Technological pathways towards the ratification of the amended Gothenburg Protocol in Serbia, Georgia, Kazakhstan, Moldova, Montenegro and Armenia

November 2024

Prepared by TFTEI Techno-Scientific Board
Nadine Allemand
Natalia Sirina-Leboine

Technological pathways towards the ratification of the amended Gothenburg Protocol in Serbia, Georgia, Kazakhstan, Moldova, Montenegro and Armenia

For more information

TFTEI Techno-Scientific Board
Dr. Nadine Allemand and Dr. Natalia Sirina-Leboine
Citepa
42 Rue de Paradis
75010 Paris
France
T: + 33 (0)1 44 83 68 83
E: nadine.allemand@citepa.org
E: natalia.sirina-leboine@citepa.org

Content

List of abbreviations and acronyms

AGP	Amended Gothenburg Protocol
AA	Association Agreement (with the EU)
AAP	Advisory Assistance Programme
API	Air Pollution Index
AQM	Air Quality Management
BAT	Best available technique
BAT AEL	Best available technique associated emission level
BC	Black carbon
BF	Baghouse filter
BREF	Best available technique reference document
CCAC	Climate and clean air coalition
CCGT	Combined cycle gas turbine
CEPA	Comprehensive and Enhanced Partnership Agreement
CFB	Circulating fluidised bed
CHP	Combined Heat and Power plant
CLP	Classification, labelling and packaging
CLRTAP	Convention on long-range transboundary atmospheric pollution
CMR	Carcinogenic, mutagenic or toxic for reproduction
CN	Combined nomenclature
CNG	Compressed Natural Gas
DLN	Dry low NOx (burner)
DSI	Duct sorbent injection
DSIP	Directive specific implementation plan
EA	Environmental Assessment
EAS	Environmental Approximation Strategy
EC	European commission
EU	European Union
EGR/FGR	Exhaust/Flue-gas recirculation
EIA	Environmental impact assessment
ELV	Emission limit value
EMEP	European monitoring and evaluation programme
EP	Environmental permit

EPCG	Elektroprivreda Crne Gore AD Nikšić
EPIP	Environmental performance improvement programme
E-PRTR	European pollutant release and transfer register
ESP	Electrostatic precipitator
EAEU	Eurasian Economic Union
EPMIB	Environmental Protection and Mining Inspection Body
FBC	Fluidised bed combustion
ECA	Emission Control Areas
FCC	Fluid Catalytic Cracking
FGD	Flue gas desulphurisation
GAINS	Greenhouse gas and air pollution interactions and synergies
GDP	Gross domestic product
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
HF	Highest Frequency (in Kazakhstan)
HF	Hydrogen fluoride
IBRD	International Bank for Reconstruction and Development
IHMS	Institute for Hydrometeorology and Seismology (Montenegro)
IEA	International Energy Agency
IED	Industrial emission directive
IEP	Integrated environmental permit
IIR	Informative inventory report
IPA	Instrument for Pre-Adhesion of the European Union
IPPC	Integrated pollution prevention and control
IGTIPC	International Green Technologies and Investment Projects Centre
JRC	Joint research centre
KAP	Kombinat aluminum Podgorica
LCP	Large combustion plant
LEPL	Legal Entity of Public Law
LRTAP	Long-range transboundary air pollution
LNB	Low-NOx burner
LPG	Liquefied petroleum gas
LV	Limit Value
MAC	Maximum Allowed Concentrations

MCP(D)	Medium Combustion Plant (directive)
MEP	Ministry of the Environment Protection
NDC	National Determined Contribution
NEA	National Environmental Agency
NERP	National Emission Reduction Plan
NEAS	National Environmental Approximation Strategy
NFR	Nomenclature For Reporting
NOx	Nitrogen oxides
OGRS	Official gazette of the Republic of Serbia
OFA	Over-fire air
PAH	Polycyclic aromatic hydrocarbon
PC	Pulverised combustion
PER	Perchloroethylene
PTPP	Pljevlja Thermal Power Plant
PM	Particulate matter
Poly-SUMP	Polycentric Sustainable Urban Mobility Plan
PP	Power plant
RAC	Regenerated activated carbon
RES	Renewable Energy Source
RFO	Refinery fuel oil
RS	Republic of Serbia
RTO	Regenerative thermal oxidiser
SCR	Selective catalytic reduction
SDA	Spray dry absorber
SEPA	Serbian Environment Protection Agency
SNCR	Selective non-catalytic reduction
SI	Standard Index
SO2	Sulphur dioxide
SRU	Sulphur recovery unit
STS	Surface treatment using solvents
SUMP	Sustainable Urban Mobility Plan
TA	Technical Annexes
TFTEI	Task force on techno-economic issues

TiO2	Titanium dioxide
TPP	Thermal power plant
TSP	Total suspended particles
UBA	Environment Protection Agency
UNECE	United Nations Economic Commission for Europe
US EPA	United States environmental protection agency
US(A)	United States (of America)
WB	Water based
WG	Working group
WGC	Waste gas management and treatment systems in the chemical sector
WGSR	Working Group on Strategies and Review
VRU	Vapour recovery unit

Summary

TFTEI developed 6 case studies to explore possible technological pathways towards the ratification of the Amended Gothenburg Protocol (AGP), in selected EECCA and SEE and Balkan countries, as preparatory phase, firstly, as part of the document ECE/EB.AIR/2022/5, ‘Technical information for the review of the Gothenburg Protocol’ to support the discussion on barriers to ratify the AGP, at the 42nd session of the Executive Body (EB) in December 2022 and, secondly, for further discussions during 2023 and 2024.The summary conclusions for Armenia, Georgia, Kazakhstan, Moldova, and the Balkan countries Serbia, and Montenegro are presented here.

The Amended Gothenburg Protocol (AGP) under the LRTAP Convention (now Air Convention) sets ambitious targets for reducing air pollutant emissions. Serbia, Montenegro, Moldova, Armenia, Georgia, and Kazakhstan, as Parties to the Convention, are progressing at different paces in aligning their national framework with the Protocol’s requirements.

Serbia and Montenegro, driven by the EU accession process, have made significant strides in transposing the Protocol’s key provisions into their national legislations. Their alignment reflects the integration with the EU environmental standards, including mechanisms for air pollution control and emissions reduction. In contrast, and driven by the EU Association Agreements, Georgia, Armenia, and Moldova are in progressive stages of aligning their regulations with the AGP Technical Annexes (TA) provisions through alignment with key EU Directives. These countries are working to adopt legislative and technical frameworks consistent with the Protocol's provisions, though challenges remain in fully implementing advanced air pollution measures. Kazakhstan, while beginning to implement the Best Available Techniques (BAT) approach, has notable room for improvement in strengthening its regulatory framework, soto meet the Protocol’s provisions. The varying stages of alignment highlight the importance of tailored support and capacity-building efforts to enable these countries to achieve compliance with AGP provisions and enhance air quality outcomes.

Serbia

Air quality and sources of emissions

In the Republic of Serbia, geographical zones and agglomerations are classified into three categories numbered from “1” for “pure or slightly polluted air” to “3” for “too polluted”. In 2019, in the zones and agglomerations where air quality was monitored, 43% of the population lived in category 3 zones, ‘too polluted’. Looking only at the agglomerations and cities, where air quality has been measured, deterioration of air quality is observed. In the Republic of Serbia, PM_{10} and $PM_{2.5}$ are, by far, the main air quality problem, with concentrations of PM_{10} and $PM_{2.5}$ in ambient air, exceeding the EU air quality limit values to a large extent. Excessively high concentrations of PM_{10} and $PM_{2.5}$ are widespread throughout the region.

There are less challenges on NO_2 concentrations. Exceedances of the annual limit value were observed only in Beograd, in 2021. The hourly limit value was exceeded more than 18 hours/year in Beograd too. The Serbian NO_2 daily limit value (85 µg/Nm^3) is exceeded in a larger number of cities

In terms of $PM_{2.5}$ emissions, “Other stationary combustion” sector which includes small domestic heating appliances is the critical source and accounts for 46 kt of $PM_{2.5}$ in 2020, or 80% of total $PM_{2.5}$ emissions.

Large combustion installations for electricity generation remain, by far, the largest contributors to total SO_2 and NOx emissions in 2020 (91.3% and 41.5%, respectively).

In summary, the Serbian air quality network is well developed. The main issue concerns $PM_{2.5}$ emissions from residential heating. $PM_{2.5}$ limit values are exceeded throughout Serbia. The quality of air pollutant emission inventory should be improved to more realistically reflect the impacts of the regulations, already enforced.

