes and several exposure scenarios. An average of 8220 premature deaths a year in the 13 cities were found to be attributable to the chronic effects of PM_{10} concentrations above 20 mg/m^3 (Table 5). These correspond to 9% of all-cause mortality (excluding accidents) in the population over 30 years of age. The magnitude of this estimated impact underscores the need for urgent action to reduce the health burden of air pollution.

Table 5 Deaths attributable to levels of PM_{10} exceeding 20 $\mu g/m^3$

	males		females		total			
	No.	95% CrI	No.	95% CrI	No.	95% CrI	% attr cases	95% CrI
Chronic effects (a)								
All causes of mortality (excluding accidents)	3909	2996–4827	4311	3315–5310	8220	6308–10140	9	6.9–11.1
Lung cancer	551	392–711	191	137–245	742	530–956	11.6	8.3–14.9
Infarction	1293	1220–1367	1269	1198–1341	2562	2418–2707	19.8	18.7–21
Stroke	126	79–174	203	132–275	329	207–452	3.3	2.1–4.6
Acute effects (b)								
All causes of mortality (excluding accidents)	654	574–735	718	631–806	1372	1204–1540	1.5	1.3–1.7
Cardiovascular causes	362	303–421	481	404–558	843	706–980	2.1	1.8–2.5
Respiratory causes	99	77–121	86	67–106	186	145–227	3.1	2.4–3.8

(a) adults ≤ 30 years of age, risk based on PM2.5 estimates, (b) all ages. Source: Martuzzi et al., 2006

Tropospheric ozone formation occurs in photochemical reactions of its precursors, nitrogen oxides (NOx) and volatile organic compounds (NMVOCs) under certain meteorological conditions. Heat waves in summer seasons characterised by long-term high atmospheric pressure intervals over large areas, high temperatures and dry conditions favour elevated ozone concentrations. (EEA, 2017) A causality between days with high ozone and PM_{10} levels, heat wave effects and total and cardiovascular mortality, especially within elderly population has been observed (Analitis et al., 2008).

As a consequence of ongoing climate change, it is expected that heat waves will become more frequent as extreme weather events, increasing air pollution peaks in the main urban areas and causing an increase in mortality and hospital admissions (WHO, 2013).

Regions most affected by climate change are generally located in the southern Europe, several of them being EUSAIR countries. The long-term target for ozone is exceeded in all these countries indicating the significance of described effects and associated health risk for the population.

Photochemical episodes leading to high ozone levels and heat waves are interlinked phenomena with a maximum intensity during summer anti-cyclonic conditions over the Mediterranean and Southern Europe. The number of people exposed to heat waves in Southern Europe is forecasted to grow by a factor of 60 by the end of the present century and the consequent number of deaths by a factor of 70 (Forzieri et al., 2017)

Heat-related risks might be reduced by alerting both the public and decision-makers through development of heat-wave early warning systems, combined with air quality warnings. The World Meteorological Organization (WMO) and the World Health Organization (WHO) are developing and disseminating guidance on Heat–Health Warning System, an example of climate-risk management in practice.

MED HISS is a project aimed at setting up a surveillance system to monitor long-term health effects of air pollution over time in Mediterranean countries (Spain, France, Italy, Slovenia). It has applied an epidemiological approach based on individual and ecological studies in which public exposure was derived from national maps of air pollution concentrations determined at a municipal level.

The health risks of air pollution in Europe – HRAPIE and REVIHAAP projects assessed the views of expert stakeholders regarding the evidence of emerging issues on risks to health from air pollution. By means of an online survey tool expert answers concerning either specific source categories (e.g. transport, biomass combustion, metals industry, refineries, power generation), specific gaseous pollutants or specific components of particulate matter (e.g. size-range, rare-earth metals, black carbon) were collected and analysed (Henschel and Chan, 2013; WHO, 2013). Experts from EUSAIR countries Italy, Slovenia, Croatia and Greece contributed to the survey. One of the main findings is that the majority of respondents identified the general categories of "road traffic", "space heating and air conditioning", and "shipping" as the top three emission source categories of concern associated with emerging issues for public health.

In the frame of a project on capacity building in environment and health (CBEH), co-funded by the European Commission, the specific capacity needs in relation to the implementation of health impact assessment (HIA) and further integration of health in environmental assessments in Slovenia were analysed (Gibson et al., 2013). According to the document, human health is a core requirement of the Strategic Environmental Assessment (SEA) Directive and the Environmental Impact Assessment (EIA) Directive is also concerned with protecting human health. Another motivation for deploying HIA in Slovenia are health inequalities and social determinants of health. The document concludes there is a need to have greater understanding regarding EIA and SEA and how sound decision-making can be underpinned by HIA.

Unfortunately, in other countries of the region, there is no systematic approach to the health impact assessment or epidemiologic studies on the adverse health effects of air pollution or particular pollutants. Nevertheless, within the national research projects there are data on a few publications on the air pollution associated risk.

