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AIR POLLUTION MANAGEMENT IN BOSNIA AND HERZEGOVINA

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Acknowledgments

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Abbreviations and Acronyms

AAP	Ambient Air Pollution
AMHIB	Air Monitoring and Health Impact Baseline
AQI	Air Quality Index
AQM	Air Quality Management
AQP	Air Quality Plan
BC	Black Carbon
BCA	Benefit-Cost Analysis
BCR	Benefit-Cost Ratio
BD	Brčko District
BiH	Bosnia and Herzegovina
BTX	Benzene, Toluene, Xylene
CAFE	Clean Air for Europe
CEA	Country Environmental Analysis
CEM	Continuous Emissions Monitoring
CMB	Chemical Mass Balance
CNG	Compressed Natural Gas
CO	Carbon Monoxide
COPD	Chronic Obstructive Pulmonary Disease
DLI	Disbursement-linked Indicator
EAS	Environmental Approximation Strategy
EBRD	European Bank for Reconstruction and Development
EC	European Commission
EEA	European Environment Agency
EIA	Environmental Impact Assessment
EPB	Environmental Protection Bureau
EU	European Union
FBiH	Federation of Bosnia and Herzegovina
FHMI	FBIH Hydro-Meteorological Institute
GAINS	Greenhouse Gas-Air Pollution Interactions and Synergies
HRAPIE	Health Risks of Air Pollution in Europe
IHD	Ischemic Heart Disease
IHME	Institute for Health Metrics and Evaluation
LAP-BD	Law on Air Protection of Brčko District
LAP-FBiH	The Law on Air Protection of the FBiH
LAP-RS	Law on Air Protection of the Republika Srpska
LC	Lung Cancer
LRI	Lower Respiratory Tract Infections
FMOIT	Ministry of Environment and Tourism of the FBiH
MOFTER	Ministry of Foreign Trade and Economic Relations of Bosnia and Herzegovina
MSPCE	Ministry of Spatial Planning, Construction, and Ecology of RS
MTFR	Maximum Technically Feasible Reductions
NGO	Nongovernmental Organization
NH_3	Ammonia
NO_2	Nitrogen Dioxide
NO_x	Nitrogen Oxides
O_3	Ozone

OECD	Organisation for Economic Co-operation and Development
PAF	Population attributable fraction
PAH	Polycyclic Aromatic Hydrocarbons
PforR	Program-for-Results
PM	Particulate Matter
PM_{10}	Particulate Matter with a diameter of 10 micrometers or less
$PM_{2.5}$	Particulate Matter with a diameter of 2.5 micrometers or less
PMF	Positive Matrix Factorization
PROPER	Program for Pollution Control Evaluation and Rating
PRTR	Pollutant Release and Transfer Register
QA/QC	Quality Assurance and Quality Control
RS	Republika Srpska
RS-HMI	Republic Hydro-Meteorological Institute
SO_2	Sulphur Dioxide
TSP	Total Suspended Particulates
VOC	Volatile Organic Compounds
VSL	Value of Statistical Life
WHO	World Health Organization
WTP	Willingness to Pay

Executive Summary

Ambient Air Quality in Bosnia and Herzegovina

Cities in Bosnia and Herzegovina (BiH) experience high ambient concentrations of health-damaging fine particulate air pollution in Europe. This report is one in a series of three reports on air quality management in BiH, Kosovo, and North Macedonia. This report examines the nature and magnitude of ambient air pollution (AAP) in BiH. It provides estimates of the health burden, and economic cost associated with the health impacts, of AAP, that is, fine particulate matter ($PM_{2.5}$) in BiH. It also provides an analysis of the impacts of various sources of $PM_{2.5}$ emissions on ambient air quality in BiH at a country level. The institutional and policy framework for air quality management (AQM) in the country is examined, including contributions of other development institutions in supporting BiH's efforts to address air pollution. Furthermore, this report presents experiences of selected countries that have applied different policy, investment, and technical interventions for air pollution, prevention, reduction, and abatement. Finally, it provides recommendations for reducing air pollution in BiH.

BiH and people living in the Balkans and Eastern Europe are typically breathing more toxic particulate air pollution than their neighbors in Western Europe. This is due to fewer air pollution reduction policies and more solid fuel heating and cooking (meaning many more residential wood and coal stoves) in Eastern European and Balkan countries compared to the rest of Europe. Western Europe has mostly moved away from coal-fired power plants (or at least has pledged to reduce coal consumption to meet climate goals), but in the Balkans and in Eastern Europe, they are still widely in use. In fact, the Balkan region is home to many coal and lignite-fired units and to 7 of the 10 most polluting coal-fired power stations in Europe.

Exposure to $PM_{2.5}$ is particularly dangerous to human health because these particles find their way deep into lungs and the bloodstream, resulting in disease and death. Consequently, they can cause serious health effects such as lower respiratory infections; trachea, bronchial, and lung cancer; ischemic heart disease; strokes; and chronic obstructive pulmonary disease (COPD). In addition to causing pain and suffering, premature deaths and illnesses caused by air pollution result in increased health expenditures and labor productivity losses. In BiH, annual average ambient concentrations of $PM_{2.5}$ are often multiple times the maximum levels allowed under BiH's air quality standards (20 $\mu g/m^3$) and the World Health Organization (WHO) air quality guideline value (10 $\mu g/m^3$).

Health Burden and Economic Cost of Ambient Air Pollution in Bosnia and Herzegovina

This report estimates that about 3,300 people die prematurely every year as a result of exposure to ambient $PM_{2.5}$ air pollution in BiH. About 16 percent of this health burden is carried by Sarajevo and Banja Luka. The death toll is more than double AAP-related mortality in North Macedonia (1,600 deaths) and more than four times the AAP-related mortality in Kosovo (760 deaths). This analysis shows that 9 percent of the total annual mortality in BiH is attributable to air pollution. About 81 percent of the 3,300 AAP-related deaths in BiH are from cardiovascular diseases. The majority of AAP-related mortality occurs in people ages 50 years and older. About 68 percent of ischemic heart disease and 57 percent of strokes caused by AAP occur in people over 70 years of age. Cardiovascular diseases mostly affect people older than 65 years, suggesting that mitigation measures to reduce the health impact of air pollution in BiH should include a focus on this subgroup of the population.

The estimated economic cost associated with mortality from exposure to air pollution in BiH is in the range of US$1–1.8 billion, equivalent to 5.9–10.5 percent of gross domestic product (GDP) in 2016.[1] The economic cost associated with the health damage from AAP in BiH is on average US$1.38 billion, equivalent to 8.2 percent of GDP in 2016. The Federation of Bosnia and Herzegovina (FBiH) carries 67 percent of the total estimated cost burden, and Republika Srpska (RS) carries the remaining 33 percent. The estimated cost is conservative and does not include the costs associated with hospital stays, cost of illness, and loss of workdays, which would potentially increase the cost estimate if taken into account.

To better understand the health impacts of AAP on its population, BiH needs to strengthen health statistics and harmonize country reporting with international systems of disease classification. Notably, the government could strengthen data collection and reporting on mortality by individual disease or cause, attributable to AAP. This will facilitate ready estimation of health impacts of AAP and strengthen the knowledge and information base for decision making to reduce air pollution. It will also enable the country to assess its progress in reducing premature mortality from AAP. Furthermore, the government should strengthen the health information system countrywide and make it consistent with the International Statistical Classification of Diseases and Related Health Problems. Collection and reporting of data such as bronchitis prevalence for children, COPD in adults, hospital admissions for cardiovascular and respiratory illness, and lost workdays could be strengthened to support analysis of morbidity associated with exposure to AAP. Lastly, the government should develop and strengthen capacity for conducting environmental health risk assessment to analyze health effects associated with stationary emission sources, for example, industrial facilities.

Key Sources of $PM_{2.5}$ Exposure

Source apportionment analysis conducted in this report indicates that at a country level, the residential sector is the largest source of exposure to harmful $PM_{2.5}$ associated with the burning of solid fuels in homes. Further analysis would be needed to better understand the role of other sources and hot spots, which could be more important at the local level. This study provides a first quantitative country-level apportionment of sources of $PM_{2.5}$. Additional sources of exposure to $PM_{2.5}$ include energy, transport, industry, agriculture, and others. Being a country-level study, this report recognizes that contributions of specific sources may vary by geographical area and that pollution may be more localized in hot spots with some sources being more dominant than others. To better understand the source structure at the local level, for example, in a city or urban area, specific source apportionment studies will be needed and require comprehensive and accurate emissions inventories and reliable air quality monitoring data.

The dominant share of $PM_{2.5}$ pollution originates within the geographical boundaries of BiH, which underscores the need for the government to take concerted and committed action to tackle air pollution. The contribution of transboundary sources (about 20 percent) to AAP in the country is considerably less than domestic sources (about 65 percent). The advantage of this is that the country has direct control over the selection, implementation, and timelines for the actions that need to be taken to achieve a significant impact in improving ambient air quality. Collaborative or regional approaches will, however, be needed to address AAP that is imported from neighboring countries.

The analysis points to a clear need to develop a comprehensive and accurate emissions inventory for BiH that covers various sectors and prioritizes the residential sector to improve estimation of emissions

[1] This cost estimate does not include Brčko District (BD).

and strengthen effectiveness of interventions to reduce AAP. Uncertainties related to activity and fuel use data and use of waste in the residential sector need to be addressed. In the transport sector, uncertainties related to vehicle age and imported used vehicles will also need to be addressed to improve completeness and accuracy of emission inventories.

Notwithstanding the significant health impacts and cost of AAP, monitoring efforts in the country focus primarily on the less harmful PM_{10}. Furthermore, monitoring data have many shortcomings, notably poor levels of completeness of air quality monitoring data. This report found that many monitoring stations only measure PM_{10}, but there is a need to monitor $PM_{2.5}$ at all stations. The available monitoring data for $PM_{2.5}$ are often incomplete due to many stations not monitoring at all or not consistently monitoring $PM_{2.5}$.

Given the widespread practice of burning solid fuels in homes as well as coal for power generation in BiH, monitoring efforts should be expanded to include the measurement of chemical species and constituents of particulate matter (PM) (for example, elemental carbon, organic carbon, and sulfates), which are associated with combustion processes and have been associated with adverse effects on human health. In addition, monitoring efforts should include measurement of precursors of $PM_{2.5}$ including sulphur dioxide (SO_2), nitrogen oxides (NO_x), ammonia (NH_3), and non-methane volatile organic compounds (NMVOC); black carbon (BC) (a constituent of PM, which also has climate warming properties); and toxic heavy metals such as lead.

$PM_{2.5}$ emissions are not expected to decline markedly under existing policies due to the burning of solid fuel for heating. Using the Greenhouse Gas-Air Pollution Interactions and Synergies (GAINS) model to simulate emission scenarios up to 2030 and generate country-level source apportionments, this study found that if effectively enforced, the existing environmental and air quality policies are expected to deliver a strong decline in the emissions of SO_2 and NO_x but will not have major impacts on primary $PM_{2.5}$ emissions, as current energy projections do not foresee major shifts away from fuelwood combustion in household stoves and boilers. Furthermore, since the contributions from the power sector will decline significantly, the residential sector will remain the dominant $PM_{2.5}$ emission source.

Furthermore, while the existing policies should lower concentrations in large parts of the country to levels around the health-based WHO guideline value, concentrations in urban areas will remain high and in violation of the WHO guideline value. In hot spots, ambient concentrations may exceed WHO guideline values by up to a factor of 3, mainly due to the persistence of fuelwood burning for heating.

While it would be technically feasible through measures in the residential sector to bring ambient $PM_{2.5}$ concentrations in most of the country, including cities below or slightly above the $PM_{2.5}$ guideline value, full implementation of all measures will be challenging and require strong government commitment. Relevant measures would require (a) early compliance of all new household stoves and boilers burning fuelwood with the stringent standards of the Ecodesign Directive of the European Union (EU); (b) replacement of the oldest existing installations; and (c) assurance of adequate quality of fuelwood, through burning of only dry fuelwood and proper storage of fuelwood. Such changes would require strong financial and governance mechanisms for their realization.

Policy and Institutional Aspects of Air Quality Management in Bosnia and Herzegovina

BiH's continued efforts to improve AQM are underscored by programs and projects undertaken both by domestic institutions and with support of external agencies to address air quality and progress in harmonizing country environmental legislation with EU legislation. This progress notwithstanding, the institutional and policy framework for AQM in BiH is characterized by the existence of different legal and planning instruments in each jurisdiction**.** Environmental legislation was highly harmonized across the FBiH, RS, and BD in the early 2000s, when each of the jurisdictions had adopted similar packages of environmental laws. With each of the entities FBiH, RS, and BD being ultimately responsible for AQM over their territories, this leads to at least duplication of administrative structures that conduct the same line of work.As a result, the country has three separate legal frameworks, organizational structures, and air quality networks.

BiH's constitution does not provide for the establishment of a country-level environmental protection ministry or agency, which is important for effective tackling of air pollution. To improve AQM outcomes at a country level, the Ministry of Foreign Trade and Economic Relations (MOFTER) and the Inter-Entity Coordination Body for the Environment could be strengthened to enhance consolidation and coordination between the FBiH, RS, and BD on air quality issues. Such coordination should be backed by legislation and include priority-setting criteria, clear accountability mechanisms that cover relevant stakeholders across jurisdictions, monitoring and evaluation of outcomes, mechanisms for conflict resolution, and social-learning mechanisms to promote continuous improvement of the coordination. Although time intensive and requiring adequate budgetary and human resources, coordination is logical to effectively tackle air pollution at a country level. With respect to the Inter-Entity Coordination Body for the Environment, legislation in all jurisdictions should be harmonized in their definitions of the function and composition of the body. Some areas where such coordination is needed include (a) establishing a clear institutional mandate for in-country and international reporting of air quality data for the country and (b) data sharing on air quality.

Formal mechanisms of vertical and inter-sectoral coordination are also needed to effectively tackle air pollution at a country level. Although some informal coordination takes place among the organizations responsible for air pollution management in the FBiH, RS, and BD, it is not a substitute for institutional coordination. Vertical coordination, that is, between the constitutional entities and lower levels of government, in all jurisdictions should be reinforced by establishing clear procedures and mechanisms for air quality data sharing and gradually for a broader range of topics such as alignment of strategies and plans, as well as enforcement. Efforts to align legal and policy frameworks at different levels of government should be guided by the shared aspiration to fully transpose the EU acquis. Similarly, inter-sectoral coordination needs to be bolstered, particularly between environmental authorities and other sectors including health as well as transport, industrial, energy, urban development, and agriculture, whose activities affect air quality. Inter-sectoral coordination should include a focus on defining agendas and priorities related to air quality across sectors with inputs from different sectors, development of monitorable and time-bound targets to guide the design and implementation of interventions, and monitoring and evaluation of effectiveness.

In the short term, MOFTER and the Inter-Entity Coordination Body for the Environment could focus efforts on further harmonization of the legal framework across jurisdictions, transposing outstanding air quality-related EU Directives, and filling gaps in legislation. Harmonization should cross all the building blocks of AQM, including the legal and policy frameworks related to air quality monitoring, emissions inventories, and analysis of air pollution, organizational frameworks, public participation, and enforcement. Vertical harmonization of legislation should also take place. With respect to EU Directives, areas that could be addressed by the government include harmonization of timelines for achieving ambient air quality standards for specific pollutants. In addition, the government could focus on full transposition of EU legislation that relates to (a) sulfur content of liquid fuels; (b) the National Emissions Ceilings Directive; (c) control of volatile organic compounds from petrol storage and distribution; (d) petrol vapor recovery during refueling of ore vehicles at service stations; and (e) limit values for industrial emissions for new plants. In addition, development of air quality strategies of each jurisdiction should include formal mechanisms of coordination between the FBiH, RS, and BD to ensure that strategy implementation processes are complementary and synergistic. In addition, legislation on environmental inspections for air pollution sources is lacking and should be developed.

There is a need to scale up the adoption of air quality plans (AQPs) at the local level. The impacts of air pollution are most profoundly experienced at a local level. Government support to local levels of government for the development of AQPs is crucial. While cantons of Sarajevo and Una-Sana have developed plans, it is important to scale up the preparation of AQPs to other cantons and municipalities in the country. The AQPs should take a comprehensive approach, which includes the development of emissions inventories, reliable air quality monitoring, understanding of the contributions of different sources to local air pollution, understanding of health impacts of air pollution, and identification of economically effective interventions for reducing air pollution. To this end, capacities of cantons and municipalities could be strengthened so that they can develop emissions inventories; obtain reliable time series of air quality monitoring data; and conduct air quality modeling, source apportionment studies, laboratory analyses, health impact analyses, and economic effectiveness analyses of alternative air pollution reduction interventions needed to underpin and inform the design and implementation of AQPs.

BiH should take specific measures to build on the legal framework to reduce pollution from stationary and mobile sources. Some of the specific areas that should be addressed include (a) taking time-bound steps to bring standards for liquid fuel quality, including gasoline, heavy fuel oils, and gas oils, into compliance with EU legislation for the entire country; (b) introducing more stringent standards for solid fuel quality for use in households (the current legislation requires that coal for use in households must have a total sulfur content of less than 2.5 percent by weight and allows municipalities to adopt more stringent standards; by way of comparison, in Ireland coal sold for home heating must have a sulfur content no greater than 0.7 percent by weight); (c) starting with large facilities, closing loopholes that allow stationary sources to operate without the necessary pollution control equipment and in violation of air emissions standards; and (d) building on the country's efforts to introduce measures to restrict imports of vehicles that do not meet Euro 4 standards—additional measures could be taken to revisit and issue country-level regulations establishing mandatory monitoring and inspection programs, to better link the price of annual Eco tests to the emission characteristics (Euro) of the vehicle, which would incentivize vehicle owners to undertake the tests and to replace old vehicles with less polluting ones. Recent consultations by MOFTER on a proposed decision on temporary suspension and reduction of duties on imported new vehicles with a view to promoting imports of new, particularly electric, vehicles should be consolidated and take into account distributional impacts of proposed policy actions.

BiH could expand the menu of instruments for AQM beyond 'command-and-control' instruments. In addition to strengthening the existing 'command-and-control' regulations, the different jurisdictions might consider developing economic instruments that have been used to reduce air pollutant emissions more efficiently and effectively in other countries such as taxes, fees, pollution charges, tradable permits, or pricing policies. In the FBiH, environmental fees and taxes are in use. However, fees for stationary sources could be updated and indexed to avoid erosion by inflation over time. To this end, third-party verification is needed of reported emissions used for computation of fees. For mobile sources, there is a need to better link fees to vehicle use and maintenance, in addition to technology-related parameters currently used to calculate fees. In addition, incentives for people to replace old vehicles with new, cleaner cars should be strengthened. Furthermore, as the government considers the reduction of duties on new imported vehicles, it would be important that adequate incentives are also put in place to discourage importation of old, polluting vehicles. In RS, the government should expedite efforts to establish a system to operationalize the amendments to the environmental protection law adopted in 2017, which introduced the first set of environmental economic instruments. Similarly, opportunities may exist in BD to develop economic instruments, which are currently lacking.

BiH could enhance the efficiency of its environmental funds in supporting air pollution reduction. Both the FBiH and RS have established environmental funds: the Environmental Fund of the FBiH and the Environmental Protection and Energy Efficiency Fund of RS. To strengthen the effectiveness of these funds in addressing air pollution, the respective funds could further improve criteria used for prioritizing and selecting projects or activities to which funds are allocated and enhance transparency related to the allocation of proceeds from fees to specific projects that reduce air pollution. For example, criteria could be incorporated that target activities that will have the most significant effect on reducing health impacts or the cost of environmental degradation due to air pollution.

There is a need to strengthen agencies with responsibilities for AQM at all levels and provide them with adequate resources. A priority for strengthening AQM consists of building capacity to design and implement AQM policies, including recruiting a higher number of specialized personnel in all agencies responsible for AQM-related tasks. Strengthening institutional capacity to enforce existing air quality standards is a pressing priority. To that end, sustained, higher resource allocation and strong government commitment will be key. In some instances, outsourcing of these functions to specialized firms or research organizations may be more efficient. Technical capacity of existing institutions could be strengthened through partnerships with research centers to conduct applied research, improve local and regional models, and create centers of excellence in the country on AQM.

Putting in place measures to strengthen enforcement of regulations related to AQM, particularly at the local level, is crucial for improving the effectiveness of the government's efforts to tackle air pollution. There is a need to strengthen inspection at the municipal level, increase the number of inspectors, and provide them with training and resources to conduct field investigations. Also, there is a need to build capacity for third-party verification of emissions reported by polluters. Given the prominent role of domestic heating in air pollution, efforts should be made to legally allow for household inspections to be conducted, to further strengthen such inspections, and increase public awareness, targeted to households, on air pollution and low-emission practices for household heating. Tested approaches to reinforcing compliance and enforcement include public disclosure of emitters' environmental compliance, judicial action, and increasing fines and expanding the range of sanctions for noncompliance, potentially including civil, judicial or administrative, as well as criminal enforcement on legal representatives of a polluting body.

Current air quality monitoring efforts can be improved through investments in more robust systems for air quality monitoring, data analysis, data quality control and assurance, data management, and

capturing of emission sources. Efforts to establish a reliable air quality monitoring network should prioritize a focus on pollutants that are critical to health and increased geographic and time series coverage, notably of $PM_{2.5}$. In BD, monitoring efforts, which currently focus on total suspended particulates (TSP), could shift toward $PM_{2.5}$, the more scientifically valid health-based indicator of PM. Additional ways to strengthen the current monitoring program include establishing a centralized depository of air quality data collected across the country and building the capacity within the relevant agencies in the FBiH, RS, and BD to carry out modeling and speciation efforts. Given that multiple institutions are involved in operation and maintenance of air quality monitoring networks in the country, it is important to have harmonized methodologies for sampling and analyses and standard operating procedures for operation and maintenance of monitoring stations to improve their operation as well as data quality and completeness. Furthermore, quality assurance and quality control (QA/QC) of data collected or generated at monitoring stations is vital, and there should be official written procedures for formatting, storage, and QA/QC of such data. These procedures should be harmonized across all constitutional entities to facilitate country-level assessments of air quality. Similarly, QA/QC procedures for maintenance and calibration of analytical instruments should be documented and harmonized across the country and include the practice of inter-laboratory calibration. It is recommended that the government sustains momentum on the ongoing efforts to establish a reference laboratory in the country.

Interventions to Reduce Exposure to Ambient Air Pollution

Addressing air pollution effectively in BiH will require policy, institutional, and investment interventions in various sectors, including residential and transport whose activities affect air quality. Some interventions that the government may consider include the following:

- **Residential.** The government could develop a large-scale program to substitute traditional stoves with more efficient ones. It could start with implementing a pilot program in the short term. Lessons from such a pilot, and other existing initiatives, could be taken into account to inform the development of a possible large-scale stove replacement program. In many countries, similar programs have been implemented with targeted subsidies for project beneficiaries who cannot afford to pay the full costs of substituting their stoves with cleaner alternatives. An awareness program would help educate the public on the purpose of stove replacement, low-emission stove use, and available resources for households and promote adoption of clean stoves in households. Additional measures such as expanding district heating could be developed over the medium to long term. Selection of interventions such as restrictions on burning of solid fuels in households, increased gas connections, expansion of district heating, and energy efficiency measures such as those contemplated in the Sarajevo Cantonal Environmental Action Plan should be based on analysis of the benefits and costs of alternative interventions. Furthermore, the distributional impacts of alternatives should be well understood to ensure that they do not disproportionately burden poor households.

- **Mobile sources.** Despite its apparently small share of pollution, transport is known to be highly locally polluting and should be addressed. Current standards for fuel quality allow high sulfur content up to 350 ppm for diesel and 150 ppm for gasoline compared to the 10 ppm limit on sulfur content required by EU legislation. BiH has taken measures to restrict imports of vehicles that do not meet Euro 4 standard and has recently been consulting introduction of temporary suspension of duties on imported new vehicles, to promote importation of new and electric vehicles.

However, if the disincentive to import old, polluting vehicles is not sufficiently strong, it may have limited impact on reducing air pollution. Additional measures that the government could consider include (a) revision of fuel quality standards to make them more stringent; (b) putting in place of additional economic incentives to replace older vehicles with more modern, cleaner vehicles; (c) stricter enforcement of measures to reduce importation of old, polluting vehicles, including the requirement for inspections at the point of entry; (d) putting in place of mandatory monitoring and inspection programs that are strictly enforced; and (e) inclusion of criteria related to vehicle use and maintenance in parameters for ECO tests for vehicles. Further strengthening and expansion of the public transport in urban areas, in particular using environment-friendly vehicles, could additionally help decrease pollution from mobile sources.

- **Stationary sources.** Starting with large facilities, there is a need to close loopholes that allow stationary sources to operate without the necessary pollution control equipment and in violation of air emissions standards. The legal framework could be tightened to ensure that the sanctions for facilities operating without a valid environmental permit, and facilities that exceed their approved emissions levels, are clear and commensurate with the damage they cause. In addition, enforcement of sanctions would need to be strengthened. Also, the government could provide financial incentives for smaller industrial undertakings to strengthen AQM. Additional measures that are available to control emissions from stationary sources include setting consumption caps to gradually reduce coal use; incorporating new technologies for desulfurization, denitrification, and dust elimination; setting more stringent emission control standards for coal-fired plants; and setting resource and energy conservation goals targeted at resource-intensive industries. However, it would be important to assess whether the benefits of these interventions would outweigh their costs.

Learning from International Experience in Tackling Air Pollution

Addressing air pollution effectively requires strategic, integrated approaches and solutions that are appropriate to the specific city or geographical context and various actors. A single sector or institution cannot solely undertake the extensive work involved in AQM given its cross-cutting nature. Experiences from other countries that are making progress in tackling air pollution show that an integrated approach is required. By supporting these countries, the World Bank has demonstrated its ability to play an integrative role through bringing together and fostering dialogue between, and engagement of, various country and international stakeholders and supporting crucial analytical work to inform investments and policy and institutional actions for AQM.

The design and implementation of economically effective interventions to successfully reduce air pollution must be underpinned by a sound foundation of analytical work to inform the selection of priorities and interventions and to set realistic and achievable air quality targets. As may be seen from the Peru and Mongolia examples, such analytical work also provides a platform around which various relevant stakeholders, including, among others, the government (across different sectors and different levels of government), think tanks, academia, the private sector, and donor agencies, can engage and come to informed conclusions about possible interventions and implementation of an appropriate air pollution reduction program. The government could consider setting interim air quality targets for ambient air quality concentrations of $PM_{2.5}$ and understanding how various pollution contributors can engage in actions to achieve the set target, as part of a phased approach for bringing ambient $PM_{2.5}$ concentrations down.

Conducting in-depth analytical work is often time intensive and could span several years, requiring adequate budgetary resources. It is recognized that in many contexts, the severity of air pollution and its health impacts as well as public pressure on government and city officials to act may call for interventions in the immediate to short term to reduce air pollution. In such cases, a city could consider applying reasonable interventions and policy options that would help alleviate air pollution in the short term such as restricting pollution from known stationary sources or traffic restrictions. However, such short-term actions are unlikely to be able to effectively reduce air pollution in the long term, in particular where air pollution sources are many and varied, and cannot replace a strategic and integrated approach involving rigorous analytical work and engagement of various relevant stakeholders across different sectors (e.g. environment, energy, transport, economy, agriculture etc.), development partners, academia, and others, to inform design and implementation of economically effective interventions for sustained or long-term air pollution reduction.

BiH, together with neighboring countries, could establish a knowledge platform for collaboration on transboundary air pollution. Although most of the pollution in BiH is from domestic sources, the transboundary contribution is important (at 20 percent). To maximize the synergies between similar or shared air quality-related problems, BiH could consider setting up, together with neighboring Balkan countries, a Balkan Knowledge Platform on transboundary air pollution. The knowledge platform could begin with coordination and knowledge sharing on technical aspects related to transboundary air pollution and gradually broaden the scope to collaboration on measures to address transboundary pollution based on experience and knowledge gained through interaction on the platform.

Benefit-cost analysis should be used to provide an informed basis for prioritizing and selecting interventions to reduce air pollution from different sectors. The interventions for tackling air pollution in different sectors are generally well-known, for example, promoting cleaner fuels, implementing district heating, and introducing transportation interventions. However, it is important that economically effective interventions are selected, which have a benefit-to-cost ratio greater than 1. In other words, the health benefits of an intervention—that is, avoided cost of premature mortality and morbidity—should be greater than the cost of implementing the intervention. It is recognized that such analysis should take into account existing policy and operational constraints that could foreclose or limit the implementation of certain air pollution reduction interventions.

The experiences of different cities around the globe show that in addition to technical interventions, a menu of instruments, including market-based, economic, and command-and-control instruments, are needed to effectively reduce AAP. Examples from Peru, Mongolia, and China illustrate the types of interventions that have had a strong impact on reducing air pollution, over different time frames, and may provide useful lessons for BiH as it strives to reduce air pollution. Cities in the aforementioned countries have successfully used a variety of instruments in their efforts to reduce air pollution, including market-based instruments, economic instruments, command-and-control instruments, investments in technical interventions, and policy and institutional reforms.

It is important that strategies and interventions to reduce air pollution do not disproportionately burden poor and vulnerable groups of people. Poor people are more likely to drive older, polluting vehicles. Poor people are also more likely to burn cheap and highly polluting fuels for domestic purposes.

Therefore, policies that prohibit the use of old, polluting vehicles in favor of newer, clean vehicles could incorporate financial or other suitable incentives for poorer people to comply with the policies. Similarly, programs to promote replacement of polluting stoves with clean, efficient stoves should incorporate incentives that will help low-income households' transition to burning cleaner fuels. It would be important to take into account distributional and social impacts of a ban on coal heating, if implemented, on affected populations in different income groups. Poverty and social impact analysis could be used to understand distributional impacts of policies to reduce air pollution to ensure that the poor and vulnerable are not disadvantaged by actions resulting from those policies.

Several development partners are supporting BiH's efforts to reduce air pollution, and stronger in-country coordination could help optimize this support. The technical assistance of development partners (for example, the World Bank, WHO, U.S. Embassy in Sarajevo, Government of Sweden, Embassy of Switzerland, UN Environment, United Nations Development Programme, and European Bank for Reconstruction and Development [EBRD]) has been instrumental in a number of advances being made in the areas of emissions inventory, monitoring, health impacts, dissemination of data, and abatement measures. Though very valuable, BiH has much work ahead to put in place structures that will allow it to successfully address its highly polluted air. The lack of coordination and harmonization and central authority for AQM is part of the root problem holding the country back in its efforts to address pollution. Without strong coordination, relevant institutions cannot create a policy and enforcement landscape that effectively controls pollution as severe as that in BiH.

There is a need to take stock of the outcomes of development support on air pollution and to identify opportunities where investments and policy and institutional actions can scale up impacts on air quality supported by appropriate financing mechanisms. The work of the abovementioned development partners and others has been instrumental in advancing progress on AQM in BiH. Stocktaking of the outcomes of the ongoing donor-supported activities and identification of opportunities and financing mechanisms should be coordinated among donors and conducted in collaboration with the government. Furthermore, the air pollution problem is significant and cannot be resolved without sustained government commitment combined with targeted policy actions; strong and adequately resourced institutions at all levels of government, particularly at the local level where the impacts are most felt; and sound planning and investments underpinned by rigorous analytical work. Government commitment is needed to ensure that institutions responsible for reducing air pollution are strong and well-staffed, supported by adequate budgetary resources, and are able to undertake sound planning and investments underpinned by requisite analytical work.

Recommendations for Air Quality Management in Bosnia and Herzegovina

The recommendations of this report are summarized in Table ES.1.

Table ES.1. Summary of key recommendations on AQM in BiH

Recommendation	Time frame
Legal and policy framework	
Strengthen the legal framework, focusing on specific instruments that reduce pollution from mobile sources, large stationary sources, and district heating.	Short to medium term
Harmonize regulations on sulfur content in liquid fuels at the country level and in compliance with the EU Directive on sulfur content in liquid fuels (1999/32/EC).	Short term

Recommendation	Time frame
Harmonize timelines for achieving ambient air quality standards for specific pollutants; fully transpose EU legislation that relates to the National Emissions Ceilings Directive, control of volatile organic compounds from petrol storage and distribution, petrol vapor recovery during refueling of ore vehicles at service stations, and limit values for industrial emissions for new plants.	Short to medium term
Adopt and implement legislation on environmental inspections for air pollution sources.	
Strengthen the legal framework by adopting and implementing a menu of air pollution management instruments, including economic and market-based instruments.	Medium term
Introduce more stringent standards for solid fuel quality for use in households.	Short to medium term
Scale up adoption and implementation of local AQPs.	Short to medium term
Air quality, emissions, and health data and analysis	
Strengthen the air quality monitoring network to provide reliable time series data on pollutants, notably $PM_{2.5}$, including clear protocols and procedures to strengthen QA/QC related to monitoring, data analysis, management, and reporting.	Short term
Expand air quality monitoring to include chemical constituents and species of PM such as pollutants including elemental carbon, organic carbon, sulfates, associated with combustion processes; $PM_{2.5}$ precursors including SO_2, NO_x, NH_3, and NMVOC; BC; and metals such as lead.	Short term
Improve meteorological observation for Sarajevo valley area, background monitoring data, and a comprehensive inventory of pollutants to improve air quality modeling.	Short to medium term
Develop an inventory of stationary and mobile air pollution sources prioritizing the residential sector and addressing all pollutants including BC: (a) **Residential.** Strengthen information on solid fuel statistics, burning of waste in the residential sector, typical solid fuel quality, and combustion technology used in the country. (b) **Transport**. Address uncertainties related to vehicle age and imported used vehicles, address all pollutants including BC, and conduct source apportionment analyses in large, densely populated urban centers.	Medium term
Consolidate a centralized and consistent depository of air quality data collected across the country and build the capacity to conduct modeling and speciation efforts.	Medium to long term
Harmonize country health reporting with international systems of disease classification, that is, the International Statistical Classification of Diseases and Related Health Problems.	Short to medium term
Improve collection and reporting of morbidity data by disease and age group.	
Strengthen capacity for conducting health risk assessments for individual industrial facilities.	
Reducing pollution from different sectors/sources	
Residential: (a) Implement a pilot program to replace polluting stoves and boilers with more efficient ones, including Ecodesign stoves, and build on lessons learned and experience to date to develop a large-scale program; (b) put in place targeted financial incentives to help poor households adopt clean, efficient stoves; and (c) implement public awareness campaigns to promote stove replacements.	Short to medium term
Where approved local environmental action plans exist that contemplate interventions such as increased gas connections and expansion of district heating, conduct (a) cost-benefit analysis to inform selection of interventions and (b) analysis of distributional impacts of proposed interventions.	Medium to long term
Mobile sources: (a) revision of liquid fuel quality standards to make them more stringent; (b) establishment of additional economic incentives to replace older vehicles with more modern, cleaner vehicles; (c) stricter enforcement of measures to reduce	Medium to long term

Recommendation	Time frame
importation of old, polluting vehicles, including requirement for inspections at point of entry; (d) establishment of mandatory monitoring and inspection programs that are strictly enforced; and (e) inclusion of criteria related to vehicle use and maintenance in parameters for ECO tests for vehicles.	
Transboundary: Establish, together with neighboring countries, a technical knowledge platform on transboundary pollution.	Short to medium term
Organizational framework for AQM	
Strengthen capacity of agencies with responsibilities for AQM at the FBiH, RS, and BD levels and provide staffing with requisite expertise and adequate budgetary resources. Areas where staff capacity could be enhanced include source apportionments, inventory development, air quality modeling, and health impact analysis.	Short term
Bolster inter-sectoral coordination, particularly between environmental authorities and other sectors such as health as well as transport, industry, energy, urban development, and agriculture whose activities affect air quality. Include criteria for priority-setting, accountability mechanisms that cover relevant stakeholders, monitoring and evaluation of outcomes, and social-learning mechanisms to promote continuous improvement.	Short to medium term
Strengthen MOFTER and the Inter-Entity Coordination Body for the Environment to facilitate harmonization of legal, policy, and organizational frameworks.	Medium term
Strengthen horizontal and vertical coordination by establishing formal and permanent mechanisms for AQM policy development, implementation, monitoring, and evaluation.	Medium to long term
Establish reference laboratory for country and institute inter-laboratory calibration exercises.	Medium term
Strengthen effectiveness of environmental funds, established in the FBiH and RS, in addressing air pollution, by clarifying and developing criteria for prioritizing and selecting projects or activities to which funds are allocated and enhancing transparency related to the allocation of proceeds from fees to specific projects that reduce air pollution.	
Public participation and stakeholder engagement	
Develop an air quality index (AQI) to disseminate information to the public in a manner that is easily understandable and accessible to diverse audiences and facilitate issuance of health-related air quality alerts, for sensitive population groups and to the population as a whole, when necessary.	Short term
Develop public disclosure mechanisms for emissions reporting by operators of facilities.	Medium to long term
Enforcement	
Expand the number of inspectors and provide them with training and resources to conduct field investigations.	Short term
Put in place third-party verification of emissions reported by operators of polluting facilities.	Short to medium term
Put in place regulations to legally allow household inspections.	Short term
Strengthen enforcement by clarifying sanctions for noncompliance, increasing fines, and expanding the range of sanctions, in particular for stationary sources.	Medium term

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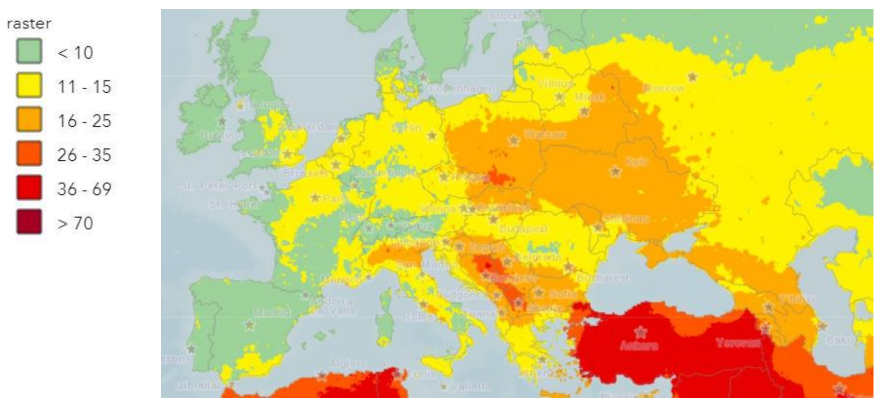
Chapter 1. Ambient Air Quality in Bosnia and Herzegovina

1.1. Background

People living in the Balkans and Eastern Europe are typically breathing more harmful air than their neighbors in Western Europe (Figure 1.1). The burning of solid fuels for domestic heating and cooking, wide use of coal-fired power plants, industry, and aging vehicle fleets are contributory factors to elevated concentrations of ambient air pollution (AAP).