Current legislations and programmes for the alignment with several EU Directives and Regulations

Serbia has been committed to lowering its air pollutant emissions and improving air quality for many years by implementing national regulations, which often transpose EU Directives. A legislative framework is in place and regulations have been adopted to limit emissions from Large Combustion Plants (LCPs) and industrial sources, as well as in a number of other activities and areas. As EU candidate country, Serbia started several years ago to align its own air quality policies and regulations with the EU legislations, in particular with regard to the following EU Directives (however, for some of them, transitional periods will have to be requested for full alignment and will be subject to further negotiations with the EU):

a) Directive 2008/50/EC of 21 May 2008 on ambient air quality and cleaner air for Europe,
b) Directive 2004/107/EC of 15 December 2004 on arsenic, cadmium, mercury, nickel, and polycyclic aromatic hydrocarbons in ambient air,
c) Directive 2010/75/EC of 24 November 2010, on Industrial Emissions (IED),
d) Directive 1994/63/EC of 20 December 1994 on the control of VOC emissions resulting from the storage of petrol and at distribution from terminals to service stations (Stage I Petrol vapour recovery) and Directive 2009/126/EC of 21 October 2009 on Stage II petrol vapour recovery during refuelling of motor vehicles at service stations,
e) Directive 2009/30/EC of 23 April 2009 as regards the specification of petrol, diesel and gas-oil,
f) Directive 2016/802 of 11 May 2006 relating to a reduction in the sulphur content in certain liquid fuels,
g) Directive 2004/42 on the limitation of emissions of volatile organic compounds due to the use of organic solvents in certain paints and varnishes and vehicle refinishing products,
h) Directive 2284/2016 of 14 December 2016 on the reduction of national emissions of certain atmospheric pollutants.

The Republic of Serbia is at a fairly advanced stage, in terms of drafting its legislation and aligning it with the main EU Directives.

As far as industrial emissions are concerned, the legislative framework for transposing the EU Industrial Emissions Directive (IED) has been adapted through various international projects and is ongoing in order to ensure full alignment in the near future. A recent project entitled “Green Transition – Implementing Industrial Emissions Directive in Serbia 2021-2025” provides technical and administrative support to the Ministry of Environmental Protection and other competent authorities, in the preparation of draft integrated permits for selected companies. The number of large industrial facilities with integrated permits is increasing (20% by 2022). With the adoption of IED, the emission limit values (ELVs) for stationary sources in AGP Technical Annexes IV, V, VI and X should be respected, assumed that enforcement is continued.

With regard to the quality of fuels and their sulphur content (with reference to the sulphur content of gasoil covered in AGP Annex IV and the characteristics of petrol and diesel fuels in AGP Annex VIII), the legal framework has also been adapted to transpose several EU directives. The sulphur content of gasoil is 0.1% w/w and the sulphur content of petrol and diesel are considered as applied in the Republic of Serbia. However, it has not been possible to obtain the full characteristics of diesel and petrol and compare them with the characteristics of petrol and diesel provided in AGP Annex VIII.

The limit values prescribed by the AGP Annex VI, to control VOC emissions from the distribution of petrol from terminals to service stations and from the refuelling of cars have been derived from the limit values in Directive 1994/63/EC of 20 December 1994, on the control of volatile organic compound (VOC) emissions resulting from the storage of petrol and its distribution from terminals to service stations and Directive 2009/126/EC on Stage II petrol vapour recovery during refuelling of motor vehicles, at service stations. In recent years, the Republic of Serbia has endeavoured to upgrade its regulations to be in line with the two above mentioned EU Directives and to ensure full implementation of the requirements of both Directives, relating to the petrol distribution chain from terminals to service stations and vehicle refuelling.

For what concerns the solvent content in products, the limit values for the VOC content in products, prescribed by the AGP [31] Annex XI, have been mainly developed on the basis of the limit values given in Directive 2004/42/EC on the limitation of emissions of VOCs related to the use of organic solvents in decorative paints and varnishes. The main provisions of such Directive have been transposed, with the exception of provisions prescribed for EU Member States only (e.g. reporting to the Commission), through amendments to the Law on chemicals and the Rulebook on Bans and Restrictions of Production, placing on the Market and Use of Chemicals between 2010 and 2021. A number of remaining requirements should be transposed by end of 2025.

The Republic of Serbia's Air Protection Programme, for the 2022 to 2030 period, and its action plan, were adopted in December 2022. The plan defines the emission sources for which the efforts to reduce pollutant emissions and improve air quality can be prioritised, as well as the actions to be implemented to achieve its objectives. One of the key measures, in the plan, relates to domestic heating using solid fossil and biomass fuels. Proposed measures include the faster replacement of existing domestic heating appliances with new eco-design-compliant appliances, combined with financial incentives. However, further activities are required by the Ministry of Mining and Energy, such as, further work on full harmonisation of national legislation with the EU Eco-design Directive, [41]and work on the transposition of EU Regulation 2015/1189/EU and Regulation 2015/1185/EU with regard to eco-design requirements for solid fuel boilers and solid fuel space heaters, respectively, as well as, the establishment and implementation of a financial incentive mechanism for the replacement of existing heating equipment in households with new EU-compliant appliances and heat pumps.

For what concerns the road vehicles, the limit values for light and heavy-duty vehicles, as referred to in AGP Annex VIII are mainly based on the 2008 and 2009 EU directives implementing the Euro 5/V and Euro 6/VI standards. These directives have been transposed by Serbia, and the Euro 6 limit values for light duty vehicles entered into force in 2019, and Euro VI in 2020 for heavy duty vehicles. Serbia continues the process to align its legislative framework with recent EU regulations, adopted after 2010, expected to be completed by the last quarter of 2025.

The Air Protection Programme should have enforced minimum Euro standards for imported used vehicles: Euro 5/V starting from 1 January 2024 and Euro 6/VI from 1 January 2025, but imports of older Euro 3/III and Euro 4/IV vehicles still exist still in the fleet, in the first half of 2024, with Euro 3 and Euro 4 vehicles accounting for around 40% of the imported vehicle. Some delays in the adoption process appear to be occurring.

The limit values in Annex VIII for NRMM, engines for locomotive propulsion and inland waterways were based on EU regulations adopted before 2010. These regulations have been transposed through different rulebooks for NRMM and engines produced in Serbia. Serbia has a plan to further adapt its legal framework to adopt the EU directives implemented after 2012 on these subject, expected to be concluded by last quarter of 2025.

Technological pathways

For stationary sources, the implementation of the following techniques can be recommended:

SO_x: Activities covered by AGP Annex IV: use of low-sulphur fuels and fuels switching, boiler sorbent injection, dry sorbent injection, spray dry absorber, circulating fluidised bed dry scrubber and wet flue-gas desulphurisation, possibly combined with the use of low-sulphur fuels (solid or liquid). With the enforcement of the updated Serbian legislation on industrial installations, the use of these techniques is underway.

NO_x: Activities covered by AGP Annex V: combustion optimisation, combination of primary techniques for NO_x reduction, e.g. air or fuel staging, flue gas recirculation, low-NOx burners, selective non-catalytic reduction and selective catalytic reduction. With the enforcement of the updated Serbian legislation on industrial installations, and the current legislation on medium combustion plants, the use of these techniques is underway.

PM: Industrial activities covered by AGP Annex X: bag filters and electrostatic precipitators in industrial processes, with appropriate equipment sizing. With the enforcement of the updated Serbian legislation on industrial installations, and the current legislation on medium combustion plants, the use of these techniques is underway.

PM: Domestic activities covered by AGP Annex X:

The domestic heating remains the main issue for PM emissions.

One of the key measures in the 2022-2030 Air Protection Programme, adopted in December 2022, relates to domestic heating with solid fossil fuels and biomass. The proposed measures include a programme to more quickly replace existing domestic heating appliances, with new Eco-design-compliant appliances, combined with financial incentives. In the cities of Kragujevac, Beograd, Nis, Valjevo and Užice (5 cities considered to be PM hot spots), a higher rate of replacement of the oldest appliances is foreseen. These measures are also linked to an energy policy aimed at reducing energy demand through achieving a higher level of energy efficiency.

In order to rapidly introduce more efficient appliances, the programme also includes activities for Serbia, such as the completion of the legal framework for the full harmonisation of its national legislation with the Eco-design Directive and the transposition of the two EU regulations on emissions and energy efficiency of solid fuel boilers and solid fuel local space heaters (Regulation 2015/1189/EU and Regulation 2015/1185/EU[42]). The establishment and implementation of the financial incentive mechanism for the replacement of existing heating equipment in households, with new EU-compliant appliances and heat pumps need also be put in place.