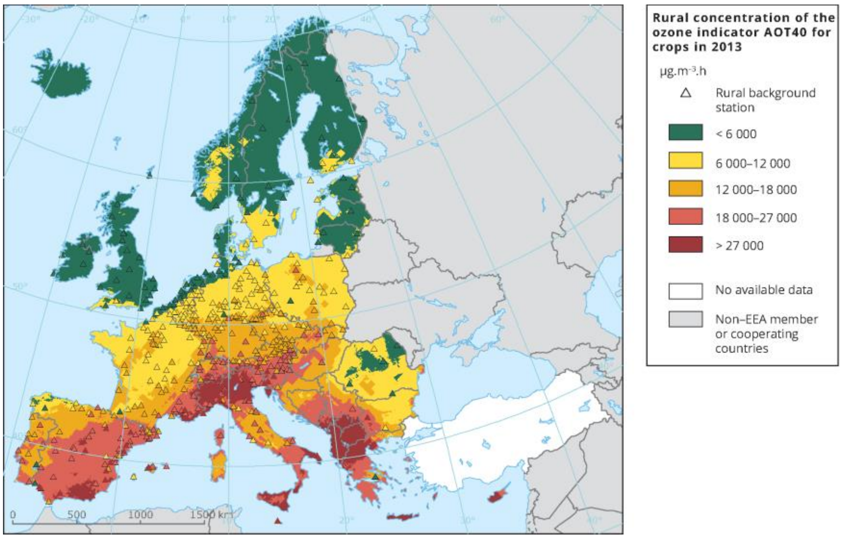
The main obstacle for more detailed studies is lack of long-term data series on continuous air quality measurements as well as statistical data on the epidemiological records.

5.2 Other impacts of air pollution

Impacts on ecosystems and crops

Air pollution also impacts on the environmental compartments: water, soil, forests and the biota. The atmospheric deposition of sulphur and nitrogen compounds has acidifying effects on soils and freshwaters. Acidification may lead to increased mobilisation of toxic metals, which in turn increases the risk of uptake in the food chain. Deposition of nitrogen compounds can also lead to eutrophication, an oversupply of nutrients that may cause changes in species diversity like blooming of toxin-producing algae or invasions of alien species (EEA, 2016).

Figure 26. Rural concentrations of the ozone indicator AOT40 for the crops in 2013.



Source: EEA, 2016

Ozone damage to plants is of particular importance for the economy, since it markedly reduces the yield of agricultural crops. The impacts of ozone on crops are complex. They depend primarily on the ozone levels, but also on soil moisture and plant growth stage, which influence uptake of the ozone by the plants. Yield loses depend also on the sensitivity to ozone, which varies among the plant species. For wheat, the estimated yield reduction for the EU is 13 % with an economic loss of 3.2 billons EUR. For tomato, a horticultural crop representative for southern Europe, yield loss was estimated to be 9.4 % with yearly economic loss of 1 billon EUR. The EUSALP area is prone to high levels of ozone in its southern parts and in mountainous areas in particular. Ozone AOT 40 values, which are indicators of the exposure of the plants to the ozone, are among the highest in the EU (Figure 26).

The forest ecosystems of the EUSALP macro-region are also affected by the elevated ozone levels. For instance, recent studies estimate the growth loses in Swiss forests caused by ozone to be 11 % (Braun, 2014).

Determining the extent to which air pollutants affect biodiversity is complicated. Different pollutants affect species in a variety of ways. The mixture of air pollutants and their products to which organisms are exposed varies in composition, and each combination has a slightly different effect (EEA, 2016). The influence of air pollution on biodiversity in the Alpine areas in particular could be exacerbated by further climate change, which is already a cause of stress for the Alpine ecosystem (EEA, 2017).

Impacts on built environment and cultural heritage

Air pollution plays a pivotal role in the deterioration of many materials used in buildings and cultural monuments. Air pollution contributes to the superficial recession or corrosion of buildings, industrial installations and cultural materials. Cultural heritage in particular undergoes damage due to the loss of original material, having both economic and social consequences.

Recent studies for Italy showed, that the corrosion levels for limestone, copper and bronze decreased from 2003 to 2010 due to decreases in acidifying pollutant concentrations. However, some problems related to air pollution persists particularly in Northern Italy. In particular, PM_{10} and nitric acid are considered to be mainly responsible for limestone corrosion (De Marco A.， 2017). Buildings and monuments are typically blackened, due to the accumulation of atmospheric pollutants. The main components of the black crust are elemental and organic carbon as well as products of the surface decomposition due to the acid pollutants (Barca D.， 2014).

6 Measures implemented to improve air quality

To protect human health and the ecosystems, Member States take action in order to comply with limit values and critical levels, and where possible, to attain the target values and long-term objectives set by the AQDs (Directives 2008/50/EC and 2004/107/EC). When the levels of pollution exceed the limit values or target values Member States, and subsequently local authorities, shall establish air quality plans where measures to tackle the pollution sources and bring the air quality levels below those thresholds are listed. Moreover, according to the Commission Implementing Decision of 12 December 2011, information about the contribution of sources and scenarios that supports these air quality plans must be reported by Member States to the Commission through the so-called e-reporting scheme.

To develop an air quality plan, it is first necessary to understand what are the causes of air pollution exceedances and to adopt available tools to predict air quality and their effects (Miranda et al, 2015). The successful preparation and monitoring of the implementation of air quality plans strongly depends on key elements such as: emission inventory, monitoring network, air quality modelling, source apportionment and control strategies. In order to select most appropriate emission abatement measures, numerical models are applied (in combination with monitoring) to estimate the actual contribution of emissions to concentrations and to assess the resulting air quality from both baseline and emission abatement scenarios (Gulia et al, 2015).
Detailed emission inventories, comprehensive sets of meteorological and air quality data (long-term data series available for different parameters) and source apportionment studies are prerequisites for developing pollution control strategies. The lack of reliable data and limited skills on the use of state-of-the-art techniques may lead to inadequate abatement measure implementation.

Using Integrated Assessment Methodologies (IAM) in relation to economic and technical feasibility and to effects on the environment and human health should be properly considered (Miranda et al., 2015). Cost–effectiveness assessment (CEA) provides the ratio between a gain in health from a measure (e.g. increased life expectancy) and the cost associated to its implementation. This kind of tools supports the policy maker in comparing the relative costs and the potential air quality and/or health impact deriving from the implementation of different measures.