In Bosnia and Herzegovina (BiH), large numbers of people are exposed to ambient concentrations of fine particulate matter ($PM_{2.5}$), which exceed the World Health Organization (WHO) Air Quality Guideline value of 10 $\mu g/m^3$ and the less stringent European Union (EU) limit value of 25 $\mu g/m^3$ (see Figure 1.1). $PM_{2.5}$ is the most documented air pollutant for its adverse effects on human health and is one of the world's leading causes of illness and death, associated with lung cancer (LC), ischemic heart disease (IHD), stroke, chronic obstructive pulmonary disease (COPD), and respiratory disease. In addition, particulate matter (PM) comprises black carbon (BC), which is formed from incomplete combustion of fossil fuels, wood, and other fuels, and has climate warming properties (Annex A provides an overview of the primary air pollutants discussed in this report).

Figure 0.1. Locations where annual mean $PM_{2.5}$ ($\mu g/m^3$) meets or exceeds WHO guidelines (2016)

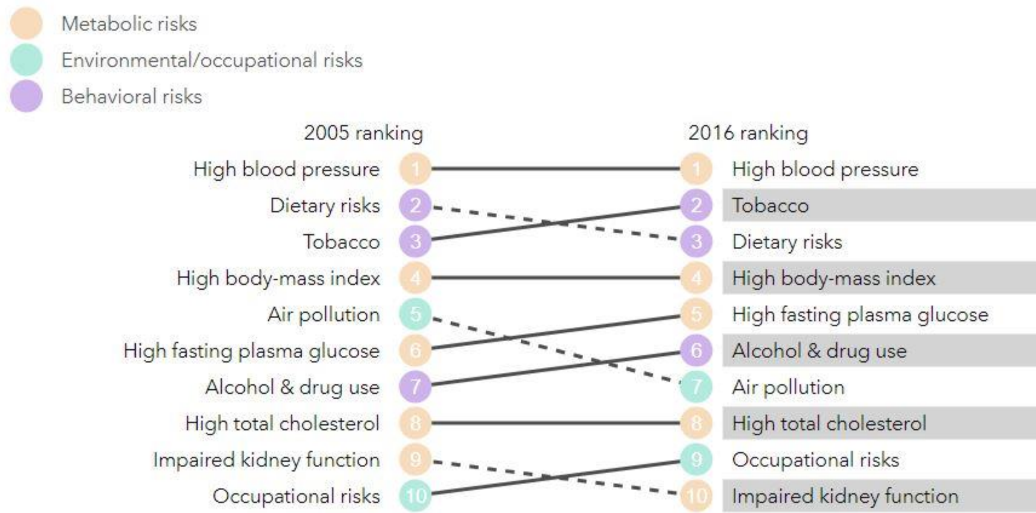


Source: WHO 2018. http://maps.who.int/airpollution.

According to the Institute for Health Metrics and Evaluation (IHME), an independent global health research center, air pollution is the leading environmental risk factor that drives the most death and disability combined in BiH (Figure 0.2). In cities such as Sarajevo, the capital city and home to about 10 percent of the population, average annual ambient $PM_{2.5}$ concentrations reach thrice the WHO Air Quality Guideline level (Figure 0.3). The city is prone to heavy fog in winter that converts into smog when mixed with high levels of pollution. Major emission sources are similar to countries in other parts of the region including residential heating and cooking, industry, coal-powered power plants, and road transport. In the industrial city of Tuzla, annual average ambient $PM_{2.5}$ concentrations have reached almost seven times the WHO Air Quality Guidelines, while PM_{10} concentrations have exhibited peaks of over 300 $\mu g/m^3$. According to the WHO global database for ambient air quality, Tuzla and Lukavac are the two most polluted cities in Europe, followed by Tetovo in North Macedonia.

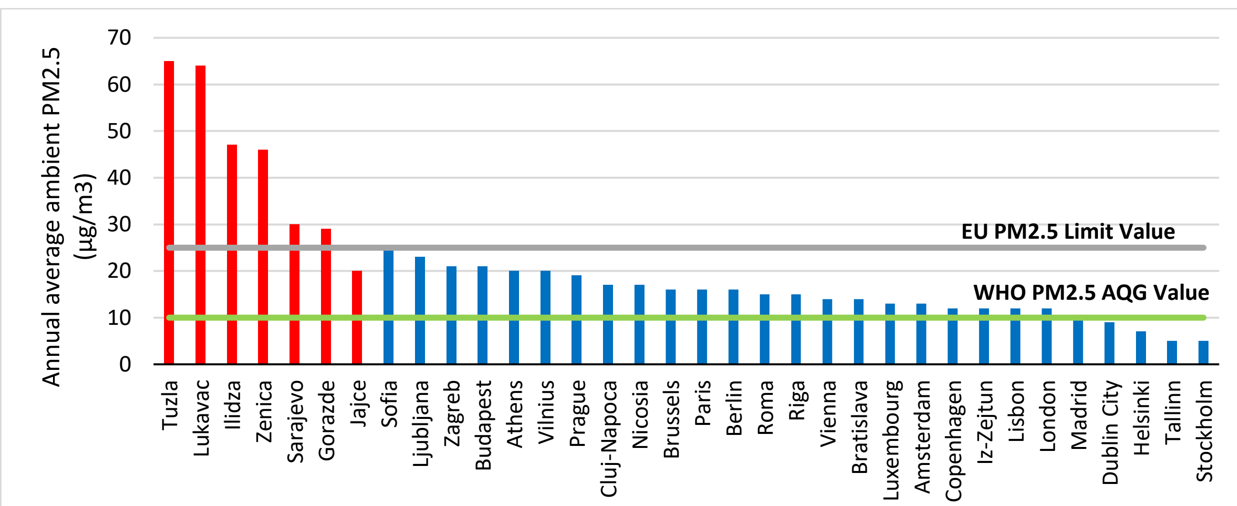
There has been a growing interest and pressure from the public in BiH to continue to tackle the problem of air pollution, often triggered by episodes of high pollution in urban centers and cities. Air pollution tends to be significantly worse in cities situated in valleys such as Zenica, Tuzla, and Sarajevo during winter months, as the topographic conditions and little wind prevent dispersion of pollutants. In Zenica, the largest and most industrial town in the country, public demonstrations have taken place in response to high pollution levels caused by large polluting power and steel plants that account for significant emissions of air pollutants.

Figure 0.2. Risk factors that drive the most death and disability combined in BiH



Source: IHME 2018. http://www.healthdata.org/bosnia-and-herzegovina.

Figure 0.3. Air pollution levels in cities in BiH compared to other European cities



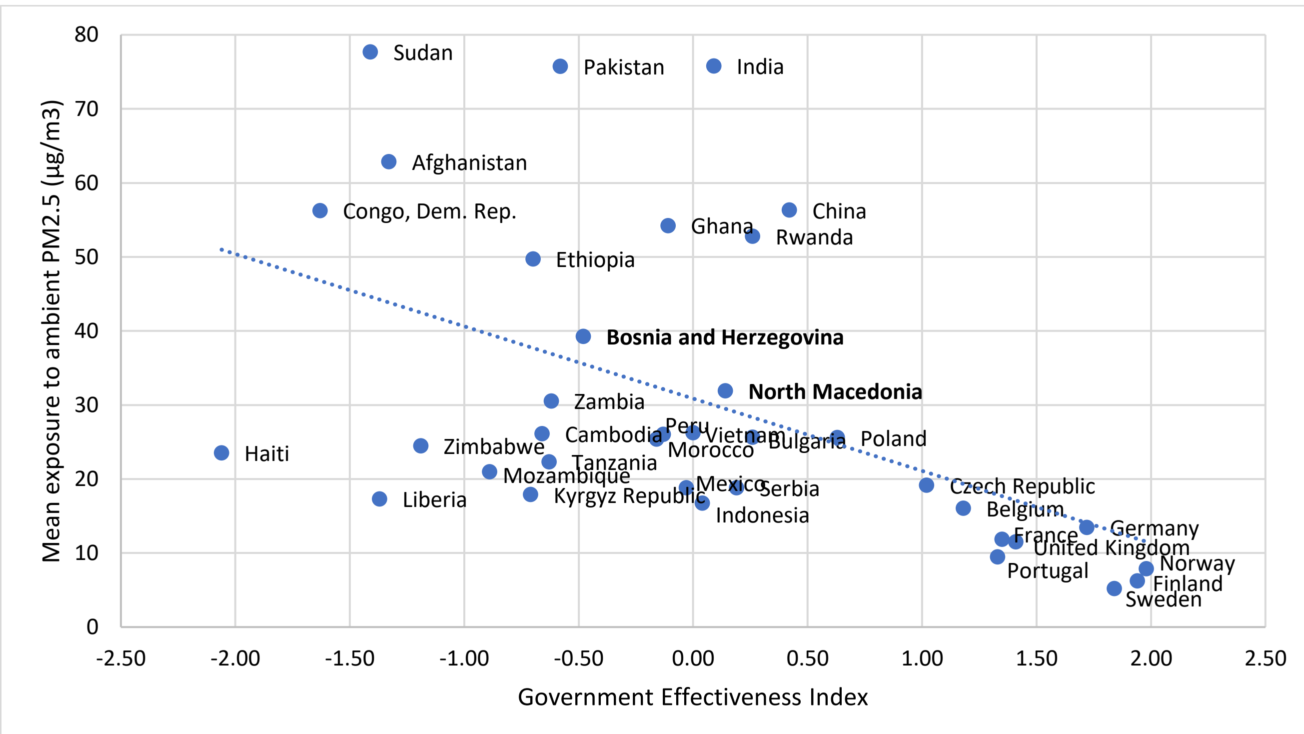
Source: WHO 2018.

The EU accession process provides an incentive to adapt legislation and learn from experience of other EU countries how air quality can be improved through emission reductions from key sources of polluting air emissions. BiH was identified as a potential candidate for EU membership during the Thessaloniki European Council summit in June 2003 and the country applied for membership in the EU in February

2016.[2] While important measures have been implemented to improve AQM, further efforts are needed to meet key obligations and requirements under the EU accession process. Under the EU's Industrial Emissions Directive, the country must reduce emissions by 90 percent for sulfur dioxide (SO_2), 67 percent for nitrogen oxides (NO_x), and 94 percent of airborne particulates by 2028 for potential accession to the EU.

Environmental quality indicators correlate with governance indicators such as government effectiveness, voice and accountability, political stability, regulatory quality, rule of law, and control of corruption (Figure 1.4). The World Governance Indicators, published annually by the World Bank, reflect institutional problems that are relevant to environmental quality management (World Bank 2018). The Government Effectiveness Index captures perceptions of the quality of public services, the quality of the civil service, the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies. Some of these governance issues are relevant to air quality management (AQM) and could be relevant to the institutional framework for AQM in BiH. A positive correlation exists between government effectiveness and air quality. Both BiH and North Macedonia, also a West Balkan country, have higher levels of AAP than some other countries with lower government effectiveness indexes.

Figure 0.4. Government effectiveness and air pollution ($PM_{2.5}$)



Source: Data from World Development Indicators 2018.

[2] Bosnia and Herzegovina signed the Stabilisation and Association Agreement (SAA) in 2008, which includes the obligation to bring in line all legislation, rules, and procedures of the accessing country with the EU acquis.

1.2. Objectives of this Report

This report is one in a series of three reports on AQM in BiH, Kosovo, and North Macedonia. It examines the nature and magnitude of AAP in BiH. It provides estimates of the health burden, and economic cost associated with the health impacts, of AAP, that is, $PM_{2.5}$ in BiH. It also provides an analysis of the roles of various sources of $PM_{2.5}$ emissions on ambient air quality in BiH at a country level. The institutional and policy framework for AQM in the country is examined, including contributions of other development institutions in supporting BiH's efforts to address air pollution. Furthermore, the report presents experiences of selected countries that have applied different policy, investment, and technical interventions for air pollution, prevention, reduction, and abatement. Finally, it provides recommendations for reducing air pollution in BiH.

1.3. Methodology

Air quality assessment. This report provides an assessment of the ambient air quality status in BiH based on desktop review of available data and information from the Federation of Bosnia and Herzegovina (FBiH) Hydrometeorological Institute and the Republika Srpska (RS) Hydrometeorological Institute, as well as reports and information received from local consultants and relevant government counterparts.

Economic analysis of health effects of ambient air pollution. The environmental health and economic analysis relies on primary data and publications from the FBiH and RS (FHMI 2016, 2017; MAENR-RS 2016) as well as from various reports that summarize this information (BreatheLife 2030[3]; EEA 2018; UN SDG 2018). The analysis also uses peer-reviewed publications on Western Balkans (Bartoš et al. 2009; De Pieri et al. 2014; HEAL 2016; Quartz 2018) and publications from global and European sources (EC 2018; EEA 2017; EEA 2018b; Eurostat 2016[4]; UN SDG 2018; Van Donkelaar et al. 2015). Quantification of health effects from air pollution is grounded in commonly used methodologies that link mortality of the population and exposure to pollution (GBD 2016 Disease and Injury Incidence and Prevalence Collaborators 2017; Landrigan et al. 2017). The economic costs of these health effects are assessed using standard valuation techniques that present the economic value of the attributable mortality in monetary terms (Lindhjem et al. 2011; Narain and Sall 2016), based on economic indicators from statistical yearbooks of the FBiH and RS (Institute for Statistics of FBiH 2016; RS Institute of Statistics. 2017.).

Institutional and policy review. This report includes a desk review of the institutional and policy framework for AQM in BiH, including progress in transposing EU legislation, and key aspects of AQM such as monitoring, data management, and dissemination of air quality information that can inform strategies and interventions to reduce air pollution. It also summarizes the roles of organizations that are responsible for developing, implementing, monitoring, evaluating, and enforcing air quality legal and policy instruments. Based on information obtained from development partners active in BiH, it also discusses how they are contributing to AQM efforts in the country.

Analysis of key sources of $PM_{2.5}$ exposure. Following a qualitative overview of sources of exposure to $PM_{2.5}$ in the country, this report provides a quantitative analysis of the source structure of $PM_{2.5}$ emissions for the first time in this region (covering BiH, Kosovo, and North Macedonia) in a harmonized way,

[3] BreatheLife 2030. http://breathelife2030.org/. Accessed September 7, 2018.
4 Eurostat. 2016. Energy Balance Sheets 2014 DATA 2016 edition. https://ec.europa.eu/eurostat/web/energy/data/energy-balances.

comparing model calculated $PM_{2.5}$ concentrations with recent observations from local measurement networks as available and developing source apportionments for ambient $PM_{2.5}$ for BiH and the two other countries mentioned. The quantitative analyses were performed with the Greenhouse Gas-Air Pollution Interactions and Synergies (GAINS) model developed at the International Institute for Applied Systems Analysis (Amann et al. 2011), which allows simulation of the impacts of policy actions that influence future driving forces (for example, energy consumption, transport demand, agricultural activities) dedicated measures to reduce the release of emissions to the atmosphere, on total emissions, resulting air quality, and a basket of air quality and climate impact indicators.

1.4. Analytical Value-Added

This report provides analysis that adds to knowledge in the following areas:

(a) A country-level assessment of health and economic damages from air pollution in BiH, primarily from $PM_{2.5}$ (the most detrimental air pollutant to health), and based on the most up-to-date methodologies

(b) Development, for the first time, of a preliminary country-level source apportionment analysis for $PM_{2.5}$

(c) Analysis of scenarios of $PM_{2.5}$ emissions, and ambient concentrations, from a baseline of 2015 up to 2030

(d) Global experiences and lessons learned from interventions by other World Bank client countries to address AAP in key sectors

(e) A basis to inform possible long-term engagement by the World Bank in supporting BiH in tackling air pollution, taking into account efforts of other development partners

1.5. Ambient Air Quality in Bosnia and Herzegovina

Ambient air quality is assessed not only by the concentration of a pollutant but also by the number of times that the limit value for that pollutant is exceeded. Ambient air quality standards in the FBiH and RS are provided in Table 1.1 along with EU limit values and WHO guideline values. The country's air quality standards are aligned with EU air quality standards.

Table 0.1. Air quality standards in BiH compared to WHO guidelines and EU standards

Pollutant	Averaging time	WHO air quality guideline value (μg/m^3)	FBiH (μg/m^3)	RS (μg/m^3)	EU air quality standards (μg/m^3)
PM_{10}	Annual mean	20	40	40	40
	24-hour mean	50	50	50	50 (not to be exceeded more than 35 times a calendar year)
$PM_{2.5}$	Annual mean	10	20	20	25
	24-hour mean	25	n.a.	n.a.	—

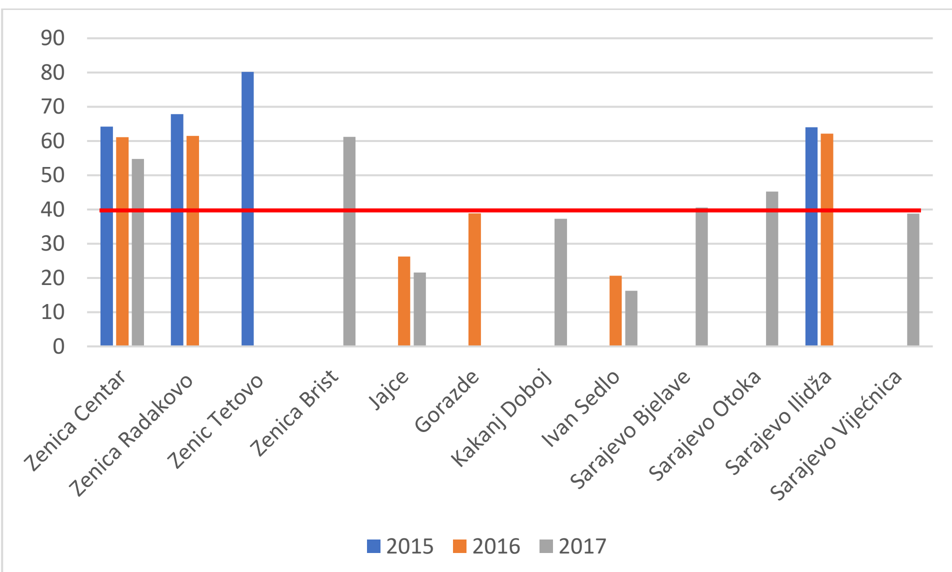
Pollutant	Averaging time	WHO air quality guideline value (µg/m³)	FBiH (µg/m³)	RS (µg/m³)	EU air quality standards (µg/m³)
Ozone (O_3)	8-hour mean	100	120	120	120
Nitrogen dioxide (NO_2)	Annual mean	40	40	40	40
	1-hour mean	200	200	150	200
SO_2	24-hour mean	20	125	125	125
	10-minute mean	500	350	350	350

Source: Based on EU 2008; GFBiH 2012; GSR 2012; WHO 2006.

The FBiH and RS each operate a separate air quality monitoring network.

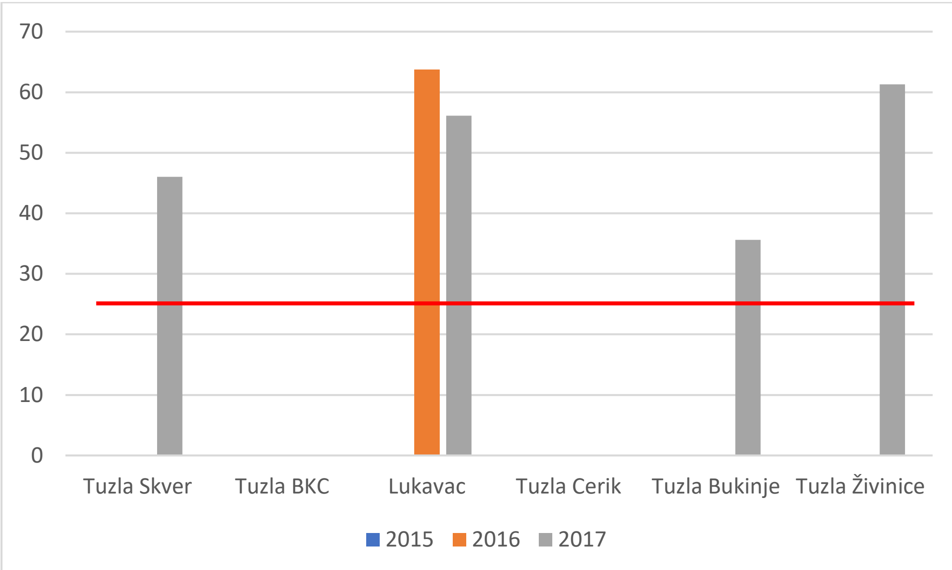
FBiH. During 2015–2017, most of the FBIH's air quality monitoring stations recorded annual average PM_{10} concentrations close to or higher than EU ambient air quality limit values with the exception of the Ivan Sedlo monitoring station, which is a regional background station, and Jajce station. Recorded ambient PM_{10} concentrations were about 50 percent higher than the FBiH and EU limit values. In 2015–2016, highest annual average PM_{10} concentration was recorded at Zenica Tetovo, where there is a major iron and steel industry. During 2017, the highest concentrations were recorded at Sarajevo Otoka and stations in Zenica. Figure 1.5 shows annual average PM_{10} concentrations and exceedances for 2015–2017.

Figure 0.5. Annual mean PM_{10} concentrations in the FBiH (red line shows annual PM_{10} limit value)



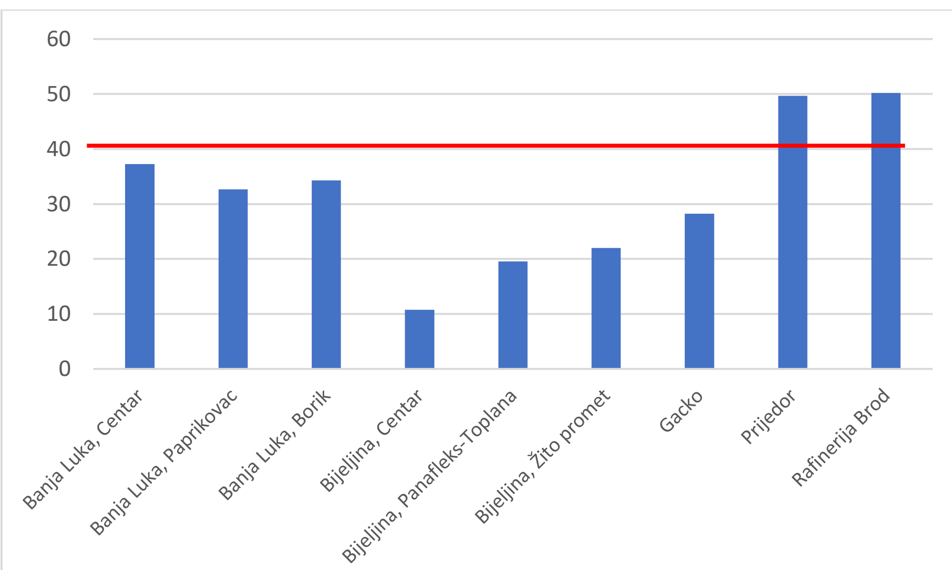
$PM_{2.5}$ ambient concentrations are measured only at stations in Tuzla. In 2015 and 2016, most of the stations lacked data. In 2017, a total of six stations monitored and recorded $PM_{2.5}$ concentrations (Figure 1.6). $PM_{2.5}$ concentrations measured at all stations exceeded the limit value. The measured concentration at Zivinice station was about 2.5 times higher than the limit value. The high $PM_{2.5}$ concentrations may be affected by emissions from industrial activities in the vicinity of monitoring stations. For example, there are several major industrial facilities including JP EP BiH-TE Tuzla Power Plant, Sisecam Soda chemical manufacturing facility, and Fabrika Cementa Lukavac Cement Factory near Lukavac monitoring station. However, further investigation would be required for accurate assessment of any contributions from these industrial facilities.

Figure 0.6. Annual mean $PM_{2.5}$ concentrations in the FBiH (red line shows annual $PM_{2.5}$ limit value)



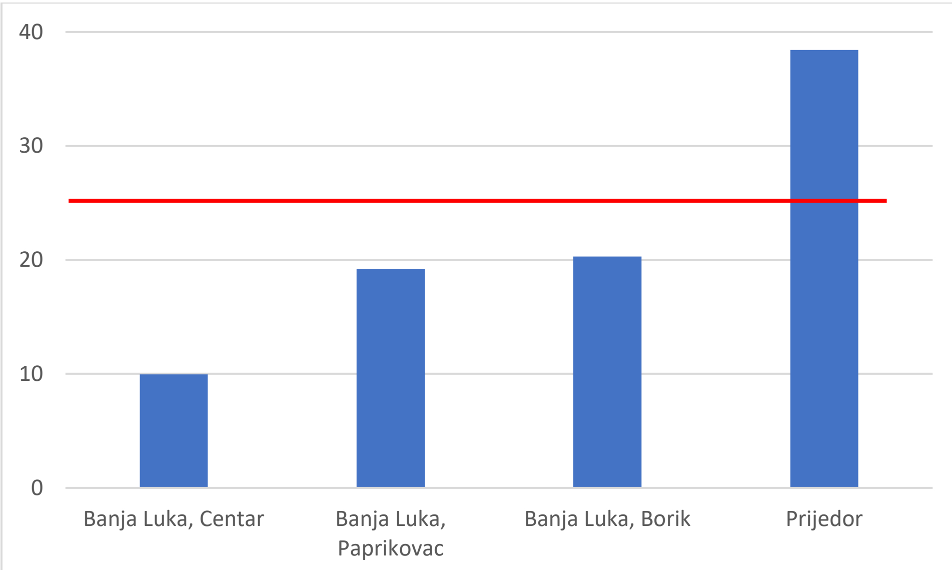
RS. During 2016–2017, stations at Banja Luka and Bijeljina recorded PM_{10} concentrations at daily intervals whereas the remaining stations recorded measurement on hourly intervals. In addition, there was about six months of missing data at stations in Banja Luka. Annual average PM_{10} concentrations recorded during 2016 and 2017 at nine monitoring stations in RS are shown in Figure 1.7. The PM_{10} limit value was exceeded at Prijedor and Rafinerija Brod stations, with concentrations reaching about 25 percent higher than the limit value. Measurements at the remaining stations were compliant with the limit value.

Figure 0.7. Annual average PM_{10} concentrations in RS (2016–2017)



$PM_{2.5}$ concentrations were measured at stations in Banja Luka (that is, Centar, Paprikovac, and Borik) at daily intervals and at Prijedor station on an hourly basis (Figure 1.8). There were about six months of missing data at stations located in Banja Luka. Prijedor station had a higher data capture (that is, about 80 percent data captured during 2016–2017). Annual average $PM_{2.5}$ concentrations recorded at these stations are shown in Figure 1.8. All the stations except Prijedor complied with annual average limit values.

Figure 0.8. Annual average $PM_{2.5}$ concentrations in RS (2016–2017)



Monitoring Data Completeness

The abovementioned examination of ambient air quality indicates that monitoring data completeness is a challenge in both the FBiH and RS. Monitoring data for PM_{10} and $PM_{2.5}$ and data completeness in the FBiH are presented in Tables 1.2 and 1.3. The EU Directive 2008/50/EC on ambient air quality requires that data should be recorded at least 90 percent of the time at a given station (excluding regular maintenance times) as a data quality objective for ambient air quality assessment. As shown in Table 1.2, in 2015 most of the stations suffered from low data capture. Although the situation improved in 2017, only about 50 percent of the stations met data completion requirements of the EU Directive pointing to the need for better understanding of the reasons behind this shortcoming and for measures to be put in place to improve data capture in the country. Similarly, for $PM_{2.5}$, data completeness was low at most monitoring stations in 2015 and 2016, and by 2017 only two of the seven stations had poor data completeness in addition to a station, where monitoring data were absent (Table 1.3).

Table 0.2. Annual average concentration and data completeness for PM_{10} in stations in the FBiH (2015–2017)

	2017		2016		2015	
	Valid data (%)[a]	Annual average concentrations (μg/m³)	Valid data (%)	Annual average concentrations (μg/m³)	Valid data (%)	Annual average concentrations (μg/m³)
Zenica Centar	90.32	54.77	91.27	61.13	94.63	64.22
Zenica Radakovo	61.16	63.41	89.86	61.45	86.94	67.80
Zenica Tetovo	19.68	60.32	78.23	69.10	82.45	80.13
Zenica Brist	97.65	61.19	76.63	61.40	27.68	85.41
Jajce	96.16	21.62	97.85	26.23	45.17	20.58
Gorazde	77.59	40.45	88.73	38.91	—	—
Kakanj Doboj	94.32	37.32	47.45	49.54	—	—
Ivan Sedlo	88.34	16.22	80.70	20.65	20.98	21.35
Sarajevo Bjelave	88.60	40.53	71.36	42.60		
Sarajevo Otoka	93.32	45.26	45.58	84.84	59.66	86.81
Sarajevo Ilidža	65.29	66.76	81.86	62.17	82.42	63.97
Sarajevo Vijećnica	89.19	38.74	59.23	50.34	—	—
Sarajevo Alipašina	—	—	—	—	59.20	39.95
Kaknj Dom Kulture	—	—	—	—	71.45	57.47
Kakanj Transport	—	—	—	—	35.86	53.61

Note: a. Percentage of time for which measurements are recorded in a given year.

Table 0.3. Annual average concentration and data completeness for $PM_{2.5}$ in stations in the FBiH (2015–2017)

	2015		2016		2017	
	Valid data (%)[a]	Annual average concentrations (μg/m³)	Valid data (%)	Annual average concentrations (μg/m³)	Valid data (%)	Annual average concentrations (μg/m³)
Tuzla Skver	53.03	85.02	54.37	66.02	92.83	46.00
Tuzla BKC	8.54	206.77	20.20	135.13	75.32	48.52
Lukavac	52.07	102.82	95.42	63.68	96.38	56.11
Tuzla Cerik	26.36	59.64				
Tuzla Bukinje	—	—	8.71	99.20	95.88	35.61
Tuzla Živinice	—	—	5.89	160.35	95.20	61.28
Gorazde	—	—	—	—	77.38	32.56

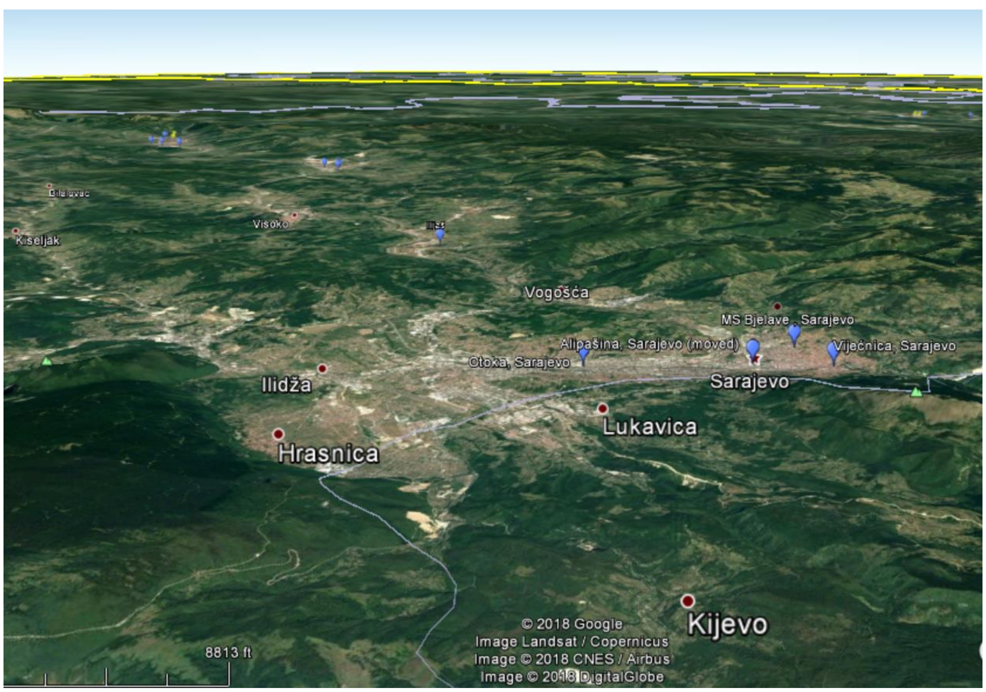
Note: Percentage of time for which measurements are recorded in a given year.

Long-term Air Quality Assessments and Trends

Understanding air quality trends provides useful information about the effectiveness of AQM measures and insight about the relationships between emission sources and ambient concentrations of pollutants. Problems of data completeness as experienced in monitoring stations in the FBiH and RS, however, constrain accurate assessment of long-term air quality trends. For air quality assessments, it is useful to conduct simultaneous measurements of $PM_{2.5}$ and PM_{10} at the same station. However, in 2017 none of the stations in the FBiH measured $PM_{2.5}$ and PM_{10} simultaneously. For these reasons, this study could only conduct a limited assessment of air quality trends and focused on the capital city of Sarajevo, the country's largest city and home to 10 percent of the population. Contributors of polluting emissions in Sarajevo include traffic, residential heating, and minor manufacturing. There is no major PM emitting industry in Sarajevo, with the exception of Tvornica Opeke Sarajevo, a bricks, tiles, and construction product manufacturing facility located on outskirts of the city in a suburban area on the north-west.

Locations of the monitoring stations in Sarajevo are shown in Figure 1.9. At the time of this study, four monitoring stations (Ilidza, Vijenica, Bjelave, and Otoka) were operating at Sarajevo.[5] The city is located in a long area that runs from east to west and is surrounded by elevated terrain, which could limit dispersion of air pollutants, especially during winter when stagnant weather conditions are more prominent. Further investigation on the assessment of monitoring locations, including the number, coverage, and type (for example, background, urban, sub-urban, and traffic) of monitoring stations, might be helpful to assess diverse emission sources and effectiveness of measures.

Figure 0.9. Location of monitoring stations in Sarajevo

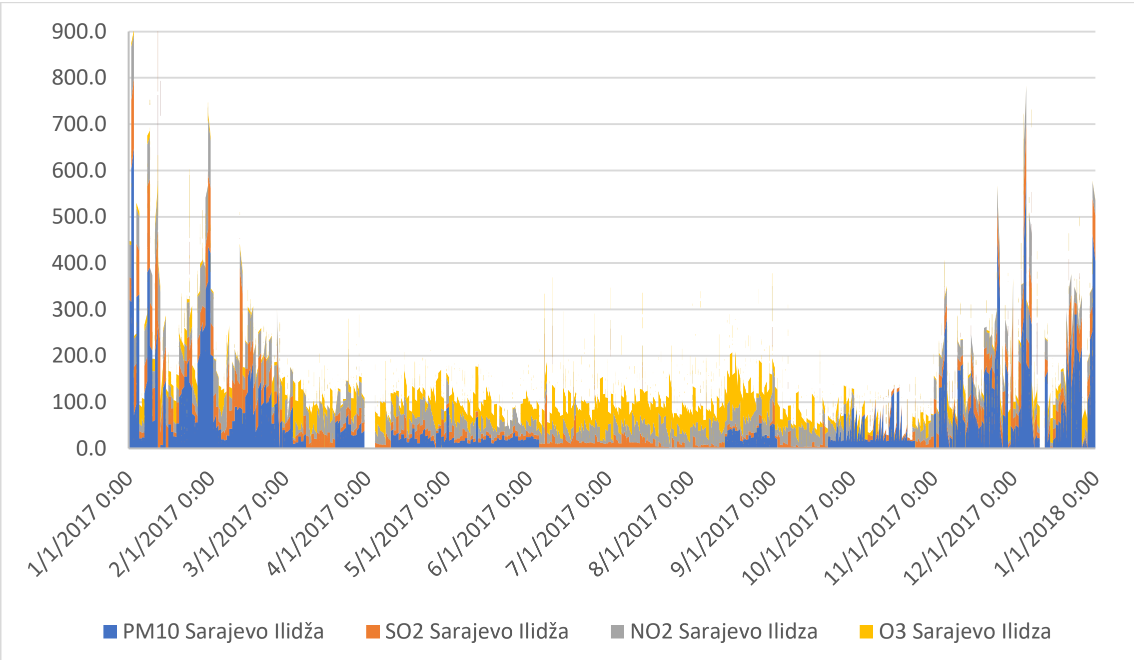


Data recorded at the Ilidza station in 2017 were used for further assessment as this station has the most complete PM_{10} data, and PM_{10} data completeness during the past three years was better at this station

[5] Alipasina station was moved to Viјećnica.

than at other stations at Sarajevo. Temporal variations of pollutants monitored at this station during 2017 are presented in Figure 1.10.

