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ASSESSMENT OF SHORT-LIVED CLIMATE POLLUTANT MITIGATION IN SERBIA

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REPUBLIC OF SERBIA
Ministry of
Environmental Protection

CLIMATE & CLEAN AIR COALITION
TO REDUCE SHORT-LIVED CLIMATE POLLUTANTS

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ASSESSMENT OF SHORT-LIVED CLIMATE POLLUTANT MITIGATION IN SERBIA

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Contents

1. Introduction

Air pollution and climate change are two of the biggest environmental issues that are faced globally. Exposure to air pollution from indoor and outdoor sources, was associated with 4.9 million premature deaths in 2017 from respiratory and cardiovascular diseases[1]. It is also linked with other non-fatal health impacts, such as adverse pregnancy outcomes, asthma, and emergency room visits. The two pollutants that have the largest effects on human health are fine particulate matter ($PM_{2.5}$) and tropospheric ozone (O_3). According to a 2019 WHO report[2], analysis of the national data shows that nearly 3600 premature deaths every year are attributable to exposure to fine particulate matter measuring ≤ 2.5 μm ($PM_{2.5}$) in 11 studied cities in Serbia.

At the same time, emissions are warming the atmosphere. Since preindustrial times, global average temperatures have increased by 1.1°C, with the Paris Agreement setting the goal of limiting global average temperature increases to 'well below 2°C', and ideally to 1.5°C[3]. Current climate change commitments are estimated to be consistent with over 3°C of warming by 2100[4], and therefore more action is needed to meet the goals of the Paris Agreement and meet these temperature goals. Impacts of climate change include increased frequency of extreme weather events, such as storms, flood, droughts and heatwaves, impacts on agriculture and food security, impacts on human health, and on biodiversity.

The issues of climate change and air pollution are closely linked because, i) in many cases greenhouse gases and air pollutants are emitted from the same sources, and ii) some of the same substances contribute to climate change, and to air pollution impacts, such as methane, black carbon and tropospheric ozone, i.e. the Short-lived Climate Pollutants (SLCPs) (Figure 1). These two linkages provide substantial opportunity to design strategies and identify mitigation measures that can simultaneously reduce air pollution and mitigate climate change. Global and regional studies have shown that there are a variety of strategies and actions that can be taken to target the major sources

[1] https://vizhub.healthdata.org/gbd-compare/

[2] https://serbia.un.org/sites/default/files/2019-10/Health-impact-pollution-Serbia_0.pdf

[3] https://unfccc.int/sites/default/files/english_paris_agreement.pdf

[4] Rogelj, J., Den Elzen, M., Höhne, N., Fransen, T., Fekete, H., Winkler, H., Schaeffer, R., Sha, F., Riahi, K., Meinshausen, M., 2016. Paris Agreement climate proposals need a boost to keep warming well below 2 °c. Nature. https://doi.org/10.1038/nature18307

of SLCPs and simultaneously improve air pollution locally while reducing a countries contribution to global climate change[5] [6].

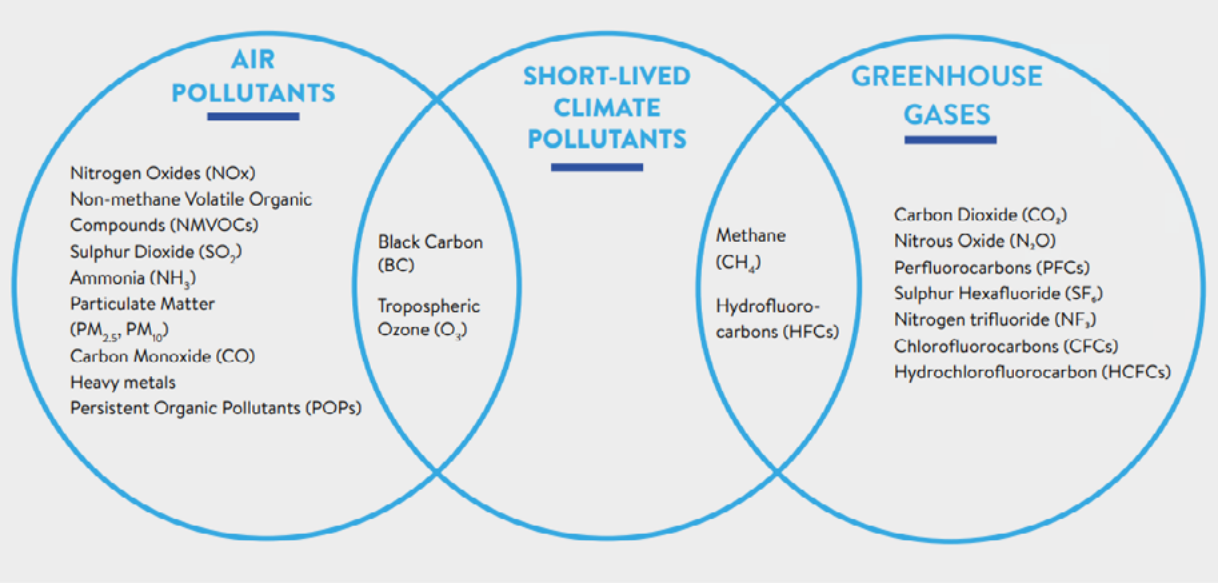


Figure 1: Summary of pollutants that are classified as air pollutants, short-lived climate pollutants and greenhouse gases *(source: www.ccacoalition.org)*

The UNEP/WMO (2011) Integrated Assessment of Black Carbon and Tropospheric Ozone was a global assessment of the benefits of taking actions to reduce black carbon and tropospheric ozone. Mitigation measures that targeted the main sources of black carbon and the main sources of methane (a precursor of tropospheric ozone) were evaluated in terms of their impacts on air quality and on climate. In total, 16 measures were identified that provided 90% of the climate benefits from the hundreds of measures that were evaluated. These included 9 measures that targeted black carbon, including measures in the residential, agriculture, transport and industry sectors, and 7 measures that targeted methane in the agriculture, oil and gas and waste sectors (Chapter 3 includes a complete description of these measures). The Assessment calculated that the full implementation of these measures would yield substantial air quality and climate benefits, estimating that by 2.4 million premature deaths would be avoided in 2030 compared to the baseline, as well as 52 million additional tonnes of 4 staple crops (rice, wheat, maize and soy) due to less crop damage from ozone exposure. These air quality benefits are disproportionately achieved locally, in those countries and regions where the emission reductions occur. At the same time, implementation of these measures would also

[5] Shindell, D., Kuylenstierna, J.C.I., Vignati, E., van Dingenen, R., Amann, M., Klimont, Z., Anenberg, S.C., Muller, N., Janssens-Maenhout, G., Raes, F., Schwartz, J., Faluvegi, G., Pozzoli, L., Kupiainen, K., Hoglund-Isaksson, L., Emberson, L., Streets, D., Ramanathan, V., Hicks, K., Oanh, N.T.K., Milly, G., Williams, M., Demkine, V., Fowler, D., 2012. Simultaneously Mitigating Near-Term Climate Change and Improving Human Health and Food Security. Science (80-.). 335, 183–189. https://doi.org/10.1126/science.1210026

[6] https://www.ccacoalition.org/en/resources/opportunities-increasing-ambition-nationally-determined-contributions-through-integrated

avoid 0.5°C of global temperature increase, making an important contribution to limiting global temperature rises when combined with fast and ambitious CO_2 mitigation (Figure 2). Black carbon, methane and tropospheric ozone, together with hydrofluorocarbons, have been called 'short-lived climate pollutants' because of the relatively short time they spend in the atmosphere once emitted (days to two decades), and their simultaneous impacts on climate and air quality (except for HFCs, which just impact climate). This means that actions on SLCPs can quickly produce multiple benefits for air quality and climate change[7].

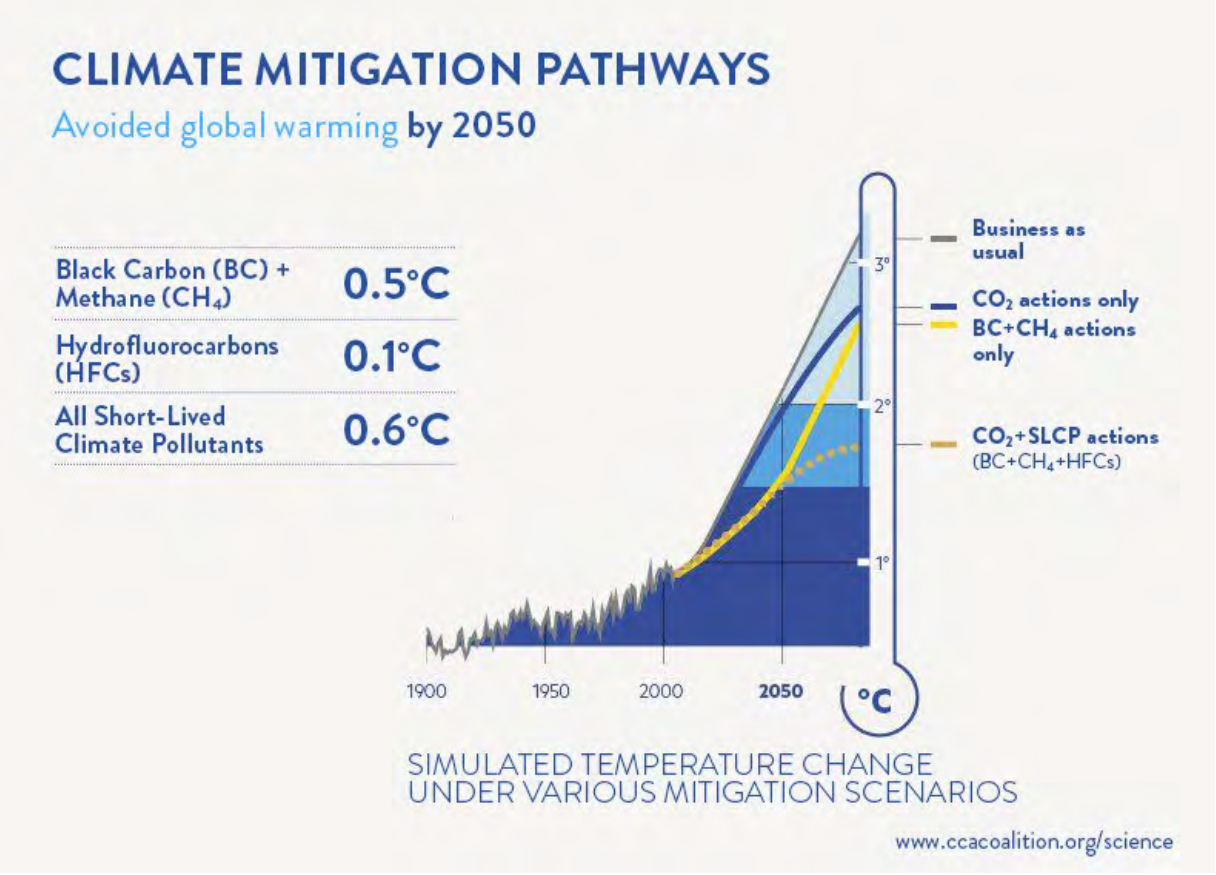


Figure 2: Overview of climate change benefits from taking action on short-lived climate pollutants

It is important to note that the benefits that are achieved by the measures that target SLCP source sectors are achieved for two reasons. Firstly, it is because they reduce SLCPs themselves, which, in the case of black carbon and methane have direct impacts on both air quality and on climate. But it is also because many of the SLCP source sectors are also major sources of greenhouse gases (e.g. CO_2) and other air pollutants. Therefore, the implementation of mitigation measures in these sectors can also reduce emissions of greenhouse gases and other air pollutants, in addition to reducing SLCPs.

[7] UNEP/WMO, 2011. Integrated Assessment of Black Carbon and Tropospheric Ozone. United Nations Environment Programme, World Meteorological Organisation Report. Available at: https://wedocs.unep.org/rest/bitstreams/12809/retrieve.

The aim of this document is to provide a first overview of short-lived climate pollutants in Serbia, and to provide recommendations as to how actions to reduce SLCPs could be enhanced and increased in Serbia through climate change planning, air quality management and other planning and policy processes. Specifically, the objectives of this document are:

- To present existing information on the **magnitude of emissions of SLCPs** in Serbia, to identify the contribution of different source sectors to these emissions, and to identify the overlap between the major sources of SLCPs with the largest sources of GHGs and air pollutants, to identify those sectors where actions could be most effective at simultaneously improving air quality and mitigating climate change.
- To **evaluate existing plans, strategies, policies etc.** to identify to what extent they include mitigation actions in key SLCP source sectors, to identify gaps where actions to reduce SLCPs could be increased.
- To provide **recommendation**s as to how SLCP and integrated climate change and air pollution mitigation can be enhanced in Serbia, including through climate change and air quality planning processes.

1.1 Overview of policy and legislation

An overview of policies and regulations in the Republic of Serbia related to climate change and air protection is presented in Table 1, including a brief information on the most important provisions of these documents.