The time frame for the planning, implementation and the achievement of acceptable air quality levels is a key aspect. To avoid unexpected delays or missed targets, a careful evaluation of the following factors is essential: a) the procedures for acquiring the resources, b) the timing of the technical steps to implement measures, c) the atmospheric processes leading to the abatement of pollutants (reducing emissions does not always reduce concentrations), and d) the strategies to promote consensus and acceptability of the measures in the affected population.

To improve the status of the implementation of the air quality legislation more effort in terms of institutional capacity and staff training in the area of air quality is required, especially in the Western Balkans.

6.1 EUSALP

As shown in Section 2.2, many of the EUSALP areas undergo exceedances of EU limit values. Consequently, Air Quality Plans have been developed and implemented. In Switzerland, where the national Air Quality standards are more stringent than those in EU, the national limit values are also exceeded. The Swiss Cantons also have the obligation to prepare Air Quality Plans.

The information on the measures included in the adopted Air Quality Plans is reported by Member States pursuant to the provisions of the Commission implementing decision 2011/850/EU to the EEA (data flow K).

Air quality plans consist of several sets of measures targeting most important pollution sources, transport, small combustion installations mainly in residential sector, industry and depending on the spatial coverage of the plan, the agricultural sector as well. The number of the measures in the air quality plans is relatively high, since a combination of several measures is needed to effectively tackle pollution sources. For instance, the Air Quality Plan for Zürich (Kanton Zürich, 2016) consists of 32 measures, the Air Quality Plan for Ljubljana (MOP, 2014) encompasses 36 measures while the air quality plan for Lombardy region (Regione Lombardia, 2013) includes 91 individual measures.

At present, a database with approximately 70 measures, implemented by the EU member states to tackle air pollution is available at the FAIRMODE website: http://fairmode.jrc.ec.europa.eu/measure-catalogue/). The German Environmental Protection Agency also prepared a list and evaluation of the air quality measures, implemented in German Air Quality Plans (Diegmann V., 2015).

Structural measures in **transport sector** at urban and regional level aim to reduce the mobility demand by appropriate spatial planning and telecommuting (working from home), modal shifts towards less polluting transport means (public transport and active transport- cycling , walking) and fuel change. Integration with sustainable mobility plans is essential. There are also examples of introducing low polluting vehicles in public transport and public utilities vehicle fleets (fuelled by compressed natural gas or electricity). In Zürich this kind of measure obliges public authorities in larger construction sites to transport construction material by train.

The low emission zones, which prevent circulation of older polluting vehicles within certain areas, are frequently used in Germany, where there are 22 low emission zones in Baden-Württemberg and 3 in Bayern (http://gis.uba.de/website/umweltzonen/umweltzonen.php). In France there are two types of low emissions zones: permanent and temporary. Zones of limited traffic are permanent environmental zones while the air protection zones (Arve valley) are activated only in the case of pollution episodes. In Austria low emission zones are enforced for heavy-duty vehicles only. In Milan (Italy), the existing low emission zone has been converted into a congestion charge zone.

In the European context, the EUSALP macro-region is at the centre of a dense network of freight transport. An integrated and future-oriented transport concept for the Alpine region is vital for both the overall performance of Europe's transport system and the preservation of nature and peoples' living conditions in this macro-region. In 2015, the EU and seven Alpine States signed a joint declaration with the commitment to completing all the key railway projects by 2030. These include the nine rail freight corridors of the Trans European Transport Network (TEN-T), adopted in 2013, aiming at enhancing cross border connections, integrating transport modes and promoting interoperability (European Commission, 2014). The four corridors relevant for the EUSAIR macro-region are: Rhine-Alpine, Scandinavian-Mediterranean, Baltic-Adriatic and Mediterranean. For every corridor a work plan and dedicated studies are under development. Stakeholder participation and consultation are also foreseen (more details in Box 7).

Box 7. Modal shift from road to rail of freight traffic in the Alps

One of the principles of Alpine transport policy is that rail is the preferential transalpine freight traffic mode. In practical terms this means that the number of trucks crossing the Alps each year (1.0 mln in 2014) should be reduced to a maximum of 650,000 by 2018 (Swiss Federal Office of Transport, 2016).

A package of measures has been implemented by the Swiss authorities to achieve this objective, including taxation policy and infrastructure development.

The Heavy Goods Vehicle Charge (HGVC) was introduced in Switzerland in 2001 to cover the external costs of heavy goods transport on the basis of the polluter pays principle. It is a toll for trucks based on the overall weight of the vehicle, its level of emissions and the distance travelled. The maximum amount of the HGVC has been laid down in law in the Land Transport Agreement between Switzerland and the European Union.

In order to shift as much transalpine freight traffic as possible from road to rail, infrastructures are being modernised and expanded. The creation of the New Rail Link through the Alps (NRLA) involves the construction of three new base tunnels: Lötschberg, Gotthard and Ceneri. The expansion measures on the approach routes to the tunnels will lead to shorter, faster and more efficient north-south links for passenger and freight traffic. The NRLA costs amount to 23.5 billion Swiss francs (ca. 22 billion Euros).

The Rhine-Alpine Corridor constitutes one of the busiest freight routes of Europe (one billion tonnes of goods transported in 2013), connecting the North Sea ports of Rotterdam and Antwerp to the Mediterranean basin in Genoa, via Switzerland and some of the major economic centres in the Rhein-Ruhr, the Rhein-Main-Neckar, regions and the agglomeration of Milan in Northern Italy. This multimodal corridor includes the Rhine as inland waterway. Key projects are the base tunnels, partly already completed, in Switzerland and their access routes in Germany and Italy.