Figure 0.10. Trend analysis of air quality monitoring data recorded at Sarajevo Ilidza station in 2017

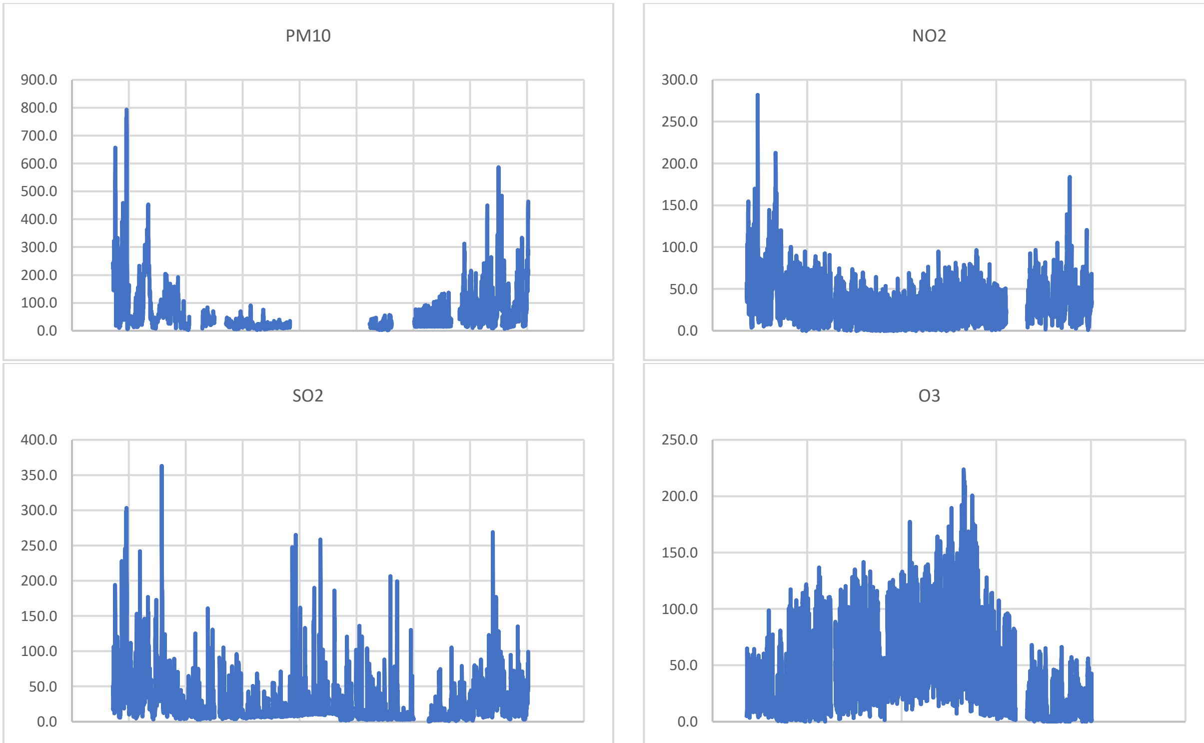


Trend analysis shows that the concentrations of all the pollutants, with the exception of O_3, are highest during winter months and low during summer months. Higher winter concentrations might be associated with adverse atmospheric dispersion conditions during the winter coupled with high pollutant emissions from residential heating sources. Table 1.4 provides statistical correlations between the pollutants, which confirm relationships between ambient concentrations of PM_{10}, SO_2, and NO_2. Such relationship may indicate common emission sources for these pollutants and suggests the need for further analysis. The results of further trend analysis of the individual pollutants are illustrated in Figure 1.11.

Table 0.4. Correlation between air pollution parameters recorded at Ilidza station in 2017

	PM_{10}	SO_2	NO_2	O_3
PM_{10}	**1.00**			
SO_2	0.58	**1.00**		
NO_2	0.63	0.55	**1.00**	
O_3	−0.39	−0.24	−0.42	**1.00**

Figure 0.11. Air quality monitoring data recorded at Sarajevo Ilidza station in 2017



O_3 is a secondary pollutant formed through photochemical reactions of NOx and hydrocarbons in the atmosphere, while NOx and SO_2 are precursors of PM. O_3 concentrations are expected to be higher during the summer season when sun intensity is high and lower during the winter season when photochemical reaction is not favorable due to lower sun intensity. Figure 0.10 confirms the expected temporal trend for O_3.

Furthermore, SO_2 concentrations exhibit similar pattern as NO_2 and PM_{10} during the winter season—that is, highest concentrations are observed during the winter. However, unlike NO_2 and PM_{10}, summer-time SO_2 concentrations exhibit some highs, indicating that an additional continuous SO_2 emission source is influencing this monitoring station. Further investigation is needed to identify continuous emission sources of SO_2.

PM_{10} may be emitted directly from emission sources (such as residential heating and transport) and may also be formed in the atmosphere through atmospheric reactions of PM_{10} precursors (that is, SO_2, NOx, non-methane volatile organic compounds [NMVOC], ammonia [NH_3]). Chemical speciation analysis of PM_{10} is required to identify the contribution of secondary PM_{10} formation. However, chemical speciation of PM_{10} is not available in the FBiH. Although previous assessments[6] state that a few detailed sampling campaigns were conducted during 2017 and 2018 to investigate chemical composition of PM, results were not available during this study. Furthermore, those assessments were limited to statistical analysis of various pollutants and do not elaborate on potential emission sources.

[6] Federalni hidrometeorološki zavod, 2018. GODIŠNJI IZVJEŠTAJ O KVALITETU ZRAKA U FEDERACIJI BOSNE I HERCEGOVINE ZA 2017. GODINU; J.U. ZAVOD ZA JAVNO ZDRAVSTVO KANTONA SARAJEVO, 2017. IZVJEŠTAJ O MONITORINGU KVALITETA ZRAKA U KANTONU SARAJEVO ZA 2016. GODINU.

Analysis of $PM_{2.5}/PM_{10}$ ratios could provide a useful way of identifying emission sources of PM, especially fuelwood burning for residential heating. High $PM_{2.5}/PM_{10}$ ratios indicate abundance of fine particulates from combustion sources. However, lack of stations where $PM_{2.5}$ and PM_{10} concentrations are measured simultaneously precludes $PM_{2.5}/PM_{10}$ ratio analysis.

The limited analysis conducted in this report demonstrates the importance of sustained air quality monitoring efforts and good quality monitoring data for understanding emission sources. Furthermore, emissions sources can vary between different locations within a single city, thus underscoring the importance of robust analytical and laboratory capacity to enable the identification of emission sources that influence different parts of a city and plan mitigation measures accordingly. Building capacity to conduct analyses such as source apportionment studies including chemical speciation of PM (heavy metals, major ions, and so on); monitoring of additional parameters such NH_3 and NMVOC, which are PM precursors, as well as BC; and conducting receptor modelling (such as Chemical Mass Balance [CMB] or Positive Matrix Factorization [PMF] would enable quantitative assessment of emission sources. Air quality plans (AQPs) that are established on such assessments are expected to be more effective.

1.6. Summary

AAP, notably $PM_{2.5}$, is a problem in cities and urban centers in BiH. $PM_{2.5}$ and PM_{10} exceedances of EU/WHO standards in BiH are widespread and deleterious to human health. Severe exceedances of ambient air quality standards occur during the winter season.

A preliminary assessment based on desktop review indicates that the number and coverage of air quality stations in BiH are sufficient, but a number of areas could be further strengthened. Further investigation and detailed assessment including site visits and stakeholder interviews are recommended to confirm these preliminary findings. Key findings and recommendations on air quality monitoring in BiH based on this preliminary assessment are as follows:

- **Data completeness is a serious shortcoming at many stations.** Further investigation on operation and maintenance of monitoring stations should be performed to identify problems, and mitigation measures should be identified and implemented to improve operation of the stations, data completeness, and data quality. Furthermore, standard operating procedures should be reviewed and strengthened.

- **Procedures and routine assessments for quality assurance and quality control (QA/QC) of data collected from the monitoring network are needed.** QA/QC procedures to ensure precision and accuracy of measurements and data analyses should be developed. Consistent format and medium for air quality data recording and reporting should be developed and utilized by the FBiH and RS to facilitate nationwide assessments of improvements in air quality.

- **Human and financial resources for operation and maintenance of monitoring stations in the country need to be strengthened.** An assessment of existing human and financial resources needs to be performed, and measures should be put in place to strengthen institutional capacity for monitoring to ensure adequate numbers of staff with requisite technical expertise to conduct monitoring and related activities such as laboratory analyses and data analysis, management, and reporting.

- **Source apportionment studies at the city level should be conducted in large densely populated urban centers.** Furthermore, chemical speciation of PM (for example, heavy metals and major ions) and measurement of additional parameters such as NH_3 and NMVOC, which are PM precursors, as well as BC, should be included in monitoring efforts. In addition, source apportionment studies conducted utilizing receptor models such as CMB or PMF may provide quantitative assessment of the emission sources.

- **The number of stations in the respective networks of the FBiH and RS that measure both $PM_{2.5}$ and PM_{10} should be increased.** First, monitoring of the more health-damaging $PM_{2.5}$ will help inform health impact assessments and decision making on interventions to reduce the health damage and associated cost burden of $PM_{2.5}$. Second, measurement of $PM_{2.5}$ and PM_{10}, in addition to providing an indication of the sources of PM pollution, provides a ready way of detecting problems associated with operation, and providing quality assurance, of the network.

- **Emissions from industrial sources are particularly important in the locality of such sources.** There is a need to better understand the impact of industrial emissions on ambient air quality and human health particularly. Capacity for conducting health risk assessments in the vicinity of industrial installations should be strengthened.

Chapter 2. Health Burden and Economic Cost of Ambient Air Pollution in Bosnia and Herzegovina

2.1. Introduction

It is well documented that the strongest and most rigorously proven causal associations between health and poor air quality are between cardiovascular and pulmonary disease and $PM_{2.5}$ pollution. Particles of smaller size reach deeper into the lower respiratory tract and thus have greater potential for causing lung and heart diseases. As a Lancet review (Landrigan et al. 2017) reports, $PM_{2.5}$ air pollution is associated with several risk factors for cardiovascular disease, including hypertension, increased serum lipid concentrations, accelerated progression of atherosclerosis, increased prevalence of cardiac arrhythmias, increased numbers of visits to emergency departments for cardiac conditions, increased risk of acute myocardial infarction, and increased mortality from cardiovascular disease and stroke. Recent work by Burnett et al. (2018) suggests that health impacts of $PM_{2.5}$ are more significant than previously understood and that exposure to $PM_{2.5}$ contributes to mortality from causes other than typically examined in global burden of disease studies (that is, LC, IHD, COPD, lower respiratory tract infections [LRI], and stroke). These findings underscore the need to prioritize actions to tackle AAP.

This chapter focuses on estimation of the health burden (that is, mortality) and cost of AAP ($PM_{2.5}$), based upon available information on population exposure, background health statistics, and economic data for BiH. In winter months, in addition to long-term mortality, air pollution is responsible for acute health effects, such as increases in cardiovascular and respiratory hospital stays, and lost workdays. However, these acute health effects are not estimated due to lack of background morbidity information at the time of this study.

2.2. Analytical Approach to Health Damage Estimation

In line with the EU strategy 'Clean Air for Europe' (CAFE) (CEC 2001) and the guidance of the European Environment Agency (EEA 2018), the problems of toxic emissions and their impacts on human health need to be addressed with an integrated approach. This approach includes estimation of the health burden of air pollution, valuation of attributable health burden, identification of responsible polluters, and prioritization of cost-efficient mitigating interventions. This report focuses on estimation of the cost of AAP using available information on population exposure, background health statistics, and economic data. Annexes B and C of this report provide additional details on the methodology used in this chapter.

Step 1. Estimate *population exposure* to the pollutant of interest (PM with diameter less than 2.5 µm [$PM_{2.5}$]) in terms of the number of people exposed and level(s) of concentration.

Step 2. Calculate the *health burden*, premature death (mortality) due to a disease, that may be *attributed to the pollutant* in question ('population attributable fraction' [PAF]) based on population exposure and relative risk that the pollutant presents for the occurrence of the disease, as per epidemiological studies.[7]

Step 3. Estimate the *economic value* of this health burden in monetary terms based on the welfare-based approach.

Through these steps, this study provides an assessment of the health cost of AAP in BiH. The analysis is conducted separately in the FBiH and in RS. Brčko District (BD), an autonomous district of BiH, has a population of approximately 83,500 (BiH Census 2013). Economic, demographic, and air pollution information on the district is not included in statistical yearbooks, and so lack of data at the time of the study prevented the inclusion of the cost of air pollution in BD in the total cost of air pollution for BiH.

As the 'Health risks of air pollution in Europe' (HRAPIE) (WHO/Europe 2013a, 2013b) advised for the use in Europe and based on the established methodology in the World Bank (World Bank and IHME 2016), this report estimates risk of long-term mortality associated with air pollution as PAFs of

1. Ischemic heart disease (population above 30 years of age);
2. Stroke (population above 30 years of age);
3. Lung cancer (population above 30 years of age);
4. Chronic obstructive pulmonary disease (population above 30 years of age); and
5. Lower respiratory tract infections (all ages).

This approach allows estimating age-specific mortality attributed to AAP for the most affected population groups. Risks associated with exposure to $PM_{2.5}$ are estimated using methods described in Burnett et al. (2014) that assume supra-linear and age-specific (for IHD and stroke) function of relative risk attributed to air pollution. Relative risk estimates for all five diseases in question are consistent with the Global Burden of Disease Study 2016 (GBD 2016 Disease and Injury Incidence and Prevalence Collaborators 2017).

2.3. Ambient Air Quality and Exposed Population in Bosnia and Herzegovina

Relatively few monitoring stations in BiH measure $PM_{2.5}$, but most measure PM_{10}. Thus, to estimate exposure to $PM_{2.5}$ pollution the share of $PM_{2.5}$ in PM_{10} applied is 0.7. It is a conservative estimate, since in Gorazde (the only station where measurements of both PM_{10} and $PM_{2.5}$ concentrations are available) this share is 0.8. The $PM_{2.5}$ exposure in the FBiH is estimated at 30 μg/m^3 (Table 2.1).

Table 0.1. Exposure to $PM_{2.5}$ pollution in the FBiH

Agglomeration	Average annual $PM_{2.5}$ concentration (μg/m^3)	Population (million, 2016)

[7] Relative risk is defined as the ratio of the probability of a health outcome, namely premature death (mortality) or disability from a disease, occurring in an exposed group to the probability of it occurring in a non-exposed group. PAF is defined as the reduction in population health outcome that would occur if exposure to the pollutant were reduced to an alternative ideal exposure scenario, such as pollutant concentrations below WHO limits. (Adapted from WHO definition at www.who.int/healthinfo/global_burden_disease/metrics_paf/en/ (accessed on 2/February 13, /2018).)

Zenica	38	0.40
Jajce	15	0.24
Sarajevo	25	0.44
Gorazde	33	0.28
Tuzla	50	0.48
Other	15[a]	0.46
Population-weighted average annual $PM_{2.5}$ concentration (µg/m^3)	30	

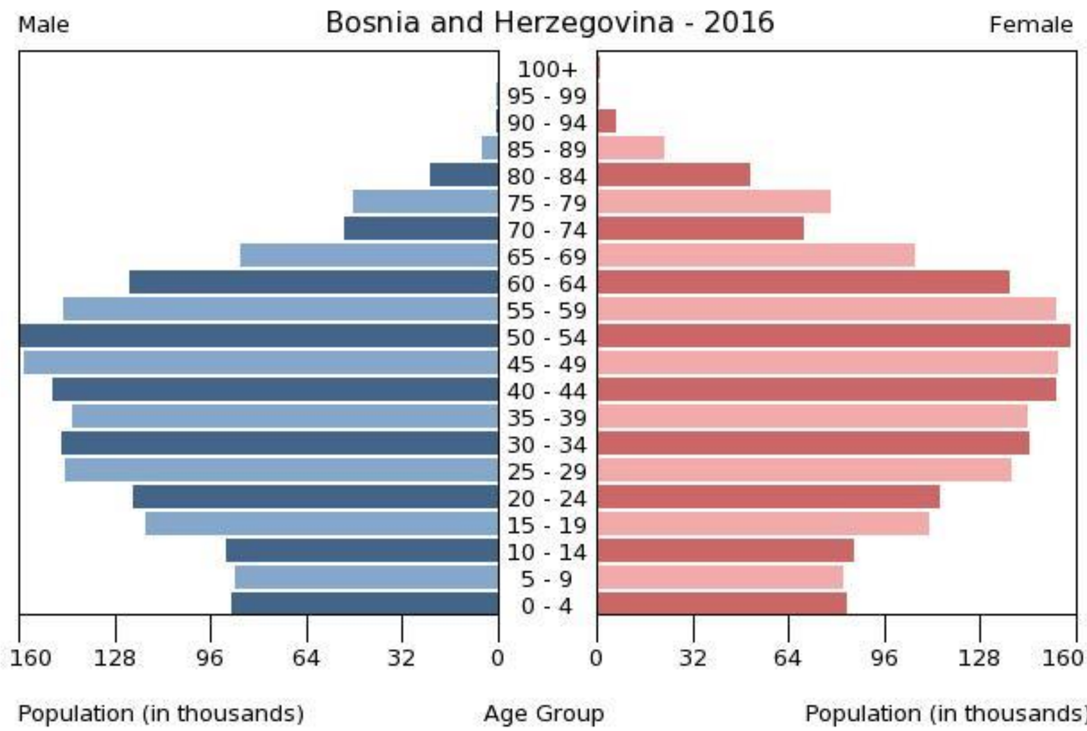
Source: Estimated by authors based on FHMI FBiH Air Quality 2017 Report (Bosnia 2018), and Institute for Statistics of FBiH 2016.
Note: a. Estimated based on Van Donkelaar et al. 2015.

It is assumed that the rural population of the FBiH is exposed to the estimated $PM_{2.5}$ pollution level (30µg/m^3), since most of the rural population areas are affected by pollution generated by residential boilers that use solid fuel for heating. $PM_{2.5}$ pollution is even higher in the winter, with average monthly $PM_{2.5}$ concentrations reaching 90–180 µg/m^3 in January 2017 for Tuzla (FBiH Air Quality in 2017 Report 2018, page 45).

In RS, the population-weighted average annual $PM_{2.5}$ concentration is estimated at 19 µg/m^3 (based on the 2016 report on air quality in RS). In Brod, where a refinery is located, the annual average $PM_{2.5}$ concentration reaches 33 µg/m^3. However, with the population of Brod below 10,000, it does not significantly affect the annual average $PM_{2.5}$ population-weighted concentration in RS.

The age structure of a society is relevant to health statistics, as older people are more likely to die as a result of pollution. Most European countries are aging rapidly. BiH has an age structure that is similar to other countries in Central and Eastern Europe (Figure 2.1).

Figure 0.1. Demographic age structure in BiH



Source: World Factbook of the U.S. Central Intelligence Agency 2016.

2.4. Health Burden of Exposure to Ambient Air Pollution in Bosnia and Herzegovina

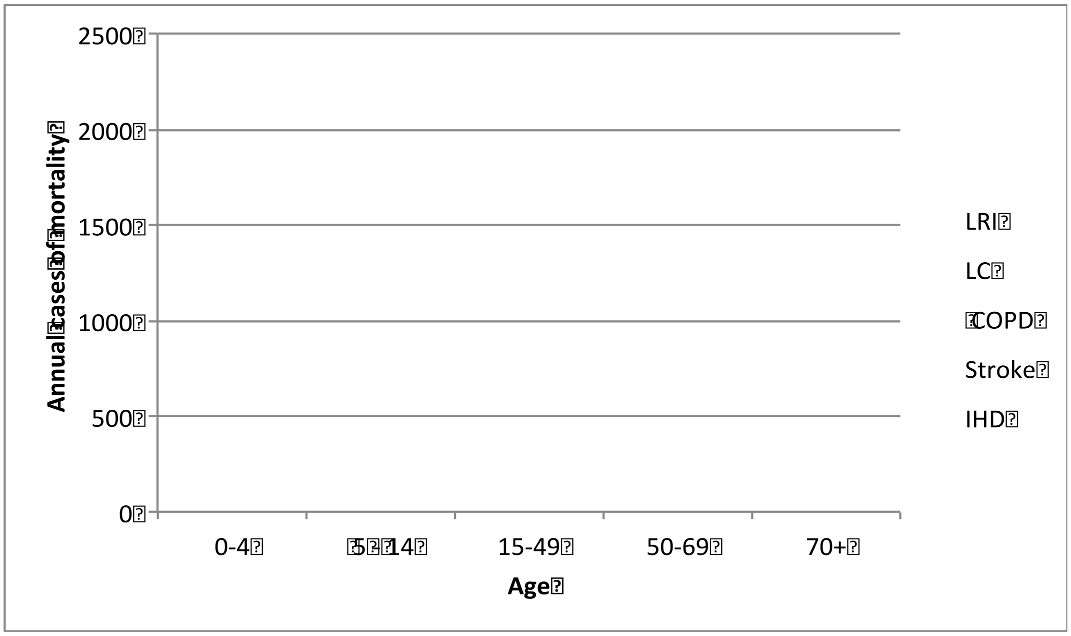
The health burden of exposure to AAP was estimated separately for the FBiH and for RS based on $PM_{2.5}$ population-weighted concentrations of 30 μg/m^3 and 19 μg/m^3, respectively. Economic, demographic, and air pollution information on BD is not included in the Statistical Yearbooks of BiH. Lack of access to data at the time of this study precluded estimation of the cost of air pollution in BD as part of the total cost of air pollution for BiH. The methodology used for estimation of health burden attributed to AAP is presented in Annex B.

The health burden attributable to AAP in BiH is estimated based on the Global Burden of Disease 2016 methodology. The shares of the diseases are estimated from Global Burden of Disease Study 2016 for the FBiH and for RS and applied to the total number of non-accidental deaths in the FBiH and in RS.

In total, about 3,300 people die every year from causes associated with AAP in BiH. This is more than double the AAP-related mortality in North Macedonia (1,600 deaths) and more than four times the AAP-related mortality in Kosovo (760 deaths). About 81 percent of the 3,300 AAP-related deaths in BiH are from cardiovascular diseases; 68 percent of IHD and 57 percent of strokes occur in people over 70 years of age. Cardiovascular diseases mostly affect people older than 65 years. Thus, this subgroup of the BiH population should be a focus of specific mitigation measures to reduce the health impact of air pollution in BiH. About 16 percent of the total health burden attributed to AAP occurs in Sarajevo and Banja Luka.

Figure 2.2 and Table 2.2 present the total annual mortality attributed to AAP in BiH in 2016.

Figure 0.2. Annual health burden attributed to air pollution in BiH



Source: Estimated by authors from GBD 2016.

Table 0.2. Annual mortality attributed to AAP in BiH

Age group	0–4	5–14	15–49	50–69	70+	Total
IHD	0	0	64	408	1,018	1,490
Stroke	0	0	30	454	653	1,137
COPD	0	0	4	62	189	254
LC	0	0	16	186	117	318
LRI	1	0	4	17	46	68
Total	1	0	117	1,127	2,022	3,267

Source: Estimated by authors.

2.5. Economic Cost of Exposure to Ambient Air Pollution in Bosnia and Herzegovina

In monetary terms, the economic burden associated with the health impacts of AAP is quantified using a welfare-based approach. The welfare-based cost of mortality is calculated by multiplying the estimated number of premature deaths by the value of a statistical life (VSL). The VSL represents an aggregate of individuals' willingness to pay (WTP) for marginal reductions in their mortality risks and thus estimates a welfare loss of the individual associated with a statistical case of mortality. The methodology used for mortality valuation is provided in Annex C.

The annual cost of mortality caused by AAP in BiH is in the range of US$1.0–1.8 billion (5.9–10.5 percent of gross domestic product [GDP] in 2016). On average, the economic cost associated with the health damage from AAP in BiH is US$1.38 billion, equivalent to 8.2 percent of GDP in 2016 (Table 2.3). The health cost of air pollution in the FBiH is 67 percent of the total, and in RS it is 33 percent of the total.

Table 0.3. Annual cost of AAP in BiH (US$, billions)

	Value	High	Low

FBiH	0.92	1.17	0.66
RS	0.47	0.60	0.34
BiH	1.39	1.77	1.00
% GDP in 2016	8.2	10.5	5.9

Source: Estimated by authors.

2.6. Conclusions and Recommendations

The health and economic burdens of poor ambient air quality in BiH are startlingly large with an estimated annual cost of mortality in the range of US$1.0–1.8 billion. Based on the estimated exposure, about 16 percent of the total health burden attributed to AAP occurs in Sarajevo and Banja Luka. This analysis shows that 9 percent of the total annual mortality in BiH can be attributed to air pollution. These health effects in productive ages of the workforce lead to reduced labor productivity.

Based on the findings of the analysis in this chapter, the following recommendations are provided.

Strengthening collection and reporting of health statistics associated with ambient air pollution:

Background mortality is crucial for economic analysis of AAP-related health burden. BiH, including the FBiH, RS, and BD, needs to prepare background health information aligned to the areas with elevated levels of reported/predicted annual PM pollution:

- Harmonize country reporting with the WHO requirements in the International Statistical Classification of Diseases and Related Health Problems 10th Revision (ICD X) and upcoming ICD XI.
- For mortality analysis, data collection and reporting should include mortality by individual disease or cause, attributable to AAP. This would enhance understanding and estimation of the health burden associated with air pollution and facilitate international comparisons using global databases such as the Global Burden of Disease.
- Completeness and comprehensiveness of morbidity data collected in the country could be strengthened to include morbidity related to specific diseases, age groups, and locations in the format appropriate for health risk analysis. As a minimum, the following data should be collected:
    - Bronchitis prevalence for children 6–12 years of age
    - Chronic bronchitis (COPD included) incidence for adults above 18 years of age
    - Hospital admissions cardiovascular
    - Hospital admissions respiratory
    - Lost workdays
- All the mortality and morbidity data should be area specific for urban or rural localities for which ambient air quality monitoring information is in place.

Health risk assessment:

- Develop capacity to conduct routine environmental health risk assessment to analyze the health effects associated with emissions from individual industrial facilities.

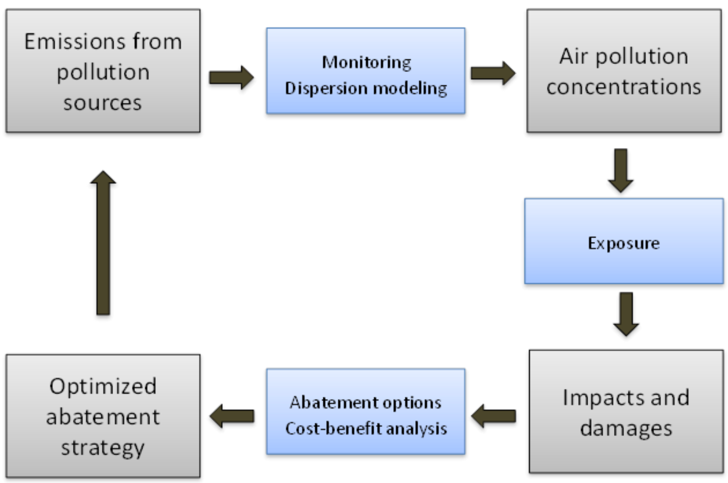
- The health risk assessment should be used to prioritize pollution control activities.

Chapter 3. Key Sources of $PM_{2.5}$ Exposure

3.1. Introduction

To effectively address air pollution, a comprehensive and integrated approach to AQM is needed. This approach embodies the concept of a continuous cycle of planning, implementing, evaluating, and adjusting abatement strategies and measures for continual improvements (Figure 3.1). The key elements of this approach include (a) understanding air pollution sources such as energy generation, traffic, households, industry, agriculture, and others; (b) understanding air quality; (c) understanding health impacts; and (d) optimizing the abatement strategy on the most economically effective interventions. This approach should also take into account existing policy and operational constraints that could foreclose or limit the implementation of certain air pollution reduction interventions.

Figure 0.1. Framework for Comprehensive Integrated AQM



Source: Awe et al. 2015.

This chapter addresses the following foundational pillars of the above framework:

(a) Understanding of air pollution sources which involves the identification of emission sources including their geographic location, by conducting a detailed inventory and analysis of emission sources, including stationary and non-stationary (fixed and area) sources. Emission inventories are needed both at a country level as well as at the local level where people are most exposed to air pollution and where AQM actions are taken. Emission inventories also provide a vital input for understanding the contributions of different polluting sources to ambient pollutant concentrations.

(b) Understanding ambient air quality, based on atmospheric modeling to determine ambient concentrations of air pollutants.

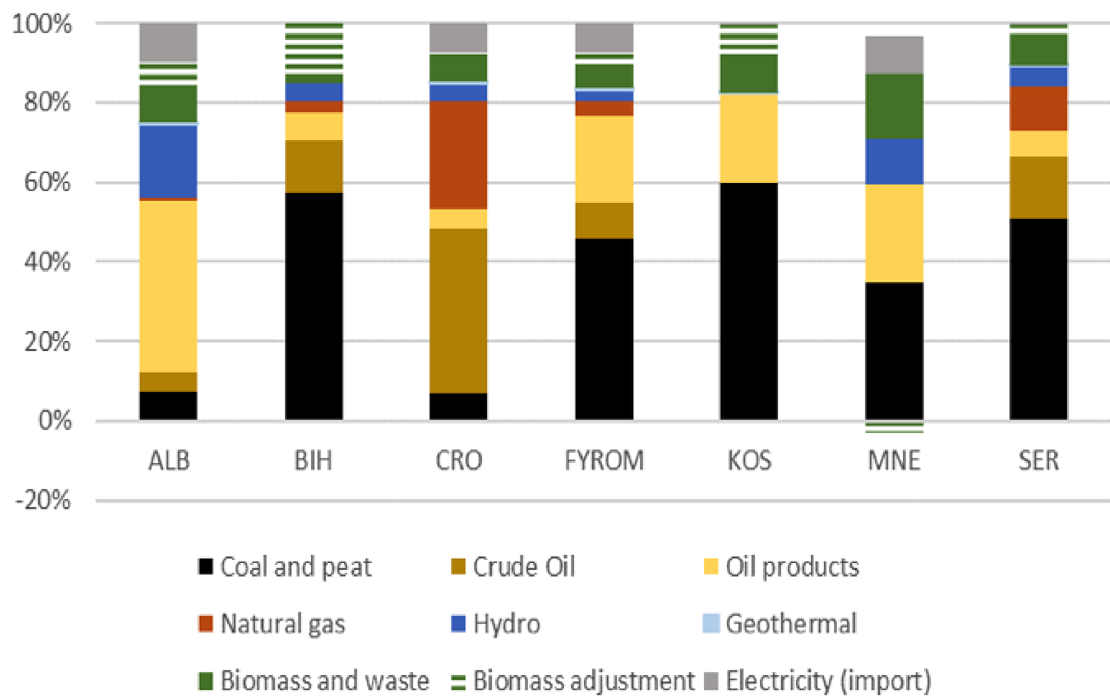
The following sections of this chapter first provide a qualitative description of AAP sources, primarily PM, in BiH. This is followed by a more quantitative analysis, using the GAINS model to better understand the emission source structure and key contributors to air pollution in BiH, by generating modeled $PM_{2.5}$ concentrations and developing future emission scenarios and a source apportionment for populations' exposure to ambient $PM_{2.5}$. The analysis and discussion in this chapter focus primarily on $PM_{2.5}$, the most documented pollutant for its detrimental effects on human health. Some precursors of $PM_{2.5}$ are also discussed.

3.2. Air Pollution Emission Sources in Bosnia and Herzegovina

There is currently no country-level emissions inventory for BiH. Sources of air pollution include residential heating and cooking with solid fuels, coal-fired power plants, industry, and aging vehicles, which are common in the Western Balkans subregion.

The use of wood for heating in households in the winter causes serious air quality problems in densely populated residential areas since many households in the country still use fuelwood as a primary source of heating. The primary energy supply profile for BiH indicates that coal and peat accounted for almost 60 percent of primary energy supply in 2012, followed by crude oil and biomass and waste accounting for less than 20 percent each, respectively (Figure 3.2) (World Bank 2017).

Figure 0.2. Primary energy supply of Western Balkan countries, adjusted for unregistered biomass consumption



Source: World Bank 2017.
Note: ALB = Albania; CRO = Croatia; FYROM= North Macedonia; KOS = Kosovo; MNE = Montenegro; SER = Serbia.

With respect to industrial sources, the FBIH Hydrometeorological Institute (FHI 2017) prepared an air emission inventory for industrial plants in the FBiH for 2016. Shortcomings of the inventory include lack of data verification mechanisms and incompleteness of data. Table 3.1 lists facilities with the highest PM_{10} emissions cited in the report. Major air pollution emitters include power generation, iron and steel, cement production, and chemical industries, most of which are located in Tuzlanski and Zeničko-dobojski cantons. In RS, emitting activities include power plants and coal mines in locations such as Ugljevik and

Gacko. It is thought that emissions from these heavy industries might contribute to local AAP and may also be transported to other parts of the country.

Table 0.1. List of major sources of PM emissions from industry in the FBiH

No	Company name	Facility name	Location	NACE code	NACE description
1	ArcelorMittal Zenica d.o.o.	Priprema rude i aglomeracija	ZDK	C24.1.0	Manufacture of basic iron and steel and of ferroalloys
2	JP EP BiH-TE Tuzla	Blok 4	TK	D35.1.1	Production of electricity
3	JP EP BiH-TE Tuzla	Blok 5	TK	D35.1.1	Production of electricity
4	ArcelorMittal Zenica d.o.o.	Energetika	ZDK	D35.3.0	Steam and air conditioning supply
5	JP EP BiH-TE Tuzla	Blok 6	TK	D35.1.1	Production of electricity
6	ArcelorMittal Zenica d.o.o.	Koksara	ZDK	C19.1.0	Manufacture of coke oven products
7	Sisecam Soda d.o.o. Lukavac	Sisecam Soda	TK	C20.1.3	Manufacture of other inorganic basic chemicals
8	ArcelorMittal Zenica d.o.o.	Visoka peć	ZDK	C24.1.0	Manufacture of basic iron and steel and of ferroalloys
9	Natron-Hayat d.o.o. Maglaj	Natron-Hayat	ZDK	C17.1.2	Manufacture of paper and paperboard
10	JP EP BiH -TE Tuzla	Blok 3	TK	D35.1.1	Production of electricity
11	Hercegovačka pivovara d.o.o. Mostar	Pivovara			
12	JP EP BiH, TE Kakanj	Blok 7	ZDK	D35.1.1	Production of electricity
13	Fabrika cementa Lukavac d.d.	Proizvodnja cementa	Lukavac	C23.5.1	Manufacture of cement
14	B.S.I. d.o.o. Jajce	Proizvodnja i trgovina ferolegurama	SBK	C24.1.0	Manufacture of basic iron and steel and of ferroalloys
15	Tvornica opeke Sarajevo d.o.o.	Proizvodnja cigle i eksploatacija gline	KS	C23.3.2	Manufacture of bricks, tiles, and construction products, in baked clay
16	JP EP BiH, TE Kakanj	Blok 5	ZDK	D35.1.1	Production of electricity
17	Ingram d.d. Srebrenik	R.J: Fabrika kreča i hidratizara	TK	B8.1.1	Quarrying of ornamental and building stone, limestone, gypsum, chalk, and slate
18	JP EP BiH, TE Kakanj	Blok 6	ZDK	D35.1.1	Production of electricity
19	Tvornica cementa Kakanj d.d.	Tvornica cementa Kakanj d.d.	ZDK	C23.5.1	Manufacture of cement
20	SurTec-Eurosjaj d.o.o. Konjic	Proizvodnja hemikalija i zaštita metala	HNK	C25.6.1	Treatment and coating of metals

Source: Modified from emission inventory report of FBiH (FHI 2017).
Note: ZDK = Zeničko-dobojski kanton; TK = Tuzlanski kanton; SBK = Sredjnobosanski kanton; KS = Kanton Sarajevo; HN = Hercegovačko-neretvanski kanton.

In many countries, transport is typically a source of air pollution, notably in urban areas, often related to factors such as high intensity of traffic and partly because of old vehicles, which is linked to the vehicle emission control technology, and inadequate vehicle maintenance. In BiH, the average age of cars is 17 years, and about 70 percent of the cars operate on highly polluting diesel. Light duty vehicle standards are Euro 3 for used vehicles and Euro 5 for new vehicles. Although gasoline is lead free in the country, current standards for fuel quality allow high sulfur content up to 350 ppm for diesel and 150 ppm for gasoline compared to the 10 ppm limit required by EU legislation. At the same time, upgrades to the country's Brod oil refinery have enabled capacity to produce some diesel fuel to Euro 4 and Euro 5 standards and fuels that comply with EU legislation.

3.3. Analysis of Sources of $PM_{2.5}$ Exposure and Ambient Concentrations of $PM_{2.5}$

GAINS methodology. The development of any AQM plan, including economically effective interventions to address air pollution, requires a firm understanding of the contributions of various economic activities to ambient air quality. This study produced a country-level source apportionment that estimates the current contributions of key sectors (for example, power plants and industry, transport, residential combustion, agriculture) to ambient $PM_{2.5}$ concentrations. It is important to note that this analysis provides a country-level source apportionment and that additional analysis would be required to better understand source apportionment at the local level, including in hot spots.

The quantitative analyses in this chapter were performed using the GAINS model developed by the International Institute for Applied Systems Analysis (Box 3.1) (Amann et al. 2011). GAINS is used as part of the standard modeling framework for negotiations under the Convention on Long-range Transboundary Air Pollution and the EU.[8]

GAINS uses linear source-receptor coefficients to calculate ambient $PM_{2.5}$ concentrations from emissions of $PM_{2.5}$ and precursor gases (SO_2, NO_x, NH_3, NMVOC). These source-receptor coefficients are derived from full-year perturbation simulations of the EMEP Chemical Transport Model (Simpson et al. 2012), in which emissions from one source country and one pollutant are reduced by a given percentage. The response in simulated ambient concentrations is then used to define source-receptor coefficients from countries to grid concentrations at approximately 28 km resolution ($0.5^o \times 0.25^o$). For primary PM emissions from low-level sources (residential combustion, traffic), a downscaling is applied to 7 km resolution ($0.125^o \times 0.0625^o$) to reflect small-scale concentration gradients. For details see Kiesewetter et al. 2015a, 2015b.