Table 1: Policy and legislation related to Air Quality and Climate change in the Republic of Serbia

No.	Name	
1	Serbia's Second Biennial Update Report to the UNFCCC - draft document	This draft document completely covers present status for GHG national inventory and GHG mitigation potential. National GHG inventory is fully described from legal, institutional and procedural arrangements, through methodologies and key categories to inventories and trends by sectors and gases. Sectors analyzed include four dominant sources of GHG emissions: energy, industrial processes and product use (IPPU), agriculture, forestry and other land use (AFOLU) and waste. GHG gases analyzed include CO_2, CH_4, N_2O, HFCs and SF_6

2	Greenhouse gas inventory	Inventory of GHG for Republic of Serbia is prepared based on National Register of Pollution Sources, Energy Balance and other relevant official statistics and documents that is the subsystem of the Environmental information system. This system includes six thematic units: Pollution Release and Transfer Register (PRTR), emissions of pollutants into the air, emission of pollutants into water, emissions of pollutants into the soil, waste management, products that become
3	Second National Communication[8]	The GHG Inventory of the Republic of Serbia was performed by using the Intergovernmental Panel on Climate Change (IPCC) Inventory Software, according to the Tier 1 approach of the 2006 IPCC Guidelines and default emission factors for all source categories and removals. Regarding Short-Lived Climate Pollutants (SLCPs) the Second National Communication of the Republic of Serbia brings data for Methane, Hydrofluorocarbons (HFCs) and Black carbon (production).
4	Second/revised Serbia's nationally determined contribution – CCM component[9]	Revised GHG emission reduction target is defined in the Low Carbon Development Strategy (LCDS) with Action plan (LCDS). The LCDS provides framework for development by the year 2050 accompanied by the GHG emission reduction, taking into account the EU development goals and priorities in line with Serbia's status of the EU candidate country.
5	Revision of the Nationally Determined Contribution of the Republic of Serbia under the Paris Agreement Climate Change Adaptation - component[10]	This revision propose adaptation measures for the most vulnerable sectors of the Republic of Serbia, the national strategic goals, legal framework related to climate change and adaptation, as well as overview of national documents relevant to reducing risks and consequences of extreme weather events and slow-onset events caused by climate change. As presented in the NDC, the sectors that are most vulnerable to climate change in Serbia include: agriculture, water management, forestry, biodiversity and public health.

[8] https://www.klimatskepromene.rs/wp-content/uploads/2017/12/SNC-Eng_Serbia.pdf; https://unfccc.int/sites/default/files/resource/SNC%20Eng_Serbia.pdf

[9] https://www.klimatskepromene.rs/wp-content/uploads/2020/10/CCM-revised-NDCs-DRAFT-OCT-2020_.pdf

[10] https://www.klimatskepromene.rs/wp-content/uploads/2020/10/CCA-revised-NDCs-DRAFT-OCT-2020.pdf

6	Draft Low Carbon Development Strategy with Action plan[11]	In order to evaluate different mitigation options, six GHG emission scenarios are developed, while the Strategy determines the pathway until 2030 and proposes a range up to 2050. Those scenarios have two Baseline scenarios: B1 and B2 (meaning without the introduction of any new measures aimed at reducing GHG emissions) and four mitigation scenarios (aimed at reducing GHG emissions, including through the implementation of the EU acquis).
7	National Environmental Approximation Strategy for the Republic of Serbia[12]	In order to achieve EU membership Serbia has to complete the approximation process of transposing, implementing and enforcing all the chapters of the EU Acquis, including Chapter 27 on environment. The main costs imposed by the legislation in the air quality sector will be incurred by: • Establishing and maintaining a network of air quality monitoring stations and associated quality assurance equipment and reporting the monitoring results. • Preparing emission inventories of greenhouse gases and pollutants that significantly affect air quality. • Preparing plans and programs to achieve compliance with ambient air quality limits. Compliance with emission limits and technical requirements under the directives, or by the implementation of plans and programs designed to improve ambient air quality.
8	Law on Air Protection	This law regulates the management of air quality and determines the measures, organization and control of the implementation of protection and improvement of air quality. The instruments of air protection policy and planning are: • Air protection strategy. • Air quality plans. • Short-term action plans. • National program for gradual reduction of annual maximum national emissions of pollutants. Operator plans to reduce emissions from stationary plants.

[11] http://www.serbiaclimatestrategy.eu/

[12] http://www.misp-serbia.rs/wp-content/uploads/2010/05/EAS-Strategija-ENG-FINAL.pdf

9	Climate change law – draft	The provisions of this law apply to anthropogenic GHG emissions and sectors and systems exposed to the effects of climate change.
10	Decree on the methodology of data collection for the National Inventory of Greenhouse Gas Emissions	This Decree prescribes the methodology for collecting data for the National Inventory of Greenhouse Gas Emissions. Data in accordance with this Regulation shall be submitted by reporting entities that collect and/or have the data required for the Inventory.

There are no law-stipulated instruments in the public policy domain, such as the Air Protection Strategy, or they are adopted with a small amount of data and limited implementation capabilities such as air quality plans or short-term action plans[13].

The provisions on limit values for the emission of pollutants, although harmonized with EU standards, have either not been respected or it is impossible to find out whether they are being respected. Emission measurement did not comply with legal regulations, although positive developments in this direction were recorded. Standards, best available techniques and other air pollution prevention tools are not applied sufficiently as air quality improvement tools.

Operators responsible for the largest emissions are still not punished for breaking the law, while the number of household polluters is an issue too large to be resolved within the existing institutional framework.

There is great disproportion in policy development and genuine commitment to progress in both prevention and mitigation of climate change.

A series of announced changes to legislation development has been performed but data transparency, reliability and availability still remain unclear. Even though a series of legislative changes to transposition of EU acquis, as well as to declarative commitment to the European path, have been announced the fact remains that a relevant area such as energy points to lack of connectivity between various sectors.

Strategy on Climate Change and Action Plan have finally been drafted recently. After the Strategy adoption, follows the realization of the proposed activities and adoption of

[13] https://www.koalicija27.org/wp-content/uploads/2019/10/izvestaj_2019_WEB.pdf

appropriate bylaws. The mentioned Strategy is also in accordance with the Development Strategy of the Republic of Serbia for the period by 2025 with projections by 2030.

Accurate, verifiable and/or reliable information on greenhouse gas inventory are still missing. According to the State of the Environment in 2019 Report, prepared by the Serbian Environmental Protection Agency (SEPA), information on the GHG inventory is presented in accordance with NCs BuRs.

The Draft Climate Change Law was prepared, after which it passed the public debate process, and it is currently pending parliamentary procedure. The Draft Law itself, however, is the basic prerequisite towards successful and full transposition and implementation of the EU Emissions Trading System Directive (EU ETS), which is a key part of the European Union's climate change legislation.


Klub Satelit Zlatibor

2. Emissions of Short-Lived Climate Pollutants in Serbia 2000-2018

Exposure to air pollution, and the resultant health impacts, occurs due to emissions of a variety of different gases and particles, from a range of different emission sources. In addition, greenhouse gases and SLCPs are also emitted from a wide variety of sources (often the same as air pollutants). Therefore, a first step in understanding SLCPs, and the link between air pollution and climate change in Serbia is to understand the magnitude of emissions and the contribution of different source sectors to the emissions of different pollutants. Understanding the contribution of different source sectors is also a starting point to identifying priority actions that can be taken to reduce SLCPs, improve air quality and mitigate climate change.

Serbia, through its submissions to the UNFCCC and Convention on Long-Range Transboundary Air Pollution (CLRTAP) already develops emission inventories that cover all relevant pollutants. This section therefore presents a compilation of SLCP, air pollutant and greenhouse gas emissions, using the latest emission estimates of SLCPs, air pollutants and GHGs submitted to the CLRTAP[14] and UNFCCC[15]. Section 2.1 describes the key features of these inventories, while Section 2.2 presents the key emission results.

2.1 Sources and pollutants covered in inventory

Pollutants Included

The purpose of presenting the emissions of short-lived climate pollutant (SLCP), greenhouse gas (GHG) and air pollutant emission inventory is to show the commonality of sources of the emissions of pollutants that contribute to global temperature increases, and to air pollution and its effects on human health. Therefore, the pollutant characterized

[14] https://www.ceip.at/status-of-reporting-and-review-results/2020-submissions

[15] SNC_eng.pdf (klimatskepromene.rs)

in this inventory are those that are greenhouse gases, like carbon dioxide and methane, and those pollutants that contribute to the formation of particulate matter (PM), and tropospheric ozone (O). These are the two pollutants that have the largest effect on human health, and therefore the pollutants whose emissions are quantified in this emission inventory make the largest contribution to air pollution in Serbia, as well as Serbia's contribution to global climate change. The emission inventory of short-lived climate pollutants, greenhouse gases and air pollutants covers 11 pollutants in total, including:

Short-Lived Climate Pollutants

- Black carbon (BC): A component of direct particulate matter (PM) emissions that contributes to the negative effects of air pollution on human health. Emissions of black carbon also warm the atmosphere through direct absorption of incoming solar radiation, and through indirect effects such as deposition on snow and ice and cloud interactions. With an atmospheric lifetime of a few days, it is a short-lived climate pollutant. It is mainly emitted through incomplete combustion.
- Methane (CH_4): A greenhouse gas and short-lived climate pollutant with an atmospheric lifetime of approximately 15 years, methane emissions make the second largest contribution to global temperature increases after carbon dioxide. It also contributes to the formation of tropospheric ozone (O_3), which has negative effects on respiratory health.

Air Pollutants

- Particulate Matter ($PM_{2.5}$ and PM_{10}): Particulate matter (with aerodynamic diameter less than 2.5 µm ($PM_{2.5}$) and 10 µm (PM_{10})) are small solid particles in the atmosphere. They make the largest contribution to air pollution effects on human health through effects on the cardiovascular and respiratory systems. The emissions of $PM_{2.5}$ and PM_{10} calculated here represent the direct emissions to the atmosphere of particulate matter. However, other gaseous pollutants, like Nitrogen oxides, Sulphur dioxide, ammonia and volatile organic compounds, also contribute to the $PM_{2.5}$ and PM_{10} concentrations that people are exposed to, through chemical reactions in the atmosphere that convert gaseous pollutants into solid particles.
- Nitrogen Oxides (NO_x): An air pollutant which is a precursor to the formation of particulate matter and tropospheric ozone, NO_x is made up of two pollutants, nitrogen oxide (NO) and nitrogen dioxide (NO_2).
- Sulphur dioxide (SO_2): An air pollutant which is a precursor to the formation of particulate matter.
- Ammonia (NH_3): An air pollutant which is a precursor to the formation of particulate matter.

- Organic Carbon (OC): A component of direct particulate matter (PM) emissions that contributes to the negative effects of air pollution on human health.
- Non-methane volatile organic compounds (NMVOCs): A collection of a range of different organic molecules emitted from a range of emission sources. NMVOCs are precursors to the formation of tropospheric ozone and particulate matter
- Carbon monoxide (CO): A gaseous air pollutant which contributes to the formation of tropospheric ozone

Greenhouse Gases

- Carbon dioxide (CO_2): A greenhouse gas with an atmospheric lifetime of hundreds of years, that makes the largest contribution to global climate change.

The emissions of black carbon, and the other air pollutants were taken from the 2020 submission of Serbia to the European Monitoring and Evaluation Programme (EMEP) Centre on Emission Inventories and Projections (CEIP). Emissions of methane and HFCs were taken from Serbia's 2nd National Communication to the UNFCCC.

Source sectors

The emission sources covered in the inventory cover all the major sources of SLCPs and air pollutants, and greenhouse gases, with the exception of land-use and land-use change emissions. Emission sources were grouped according to the IPCC source categories. The source sectors covered are described in Table 2.

Table 2: Source sectors covered in emission inventory

Source Sector	Sub-sectors	
1 - Energy	**1A1a**	**Public Electricity and Heat Production**
	1A1c	**Manufacture of Solid Fuels and Other Energy Industries**
	1A2	**Manufacturing Industries and Construction**
	1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel
	1A2c	Stationary combustion in manufacturing industries and construction: Chemicals
	1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages, and tobacco
	1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals

	1A2gvii	Mobile Combustion in manufacturing industries and construction:
	1A2gviii	Stationary combustion in manufacturing industries and construction
	1A3b	**Road transportation**
	1A3bi	Road transport: Passenger cars
	1A3bii	Road transport: Light duty vehicles
	1A3biii	Road transport: Heavy duty vehicles and buses
	1A3bv	Road transport: Gasoline evaporation
	1A3bvi	Road transport: Automobile tire and brake wear
	1A4a	**Commercial/Institutional**
	1A4ai	Commercial/institutional: Stationary
	1A4b	**Residential**
	1A4c	**Agriculture, Forestry, Fishing**
	1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery
	1B1a	Fugitive emissions from coal mining
	1B1b	Fugitive emission from solid fuels: Solid fuel transformation
	1B2av	Distribution of oil products
2- Industrial Processes	**2A2**	**Lime production**
	2A5a	Quarrying and mining of minerals other than coal
	2B10a	Chemical industry: Other
	2C1	Iron and steel production
	2C7a	Copper production
	2D3a	Domestic solvent use including fungicides
	2D3b	Road paving with asphalt
	2D3h	Printing
	2D3i	Other solvent use
	2H1	Pulp and paper industry
	2H2	Food and beverages industry
	2K	Consumption of POPs and heavy metals
3 - Agriculture	3B1a	Manure management - Dairy cattle
	3B1b	Manure management - Non-dairy cattle
	3B3	Manure management - Swine
	3B4gi	Manure management - Laying hens
	3Da1	Inorganic N-fertilizers
	3Dc	Farm-level agricultural operations including storage, handling, and transport of agricultural products

5 - Waste	5A	Biological treatment of waste - Solid waste disposal on land
	5B1	Biological treatment of waste - Composting
	5B2	Biological treatment of waste - Anaerobic digestion at biogas facilities
	5C1a	Municipal waste incineration
	5C1bi	Industrial waste incineration
	5C1bii	Hazardous waste incineration
	5C1biii	Clinical waste incineration
	5C1biv	Sewage sludge incineration
	5C1bv	Cremation
	5C1bvi	Other waste incineration
	5C	Open burning of waste
	5D	Domestic wastewater handling
	5D2	Industrial wastewater handling
	5D3	Other wastewater handling
	5E	Other waste

2.2 Emissions of SLCPs between 2000 and 2018

To develop this section, two sources of information were used:

a) Serbia's submission to the LRTAP convention: from which information on NO_x (as NO_2), NMVOC, SO_x (as SO_2), NH_3, $PM_{2.5}$, PM_{10}, TSP, BC, and CO were extracted

b) Serbia's 2nd National Communication: from which information on CH_4, CO_2 and HFCs was extracted

The total emissions (in kilotonnes) of each pollutant estimated in this inventory is shown in Table 3 between 2000 and 2018. In the Republic of Serbia, the most important emissions related to greenhouse gases and climate change are CO_2 emissions which, as discussed in the Second National Communication of Serbia, have shown a 7.8% increase between 2000 and 2014. The energy sector is responsible for the majority of CO_2 emissions and in the year 2014 the energy sector accounted for 95.0% of the total CO_2 emissions in Serbia. The main sources of methane in the Republic of Serbia are the Energy, Agriculture, Forestry and Other Land Use (AFOLU), and Waste sectors. Methane emissions on the other hand, have shown a decrease between 2000 and 2014. This decrease, according to the Second National Communication of Serbia is attributed to

reductions in the AFOLU and Waste sectors. HFC emissions have increased significantly between 2000 and 2014, with 100% of HFC emissions coming from the Industrial Processes and Product Use (IPPU) sector.