The AGP Annex X recommends PM emission limits for small appliances. These limit values could be a good starting point for guiding the production of new appliances with improved performances and reduced emissions. As far as domestic appliances and combustion are concerned, it is possible to reduce particulate emissions by optimising combustion parameters in a number of ways, to ensure the best possible conditions in terms of temperature, residence time (enough time is needed) and turbulence (to ensure good mixing of the combustion gases) (the three T rules), but also in terms of geometry of the combustion chamber, air supply and reduction of user intervention, through automated combustion systems. Solutions for these three parameters can be applied to different types of appliances, particularly to stoves.

Reducing emissions from small appliances also depends on the building/house energy efficiency. Policies aimed at increasing the energy efficiency of houses have a beneficial effect on air pollution, as they reduce the demand for energy and therefore emissions. In suburban areas, district heating can also be developed.

VOC: industrial activities covered by AGP Annex VI: the techniques available to comply with the AGP VOC emission limit values are primary measures such as low solvent content, water-based or solvent-free products, more efficient application methods and secondary measures such as thermal or catalytic oxidation, activated carbon adsorption, biological scrubbing. There are different combinations of primary and secondary measures depending on the type of activity. Good solvent management systems are recommended, with identification and quantification of solvent inputs and outputs. These latter can be used to set VOC emission reduction targets and monitor the progress achieved. Priority should be given to replacing hazardous solvents with non-hazardous products. With the enforcement of the updated Serbian legislation on industrial installations, the use of these techniques is underway.

VOC: VOC content in products covered by AGP Annex XI. The use of low solvent-based products or water-based products is necessary. The use of such products started several years ago in Serbia.

For **road transport vehicles**, the Republic of Serbia has been transposing the latest EU directives or regulations to apply to domestic vehicle production and new imported vehicles. However, the time taken to align the Serbian regulations and implement them can be lengthy. Consideration should be given to whether these timescales can be shortened.

For imported used vehicles, it could be examined if the actions scheduled in the Air Protection Programme are enforced without delay.

With regard to **Non-Road Mobile Machinery**, according to the information collected, the limit values for NRMM produced in Serbia comply with the standards of Tables 4 to 6 of AGP Annex VIII. Regulation 2016/1628 adopted by the EU in 2016 and introducing stricter limit values will be fully transposed as Rulebook on emission limit values of gaseous and particulate pollutants and homologation of internal combustion engines for non-road mobile machinery is expected in the second quarter of 2025. The possibility of reducing this timescale should be examined.

As candidate country, Serbia has been developing its legislative framework to make it in line with several key EU Directives and Regulations, so enabling the legislative framework to be aligned with most of provisions of the five AGP Technical Annexes IV, V, VI, X and XI for stationary sources and Annex VIII for mobile source but further legislation framework development may be needed, case by case. The action plan of the Air Protection Programme adopted in 2022 requires considerable further efforts in terms of legal framework development for limiting $PM_{2.5}$ emissions from small heating domestic appliances and adoption of other types of measures aiming at accelerated phase out of old appliances and reduce fuel demand through increased energy efficiency of houses/buildings. Enforcement of all these regulations will enable progressive reduction of emissions. There is room for stricter requirements in the road transport and NRMM sectors, through adoption of the newest EU Regulations and adoption of non-technical measures. Requirements on import of used vehicles could be made stricter and not further delayed. The impact of these regulations should be made visible in the emission inventory by improving the methods used and make use of reports from industry for the Pollutant Release and Transfer Register (PRTR) after checking them, for example.

Georgia

Air quality and sources of emissions

In Georgia, ambient air is monitored through eight automatic stations, one mobile station and passive tube measurement campaigns. In 2019, the highest $PM_{2.5}$ concentrations were observed in Georgia's most industrialised cities. Average annual NO_2 concentrations were above the annual limit value, in Tbilisi, and a few other cities. The legal framework has been adapted to transpose Directive 2008/50/EC of 21 May 2008 on ambient air quality and cleaner air for Europe (within 2023). Directive 2004/107/EC of 15 December 2004 relating to arsenic, cadmium, mercury, nickel, and polycyclic aromatic hydrocarbons in ambient air will be transposed into the legal framework within 2025.

The "Other combustion stationary sources" sector, which includes small domestic combustion installations, accounted for 7.25 kt of $PM_{2.5}$ in 2020, equal to 77 % of total $PM_{2.5}$ emissions in Georgia. In this sector, residential heating is the largest source of $PM_{2.5}$ emissions. Industrial combustion and processes accounted for 11% in 2020.

In terms of NOx emissions, road transport is the largest source, accounting for 41% of total NOx emissions in Georgia, in 2020. Large combustion installations for electricity production burns natural gas. Industry is the second largest source of NOx emissions, with 7.5 kt, equal to 16 % of the total emissions.

SO_2: Although a significant reduction in emissions has been observed in recent years, industrial activities are the main source of SO_x emissions, e.g., iron and steel production.

In summary, the Georgian air quality network should be extended to better cover the entire territory. Industrialised cities face high concentrations of PM and NO_2 limit values are exceeded in cities, mainly due to the road traffic. The air pollutant emission inventory should be improved to be more consistent and complete and being able to reflect effects of the existing regulations and those under preparation.

Current legislations and programmes for alignment with several EU Directives and Regulations

Georgia is working to develop regulations and improve of air quality. To this end, Georgia is endeavouring to align its national policies on fuel quality, petrol distribution and industry with numerous EU directives or regulations which, in most cases, have served as the basis for defining the limit values established by the AGP Technical Annexes IV, V, VI, X and XI. Currently the Association Agreement (AA) between the European Union and the European Atomic Energy Community and their Member States, on one side, and the Republic of Georgia, of the other side is under development. The Agreement sets out the roadmap for a number of key EU Directives, notably for air quality and sectoral emissions:

a) Directive 2008/50/EC of 21May 2008 on ambient air quality and cleaner air for Europe,
b) Directive 2004/107/EC of 15 December 2004 relating to arsenic, cadmium, mercury, nickel, and polycyclic aromatic hydrocarbons in ambient air,
c) Directive 2010/75/EC of 24 November 2010, on Industrial Emissions (IED),
d) Directive 1994/63/EC of 20 December 1994 on the control of VOC emissions resulting from the storage of petrol and at distribution from terminals to service stations Stage I Petrol vapour recovery and Directive 2009/126/EC of 21 October 2009 on Stage II petrol vapour recovery during refuelling of motor vehicles at service stations,
e) Directive 1999/32/EC of 26 April 1999 relating to a reduction of sulphur content of certain liquid fuels,

f) Directive 2004/42 on the limitation of emissions of volatile organic compounds due to the use of organic solvents in certain paints and varnishes and vehicle refinishing products.

The legal framework for the adoption of EU standards similar to, or even stricter than, the limit values established by the AGP Technical Annexes is in a well advanced status, and key legislation has been or will be soon adopted.

A Law on Industrial Emissions was adopted by the Parliament in June 2023, transposing the IED Directive. Several by-laws will be adopted by September 2025. Five EU BAT Conclusions have been translated into Georgian language (LCPs, cement, lime and magnesium oxide production, waste incineration, iron and steel plants and intensive rearing of poultry or pigs)[55]. A by-law on BAT conclusions shall be adopted by September 2025.

Integrated permits will be gradually implemented in existing installations, likely, within 2031, at the latest.

The introduction of legal requirements concerning the use of organic solvents in paints and varnishes to reduce VOC emissions, on the basis of EU Directive 2004/42/EC, has been completed. A by-law on solvents in paints and varnishes was adopted by the Government of Georgia, on 3 April 2024 and will come into force in July 2025.

The introduction of legal requirements for the storage and distribution of petrol is currently underway. It is based on the transposition of Regulation 94/63/EC on the control of VOC emissions resulting from the storage of petrol and its distribution from terminals to service stations, or Stage I. Full implementation for service stations and terminals will take place between 2024 and 2032.

For mobile sources falling within the scope of AGP Annex VIII, the situation is as in the following:

- For diesel, the sulphur content is limited to 0.001%w/w since 1 January 2023, with the Government Decree N° 238, adopted on 28 June 2023, imposing not only minimum Euro 5b standards for first registration of vehicles, but also the fuel characteristics. The sulphur content of diesel and petrol is aligned with the AGP, Tables 13 and 14 of Annex VIII since 2023, along with the other characteristics of fuels, with just some exceptions.
- Road vehicles are not produced in Georgia but imported only. By the Government Decree N° 238, adopted on 28 June 2023, EURO 5b emission standards have been established to first registration of vehicles (which is almost equivalent to imports,). The requirements of the Decree entered into force on 1 January 2024 for M1 and M2 category vehicles and will enter into force from 1 January 2025 for M3, N1, N2, N3 categories (This date could be possibly postponed to one year later, accordingly).
- Currently, limit values for NRMM, motorcycles and mopeds and other engines installed on locomotives, inland water vessels or recreation crafts have not been established yet, in Georgia. Currently, there are no legislative developments in this area.