To estimate contributions from individual source sectors to ambient $PM_{2.5}$, bottom-up calculated emissions from individual sectors are multiplied with the appropriate pollutant-specific transfer coefficients and then summed across pollutants. Population exposure is calculated from the overlay with gridded population (Gallego 2010) at the same resolution.

In this report, the GAINS model is used to (a) estimate baseline and future emission scenarios of $PM_{2.5}$, $PM_{2.5}$ precursor emissions (SO_2, NO_x, NMVOC, NH_3), and BC up to 2030; (b) estimate ambient $PM_{2.5}$ concentrations at the spatial resolution of 7 × 7 km, with the sectoral emission estimates of the GAINS model, computations of the EMEP atmospheric chemistry transport model of the long-range dispersion

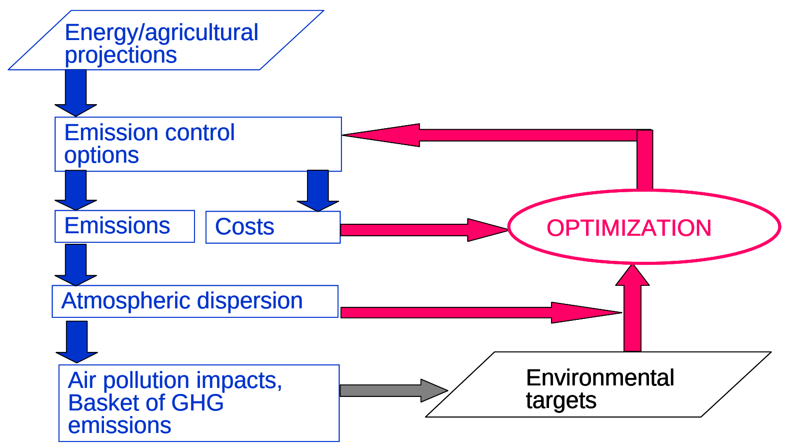
[8] Available at http://www.iiasa.ac.at/web/home/research/researchPrograms/air/GAINS.html.

of pollutants, and local information on the distribution of low-level emission sources, meteorology and topography (Kiesewetter et al. 2015b); and (c) extract the contributions made by each individual emission source to ambient $PM_{2.5}$ concentrations at a given receptor site based on the model calculations.

Box 0.1. The GAINS Model

The Greenhouse Gas-Air Pollution Interactions and Synergies (GAINS) model explores cost-effective multi-pollutant emission control strategies that meet environmental objectives on air quality impacts (on human health and ecosystems) and greenhouse gases. GAINS brings together data on economic development (including energy and agricultural projections that typically originate from external supply-demand models), the structure, control potential and costs of emission sources, the formation and dispersion of pollutants in the atmosphere, and an assessment of environmental impacts of pollution. The model allows simulation of the impacts of policy actions that influence future driving forces (for example, energy consumption, transport demand, agricultural activities), dedicated measures to reduce the release of emissions to the atmosphere, resulting air quality, and a basket of air quality and climate impact indicators. GAINS addresses air pollution impacts on human health from $PM_{2.5}$ and ground-level O_3, vegetation damage caused by ground-level O_3, the acidification of terrestrial and aquatic ecosystems, and excess nitrogen deposition to soils, in addition to the mitigation of greenhouse gas emissions.

GAINS assesses, for each of the source regions considered in the model, more than 1,000 measures to control emissions to the atmosphere. It computes the atmospheric dispersion of pollutants and analyzes the costs and environmental impacts of pollution control strategies. In its optimization mode, GAINS identifies the least-cost balance of emission control measures across pollutants, economic sectors, and countries that meet user-specified air quality and climate targets. The flow of information in the cost-effectiveness analysis of the GAINS model is illustrated below:



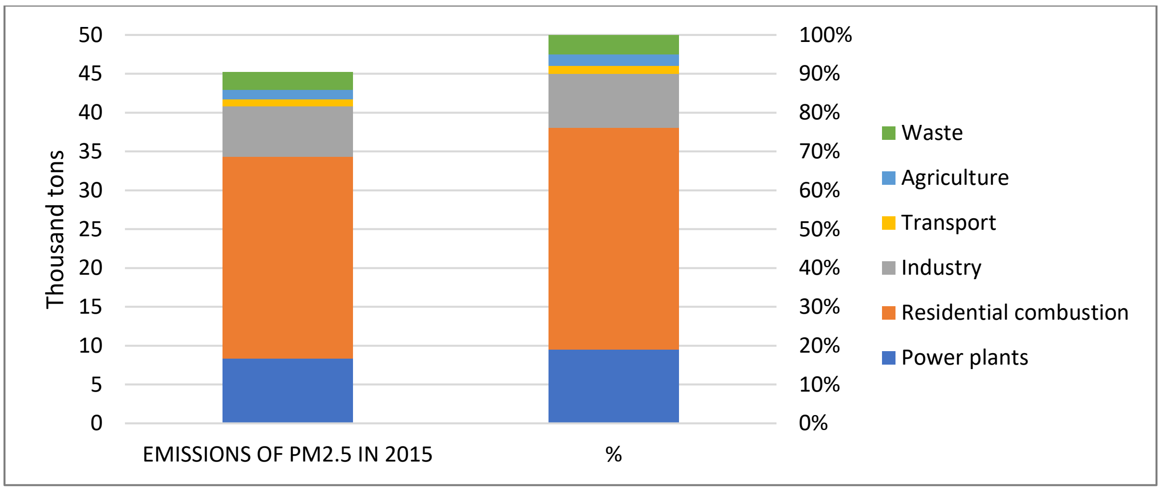
An essential element of the GAINS calculation is reliable information about activity statistics on fuel use, industrial production, fleet composition and distance travelled, and livestock numbers. GAINS draws on international and country statistical data on energy use, which provide this information for fossil fuel use and key economic sectors. However, in many countries as is the case in BiH, data for the residential sector, especially for household heating devices, are often of poor quality or suffer large uncertainties. This includes information about the use of noncommercial biomass (fuelwood), low-quality coal, and municipal waste, for which the real amounts are often unknown and/or not well reflected in country statistics. In addition, official statistical data often do not include information about the structure of fuel use in the residential sector, for example, allocated to heating stoves, manual boilers, automatic boilers, and pellet stoves.

Updated fuel use data by combustion technology were then used in the GAINS model to calculate emissions of primary PM ($PM_{2.5}$), particulate BC, and PM precursor emissions (SO_2, NO_x, NMVOC, NH_3). The resulting emission estimates were compared with available country inventories submitted to the Convention on Long Range Transboundary Air Pollution.

3.4. Annual $PM_{2.5}$ Emissions Estimates in Bosnia and Herzegovina in 2015

Modeled $PM_{2.5}$ emissions by sectoral contributions at the country level are illustrated in Figure 3.3. In 2015, total $PM_{2.5}$ emissions in BiH were estimated by GAINS to be about 45 kilotons, with residential combustion contributing almost 60 percent, power and heating plants contributing about 19 percent, and industry contributing about 14 percent. It is important to note that in the transport sector, addressing uncertainties related to vehicle age and imported used vehicles will help improve completeness and accuracy of transport emission inventories.

Figure 0.3. Annual emissions of $PM_{2.5}$ in BiH in 2015



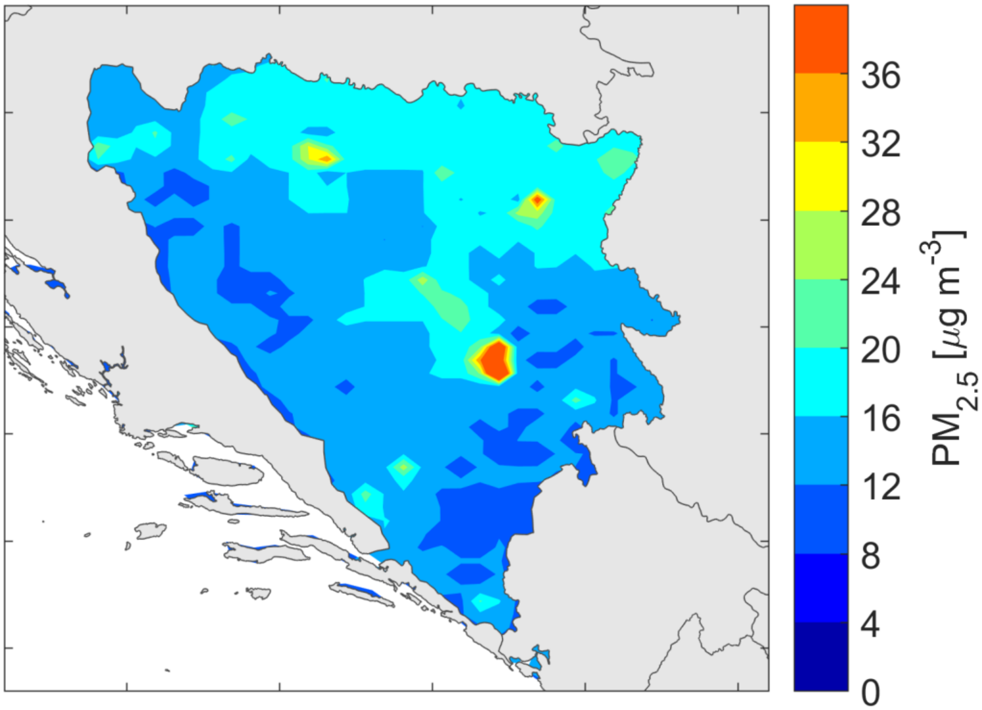
Source: GAINS Model 2018.

3.5. Ambient Concentrations of $PM_{2.5}$

As indicated previously, for this study, the GAINS model performs a country-level source apportionment. Understanding concentrations and sources at a local level will require further analysis not conducted within the scope of this study. As a starting point for the source apportionment, the analysis computed the spatial patterns of ambient concentrations of $PM_{2.5}$ in BiH for the baseline year 2015 (Figure 0.4) and compared them with available monitoring data.

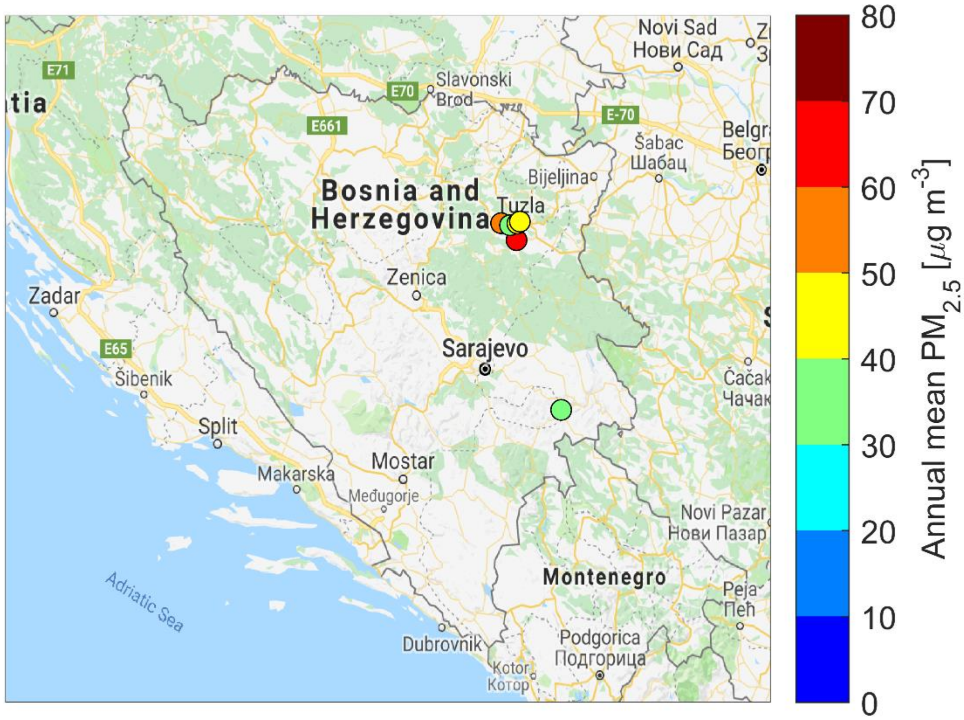
The model calculation (Figure 0.5) was found to be in reasonable agreement with observational data from stations in the country with a temporal coverage of at least 75 percent (Figure 0.5), thus providing a reasonable basis for subsequent source apportionment and scenario analyses.

Figure 0.4. Annual average $PM_{2.5}$ concentrations estimated for 2015 in BiH



Source: GAINS Model 2018.

Figure 0.5. Annual average $PM_{2.5}$ concentrations in 2017 for available stations in BiH



Source: BiH Measurement Network 2017.

3.6. Source Apportionment for Population Exposure to $PM_{2.5}$

The model calculations deliver estimates of concentrations of $PM_{2.5}$ in ambient air across the full model domain. By contrast, monitoring data are restricted to a few places of interest, often to locations of high population densities (urban areas) or with high pollution levels (for example, industrial areas). Although there may be overlaps between the full model domain and monitoring locations, the spatial distribution of population is not always identical to the distribution of pollution. Model results, combined with population data, can be used to compute the overall population exposure, which then provides important input for the development of economically effective policy interventions to reduce the harmful impacts of pollution. However, strategies targeted at improvements in total population exposure could be different from priority actions to alleviate concentrations in the most polluted locations.

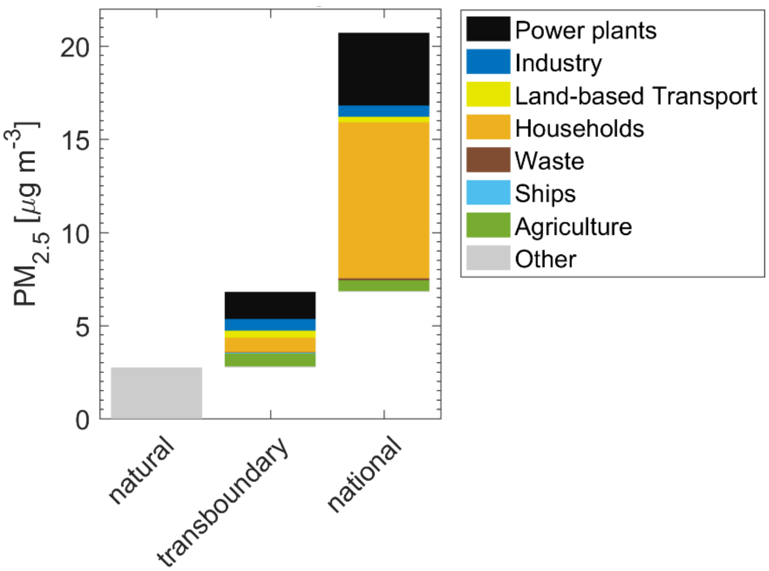
The calculations deliver estimates of concentrations of $PM_{2.5}$ in ambient air across the full model domain. In contrast, monitoring data are necessarily restricted to a few places of interest, often to locations of high population densities (urban areas) or with high pollution levels (for example, industrial areas). Such places could overlap, but in many cases the spatial distribution of population is different from the distribution of pollution. Model results, combined with population data, can be used to compute the overall population exposure in a region, which then provides important input for the development of cost-effective policy interventions to reduce the harmful impacts of pollution. Strategies targeted at improvements in total population exposure could be different from priority action to alleviate concentrations at the most polluted locations.

This country-level study provides model-based source apportionment analyses for population exposure, which integrate over the total population, both within the cities and in rural areas. Further analysis with more detailed information would be required to conduct reliable source apportionments for specific cities and locations.

As with North Macedonia and Kosovo, results of the source apportionment from the GAINS model show three notable features (Figure 3.6). The 'natural' contribution refers to natural sources such as soil, dust, forest fires, and sea salt.

- First, while there are pollution hot spots in all areas, even the population-weighted mean exposure to $PM_{2.5}$ exceeds the WHO guideline value for $PM_{2.5}$ by a factor of about 2 in BiH.
- The dominant share (about 65 percent) of $PM_{2.5}$ pollution originates from within the country, and only about 20 percent is imported from the neighboring countries. This is different from many countries in Europe, where the transboundary component causes the largest share (Kiesewetter and Amann 2014) but is significant.
- Third, the residential sector is by far the largest source for population-weighted $PM_{2.5}$ exposure.

Figure 0.6. Source apportionment for population-weighted annual mean concentrations of $PM_{2.5}$ in BiH for 2015



Source: GAINS Model 2018.

3.7. Future Emission Trends

Emission Scenarios

To explore the likely future evolution of emissions, air quality and population exposure to $PM_{2.5}$ in the region, as well as the scope for improvements through dedicated policy interventions, two emission scenarios have been developed. Both scenarios use the same assumptions about the future economic development and the evolution of pollution generating activities up to 2030. Future levels of energy use, industrial production, transport, and agricultural activities are based on the macroeconomic and energy projections of the World Energy Outlook 2017 developed by the International Energy Agency and on the projections developed for the European Commission with the PRIMES energy model and the Common Agricultural Policy Regional Impact Analysis (CAPRI) agricultural model, respectively.

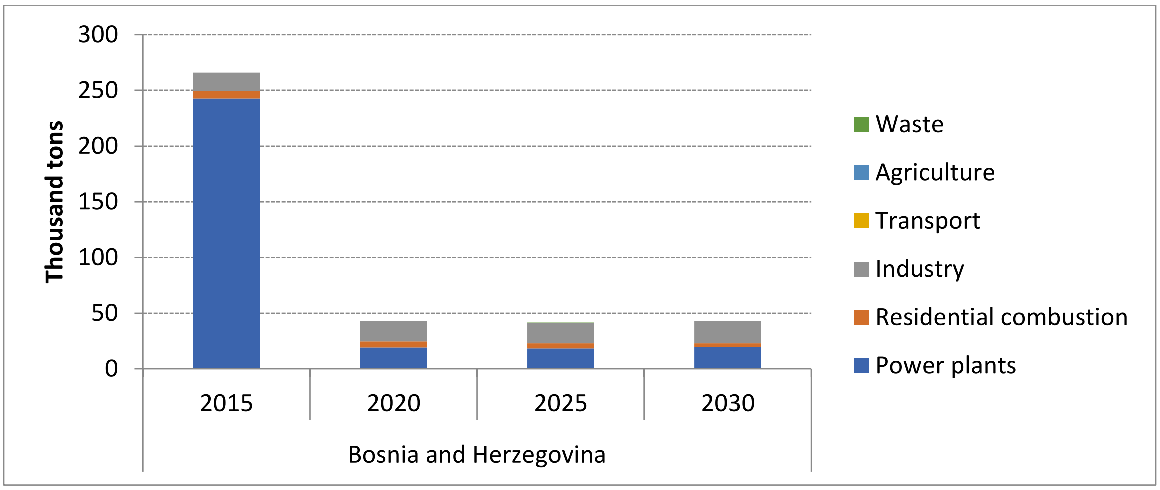
- The **baseline case** illustrates the likely development of emissions and air quality assuming compliance with the current environmental laws, considering both country and international legislation that is applicable to the countries. The key laws significantly affecting the trajectory of future emissions include the provisions of the Energy Community Treaty (Energy Community 2005), which requires compliance with the EU Large Combustion Plant Directive (EC 2001) by 2018, and the legislation for the transport sector, which are assumed to be introduced with a 10-year delay in comparison with the EU member states.

- The **maximum technically feasible reductions (MTFR) or maximum mitigation case** outlines the scope for emission reductions that could be achieved through immediate and full application of the best available technologies for all new equipment (to the technically feasible extent), as characterized in the GAINS model. However, this case does not consider the potential from changes in energy, agricultural, and transport policies, which would affect future levels of polluting activities.

Emissions in Baseline Case Scenario

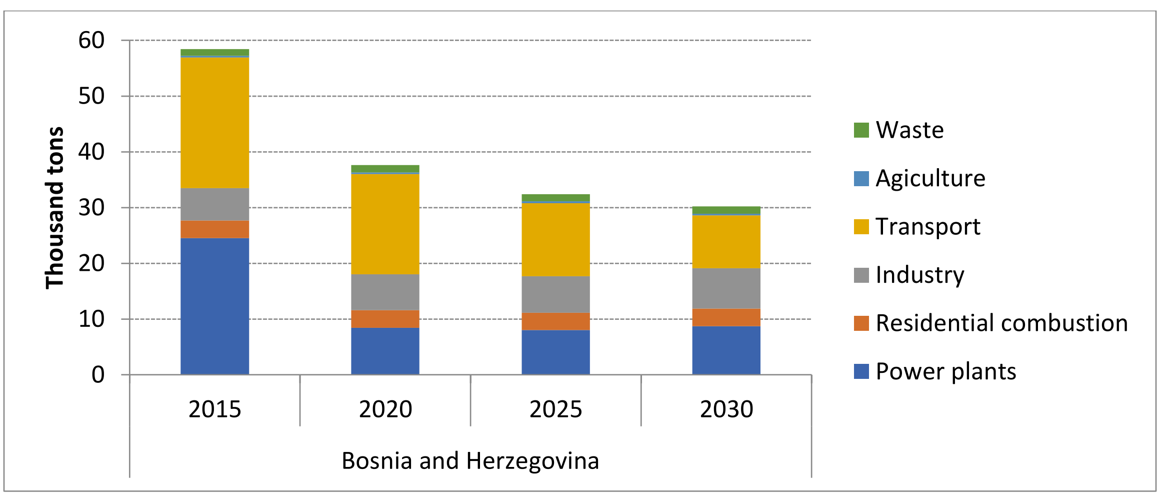
The emission trajectories for air pollutants, in the baseline scenario, are presented in the following figures. Existing environmental and air quality policies, if effectively enforced, are expected to deliver a strong decline in the emissions of SO_2 and NO_x (Figures 3.7 and 3.8), mainly due to EU legislation for large combustion plants and the emission standards for new vehicles. SO_2 emissions in the power sector will be cut by more than 90 percent, and NO_x emissions by almost 50 percent. At the same time, emissions of primary $PM_{2.5}$ are not likely to significantly change in the near term (Figure 3.9), as the underlying energy projections do not foresee major shifts away from fuelwood combustion in household stoves and boilers. Emissions of BC, NMVOC, and NH_3 are expected to remain at about the same level or could even increase (presented in Annex D).

Figure 0.7. Emissions of SO_2 in the baseline scenario



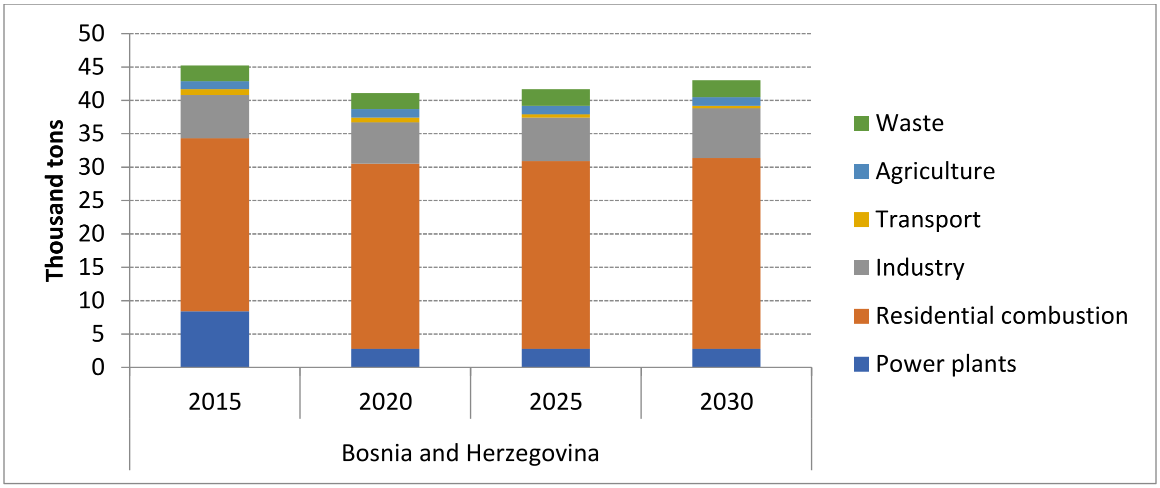
Source: GAINS Model 2018.

Figure 0.8. Emissions of NO_x in the baseline scenario



Source: GAINS Model 2018.

Figure 0.9. Emissions of $PM_{2.5}$ in the baseline scenario

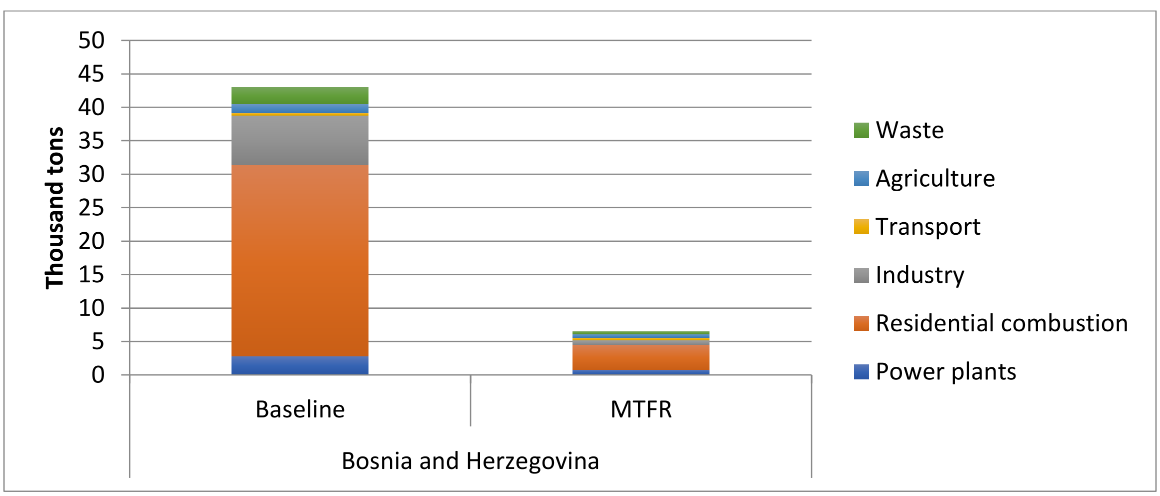


Source: GAINS Model 2018.

Emissions in Maximum Mitigation Case Scenario

For $PM_{2.5}$, the largest mitigation potential emerges in the residential combustion sector and in industry (Figure 3.10). Since these sectors make the largest contributions currently, the overall emission reduction potential for $PM_{2.5}$ is about 90 percent and similar for BC (Annex D). The measures that would lead to such emission reductions include, among others, (a) immediate compliance of all new household stoves and boilers burning fuelwood with the stringent standards of the Ecodesign Directive of the EU; (b) replacement of the oldest existing installations; (c) assurance of adequate quality of fuelwood (fuelwood shall be dry when burned), which implies proper storage of the wood; and (d) compliance of all new industrial installations with the EU Industrial Emissions Directive. In the absence of strong financial and governance mechanisms, such in-depth changes are unlikely to occur in the near future under the assumed projections of socioeconomic development, that is, population and economic growth.

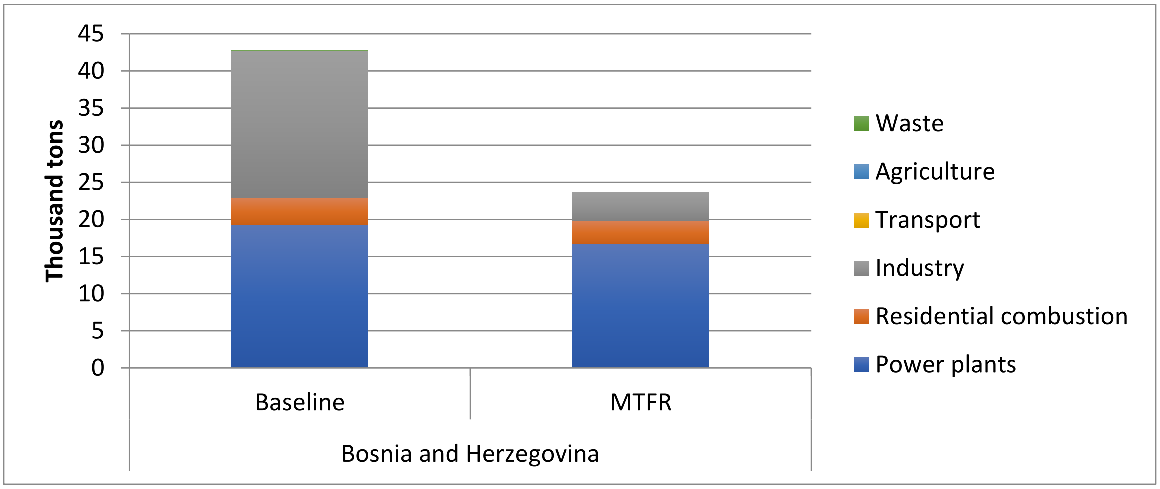
Figure 0.10. Emissions of $PM_{2.5}$ in 2030 for the baseline and MTFR scenarios



Source: GAINS Model 2018.

For SO_2, power plants and industrial emission contribute the dominating shares to country emissions. Owing to the commitments that are part of the Energy Community Treaty of which BiH is a member, emissions from the power sector are expected to decline sharply by 2030 in the baseline (Figure 3.11), which leaves the largest mitigation potential to the industrial sector.

Figure 0.11. Emissions of SO_2 in 2030 for the baseline and MTFR scenarios



Source: GAINS Model 2018.

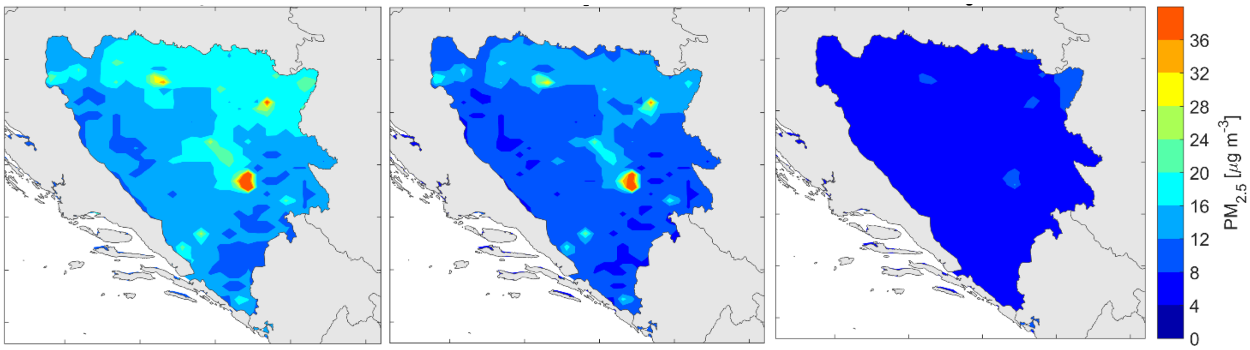
For BC and NMVOC, the largest reduction potentials beyond current legislation emerge in the residential sector (Annex D). In addition, solvent use (under industry) offers important opportunities for NMVOC reductions (for example, low solvent products or end-of-pipe measures such as incineration or recovery, which are widely applied within the EU).

NO_x emissions can be reduced by about 55 percent by 2030 compared to the baseline (Annex D) through best available technology standards involving, for example, selective catalytic or non-catalytic reduction in the power and industrial sectors, and Euro 6 equivalent standards for vehicles. In BiH, reductions in NH_3 emissions of about 40 percent could be achieved where measures such as reducing input of nitrogen into the system and optimizing the use of nitrogen-rich manures can help avoid losses to the atmosphere, depending on the structure of emission sources (for example, the importance of urea-based fertilizer application and share of cattle in total livestock).

3.8. Future Ambient Particulate Matter Concentrations

The envisaged future emissions discussed in the previous section will have significant impact on future air quality in the region. Currently, for most areas in BiH, the estimated levels of $PM_{2.5}$ concentrations are significantly above the WHO guideline value of 10 µg/m^3, with urban areas exceeding this value by a factor of almost 4 (Figure 3.12). Emission changes of the baseline scenario should lower concentrations in large regions of the country to levels close to the WHO guideline value. However, in urban areas, exceedances will remain high and violate the guideline value typically by a factor of about 3 because of the persistence of firewood use for heating. In contrast, it would be technically feasible through measures for the residential sector to bring most of the area, including many cities, below or slightly above the $PM_{2.5}$ guideline value, although full implementation of all measures may be challenging.

Figure 0.12. Ambient $PM_{2.5}$ concentrations in the BiH in 2015 (left panel), for the baseline scenario in 2030 (center panel), and the MTFR scenario in 2030 (right panel)



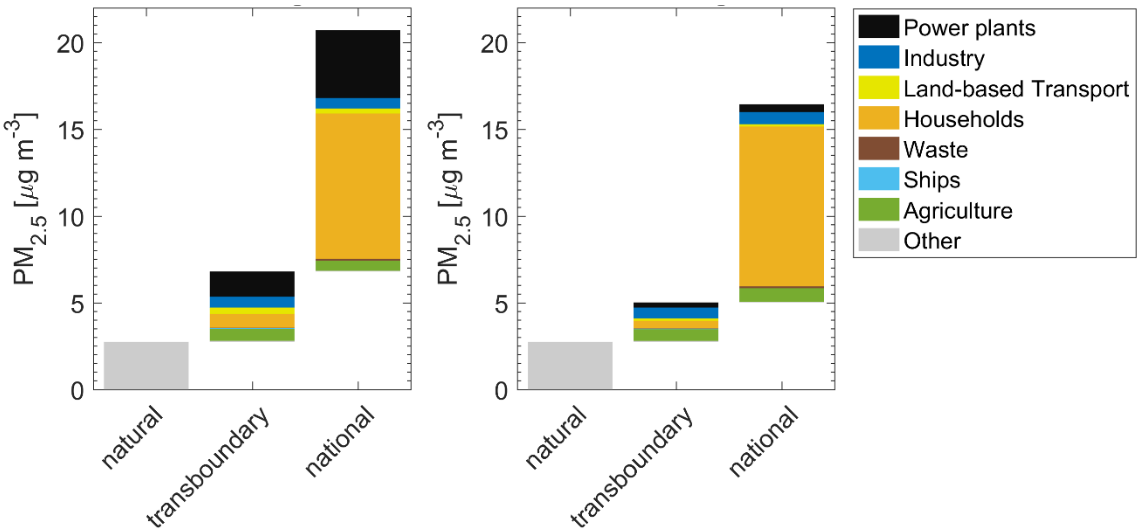
Source: GAINS Model 2018.

3.9. Future Source Apportionment

The expected declines in the emissions of the various sectors will not only have important impact on ambient $PM_{2.5}$ levels in the region but will also change the relevance of the remaining emission sources. In the baseline scenario, the emissions contributions from the power sector are strongly declining. By contrast, there will be only little changes in the emissions contributions of the residential sector, leaving considerable potential for further emission reductions by 2030.

Currently the domestic sector makes a large contribution to population exposure to $PM_{2.5}$ in BiH, but the impact of other sectors, in particular power generation, is also considerable (Figure 0.13). About 70 percent of the total population exposure to $PM_{2.5}$ originates from sources within the country. By 2030, current measures for large sources, if effectively implemented, will sharply reduce their impact on population exposure, both from within the country and from the inflow from neighboring countries. In the absence of dedicated policies, the contributions from the domestic sector will persist, so that overall population exposure is expected to decline by about 30 percent. At the same time, the potential for elimination of emissions from residential combustion sources will be still untapped in 2030. From a technical perspective, measures for this sector could reduce exposure by up to 70 percent compared to current levels. However, hot spots exist and will remain in the baseline case in 2030.

Figure 0.13. Source apportionment of population-weighted mean $PM_{2.5}$ concentrations in the BiH in 2015 (left panel) and for the baseline scenario in 2030 (right panel)



Source: GAINS Model 2018.

3.10. Conclusions and Key Recommendations

Summary of Conclusions

Several areas in BiH suffer from poor air quality, with concentrations significantly exceeding the global air quality guideline for $PM_{2.5}$ established by the WHO and the air quality limit values for PM_{10} and $PM_{2.5}$ of the EU. Especially in the winter, urban areas face severe smog episodes, caused by the increased demand for heat from the residential and commercial sectors, which is mainly covered by fuelwood.

As the first study analyzing the source structure of $PM_{2.5}$ precursor emissions in this region (Western Balkans) in a harmonized way, it compares modeled $PM_{2.5}$ concentrations with recent observations from local measurement networks and develops source apportionments for ambient $PM_{2.5}$ for all considered countries. It explores the future trends in emissions and air quality and identifies measures that could effectively improve the situation.

Source apportionments that quantify the contributions of key sectors to ambient $PM_{2.5}$ concentrations have been developed. The results show that (a) the population-weighted mean exposures to $PM_{2.5}$ exceed the WHO guideline value for $PM_{2.5}$ by a factor of about 2; (b) most $PM_{2.5}$ pollution originates from within the country, and not from other countries; and (c) the residential sector is clearly the largest source for population-weighted $PM_{2.5}$ exposure in the country.

If effectively enforced, existing environmental and air quality policies are expected to deliver a strong decline in the emissions of SO_2 and NO_x but will not have major impacts on primary $PM_{2.5}$ emissions, as the current energy projections do not foresee major shifts away from fuelwood combustion in household stoves and boilers. While these policies should lower concentrations in large parts of the country to levels close to the WHO guideline value, concentrations in urban areas will remain high and exceed the guideline value and in hot spots may exceed the guidelines by up to a factor of 3, mainly due to the persistence of firewood for heating.

The expected declines in baseline emissions of the various sectors will not only have important impact on ambient $PM_{2.5}$ levels in the region but will also change the relevance of the remaining emission sources to population-weighted exposure to $PM_{2.5}$. Notably, since the contributions from the power sector will decline significantly, the residential sector will remain the dominant PM emission source.