Table 3: Total national emissions of GHGs, SLCPs and air pollutants in Serbia between 2000 and 2018 (kilotonnes).

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Carbon Dioxide (incl. removals)	35,493					46,138				
Black Carbon	3.1	3.0	3.1	3.1	3.2	3.0	2.8	3.3	3.1	3.8
Methane	382.14					344.35				
HFCs[11]	1.12					10.49				
Nitrogen Oxides	146.6	151.2	168.4	169.8	179.3	175.1	176.6	173.4	146.6	174.1
Non-Methane Volatile Organic Compounds	120.9	118.3	117.9	119.7	120.0	115.0	111.2	114.9	120.9	108.6
Sulfur Dioxide	462.5	457.1	481.6	506.0	515.5	442.7	459.9	469.1	462.5	431.1
Ammonia	99.5	94.6	99.5	96.7	103.4	100.5	98.5	100.4	99.5	95.4
Particulates $PM_{2.5}$	39.8	39.6	40.8	41.5	42.0	39.5	36.5	40.6	39.8	42.8
Particulates PM_{10}	52.6	52.0	53.6	54.2	55.2	52.7	49.9	54.1	52.6	55.0
TSP	84.1	84.6	98.5	93.7	113.0	111.2	92.7	111.0	84.1	86.5
CO	399.8	401.4	402.0	417.3	434.0	402.9	357.7	402.7	399.8	359.3

	2010	2011	2012	2013	2014	2015	2016	2017	2018
Carbon Dioxide (incl. removals)	36,088	38,719	33,304	33,570	35,700				
Black Carbon	3.7	3.6	3.8	3.4	3.3	3.3	3.4	3.2	3.3
Methane	328.01	337.9	349.01	347.6	351.38				
HFCs*	68.72	80.11	107.1	143.33	188.07				
Nitrogen Oxides	155.1	170.5	151.6	163.4	132.5	152.2	135.2	134.3	126.3

[16] HFCs for the period 2000-2014 are reported in Gg CO2e

Non-Methane Volatile Organic Compounds	101.1	98.8	95.5	91.9	89.7	89.3	87.0	84.2	83.2
Sulfur Dioxide	400.4	456.0	418.8	434.0	341.1	360.8	368.7	365.2	343.3
Ammonia	86.2	87.2	90.4	87.3	81.8	81.3	80.1	80.0	74.8
Particulates $PM_{2.5}$	42.3	41.9	41.8	37.1	36.5	37.6	40.1	37.7	38.3
Particulates PM_{10}	54.8	54.8	54.0	49.4	48.7	50.6	53.6	50.9	51.8
TSP	99.9	110.7	112.8	110.8	93.9	89.4	84.6	92.7	97.2
CO	347.9	344.9	308.0	283.5	266.7	268.7	250.2	243.0	249.7

Figures 3 and 4 show the percentage contribution of the different GHG, SLCPs, and air pollutants from the different sectors for two specific years, 2014 and 2018. For both years, the residential sector is the main source of $PM_{2.5}$, PM_{10}, Black Carbon and CO. Electricity generation is the main source of NO_x and SO_x. In the case of NMVOCs, the IPPU and residential sector are contributing to the emissions and the agricultural sector to a smaller degree. The agricultural sector is the main source of NH_3 emissions for both years.

Figure 3: Contribution of different sources to SLCP, air pollutant and GHG emissions in Serbia in 2014

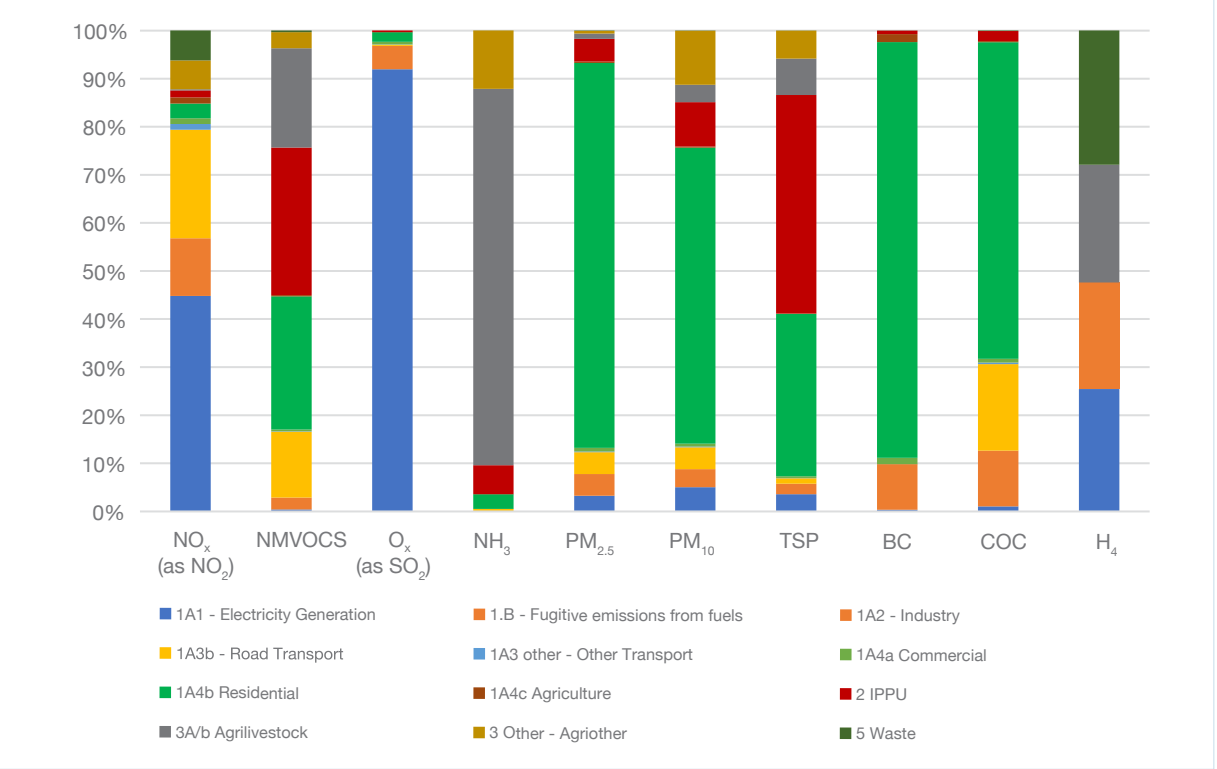
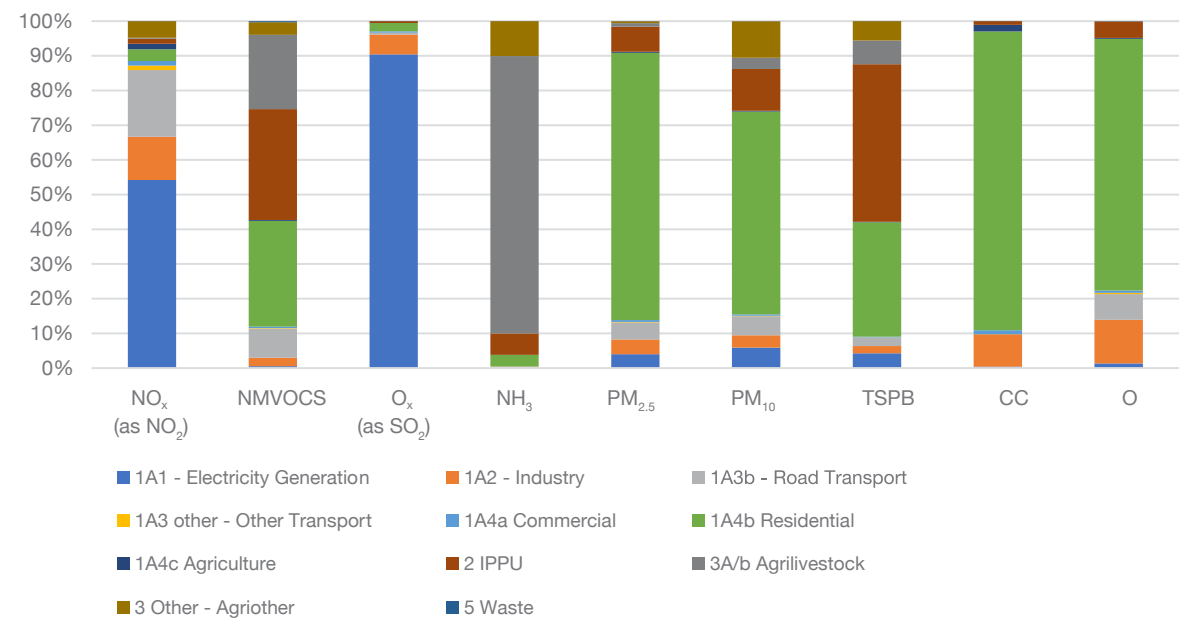


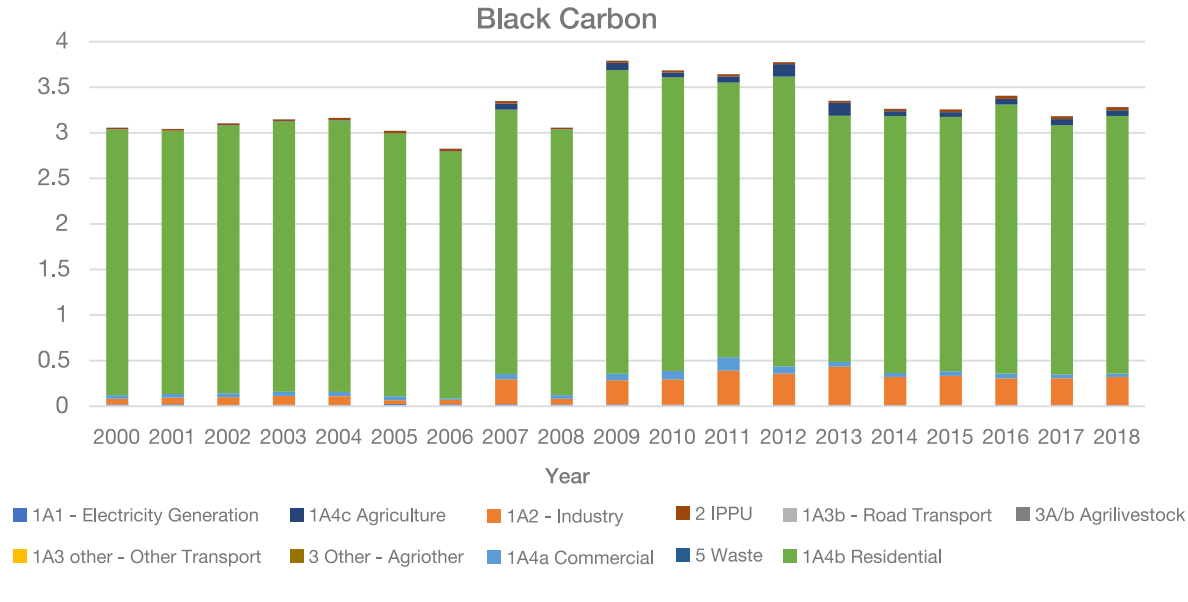
Figure 4: Contribution of different sources to SLCP, air pollutant and GHG emissions in Serbia in 2018