Technological Pathways

The implementation of the Law on Industrial Emissions should enable Georgia to be in compliance with the limit values established by the four AGP Technical Annexes IV, V, VI and X, including LCPs and industrial installations.

The following techniques are recommended (few examples) for stationary sources:

NO_x: activities covered by the AGP Annex V: combustion optimisation; combination of primary techniques, e.g. air or fuel staging, flue gas recirculation, low-NO_x burners, selective non-catalytic reduction and selective catalytic reduction. With the enforcement of newly adopted Georgian legislation on industrial installations, the use of these techniques will be progressively implemented.

PM: industrial activities covered by the AGP Annex X: bag filters and electrostatic precipitators, with appropriate equipment sizing. With the enforcement of newly adopted Georgian legislation on industrial installations, the use of these techniques will be progressively implemented.

Domestic heating by solid fuels: The AGP Annex X recommends emission limits of PM in small appliances. These limit values could be a good starting point for the production of new, more efficient and less polluting appliances. As far as domestic appliances and combustion are concerned, reducing PM emissions can be achieved by optimising combustion parameters in a number of ways, to ensure the best possible conditions in terms of temperature, residence time (sufficient time is needed) and turbulence (to ensure good mixing of the combustion gases) (the three T rules), but also the geometry of the combustion chamber, air supply and reducing the user intervention, through automated combustion control systems. Solutions for these three parameters can be applied to different types of appliances, particularly stoves.

Reducing emissions from small appliances also depends on the energy efficiency of houses/buildings. Policies aimed at increasing the energy efficiency of houses have a beneficial effect on air pollution, as they reduce the demand for energy and therefore emissions. In suburban areas, district heating can also be developed.

VOC: industrial activities covered by AGP Annex VI:

The techniques available to comply with the AGP VOC emission limit values are primary measures such as low solvent content, water-based or solvent-free products, more efficient application methods and secondary measures such as thermal or catalytic oxidation, activated carbon adsorption, biological scrubbing. There are different combinations of primary and secondary measures depending on the type of activity. Good solvent management systems are recommended, with identification and quantification of solvent inputs and outputs. These latter can be used to set VOC emission reduction targets and for monitoring progresses. Priority should be given to replacing hazardous solvents with non-hazardous products. With the enforcement of legislation on industrial installations, the use of these techniques will be progressively implemented.

VOC: VOC content in products covered by AGP Annex XI . The use of low solvent-based products or water-based products is necessary. With adoption of a recent by-law on these products, these low solvent content products will be more and more used.

For **road transport**, the recent adopted Government Decree N° 238 adopted on 28/06/2023 introducing Euro 5b emission standards for vehicles registered for the first time in Georgia will be helpful to reduce pollutant emissions.

It is recommended to continue to the development of the legal framework to go further (such as the adoption of Euro 6c and 6d standards for light duty vehicles, on the basis of a test procedure, in real road driving conditions).

Many different measures can also be implemented to reduce emissions from road transport. Measures such as wider developing of the public transport system, so improving its attractiveness, providing incentives to use public transport, developing car-sharing schemes and promoting walking and cycling in cities, can be considered and planned. These latter measures enable the integrated approach which ultimately can be beneficial for air quality and reduce the GHG emissions. The use of new-generation vehicles and the development of electro-mobility in road traffic could also be envisaged.

Through efforts to develop a legislative framework for limiting emissions from industrial sources, which could be completed by September 2025, Georgia is making a considerable progress towards the reduction of pollutant emissions from industrial sources. This reduction will be progressive as integrated permits delivered to industrial installations are expected to be completed by 2031. The fleet of vehicles is quite old, but the recent Decree adopted in 2023, introducing Euro 5b emission standards for vehicles registered for the first time in Georgia, will progressively enable reduced emissions from road traffic. The sulphur content of gasoil, petrol and diesel is aligned with the AGP Technical Annexes. The use of solvent in domestic and building paints and varnishes will decrease with the introduction of the recent adopted by-law on the solvent content in these kinds of products, making Georgia aligned with AGP Annex XI. Implementation of policies and measures would be necessary to tackle the problem of PM emissions generated by domestic heating appliances, using biomass. Alignment of Georgia with all requirements of AGP Annex VIII (mobile sources) is not yet planned.

Kazakhstan

Air quality and sources of emissions

Kazakhstan's air quality monitoring network includes both manual and automatic stations with continuous monitoring. The network consists of 84 automatic and 56 manual monitoring stations with a total of 140 monitoring stations, encompassing 45 settlements. There is one background air quality station – Borovoe. In addition, there were 14 mobile air quality monitoring stations. Air quality stations monitored a total of about 35 pollutants, including the key air quality pollutants covered by the AGP: PM (PM_{10} and $PM_{2.5}$), NOx, SO_2, and O_3.

Ten cities in Kazakhstan have high air pollution levels. These are Aktobe, Almaty, Atyrau, Balkhash, Karaganda, Nur-Sultan, Shymkent, Temirtau, Ust-Kamenogorsk, and Zhezkazgan. Air quality monitoring data provided for these cities showed that concentrations of the key air quality pollutants covered by the AGP (PM (PM_{10} and $PM_{2.5}$), NOx, SO_2, and O_3) in the ambient air consistently exceeded the limit values of both Kazakhstan and the European Union (EU) legislation, especially in winter. In some cases, annual average concentrations exceeded the EU limit values, for annual concentrations, by two to three times. Kazakhstan has a legal and regulatory framework for air quality management (AQM). Basic ambient air quality standards have been established and they are mandatory, although their levels and definitions need to be aligned with international best practices and enforced.

The primary sources of air emissions in Kazakhstan are public power plants, which contributed approximately to 66% of SO_2 and 48% of NO_x emissions, in 2020. Industrial sectors followed with 24% and 25% of SO_2 and NO_x emissions, respectively, primarily from oil refining, solid fuels manufacturing, and iron and steel industry combustion. Road transport emissions are minimal, below 1%, though local experts highlight uncertainties in transport emissions data, due to insufficient statistical details for accurate calculations.

For PM_{10} emissions, industrial processes dominate at 37%, mainly from construction and demolition (70%) and iron and steel combustion (10%). Fugitive sources contributed significantly to PM_{10}, $PM_{2.5}$, and VOC emissions (28%, 47%, and 33% respectively), with oil and gas venting and flaring as key contributors. The residential sector also played a role, emitting 9% of SO_2, 16% of PM_{10}, 28% of $PM_{2.5}$, and 13% of VOCs. Interestingly, public power plants accounted for only 3% of PM_{10} and 2% of $PM_{2.5}$ emissions.

However, there are significant gaps in existing air quality monitoring data and emission source inventories, which provide strong rationale for improving knowledge and taking action to make progress in the attribution of air emission sources and emission reduction measures.

Current legislations and programmes for alignment with several EU Directives and Regulations

Three strategic documents have been developed in Kazakhstan, namely the strategy "Kazakhstan 2050: a New Political Course of the Established State", the Concept for Transition of the Republic of Kazakhstan to Green Economy, and "Strategic Plan for Development until 2025". They refer to measures that can directly or indirectly reduce emissions of pollutants (SO_2, NOx, PM, and NMVOC), including increasing the share of Renewable Energy Sources (RES), bringing production facilities and transport fuels in line with the latest technological standards, reducing SOx and NOx emissions, improving energy efficiency, etc.

Legal framework for issuing permits with emission limit values (ELVs) based on BATs started in Kazakhstan since 2007. However, it has not been exercised due to the complexity of the process and the lack of relevant knowledge. Until first of January 2025, industrial facilities still will apply for and will receive conventional environmental permits for emissions based on practices pertaining from the past. The conditions for such permits are derived from capacity of installations, maximum allowable concentrations (MAC values), classes of environmental and sanitary exposure and sanitary zones.

Kazakhstan’s new Environmental Code, which came into force on July 1, 2021, is an important step toward bringing environmental management in line with international best practices. The Code introduces mandatory integrated environmental permits (IEPs) since the first of January 2025, based on BAT for the most polluting enterprises, the Category I installations. The design of follow-up regulations and technical reference documents for BAT contributes to reduce air pollution and long-term phase-out of fossil fuels.

The coordination between the two systems should be carefully considered, along with the institutional capacities that need to be established, to monitor compliance with the newly introduced IEP system.

In the period 2021-2023, Kazakhstan has developed sixteen best available techniques reference documents (BREF). They cover ELVs of large combustion plants, iron and steel production, oil and gas refining and production and others. Three of them were enacted at the end of 2023, namely Production of inorganic chemicals, Production of Cement and Lime, and Zinc and Cadmium Production.