While it would be technically feasible through measures in the residential sector to bring ambient $PM_{2.5}$ concentrations in most of the country, including cities below or slightly above the $PM_{2.5}$ guideline value, full implementation of all measures will be challenging. Relevant measures would require (a) immediate compliance of all new household stoves and boilers burning fuelwood with the stringent standards of the Ecodesign Directive of the EU, (b) replacement of the oldest existing installations, and (c) assurance of adequate quality of fuelwood, by burning of only dry fuelwood and proper storage of fuelwood. Such changes would require strong financial and governance mechanisms for their realization.

Key Recommendations

Based on the analysis of the emission inventories, current and potential future ambient $PM_{2.5}$ concentrations, and source apportionments, the following are recommendations for improving AQM in BiH:

- **Develop comprehensive and accurate emissions inventory, prioritizing the residential sector.** There is a need to achieve full coverage of all emission source sectors, with emphasis on the residential sector. Furthermore, there is a need to validate data from transport and industry sectors. Measures should be taken including advancing the use of Tier 2 methods for key sources to capture the local peculiarities and technical features of the most important emission sources and to uncover opportunities for emission reductions.
- **Strengthen temporal coverage of air quality monitoring.** Due to the serious impacts of winter pollution episodes on air quality, attention should be given to improving the air quality monitoring system to achieve acceptable temporal coverage and quality control of air quality monitoring, with special emphasis on the winter period and areas with high population exposure to pollution.
- **Fill information and data gaps on fuelwood use and technology of combustion devices.** Given the impact of fuelwood combustion on air quality in the country, there is an urgent need to (a) improve statistical information on the use of fuelwood in the country, including from noncommercial sources; (b) analyze the typical quality of fuelwood used in the country; (c) assess the types of stoves and boilers used in the country and the options to reduce emissions from improved use practices; and (d) inform households on low-emission operation of fuelwood stoves and boilers, through public awareness campaigns.
- **Strengthen incentives and legislation to address emissions from stationary and mobile sources.** It is essential that BiH enforces full compliance with its current emission control legislation for stationary and mobile sources. Furthermore, to harness the potential for further emission reductions in the residential sector, the country could (a) put in place financial incentives and mechanisms to accelerate the replacement of old stoves and boilers and (b) expedite adoption of the EU’s Ecodesign standards for small combustion devices in the household sector.

- **Promote regional coordination on transboundary air quality issues.** The analysis in this report shows that while the dominant share (about 65 percent) of $PM_{2.5}$ pollution originates within the country, there is also an important share (about 20 percent) imported from neighboring countries. To maximize the synergies between similar or shared problems, BiH could consider setting up, together with neighboring Balkan countries, a Balkan Knowledge Platform on transboundary air pollution. The knowledge platform could begin with coordination and knowledge sharing on technical aspects related to transboundary air pollution and gradually broaden the scope to collaboration on measures to address transboundary pollution based on experience and knowledge gained through interaction on the platform.

Chapter 4. Air Quality Management Institutions

4.1. Introduction

The institutional and policy framework for AQM in BiH is characterized by fragmentation and the existence of different legal and planning instruments in each jurisdiction.[9] Environmental legislation was highly harmonized across the FBiH, RS, and BD in the early 2000s, when each of the jurisdictions had adopted similar packages of environmental laws. The legal frameworks have since diverged, leading to duplication of administrative structures and inherent inefficiencies. As a result, the country has three separate legal frameworks, organizational structures, and air quality networks.

There is currently no country-level environmental protection law. Instead, each jurisdiction has its own set of environmental and air quality laws. The EU acquis provides the main guidance for potential harmonization efforts, given that the three jurisdictions aim to fully transpose it to their legislation. While important measures have been implemented to improve AQM, further efforts are needed to meet key obligations and requirements under the EU accession process. Under the EU's Industrial Emissions Directive, for instance, the country must reduce emissions by 90 percent for SO_2, 67 percent for NO_x, and 94 percent of airborne particulates by 2028 for potential accession to the EU.

The country's constitution does not provide for the establishment of a country-level environmental protection ministry or agency. At the country level, environmental issues, and activities related to international cooperation and treaties on environmental issues, fall under the responsibilities of the Ministry of Foreign Trade and Economic Relations (MOFTER), and specifically as part of the duties of the ministry's Sector for Water Resources, Tourism, and Environmental Protection. The ministry's formal responsibilities include defining basic principles for environmental management (for example, the 'polluter pays' principle or the precautionary principle), coordination with other sectors and levels of government, and facilitation of efforts to harmonize environmental policy and legislation. However, the ministry's role is constrained by the division of powers established in the Constitution, which assigns primary responsibility for environmental issues to the constitutional entities: the FBiH, RS, and BD. In addition, there is no formal mechanism to address diverging positions between the constitutional entities, which raises questions in terms of what the ministry can actually do when those positions are mutually exclusive.

An Inter-Entity Coordination Body for the Environment was established in 2006 to help develop a harmonized approach for environmental protection among the FBiH, RS, and BD. However, its decisions are not legally binding, and the body does not engage the public in its activities.

Significant challenges remain in terms of bringing down AAP levels. Pollution levels in BiH frequently exceed the guidelines developed by the WHO and the EU's air quality standards, especially in urban areas, and the country has one of the highest mortality rates associated with air pollution in Europe. In the absence of targeted interventions, air pollution could continue to worsen as a result of increasing motorization and proposals to develop new lignite-based power plants.

Some actions that BiH should take in the short to medium term include the following:

[9] The two constitutional entities, that is, the FBiH and RS each with its own constitution, as well as the self-governing BD.

- Fully develop the legal and policy framework related to AAP, with a view toward harmonizing the legal and institutional framework for AQM and environmental management, in general.
- Strengthen MOFTER and the Inter-Entity Coordination Body for the Environment to facilitate harmonization of legal, policy, and organizational frameworks.
- Strengthen agencies with responsibilities for AQM at the FBiH, RS, and BD levels (including expansion of inspectors for enforcement) and provide adequate resources.
- Strengthen the air quality monitoring network focusing on pollutants such as $PM_{2.5}$, SO_2, NO_x, lead, and other toxic substances.
- Develop an air quality index (AQI) to disseminate understandable and easily accessible information on air quality to the public and facilitate issuance of health-related air quality alerts.

This chapter provides an overview of BiH's AQM institutions and policies. It does not provide an exhaustive assessment of the effectiveness and efficiency of the institutional and policy frameworks for AQM. While the merits of such an assessment are recognized, it would entail the additional use of surveys, focus groups, stakeholder analyses, interviews, and other tools, at various levels of government and stakeholder groups, beyond the scope of this study. The first section briefly introduces the existing legal framework on AQM across the jurisdictions. The following sections describe the organizational structure including existing coordination of responsibilities for AQM. Subsequent sections focus on BiH's capacity to monitor AAP and stationary sources and public disclosure of air quality-related information. In addition, the chapter identifies areas for strengthening enforcement of air quality policies. Some recent and ongoing activities of international development partners in supporting BiH's efforts to improve AQM are presented. Finally, the chapter presents recommendations for strengthening the institutional and policy framework for AQM in BiH.

4.2. Air Quality Regulatory Framework

The Constitution of BiH explicitly recognizes the competence of the state government over a limited number of policy areas, including foreign policy, customs, and monetary policy. All other policy matters, including environmental policy, fall under the responsibility of the constitutional entities of the FBiH and RS, which have significant autonomy, in addition to BD. Each of the jurisdictions in BiH has its own legislative, executive, and judiciary branches. They also have distinct institutional and organizational frameworks for AQM, as well as different technical capabilities and resources. Although the legal frameworks of these three jurisdictions were similar in the early 2000s, they have increasingly diverged.

EU Approximation Process

While each jurisdiction has used the EU approximation process to guide the development of their legislation, there are evident differences in areas such as the type and duration of air quality planning instruments contemplated in each legislation. There has been considerable progress in transposing EU legislation to country legislation; however, some key EU legislations related to air quality have either not been fully transposed or not transposed at all to country legislation (Belis, Paradiž, Knezević 2017):

- Directive on ambient air quality and cleaner air for Europe (2008/50/EC) and Directive relating to arsenic, cadmium, mercury, nickel, and polycyclic aromatic hydrocarbons in ambient air

(2004/107/EC). In the FBiH, RS, and BD, the limit and target values have been harmonized with those defined by the directives. However, the deadlines for meeting those values have been postponed to various dates ranging between 2018 and 2024, depending on the pollutant and the jurisdiction.

- National Emissions Ceilings Directive (2016/2284/EU)—not yet transposed.
- Directive on Sulphur Content of Liquid Fuels (1999/32/EC)—not fully transposed
- Directive on the control of Volatile Organic Compound emissions resulting from storage of petrol and its distribution from terminals to service stations (94/63/EC)—not yet transposed.
- Directive on Stage II petrol vapor recovery during refueling of motor vehicles at service stations (2009/126/EC)—not yet transposed.
- Directive on Industrial Emissions for New Plants (2010/75/EU). Emission limit values on industrial emissions for new plants have not yet been transposed (UNECE 2017).

Failure to transpose the EU legislation has already caused some conflicts for BiH. In February 2013, the Secretariat of the Ministerial Meeting to the Energy Community[10] initiated dispute settlement procedures against BiH based on the country's failure to transpose Directive (1999/32/EC), which bans the use of heavy fuel oils with a sulfur content of more than 1.0 percent by mass and of gas oils with a sulfur content above 0.1 percent by mass. In its response, BiH explained that the relevant legislation had been transposed in the FBiH and BD but not in RS, because the single domestic producer of these fuels could not meet European requirements and an exception was needed to ensure a reliable supply of such fuels (Secretariat of the Energy Community 2016). Given that countries are required to ensure that the transposition of EU acquis is implemented in their entire territory, the Ministerial Council of the Energy Community adopted a decision in October 2016 establishing that BiH was in breach of the Energy Community Law. Subsequently, in October 2017, the Secretariat to the Ministerial Council considered that BiH had failed to take actions to correct the situation and requested the Ministerial Council to declare its breach of law as serious and persistent (Secretariat of the Energy Community 2017).

In the past, aspirations of accession to the EU, coupled with EU financial support, have provided the Government of BiH with the impetus to consolidate the institutional framework in a number of areas, including AQM. However, the government has been unable to meet the requirements for continued EU support, partly because the country's intricate governance structure demands comparatively more time and efforts to introduce and implement legal and policy measures. For instance, funding from the Instrument for Pre-Accession Assistance to BiH was discontinued in 2012 because the country had failed to adopt an Environmental Approximation Strategy (EAS) describing the actual status and required changes in the legal framework for transposition of the EU environmental acquis, including on air quality. It was only in May 2017 that the EAS was approved. The EAS is supplemented by environmental approximation programs from the FBiH, RS, and BD (UNECE 2017).

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[10] The Energy Community is an international organization that brings together the EU and its neighbors to create an integrated pan-European energy market. https://www.energy-community.org/aboutus/whoweare.html.

The FBiH has an extensive legal and policy framework for AQM in the country. The Law on Air Protection of the FBiH (LAP-FBiH) was adopted in 2003 and amended in 2010. It gives the Ministry of Environment and Tourism of the FBiH (FMOIT) the responsibility for developing a FBIH Strategy for Air Protection for at least 10 years, which must be enacted in regulations by the Parliament of the FBiH. Currently, the Government of the FBiH is implementing the FBiH Strategy for Environmental Protection 2008–2018, which includes the Strategy for Air Protection (FBiH 2010). Several instruments complementary to the LAP-FBiH have been developed (see Table 4.1).

Table 0.1. Development of an air quality regulatory framework in the FBiH

Law, strategy, plan, or standard	Requirement
LAP-FBiH	Amended in 2010 and provides the backbone of the legal framework for environmental protection and includes detailed provisions to control emissions from stationary sources.
LAP-FBiH complementary instruments	
Regulation on the Method of Air Quality Monitoring and Defining the Type of Awareness Materials, Cross-Border Values and Other Air Quality Standards (O.G. FBiH No. 1/12)	Sets air quality limit values and air quality standards. Air quality standards in the FBiH reflect the transposition of EU Directive 2008/50/EC. The FBiH established 2016 as a deadline to reach the EU air quality standards for carbon monoxide (CO), lead (Pb), and benzene and 2021 for SO_2, NO_2, PM_{10}, and $PM_{2.5}$. The 2016 targets for CO were met, but those for benzene were exceeded in the vicinity of coke plants.
Regulation on Air Quality Monitoring (O.G. FBiH No. 12/05)	Sets air quality limit values and targets for planning and defines information and alarm thresholds for timely action in case of short-term occurrences of high pollution concentrations for SO_2, NO_2, NO_x, PM_{10}, total suspended particles (TSP), smoke O_3, CO, Pb, cadmium (Cd), and zinc (Zn).
Regulation on Monitoring the Emission of Pollutants into the Air (O.G. FBiH No. 9/14)	Establishes the obligations of operators to carry out the verification or monitoring of pollutant emissions from stationary sources of pollution and defines the sources that are subject to these requirements, as well as the methodologies that must be used.
Regulation on Conditions for Operation of Incineration Plants (O.G. FBiH No. 12/05) Regulation on Amendments to the Ordinance on Conditions for the Operation of Waste Incineration Plants (O.G FBiH No. 102/12)	Regulates the working conditions and measures for regulating air, ground, surface, and groundwater emissions and human health risks from incineration and incineration plants. Does not apply to plants handling plant waste, wood waste, radioactive waste, animal wastes, waste from petroleum exploitation, and installations with a capacity of less than 50 tons per year.
Regulation on Limit Values for Air Emissions from Combustion Plants (O.G. FBiH No. 12/05)	Sets the emission limit values for air pollutant emissions from combustion plants.
Regulation on the Emission of Volatile Organic Compounds (O.G. FBiH No. 12/05)	Regulates the measures and procedures for preventing or reducing the direct or indirect effects of emissions of volatile organic compounds into the environment. All plants using organic solvents must comply with emission limit values for waste gases and emission values.
Regulation on the Conditions for Measurement and Control of Sulfur Content in Fuel (O.G. FBiH No. 6/08)	Establishes the requirements for measurement and control of sulfur content in liquid petroleum fuels and for defining the measuring methods and way of checking the quality of measurements and related data.
Regulation on Types of Fees and Criteria for Fee Compensation for Air Pollutants (O.G. FBiH No. 66/11)	Establishes fees that are applicable to technological processes, industrial plants, and installations that emit SO_2, NO_2, and solid particles (dust) into the air. Fees are applicable to all legal bodies

Law, strategy, plan, or standard	Requirement
	that cause air pollution and are calculated based on the emissions' type, quantity, and characteristics
Regulation on Special Environmental Remedies (O.G. BiH No. 26/11)	Establishes the special environmental fees to be paid when registering motor vehicles. A correction coefficient was introduced in April 2013 with the aim of establishing a stronger link between the environmental damage caused by the vehicle and the paid fee.

Note: O.G. = Official Gazette.

Table 0.2. Comparison of air quality standards between the EU, FBiH, and WHO (µg/m³)

Pollutant	Averaging Time	EU air quality standards	FBiH	WHO air quality guidelines
$PM_{2.5}$	Annual mean	25	20	10
	24-hour mean	n.a.	n.a.	25
PM_{10}	Annual mean	40	40	20
	24-hour mean	50	50	50
NO_2	Annual mean	40	40	40
	1-hour mean	200	200	200
O_3	8-hour mean	120	120	100
SO_2	24-hour mean	125	125	20
	1-hour mean	350	350	500 (10-minute mean)
CO	8-hour mean	10	10	10
	1-hour mean			30
Lead	Annual mean	0.5	0.5	0.5
Benzene	Annual mean	5	5	n.a.

Source: Based on EU 2008; GSR 2012; WHO 2006.

At the FBiH canton level, cantonal assemblies are mandated to develop corresponding AQPs for at least five years, which must be harmonized with the Federal Strategy for Air Protection. To date, only Sarajevo canton (Box 4.1) and Una-Sana canton have adopted AQPs.

An Environmental Performance Review (conducted by the United Nations Economic Commission for Europe, 2017) notes among the shortcomings of the FBiH's existing legal framework that the regulation of emission ceilings and emission registries has not been fully executed, and there is no specific law on environmental inspections. In addition, only Central Bosnia, Sarajevo, and Tuzla cantons have adopted laws on air protection or quality, while the existing legislation is not yet harmonized vertically between the Federation and cantonal levels.

Environmental fees. The Regulation on Types of Fees and Criteria for Fee Compensation for Air Pollutants establishes fees that are applicable to technological processes, industrial plants, and installations that emit SO_2, NO_2, and solid particles (dust) into the air. Fees are applicable to all legal bodies that cause air pollution and are calculated based on the emissions' type, quantity, and characteristics. The fee that each operator of a large emission source is required to pay is calculated based on the report that the same operator submits annually with the results of continuous monitoring at the point of emissions and certifications from laboratories accredited by a state Institute. For small polluters, a computing procedure fixed by law is used instead of requiring data from a continuous monitoring. These fees were introduced in 2011 and have since not been adjusted.

The Regulation on Special Environmental Remedies establishes the special environmental fees to be paid when registering motor vehicles. A correction coefficient, aimed at establishing a link between the environmental damage caused by the vehicle and the fee, takes into account the engine type, fuel type, and vehicle age. However, this link, depending on the use of the vehicle, is still weak. For instance, the same fee applies to all vehicles that comply with Euro 3, 4, and 5 standards. In addition, a luxury tax that is charged on new vehicles might constitute an incentive to continue using older, more polluting vehicles.

The environmental fees collected based on the two regulations mentioned earlier, as well as all fines imposed for noncompliance with environmental regulations, are allocated to the cantons (about 70 percent) and to the Environmental Protection Fund (about 30 percent), in accordance with the Environmental Protection Strategy. The fund can allocate resources to a broad array of users, including authorities, bodies, and institutions of state administration and local government; public companies; businesses and other legal persons; civil society associations and organizations; agencies and chambers; employers' associations; and educational and research institutions, including schools and universities. To strengthen the effectiveness of the fund in addressing air pollution, project selection criteria that target activities that will have the most significant effect on reducing health impacts or the cost of environmental degradation due to air pollution could be incorporated.

Box 0.1. Sarajevo Cantonal Environmental Action Plan - AQM Measures

Sarajevo canton (SC) developed a Cantonal Environmental Action Plan (CEAP) for 2016–2021. With respect to air pollution, the CEAP has three strategic goals: (a) reducing SO_2 and dust emissions, (b) managing air quality, and (c) improving energy usage. Forty-five measures including policy actions, investments, studies, and institutional strengthening have been identified in the CEAP to achieve its specific operational objectives:

Reducing SO_2 and PM emissions from small fires: (a) a study of emission sources, (b) legislation to limit use of solid fuels, and (c) a strategy to restrict the use of solid fuels in Sarajevo basin.

Reducing air pollution from industrial plants: (a) implementation of a strategy to limit fuel use in SC, (b) increased inspection control of reporting obligations of plant operators and quality of reported emissions data, (c) training of inspectors to improve inspections, and (d) promotion of resource efficiency and cleaner production.

Reducing air pollution from traffic: (a) preparation of technical documentation for a project to reconstruct a tram line in SC; (b) preparation of technical documentation for a project to reconstruct trolley bus infrastructure on the Sarajevo-Vogosca line in SC; (c) implementation of measures from the Transport Strategy, including new concepts of public transport system in SC; and (d) creation of project technical documents for establishment of compressed natural gas (CNG) filling stations for public transport vehicles.

Reduction of emissions of black smoke particles: stricter implementation of the legal framework related to technical vehicle safety and emissions control of exhaust gases.

Air quality planning: (a) decision of the establishment of the air quality management center in SC; (b) development of a plan for establishment of the air quality management center; (c) procurement of equipment and execution of radio sensing measurements to examine the state of the atmosphere and inversion layer in Sarajevo basin area; (d) establishment of a public information system of the registry of pollutants and update of the database of polluters; (e) development of a base dispersion model and air quality zoning for spatial planning in SC; (f) integration of dispersion modeling in the existing GIS of the Department of Development Planning; and (g) development of a methodology for assessing impacts on air quality of new interventions; and (h) a study of the microclimate of the Sarajevo valley and high-impact analysis of the airspace.

Continuous monitoring of air quality: (a) maintenance of existing monitoring stations and measurement and reporting of pollution status of SC and (b) expansion of the monitoring network in SC, including procurement of five new stations.

Development and modernization of transport and traffic infrastructure with respect to environmental norms: (a) implementation of a project for renewal of the public transport fleet in SC; (b) conversion of vehicles—particularly buses for public transport, public enterprises, and institutions—to natural gas or biogas; (c) establishment of traffic control and regulatory center: introduction of Intelligent Transportation System and automatic traffic management in SC and project for automatic control of traffic lights in SC; (d) development of a road network development strategy in SC; (e) a study for establishment of a network grid for electronic vehicles in SC; and (f) training on eco-driving for fuel consumption savings. **Establishing continuous noise monitoring:** (a) a study on establishing cells for continuous noise monitoring; (b) acquisition and installation of noise monitoring stations and implementation of measurements; and (c) creation of baseline noise maps for SC. **Planning for improved energy usage:** (a) preparation of an energy development plan in SC until 2030, which addresses the existing energy conditions, energy recovery projects, and justification of potential use of thermal energy for heating SC from the Kakanj thermal power plant and environmental aspects of energy recovery in SC; (b) a study of central heating systems via block boiler rooms in SC; (c) a study on extension of district heating in Hrasnice region; (d) feasibility study on heating systems for apartments in Vogošća from the BAGS-Energetika heating plant; (e) strengthening the regulatory framework and institutional capacity on energy and environment topics; and (f) urgent adoption of the rules on conditions for performance of energy activities, production, and delivery of heat energy. **Increasing energy efficiency:** (a) development of energy efficiency in SC; (b) increasing of energy efficiency in residential buildings in SC covering approximately 200,000 m^2; (c) increasing of energy efficiency of public buildings, including schools, health centers, ambulances, and municipal buildings, in SC municipality that are heated by the Toplane Sarajevo plant system covering approximately 140,000 m^2; (d) enhancement of energy efficiency and reduction of polluting emissions from public buildings; (e) investments to increase energy efficiency in the Toplane Sarajevo plant system; (f) construction of central heating systems, based on community choice aggregation, including 16 MW and 21 MW boilers included in the regulatory plan for 'Alipašin Bridge VII'; and (g) a program to ensure that end users in public buildings in SC regularly enter energy consumption data into the energy management information system. **Promoting the use of renewable energy sources:** construction of a wood biomass plant in the Toplane Sarajevo plant.

Republika Srpska

The Law on Air Protection of RS (LAP-RS) is the backbone of the legal framework for AQM in RS. It establishes five air pollution policy and planning instruments and requires that regulations be developed in a number of areas, including for setting limits for air emissions, defining methodologies and criteria to measure pollutant emissions, and for fuel quality (see Table 4.3).

Table 0.3. Development of an air quality regulatory framework in RS

Law, strategy, plan, or standard	Requirement
LAP-RS	Establishes the pollutants that must be monitored to evaluate air quality (RS 2011).[11] Monitoring of air quality is the responsibility of the Republic and of local self-government units. In April 2017, the National Assembly of RS amended the LAP-RS to introduce two types of environmental fees to incentivize reductions in air pollution in RS, including for importers of substances that deplete the O_3 layer and motor vehicles.

[11] Pollutants that must be monitored include SO_2, nitrogen dioxide (NO_2), NOx, suspended particles (PM_{10}, $PM_{2.5}$), lead (Pb), benzene, CO, ground-level O_3, arsenic, cadmium (Cd), nickel, and (benzo) pyrene.

Law, strategy, plan, or standard	Requirement
Law on Meteorological and Hydrological Activities (O.G. of RS No. 20/2000)	Defines responsibilities of the Republic Hydro-Meteorological Institute (RS-HMI), the official organization that performs air quality monitoring.
Air Protection Strategy	Medium-term planning instrument for AQM that serves as the basis for the development of shorter-term instruments. The strategy must be adopted by the National Assembly and has a six-year time frame. Although the government drafted an Air Protection Strategy for 2011–2017, it was never formally adopted.
Action Plan for the Protection of Air, Atmosphere and Climate Change Mitigation	The Air Protection Strategy is operationalized through the Action Plan.
Republic Program for the Gradual Reduction of Annual Maximum Republic Emissions of Pollutants	The program has a four-year time frame and aims to harmonize total emissions in the Republic with increasingly stringent target values. It covers SO_2, NO_x, volatile organic compounds, and gaseous NH_3.
Air Quality Plans	Planning instruments that must be adopted in agglomerations and zones where the concentrations of one or more pollutants exceed the margin of tolerance or where efforts are needed to achieve appropriate limit or target values.
Short-Term Action Plans	Local self-government units are required to adopt Short-Term Action Plans when there is a danger that the levels of air pollutants, or ground-level O_3, might be exceeded. In areas with poor air quality, environmental authorities have the responsibility to require operators of stationary sources of pollution to develop a plan to reduce their emissions, including the measures that will be adopted, technologies or other solutions that will be implemented, the deadline for implementation of planned activities, and the estimated budget.
LAP-RS complementary regulations	
Rulebook on air quality limit values (O.G. of RS No. 39/05)	The timelines for achieving air limit values and interim air target values established by the regulation sometimes differ from the EU air quality standards. RS plans to align air quality standards for all air pollutants with the EU standards by 2021.
Regulation on Conditions for Air Quality Monitoring (O.G. of RS No. 124/12)	Establishes responsibilities for the competent authorities of RS and municipalities for air quality monitoring and data collection, within the scope of their competences prescribed by the law.
Decision on the Quality of Liquid Petroleum Fuels ('O.G. of BiH' No. 27/02)	Limits the contents of sulfur, lead, benzene, and other fuel characteristics for unleaded petrol, gasoline engine, petroleum for burning and petroleum fats, and fuel for diesel engines—not fully transposed from the EU legislation and cause of a dispute between the Energy Community and BiH.
Regulation on the Emission Limit Values for Air Emissions from the Combustion Plant (O.G. of RS No. 39/05)	Sets the emission limit values of air pollutants from fossil fuels (solid, liquid, or gaseous), based on the output of individual furnaces. It also sets limits to sulfur content in coal for households and institutions, boilers, and power plants. Coal for use in households and institutions must have a sulfur content of less than 2.5% by weight and municipalities may adopt more stringent standards. Boilers and heat generators up to 10 MW may use coal with sulfur content less than 5% by weight. Boilers and power plants over 10MW may use coal with a higher sulfur content where the environmental permits.
Regulation on Emission of VOC (O.G. of RS No. 39/05)	Regulates the measures and procedures for preventing or reducing the direct or indirect emissions of volatile organic compounds into the environment. Its provisions cover all plants using organic solvents. It

Law, strategy, plan, or standard	Requirement
	also sets measurement requirements, including the emissions threshold above which continuous monitoring is required.
Regulation on Conditions for Operation of Incineration Plants (O.G. of RS No. 39/05)	Regulates the issuing of permits for waste management, waste disposal and reception, plant operating conditions, emission limit values, waste water from waste gas purification, requirements related to measurements, access to information, and emergency situations.
Regulation on Limiting Emissions to Air from Biomass Burning Plants (O.G. of RS No. 39/05)	Sets limits for plants that burn mass of plant or animal origin in any form and condition, suitable for use as an energy (fuel).
Decision on Unit Compensation for Environmental Pollution for Motor Vehicles (O.G. of RS No. 116/18)	Prescribes unit fees for certain types of motor vehicles on the basis of which the compensation for environmental pollution for motor vehicles is calculated.

Note: O.G. = Official Gazette.

Based on the rulebook on air quality limit values, RS plans to align air quality standards for all air pollutants with the EU standards by 2021. Table 4.4 presents a comparison of air quality standards with the EU and the WHO.

Table 0.4. Comparison of air quality standards between the EU, RS, and WHO (µg/m^3)

Pollutant	Averaging time	EU air quality standards	RS	WHO air quality guidelines
$PM_{2.5}$	Annual mean	25	20	10
	24-hour mean	n.a.	n.a.	25
PM_{10}	Annual mean	40	40	20
	24-hour mean	50	50	50
NO_2	Annual mean	40	40	40
	1-hour mean	200	200	200
O_3	8-hour mean	120	120	100
SO_2	24-hour mean	125	125	20
	1-hour mean	350	350	500 (10-minute mean)
CO	8-hour mean	10	10	10
	1-hour mean	—	—	30
Lead	Annual mean	0.5	0.5	0.5
Benzene	Annual mean	5	5	n.a.

Source: Based on EU 2008; GSR 2012; WHO 2006.

Similar to BiH, the Environmental Performance Review conducted by the United Nations Economic Commission for Europe found shortcomings in the legal framework of RS for AQM; specifically, the regulation of emission ceilings and registries has not been fully executed, and a specific law on environmental inspections is lacking.

Environmental fees. The LAP-RS was amended in April 2017 to introduce two types of environmental fees (Tadic 2017). A fee for environmental pollution was established for importers of substances that deplete the O_3 layer. In addition, a compensation for the pollution emitted by motor vehicles was also established, which must be paid by vehicle owners annually, during the vehicle's registration. The implementation of the compensation is contingent on the government's establishment of a system to operationalize the recently adopted decision on unit compensation for environmental pollution for motor vehicles. Fees paid would be invested in the development of environmental protection technologies. Before the adoption of these amendments, there were no other economic instruments aiming to incentivize reductions in air pollution in RS.

Brĉko District

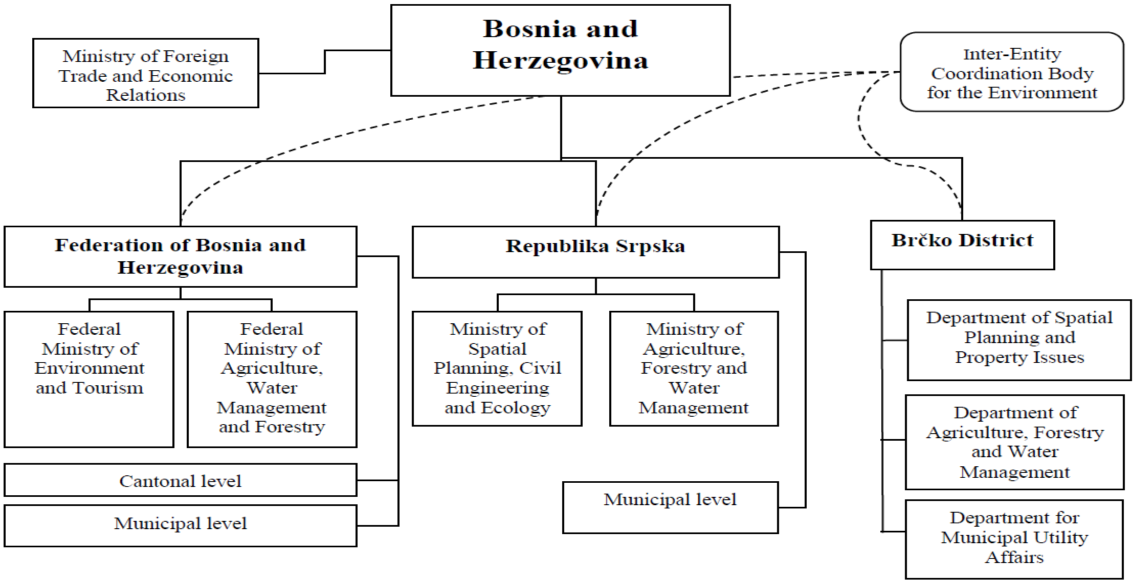
The Law on Air Protection of BD (LAP-BD) regulates the protection of air pollution to protect human health, climate, and the environment from the harmful effects of polluted air. This law defines general restrictions and obligations for air emission sources. The LAP-BD defines the specific limits for emission sources, fuels for domestic use, industrial plants, waste incineration plants, motor vehicles, fuel quality, volatile organic compounds, O_3 depletion, and the emissions registry. This law also defines various aspects of air protection: air quality values, air quality measures, measures for vulnerable areas, states of extreme pollution, information exchange, and public information. BD has also adopted a Decree on Air Quality Limit Values (Official Gazette BD 124/12), the Rulebook on Measures for Preventing and Reducing Air Pollution and Improving Air Quality (Official Gazette BD No. 3/15, 51/15, 47/16), the Regulation on Limit Values of Air Emissions (Official Gazette BD No. 30/06), and the Regulation on Limit Values of Air Emissions from Combustion Plants (Official Gazette BD No. 30/06).

4.3. Organizational Structure for Air Quality Management

A major difference between BiH and most countries in the world is the lack of an environmental protection agency or ministry at the country level. Environmental responsibilities in BiH are distributed among several government agencies at various levels as shown in Figure 4.1. Cooperation between competent institutions at the level of the constitutional entities and country-level institutions is based on the Decision on the European Integration Processes Coordination System in BiH (Official Gazette of BiH No. 72/16 and 35/18). At the country level, MOFTER, through its Sector for Water Resources, Tourism, and Environmental Protection, coordinates environment-related issues in addition to activities related to international cooperation and treaties on environmental issues. MOFTER faces human and budgetary resource constraints to conducting its mandate. By 2017, the sector had four staff working on water resources, four staff on tourism, and eight staff on environmental protection issues. The number of staff dealing with environmental issues remained constant between 2011 and 2017 (UNECE 2017).

Responsibility for environmental issues, including AQM, is assigned to entity ministries, based on the Constitution of BiH. The corresponding authorities are the FMOIT; the Ministry of Spatial Planning, Construction, and Ecology of RS (MSPCE); and the Department for Spatial Planning and Property Rights Matters of BD. Cantons and municipalities have jurisdiction for AQM below the level of the constitutional entities of the FBiH and RS.

Figure 0.1. Distribution of environmental responsibilities in BiH



Source: UNECE 2017.

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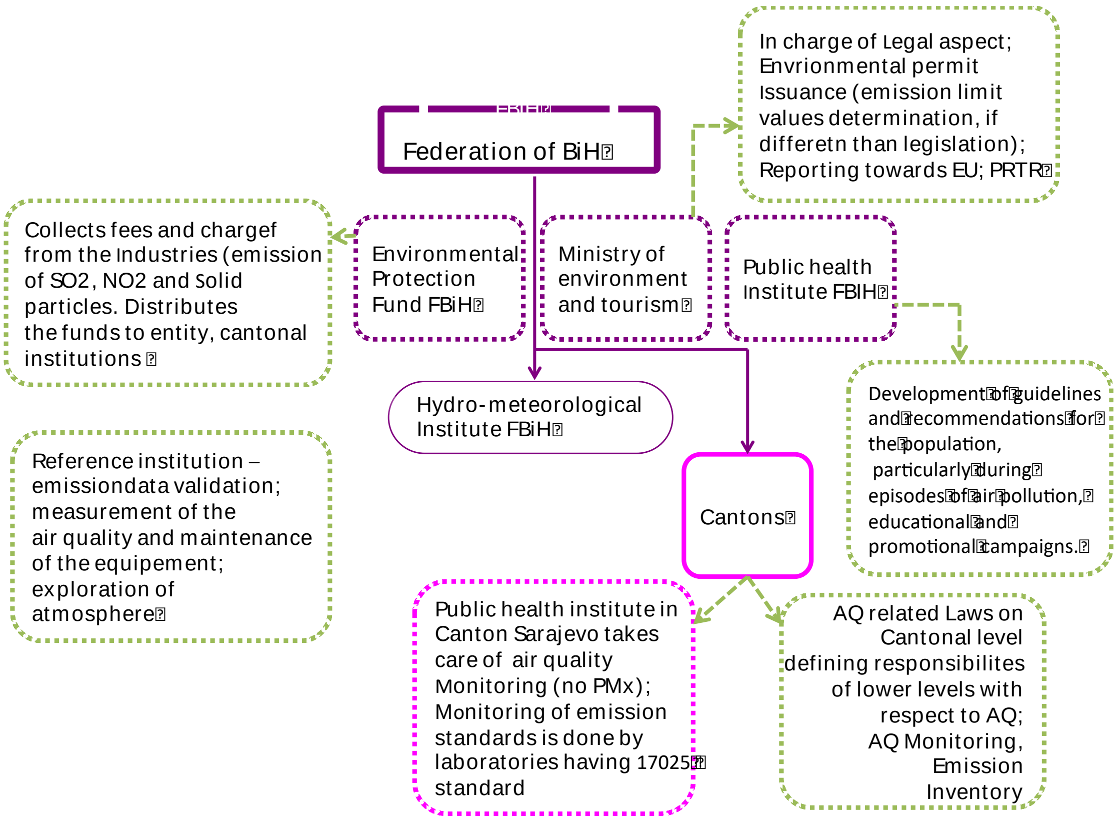
The FMOIT has the main responsibilities for AQM, including the development of environmental strategies, policies, and standards; environmental monitoring; and issuance of environmental permits. The Public Health Institute also plays an important role, particularly in terms of developing guidelines and recommendations for the population, especially during episodes of poor air quality. In addition, an Advisory Council for the Environment is responsible for providing scientific and expert support in the environment sector to the FMOIT and the federation government.

Figure 4.2 shows the organizational structure for AQM in the FBiH. AQM activities are mainly funded by government resource allocations, with the Environmental Protection Funds providing complementary resources. Budget allocations for AQM are insufficient, as evidenced by the limited number of staff, as well as limited budgetary resources to adequately operate the air quality monitoring network, purchase equipment, and develop robust analytical and modeling capabilities. As of mid-2017, the ministry had a total staff strength of 13 people working on all environmental issues: 7 in the environment sector and 6 in the environmental permitting sector. By mid-2018, the Federation Hydro-Meteorological Institute (FHMI) had a total staff strength of 80, of which only 2 focused on air quality and another 2 on laboratory aspects. The Environmental Protection Fund of the FBiH undertakes fundraising for, and financing of, the preparation, implementation, and development of programs and projects addressing conservation, sustainable use of natural resources, environmental protection, and use of renewable energy sources. The MFOIT oversees the fund's activities and the Environmental Inspectorate supervises the fund's compliance with the legal framework. AQM activities that have been financed by the fund include air quality monitoring projects in urban areas, studies on use of clean fuels in road transport, energy efficiency programs on public buildings, and operation of the air quality monitoring network operated by the FHMI.