Short-Lived Climate Pollutants

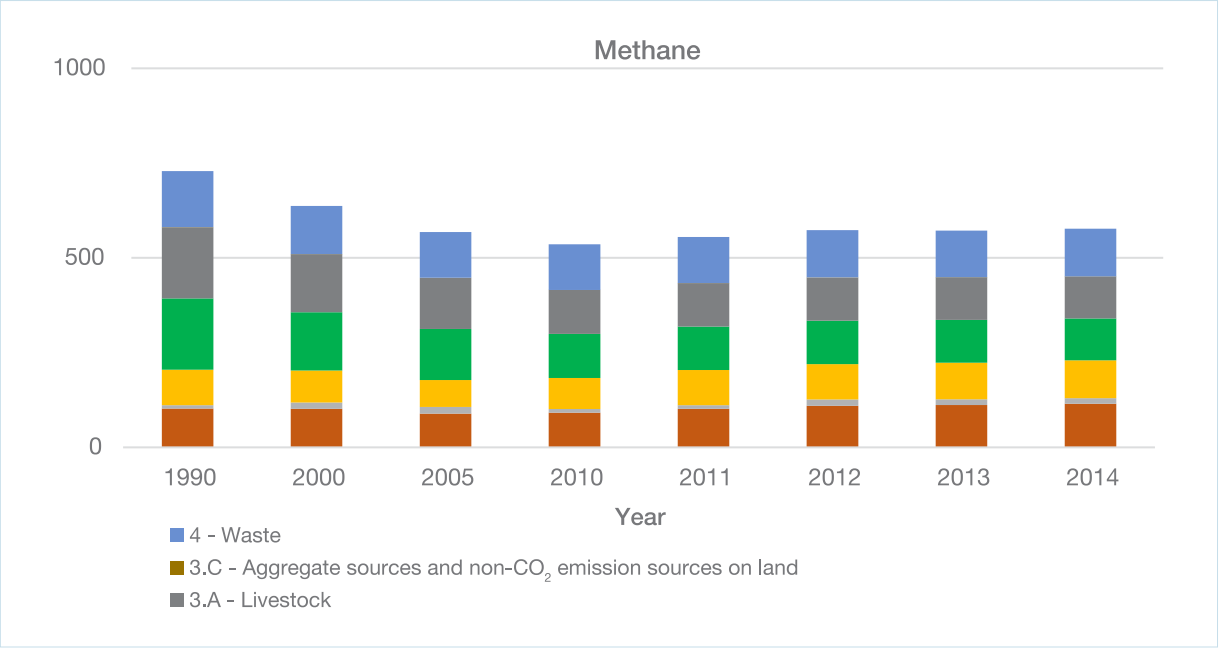
In 2018 there were 3.2 kt of black carbon emitted to the atmosphere in Serbia. This value does not vary greatly from the 2000 value estimated to be ~3 kt. The residential sector is the largest contributor of black carbon emissions, followed by industry. The agricultural sector also is contributing to the BC emissions (Figure 5).

Figure 5: Black Carbon emissions in Serbia between 2000 and 2018 (units: kilotonnes)



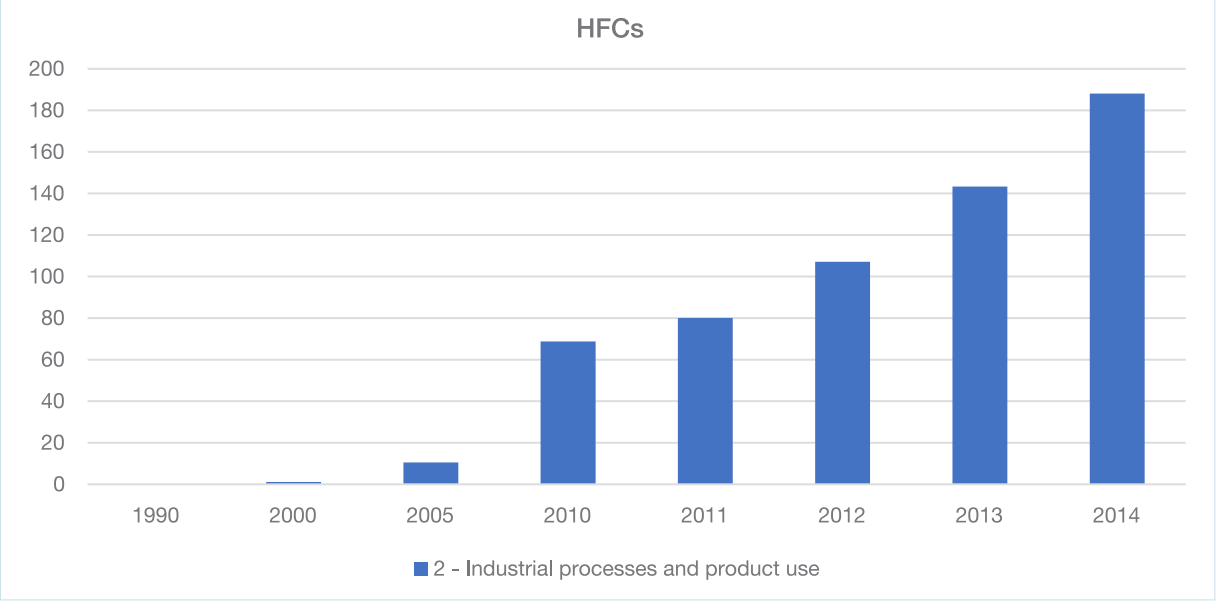
Methane emissions have been relatively stable between 2005 and 2014. In this case agricultural emissions were the largest source of methane emissions, followed by the waste sector (Figure 6).

Figure 6: Methane emissions in Serbia between 1990 and 2014 (units: kilotonnes)



HFC emissions in Serbia have been steadily increasing since 2000 to 2014, from a value of ~1 kt in 2000 to ~188 kt in 2014. The IPPU sector is the only source of HFCs in Serbia (Figure 7).

Figure 7: HFC emissions in Serbia between 1990 and 2014 (units: kilotonnes)

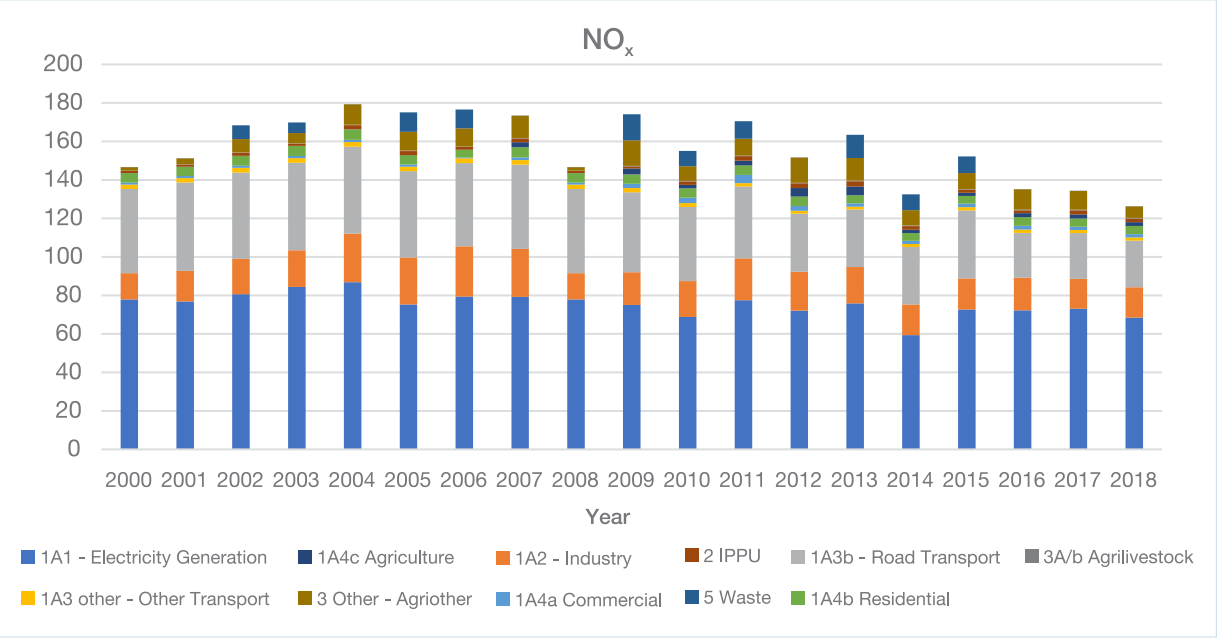


Air pollutants

In terms of other air pollutants, the emissions between 2000 and 2018 are presented in Figures 8-15:

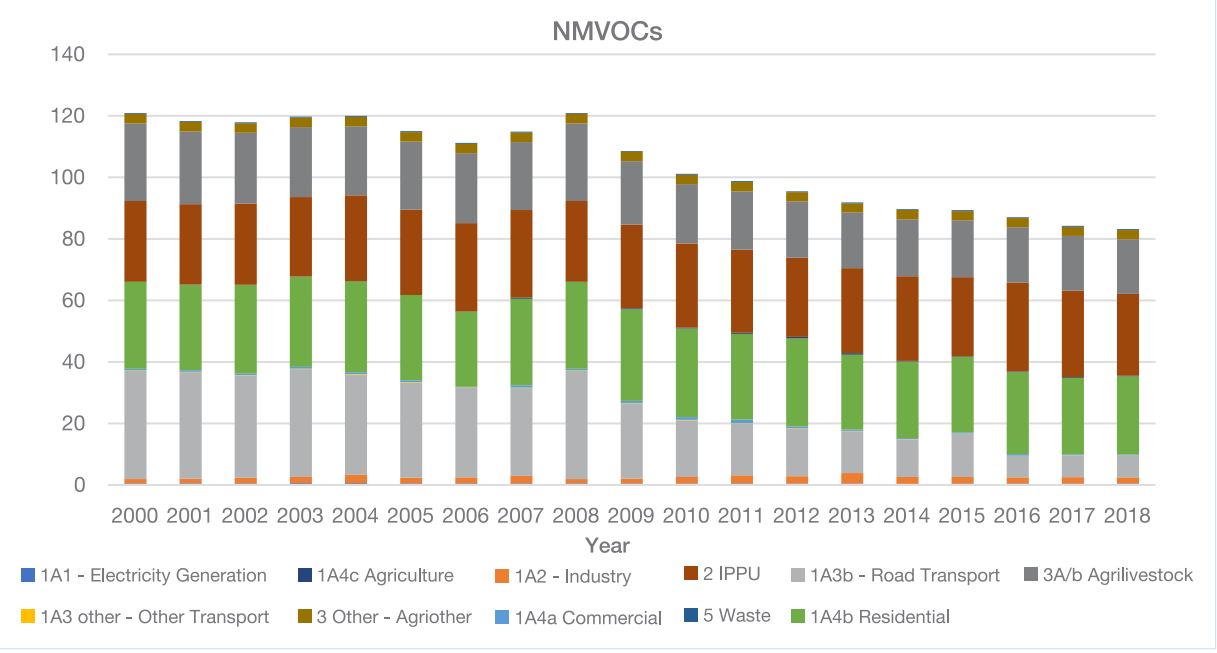
NO_x (as NO_2) emissions in Serbia are coming predominately from Electricity Generation, Road Transport and Industry. There is a relatively small contribution from the Waste and Agricultural sector ('Agriother') as shown in Figure 8. Overall, NO_x emissions in Serbia in 2018, are decreased compared to emissions in 2000.

Figure 8: Nitrous Dioxides emissions in Serbia between 2000 and 2018 (units: kilotonnes)



NMVOC emissions in Serbia are coming predominately from Road Transport, the Residential and IPPU sectors and Agriculture as shown in Figure 9. Overall, NMVOC emissions in Serbia have been on a steady decline between 2000 to 2018, with the reduction coming predominately from Road Transport.

Figure 9: Non-Methane Volatile Organic Compounds emissions in Serbia between 2000 and 2018 (units: kilotonnes)

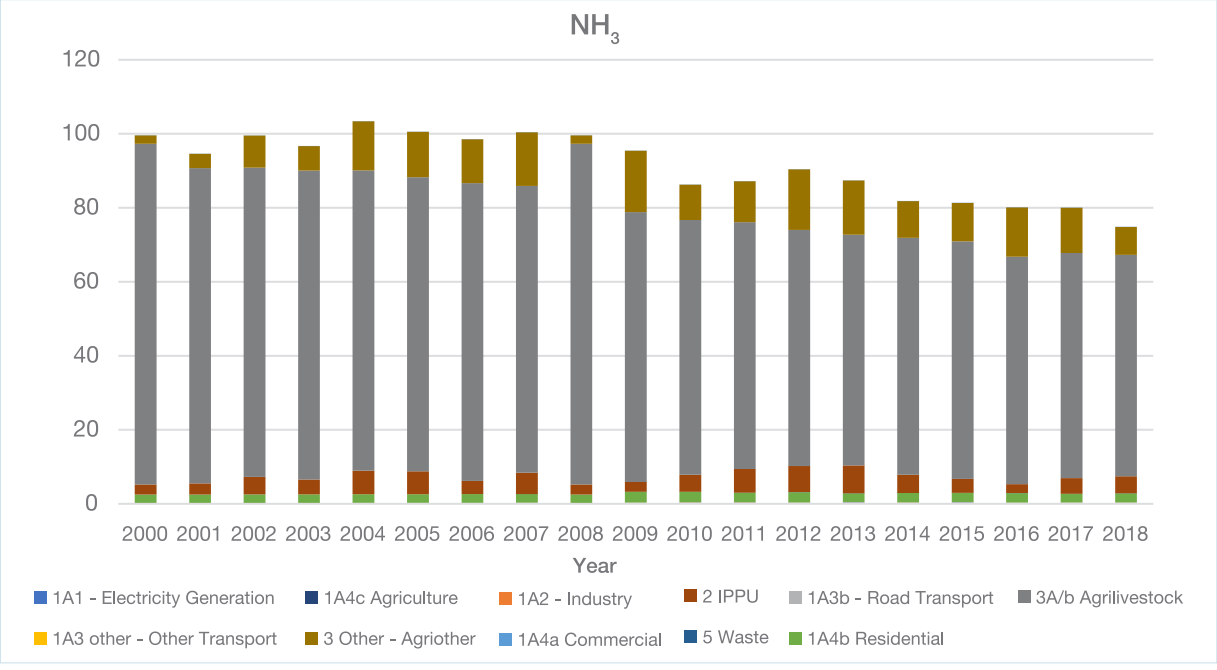


SO_x (as SO_2) emissions in Serbia are coming from Electricity Generation. While there are other sectors that are contributing to these emissions (e.g. Industry and Waste) more than 90% of SO_x emissions are due to Electricity Generation as shown in Figure 10. Overall, SO_x emissions in Serbia have been on a steady decline between 2000 to 2018.