Seventeen other BREFs are planned to be developed between 2024 and 2027. These include: Production of titanium and magnesium, Wastewater treatment of centralized wastewater disposal systems of settlements, Monitoring of pollutant emissions into atmospheric air and water bodies, Production of rare non-ferrous metals, Destruction and disposal of waste by thermal treatment, Waste neutralisation, Landfilling of waste, Intensive breeding of pigs and poultry, Slaughter of animals at meat processing plants, meat and cold slaughterhouses, Manufacture of food, beverages, milk and dairy products, Tanning, dyeing, dressing of hides and skins, Production of pulp from wood or other fibrous materials, Production of glass, ceramic products, Dyeing of textile fibres bleaching, dyeing of textile products. The largest sources of industrial pollution in Kazakhstan, Category I enterprises, must obtain an IEP based on BAT, starting from 2025.

As example, the BREF RK “Combustion of Fuels in Large Plants for Energy Production” for new installations requires equal or stricter ELVs as compared to the ELVs of large combustion plants under the AGP, but with several important exceptions. For existing plants, ELVs may be close to, equal to or less stringent depending on fuels and pollutants considered.

The legal framework for the sulphur content of gasoil (0.1% w/w) has not been clearly identified, hence, the analysis of the current situation has resulted quite challenging.

According to the information collected, there is no legal requirements introduced for the storage and distribution of petrol.

With regard to solvents in products (AGP Annex XI), there are certain regulations setting hygienic and toxicological standards, but detailed information on these regulations was not possible to obtain.

With regard to emissions from the road transport sector, Kazakhstan became a founding member of the Eurasian Economic Union (EAEU) on January 1, 2015, when the union officially came into effect. In this frame, Kazakhstan adheres to the Technical Regulation TR CU 018/2011, titled "On the Safety of Wheeled Vehicles". This regulation establishes safety and environmental standards for vehicles within the EAEU, including emission requirements comparable to the Euro-5 standard. According to the regulation, vehicles must meet specific environmental classes, with Euro-5 being one of the stipulated standards. So, Kazakhstan has been progressively aligning its vehicle emission standards with the Euro-5 benchmark. Currently K5 is the highest environmental class of cars (lowest level of pollutant emissions), in

Kazakhstan (comparable to Euro-5/V in the EU). However, according to the requirements of the AGP, the transition to Euro-6 and Euro-VI standards is necessary. The sulphur content of diesel and petrol is aligned with the AGP Annex VIII, since 2018, but other fuel characteristics may vary.

No information was available on NRMM regulation, but it is unlikely that new engines produced in Kazakhstan comply with the limits of AGP Annex VIII.

Technological Pathways

Kazakhstan's new Environmental Code (2021) introduces mandatory integrated environmental permits (IEPs), based on BAT in Kazakhstan, and in long term the Code will allow to reduce emissions from the largest emitting sectors, including LCPs and large industrial plants.

The following techniques can be recommended (few examples) for stationary sources:

SO_2: activities covered by AGP Annex IV: application of one or a combination of the following techniques, combined with the selection of low sulphur fuels: boiler sorbent injection, duct sorbent injection (DSI), spray dry absorber (SDA), circulating fluidised bed (CFB) dry scrubber, wet flue-gas desulphurisation (FGD). With the application of the corresponding developed BREF, the use of these techniques will be underway, especially for new installations in Category I.

NO_x: activities covered by AGP Annex V: combustion optimisation; combination of primary techniques, e.g. air or fuel staging, flue-gas recirculation, low-NO_x burners, selective non-catalytic reduction, selective catalytic reduction. With the application of the corresponding developed BREF, the use of these techniques will be underway, especially for new installations.

PM: industrial activities covered by AGP Annex X: Bag filters and electrostatic precipitators, with proper sizing of the equipment. With the application of the corresponding developed BREF, the use of these techniques will be underway, especially for new installations.

In Kazakhstan, priority measures to improve air quality in cities could also involve small residential appliances for heating, like stoves and boilers, using coal and biomass. Although, in some regions, power plants and industry can play a major role, residential heating using solid fuels is one of the main contributors to the adverse health effects, associated with winter smog in Kazakhstan's cities.

AGP Annex X, recommends PM emission limits for small combustion appliances. These limit values could be a good starting point for the production of new appliances with improved performances and reduced emissions. As far as domestic appliances and combustion are concerned, reducing particulate emissions can be achieved by optimising combustion parameters in a number of ways, to ensure the best possible conditions in terms of temperature, residence time (enough time is needed) and turbulence (to ensure good mixing of the combustion gases) (the three T rules), but also the geometry of the combustion chamber, air supply and reducing user intervention, through automated combustion systems. Solutions for these three parameters can be applied to different types of appliances, particularly stoves.
Reducing emissions from small appliances also depends on the energy efficiency of houses/buildings. Policies to increase the energy efficiency of houses have related benefits in terms of air pollution, as they reduce fuel/energy demand and therefore emissions.

VOC: industrial activities covered by AGP Annex VI: The techniques available to comply with VOC emission limit values are primary measures such as low solvent content or solvent-free products, higher efficient application methods and secondary measures such as thermal or catalytic oxidation, activated carbon adsorption, biological scrubbing. There are different combinations of primary and secondary measures depending on the type of activity.

VOC: VOC content in products covered by AGP Annex XI: The use of low solvent-based products or water-based products is necessary. There was insufficient information available to draw conclusions about the existing regulations on this matter.

Passenger cars, light and heavy-duty vehicles:

In Kazakhstan, K5 is the highest ecological class of vehicles currently implemented (comparable to Euro 5/V in the EU). However, according to the requirements of the Amended Gothenburg Protocol, the transition to Euro-6 and Euro-VI standards is required. The sulphur content of diesel and petrol is aligned with AGP Annex VIII since 2018.

The legal framework could be improved to allow the introduction of the latest Euro 6/Euro VI standards, for new vehicles imported and produced in Kazakhstan.

Many different approaches can also be implemented to reduce emissions from road transport. These include measures such as developing an improved public transport system, making it more attractive, offering incentives to the use of public transport, implementing car-sharing schemes, promoting walking and cycling in towns and cities, etc. These measures enable an integrated approach that can be beneficial for air quality and climate change.

Non-Road Mobile Machinery:

As soon as no information was available on NRMM or relevant regulation, a study could be envisaged to define the state of the art in Kazakhstan for non-road mobile machinery and assess the extent to which recent standards could be introduced.

The implementation of the 2021 Environmental Code and supporting regulations, the definition of BAT and the introduction of integrating permit system will allow the legal framework in Kazakhstan to be consistent with some of the requirements of AGP Technical Annexes IV, V and X, for the LCPs and industrial sources covered, but only if the technological emission values associated with application of the best available techniques implemented are the same as or more stringent than BAT-AELs in AGP Technical Annexes. It was noted that some BAT-AELs could not enable compliance with the ELVs in AGP Technical Annex X for PM emissions, from LCPs.

Evolution of the regulatory framework for LCP and Category I industrial sources could be achieved in 2026-2028, according to TFTEI, through intensive work on BAT definition and BREF development. Implementation of BATs on LCPs and in industrial processes will reduce SO_2, NOx and dust emissions, but emission reduction will be effective if/once the measures are enforced.

For the AGP Annexes VI and XI, there was insufficient reliable information to assess the legal framework for VOC limit values in industrial processes or related products.

The AGP Annex VIII sets Euro 5/V standards only for road vehicles (passenger cars and duty vehicles). For all other vehicles, covered by Annex VIII such as NRMM, there was insufficient reliable information to assess the legal framework.

Studies could be envisaged to know better the status of engine performance and to assess whether the engines currently produced comply with the limit values specified in Tables 4 to 9 of the AGP Annex VIII.

Moldova

Air quality and sources of emissions

In the Republic of Moldova, air quality is currently monitored by a network of 17 obsolete fixed stations, installed during the period 1970-1978. These stations are not internationally recognised. It has been difficult to draw conclusions about air quality in the country.

Residential heating is a major source of SO_2 emissions (44% of total emissions), PM_{10} emissions (71%), $PM_{2.5}$ emissions (88%), and VOC emissions (24%). Residential heating emissions are driven by the solid fuel consumption.

VOC emissions come mainly from the solvent sectors (49%).

Road transport is the main source of NOx emissions with a relative contribution of 48%, mainly due to emissions from heavy-duty vehicles and buses (N2-N3 trucks, and M2-M3 buses). Public power (electricity generation) is another major source of NOx emissions accounting for 17% of total NOx emissions.

Industry is also the main source of SO_2 emissions, mainly due to combustion in stationary sources (36% of total emissions), mainly due to non-metallic minerals (95% of stationary combustion sources). Industry also has a significant share of PM_{10} emissions (14% of total emissions) mainly due to the sector of road paving with asphalt (62% of industrial sources).