Figure 0.2. Organizational structure for AQM in the FBiH



Note: AQ = Air quality; PRTR = Pollutant Release and Transfer Register.

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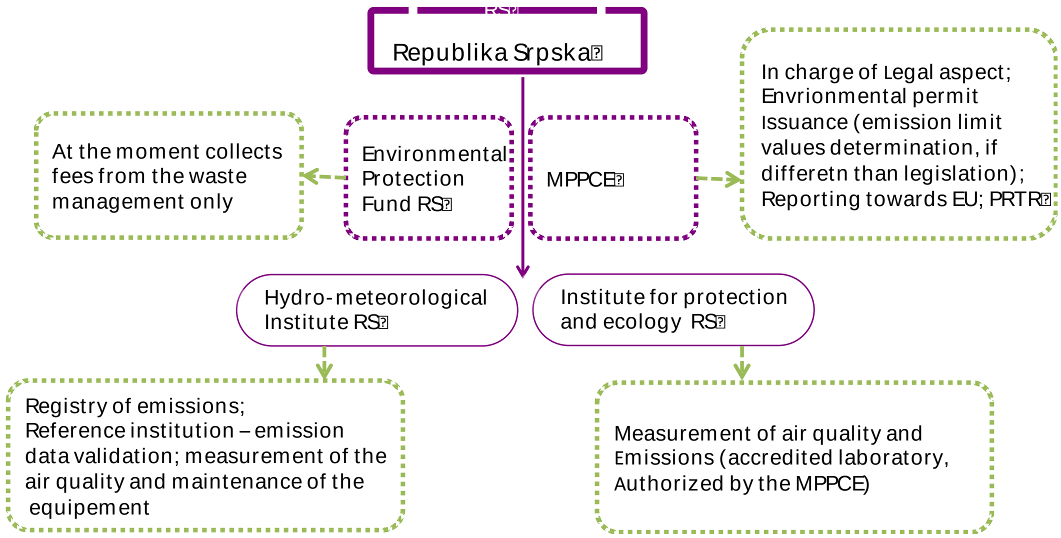
The MSPCE is responsible for developing regulations on air quality and pollution control, defining measures to improve air quality, and supervising the application of the LAP-RS and its regulations. The RS-HMI is responsible for air quality monitoring. The Institute for Environmental Protection and Ecology is the licensed laboratory for air quality and emissions measurements. Over the last five years, the institute has invested in the purchase of equipment for air quality emission measurements and air monitoring, and the laboratory has ISO 17025 accreditation to test air quality parameters. There is no reference laboratory in RS. As of 2017, the Department of Environmental Protection within the MSPCE had a staff strength of 11, including 1 senior air protection specialist. See Figure 0.3 for the organizational structure for AQM in RS.

The RS Fund for Environment Protection and Energy Efficiency invests in environmental protection, energy efficiency, and renewable energy projects. Sources of funding for the fund include fees paid by environmental polluters, waste management fees, water protection fees payable by owners of transport equipment using oil or oil derivatives, funds generated on the basis of international programs, contributions, and donations. As in the case of the FBiH, AQM activities in RS are mainly funded by government resource allocations and limited contributions from the Environmental Protection Fund. Limited human, technological, and financial resources point at the need to increase budget allocations.

Figure 0.3. Organizational structure for AQM in RS



Brĉko District

In BD, the Department for Spatial Planning and Property Rights Matters is responsible for environmental issues. The sub-department of Spatial Planning, Urban Development, and Environmental Protection bears the main responsibilities for activities related to environmental protection, including issuing environmental permits, approving Environmental Impact Assessments (EIAs), issuing permits for import and export of hazardous waste, monitoring air quality, and developing laws and subsidiary legislation (UNECE 2017).

4.4. Coordination of AQM: Roles and Responsibilities

Institutional coordination among environmental organizations with responsibilities for AQM is limited. At the country level, formal responsibilities of the MOFTER include defining basic principles, coordinating with other sectors and levels of government, and facilitating efforts to harmonize environmental policy and legislation. However, the ministry's role is constrained by the division of powers established in the Constitution, which assigns primary responsibility for environmental issues to the constitutional entities. There is no formal mechanism to address diverging positions between the constitutional entities. In 2006, an Inter-Entity Coordination Body for the Environment was established to deal with environmental protection issues that require a harmonized approach among the FBiH, RS, and BD. However, its decisions are not legally binding, and its composition differs in the respective environmental protection laws. The body does not engage the public in its activities and neither does it disseminate information about its agendas or meetings. Whereas the body has been credited for achieving the country's ratification of several international agreements, its effectiveness in achieving its core objective of harmonizing environmental laws and subsidiary legislation is more debatable. Informal arrangements for coordination exist between some institutions at the level of the FBiH and RS. For example, through such arrangements, the FHMI and RS-HMI alternately undertake reporting of air quality information for the country to the European Environment Agency. The effectiveness of such informal arrangements, however, merits further examination, and they are not substitutes for formal mechanisms of interinstitutional coordination.

Vertical coordination is another challenge for AQM, in particular for the FBiH. Legislation at the FBiH level is not consistent with that of the cantons. Given that each canton has its own set of laws and governmental institutions, that is, their own requirements, integration of information at a higher level and therefore, provision of consistent reports to the public or external organizations, are challenging.

Inter-sectoral collaboration, involving key sectors such as transportation or energy, is incipient across the country. Between 2002 and 2005, a National Steering Committee for Environment and Sustainable Development brought together 56 members from various governmental institutions and other stakeholders, under the leadership of MOFTER. However, in the absence of strong political support, the committee was discontinued when donor funding supporting it ended. No other inter-sectoral collaboration body has since been created.

4.5. Monitoring and Reporting of Ambient Air Quality

Monitoring. The number of air quality monitoring networks across the country has been expanded in recent years. Measured pollutants across the three jurisdictions include SO_2, NOx, CO, O_3, benzene, toluene, and xylene (BTX), PM_{10}, $PM_{2.5}$, heavy metals, TSP (in BD), and polycyclic aromatic hydrocarbons (PAH) (in RS), but these are not all monitored in each station. With respect to PM, monitoring focuses primarily on PM_{10} and not $PM_{2.5}$. However, restricted budget support for the monitoring stations affected the availability of trained personal, maintenance parts, and consumables. In addition, not all monitoring stations collect data on all priority pollutants. Additional challenges stem from lack of harmonization among the FBiH, RS, and BD in the development of air quality monitoring networks. The availability of data, coverage of monitoring stations, and methods used to analyze available information are not consistent across the three jurisdictions. This situation has several implications, including absence of country-scale information to monitor pollution trends and inform potential actions to improve air quality.

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Monitoring of air quality in the FBiH is the responsibility of the FHMI and the competent cantonal authorities and local self-government units that should provide metering points and metering stations for fixed measurements in Federation and local air quality monitoring networks. The FMHI operates 5 monitoring stations, while 11 additional monitoring stations are operated by cantonal public health institutes in Sarajevo and Mostar, the Environmental Protection Directorate of Tuzla canton, and by Općina Zenica. One automatic monitoring station in Sarajevo (Ilidza, Canton Sarajevo) is mobile. Most of these stations are automatic, supply online data to the FHMI, and measure SO_2, NO_x, CO, O_3, BTX, PM_{10}, and $PM_{2.5}$, although not all stations monitor all pollutants. The FHMI also conducts meteorological forecasting, which is an input for air quality modeling. Due to resource constraints, such forecasting is limited to elevations at 800 m above sea level or higher and, as a result, is unable to capture conditions at lower elevations such as in Sarajevo and other places in valleys. The FHMI currently lacks capacity for air quality modeling and laboratory analysis and is working on projects to address these gaps. The FHMI publishes annual reports on air quality, based on results of air quality obtained from measurements from the air quality network, which are compared with the EU air quality standards. Hourly air quality data from monitoring stations in the FBiH can be obtained online.[12] In addition, detailed inventory reports on

[12] http://www.hidrometeo.ba/#.

emissions of air polluting substances from point sources (industry) that fall within the jurisdiction of the FBiH are published annually.

Republika Srpska

In RS, the RS-HMI is the official organization that performs air quality monitoring and its tasks are defined in the Law on Meteorological and Hydrological Activities (Official Gazette of RS No. 20/2000). The RS-HMI operates 2 automatic stations in Banja Luka, while the Institute of Protection, Ecology, and Informatics operates 10 stations in Banja Luka and other municipalities. In 2016, a new automatic monitoring station operated by the RS-HMI was launched in Prijedor. Measured pollutants are SO_2, NO_x, CO, O_3, PM_{10}, $PM_{2.5}$, heavy metals, PAH, and BTX, but not all pollutants are measured in each station.

Brĉko District

BD operates three automatic monitoring stations measuring SO_2, NO_x, CO, TSP, and black smoke.[13] Six automatic monitoring stations are operated by companies, measuring SO_2, NOx, CO, and TSP.

Reporting. Both hydro-meteorological institutes in the FBiH and RS use the European software DEM for emissions to analyze statistical data on air pollution, which the European Environmental Agency can access on their websites. However, the FHMI uses the CORINAR methodology for reporting and data compatibility verification, while the RS-HMI uses the methodology from the Inter-Governmental Panel on Climate Change. As a result, no aggregated air quality data are available for the entire country nor formal cooperation and communication between the respective hydro-meteorological institutes on collection and reporting of air quality data.[14] Also, BiH has committed to report air quality data to the European Environmental Agency as part of its responsibilities in its new EAS. Still, there is no institution at the country level with a formal mandate to report on air quality to international institutions and convention.

4.6. Public Disclosure of Air Quality Information

The Laws on Environmental Protection of the country recognize the rights of individuals and organizations to participate in decision-making processes. Provisions in the legal framework include obligations for government agencies to encourage public awareness and participation and to facilitate access to relevant environmental information. In addition, the legal framework of each jurisdiction requires the creation of environmental advisory councils that assist in the evaluation of environmental plans and programs, which should constitute an avenue for public participation in environmental decision making. Also, the public and organization can take steps, through the legal system, to initiate court procedures when the government fails to adequately regulate or enforce environmental protection measures.

The FHMI and the RS-HMI publish annual reports on air quality in their jurisdictions. Information in these reports includes the results of air quality obtained from measurements from the air quality network,

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[13] Black smoke refers to the historical measure of PM darkness. It was standardized in the United Kingdom in the late 1960s and later used throughout Europe. Black smoke is not synonymous to BC and estimating BC emissions from black smoke is not a straightforward task (Heal and Quincey 2012).

[14] CORINAIR and IPCC are bottom-up and top-down approaches for compiling greenhouse gas inventories, including CO_2, methane (CH_4), nitrous oxide (N_2O), CO, NO_x, and NMVOC from six main sectors.

which are compared with the EU air quality standards. Hourly air quality data from monitoring stations in the FBiH can be obtained online.

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In the FBiH, environmental permits do not include an obligation for permit holders to report emissions to the PRTR[15], but instead, permit holders submit reports, which are then manually fed into the register by officials from the FMOIT. Information from the PRTR is not publicly accessible and data in the register are often incomplete and inaccurate as some operators do not submit their reports, omit information about some pollutants, or report data obtained through poorly functioning emission monitoring systems. The FMOIT does not have the capacity to maintain the PRTR and operators have not received training on how to report data correctly.

The provisions of the LAP-FBiH also stipulate that the FMOIT and cantons must publish a report on emissions inventories for air pollutants on a yearly basis. These inventories must include sector-disaggregated emissions of specific pollutants.[16] The LAP-FBiH also establishes that a designated expert institution must produce an annual assessment report on air quality, including information about exceedance of air pollution limit values, alert thresholds, target values, and long-term objectives. This expert institution is also required to make information on AAP concentrations routinely available to the public. The LAP-FBiH also describes the action plans that cantons must develop in cases when an alert threshold is exceeded or when ambient air quality limit values of one or more pollutants are exceeded (FBiH 2010).

Republika Srpska

In RS, maintaining the PRTR is the responsibility of the RS-HMI. Although permit holders have an obligation to report to the PRTR, based on provisions of the LAP-RS and as a condition included in environmental permits, the number of reports submitted by operators to the RS-HMI remained unsatisfactory by 2017 (UNECE 2017).

4.7. Enforcement of Regulations

Although the Criminal Code of BiH and the criminal codes of the FBiH, RS, and BD contemplate environmental crimes, they are not consistent with each other or Directive 2008/99/EC on the protection of the environment through the criminal law. The capacity and willingness to prosecute environmental crimes is generally low in BiH (UNECE 2017). Especially at the municipal level, environmental inspections and enforcement of environmental laws are weak and significant pollution sources such as domestic heating remain unchecked.

Mobile sources. A country-level regulation related to technical review, including emissions testing, of vehicles exists but has not been updated recently. Noting increasing noncompliance with legislation, the government concluded in 2017 that there was a need for a joint rulebook and price list for technical

[15] The PRTR is a publicly accessible database or inventory of chemicals or pollutants released to air, water, and soil and transferred off-site for treatment. It brings together information about which chemicals are being released, where, how much, and by whom. The European Pollutant Release and Transfer Register (E-PRTR) is a web-based register established by Regulation (EC) No 166/2006 which implements the UNECE PRTR Protocol, signed in May 2003 in Kiev. Accessible at http://prtr.eea.europa.eu/.

[16] SO_2, NOx, CO_2, CO, NH_3, nitrous oxide (N_2O), CH_4, non-methane hydrocarbons, benzene, and PM_{10}.

inspections to be used throughout the country. Under the rulebook, vehicles of lower euro characteristics would pay higher prices for the technical vehicle emissions tests (or ECO tests) than vehicles of higher euro characteristics and hybrid, and gas-powered, vehicles. Failing issuance of the joint rulebook, the FBiH developed a rulebook that requires an annual ECO test for vehicles. However, the test was reported to be expensive, which could discourage vehicle owners from undertaking the test.

Stationary sources. The FBiH and RS are responsible for overseeing environmental compliance from larger polluters. The FBiH and RS each have an independent body with environmental inspection authority, the Administration of Inspection Services. The administration supervises compliance by permit holders with the conditions set by environmental permits issued by ministries (and cantonal authorities in the case of the FBiH). There are four regional units in the FBiH, with about 150 inspectors, and RS has six units with 250 inspectors. However, the FBiH and RS each have a total of five positions for environmental inspectors. In addition, this limited number of inspectors do not have periodic and systematic training to update and upgrade their knowledge and skills in the changing industrial technologies and associated with the EU's Best Available Techniques reference documents (UNECE 2017). There is an urgent need to increase the number of inspectors and ensure that adequate resources, equipment, and training are provided.

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In the FBiH, the FMOIT and cantons issue environmental permits for five-year periods, which prescribe emission levels based on the emission limits set by the corresponding rulebook and conduct inspections. In the case of new installations, emission limits are largely based on Best Available Techniques described in EU documents. The EU's emission limit values for large combustion plants are transposed into the FBiH's legislation (UNECE 2017). Compliance with the emission limits included in the permits is generally low because abatement equipment is not installed or does not function properly. Reports of major emission incidents and visits to the affected locations are only conducted in response to complaints by citizens or legal bodies. In addition, inspectors do not have the equipment or expertise to identify individual specific incidents or to verify emissions reported by operators of facilities. Problems arise if a new permit is needed after five years and the permit holder has not adopted proper measures to achieve prescribed emission limits. In some cases, this may lead to the operation of emission sources without a valid permit given lengthy permitting processes. Financial sanctions, ranging from around €500 to €5,000 for noncompliance, are generally not commensurate with the damage caused and do not constitute a deterrent to noncompliance. In accordance with the FBiH Strategy for Environmental Protection Environmental, fees and fines are allocated to the cantons (70 percent) and a Project Implementation Fund (30 percent).[17] With only five environmental inspectors for the FBiH, institutional capacity for enforcement of environmental permits is insufficient.

Republika Srpska

In RS, the Ministry of Spatial Planning, Construction, and Ecology and local self-governing units issue five-year environmental permits that set emissions levels based on the Decree on Emission Limit Values of polluting substances into the air. There are rulebooks on limit values of emissions from biomass

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[17] The fund can allocate resources to a broad array of users, including authorities, bodies, and institutions of state administration and local government; public companies; businesses and other legal persons; civil society associations and organizations; agencies and chambers; employers' associations; and educational and research institutions, including schools and universities.

combustion plants and on the emission of volatile organic compounds. The limits for large combustion plants are based on the EU Large Combustion Plants Directive, but the limit values from the EU Industrial Emissions Directive are not yet transposed (UNECE 2017). The Authority for Inspection Activities of RS comprises 13 inspectorates, including the Inspectorate on Urban Planning, Construction, and Environment. The inspectorate supervises the application of regulations concerning urban planning and construction, environmental protection and spatial development, waste management, and surveying activities.

Brĉko District

Environmental inspection activities are carried out by the Inspectorate of BD, which supervises compliance with the permits issued by the Department for Spatial Planning and Property Rights Matters. The regulations and standards applied in BD are found in the Rulebook on Air Quality Monitoring under the Law on Air Protection. Environmental inspection activities are carried out by the Inspectorate of BD.

4.8. Efforts of Development Partners to Support AQM in Bosnia and Herzegovina

This section discusses some recent and ongoing efforts of international development partners to support improvement of AQM in BiH. Taking this type of discussion into account could help inform efforts of development partners by making sure that they are complementary, mutually reinforcing, and not duplicative. Some of the activities of development partners working directly and tangentially on AQM-related issues in BiH are as follows:

- **The World Health Organization.** As part of the Biennial Collaborative agreement (2018–2019), BiH is receiving support for local-level implementation of WHO guidelines, tools, and methodologies for preventing and managing the health impacts of environmental determinants of health, for example, those associated with air pollution and chemical exposures.
- **The U.S. Embassy in Sarajevo.** In partnership with the United States Environmental Protection Agency, the Embassy is providing technical assistance and equipment to support PM monitoring and provide real-time information to the general public and engaging with public health institutes on AQM. Specifically, two Federal Equivalent Method (FEM) monitors were installed at the Embassy reporting hourly $PM_{2.5}$ concentrations. In cooperation with the Sarajevo Medical Faculty, the Embassy is supporting an initial baseline assessment (pilot study) of the negative health effects of air pollution using historical PM_{10} measurements and existing health statistics.
- **The Government of Sweden.** The Embassy of Sweden and the Swedish Environmental Protection Agency are providing technical assistance to BiH for improving air quality and AQM capacity. This three-year program will address the following aspects: (a) data and information management; (b) quality assurance; (c) source apportionment studies in five cities in the FBiH and RS, including Sarajevo, Banja Luka, and Tuzla; (d) promotion of interventions to expand traffic-free zones in Sarajevo; (e) information campaigns and public dissemination based on results of source apportionment studies; and (f) technical cooperation for training of environmental inspectors.
- **The Embassy of Switzerland.** As part of a health project, the embassy is addressing key public health issues concerning prevention of noncommunicable diseases and health promotion. Actions

for the next phase could include multisectoral interventions for reducing air pollution or decreasing its effects and/or related counselling of patients by health professionals.

- **The United Nations Environment Programme.** UN Environment is providing technical assistance for aspects of management and dissemination of air quality data, awareness raising on health issues associated with air pollution, and cost-effective monitoring solutions. Specifically, work is ongoing in cooperation with hydrometeorological experts and health professionals in BiH, for developing an AQI, including health messages intended for general public. As part of the BreatheLife Campaign, Sarajevo joined an alliance of "BreatheLife" cities working on air pollution reductions. UN Environment is also supporting a feasibility study plan for a cost-effective urban air quality monitoring solution, which would roll-out an affordable monitoring approach in partnership with the private sector.
- **The United Nations Development Programme.** The United Nations is providing investments and support in the areas of biomass energy, renewable energy and green economic development, which could have the effect of reducing polluting emissions. Actions include support for the sustainable use of wood biomass (for example, establishment of a market value chain framework and awareness rising of general public on positive aspects of utilization of this energy source (2016–2019); promotion and utilization of renewable energy sources and improvements in access to district heating in BiH and the Canton of Sarajevo; and contribution to the creation of a favorable environment for investing in energy efficiency measures in public sector buildings in BiH (2014–2020).
- **OpenAQ.** In BiH, OpenAQ is hosting a web platform that collects real-time data/air quality measurements from nine areas and 21 locations/monitoring stations.

These projects are expected to make valuable contributions to addressing air quality in BiH. These donor-supported activities are largely providing technical assistance to strengthen specific areas of AQM and highlight potential opportunities for other financing, including lending and knowledge development and advisory services, and for investments in abatement interventions.

European Bank for Reconstruction and Development (EBRD). Banja Luka, Zenica, and Sarajevo joined EBRD's Green Cities Program in 2018. Through the program, Banja Luka aims to address traffic, waste, and energy efficiency issues. Zenica aims to introduce best practices for tackling air quality issues related to industry, and Sarajevo aims to address air pollution from traffic and solid fuel-based heating.

4.9. Conclusions and Recommendations

Recognizing the importance of reducing AAP, the country has undertaken initial efforts to develop a legal and regulatory framework on AQM and establish environmental institutions with dedicated responsibilities for AQM. Significant challenges remain in terms of harmonizing the legal and institutional framework across the jurisdictions for environmental management in general and AQM in particular. Overlapping roles and responsibilities for implementing legislation and lack of organizational, human, and financial resources to conduct key actions present obstacles for meaningful progress toward improving air quality in BiH.

The following paragraphs provide recommendations for how the Government of BiH could improve AQM.

Strengthen the Legal and Institutional Framework for AQM

Strengthen mechanisms for coordination and cooperation across jurisdictions. An important first step would be to promote coordination and cooperation between the FBiH, RS, and BD. In this context, MOFTER and the Inter-Entity Coordination Body for the Environment should be strengthened in their roles of fostering coordination between the FBiH, RS, and BD on air quality issues. Such coordination should be backed by legislation and include priority-setting criteria, clear accountability mechanisms that cover relevant stakeholders across jurisdictions, monitoring and evaluation of outcomes, and social-learning mechanisms to promote continuous improvement of the coordination. Although time intensive and requiring adequate budgetary and human resources, coordination is logical for effectively tackling air pollution at a country level. With respect to the Inter-Entity Coordination Body for the Environment, legislation in all jurisdictions should be harmonized in their definitions of the function and composition of the body. Some areas where such coordination is needed include (a) establishing a clear institutional mandate for in-country and international reporting of air quality data for the country and (b) data sharing on air quality.

Establish additional formal coordination mechanisms on AQM. Achieving reductions in air quality pollution will require strengthened coordination among the organizations that are responsible for air pollution management in the FBiH, RS, and BD. Although some informal coordination takes place, it is not a substitute for institutional coordination. Vertical coordination in all jurisdictions should be reinforced by establishing clear procedures and mechanisms for air quality data sharing and gradually for a broader range of topics such as alignment of strategies and plans, as well as enforcement. Any efforts to vertically align legal and policy frameworks should be guided by the shared aspiration to fully transpose the EU acquis. Similarly, inter-sectoral coordination needs to be bolstered, particularly between environmental authorities and organizations with a lead role in defining policies in the transport, industrial, energy, urban development, agriculture, and health sectors, all of which undertake activities that affect or relate to air quality. Inter-sectoral coordination should include a focus on defining agendas and priorities related to air quality across sectors with inputs from different sectors, development of monitorable and time-bound targets to guide the design and implementation of interventions, and monitoring and evaluation of effectiveness.

Fully develop and harmonize the legal framework. In the near term, MOFTER and the Inter-Entity Coordination Body for the Environment should focus efforts on coordinating the harmonization of the legal framework across jurisdictions and transposing air quality-related EU Directives. Efforts should aim to promote harmonization across all the building blocks of AQM, including the legal and policy frameworks related to air quality monitoring, emissions inventories, and analysis of air pollution, organizational frameworks, public participation, and enforcement. Vertical harmonization of legislation should also take place, that is, between upper and lower levels of government: cantons and municipalities (FBiH) and municipalities (RS). With respect to EU Directives, areas that could be addressed by the government include harmonization of timelines for achieving ambient air quality standards for specific pollutants. In addition, the government could focus on full transposition of EU legislation that relates to (a) sulfur content of liquid fuels, (b) the National Emissions Ceilings Directive, (c) control of volatile organic compounds from petrol storage and distribution, (d) petrol vapor recovery during refueling of ore vehicles at service stations, and (e) industrial emissions for new plants. The air quality strategies for the FBiH and RS have different timelines: 10 years for the FBiH and 6 years for RS. While the differences in timelines may reflect specific constraints faced in the FBiH and RS, there should be formal mechanisms of coordination to ensure that strategy implementation processes are complementary and synergistic. In addition, the government should develop a law on environmental inspections for air pollution sources.

Specific measures that could be adopted in the short term include revising the legal framework to reduce pollution from the following sources:

- **Sulfur content in liquid fuels:** There is a need to harmonize regulations on the sulfur content in liquid fuels at a country level. Based on current noncompliance with the EU Directive in RS, the Energy Community has found that the country has seriously and persistently breached the European law. BiH should take time-bound steps to ensure that standards for liquid fuel quality, including gasoline, heavy fuel oils, and gas oils are brought into compliance with EU legislation for the entire country.

- **Domestic heating:** Burning of coal and wood for heating is a key source of air pollution, including $PM_{2.5}$, during winter months. Interventions should consider establishing more stringent standards for solid fuel quality for use in households. The current legislation requires that coal for use in households must have a total sulfur content of less than 2.5 percent by weight and allows municipalities to adopt more stringent standards. By way of comparison, in Ireland coal sold for home heating must have a sulfur content no greater than 0.7 percent by weight. The government could also develop a large-scale program to substitute traditional stoves with more efficient ones. The government could start with implementing a pilot program in the short term. Lessons from such a pilot, and other existing initiatives, could be taken into account to inform the development of a possible large-scale stove replacement program. In many countries, similar programs have been implemented with targeted subsidies for project beneficiaries who cannot afford to pay the full costs of substituting their stoves with cleaner alternatives. A public awareness program would help educate the public on the purpose of stove replacement, low-emission stove use, and available resources for households and promote adoption of clean stoves in households. Additional measures such as expanding district heating could be developed over the medium to long term. Interventions such as restrictions on burning of solid fuels in households, increased gas connections, and expansion of district heating, which are being contemplated in the Sarajevo CEAP, should assess the distributional impacts of such interventions to ensure that they do not disproportionately burden poor households. Moreover, selection of specific interventions should be based on analysis of the benefits and costs of alternative interventions.

- **Stationary sources:** Starting with large facilities, there is a need to close loopholes that allow stationary sources to operate without the necessary pollution control equipment and in violation of air emissions standards. The legal framework could be tightened to ensure that the sanctions for facilities operating without a valid environmental permit, and facilities that exceed their approved emissions levels, are clear and commensurate with the damage they cause. In addition, the government could provide financial incentives for smaller industrial undertakings to strengthen AQM. Additional measures that are available to control emissions from stationary sources include setting consumption caps to gradually reduce coal use; incorporating new technologies for desulfurization, denitrification, and dust elimination; setting more stringent emission control standards for coal-fired plants; and setting resource and energy conservation goals targeted at resource-intensive industries. However, it would be important to assess whether the benefits of these interventions would outweigh their costs.

- **Mobile sources:** The average age of the private car fleet was 17 years and about 70 percent of the cars ran on diesel as of 2017. More than 50 percent of the vehicles achieve below Euro 3 standards. In 2016, the Council of Ministers of BiH introduced a measure to restrict imports of vehicles that do not meet the Euro 4 standard (UNECE 2017). However, it is not clear that such measures alone can lead to significant improvements in air quality. More comprehensive measures, in addition to adherence to Euro standards, would be needed at the country level to effectively tackle air pollution from mobile sources. The existing framework in the FBiH contemplates registration fees for vehicles but does not provide economic incentives to replace older vehicles with more modern, cleaner ones. Recently, MOFTER has been holding consultations on a proposal for a decision on temporary suspension and reduction of duties on imported new vehicles with a view to promoting imports of new, and particularly electric, vehicles.[18] Country-level regulations establishing mandatory monitoring and inspection programs should be revisited and issued, including linking the price of annual Eco tests to the emission characteristics (Euro) of the vehicle to incentivize vehicle owners to undertake the tests and to replace old vehicles with less polluting vehicles. These types of programs are generally implemented at the municipal or metropolitan level and could be developed by the FBiH, RS, and BD.

Expand menu of instruments for air quality management. In addition to strengthening existing 'command-and-control' regulations, the different jurisdictions might consider developing economic instruments that have been used to reduce air pollutant emissions more efficiently and effectively in other countries such as taxes, fees, pollution charges, tradable permits, or pricing policies. Economic instruments are based on the 'polluter pays' principle where the polluting party pays for the damage done to the natural environment. In the FBiH, environmental fees and taxes are in use. Fees for stationary sources could be updated and indexed to avoid erosion by inflation over time. In addition, there is a need for third-party verification of emissions reported by large polluters and used for the computation of fees. For mobile sources, there is a need to better link fees to vehicle use and maintenance, in addition to technology-related parameters (engine type, fuel type, emission class, and vehicle age) that are currently used to calculate fees. In addition, incentives for people to replace old vehicles with new, cleaner ones should be strengthened. Furthermore, as the government considers the reduction of duties on new imported vehicles, it would be important that adequate incentives are also put in place to discourage importation of old, polluting vehicles. In RS, amendments to the environmental protection law adopted in 2017 introduced the first set of environmental economic instruments. However, the government still needs to establish a system to operationalize them. No economic instruments currently exist in BD.

Enhance effectiveness of environmental funds. Both the FBiH and RS have established environmental funds: the Environmental Fund of the FBiH and the Environmental Protection and Energy Efficiency Fund of RS. To strengthen the effectiveness of these funds in addressing air pollution, the FBiH and RS could clarify and develop criteria used for prioritizing and selecting projects or activities to which funds are allocated and strengthen transparency related to the allocation of proceeds from fees to specific projects that reduce air pollution.

[18] http://www.mvteo.gov.ba/Publication/Read/smanjenju_carinskih_stopa_pri_uvozu_elektricnih_automobila

Build Capacity to Design, Implement, and Enforce AQM Policies

Scale up adoption of air quality plans. The impacts of air pollution are most profoundly experienced at a local level. For this reason, it is important that comprehensive plans exist at the local level for tackling air pollution. Government support to local levels of government for the development of AQPs is crucial. While cantons of Sarajevo and Una-Sana have developed plans, it is important to scale up the preparation of AQPs to other cantons and municipalities in the country. The AQPs should take a comprehensive approach, which includes the development of emissions inventories, reliable air quality monitoring, understanding of the contributions of different sources to local air pollution, understanding of health impacts of air pollution, and identification of economically effective interventions for reducing air pollution. In this context, the capacities of cantons and municipalities could be strengthened so that they can develop emissions inventories; obtain reliable time series of air quality monitoring data; and conduct air quality modeling, source apportionment studies, laboratory analyses, health impact analyses, and economic effectiveness analyses of alternative air pollution reduction interventions that are needed to underpin and inform the design and implementation of AQPs.

Strengthen staffing for AQM. A priority for strengthening AQM consists of building capacity to design and implement AQM policies, including recruiting a higher number of specialized personnel in all agencies responsible for AQM-related tasks. Strengthening institutional capacity to enforce existing air quality standards is a pressing priority. To that end, sustained, higher resource allocation and strong political support will be key. In some instances, outsourcing of these functions to specialized firms or research organizations may be more efficient. Technical capacity of existing institutions could be strengthened through partnerships with research centers to conduct applied research, improve local and regional models, and create centers of excellence in the country on AQM.

Clarify sanctions and strengthen inspection and enforcement. The FBiH, RS, and BD should consider revising their legal frameworks to include adequate sanctions for violations of environmental laws, specifically to ensure that (a) clear provisions exist on the consequences for large emitters for operating without a valid environmental permit; (b) fines are set at a level to act as a deterrent for environmental violations; and (c) repeat violators face civil, judicial, or administrative sanctions and criminal enforcement can include jail sentences for legal representative of the polluting body. In addition, there is a need to strengthen inspection at the municipal level, increase the number of inspectors, and provide them with training and resources to conduct field investigations. Also, there is need to build capacity for third-party verification of emissions reported by polluters. Given the prominent role of domestic heating in air pollution, efforts should be made to legally allow for household inspections to be conducted, to further strengthen such inspections, and increase public awareness, targeted to households, on air pollution and low-emission practices for household heating.

Finally, when regulatory avenues for environmental enforcement fail, the judicial system is often the only other recourse for resolving environmental conflicts. Environmental nongovernmental organizations (NGOs) have filed lawsuits in response to the issuance of environmental permits for new thermal power plants. The results of those court proceedings might set important precedents for AQM in BiH.

Invest in a Robust Air Quality Monitoring Network, Data Analysis and Management, Registry of Emission Sources

Investing in a robust air quality monitoring program is essential to understand fully the risks generated by air pollution and the effectiveness of government interventions to address it. Efforts to establish a reliable air quality monitoring network should prioritize a focus on pollutants that are critical for health and increased geographic and time series coverage, notably of $PM_{2.5}$. Furthermore, given the heavy dependence on combustion of solid fuels in BiH, for power generation in households, routine monitoring efforts could be expanded to include chemical species of constituents of $PM_{2.5}$, which have effects on health such as elemental carbon, organic carbon, sulfates, and BC, which has the dual property of being a component of $PM_{2.5}$ and a climate warmer. In addition, monitoring should be expanded to precursors of PM, that is, SO_2, NO_x, NH_3; Pb; and other toxic substances. In BD, monitoring efforts, which currently focus on TSP, could shift toward $PM_{2.5}$, the more scientifically valid health-based indicator of PM.

It is recommended to establish a centralized depository of air quality data collected across the country and build the capacity within the relevant agencies in the FBiH, RS, and BD to carry out modeling and speciation efforts. While the latter are medium- to long-term priorities, they are essential to assess the present and future contributions of mobile, stationary, nonpoint, and natural sources of key pollutants, as well as their composition. Given that multiple institutions are involved in operation and maintenance of air quality monitoring networks in the country, it is important to have harmonized methodologies for sampling and analyses and standard operating procedures for operation and maintenance of monitoring stations to improve their operation as well as data quality and completeness.

QA/QC of data collected or generated at monitoring stations in the country is vital, and there should be official written procedures for formatting, storage, and QA/QC of such data. These procedures should be harmonized across the constitutional entities of BiH to facilitate country-level assessments of air quality. Similarly, QA/QC procedures for maintenance and calibration of analytical instruments should be documented and harmonized across the country and should also include the practice of inter-laboratory calibration. It is recommended that the government sustains momentum on efforts to establish a reference laboratory in the country.

Developing a registry of air pollution sources is an indispensable pillar of AQM. Over the medium term, the jurisdictions should develop a registry of air pollution sources, starting with stationary sources. A registry would provide information to help environmental agencies map the location of different sources of air pollution, assess the types and quantities of pollutants being discharged into the environment, identify noncompliant units, and develop the necessary corrective actions. Incorporation of small and medium enterprises in the registry would be crucial, as these sources may cumulatively emit large quantities of air pollutants.

Strengthen Stakeholder Engagement

Experiences from across the globe show that stakeholder engagement is crucial to reform and bolster environmental actions, particularly when well-articulated constituencies can demand improved governmental responses to a clearly identified priority issue (World Bank 2011). Opportunities to strengthen environmental accountability in BiH include a public information program to support clean air through the public provision of air quality information. Harmonization of data collection, management, and dissemination is necessary. With support from UN Environment, authorities are developing an AQI similar to those that have been adopted in many countries and across Europe. The index could help reach a broader audience and build support for initiatives to improve air quality and enable the issuance of health alarms when air quality poses risks to sensitive groups of people (for example, people with asthma and COPD, young children, and the elderly) or to the country's population.

Growing evidence from industrialized and nonindustrialized countries suggests that disclosure can spur emissions reductions. The Governments of FBiH, RS, and BD should consider adopting a public disclosure scheme requiring industries to report their pollutant emissions and rate themselves on compliance with the applicable standards. Such mechanisms promote accountability on the part of those being regulated and have been successful elsewhere. An example is the pioneering public disclosure scheme in Indonesia (the Program for Pollution Control Evaluation and Rating [PROPER]), which encouraged firms to clean up their air and water pollution. A color-coded rating scheme was developed to grade factories' performance against the regulatory standards. The incentive associated with factories with strong environmental performance was public praise, which would enable them to gain a competitive edge in the market. Deterrents for factories with poor environmental performance were public pressure and legal enforcement. The disclosure program was voluntary in its first phase, but in the second phase of the program, the government made the disclosure program compulsory.

Chapter 5. Learning from International Experience in Tackling Air Pollution

5.1. Introduction

Air pollution by nature cuts across activities of various sectors of the economy and geographic boundaries and respects no age group of persons. Addressing such a cross-cutting problem effectively requires concerted, sustained, multidisciplinary, and cross-sectoral efforts that engage a broad range of stakeholders including the government, civil society, academia, private sector and international development partners.

The complexity of air pollution calls for a strategic and integrated approach based on a comprehensive understanding of the air pollution problem and solutions appropriate to the specific context of the affected city or country. The complexity of air pollution is borne out in the varying levels of progress that cities in developed and developing countries have made in improving air quality and the time frames within which such progress has been achieved. For illustrative purposes, it took about 50 years for cities in the United States to achieve the WHO Air Quality Guideline value for PM_{10}; they went from an average value of 60 μg/m^3 in the 1960s to around 20 μg/m^3 in the 2010s (World Bank 2012). Cities in developing countries are also recording progress in their efforts to reduce AAP and the results show that with government commitment and sustained and focused efforts, it is possible to achieve improved air quality outcomes and in shorter time frames (Table 5.1). These country experiences and results lend support to optimism for similar positive progress in BiH.