The Rhine-Alpine corridor

Source: European Commission, 2014

In order to prevent that the measures for reducing congestion and atmospheric pollution result in another type of annoyance for the population, a railway noise reduction programme was also introduced in Switzerland. The package included modifications to rolling stock, building noise barriers and fitting soundproof windows. The package of noise reduction measures was completed in 2015. A ban on goods wagons that have not been modified to reduce noise levels is planned in a subsequent programme that will come into effect by 2020.

Biomass is a relatively carbon neutral fuel whose use contributes to the national share of renewable energy target and represents a relatively secure energy source (in terms of security of supply) that is not affected by global trade and geopolitical fluctuations. On the other hand, **domestic combustion** of biomass for heating purposes in the EUSALP macro-region is associated with emissions of $PM_{2.5}$, black carbon and benzo(a)pyrene (Muntean et al., in prep.). The measures aiming to reduce emissions from small combustion installations are mainly targeted at wood-fired appliances, which are among the most polluting ones. The existing schemes, mostly at the national level, subsidise the installation of new wood-fired systems with lower PM emission levels. In Germany households obtain higher subsidies if they install wood combustion equipment fitted with electrostatic precipitators or other efficient end-of–pipe devices that reduce PM emissions (http://www.bafa.de/). In Slovenia, subsidies for new, low emissions wood-fired installations for households are higher in the areas, where the air quality plans have been adopted (MOP, 2014). The reduction of heating demand by better insulation of the buildings could be considered under this section since in addition to improving the energy efficiency it is also an emission abatement measure.

6.2 EUSAIR

In this macro-region the AQ policies are more heterogeneous as a consequence of the different legislations in force. Montenegro and Serbia have started to implement the Air Quality Directive provisions concerning air quality plans. In general, PM_{10} exceedances were the main target of AQ Plans with the exception of Bor (a hot spot in Serbia) where the breach concerned SO_2. According to progress reports for Bosnia and Herzegovina, air quality plans for the areas where pollutant levels exceed limit values are still to be adopted.

Road transport is one of the major sources of PM_{10} and NO_2 in urban areas. Regulations to reduce vehicle emissions are in force in most of the EUSAIR countries. In the latest five years, schemes to modernise the public transport fleet and private vehicles were implemented in Serbia, Slovenia, Montenegro, Croatia Italy and Greece. Shift to electric and natural gas-propelled vehicles was the target in Slovenia and Croatia. Also non-technical measures were put in place in many EUSAIR countries. Development of biking infrastructures and measures to promote eco-driving systems were introduced in Serbia and Croatia. Congestion charge schemes are in place in Italy and Montenegro.

Emission reductions are also expected from new infrastructure projects: highways to divert part of the traffic flows out of the city cores and increasing the carrying capacity of the rail system. Additionally, renewal of the public transportation fleets and modernisation of the administrative and organizational arrangements is in progress in several countries.

Domestic combustion contributes to high PM levels in the macro-region. Measures to improve the energy efficiency of buildings were implemented in almost all EUSAIR countries. Extensive use of wood for household heating in winter has been associated with air pollution in Slovenia, Italy, Croatia and to a lesser extent in Greece. This source contributes to the exceedances of the European air quality limit values for PM. Moreover, in some Western Balkan countries coal fired residential heating also contributes to both PM and SO_2 emissions. Schemes to promote replacement of out of date appliances and for the development of district heating networks were adopted in Slovenia, Serbia Montenegro and Croatia. Among the non-technical measures, information campaigns about the proper use of the stoves and boilers fuelled with biomass were launched in Croatia and Slovenia.

To reduce the emissions from the **Energy production sector** technical measures in power plants were implemented in some EUSAIR states. In Croatia a new power plant block fuelled only with natural gas for the production of electricity and heat was recently constructed (Sisak). Improving and adjusting the electrostatic precipitator performance to achieve the certified efficiency was accomplished in Bosnia & Herzegovina. A new ash removal and transport system and filters were installed in the largest power plant in Serbia (near Belgrade) with the support of EU funds.

In the **Industry sector** measures in the EUSAIR were targeted to modernise plants by implementing less polluting processes or by substituting fuels. For instance, a new copper smelter in Mining and Smelting Combine Bor started to work as part of the measures contained in the air quality plan for the agglomeration of Bor (Serbia). In Croatia, the Rafinery Sisak shift to low-sulphur fuel. In Slovenia, voluntary measures, like introduction of the environmental management systems and best operational practices were implemented.

Motorways of the Sea (MoS) is a TEN-T horizontal priority that aims to promote the development of maritime transport to achieve a complete integration of this mode into the global logistics chain (European Commission, 2014c). The final goals of the initiative are to support Europe's external and internal trade (74% and 40% respectively are carried by maritime transport), to protect the environment by reducing emissions and to improve the safety of maritime operations.

One of the MoS priorities is the implementation of projects and studies focussed on the environmental challenges of the maritime sector with particular reference to the Annex VI of the IMO MARPOL Convention and Directive 2012/33/EU.

The energy sector in Western Balkan countries is besides hydropower based mainly on outdated coal fired power plants. Planned measures for air quality improvement in this sector include the use of low sulphur content coal, technical abatement measures and when feasible replacement of the installations.