Figure 10: Sulfur Dioxide emissions in Serbia between 2000 and 2018 (units: kilotonnes)

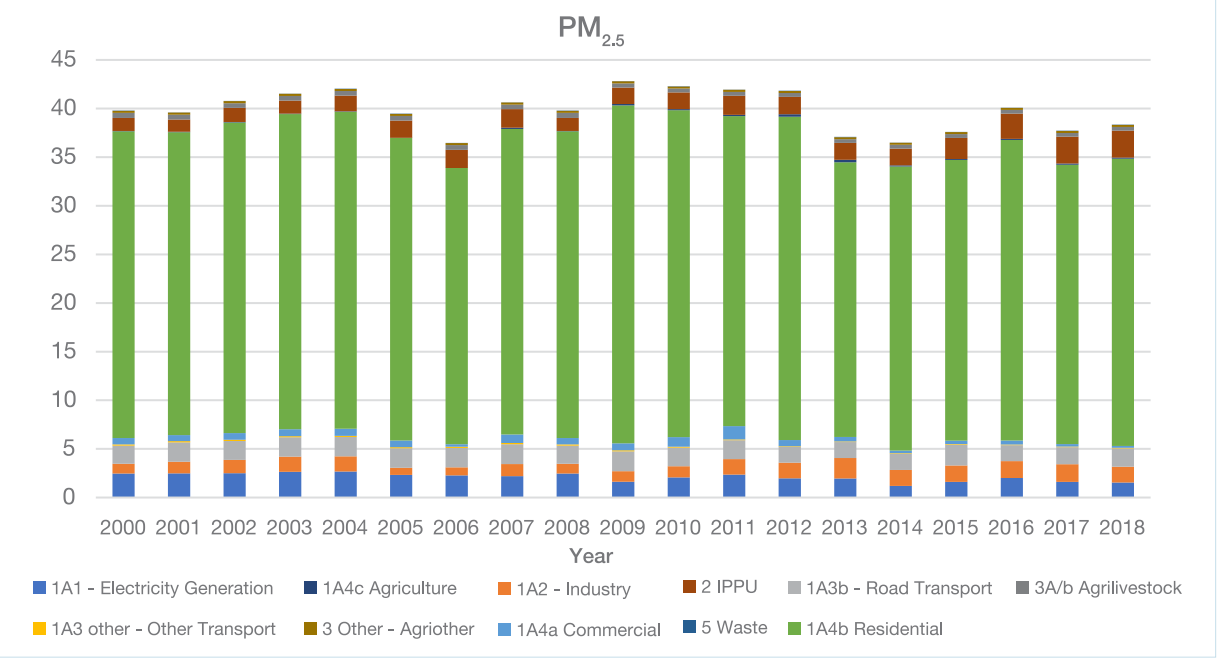
NH3 emissions in Serbia are coming from the Agricultural sector. While there are other sectors that are contributing to these emissions (e.g. IPPU) the majority of NH_3 emissions are due to the sector as shown in Figure 11. Overall, NH_3 emissions in Serbia have been on a steady decline between 2000 to 2018.

Figure 11: Ammonia emissions in Serbia between 2000 and 2018 (units: kilotonnes)



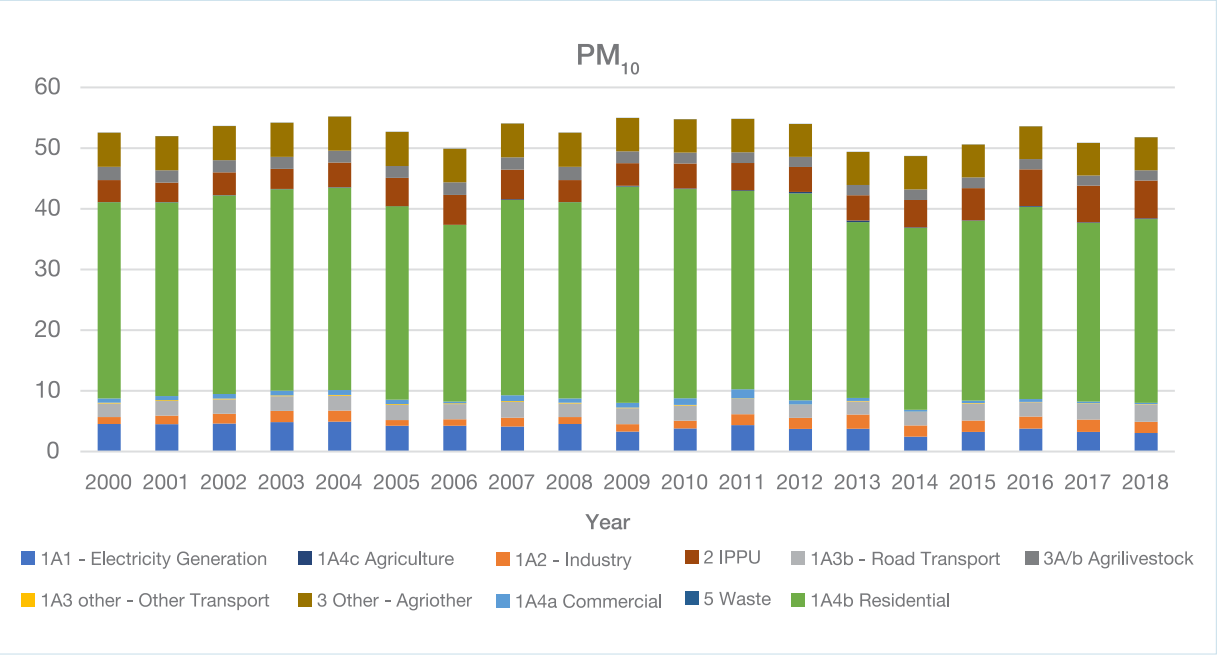
$PM_{2.5}$ emissions in Serbia are coming from the Residential sector. While there are other sectors that are contributing to these emissions (e.g. IPPU and Electricity Generation) the majority of $PM_{2.5}$ emissions are due to the Residential sector as shown in Figure 12. Overall, $PM_{2.5}$ emissions in Serbia have been relatively constant between 2000 to 2018.

Figure 12: $PM_{2.5}$ emissions in Serbia between 2000 and 2018 (units: kilotonnes)



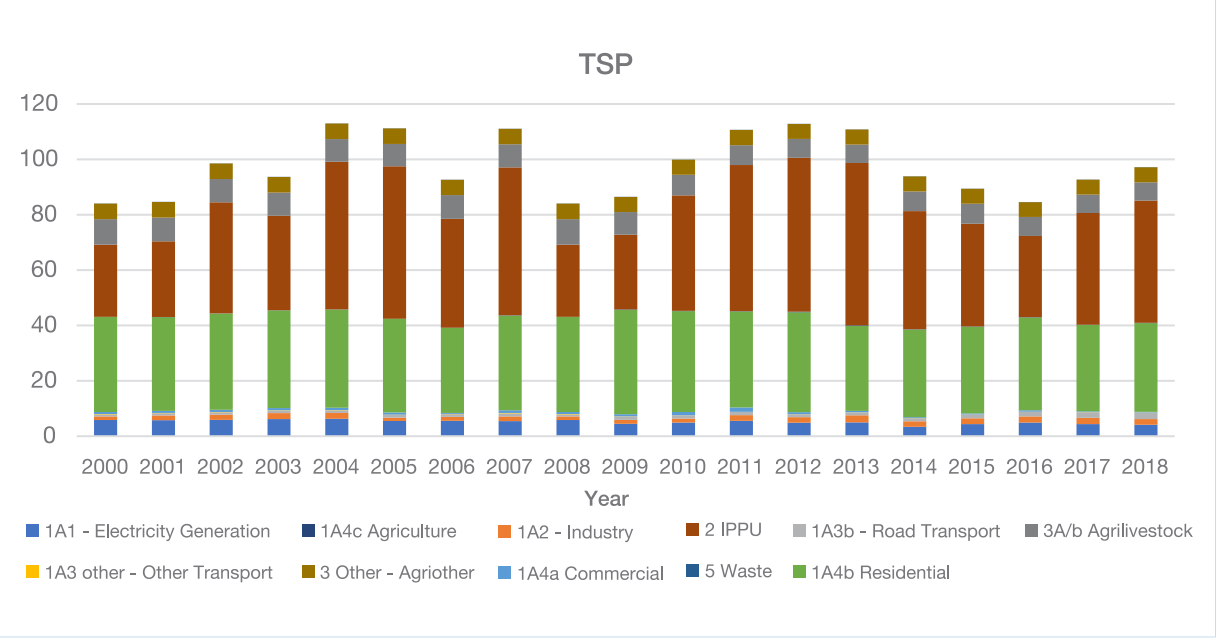
PM_{10} emissions in Serbia are coming from the Residential sector. While there are other sectors that are contributing to these emissions (e.g. IPPU, Agriculture and Electricity Generation) the majority of PM_{10} emissions are due to the Residential sector as shown in Figure 13. Overall, PM_{10} emissions in Serbia have been relatively constant between 2000 to 2018.

Figure 13: PM_{10} emissions in Serbia between 2000 and 2018 (units: kilotonnes)



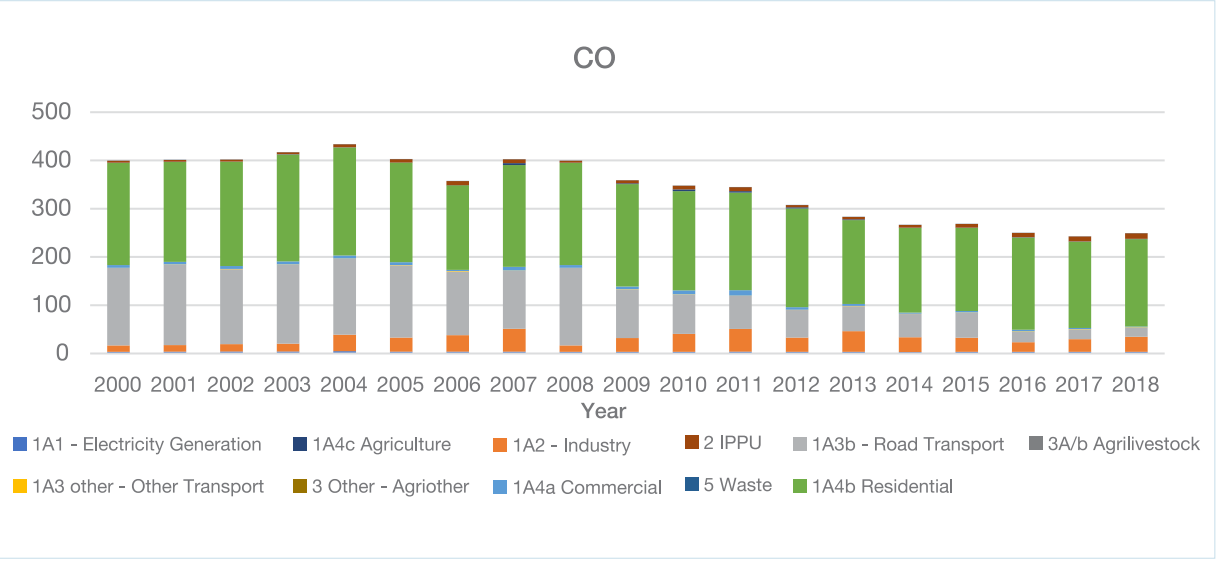
TSP emissions in Serbia are coming from the IPPU and Residential sector. Other sectors are contributing to these emissions (e.g. Waste, Agriother and Electricity Generation) as shown in Figure 14. Overall, TSP emissions in Serbia have been increasing between 2000 to 2018.

Figure 14: Total Suspended Particles emissions in Serbia between 2000 and 2018 (units: kilotonnes)



CO emissions in Serbia are coming predominately from the Residential and Road Transport sector. Other sectors that are contributing to these emissions (e.g. Industry) as shown in Figure 15. Overall, CO emissions in Serbia have been decreasing between 2000 to 2018. This decrease is predominantly due to the decrease from emissions from Road Transport.