Table 0.1. $PM_{2.5}$ and PM_{10} reduction in selected cities

City, country	Highest concentration	Reduction	Time frame
Mexico City, Mexico[19]	PM_{10} = 180μg/m^3	>70%	25 years (1990–2015)
Lima- Callao, Peru[20]	PM_{10} = 85μg/m^3	>50%	8 years (2006–2014)
Beijing, China[21]	$PM_{2.5}$ > 89g/m^3	>30%	4 years (2013–2017)
Ulaanbaatar, Mongolia[22]	$PM_{2.5}$ = 250μg/m^3	>60%	6 years (2009–2015)

This chapter presents cases illustrating how different countries have addressed, with World Bank support, air pollution from various sources using a variety of interventions including policy reforms, investments, knowledge development, and technical assistance and various policy instruments such as command-and-control, economic, and market-based instruments. The chapter draws lessons learned from the experiences of, and approaches used in, these countries, which underscore the need for integrated, strategic, and context-specific approaches to tackle AAP. The examples also demonstrate how the World Bank has played an integrative role in supporting countries in addressing a complex issue such as air pollution. It is envisaged that the discussion in this chapter could provide a background to inform potential

[19] Air Quality Mexico City, Experience 1990–2018. Presentation by Rodolfo Lacy, Government of Mexico. Presentation in Delhi, March 2018.
[20] Based on Macizo and Sanchez, forthcoming.
[21] ICCS 2018.
[22] Based on communication between World Bank staff and Prof. S. Lodoysamba (retired) of the National University of Mongolia and air quality monitoring results provided by the Ministry of Environment and Tourism in Mongolia for 2008–2015.

and ongoing efforts of the World Bank and other development partners in supporting BiH's actions to reduce air pollution in a manner that ensures that those efforts are strategic, integrated, and complementary.

5.2. Global Experiences in Tackling Air Pollution

Tackling Air Pollution from Domestic Heating in Mongolia

Background: Ulaanbaatar, Mongolia, is among the cities with the worst air quality in the world. PM might be responsible for up to one in five deaths in the city. Air pollution is particularly poor in Ger[23] areas surrounding Ulaanbaatar where about two-thirds of the city's 1.4 million inhabitants live. Annual average ambient concentrations of PM pollution can range from 200 to 350 $\mu g/m^3$. Air pollution is particularly severe during the cold winter months, when households burn coal and wood for heating and cooking, releasing polluting emissions at breathing height (2–3 m above ground). During this season, $PM_{2.5}$ concentrations can exceed the WHO guideline for daily average concentrations (25 $\mu g/m^3$) by 120 times.

Plans to establish a stove replacement program in the Ger areas were initially met with resistance from city government officials who were not convinced that a stove replacement/removal program, which could be conducted in the short term, should be prioritized and felt that alternative long-term options would be more economically effective. The government with World Bank support decided to undertake full-scale AQM planning to obtain a complete understanding on sources, concentration levels, and health impacts and identify the most economically effective abatement options for reducing air pollution in the short, medium, and long term. The World Bank mobilized grant funding, totaling about US$1 million, from several sources to provide technical assistance to the Government of Mongolia, which was underpinned by the Ulaanbaatar Air Monitoring and Health Impact Baseline (AMHIB) study conducted between 2008 and 2011.

The three-year technical assistance entailed (a) redistribution of air quality monitors across Ulaanbaatar to cover the central area, as well as the Ger areas, which were previously not monitored; (b) one full year of air quality monitoring at all locations to allow for capture of seasonal variations; (c) establishment of an inventory of emissions from all major sources in the city, air pollution modeling, and estimation of population exposure to PM pollution; and (d) a health impact assessment in Ulaanbaatar to establish a baseline for health impacts as well as local (Ulaanbaatar) dose-response relations between PM concentrations and various health end points; and (e) identification of economically effective interventions.

Process: The development of the AMHIB entailed an extensive process of bringing together and engaging various stakeholders who were already working on air quality in Mongolia as well as integrating new stakeholders to fill knowledge and technical gaps in the process. At the time of the study, several development institutions were engaged on different elements of AQM planning (see Figure 0.1) in the country. The comprehensive scope of a study of this type, and the World Bank's role in leading it in collaboration with the government, resulted in a process where the World Bank played a central role not only in technical coordination of the AQM planning process but also in administrative coordination of the engagement of diverse stakeholders. The World Bank engaged national (various ministries including Health, Energy, Transport, Housing, Urban Development; the Ulaanbaatar city departments; academia)

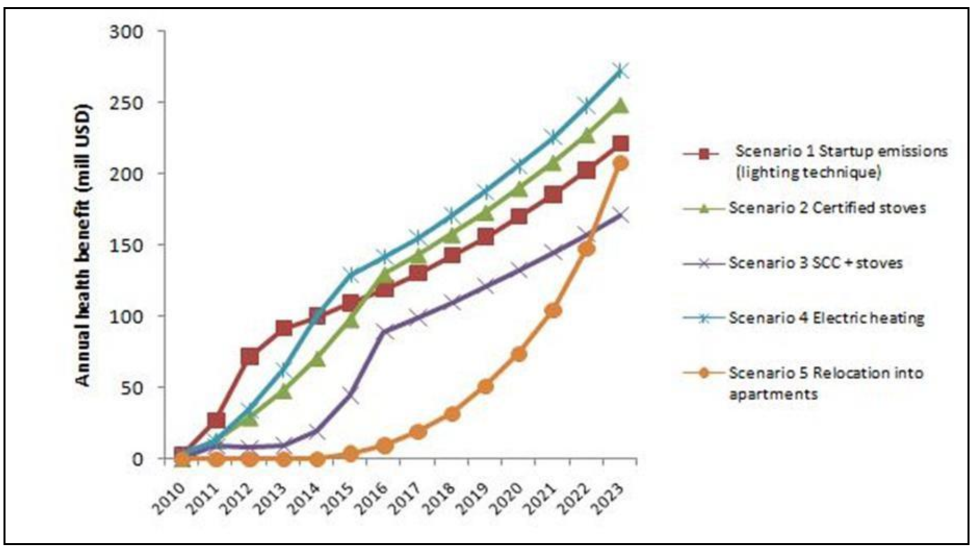
[23] Portable wooden homes traditionally used by Mongolian and other Central Asian nomads.

and international (agencies of Japan, Germany, France, and the Republic of Korea) institutions, and international experts on epidemiology and health research and economists in the AQM planning process.

Actions: The AMHIB study established that small stoves in about 150,000 Gers at the time of the study were the main source of PM in Ulaanbaatar and examined nine options for reducing air pollution: (a) reducing start-up emissions by backlighting the fire, (b) reducing start-up emissions through stove modifications, (c) replacing existing stoves with cleaner stoves and no fuel change, (d) replacing the existing stoves and fuel with cleaner stoves and semi-coked coal, (e) installing electric heating in Ger homes, (f) relocating Ger households into apartment buildings, (g) improving heat-only boilers, (h) cleaning streets to reduce road dust suspension, and (i) greening urban areas to prevent dust suspension.

Of the initial nine options, five were found to provide the highest health benefits (Figure 5.1). The abatement options that provided the highest net benefit, that is, monetary value of reduced health impact minus the cost of the abatement, were also examined. The immediate-term option with the stove start-up modification gave the highest net benefit, while improved stoves and fuels and the medium-term option with electric heating in the Gers gave significant benefits. The long-term option of moving Ger households into apartments was very costly while street cleaning and city greening had only limited health benefits. Realizing the health benefits lost (that is, the cost of not applying immediate abatement options, in favor of longer-term options such as relocation of Ger households to apartment buildings), the government decided to go ahead with a program to replace existing stoves with clean, certified stoves.

Figure 0.1. Health benefit projections under various abatement scenarios in Ulaanbaatar

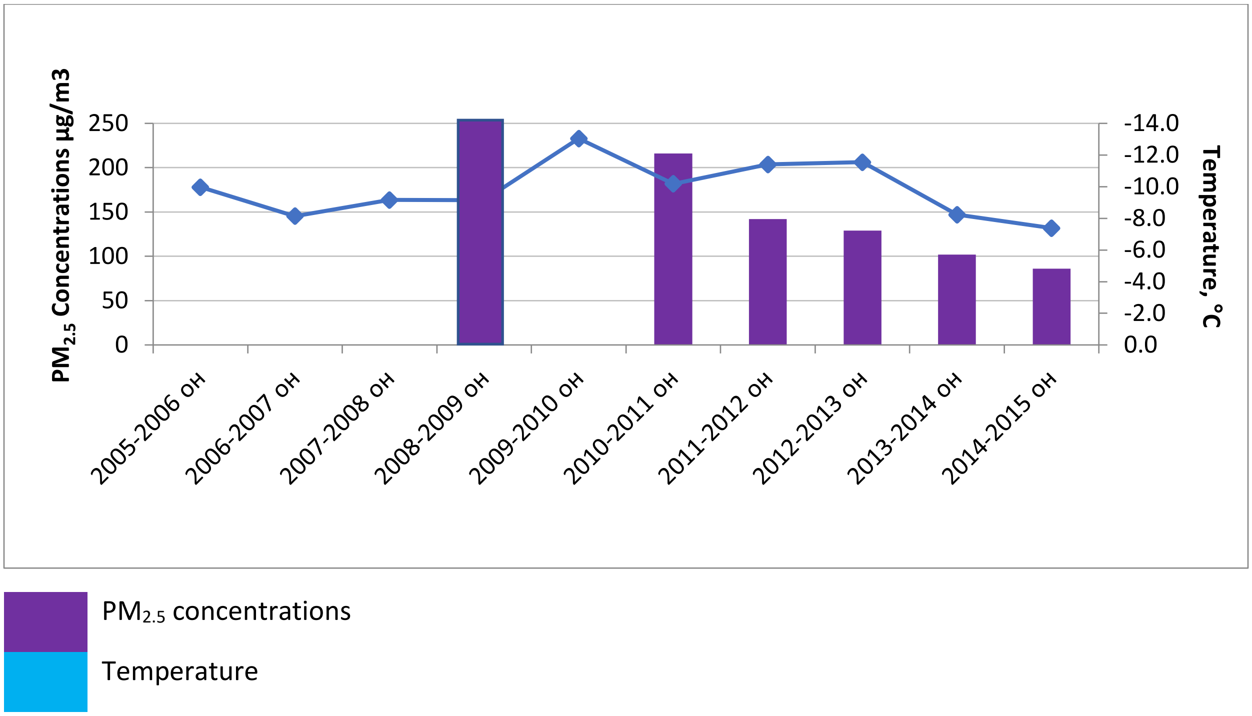


Source: World Bank 2011.

Results. Following completion of the full-scale AQM plan, the Ulaanbaatar Clean Air project, supported by a loan from the World Bank, implemented the immediate intervention of replacing stoves in Ger households with cleaner, more efficient models. Between 2011 and 2015, the Millennium Challenge Corporation, the World Bank, and the Government of Mongolia distributed more than 168,000 stoves representing 91 percent of the households that used coal-fueled stoves for cooking. Importantly, households received a subsidy that reduced the costs of replacing the stoves. During 2011–2013, the average subsidy was equivalent to 91 percent of the cost and was eventually reduced to 66 percent during 2014–2015. Subsequently all 180,000 households were covered by the stove replacement program.

The implementation of the different measures to improve air quality—among which replacing stoves with cleaner, more efficient models was the most important immediate intervention—has resulted in clear improvements in air quality in Ulaanbaatar (Figure 5.2). Air pollution remains high, which underscores the need to broaden implementation of additional, multisectoral interventions to reduce pollution emissions in the medium to long term.

Figure 0.2. PM2.5 concentrations in Ulaanbaatar 2005–2015

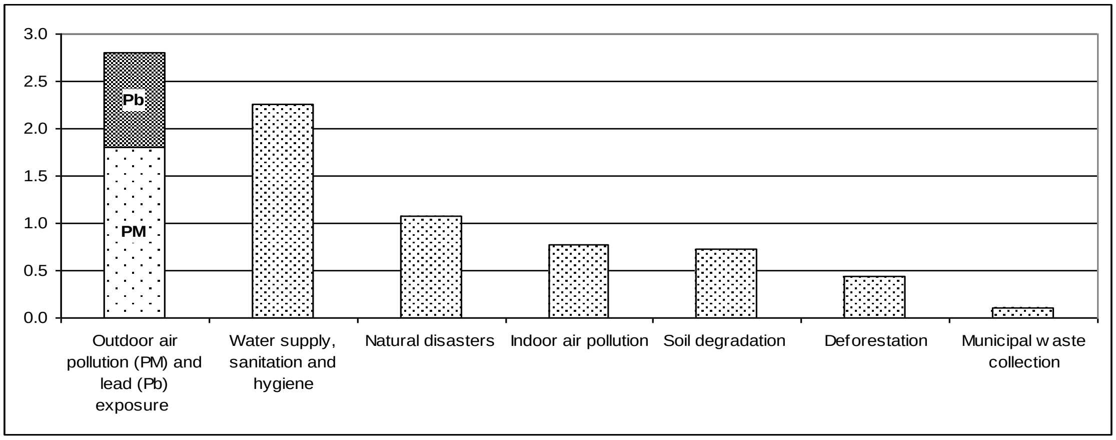


Source: Lodoysamba 2016.

Reducing Air Pollution from Mobile Sources in Peru

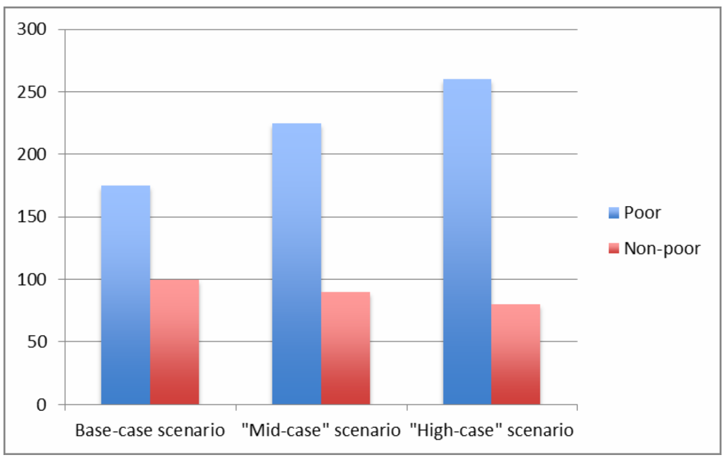
Background. By the early 2000s, the Government of Peru had identified environmental degradation as a significant challenge for sustained economic growth. Upstream analytical work, specifically a Country Environmental Analysis (CEA) for Peru, was conducted with World Bank support. According to the CEA, the main categories of environmental degradation had an estimated cost of PEN 8.2 billion, an amount equivalent to 3.9 percent of Peru's GDP in 2003. Poor air quality in urban areas—from PM and ambient lead—accounted for the largest share of the health damage, which jointly amounted to about PEN 2.8 billion or 1.3 percent of GDP (Figure 5.3). AAP caused about 3,900 premature deaths annually, and about 2,200 children suffered enough IQ loss to cause mild mental retardation associated with lead exposure. Air pollution was particularly severe in urban areas and industrial corridors such as Lima-Callao and Arequipa, the two largest cities in Peru. The CEA showed that poor people disproportionately carried the health burden of air pollution, with impacts on the poor more than three times higher than on non-poor people, relative to income (Figure 5.4).

Figure 0.3. Annual cost of environmental degradation (PEN, billions)



Source: World Bank 2007.

Figure 0.4. Health impacts of AAP on poor and non-poor people in Lima-Callao

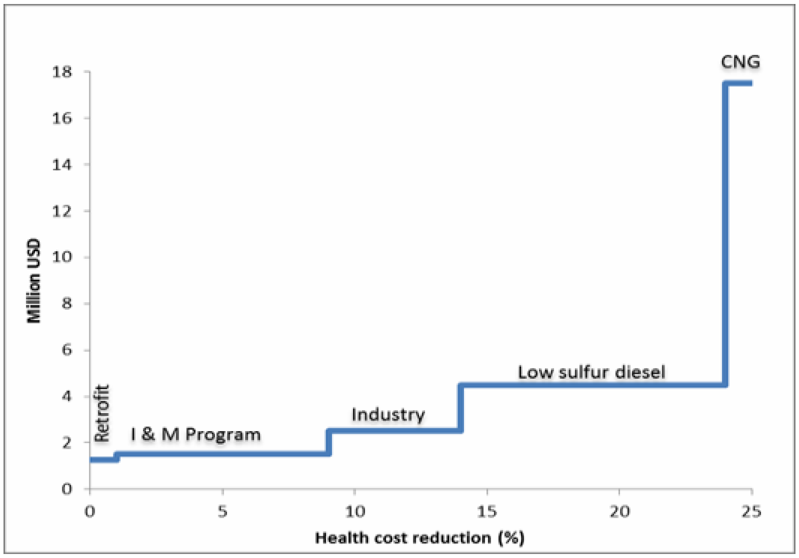


Source: Larsen and Strukova 2005.

Process. The CEA came from a process of dialogue between the Government of Peru and the World Bank and sharing with country stakeholders, to build consensus around the analysis, and provided the basis for priority setting and decision making to inform the development of the government's program of policy actions to address air pollution. Within this context, 12 options for reducing AAP were examined: (a) introduction of low-sulfur diesel; (b) promotion of use of gasoline-fueled cars instead of diesel through various tax incentives; (c) conversion of gasoline/diesel cars to natural gas; (d) conversion of some vehicles to ethanol or biofuel; (e) development of a new public transport system in Lima, the capital city; (f) provision of tax incentives to scrap older high-use cars (for example, taxis); (g) strengthening of inspection and maintenance programs; (h) retrofit of catalytic converters on cars and particle control technology on diesel vehicles; (i) bans on importation of used cars for taxi use; (j) ban on use of diesel cars and/or two stroke engines as taxis; (k) implementation of various city planning interventions such as 'green traffic light waves' and bike lanes; and (l) introduction of measures to reduce industrial emissions. Some of the options, were not considered in further detail beyond the initial examination due to various reasons. For example, the development of a new public transport system in Lima was not considered due to environmental reasons. Other policies had implications for welfare of transport users and/or affected other sectors, for example, increase in price of cars. Of the initial 12 options, 5 were ranked by comparing the health damage costs associated with a ton of emissions of PM, with the cost of a specific abatement option (Figure 5.5).

- Introduction of low-sulfur diesel
- Inspection and maintenance programs
- Retrofit of particle control technology
- Shift from low-sulfur diesel to CNG
- Reduction of industrial emissions

Figure 0.5. Marginal costs and benefits of interventions to reduce PM emissions in Peru



Source: ECON 2005.

Actions. Building on this analytical foundation, the government undertook a comprehensive and programmatic series of policy and institutional actions to address the severe costs of outdoor air pollution supported by a series of three World Bank loans totaling US$475 million over a two-year period. The government's program entailed tailored interventions to reduce emissions from mobile and industrial sources as well as interventions to strengthen the overall institutional framework for air quality and environmental management. Specific actions included strengthening the framework for air quality standards, emission levels, and air quality monitoring and incorporating environmental sustainability principles in urban transport and industry, the main sectors responsible for driving air pollution in Peru.

A first set of actions taken by the government to reduce air pollution included, among others, (a) reducing sulfur content in diesel; (b) implementing a vehicle scrappage program to replace older, polluting vehicles with newer, natural gas vehicles; (c) enacting a law requiring reduction of sulfur content in diesel; (d) issuing a decree establishing requirements for diesel vehicles to access economic incentives; and (e) establishing standards for the scrapping process. Subsequent actions by the government included the following:

(a) Actions to publish and disseminate air quality monitoring data in the highly polluted cities of Lima and La Oroya, a key center of metal smelting and refining.

(b) Issuance of a decree prohibiting supply of high-sulfur diesel (more than 50 parts per million sulfur content) in the metropolitan areas of Lima-Callao.

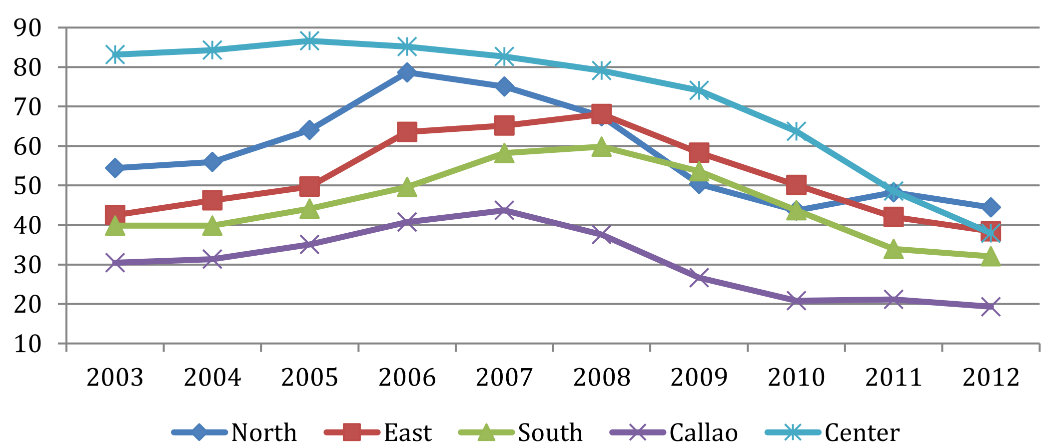
(c) Institutional measures to ensure continued funding of the vehicle conversion programs.

(d) Issuance of regulations to implement a vehicle inspection and maintenance program designed to remove highly polluting vehicles from the streets of Lima-Callao. Vehicles operating on public roads in this region were required to submit to a mandatory technical inspection for certifying the proper functioning and maintenance of motor vehicles and compliance with emission standards. As a result of these measures, approximately 1,000,000 vehicles are inspected yearly in Lima, and some 80,000 vehicles are inspected in the rest of the cities.

(e) Adoption of an investment plan for the modernization of Petróleos del Perú S.A.'s (PETROPERU) refinery that reduces the sulfur content in diesel.

Results. As a result of the comprehensive package of policy reforms and interventions adopted by the government of Peru between 2009 and 2011, air quality improved markedly in the Lima-Callao region (Figure 5.6). Additional results included (a) inspection of 585,000 vehicles conducted compared to the baseline of 60,000 vehicles; (b) conversion of 83,000 vehicles to CNG; (c) all stations in Lima-Callao supplied with clean low-sulfur diesel by 2010, and 100 percent coverage was achieved in four additional major cities by 2012; and (d) the number of service stations supplying natural gas in Lima rose from 0 to over 90.

Figure 0.6. Annual concentration of $PM_{2.5}$ in Lima-Callao, 2003–2012 (μg/m^3; 3-year average)



Source: Macizo and Sanchez, forthcoming.

Reducing Polluting Emissions through Multisectoral Interventions in China

Background. The Beijing-Tianjin-Hebei region (also known as Jing-Jin-Ji) has some of the most severe air pollution problems in China. Hebei Province is responsible for about 70 percent of emissions in the region. In 2012, the annual average concentration of ambient $PM_{2.5}$ was 112.9 μg/m^3, compared with 88.3 μg/m^3 in Beijing. Air pollution is caused by the high concentration of polluting industries, vehicles, and a large agricultural sector. Hebei is the largest iron and steel producer in China, accounting for about one-quarter of the national output. The power sector is almost entirely fueled by coal and nearly one-third of total installed capacity (15 out of 49 GW) was added since 2010. Hebei is also an important cement producer, having 21 plants with a total production capacity of 58.3 Mt per year, which is nearly 10 times the combined production capacity of Beijing and Tianjin of 6.3 Mt per year. In addition, the province accounts for 17 percent of national flat glass production. The agriculture sector is an important source of secondary PM pollution associated with NH_3 emissions from use of nitrogen-based fertilizers and livestock waste management.

As part of national efforts to improve air quality, the State Council of China issued the National Air Pollution Control Action Plan (the 'Ten Measures') in September 2013. According to the Action Plan, the Jing-Jin-Ji region was required to reduce concentrations of ambient $PM_{2.5}$ by 25 percent by 2017, compared to 2012. To achieve this goal, municipal, provincial, regional, and national governments implemented a comprehensive set of air quality improvement measures between 2013 and 2017 that targeted polluting emissions from coal, industrial sources, and mobile sources, as well as interventions to improve environmental management.

Process. In support of the government's program, the World Bank built on its long-term engagement on environmental, energy efficiency, and renewable energy topics in China, including analytical work and technical assistance, as well as established dialogue with different sectors across the government. To this end, the World Bank provided support to the Government of China to implement multisectoral interventions to address air pollution through two lending projects providing Program-for-Results (PforR) financing: the Hebei Air Pollution Prevention and Control Project (US$500 million) and the Innovative Financing for Air Pollution Control for Jing-Jin-Ji Project (US$500 million) (World Bank 2016a, 2016b).The PforR financing supports the government's program and links disbursements to the achievement of results on the ground. Through the process of preparing these projects, the World Bank systematically reviewed the measures contained in the government's programs and plans; mobilized grant funding; and deployed international expertise and best practice across various relevant disciplines to provide technical assistance to the government for the identification, selection, and design of substantive actions that could be used as disbursement-linked indicators (DLIs) for the two projects. In addition, the process involved collaboration with think tanks, academia, and other development partners working on air quality issues in China.

Actions. The Hebei PforR Project aimed to reduce emission of specific air pollutants from industry, rural areas and vehicles, and to improve air quality monitoring in Hebei. The Jing-Jin-Ji PforR Project aims to reduce air pollutants and carbon emissions through increasing energy efficiency and clean energy in Jing-Jin-Ji and neighboring regions.

Under the **Hebei PforR**, among the key actions taken to reduce polluting emissions are the following:

- **Continuous air emissions monitoring in industry and other point sources.** The province of Hebei is strengthening the system of continuous emissions monitoring (CEM) for air emissions and, to date, has broadening its implementation by Environmental Protection Bureaus (EPBs) at the provincial and prefecture levels for enforcing emission standards. To date, 12 EPBs are implementing the CEM. In addition, the government strengthened implementation and expanded the coverage of the CEM system for industrial and other point sources of pollution. Currently, all state- and municipal-controlled enterprises have been integrated into the CEM system.

- **Installation of clean stoves in households.** The government strengthened technical standards for clean and efficient stoves and provided incentives for adoption of clean stoves that use processed biomass or coal briquettes, by rural households. More than 1,200,000 clean stoves have been installed.

- **Adoption of environment-friendly fertilizers.** The actions aimed to support the adoption by farmers of environment-friendly, slow-release fertilizers that increase efficiency of nitrogen use based on soil testing and nutrient needs of crops. Nitrogen utilization efficiency has been increased in over 2 million ha of land planted with wheat.

- **Replacement of diesel buses with clean energy buses.** To reduce vehicular emissions, the government targeted urban public transport to accelerate the elimination of diesel buses, their replacement with battery and plug-in electric vehicles, and their proper disposal in accordance with national regulations. More than 2,400 diesel buses have been decommissioned and replaced with clean energy buses.

- **Establishment of air quality monitoring and warning systems and planning tools.** The government program supported (a) strengthening of the data collection system to have a comprehensive and complete source and composition inventory of the source structure of both primary and secondary PM and (b) the development of a five-year plan for air pollution prevention and control, using modern ambient AQM planning tools to ensure cost-effectiveness and prioritization.

Under the **Jing-Jin-Ji PforR**, among the key actions taken to reduce polluting emissions are the following:

- **Reduction of coal consumption.** The national government set coal consumption cutting goals, which for Jing-Jin-Ji meant reducing 13 million tons, 10 million tons, and 40 million tons for Beijing, Tianjin, and Hebei, respectively. Measures to achieve these goals included the replacement of coal-fired power generation, upgrading of industrial boilers, switching of thermal power sources, and control of raw coal burning.

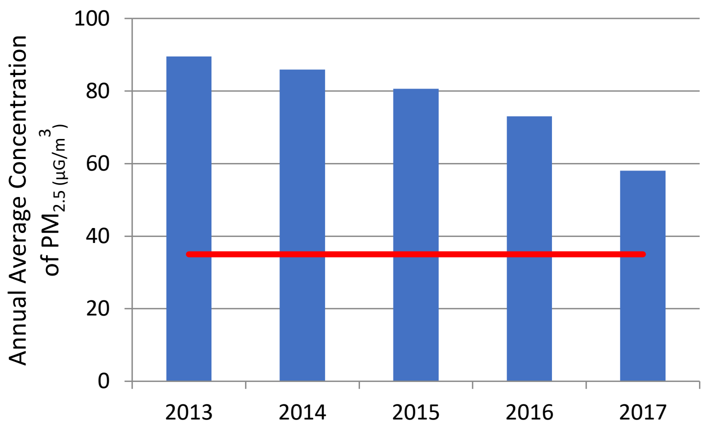
- **Desulfurization, denitrification, and dust elimination.** According to the Action Plan, by the end of 2015, Jing-Jin-Ji and its surrounding areas were expected to build or retrofit 59.7 GW of desulfurization capacity for coal-fired units, add or retrofit 16,000 m^2 of sinter machines for iron and steel manufacturers, add 110 GW of denitrification capacity for coal-fired power plants, and add or retrofit production capacity of 110 million tons of denitrification of cement clinker.

- **Ultralow emission control.** Beginning in 2015, China started the ultra-low emission conversion of coal-fired power stations, which required that the pollutant emissions of these plants have the same emissions levels as those from combustion gas turbines. Nationwide, a total of 444 GW of coal power-generating units are being converted to ultra-low emission units.

- **Optimize industrial structure and eliminate disqualified enterprises.** The national government has revised regulations and requirements for high-energy consumption, high pollution, and resource-intensive industries. It also set new targets for resource and energy conservation and pollutant emissions. Regions with severe pollution problems, such as Jing-Jin-Ji, can adopt even more stringent requirements. As a result, by the end of 2017, more than 60 million tons of steel production capacity was eliminated from the Jing-Jin-Ji region. In addition, coal-fired non-heat and power cogeneration units of less than 100 MW were completely phased out, while the elimination of units of less than 200 MW started.

Results. As a result of the adoption of comprehensive measures to improve air quality, $PM_{2.5}$ concentration in the Jing-Jin-Ji region declined by an average of 39 percent between 2013 and 2017. Air quality improvements have been especially significant in Beijing, where the annual average concentration of $PM_{2.5}$ fell from 89.5 $\mu g/m^3$ in 2013 to 58 $\mu g/m^3$ in 2017 (Figure 5.7). However, $PM_{2.5}$ concentration in the city still substantively exceeds China's national standard. In addition, the share of renewable energy in Beijing increased from about 3 percent in 2010 to 7.6 percent in 2017. The reductions in coal consumption (72.3 million tons) for the region were also accompanied by significant reductions in CO_2 emissions (105.31 million tons).

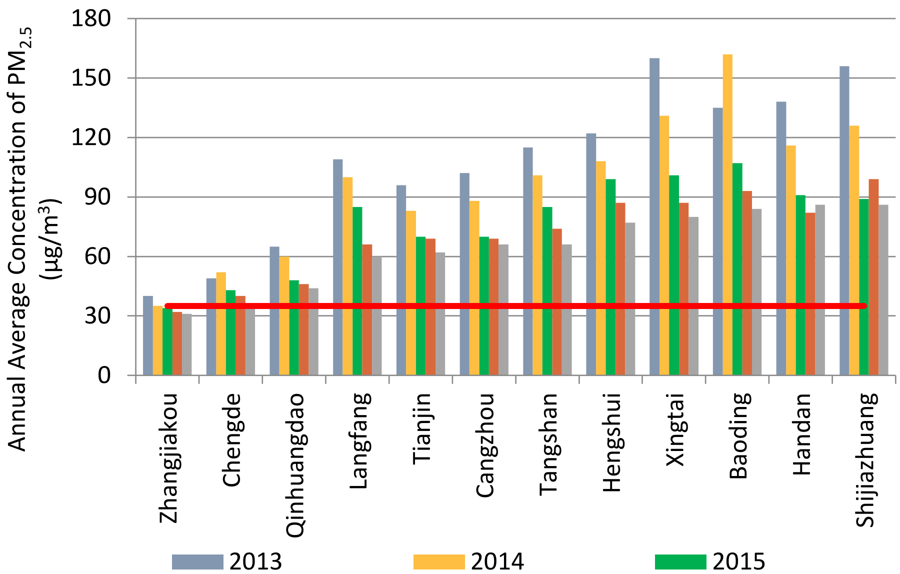
Figure 0.7. Annual average concentration of $PM_{2.5}$ in Beijing from 2013 to 2017



Source: ICCS 2018.

In most cities surrounding Beijing, $PM_{2.5}$ concentrations have been falling constantly, but only two cities (Zhangjiakou and Chengde) met the national standard in 2017. Only in one city (Handan City in Hebei Province) did pollution increase in 2017 compared to the previous year (Figure 5.8). Improving air quality requires sustained commitment to implement comprehensive interventions that result in emissions reductions in the short, medium, and long term, as underscored by the fact that cities continue to exceed China's air quality standards.

Figure 0.8. Annual average concentration of $PM_{2.5}$ for 12 surrounding cities of Beijing in Jing-Jin-Ji Region, 2013–2017



Source: ICCS 2018.

5.3. Conclusions and Lessons Learned

The examples presented in this chapter illustrate the complexity of air pollution and the need for approaches and solutions that are appropriate to the specific city (or urban area) context. Below are some salient conclusions from the Mongolia, Peru, and China examples and lessons learned from their experiences, which may find application in BiH as the government advances in its efforts to tackle air pollution.

The design and implementation of economically effective interventions to successfully reduce air pollution must be underpinned by a solid and rigorous foundation of analytical work to inform the identify and selection of priorities and interventions. As seen in the Peru and Mongolia examples, such analytical work also provides a platform around which various relevant stakeholders can engage and come to informed conclusions about possible interventions and implementation of an appropriate air pollution reduction program.

Interventions for abating air pollution from different sectors are broadly well-known. The selection of specific interventions in a given context should, however, be informed based on analysis of the benefits and costs of implementing the respective intervention. Benefit-cost analysis (BCA) compares the health benefits of an intervention, that is, avoided cost of premature mortality and morbidity due to air pollution, to the cost of implementing the intervention. BCA allows decision makers to rank and prioritize alternative interventions and select interventions that have a benefit-cost ratio (BCR) greater than unity (BCR > 1). This exercise should also take into account existing policy and operational constraints related to performance of existing infrastructure and institutional capacity that could foreclose or limit the implementation of certain air pollution reduction interventions.

Conducting in-depth analytical work is often time intensive and could span several years, as in the case of Mongolia, requiring adequate budgetary resources. It is recognized that in many contexts, the severity of air pollution and its health impacts as well as public pressure on government and city officials to act may call for interventions in the immediate to short term to reduce air pollution. In such cases, a city could consider applying reasonable interventions and policy options that would help alleviate air pollution in the short term such as restricting pollution from known stationary sources or traffic restrictions. However, such short-term actions are unlikely to be able to effectively reduce air pollution in the long term, in particular where air pollution sources are many and varied, and cannot replace a strategic and integrated approach involving rigorous analytical work and engagement of various relevant stakeholders across different sectors (for example, environment, energy, transport, economy, and agriculture), development partners, academia, and others to inform design and implementation of economically effective interventions for sustained or long-term air pollution reduction.

In addition to technical interventions, for example, implementation of a clean stove program or installation of emission reduction technologies in industrial facilities such as in the China example, efforts to reduce air pollution should incorporate the use of a menu of instruments, including command-and-control, market-based, and economic instruments such as in the Peru example where a law was enacted to reduce sulfur content of diesel and a regulation was issued to implement a vehicle inspection and maintenance program (command-and-control) and use of economic incentives for replacement of diesel vehicles with cleaner vehicles. Setting air quality targets, as shown in the China example, is also an important aspect of improving air quality, and government commitment to achieving targets is required, including through supporting requisite analytical work for developing realistic and achievable targets.

Air pollution disproportionately affects people of lower economic status compared to non-poor people. It is important that policies to reduce air pollution take into account distributional and social impacts on affected populations in different income groups. Poverty and social impact analysis could be used to understand distributional impacts of policies to reduce air pollution to ensure that poor and vulnerable groups of people do not disproportionately carry the burden associated with implementation of such policies. For example, poorer people are more likely to drive older, polluting vehicles. Poor people are also more likely to burn cheap and highly polluting fuels for domestic purposes. Therefore, policies that prohibit the use of old, polluting vehicle in favor of newer, clean vehicles could incorporate financial or other suitable incentives for poorer people to comply with the policies. Similarly, programs to promote replacement of polluting stoves with clean, efficient stoves should incorporate incentives that will help low-income households transition to burning cleaner fuels.

Some ongoing efforts by various development partners to support BiH’s efforts to reduce air pollution were highlighted in the previous chapter. Moving forward, stocktaking of the outcomes of these efforts and identification of opportunities where investments and policy and institutional actions can augment impacts on air quality supported by appropriate financing mechanisms could be useful in informing the government’s next steps. Stocktaking and identification of opportunities and financing mechanisms should be coordinated among donors and conducted in collaboration with the government. Government commitment to undergird and build upon the outcomes of ongoing donor support by ensuring sustained and adequate human and budgetary support will be crucial for sustained impact in reducing air pollution.