7 Actions for an integrated air quality management

The current EU air quality standards are exceeded in many of the EUSALP and EUSAIR EU Member States. This situation impacts negatively on human health, ecosystems and economic activities. Polluted air in the EUSALP and EUSAIR shortens the life expectancy, decreases the healthy living years and generates costs to the society by additional medical expenses and absence from work. Clean air is also important for tourism, which is a key economic activity in both EUSALP and EUSAIR, with potentials for further growth. There are several local situations with similar characteristics across the EUSALP and EUSAIR areas which would benefit from a more emphasised macro-regional approach and high-level cooperation to achieve air quality improvement. Moreover, due to the transboundary nature of air pollution, local or regional air quality improvement will contribute to an amelioration in the macro-region as a whole.

Air quality is linked with many policy areas: economic growth and innovation, mobility and connectivity, environment and energy, are among the most relevant. Thus, it is imperative to integrate air quality, climate change and energy policies, fostering the synergies and balancing their trade-offs also at the macro-regional level. To contribute to the development of a comprehensive macro-regional strategy, actions (summarised in Table 6) aiming at integrating air quality issues into existing priorities or sectorial policies are discussed in this section.

Table 6. Actions to support the integration of air quality into EUSALP and EUSAIR programmes.

Action	**EUSALP Thematic priority area**	**EUSAIR Thematic priority area**
7.1 Supporting the development and monitoring of the air quality policies	Governance and innovation; environment and energy	Governance and implementation
7.2 Towards a biomass energy use strategy	Economic growth and innovation; environment and energy	Environmental quality
7.3 Disseminating best practices for the operation of residential heating	Environment and energy	Environmental quality
7.4 Fostering near zero energy wooden buildings	Economic growth and innovation environment and energy	Environmental quality
7.5 Alpine smart car-free tourism platform	Environment and energy; mobility and connectivity	-
7.6 Active travel: exploiting health benefits and reducing air pollution	Mobility and connectivity	Connecting the region; sustainable tourism
7.7 Promoting alternative fuels to abate ship emissions	-	Connecting the region; sustainable tourism
7.8 Developing an alert system for ozone episodes and heat waves	Governance and innovation; environment and energy	Environmental quality
7.9 Strengthening collaboration between EU and non-EU countries	Governance and innovation	Governance and implementation

Source: JRC

7.1 Supporting the development and monitoring of the air quality policies

The particular contexts of the EUSALP and EUSAIR macro-regions require the application of the most robust air quality modelling techniques. At present, air quality-oriented online products exist to support local authorities (e.g. AIR QUALITY PORTAL, SHERPA) for preliminary assessment and other more sophisticated (e.g. DELTA tools, GAINS, CAMs) that target expert users. Air quality policies today are deeply embedded in the fabric of society including the economic activities. For that reason integrated assessment tools, developed within some EU projects (e.g. OPERA, RIAT+) to be used by local authorities, should be further developed and widely disseminated. In addition, state-of-the-art tools tested by independent bodies (e.g. FAIRMODE) should be used by air quality experts to deal with situations needing more in-depth analysis (e.g. complex terrain areas).

In the past, some implemented measures did not deliver the expected results. Therefore, it is of outmost importance to monitor better the effects of the implementation of air quality policies and measures. The appropriate monitoring of the measures should be accomplished using appropriate data collection combined with modelling tools.

Many areas of EUSALP and EUSAIR share common air quality challenges. There are similar emissions profiles with dominating influence of the small combustion installations and road transport. A possible action to contribute to the dissemination of best air quality management practices and tools for air quality assessment and planning could be developed under the umbrella of FAIRMODE as a complement of the pilot exercise. Mirror groups at the macro-regional level could focus on the specificities of the area. Also web based platforms could be an option to support the harmonisation of the approaches for the compilation of emission inventories, source apportionment and planning.

7.2 Towards a biomass energy use strategy

In the EUSALP and EUSAIR areas wood has traditionally been used for the household heating. Biomass energy use, mostly wood combustion in residential heating appliances, represents an important share of the renewable energy consumption in the region. Biomass energy use is an important element of the national renewable energy plans (see Box 1). and increased use of the biomass is foreseen to meet the renewable energy targets. Moreover, biomass energy use significantly contributes to climate change mitigation, increases energy security of supply and has far-reaching economic and social implications. For example, every TJ of firewood burned in a logwood boiler requires 143 direct working hours in the region, while the operation of a gas heating system requires only 10 working hours per TJ of energy consumed (Austrian Biomass Association, 2016). Biomass energy use therefore provides income and employment opportunities in rural areas and consequently contributes to a more balanced regional development.

On the other hand, in all the countries of EUSALP and EUSAIR, residential combustion represents an important source of particulate matter emissions. Residential heating emissions have pronounced influence on air quality, because they are released close to the ground during the cold season, when dispersion characteristics are less favourable due to more frequent stable atmospheric conditions. In order to achieve compliance with particulate matter limit values, addressing residential heating emissions is essential in many areas.

Energy, climate change and air pollution policies are closely interlinked and must be tackled together. While most of the measures in portfolio of those policies exhibit significant positive synergistic effects, the issue of wood use for residential heating is considered as one of the most important trade-offs. For that reason, it is essential to develop policies and measures, which further stimulate energy use of biomass while simultaneously ensuring appropriate air quality.

Security of supply, climate change mitigation and air quality improvement as well as innovative inclusive growth are all accounted for in the following actions:

- reducing energy demand for heating by enhancing thermal insulation of existing and new dwellings;
- stimulating advanced, energy efficient and low emission biomass residential heating appliances including development and commercialisation of emerging technologies as for instance biomass

fuelled absorption heat pumps, and small-scale biomass cogeneration units;
- expansion of the existing district heating systems and stimulating new micro district heating systems fuelled or co-fuelled by the biomass cogeneration;
- management of the biomass flows along the entire supply chain focusing on the energy use of the biomass residues from wood harvesting, stem wood processing and production of the high added value wood products.