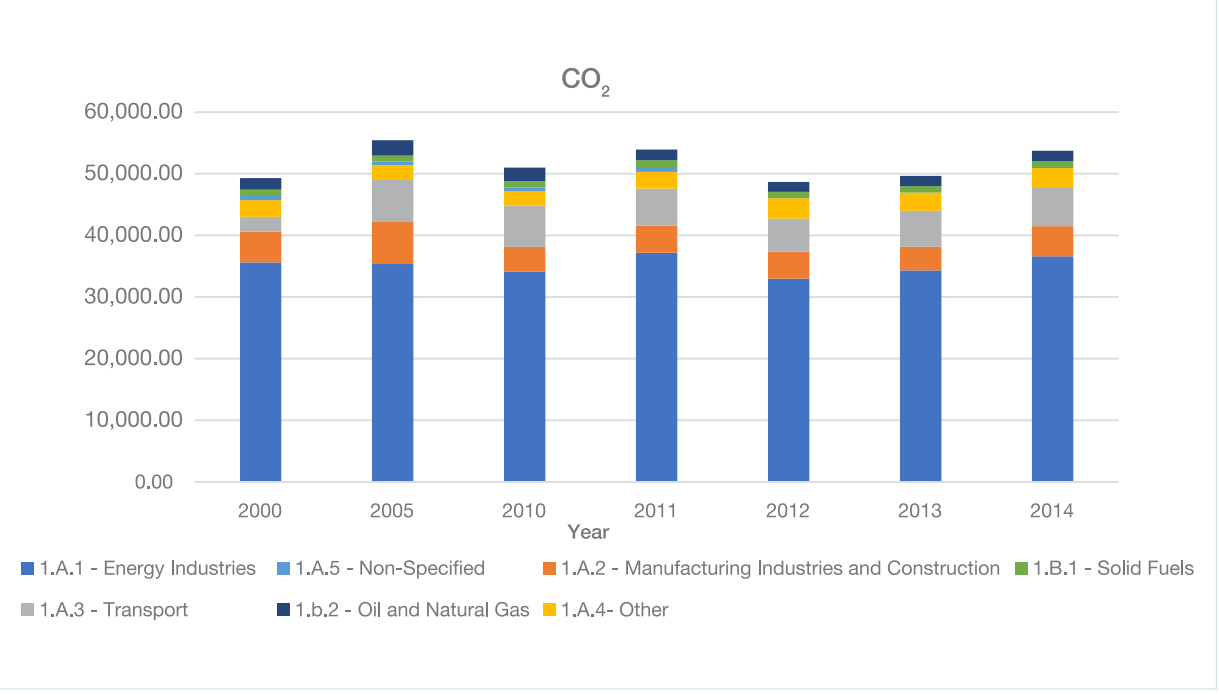
Figure 15: Carbon Monoxide emissions in Serbia between 2000 and 2018 (units: kilotonnes)



Greenhouse Gases

CO_2 emissions in Serbia are coming predominately from the Energy Industries. Other sectors that are contributing to these emissions (e.g. Manufacturing and Transport) as shown in Figure 16. Overall, CO_2 emissions in Serbia have remained relatively stable between 2000 and 2014.

Figure 16: Carbon Dioxide emissions in Serbia between 2000 and 2018 (units: kilotonnes)



3. Short-Lived Climate Pollutant mitigation options

Mitigation options were considered based on the policy and legislation (Chapter 1) and other main strategic documents for the future development of Republic of Serbia, namely:

1. Energy Sector Development Strategy of the Republic of Serbia for the period by 2025 with projections by 2030[17]

Energy Sector Development Strategy of the Republic of Serbia for the period by 2025 with projections by 2030 – the energy sector should be developed in the following directions: efficient use of relatively "clean" energy available from different sources; increase of renewable energy sources taking into account that the generation and consumption of "green" energy shall have the lowest possible impact on environment, water, air, land and directly also at whole food chain, biodiversity and human health; efficient use of energy and development of energy market.

2. Strategy of Industrial Policy for the period 2021-2030[18]

Strategy of Industrial Policy for the period 2021-2030 – the industry should be transformed into an open, regionally and globally competitive, investment-active, educated, innovative and digitally transformed industry that strongly supports economic growth and raising the quality of life of its citizens [58]. The general goal of the industrial policy is to raise the competitiveness of the industry and the most important goals are development of industry based on innovation and development of higher stages of technological production and transformation of the industry from a linear to a circular model.

[17] https://www.mre.gov.rs/doc/efikasnost-izvori/23.06.02016%20ENERGY%20SECTOR%20DEVELOPMENT%20STRATEGY%20OF%20THE%20REPUBLIC%20OF%20SERBIA.pdf

[18] https://www.pravno-informacioni-sistem.rs/SlGlasnikPortal/eli/rep/sgrs/vlada/strategija/2020/35/1/reg

3. Strategy for Agriculture and Rural Development of the Republic of Serbia from 2014 to 2024[19]

The strategy recognizes the importance of agriculture for the overall economy of the country and is one of the strategic documents in the form of a strategy, especially in the process of accession to the EU and integration into the WTO. The realization of the strategy implies respect for several key principles: sustainable agriculture, polycentric development based on respect for the diversity of the agricultural system and types of agricultural holdings, modernization of bodies and organizations and stability and consistency of the agricultural budget.

4. Forestry Development Strategy of the Republic of Serbia[20]

The strategy aims to launch all those activities that will simultaneously solve forest problems (increasing the area, rational use in the scope and quality that is in the function of forest improvement), and infrastructure works (road construction, afforestation, rural tourism, etc.) for the population in rural communities to enable further development through their work. The main goals of this strategy are focused on: conservation and enhancement of forests' condition, increase of the the forest sector contribution to the economic and social development of the Republic of Serbia, enhancement of sustainable management of the forests in the protected nature areas, sustainable development of the state forest sector, enhancement of private forests and the sustainable development of private forestry and sustainable and economically efficient wood industry sector competitive on the world market.

5. National Waste Management Strategy including National Waste Management Plan for the period 2020-2025[21]

The Waste Management Strategy (WMS) defines the goals of an integrated national waste management system and the objectives necessary. The Strategy will facilitate the process of approximation with EU legislation in the process of negotiation the accession to the Union the Strategy, as it reviews the waste management goals in the light of the requests of community legislation and provide a stepwise short-term and mid-term approach to fulfil such requirements. The Strategy defines short-term objectives (Stepwise

[19] http://www.minpolj.gov.rs/download/strategija-poljoprivrede-i-ruralnog-razvoja-republike-srbije-za-period-2014-2024-godine/

[20] https://upravazasume.gov.rs/wp-content/uploads/2015/12/Strategija-razvoja-sumarstva.pdf

[21] National Waste Management Strategy including National Waste Management Plan for the period 2020-2025, TWINNING PROJECT "EU SUPPORT TO WASTE MANAGEMENT POLICY", Belgrade, 2019

introduction of a separate collection of recyclables, Increase the recycling rate of waste from households and increase the level of diversion as percentage of totally generated paper and cardboard) as well as long-term objectives (the recycling rate of waste from households will be increased, increase the recycling rate for C&D waste, increase the level of diversion as percentage of totally generated paper and cardboard, increase the level of diversion as percentage of totally generated bio-waste).

It is important to note that previous assessments of climate change mitigation measures have evaluated their effectiveness at reducing air pollutant emissions, and on air pollution concentrations and health impacts. In the development of Serbia's Climate Strategy and Action Plan, the changes in $PM_{2.5}$ emissions associated with the 4 mitigation scenarios were calculated, and showed that for the most ambitious climate change mitigation scenario, $PM_{2.5}$ emissions could be reduced by up to 55% by 2030 compared to 2010 levels. This reduction underlines the substantial opportunity in Serbia to implement actions that can simultaneous mitigate climate change and improve air quality. The assessment also provides an estimate of the expected health benefits from these emission reductions through reduce exposure to $PM_{2.5}$. The method used is to assume a reduction in emissions of $PM_{2.5}$ would result in a linear decrease in the health impacts from $PM_{2.5}$ exposure. Unfortunately, the result is not a credible estimate of the health benefits that would result from these scenario, for three main reasons, i) direct $PM_{2.5}$ emissions are not the only emissions that contribute to $PM_{2.5}$ concentrations and health impacts, and emissions of gaseous pollutants, such as NO_x, NH_3 and SO_2, which react in the atmosphere to form $PM_{2.5}$, make a substantial contribution, ii) it is not just emissions from Serbia that contribute to $PM_{2.5}$ concentrations in Serbia, neighbouring countries' emissions also contribute, which needs to be taken into account, and iii) there are natural sources of $PM_{2.5}$ that also need to be accounted for when assessing how much $PM_{2.5}$ exposure would be reduced from actions in Serbia.

3.1 Mitigation Measures Evaluated

Detailed overview of mitigation measures and activities related to SLCP, air pollutants and GHG is listed in Table 3.1. In Table 3.1 the activities are ranked according to the priority shown as the traffic light (**red** – high priority, **yellow** – medium priority, **green** – low priority). The priority level is defined according to the analysis made in Chapter 2, which referred to the analysis of the sectors most related to the emissions of SLCP and air pollution, as well as on the trends in the change of their emissions in the period 2000-2014. In addition, all relevant documents related to the emission of SLCP and air pollution were used for the analysis.

Table 3.1: Detailed overview of mitigation measures and activities of SLCP, air pollutants and GHG

Sector	Mitigation measure	Description	Activity	SLCP affected	Air pollution affected	Time frame	Priority level	Comments
Energy sector	Implementation of the ETS Directive (Supply and Demand Sectors)	Adoption of the ETS directive and as consequence reduction of dependency on fossil fuels (of any type) in the ETS sectors (particularly power generation)	1. Introduction of an exogenous path of carbon prices 2. Increase of electricity prices 3. Introduction of the incentive to market participants either to move to zero or lower emitting fuels or adopting processes (industrial sector) less energy intensive and producing higher added value, or promoting energy efficiency in order to reduce demand for electricity 4. Improvement of metering infrastructure 5. Distribution network automation	BC	CO_2,NO_x, NMVOCs, SO_2, $PM_{2.5}$, PM_{10}, CO	2030-2050		Administrative capacity at the competent authority, no legal framework established for MRV to ensure timely smooth implementation of the EU-ETS, lack of political will to address the consequences of EU-ETS for the power sector High social impact in the initial phase of implementing ETS Directive
	Increasing the use of RES in electricity production	Construction of new production capacities and progressive reduction of the market and non-market barriers for RES deployments	1. Implementation of policies (e.g. priority access, streamlined authorisation for licensing and approval procedures) 2. Adoption of supporting schemes	CH4	CO2, NOx, NMVOCs, SO2, PM2.5, PM10, CO	2020-2050		Administrative barriers and permitting capacities at competent authorities' level, stable long-term economic/business environment
	Improving energy efficiency and increasing use of CHP and RES in district heating systems	Construction of new production capacities and progressive reduction of the market and non-market barriers for RES deployments	1. Construction of new heating sources 2. shutting down boilers which are in poor condition 3. fuel conversion, from fossil fuel to RES 4. installation of external economizer on the flue tract because of usage of waste heat of the flue gas 5. improving the system for automatic control of heating sources 6. CHP plants 7. Rehabilitation of the district heating system	BC	CO_2, N_2O NO_x, NMVOCs, SO_2, $PM_{2.5}$, PM_{10}, CO	2020-2050		
	Increasing use of RES in the industry		1. Implementation of policies (e.g. priority access, streamlined authorisation for licensing and approval procedures) 2. Adoption of supporting schemes	CH_4	CO_2, N_2O			Administrative barriers and permitting capacities at competent authorities' level, stable long-term economic/business environment

Energy sector	**Improving the efficiency in Electrical Appliances for Households**	Reducing electricity consumption from electrical appliances in households	1. Increasing lifetime of electric appliances at households, as a result of improving level of comfort for consumers 2. Improve energy efficiency of electrical appliances	BC	CO_2, NO_x, NMVOCs, SO_2, $PM_{2.5}$, PM_10, CO	2020-2050		Increased prices for quality electric appliances
	Improving the Energy efficiency in the Industrial sector	Improving energy efficiency in the industrial sector	1. Deployment of efficient equipment 2. Employment of less energy intensive processes 3. Promoting use of zero or low emitting fuels	BC	CO_2, NO_x, NMVOCs, SO_2, $PM_{2.5}$, PM_{10}, CO	2020-2050		
	Improving energy efficiency in the Tertiary sector	Reduction of energy consumption in the services/ commercial and agriculture (energy related) sectors, including activities in the market and non-market services sector, trade activities as well activities in the agricultural sector related to energy consumption and use of equipment (pumping etc)	1. Improvement of electrical appliance used in the services/commercial sector 2. Reduce consumption of energy (including electricity) 3. Replacing conventional fuels with zero or lower emission fuels for heating purposes 4. Reducing energy consumption by the deployment of efficient heating and cooling equipment used in households	BC	CO_2, NO_x, NMVOCs, SO_2, $PM_{2.5}$, PM_{10}, CO	2020-2050		Establishing an Energy Efficiency auditing procedure needed
	Improving the thermal integrity of Tertiary sector	Reduction of energy consumption in the services sector, commercial/public sectors, mainly for heating and cooling	1. Introducing improvements in insulation 2. Introducing improvements in double glassing 3. Providing financial support in the form of direct subsidies, loan facilities, tax relief schemes - focusing on low efficient buildings	BC	CO_2, NO_x, NMVOCs, SO_2, $PM_{2.5}$, PM_{10}, CO	2020-2050		No-existence of monitoring/auditing facility of Energy efficiency