Chapter 6. Recommendations for AQM in Bosnia and Herzegovina

Table 6.1. Summary of recommendations for AQM in BiH

Recommendation	Time frame
Legal and policy framework	
Strengthen the legal framework, focusing on specific instruments that reduce pollution from mobile sources, large stationary sources, and district heating.	Short to medium term
Harmonize regulations on sulfur content in liquid fuels at the country level and in compliance with the EU Directive on sulfur content in liquid fuels (1999/32/EC).	Short term
Harmonize timelines for achieving ambient air quality standards for specific pollutants; fully transpose EU legislation that relates to the National Emissions Ceilings Directive, control of volatile organic compounds from petrol storage and distribution, petrol vapor recovery during refueling of ore vehicles at service stations, and limit values for industrial emissions for new plants.	Short to medium term
Adopt and implement legislation on environmental inspections for air pollution sources.	
Strengthen the legal framework by adopting and implementing a menu of air pollution management instruments, including economic and market-based instruments.	Medium term
Introduce more stringent standards for solid fuel quality for use in households.	Short to medium term
Scale up adoption and implementation of local AQPs.	Short to medium term
Air quality, emissions, and health data and analysis	
Strengthen the air quality monitoring network to provide reliable time series data on pollutants, notably $PM_{2.5}$, including clear protocols and procedures to strengthen QA/QC related to monitoring, data analysis, management, and reporting.	Short term
Expand air quality monitoring to include chemical constituents and species of PM such as pollutants including elemental carbon, organic carbon, sulfates, associated with combustion processes; $PM_{2.5}$ precursors including SO_2, NO_x, NH_3, and NMVOC; BC; and metals such as lead.	Short term
Improve meteorological observation for Sarajevo valley area, background monitoring data, and a comprehensive inventory of pollutants to improve air quality modeling.	Short to medium term
Develop an inventory of stationary and mobile air pollution sources prioritizing the residential sector and addressing all pollutants including BC: (a) **Residential.** Strengthen information on solid fuel statistics, burning of waste in the residential sector, typical solid fuel quality, and combustion technology used in the country. (b) **Transport**. Address uncertainties related to vehicle age and imported used vehicles, address all pollutants including BC, and conduct source apportionment analyses in large, densely populated urban centers.	Medium term
Consolidate a centralized and consistent depository of air quality data collected across the country and build the capacity to conduct modeling and speciation efforts.	Medium to long term
Harmonize country health reporting with international systems of disease classification, that is, the International Statistical Classification of Diseases and Related Health Problems.	Short to medium term
Improve collection and reporting of morbidity data by disease and age group.	
Strengthen capacity for conducting health risk assessments for individual industrial facilities.	
Reducing pollution from different sectors/sources	
Residential: (a) Implement a pilot program to replace polluting stoves and boilers with more efficient ones, including Ecodesign stoves, and build on lessons learned	Short to medium term

Recommendation	Time frame
and experience to date to develop a large-scale program; (b) put in place targeted financial incentives to help poor households adopt clean, efficient stoves; and (c) implement public awareness campaigns to promote stove replacements.	
Where approved local environmental action plans exist that contemplate interventions such as increased gas connections and expansion of district heating, conduct (a) cost-benefit analysis to inform selection of interventions and (b) analysis of distributional impacts of proposed interventions.	Medium to long term
Mobile sources: (a) revision of liquid fuel quality standards to make them more stringent; (b) establishment of additional economic incentives to replace older vehicles with more modern, cleaner vehicles; (c) stricter enforcement of measures to reduce importation of old, polluting vehicles, including requirement for inspections at point of entry; (d) establishment of mandatory monitoring and inspection programs that are strictly enforced; and (e) inclusion of criteria related to vehicle use and maintenance in parameters for ECO tests for vehicles.	Medium to long term
Transboundary: Establish, together with neighboring countries, a technical knowledge platform on transboundary pollution.	Short to medium term
Organizational framework for AQM	
Strengthen capacity of agencies with responsibilities for AQM at the FBiH, RS, and BD levels and provide staffing with requisite expertise and adequate budgetary resources. Areas where staff capacity could be enhanced include source apportionments, inventory development, air quality modeling, and health impact analysis.	Short term
Bolster inter-sectoral coordination, particularly between environmental authorities and other sectors such as health as well as transport, industry, energy, urban development, and agriculture whose activities affect air quality. Include criteria for priority-setting, accountability mechanisms that cover relevant stakeholders, monitoring and evaluation of outcomes, and social-learning mechanisms to promote continuous improvement.	Short to medium term
Strengthen MOFTER and the Inter-Entity Coordination Body for the Environment to facilitate harmonization of legal, policy, and organizational frameworks.	Medium term
Strengthen horizontal and vertical coordination by establishing formal and permanent mechanisms for AQM policy development, implementation, monitoring, and evaluation.	Medium to long term
Establish reference laboratory for country and institute inter-laboratory calibration exercises.	Medium term
Strengthen effectiveness of environmental funds, established in the FBiH and RS, in addressing air pollution, by clarifying and developing criteria for prioritizing and selecting projects or activities to which funds are allocated and enhancing transparency related to the allocation of proceeds from fees to specific projects that reduce air pollution.	
Public participation and stakeholder engagement	
Develop an AQI to disseminate information to the public in a manner that is easily understandable and accessible to diverse audiences and facilitate issuance of health-related air quality alerts, for sensitive population groups and to the population as a whole, when necessary.	Short term
Develop public disclosure mechanisms for emissions reporting by operators of facilities.	Medium to long term
Enforcement	
Expand the number of inspectors and provide them with training and resources to conduct field investigations.	Short term

Recommendation	Time frame
Put in place third-party verification of emissions reported by operators of polluting facilities.	Short to medium term
Put in place regulations to legally allow household inspections.	Short term
Strengthen enforcement by clarifying sanctions for noncompliance, increasing fines, and expanding the range of sanctions, in particular for stationary sources.	Medium term

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Annex A. Overview of Major Air Pollutants

Table A.1. Major air pollutants

Pollutant	Full name	Description
PM	Particulate matter	Airborne PM includes a wide range of particle sizes and different chemical constituents. When inhaled, PM can cause inflammation and worsen heart and lung diseases, which can lead to premature death. Fine and ultrafine PM are particularly harmful, as they tend to penetrate deepest into the lungs due to their smaller size. $PM_{2.5}$, a known carcinogen, is most documented for its adverse health impacts. Primary particles are emitted directly from a source, such as combustion of fossil fuels, especially coal and diesel, in vehicles and industry, domestic heating and cooking, construction, and burning of waste crop residues. Secondary particles, on the other hand, are formed in complicated atmospheric reactions among gases that are emitted from power plants, industries, agricultural practices, and automobiles. Key precursors of secondary PM are SO_2, NO_x, and NH_3.
SO_2	Sulfur dioxide	SO_2 is a colorless gas with a sharp odor, produced by combustion of fossil fuels and the industrial refining of ores that contain sulfur. Its oxidized form, also known as sulfate, is a particulate. SO_2 can affect the respiratory system and irritate the eyes.
NO_x	Nitrogen oxides	Major emission sources of NO_x include automobiles and combustion in power plant boilers and industrial activities. NO_2 is a gas which, at higher concentrations, can irritate the airways of the lungs, increasing the symptoms of those suffering from lung diseases. It also contributes to the formation of ground-level O_3 and fine particle pollution. It is chemically related to nitric oxide (NO) and together NO_2 and NO are known as NO_x.
O_3	Ozone	O_3 is a gas which can adversely affect the respiratory system even at relatively low levels. O_3 is the most complex of the legislated pollutants, and therefore the hardest to reduce, as it is not emitted directly from any source. Instead it is formed in the atmosphere by photochemical reactions in the presence of sunlight and precursor pollutants, such as NO_X and volatile organic compounds. It is also destroyed by reactions with NO_2. Tropospheric (ground level) O_3 is a contributor to global climate change.
Toxic air pollutants	Toxic air pollutants	The air toxics are a cluster of pollutants that are implicated in higher cancer rates and higher rates of immune or neurological damage, genetic defects, and/or heart and respiratory issues. Members of this group include benzene, PAHs; polychlorinated biphenyls; and volatile organic compounds, dioxins, and furans, which are products of incomplete combustion of carbon-based fuels. Air toxics can come from mobile sources, stationary sources, or some indoor sources, such as certain solvents or building materials. Their damage is directly correlated to overall levels in the body. They can accumulate in the body's fatty tissues and can be passed to infants through breast feeding. One member of this group is the carcinogenic benzo[a]pyrene (B[a]P), which is a polycyclic aromatic hydrocarbon. Major sources of PAHs in ambient air include residential and commercial heating with wood, coal, or other biomasses; motor vehicle exhaust (especially from diesel engines); industrial emissions; and forest fires.
Heavy metals	Heavy metals	Human populations can suffer morbidity and mortality from certain heavy metals that are sometimes found in the air. Lead is the most important heavy metal for health globally, given its widespread distribution at concentrations that may damage health. Prolonged exposure to lead is linked to neurological and developmental damage in children. In addition to lead, this group includes arsenic, cadmium, manganese, mercury, and nickel. Arsenic, a carcinogen, is emitted from both natural and anthropogenic sources. Anthropogenic sources are primarily associated with the mining and smelting of base metals, fuel combustion (of waste and low-grade coal), and the use of arsenic-based pesticides.

Annex B. Calculation of the Health Burden Attributed to Ambient Air Pollution

Risk of Mortality Attributed to $PM_{2.5}$

The strongest causal associations are seen between $PM_{2.5}$ pollution and cardiovascular and pulmonary disease. Particles of smaller size reach the lower respiratory tract and thus have greater potential for causing the lungs and heart diseases. As the Lancet review (Landrigan et al. 2017) reports, $PM_{2.5}$ air pollution is associated with several risk factors for cardiovascular disease, including hypertension, increased serum lipid concentrations, accelerated progression of atherosclerosis, increased prevalence of cardiac arrhythmias, increased numbers of visits to emergency departments for cardiac conditions, increased risk of acute myocardial infarction, and increased mortality from cardiovascular disease and stroke.

Hence, epidemiological studies (Landrigan et al. 2017) established that long-term exposure to current ambient PM concentrations lead to a marked reduction in life expectancy. The increase of cardiopulmonary (IHD, stroke, COPD), lung cancer mortality in population over 30 years of age, and LRI mortality in all population are the main reasons for the reduction in life expectancy.

As the WHO project 'Health risks of air pollution in Europe' advised for the use in Europe and based on the established methodology in the World Bank (Heroux et al. 2015; World Bank and IHME 2016), this report estimates risk of long-term mortality associated with air pollution as PAFs of the following diseases (disease codes from GBD 2016 are provided in square brackets):

1. IHD (population above 30 years of age) - [B.2.2]
2. Stroke (population above 30 years of age) - [B.2.3]
3. Lung cancer (population above 30 years of age) - [B.1.11]
4. COPD (population above 30 years of age) - [B.3.1]
5. LRI (all ages) - [A2.2]

This approach allows estimating age-specific mortality attributed to AAP for the most affected population groups. Risks associated with exposure to $PM_{2.5}$ are estimated using methods described in Burnett et al. (2014) that assume supralinear and age-specific (for IHD and stroke) function of relative risk attributed to air pollution. Relative risk estimates for all five diseases in question are consistent with the GBD 2016 study (GBD 2016 Disease and Injury Incidence and Prevalence Collaborators 2017).

PAF translates the annual mortality for LRI, COPD, lung cancer, stroke, and IHD into the health burden attributed to $PM_{2.5}$ exposure. Using the established relative risk functions, the PAF by disease (LRI, COPD, lung cancer, stroke, and IHD) from $PM_{2.5}$ exposure is calculated using the following formula, for each age group l and for each disease outcome k:

$$PAF_{kl} = \frac{\sum_{i=1}^{n} P_i(RR-1)}{\sum_{i=1}^{n} P_i(RR-1)+1},$$

where, i is the level of $PM_{2.5}$ in μg/m^3, P_i is the percentage of the population exposed to that level of air pollution, and RR is the relative risk of mortality due to $PM_{2.5}$ exposure.

Then the disease burden (B) in terms of annual cases of disease outcomes due to $PM_{2.5}$ exposure is estimated by

$$B = \sum_{k=1}^{t} \sum_{l=1}^{s} D_{kl} PAF_{kl},$$

where D_{kl} is the total annual number of cases of disease, k, in age group, l, and PAF_{kl} is the attributable fraction of these cases of disease, k, in age group, l, due to $PM_{2.5}$ exposure. Additional information on the applicable functions can be found in the following sources: GBD 2016 Disease and Injury Incidence and Prevalence Collaborators (2017); Ostro et al. (2018); and World Bank and IHME (2016).

Annex C. Valuation of Mortality and Morbidity Attributed to Ambient Air Pollution

Welfare Approach for Valuation of Mortality Cases

The VSL is estimated for BiH to monetize risk of mortality cases associated with air pollution. The range in cost is due to the range of baseline VSL in Organisation for Economic Co-operation and Development (OECD), as first suggested in the OECD study (Lindhjem et al. 2011) and updated in (Narain and Sall 2016), and different elasticity of willingness to pay to avoid health risk. The baseline VSL is selected as the mean for high and median for low of VSL estimated in the OECD studies (Narain and Sall 2016).

For transfers between countries VSL should be adjusted with the difference in GDP per capita in purchase power parity (PPP) coefficient to the power of an income elasticity of VSL of 1–1.4 (Narain and Sall 2016), for low- and middle-income countries. Application of PPP for VSL estimation requires adjustment of the estimated VSL back to market prices.

VSL estimates can be transferred from OECD countries to BiH using benefits transfer method, which posits that

$$VSL_{BiH\ in\ PPP} = VSL_{OECD\ in\ PPP}\left(\frac{Y_{BiH\ in\ PPP}}{Y_{OECD\ in\ PPP}}\right)^{\varepsilon},$$

$$VSL_{BiH} = \frac{VSL_{BiH\ in\ PPP}}{PPP},$$

where

$VSL_{BiH\ in\ PPP}$	=	VSL in BiH in PPP terms (2016)
$VSL_{OECD\ in\ PPP}$	=	VSL in OECD countries in PPP terms (2011)
$Y_{BiH\ in\ PPP}$	=	Per capita GDP in BiH in PPP terms (2016)
$Y_{OECD\ in\ PPP}$	=	Per capita GDP in OECD in PPP terms (2011)
PPP	=	Purchasing power parity for BiH (2016)
ε	=	Income elasticity of VSL

Table C1 presents the derivation of a range of VSL for BiH from low-end (US$0.31 million) and high end (US$0.54 million) VSL estimates in OECD countries (Narain and Sall 2016), using the abovementioned formula. This range of adjusted VSL is used in welfare-based Cost of Environmental Degradation (CoED) estimates in this report.

Table 0.1. Benefit transfer of VSL for BiH

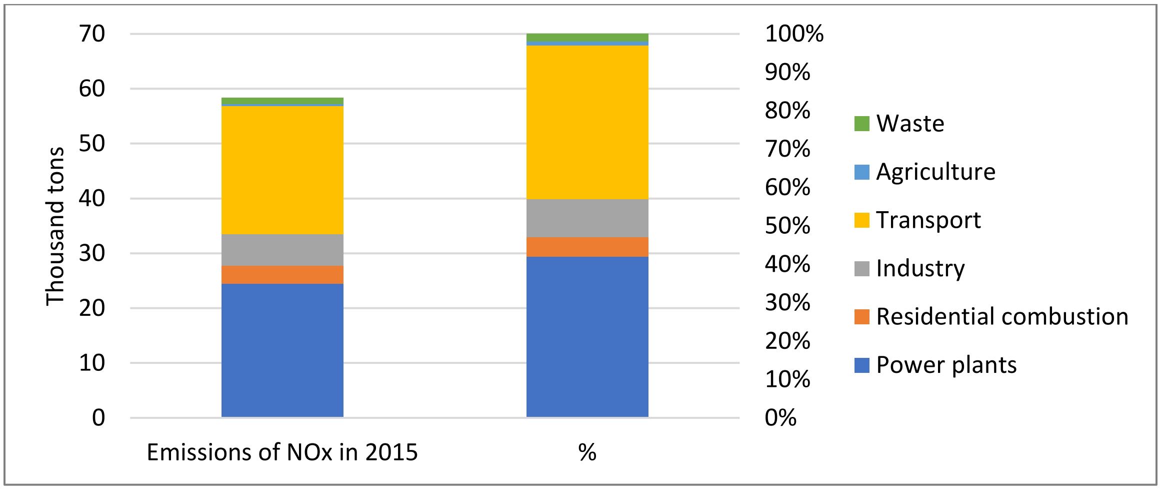
	Low	High
Average VSL estimates from OECD (US$, millions)	3.6	4.1
Country’s GDP (US$, billions) in 2016	16.9	16.9
Country’s GDP PPP (US$, billions) in 2016	42.8	42.80
Population (millions) in 2016	3.46	3.46

	Low	High
GDP per capita (PPP US$) in 2016	12,370	12,370
Average GDP/capita differential	0.33	0.33
Income elasticity of VSL	1.40	1.00
PPP	2.53	2.53
VSL transferred to BiH (US$, millions)	0.31	0.54

Source: Estimated by authors.

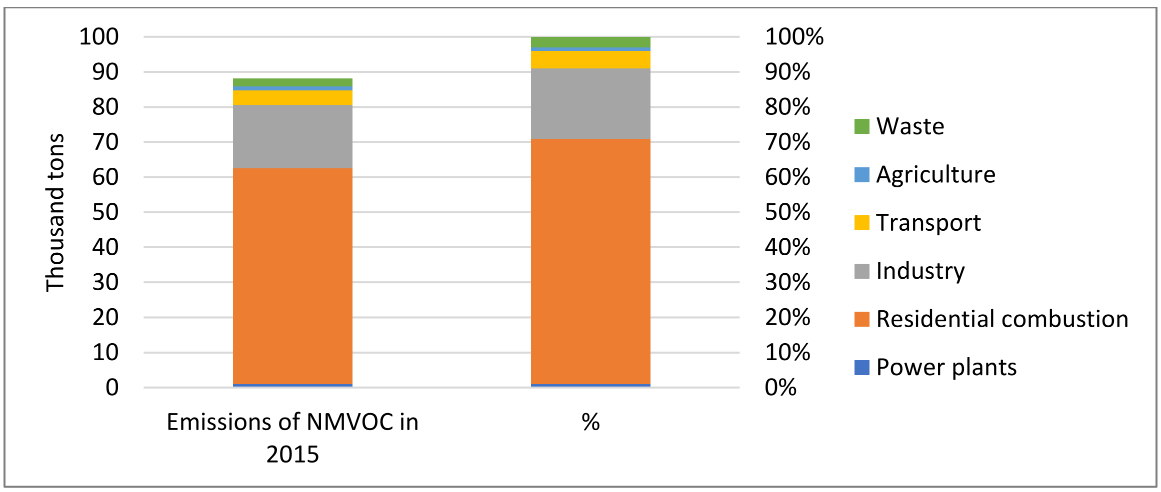
Annex D. Additional Estimates from the GAINS Model for Bosnia and Herzegovina

Figure 0.1. Emissions of NO_x in 2015



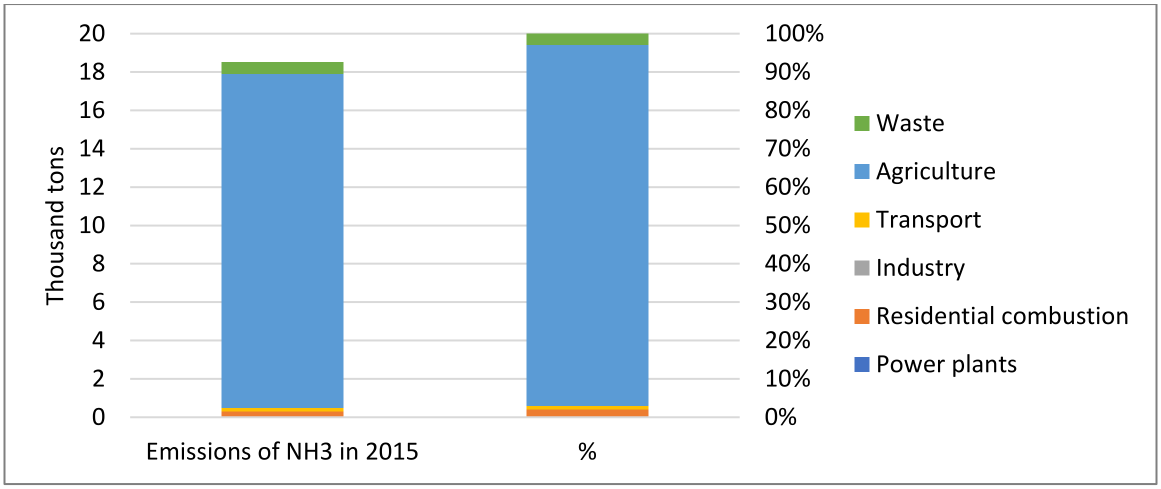
Source: GAINS Model 2018.

Figure 0.2. Emissions of NMVOC in 2015



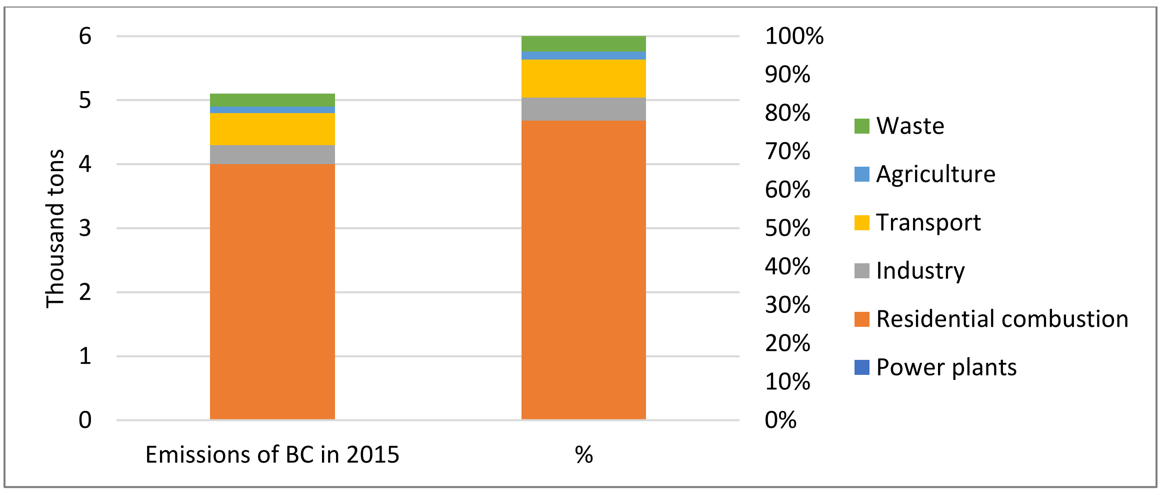
Source: GAINS Model 2018.

Figure 0.3. Emissions of NH3 in 2015



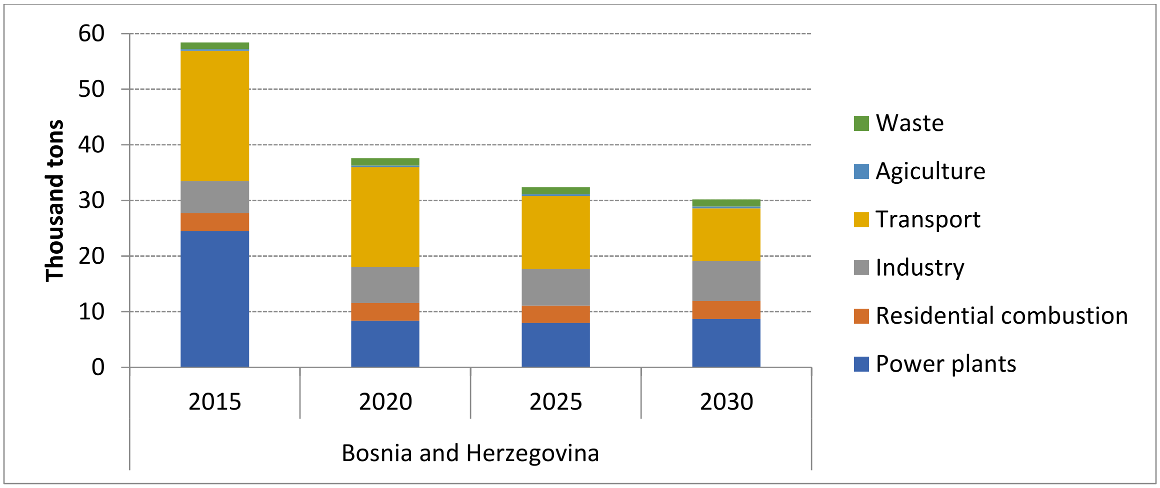
Source: GAINS Model 2018.

Figure 0.4. Emissions of BC in 2015



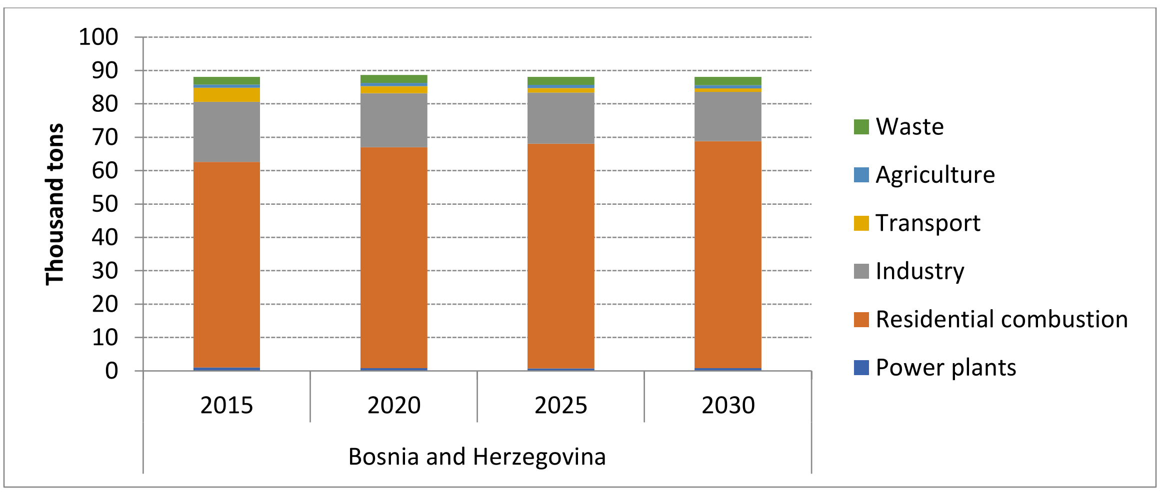
Source: GAINS Model 2018.

Figure 0.5. Emissions of NOx in the baseline scenario



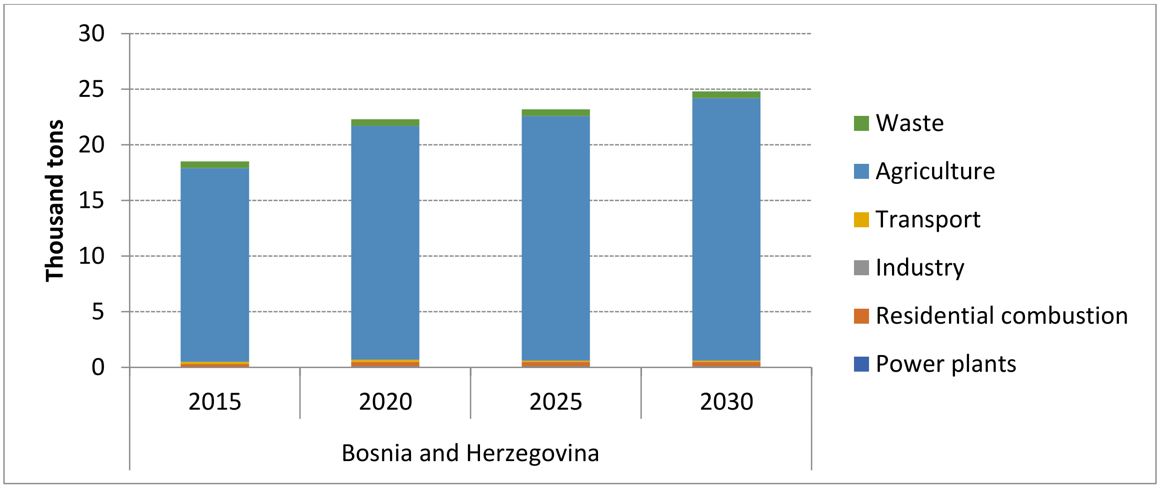
Source: GAINS Model 2018.

Figure 0.6. Emissions of NMVOC in the baseline scenario



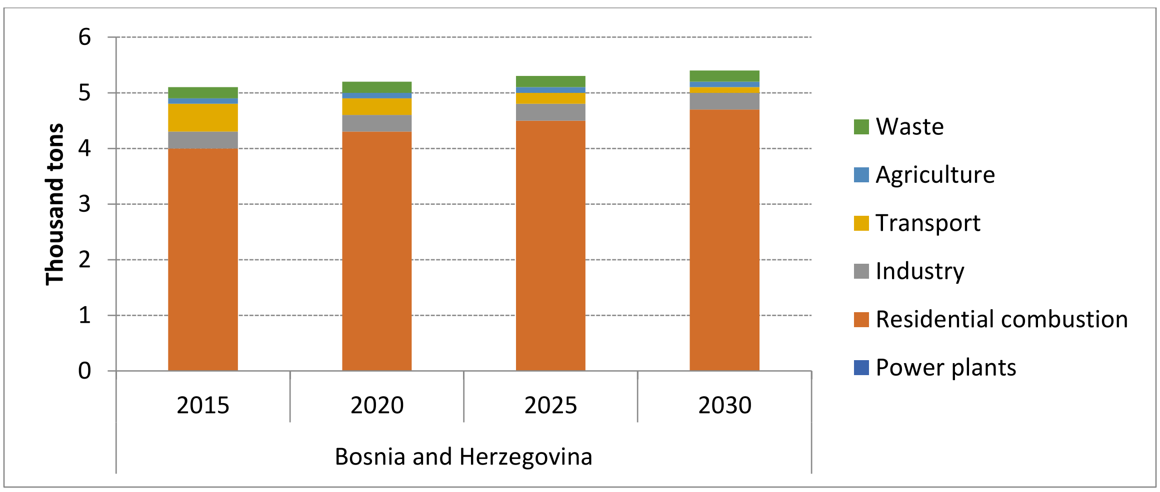
Source: GAINS Model 2018.

Figure 0.7. Emissions of NH3 in the baseline scenario



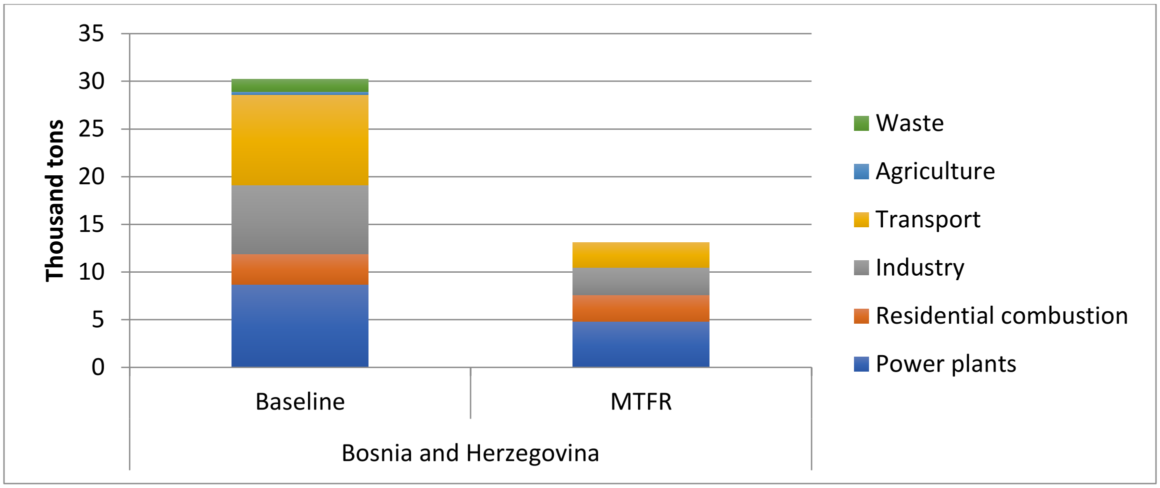
Source: GAINS Model 2018.

Figure 0.8. Emissions of BC in the baseline scenario



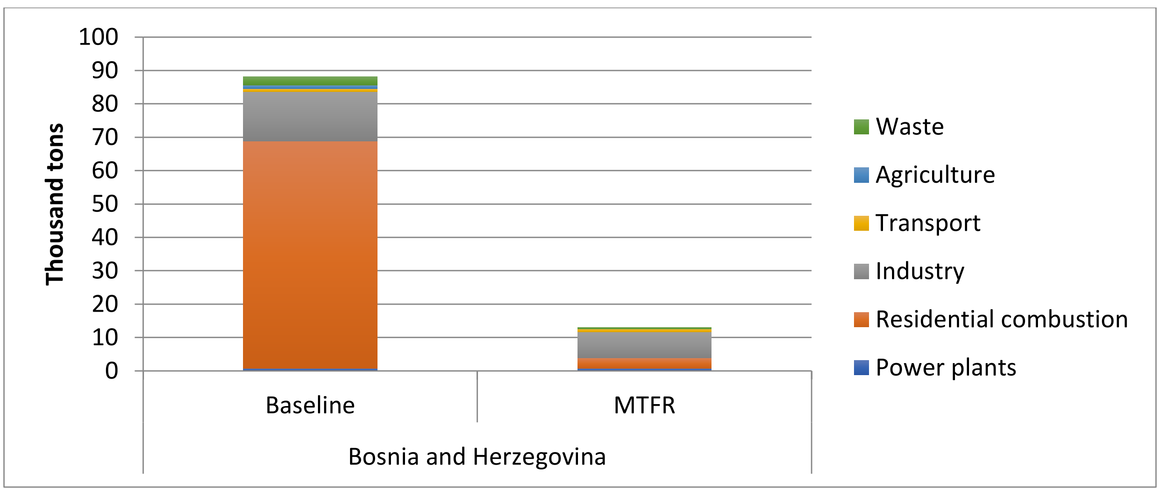
Source: GAINS Model 2018.

Figure 0.9. Emissions of NOx in 2030 for the baseline and the MTFR scenarios



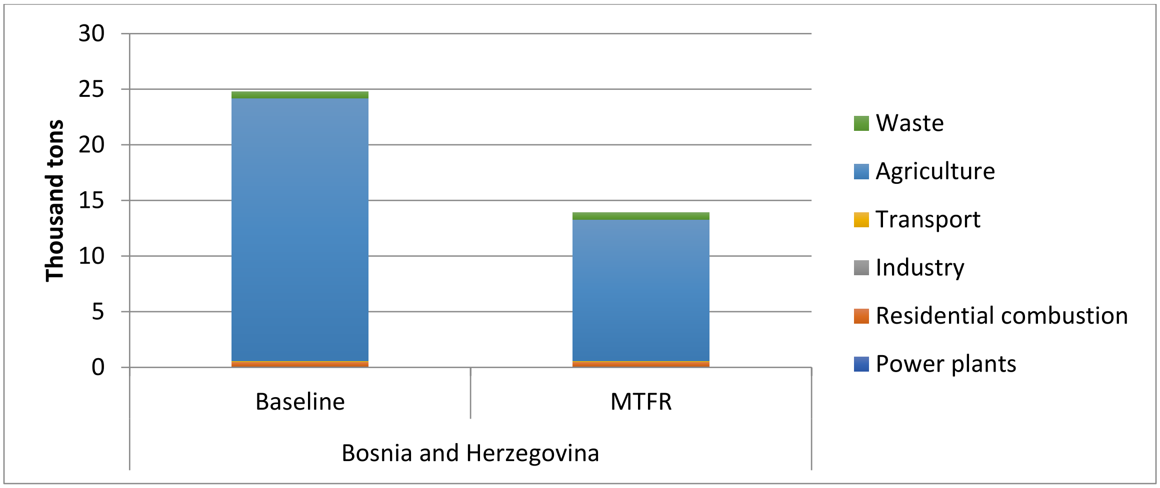
Source: GAINS Model 2018.

Figure 0.10. Emissions of NMVOC in 2030 for the baseline and the MTFR scenarios



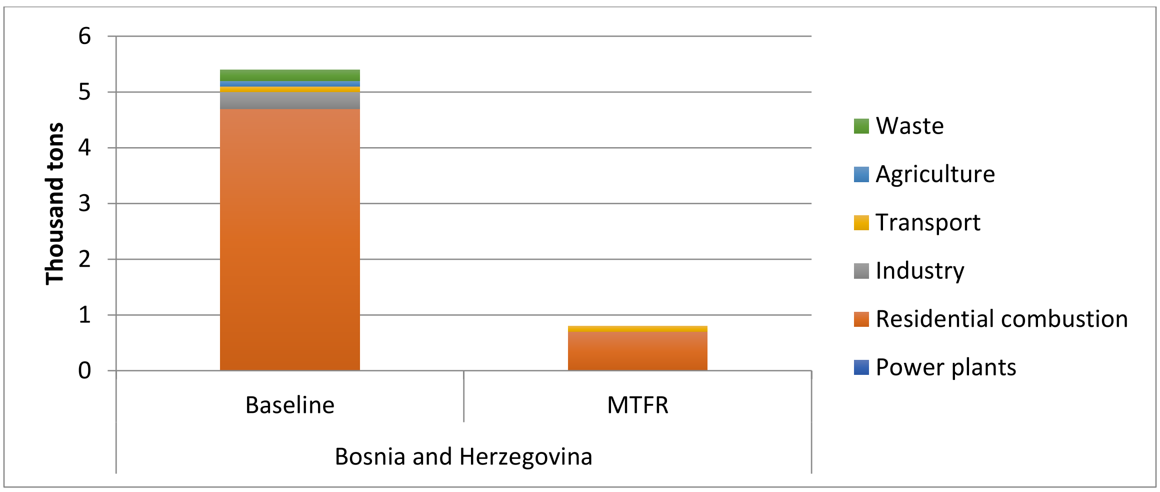
Source: GAINS Model 2018.

Figure 0.11. Emissions of NH3 in 2030 for the baseline and the MTFR scenarios



Source: GAINS Model 2018.

Figure 0.12. Emissions of BC in 2030 for the baseline and the MTFR scenarios



Source: GAINS Model 2018.