A holistic approach to the air quality improvement associated with biomass heating appliances would require non-technical measures (see section 7.3) and technical measures, such as replacement of the outdated appliances, switching to less polluting fuels and improving building insulation (see section 7.4). An action to promote communication between all the actors of the supply chain and develop a comprehensive EUSALP biomass energy use strategy would contribute to better connecting demand with supply at the local level, improving dialogue between public and private sectors and disseminating the most suitable technologies.

7.3 Disseminating best practices for the operation of residential heating installations

The replacement of the most polluting outdated wood fired residential heating appliances and other measures to comprehensively tackle the excessive pollution from residential heating systems requires significant investments by households, business and also public subsidies to stimulate the transition. Emissions from new boilers and stoves are in part addressed by the Eco-design Directive. However, the directive is expected to have a limited impact in the short-term because of the long transition periods and long lifespan of the appliances. Another issue to be taken into account is that the solid fuel use in households is often linked with energy poverty. For that reason, it is even more difficult to achieve penetration by advanced, low emission biomass combustion technologies in the household sector. Consequently, such structural changes may not be economically or socially viable in the short and even in the midterm. Additional economically and socially more appropriate short-term solutions may therefore be required, to reduce the harmful levels of emissions over a shorter time scale.

The energy efficiency and emissions of small residential wood- fired combustion appliances, conventional and advanced, depend both on the proper preparation of the fuel and their operation. Unfortunately, information on the influence of user practice on energy efficiency and emissions are scarce. However, it could be roughly estimated, that promoting best operational practices could reduce fuel consumption by 5 to 10 % with an even higher reduction in emissions. The potential for emissions reductions is estimated to be larger than that from eco-driving, which is well established in legislation and implemented through labelling systems. Better operation of the small combustion appliances is a win-win measure, since it reduces fuel costs and emissions simultaneously. In the context of air quality policies it is essential to develop such information, which is up to certain extent region-specific, and disseminate it through awareness raising campaigns.

There are already some efforts at the national level to further disseminate information on the proper operation of the residential heating appliances. However, recent surveys (Wöhler M., 2016; Reichert G., 2016) showed that there is still considerable potential for emission reductions end energy efficiency improvements. For that reason, actions to improve communication strategies in the EUSALP and EUSAIR area to raise awareness and disseminate best practices are important to stimulate changes of behaviour as a complement to technical measures.

7.4 Fostering near zero energy wooden buildings

Energy use in buildings, heating in particular, is an important source of greenhouse gas and air pollutant emissions. The most efficient solution for reducing these emissions is to abate the heating demand by improving buildings' insulation and heat recovery ventilation. To that end, the renovation of the existing building stock is an opportunity to stimulate and enforce more stringent energy efficiency standards.

In France, for example, a number of new regulations have been introduced in recent years to stimulate or enforce improved standards of energy performance in buildings. In 2013, the Réglementation Thermique 2012 came into force substantially increasing the energy performance standards for most new construction work (new builds and extensions). The Décret n° 2013-979 of 30 October 2013 extended the obligation to study different energy supply solutions for new buildings. The government has now turned its attention more firmly to property renovation projects, with a regulation that makes it obligatory for owners to undertake complete insulation of the external wall and roof as part of any major building works, including the conversion of attics, garages, etc., into habitable space. The new rules are in force since 1st January 2017.

Wood as a building material has several environmental advantages, including lower construction emissions and carbon sequestration in the building structure. Promoting the use of locally sustainably harvested and processed wood in energy efficient buildings would also be of benefit for the local economy. This action would be complementary to the quality label for Alpine wood produced according to sustainable criteria that is mentioned in the EUSALP action plan to foster a better management of mountain forests (European Commission, 2015).

7.5 Alpine smart car-free tourism platform

Approximately 120 million tourists visit the Alps every year. Thanks to its social, economic, and environmental aspects tourism is a potential driver of sustainable development in Alpine communities. On the other hand, tourism can also have a major impact on the local environment mainly due to congestion, noise and air pollution. At present, more than 80% of the tourists in this region use private vehicles as their means of transportation (Permanent Secretariat of the Alpine Convention, 2013). Such a dominant role of the private car in Alpine tourism-related mobility will inevitably impact on the most fragile mountain ecosystems and needs to be tackled.

Developing and promoting new approaches to sustainable tourism is essential to foster a liveable alpine space (European Commission, 2017). The EUSALP has a considerable potential for a smart and creative diversification in the tourism sector. The need to further strengthen this sector turning it towards environmentally sustainable tourism and year-round tourism is one of the key elements of the EUSALP action plan (European Commission, 2015). In this context, the pro-environmental image of destinations associated with smart, low-carbon mobility measures could leverage their competitiveness in the global tourism market.

The importance of sustainable travel for tourism development has been addressed in EU projects involved in the Alpine pearls network such as: Alps Mobility and Alps Mobility II (Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaf, 2006). This active network consists of 25 touristic destinations in Austria, France, Germany, Italy, Slovenia and Switzerland offering green mobility for car- and care-free holidays.

In the past few years, the Smart Cities concept has become one of the main driving forces for the urban transition towards a low-carbon environment, sustainable economy, and mobility. Tourism, as one of the fastest growing industries, is also an important generator of emissions; the recently emerging sustainable tourism concept is therefore an important part of the Smart Cities paradigm (Nitti M., 2017).