In Moldova, a deeper understanding of the sources of air emissions and effective measures to mitigate them is needed for emission inventory improvement. Currently, the country faces significant challenges in accurately identifying and quantifying emissions from key sectors, such as energy production, industry, and transportation. This lack of detailed data hinders the ability to prioritise interventions and evaluate their effectiveness.

Current legislations and programmes for alignment with several EU Directives and Regulations

Since over ten years, Moldova has been aligning its policies and regulations with EU Directives, through transposition. In 2014, the Republic of Moldova signed an Association Agreement between the European Union and the European Atomic Energy Community and their Member States, of the one hand, and the Republic of Moldova, of the other hand. It entered into force on July 01, 2016.

Under this Association Agreement, Moldova must align its legal framework with that one of the EU with regard to air quality, industrial emissions, road transport and many other sectors and within 2026, the Republic of Moldova shall endeavour to ratify the Gothenburg Protocol, including the amendments adopted in 2012 (AGP).

To date, the following Directives have been transposed:

- Directive 2004/42/EC on the limitation of emissions of VOC due to the use of organic solvents in certain paints and varnishes and vehicle refinishing products (limit values of AGP Annex XI),
- Directive 1994/63/EC, Stage I on the control of VOC emissions resulting from the storage of petrol, and its distribution, from terminals to the service stations (limit values in Table 1, AGP Annex VI,
- Directive 2016/802 on reduction in the sulphur content in fuels.

Moldova has transposed Directive 2008/50/EC on Ambient Air Quality and Cleaner Air for Europe and Directive 2004/107/EC on Arsenic, Cadmium, Mercury, Nickel and PAH in ambient air. The corresponding legislation will be implemented in Moldavia starting from 2024.

The recent Law n. LP227/2022 on industrial emissions adopted on September 30, 2022, partially transposes EU Directive 2010/75/EC on industrial emissions and Directive 2015/2193 on medium combustion plants. It includes the limitation of emissions of certain air pollutants from large combustion installations, medium-sized combustion installations, industrial activities using organic solvents, other industrial activities and defines the rules for periodic and continuous industrial monitoring of emissions. The ELV of activities using organic solvents are similar to AGP Annex VI (Tables 3-15). EU BREFs published in Romanian language in the Official Journal of the European Union, by order of the Minister of Environment, are recognised as national BREFs and published in the Official Gazette of the Republic of Moldova. The Environment Agency of Moldova shall apply the BREF Conclusions while setting permit conditions. Law n. LP227/2022 on industrial emissions will be implemented in Moldova starting from 2024.

Directive 2016/2284 on the reduction of national emissions of certain atmospheric pollutants is currently being transposed.

Moldova is taking steps to control road transport emissions. Thus, in 2018, the country completed the Fuel Economy Database of newly registered vehicles with the help of the Coalition’s Heavy-Duty Vehicles Initiative. The draft development of regulations, after the association Agreement EU – the Republic of Moldova, is foreseeable, including the draft Law on the homologation of road vehicles and the draft Regulation on the homologation of motor vehicles and the certification of their components.

With regard to fuel quality, Directive 98/70/EC on the quality of petrol and diesel has been partially transposed and provides for environmental specifications for diesel and petrol, i.e. the same level of sulphur content as in Tables 13 and 14, in the AGP Annex VIII.

Under the Association Agreement EU – the Republic of Moldova, the EU directives or regulations introducing Euro 6/VI (based on Tables 1 to 3 of AGP Annex VIII) implementing vehicle type-approval rules should have been aligned. However, no detailed information was available to analyse the situation.

In addition, the latest EU Directives or regulations concerning Euro standards for light- and heavy-duty vehicles, as well as, for other types of vehicles are recommended.

Technological Pathway

The implementation of the following techniques is recommended:

SO_x: activities covered by AGP Annex IV: Boiler sorbent injection, dry sorbent injection, spray dry absorber, circulating fluidised bed dry scrubber, wet flue-gas desulphurisation, possibly associated with the use of low sulphur (solid or liquid) fuels. With the recent implementation of the Moldavian legislation on industrial plants, the use of these techniques will be underway, for the foreseeable future.

NO_x: activities covered by AGP Annex V: Combustion optimisation, combination of primary techniques for NO_x reduction, e.g. air or fuel staging, flue-gas recirculation, low-NOx burners, selective non-catalytic reduction, selective catalytic reduction. With the recent implementation of the Moldavian legislation on industrial plants, the use of these techniques will be underway for the foreseeable future.

PM: industrial activities covered by AGP Annex X: Bag filters and electrostatic precipitators in industrial processes, with the proper sizing of the equipment. With the recent implementation of the Moldavian legislation on industrial plants, the use of these techniques will be underway for the foreseeable future.

Domestic heating

Domestic heating with solid fuels, such as coal or wood biomass is the key sector emitting PM in Moldova, for which recommended limit values are provided by the AGP Annex X. The use of the most efficient appliances, in term of PM emissions and energy efficiency is essential, but technological solutions are not sufficient. The "Code of good practices for wood burning and small combustion installations" developed by TFTEI, the report "Prioritizing reductions of particulate matter from sources that are also significant sources of black carbon - analysis and guidance" developed by TFIAM and the report "Review on Black Carbon (BC) and Polycyclic Aromatic Hydrocarbons (PAHs) emission reductions induced by PM emission abatement" developed by TFTEI provide an excellent overview of policies beyond the technical characteristics of appliances. The thematic session on residential wood combustion and air pollution held at the 56th Session of WGSR, in May 2018, is also useful for inspiring ideas in this field. In addition, the latest TFTEI informal report on limit values updates to the Technical Annexes also provides useful information.

One of the key measures relating to domestic heating with solid fossil and biomass fuels could be the development of a programme to replace existing household heating existing / old appliances with new eco-design compliant ones, combined with financial incentives. In "hot spots" of PM pollution from household heating, higher rates (i.e. faster) of replacement of older appliances could be foreseen. These measures are also linked to an energy policy aimed at reducing energy demand through achievement of higher levels of energy efficiency.

In order to rapidly introduce more efficient appliances, the programme could include activities for Moldova such as aligning its national legislation with the Eco-design Directive and work on transposing the two EU regulations on emissions and energy efficiency of solid boilers and solid fuel local space heaters (Regulation 2015/1189/EU and Regulation 2015/1185/EU). The implementation mechanism for financial incentives for the replacement of existing heating equipment in households with new appliances, compliant with EU regulations and heat pumps, has also to be put in place.

VOC: industrial activities covered by AGP Annex VI: The techniques available to comply with VOC emission limit values are primary measures such as low solvent content or solvent-free products, higher efficient application methods and secondary measures such as thermal or catalytic oxidation, activated carbon adsorption, biological scrubbing. However, they are different combinations of primary and secondary measures depending on the type of activity. With the recent implementation of the Moldavian legislation on industrial plants, the use of these techniques will be underway for the foreseeable future.

VOC: VOC content of products covered by AGP Annex XI : The use of low solvent-based products or water-based products is necessary. According to the information available, Moldova has transposed Directive 2004/42/EC on the limitation of VOC emissions due to the use of organic solvents in certain paints and varnishes and vehicle refinishing products, but no detailed information was obtained to draw conclusions.

Passenger cars, light and heavy-duty vehicles:

One efficient measure could be the ban of imported old second-hand vehicles, however more information on the existing fleet is needed to analyse the situation.

Many different approaches can also be implemented to reduce emissions from road transport. Measures such as developing an improved public transport system, making it more attractive, encouraging the use of public transport, developing car-sharing schemes, promoting walking and cycling in cities can be foreseen. These measures provide an integrated approach that can be beneficial to both air quality and climate change.

Since 2014, Moldova has been developing the legislative framework to bring it in line with EU norms, mainly within the framework of the Association Agreement EU – Republic of Moldova. With further harmonisation of the legislative framework with EU ones, Moldova's legislative framework could meet the requirements of the five AGP Technical Annexes IV, V, VI, X and XI in particular their ELVs, tentatively by 2030-35. For mobile sources, additional information is needed.

Montenegro

Air quality and sources of emissions

Air quality in Montenegro has been monitored in accordance with European standards since 2009. Over the past 10 years, the number of automatic air quality monitoring stations has been gradually increased. By repositioning them within the state network, an optimal level of representativeness of the measuring points has been achieved. In terms of air quality, the main concerns in Montenegro are PM_{10} and $PM_{2.5}$ concentrations, all over the territory, and SO_2 concentrations in the northern part of the country.

Residential heating is the major source of $PM_{2.5}$, PM_{10} and VOC emissions driven by the use of solid fuels, in small domestic heating appliances. The road transport is the main source of NOx emissions. The emissions from industrial sources are much less significant due to the few existing installations. The only existing LCP burns local coal and is the major/only important source of SO_2 emissions.