Energy sector	**Heating and Cooling infrastructure for Households**	Technological and fuel options available for improving the heating and cooling conditions of households.	1. Replacing conventional fuels with either zero or low emissions fuels for H&C 2. Reducing energy consumption by the deployment of efficient heating and cooling equipment used in households 3. Provide financial incentives for upgrading the H&C equipment 4. Expand the utilization and improve the efficiency of Networks (District heating networks, Natural Gas distribution systems)	BC, HFCs	CO_2, NO_x, NMVOCs, SO_2, $PM_{2.5}$, PM_{10}, CO	2020-2050		No access of consumers to financing instruments, Establishment of an Energy Efficiency Auditing process
	Improving the thermal integrity of Households	Reduction of the energy consumption at households mainly for heating and cooling	1. Improving the thermal integrity introducing improvements in insulation 2. Improving the thermal integrity introducing improvements in double glazing 3. Supporting the renovation of houses - providing financial support for buildings of lower efficiency standards (direct subsidies, loan facilities, tax relief schemes)	BC	CO_2, NO_x, NMVOCs, SO_2, $PM_{2.5}$, PM_{10}, CO	2020-2050		Complexities in the implementation, monitoring completion of works, no access to financing instruments, Energy Efficiency Auditing process needed
	Renewal of the passenger fleet	Improvement of efficiency and promotion of modern technologies and alternative fuels	1. Electrification of cars* 2. Increased use of advanced biofuels	BC	CO_2, N_2O, NO_x, NMVOCs, $PM_{2.5}$, PM_{10}, CO	2020-2050		Prices of new cars, access to “cheap” second-hand cars, limitations of possible instruments due to free movement of goods in the EU (customs union and the principle of non-discrimination)
	Renewal of the freight fleet	Improvement of efficiency and promotion of modern technologies and alternative fuels	1. Electrification of light commercial vehicles (LCVs)* 2. Increased use of advanced biofuels	BC	CO_2, N_2O, NO_x, NMVOCs, $PM_{2.5}$, PM_{10}, CO	2020-2050		Lack of regulatory framework for renewal of freight fleet operating mainly on internal Serbia’s transport market

IPPU	**Implementation of F-Gases regulation and MAC Directive**	Phase out refrigerants/coolants with higher GWP with low-GWP alternatives	1. Prohibition of placing on the market of: • Non-refillable containers for fluorinated greenhouse gases used to service, maintain or fill refrigeration, air-conditioning or heat-pump equipment, fire protection systems or switchgear, or for use as solvents • Non-confined direct evaporation systems that contain HFCs and PFCs as refrigerants • Fire protection equipment that contains PFCs that contain HFC-23 • Windows for domestic use that contain fluorinated greenhouse gases • Other windows that contain fluorinated greenhouse gases • Footwear that contains fluorinated greenhouse gases • Tyres that contain fluorinated greenhouse gases • One-component foams, except when required to meet national safety standards, that contain fluorinated greenhouse gases with GWP of 150 or more • Aerosol generators marketed and intended for sale to the general public with GWP of 150 or more • Domestic refrigerators and freezers that contain HFCs with GWP of 150 or more • Is fully implemented and effective by 2020	HFCs	-	2020-2050		Lack of capacity for enforcement of legal framework

Agriculture	Winter cover crops	The additional planting of winter cover crops is generally assessed as having positive effects for the management of soil erosion, soil fertility, soil quality, water, and weeds, as well as for biodiversity and the mitigation of GHG emissions	-	-	NOx	2020-2030		This is hardly feasible in Serbia. Serbia has very little or none regions with two harvests
	Increase legume share in fodder area	Additional legumes on temporary grassland increase bio-fixation and therefore reduce fertiliser needs. It is assumed that the legume share on temporary grassland can be increased to a maximum of 20%, which is equivalent to a nitrogen fixation rate of 15%. The biological nitrogen fixation processes lead to a reduction in fertilizer use.	1. Measure saves fertilizer costs hence farmers will apply this measure if it is profitable.	-	NOx	2020-2050		Serbia has the most valuable indigenous plant genetic resources in legumes, but the resources for planting are not adequate.
	Breeding for higher milk yields	A genetic selection for cows with higher milk yields may reduce overall emissions if the cow herd is reduced due to limited market outlets. An increase in milk yields per cow will also increase emissions per cow but this may be overcompensated by reduced cow numbers, basically because the maintenance requirements of the cow herd are reduced.	1. Subsidies for membership fees in breeding organizations / societies. 2. Research support; support from advisory services. 3. Potentially support for the establishment of breeding organizations	CH_4	-	2020-2050		

Agriculture	**Linseed as feed additive for cattle**	Supplementing animal diets with lipids is used to increase the energy content of the diet and to enhance energy utilization resulting in higher feed efficiency and decreasing methane emissions from cattle. One of the most efficient dietary lipids is linseed. The effectiveness of feeding linseed in decreasing enteric methane emissions depends on the share of linseed in total feed.	1. Render addition of linseed in the fodder ratio mandatory for the fodder industry in appropriate amounts. 2. Support further research. 3. Support for the extension system to help in application targeted to local conditions and avoid losses in performance.	CH_4	-	2030-2050		In Serbia, linseed is cultivated in small areas.
	Precision farming	Precision farming (PF) is a management concept based on observing, measuring and responding to inter- and intra-field variability in crops. Precision farming incorporates several technological tools, including Variable Rate Technology (VRT), Remote Sensing Technologies, Global Positioning Systems (GPS) and Geographical Information Systems (GIS) that should all help to apply inputs and machinery more precisely.	1. Render PF mandatory for farms above some size threshold. 2. Subsidies for credits. 3. Perhaps support for license fees for GPS. 4. Support from advisory services. Establishment of model farms and supports for visits. 5. Help for establishment of rental services targeting smaller or medium sized farms.	BC	CO_2, CO, NMVOC	2030-2050		This is hardly feasible in Serbia There is very little knowledge about precision farming, and almost none financial support. BioSense is the only company dealing with precision agriculture, but not farming.

Agriculture	**Anaerobic digestion**	Anaerobic digestion (AD) is the microbiological conversion of organic matter in the absence of oxygen. When this process happens in a sealed tank (anaerobic digester), biogas is produced. A by-product of the AD process is digestate, a nutrient-rich substance that is usually used as fertiliser. Many different raw materials are used as feedstock for AD, ranging from manure, harvest residues and dedicated energy crops from agriculture to organic waste products from the food industry and households. Manure has actually a rather low biogas yield potential, which is why crop material and organic wastes are often used as co-substrate to increase the yield of the biogas and profitability of the AD plant.	1. Subsidies for credits for constructing CHP facilities. 2. Support for quality improvements permitting to feed in biogas into the public gas system. 3. Support from advisory services.	CH_4	-	2030-2050		Fisible, there is Biogas Association with over 30 members, which has 14 biogas power plants.
	Nitrification inhibitors	Nitrification inhibitors are chemical compounds delaying bacterial oxidation of the ammonium-ion, by depressing the metabolism of Nitrosomonas bacteria over a certain time period. These bacteria are responsible for the transformation of ammonium via nitrite (NO_2) to nitrate (NO_3). The objective of using nitrification inhibitors is to control leaching of nitrate by keeping nitrogen in the ammonia form for a longer time, to prevent denitrification of nitrate-N and N_2O emissions from nitrification and denitrification.	1. Probably direct payment for mitigation of GHG emissions. 2. Advisory efforts explaining the effects on nitrogen use efficiency may stimulate the self-interest of farmers to save fertilizer use. 3. Research support.	-	-	2040-2050		Novel technology, not applicable in Serbia soon

Agriculture	**Anti-methanogenic vaccination**	The development of vaccines that specifically target the methane-producing methanogens in the rumen could reduce methane emissions from enteric fermentation of ruminants	1. Probably subsidies for vaccines. 2. Demonstration farms to show that vaccination does not reduce performance 3. Research support; support from advisory services.	CH_4	-	2040-2050		Not applicable in Serbia soon
	Breeding for ruminant feed efficiency of non-dairy ruminants	A genetic selection for non-dairy ruminants with lower energy and crude protein need results in lower methane emissions from enteric fermentation. The feed efficiency gains reduce feed intake and savings in feed cost. Hence, it is likely that the measure will be accepted by farmers if access to genetically improved animals is affordable and these animals do not involve other perceived risks, for example for health.	1. Subsidies for membership fees in breeding organizations/ societies. 2. Research support; support from advisory services. 3. Potentially support for the establishment of breeding organizations.	CH_4	-	2040-2050		Hardly achievable
	Nitrate as feed additive	Bacteria from the rumen are able to use nitrate as alternative electron acceptors for hydrogen, which reduces methane production. Thus, using nitrate as a feed additive can reduce methane emissions from enteric fermentation.	1. Probably subsidies for application of feed additives. 2. Research support; support from advisory services to avoid health risk that would undermine the trust of farmers in this measure.	CH_4	-	2040-2050		Hardly achievable
Land Use Change and Forestry	**Afforestation**	Afforestation – establishing new forests using site mapping and CC adapted tree species. In M2-M3 scenarios total of 2 952 ha/ year and in M4 scenario is planned 23 216 ha/year	1. The use of site mapping and climate change adapted tree species for afforestation. 2. Financial, regulatory and informational/ educational instruments will be used for implementation. 3. Increasing the forest cover and CO2 sink, while it will satisfy increasing energy demand.	-	CO_2	2020-2050		Lack of appropriate seedlings, both in quantity and quality, inadequate policy and legal coordination among sectors related to this measure Possible lack of funds

Land Use Change and Forestry	**Close to Nature Forest Management**	Change of forest management practices toward close to nature forest management approach - Additional planting of conifers 300 ha/year	1. To include measures that will be implemented in the future for the purposes of adaptation to CC. 2. The planting of conifers under the canopy of broadleaved stands, which should increase the mixture, and increase the annual increment for 1.0 m3/ha compared to pure broadleaved forests. 3. The additional planting of conifers on 300 ha annually.	-	CO_2	2020-2050		Lack of seedlings Possible discourse between different forestry related policies Lack of capacities for implementation of SFM concept
	Conversion of coppice to high forest	Conversion of coppice forest to high forests is planned on the area of 7.000 ha annually as direct conversion and is also mentioned in R5.	1. Taking into consideration of suitable coppice forests and damaged stands (ice breaks, wind breaks), while considering tree species will be done in broadleaved forests, since there is almost no coppice in coniferous forests. 2. The quantity of wood which will be felled during this process will in a certain amount of time increase the emission (during the burning process), but in the total balance, an effect will be that it will increase the gain of CO2, since the average increment of high forests is 3.0 m3/ha higher, compared to increment in coppice forests.	No SLCPs directly affected	CO_2	2020-2050		Possible silence of private forest owners
	Short Rotation Plantations	Short rotation plantations (SRP) as a measure are defined in National Strategy for incorporation of the Republic of Serbia into clean development mechanism of Kyoto protocol for waste management, agriculture and forestry and in R1 and R5. Estimation is that in Serbia, around 1 million hectares of barren agricultural land are available.	1. The proposition of an area of 1500 hectares annually to be established using poplars and willows as the main tree species.	No SLCPs directly affected	CO_2	2020-2050		Administrative barriers for buying/leasing available land Legislation from nature protection sectors Initial problem of establishing and management of SRP

Land Use Change and Forestry	**Regeneration of over mature stands**	Regeneration of over matured beech stands as a measure should be done on an area of 70.000 hectares in the period until year 2035. Felling beech over mature stands 4.200 ha/year	1. In order to finish the planned felling until year 2035, the size of felling area should be planned as 4.200 ha/annually.	No SLCPs directly affected	CO_2	2020-2035		Lack of technical capacities in enterprises for jobs in forestry Lack of seedlings for additional planting where natural regeneration is missing
	Reduction of abiotic and biotic factors	Reduction of abiotic and biotic factors – forest fires by proper forest management	1. Decreasing the number and area of forest fires can be done through control and prevention of damages caused by different factors. 2. The establishing of a fire hazard assessment system within the Meteorological Service; modernization of the observation system and notification of the occurrence of forest fires. 3. Defining degree of vulnerability of forest areas to the fire; equipping teams for quick intervention on forest fires in Forest Estates, etc.	No SLCPs directly affected	CO_2	2020-2050		Lack of experts for forest fires prevention Lack of integrated system for prevention and protection of forest fires and other biotic and abiotic factors
	Establishing of permanent research plots	Establishing of permanent research plots can be foreseen as a measure that is indirectly included in climate change mitigation, and as a support activity.	1. The using of research plots as multifunctional and serve for monitoring of climate change impacts, as well as for education of students and employees in forestry sector in relation to climate change. 2. Application of plots for implementation of previously defined measures (especially afforestation, conversion of coppice forests etc.) because they can provide precise data about habitat condition and tree species suitable for certain habitats.	No SLCPs directly affected	CO_2	2020-2050		Lack of funds Lack of human capacities for establishing, maintaining and monitoring of these plots