The conception and subsequent implementation of the innovative platform, offering the information on public transport, carpooling, one-way bicycle rentals and other means of low carbon travel with the travel planning assistance capabilities could foster accessibility of Alpine touristic destinations without the use of individual motorised transport means. A pioneer initiative in this field is the project AlpInfoNet- Sustainable Mobility information network for the Alpine Space.

A possible future direction is to further expand the existing information platforms by implementing transport demand data for the optimisation of near real-time transport services. The same platform could further be integrated with local transport networks to enable better inter-modality and integration of commuting and tourism passenger transport.

7.6 Active travel: exploiting health benefits and reducing air pollution emissions

Urban transport is responsible for 23% of EU's greenhouse gas emissions and is one of the reasons why many urban areas are in breach of air pollution standards (EU, 2016). Active travel is accomplishing short everyday journeys by physically active means, such as walking or cycling. The modal shift towards cycling and walking is considered an important measure at local level to curb emissions from cars and reduce the congestion in the cities.

Active travel may also have positive impacts on health. Lack of adequate physical activity is estimated to be associated with about 900,000 deaths per year in the European Region, where about 20-30 % of adults are estimated to be obese (WHO, 2014). Walking and cycling could help to integrate physical activity into daily life, especially in large cities. There is growing evidence about the net benefits of active travel (Tainio M., 2016; Mueller N., 2105; Andersen Z.J., 2015).

Limitations of active travel are the resistance of most people to change behaviour and the fact that when pollution levels are high, intense physical activity outdoors increases exposure to pollutants.

The FP7 research project PASTA evaluated the benefits and risks of active travel in the cities (http://www.pastaproject.eu/home/). The PASTA project was implemented in cities with moderate air pollution levels. Considering that in certain areas of the EUSALP and EUSAIR macro-regions pollution levels are significant, collection of specific data is needed.

A possible action to support active travel is to involve citizens and stakeholders in an online sustainable mobility platform with the aim of gathering evidence about the health benefits and risks of these practices and sharing information in real time to support the users in their decision about the most suitable transportation mean to adopt. To that end, existing (e.g. Cycle Tracker Pro, MTB Project) or new smartphone applications for cycling and fitness could be linked to a centralised database. The collected information about the rides would provide data for traffic management and scientific research to be distributed back to the users together with traffic, pollution and/or weather data. The initiative could be also used for demonstration purposes and dissemination of good practices.

7.7 Promoting alternative fuels to abate ship emissions

With the development of tourism and the consequent increase in the number of cruise and tourist ships, pollution levels are also expected to rise creating a potential negative feedback for the tourism industry.

The ability to reliably model, estimate and analyse ship emissions, is a fundamental prerequisite for exploring the feasibility of adopting emission control measures. This is particularly true for the design of supplementary measures beyond those dictated by the regulations for the prevention of air pollution from ships under the international framework of Annex VI MARPOL 73/78 and at European level according to the provisions of Directive 2012/33/EU (Dragovic et al., 2015). In this regard, the MoS scheme may play a fundamental role in promoting environmental friendly measures in this sector (European Commission, 2014c). Examples of priority measures in this context are:

- Actions supporting the deployment of alternative fuels and emission abatement technologies, including the use of shore-side electricity and energy efficiency measures.
- Studies and deployment of alternative fuels infrastructure (e.g. liquefied natural gas) through publicly accessible refuelling points
- Inspection schemes and voluntary measures (e.g. EMAS, eco-label) to achieve highest environmental standards

7.8 Developing an alert system for ozone episodes and heat waves

In future, the growing average temperature trends associated with climate change are likely to increase the frequency of ozone episodes and heat waves in the EUSAIR and EUSALP macro-regions. The two phenomena are correlated as they reach their maximum intensity during anticyclonic conditions typical of the summer months. In order to prevent exposure of the population to extreme conditions it is essential to develop an efficient forecasting and information system for photochemical pollution and heat episodes.

The availability in real time of updated information about the timing and geographical extension of ozone and heat wave episodes would be extremely useful for:

— health-care authorities, for the adoption of short-term measures;

— groups at risk (i.e. population suffering from asthma, cardiovascular disease and other respiratory diseases), with the aim of conveying advice about individual behaviours to prevent or limit their exposure to pollutants;

— population in general, to promote behaviour aiming to limit emissions of ozone precursors and for awareness raising.

The most effective way to deliver timely information is the development of a platform where interested citizens and authorities can receive warnings and detailed information in case of critical episodes, on the basis of weather and pollution forecasts. The platform would send regular updates and specific messages to mass media: television, radio, social media, internet and directly to the registered users via e-mail, SMS, Whatsapp, or dedicated applications for mobile phones.

The EnviroFlash system, developed by the US-EPA (www.enviroflash.info), is associated with the AirNow website (www.airnow.gov). It disseminates information, mainly based on the air quality index, to registered users and partner media. It also provides online healthcare practitioners with information to help patients reduce their risk of particulate pollution-related health effects.

In the long-term, limiting exposure to pollutants and weather extremes will influence city planning. The WHO has raised awareness among urban designers and town planners about the need of long-term intervention strategies, including the nature of the built environment, to assist with managing the heat and pollution problems. The increase of vegetation has been regarded as a structural measure for both cooling the air and scavenging particulate matter. Nevertheless, concerns have been raised about the emissions of ozone precursor from plants.

7.9 Strengthening collaboration between EU and non-EU countries

Air quality is the result of a wide range of drivers ranging from economic activities to simple individual behaviour. On the other hand, the impacts of air quality affect human health, ecosystems and in the longer term, climate. It follows that air quality management is a cross cutting issue in which all the relevant actors must be involved. The EUSALP macro-region involves non-EU countries that have different legislations (e.g. Switzerland). However, there is a long tradition of international cooperation in this area, thanks to initiatives such as Interreg, Alpine Space and the Alpine Convention.