The main source of SO_2 emissions in Montenegro is public power, accounting for 98.4%, specifically the coal fired Pljevlja Thermal Power Plant. The key contribution to NOx emissions is given by road transport, responsible for 56% share, while energy production (at TEP Pljevlja) contributes as 28%. The key source of PM_{10} and $PM_{2.5}$ emissions, accounting for 85% of the emissions for both pollutants, is “Other Stationary Combustion, predominantly residential heating, which accounts for 99% for both pollutants. The main source of VOC emissions is also Other Stationary Combustion, with the 39% share, mainly from residential heating, which accounts for 97% share for both pollutants. Road transport comprises 16%, fugitive emissions 15% (solid fuels, notably coal mining and handling), and solvents, off-road activities, and agriculture livestock each contributing 9% to the total VOC emissions. The local expert of the Ministry of Ecology, Spatial Planning and Urbanism Montenegro emphasised the need for further improvements in the emission inventory to accurately reflect the air emissions situation in Montenegro and facilitate the ratification of the AGP.

Current legislations and programmes for alignment with several EU Directives and Regulations

The draft Montenegro Air quality management strategy, for the period 2021-2029 (hereinafter the Strategy 2021-2029), was developed in 2021, as a continuation of the previous National Air Quality Management Strategy 2013, implemented by two Action plans (2013-2016 and 2017-2020), however, up to now, it is not adopted. The Strategy 2021-2029 combines air quality plans for the three established air quality zones (Northern, Central and Southern) and replaces the plans prepared for the Municipality of Pljevlja (2013), the Municipality of Nikšić (2014) and the Capital City of Podgorica (2015). In addition, the Strategy 2021-2029 includes the Plan of measures for pollution control, which has been prepared in accordance with the requirements of the relevant EU regulations and the final benchmark for the negotiation Chapter 27, considering their overall goal and objectives related to the improvement of air quality, environmental and human health protection. The Strategy 2021-2029 has been developed for 9 years, with air pollution reduction targets set until 2030.

In 2019, Montenegro enacted a new Law on industrial emissions, transposing the Directive 2010/75/EU on Industrial Emissions (IED) into Montenegrin legislation, followed by the Implementation Plan for Industrial Emissions Directive. The Law on industrial emissions prescribes the set of measures for prevention and control of emissions from industrial plants, within the country. The Law transposes Chapters I and II of the IED, which cover the main definitions, including the definitions of best available techniques, integrated permits, and inspections of permit conditions. Chapter III of the Regulation covers large and medium combustion plants, chapter IV waste incineration and co-incineration plants, chapter V installations and activities in which organic solvents are used, chapter VI plants producing titanium dioxide, and chapter VII annual reporting provisions for large combustion plants and penal provisions.

It is observed that for plants with a thermal power larger than 50 MW, as considered in the Annexes IV, V and X of the Amended Gothenburg Protocol, the Law on industrial emissions of Montenegro transposes IED Chapter III and Annex V. Additionally, Montenegro has translated into Montenegrin language the Commission Implementing Decisions, concerning large combustion plants (LCP). Montenegro legislative framework is aligned with provisions of AGP Annexes VI, V, and X for LCP. PM ELVs for medium combustion plants are aligned with recommended ELVs of AGP Annex X (Table 14).

With regard to PM emissions from domestic heating appliances using coal or biomass, the use of the most efficient appliances, in term of emissions and energy efficiency is essential. The emission limit values of PM for small-sized heating appliances in Montenegro are aligned with the ELVs for small solid fuel combustion installations as outlined in the AGP (Annex X, Tables 12-13), except the installations of 500 kWth to 1000 kWth.

The Regulation on technical conditions for air protection from emissions of VOC resulting from the storage, transfer and distribution of petrol transposes Stage I and Stage II, so far, the ELV of AGP (Annex VI).

Regarding VOC content in products, the ELVs for VOC content in coatings (paints and varnishes) are addressed by the Regulation on the prohibition and restriction of the use, placing on the market and production of chemicals that represent an unacceptable risk to human health and the environment, specifically in Annex 3, phase I (since 01.12.2013) and phase II (since 01.12.2014). The ELVs of phase II in the AGP (Annex XI, Tables 1 and 2) are completely transposed to the mentioned Regulation.

For road transport vehicles, the Republic of Montenegro has been transposing the latest EU directives and regulations for application to domestically produced vehicles and new vehicles imported.

Montenegro fully transposed the requirements of AGP Annex VIII, (tables 13 and 14) on environmental specifications for marketed fuels to be used for vehicles equipped with positive-ignition engines and compression-ignition engines, in the Regulation on limit values of the content of polluting substances in liquid fuels of oil origin, (2017).

Technological Pathways

The following techniques can be recommended (few examples) for stationary sources:

SO_2: activities covered by AGP Annex IV: application of one or a combination of the following techniques, combined with the selection of low sulphur fuels: boiler sorbent injection, duct sorbent injection (DSI), spray dry absorber (SDA), circulating fluidised bed (CFB) dry scrubber, wet flue-gas desulphurisation (FGD). With the implementation of the Montenegrin legislation on industrial facilities, the use of these techniques is underway.

NO_x: activities covered by AGP Annex V: combustion optimisation; combination of primary techniques, e.g. air or fuel staging, flue-gas recirculation, low-NO_x burners, selective non-catalytic reduction, selective catalytic reduction. With the implementation of the Montenegrin legislation on industrial facilities, the use of these techniques is underway.

PM: industrial activities covered by AGP Annex X: Bag filters and electrostatic precipitators, with proper sizing of the equipment. With the implementation of the Montenegrin legislation on industrial facilities, the use of these techniques is underway.

In terms of **domestic appliances and small combustion,** Montenegro transposed EU provisions and ELVs form small heating appliances such as regulations for solid fuel boilers and local space heating in the scope of the Eco-design Directive. These regulations will contribute to the reductions of PM emissions from these kinds of appliances.

In the scope of the draft programme of air pollution control 2021-2029, a programme for replacement of heating devices and energy efficiency measures in individual residential buildings is scheduled. Significant thermal energy savings would be achieved, and at the same time a 35% reduction in $PM_{2.5}$ emissions from the housing sector is expected, which would ultimately result in a reduction of $PM_{2.5}$ emissions at the national level in the amount of 25%. The reduction of VOC emissions would amount to 35%, which in the end, at the national level, would amount to 9%. Implementation of the measure is ongoing.

VOC: industrial activities covered by AGP Annex VI: The techniques available to comply with VOC emission limit values are primary measures such as low solvent content or solvent-free products, higher efficient application methods and secondary measures such as thermal or catalytic oxidation, activated carbon adsorption, biological scrubbing. They are different combinations of primary and secondary measures depending on the type of activity. With the implementation of the Montenegrin legislation on large industrial facilities, the use of these techniques is underway.

VOC: VOC content of products covered by AGP Annex XI The use of low solvent-based products or water-based products is necessary. Legislation concerning these products was established ten years ago in Montenegro.

For road transport vehicles, the Republic of Montenegro has been transposing the latest EU directives or regulations, applying them to both domestically produced vehicles and newly imported ones.

Various strategies can be employed to reduce emissions from road transport. These include developing an improved public transport system to enhance its appeal, providing incentives for public transport usage, establishing car sharing schemes, and promoting walking and cycling in urban areas. Such measures offer a comprehensive approach that benefits both air quality and climate change mitigation.

Non-Road Mobile Machinery:

The legal framework in Montenegro could be enhanced to facilitate the adoption of the latest standards for new engines that are either imported into or manufactured within the country. It should be noted that Montenegro does not have a significant domestic production industry for on-road vehicles or non-road mobile machinery (NRMM).

Through the implementation of key provisions from EU Directives into its legislative framework, the Emission Limit Values (ELVs) transcribed into Montenegro's legal framework could align with the requirements of the AGP Technical Annexes IV, V, VI, X (in most part) and XI, around 2025-28.

Armenia

Air quality and sources of emissions

In Armenia, dust is the main air quality problem, with concentrations in ambient air exceeding the national air quality limit values (daily average of 100 µg/m^3 in some cities or 150 µg/m^3 in other cities) in several cities. The national limit value for NO_2 (daily average of 40 µg/m^3) is not exceeded and average daily concentrations range from less than 10 µg/m^3 in Alaverdi to around 35 µg/m^3, in Yerevan in 2022.

The "Other combustion stationary sources" sector, which includes this residential heating, accounts for 86 % of total PM_{10} emissions and 93% of $PM_{2.5}$ emissions, in Armenia.

In terms of NOx emissions, road transport is the largest source, accounting for 75% of total NOx emissions in Armenia. LCPs for electricity production burn natural gas. They are the second largest source of NOx emissions, with 11 % of total emissions.