Land Use Change and Forestry	**Promotion of proper use of wood**	For promotion of proper use of wood focus should be on the promotion of use of final products made of wood instead of other materials for constructing which have much higher energy consumption to create final products than final products made of wood.	1. Promotion of proper use of wood can be implemented in several sectors, namely: energy, energy efficiency and construction sector. 2. In the energy sector, the point should be stressed on utilization of wood with lower humidity especially in households, while in the energy efficiency sector attention should be put on proper insulation of houses and promotion of use of much more energy efficient stoves in households. 3. Increased use of wood should be promoted so that beside replacement of usage of other materials with wood, further focus should be on promotion on increasing use of wood-based product as well.	No SLCPs directly affected	CO_2	2020-2050		Costs of implementation for this measure
	Improving management of private forests	Private forests in Serbia represent a significant category, because they cover almost 50% of the total forest area and their management should be imporved. Nevertheless, these forests are not in such good condition as state owned forests which are managed regularly.	1. The implementation of better management of private forest are to provide enough information to owners, as well as different educational schemes for managing their forests. 2. To foster for establishing of associations and certain funds which should be available for them to buy new equipment for jobs in forestry.	No SLCPs directly affected	CO_2	2020-2050		Costs of implementation for this measure Small forest property size Migration from rural areas Change of interests of new owners toward forest
	Implementing the NFI	National forest inventory (NFI) is an instrument in forest sector for collecting information on forests at national level and represents a reliable data base for higher-level forest area planning. The NFI is obligation defined in the Law on forests.	1. To enable the elaboration of the National Forest Program, and can serve as a basis for presentation of carbon stock in Serbian forests. 2. To create better insight of contribution of the forest to climate change mitigation and adaptation at national level.	No SLCPs directly affected	CO_2	Each 10 year		Insufficient financial resources

Land Use Change and Forestry	Reformulating the NFP	The umbrella document in the forestry sector is National Forest Program. which contains objectives, measures, timeline, subjects for implementation, financial sources, as well as indicators and reporting duties in order to follow the implementation of prescribed objectives. NFP can be considered as vision document of the forest sector taking in consideration other forest related and forest focused policies and can be seen as communication cross sectoral instrument to harmonize and make synergy among different sectoral policies, strategies and their implementation instruments.	1. The revision of NFP in a certain period of time. 2. To reformulate NFP on the basis of NFI.	No SLCPs directly affected	CO_2	Each 10 year		Insufficient financial resources
Waste	Construction of sanitary landfills	This measure implies construction of sanitary landfills in 17 out of 26 waste management regions (currently 9 sanitary landfills have been built)	1. The waste treatment targets are intensified in order to achieve higher emissions reductions. 2. An increasing investments in capacities and treatment technologies, more efficient collection system (i.e. efficiency of source separation schemes), as well as more intensive public awareness campaigns and initiatives in line with defined targets. 3. By the year 2050, combination of treatment options for diverting 85% of generated food and garden waste to compost facilities and 15% is landfilled. 4. The combination of recycling and composting treatments for paper and cardboard wastes divert 75% of generated waste from landfills (of which 50% should be recycled and 15% composted) and 10% is planned to be incinerated. Rest of the paper and cardboard waste (25%) should be landfilled.	CH_4	CO_2, CO, NMVOC, HCl, HF	In accordance with the current level of infrastructure and development status of waste management regions, it is estimated that full implementation of the observed measure will be reached by 2030		Low public awareness, NIMBY syndrome, insufficient administrative capacities in relevant institutions on local level; lack of funds

Waste	**Introduction of source separation & Construction of Material Recovery Facilities**	This measure includes establishment and implementation of source separation systems in all Serbian municipalities, following by construction of at least one Material Recovery Facility in each waste management region.	1. To increase the recycling of recyclable materials and diversion of biodegradable fractions (i.e. paper and cardboard) from landfills.	CH_4	CO_2	2020-2035		Low public awareness, NIMBY syndrome, insufficient capacities in relevant institutions on local level; lack of funds
	Construction of Biological Treatment Facilities (Composting Plants)	This measure includes separate collection of biodegradable and green waste and construction of at least one Biological Treatment Facility in each waste management region	1. Increasing diversion of biodegradable waste from landfills by introduction of defined biological treatment options (e.g windrow composting plants and production of high-quality compost). 2. The construction of anaerobic facilities and implementation of enhanced waste prevention initiatives. 3. By the year 2050, combination of treatment options to divert 85% of generated food and garden waste to compost facilities and 15% to anaerobic digestion. 4. Combination of recycling and composting treatments for paper and cardboard wastes divert 90% of generated waste from landfills (of which 60% should be recycled and 20% composted) and 10% to be incinerated. Only 10% of paper and cardboard waste is planned to be landfilled.	CH_4	CO_2	2020-2040		Low public awareness, NIMBY syndrome, insufficient capacities in relevant institutions on local level; lack of funds
	Construction of Thermal treatment (Incineration) Plant	This measure includes the construction of thermal treatment (Incineration) plant in Belgrade waste management region	1. Increasing diversion of certain biodegradable fractions (i.e. paper and cardboard) from landfills by introduction of incineration treatment options.	BC, CH_4	CO_2, CO, NMVOC, NO_x, HCl, HF, SO_x, $PM_{2.5}$, PM_{10}	2020-2025		Low public awareness, NIMBY syndrome, insufficient capacities in relevant institutions on local level, lack of funds, conflicting with Material recovery facilities objectives, institutional opposition, NGO initiatives

Waste	**Construction of Biological Treatment Facilities (Anaerobic digestion)**	This measure includes separate collection of biodegradable and green waste and construction of at least one Biological Treatment Facility in each waste management region	1. Increasing diversion of biodegradable waste from landfills by introduction of defined biological treatment options (e.g windrow composting plants and production of high-quality compost). 2. The construction of anaerobic facilities and implementation of enhanced waste prevention initiatives. 3. By the year 2050, combination of treatment options to divert 85% of generated food and garden waste to compost facilities and 15% to anaerobic digestion. 4. Combination of recycling and composting treatments for paper and cardboard wastes divert 90% of generated waste from landfills (of which 60% should be recycled and 20% composted) and 10% to be incinerated. Only 10% of paper and cardboard waste is planned to be landfilled.	CH_4	CO_2	2020-2040		Low public awareness, NIMBY syndrome, insufficient capacities in relevant institutions on local level, lack of funds
	Waste prevention initiatives	Implementation of enhanced waste prevention initiatives in order to decrease waste generation rate	1. Taking into account enhanced waste prevention of 28% by year 2050, which is about 2% of waste reduction through preventive measures per year	CH_4	CO_2	2020-2050		Lack of available financing, low public awareness, no financial incentives to change consumers behavior, initiatives are limited in time, should be accompanied with real waste prevention PaMs
	Construction of waste water treatment plant with sludge treatment	Building a system collection and treatment of wastewater together with treatment of sludge, in accordance with the Directive Specific Implementation Plan for the Council Directive of 21 May 1991concerning urban wastewater treatment (91/271/EEC).	1. The application of Directive Specific Implementation Plan for the Council Directive of 21 May 1991concerning urban wastewater treatment (91/271/EEC).	CH_4	CO_2, N_2O	2020-2050		Low public awareness, insufficient capacities in relevant institutions; lack of funds

4. Recommendations for inclusion of SLCPs in NDC revision and climate change planning in Serbia

4.1 Inclusion of SLCPs in Serbia's NDC revision

Recommendation #1: Include HFC commitment in revised NDC

- Hydrofluorocarbons are a GHG and are one of the GHGs considered in Serbia's revised NDC. They are also an SLCP because their lifetime in the atmosphere is substantially shorter than long-lived GHGs like carbon dioxide.
- The contribution that HFCs make to achieving Serbia's climate change commitment is not detailed in the NDC revision.
- Given that Serbia is part of the Montreal Protocol and is a signatory of the Kigali amendment, the HFC phasedown schedule and Serbia's HFC reduction plans could be included in the revised NDC as an additional contribution to achieving the GHG reduction target.
- The main source of HFCs is air conditioning and refrigeration. In addition to reducing HFCs, replacing air conditioners and refrigerators with low-GWP refrigerants and more efficient systems can contribute to the energy efficiency targets in the revised NDC.

Recommendation #2: Include vehicle emission standards (Euro) in transport mitigation measures to maximize SLCP reductions

- The actions in the transport sector, as described in the revised NDC, will improve air quality (such as investing in public transport). However, improving the fuel efficiency of the vehicle fleet alone will not necessarily improve the emissions of black carbon, or other air pollutants.

- Therefore, for actions in the transport sector to be consistent with reducing SLCPs (black carbon) as well as GHGs, we would recommend that it is also stated that, as well as improving fuel efficiency, vehicles should also be required to meet Euro 6 standards by a certain date which will be defined by certain regulation.

Recommendation #3: Consider including policies and measures targeting major methane sources (waste and livestock)

- The revised NDC does not consider any policies and measures that target major sources of methane, including the waste and livestock sectors.
- Considering policies to reduce emissions from the waste sector (both solid waste and waste water) could include measures to divert waste from landfill (e.g. increasing recycling, composting rates), or technical measures to capture methane from landfill.
- For the livestock sector, reducing food waste could reduce the emissions from livestock, and technical (animal husbandry practices) can increase the efficiency, and reduce emissions from meat and dairy production. CSUD and BioWaste Challenge projects are the pilot actions related to emission reduction in this sector. Additionally, the targets for emission reduction are defined in new National Waste Management Strategy including National Waste Management Plan.

Recommendation #4: Include specific section talking about importance of SLCPs, and link to air pollution/health

- The NDC (Annex 2) does an excellent job of outlining the air quality benefits from the actions that will be taken to achieve the overall NDC reduction target.
- It might be useful to have a specific section in the NDC, that specifically focusses on SLCPs, and air pollutants. The local benefits that would be achieved from taking actions in the NDC in improving air quality and the health locally in Serbia achieved by global climate change actions.

4.2 Next steps and further recommendations

Recommendation #5: Ensure consistency between GHG inventory development and air pollution emission inventories

- Serbia already develops the key tool and information to track progress on SLCP emissions (i.e. an emission inventory that quantifies the emissions of GHGs, SLCPs and air pollutants from all sources).
- We recommend that efforts are made to ensure that there is consistency between the emission inventory for GHGs (developed through UNFCCC reporting processes) and the emission inventory for air pollutants (developed through CLRTAP reporting processes).
- This consistency can be ensured by i) developing the inventories together and having a single emission inventory development platform, ii) having a data repository that is used for the development of both inventories.

Recommendation #6: Incorporate SLCPs and climate change mitigation in air quality strategy update

- As the air quality strategy is updated, we would recommend that SLCPs and climate change mitigation are integrated into it.
- This can be achieved by first assessing the air pollution benefits that can be achieved from Serbia's climate change actions (low carbon development strategy, NDC etc.) to ensure there is coherence between AQ plans and climate change action. Showing the air pollution benefits from climate change action can also act as a starting point to identify additional, specific actions to reduce air quality further, on top of improvement from climate change action.
- To facilitate this we would recommend that an integrated air pollution and climate change mitigation assessment is conducted. The emission reduction potential of all pollutants is estimated for all policies and measures being considered in climate change mitigation and AQ planning.

Recommendation #7: Increase consideration of SLCP and air pollution and climate change mitigation in sectoral strategies, plans and policies

- New sectoral strategies or plans should consider SLCP and air pollution and climate change mitigation
- One way to implement and increase consideration of air pollution and climate change

impacts in sectoral activities is to require that, for new projects and programmes, and air pollution and climate impact assessments be undertaken to quantify the impact that the programme will have on air quality and GHG and SLCP emissions, before it is implemented.

Recommendation #8: Join the Climate and Clean Air Coalition

- The CCAC is the only global organization whose goal is to reduce SLCPs and simultaneously improve air quality and mitigate climate change.
- By becoming a Partner in the CCAC, Serbia would be able to access potential opportunities for funding of projects on SLCP planning (through the SNAP initiative) or to take forward priorities in key SLCP sectors.
- Serbia would also be able to provide their view and experience in dealing with air quality and climate issues, and learn from the experience of other countries in taking forward actions to reduce SLCPs

Recommendation #9: Increasing research/filling research gaps/policy analysis on air pollution and climate change linkages

- While there is a large amount of information on SLCPs, air pollution and climate change already available in Serbia, there is also a big opportunity for further research to overcome gaps and to improve understanding and enhance the reduction of air pollution and climate change in Serbia. Potential areas of further research include:
    - Air pollution health and crop impact assessments
    - Country specific emission factors
    - Mitigation and scenario assessments taking into account air pollution and climate change
    - Cost-benefit analyses of mitigation options

Recommendation #10: Mobilize resources

- There are a large number of opportunities for funding of actions related to SLCP, or integrated air pollution and climate change mitigation, including from international donors, development banks, multilateral funds etc.
- For example, the Green Climate Fund has included ‘health’ as a priority sector for their funding submissions

Recommendation #11: Include black carbon within air pollution monitoring network

- The pollutant that are included in the national air quality monitoring network do not include black carbon
- Monitoring of black carbon concentrations through a ambient air quality monitoring network can provide key information on i) source apportionment, and ii) long-term trends, either due to socioeconomic developments, or to monitor the impact of policy interventions.
- A good example is the UK black carbon monitoring network, which monitors black carbon at 14 sites across the UK: https://uk-air.defra.gov.uk/networks/network-info?view=ukbsn

Recommendation #12: Promote regional collaborations to reduce air pollution

- Air pollution is not just a local phenomenon, and in many cases after pollutants are emitted they can be transported long distances, affecting population 10 or 100s of km from their source.
- Therefore, in addition to taking action in Serbia, promoting a regional approach to reducing air pollution can help to maximize air pollution reductions in Serbia, while also increasing benefits for the whole region.

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