On the other hand, the EUSAIR macro-region encompasses regions from EU and non-EU countries that still have different legislative and institutional frameworks. This situation represents an obstacle for the implementation of macro-regional actions. Moreover, the long-term experience of EU Member States in pollution reduction policies is an asset to be shared with those countries that only recently started to deal with the same challenges. Transfer of knowledge and experience from EU Member States regarding air pollution abatement policies and measures would facilitate a faster adoption of new standards in accession and neighbourhood countries. Furthermore, considering the transboundary nature of air pollution, such cooperation would contribute to a faster compliance with the air quality standards also in the EU.

The status of air quality in the Western Balkans is the most critical of the entire macro-region. The countries of this area are facing many challenges in a transitional phase of their economies. In this context, short term measures in the energy, transport and housing sectors, are going to influence their ability to cope with air pollution and climate change mitigation in the longer-term. It is, therefore of utmost importance to incorporate cross-cutting sustainability criteria into the above mentioned sectorial policies. To that end, exchange of good practices and regional cooperation are to be prioritised to enhance the integration between the different regions of EUSAIR. In this regard, the EU neighbourhood policy with the objective of transferring legislation (EU *aquis*) to accession countries is a potentially powerful tool and synergies with the EUSAIR action plan should be fully exploited.

8 Conclusions

Air quality is a complex and cross-cutting topic that requires comprehensive data collection and integrated analysis of economic and social implications in order to inform the development of thematic policies such as those in the areas of regional development, energy, transport and tourism, among others.

Despite the action taken, air quality is still critical in many areas of both EUSALP and EUSAIR macro-regions, mainly for PM, NO_2 and ozone. In particular, extreme PM levels are observed in the Western Balkans. The degree of implementation of the air quality legislation and integration with other sectorial policies still varies considerably among the involved regions. For that reason, a strengthened collaboration at the macro-regional level, especially between EU and non-EU countries has the potential to boost environmental policies by promoting collaboration and exchange of best practices among cities and regions that face similar challenges.

Key areas where action is expected to be most effective, considering the characteristics of both macro-regions, are those of residential heating, traffic and shipping emissions.

Most of the EUSALP and EUSAIR areas face adverse meteorological conditions, which exacerbate the influence of emissions on the air quality. Thermal inversions contributes to the accumulation of pollutants during winter in mountainous areas and adjacent basins, while high insolation and humidity contribute to high ozone levels and heat waves in Mediterranean areas.

Wood has been traditionally used for residential heating in both macro-regions and there is a considerable potential to increase the use of this locally produced largely carbon-neutral renewable energy source. However, wood combustion in mostly outdated residential small combustion installations contributes substantially to elevated particulate matter levels also in urban areas. The residential heating contribution to air pollution is an issue in the studied areas and coordinated action at macro-regional level would be beneficial.

Because of its strategic and central position, the EUSALP region is heavily affected by road traffic (freight and passenger). In addition to the pan-European routes, there are also significant local and regional transport flows. The issue of the transport and air pollution was tackled from the very beginning of the air pollution policies development and considerable investments for the development of infrastructures are in progress. However, further improvement of the air quality policies in this area is required, including technical and non-technical measures with particular reference to the urban areas. In this regard, information technologies give the opportunity to circulate targeted information in near real-time to raise awareness and promote sustainable behaviours in the population.

In the EUSAIR macro-region there is a considerable divide in the availability of essential information about air quality. While some of the countries have a dense monitoring network covering many pollutants, other are lagging behind with monitoring networks that do not fully meet the requirements of the e-reporting scheme to populate the European air quality database. Since reliable information on air quality is the basis for any assessment and planning urgent action is needed to fill the existing gap.

One of the EUSAIR specificities is that almost all countries have access to the sea and are, therefore, subject to national and international shipping emission regulations. Moreover, the expected growth in tourism will likely lead to higher number of tourist ships and consequently to rising emissions, especially in ports. In the absence of action, the degraded air quality could be counterproductive for the tourism industry. For that reason, undertaking actions for a harmonised development of tourism and maritime transport should be envisaged in the future macro-regional strategy taking into account the air quality plans.

The high levels of ozone observed in southern Europe have negative effects on both human health and ecosystems and cause losses of crop yields. In a future warmer climate, ozone levels are likely to rise and their increase is expected to be most pronounced in many areas of the EUSALP and EUSAIR macro-regions where the levels are already critical. Mitigation measures based on a more efficient dissemination of information in the short-term and urban planning in the long-term are both needed to deal with the forecasted increasing levels of ozone in southern European cities.

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List of abbreviations and definitions

AQD	Air Quality Directive 2008/50/EC
BaP	benzo(a)pyrene
EEA	European Environmental Agency
EUSALP	EU strategy for the Alpine Region
EUSAIR	EU strategy for the Adriatic and Ionian Region
JRC	Joint Research Centre
NH_3	ammonia
NMVOC	non-methanic volatile organic compounds
NOx	nitrogen oxides
NO_2	nitric oxide
$\mu g/m^3$	micrograms per cubic metre
O_3	ozone
PM_{10}	particulate matter with aerodynamic diameter below 10 micrometres
$PM_{2.5}$	particulate matter with aerodynamic diameter below 2.5 micrometres
PMF	positive matrix factorization
SO_2	sulphurous anhydride
SO_4	sulphate
WHO	World Health Organisation

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doi:10.2760/701646

ISBN 978-92-79-73639-1