SO_2 emissions are low because a very few amount of coal or heavy fuel oil is consumed in Armenia. LCPs for electricity production use natural gas. In the industry sector, natural gas is the main fuel consumed, and liquid fuels are used to a very small extent, only. In the transport sector, Armenia has one of the world's highest levels of gasification. Over 70% of the vehicles run on natural gas.

In summary, the air quality network should be improved, and current limit values be replaced by EU limit values (this is ongoing through the Association Agreement (AA), see below). The main issue concerns $PM_{2.5}$ emissions from residential heating. $PM_{2.5}$ limit values are exceeded. The air pollutant emission inventory should be improved to be consistent and complete and developed to be able to reflect the effects of the regulations which are being prepared.

Current legislations and programmes for alignment with several EU Directives and Regulations

In the recent years, Armenia has started to develop regulations and improve of air quality. To this end, Armenia is endeavouring to align its national policies on fuel quality, petrol distribution and industry with numerous EU directives or regulations which, in most cases, have served as the basis for defining the limit values prescribed by the AGP Technical Annexes IV, V, VI, X and XI.

Armenia is currently involved in an Association Agreement (AA) between the European Union and the European Atomic Energy Community and their Member States, of the one hand, and the Republic of Armenia, on the other side. The Association Agreement entered into force on 1 March 2021 and sets out the road map for a number of key EU directives, including:

a) Directive 2008/50/EC of 21May 2008 on ambient air quality and cleaner air for Europe,
b) Directive 2004/107/EC of 15 December 2004 relating to arsenic, cadmium, mercury, nickel, and polycyclic aromatic hydrocarbons in ambient air,
c) Directive 1999/32/EC of 26 April 1999 relating to a reduction in the sulphur content of certain liquid fuels and amending Directive 93/12/EC,
d) Directive 1994/63/EC of 20 December 1994 on the control of VOC emissions resulting from the storage of petrol and at distribution from terminals to service stations Stage I Petrol vapour recovery and Directive 2009/126/EC of 21 October 2009 on Stage II petrol vapour recovery during refuelling of motor vehicles at service stations,
e) Directive 2004/42 on the limitation of emissions of volatile organic compounds due to the use of organic solvents in certain paints and varnishes and vehicle refinishing products,

f) Directive 2010/75/EC of 24 November 2010, on Industrial Emissions (IED).

Armenia has been a member of the Eurasian Economic Union (EAEU) since 2015. In several areas, regulations developed by the EAEU are applied in Armenia (in particular for mobile sources and fuel quality).

For stationary sources, the legal framework for the adoption of EU standards similar to, or even stricter than, the limit values in the AGP Technical Annexes, is currently being developed:

- For industrial emissions, the AA provides a road map from 2021 to 2034 with the adoption of national legislation by 2025, the introduction of integrated permitting system by 2027 and the implementation of BAT by 2027 for new installations and 2034 for existing ones.
- The introduction of legal requirements concerning the use of organic solvents in certain products to reduce VOC emissions, on the basis of EU Directive 2004/42/EC, is under way. The timeframe set by AA is 5 years to complete the alignment of the legislative framework.
- The introduction of legal requirements to align national legislation with EU Directive 1994/63/EC on the control of VOC emissions resulting from the storage of petrol and its distribution from terminals to service stations is ongoing. The timeframe set by the AA is 9 years to complete the alignment of the legislative framework.

There are no plans yet to develop the legal framework for refuelling cars at service stations.

The legal framework for the sulphur content of gasoil (0.1% w/w) is not clearly defined.

The sulphur content of diesel and petrol is aligned with AGP Annex VIII since 2016, on the basis of an EAEU regulation, but other diesel and petrol characteristics may differ from AGP Annex VIII.

Armenia does not produce road vehicles nor NRMM and engines for propulsion of locomotives and waterway vessels.

For road transport, Armenia adopts the regulations of the Eurasian Economic Union (EAEU) and since January 1, 2018. All types of new vehicles, including freight and passenger vehicles, imported into the country, have to comply with the fifth ecological class in accordance with the Technical Regulation of the Eurasian Economic Union TR CU 018/2011, on the safety of wheeled vehicles (similar to Euro-5).

For NRMM, EAEU regulation TR CU 018/2011 based on UNECE regulation 96-02 is in force. This regulation corresponds to the Stage IIIA limit values of EU regulation 97/68 (AGP Annex VIII provisions for NRMM are based on EU Stages IIIB and IV). Armenia seems not yet aligned with Annex VIII for NRMM, but additional pieces of information should be collected as most of these engines are not produced in Armenia.

Technological Pathways

The following techniques can be recommended (few examples) for stationary sources:

NO_x: activities covered by AGP Annex V: combustion optimisation; combination of primary techniques, e.g. air or fuel staging, flue-gas recirculation, low-NO_x burners, selective non-catalytic reduction and selective catalytic reduction. With the development of the Armenian legislation on industrial emissions, these measures will be progressively used from 2027 new plants and from 2034 for existing plants.

PM: industrial activities covered by AGP Annex X: Bag filters and electrostatic precipitators, with appropriate equipment sizing. With the development of the Armenian legislation on industrial emissions, these measures will be progressively implemented from 2027 on new plants and 2034 for existing plants.

Policies to reduce air pollution and improve air quality should focus on **residential heating burning biomass** (wood is used and manure in rural area).

The AGP Annex X recommends emission limits of PM for small appliances. These limit values could be a good starting point for the production of new, more efficient and less polluting appliances. As far as domestic appliances and combustion are concerned, reducing PM emissions can be achieved by optimising combustion parameters in a number of ways, to ensure the best possible conditions in terms of temperature, residence time (sufficient time is needed) and turbulence (to ensure good mixing of the combustion gases) (the three T rules), but also the geometry of the combustion chamber, air supply and reducing user intervention, through automated combustion systems. Solutions for these three parameters can be applied to different types of appliances, particularly stoves.

Reducing emissions from small appliances also depends on the energy efficiency of houses/buildings. Policies aimed at increasing the energy efficiency of houses have a beneficial effect on air pollution, as they reduce the demand for energy/fuel and therefore emissions. In suburban areas, district heating can also be developed.

VOC: industrial activities covered by AGP Annex VI:

The techniques available to comply with the AGP VOC emission limit values are primary measures such as low solvent content, water-based or solvent-free products, more efficient application methods and secondary measures such as thermal or catalytic oxidation, activated carbon adsorption, biological scrubbing. There are different combinations of primary and secondary measures depending on the type of activity. Good solvent management systems are recommended, with identification and quantification of solvent inputs and outputs. These can be used to set VOC emission reduction targets and for monitoring progress. Priority should be given to replacing hazardous solvents with non-hazardous products. With the development of the Armenian legislation on industrial emissions, these measures will be progressively used from 2027 on new plants and from 2034 for existing plants.

VOC: VOC content in products covered by AGP Annex XI: The use of low solvent-based products or water-based products is necessary. With the AA, these products will be progressively used in a near future.

Passenger cars, light and heavy-duty vehicles:

In Armenia, K5 is the highest ecological class of vehicles currently implemented (comparable to Euro 5/V in the EU). However, according to the requirements of the Amended Gothenburg Protocol, the transition to Euro-6 and Euro-VI standards is required.

The legal framework could be improved to allow the introduction of the latest Euro 6/Euro VI standards for new vehicles imported in Armenia, as well for used imported vehicles.

Many different approaches can also be implemented to reduce emissions from road transport. Measures such as developing a better public transport system, improving its attractiveness, providing incentives to use public transport, developing car-sharing schemes and promoting walking and cycling in towns and cities can all be envisaged. These measures enable an integrated approach that can be beneficial for air quality and climate change.

Non-Road Mobile Machinery:

The legal framework could be improved to allow the introduction of the latest standards for new engines imported and produced in Armenia.

By way of final conclusions, it can be observed that all six countries examined have been working on programmes to develop their legislative framework in the activities covered by the AGP Technical Annexes IV, V, VI, X for stationary sources and XI.

The EU industrial emission directive is currently being transposed in Serbia, Georgia, Moldova, Montenegro and Armenia, with varying degrees of completion, Armenia having only just begun this transposition, unlike the other countries. Kazakhstan has transposed the concepts of BAT, BREFs and integrated permits into its latest legislation. The preparation of BREFs in key sectors started in 2021. To date, sixteen draft country-specific BREFs have been drawn up in key industrial sectors, with a further seventeen planned for the period 2024-2027. Three of the BAT reference documents were adopted by the end of 2023. However, the technological ELVs associated with the application of BAT are not always equal to or lower than the AGP ELVs. Nevertheless, the ELVs for new plants are generally in line with or below the AGP ELVs.

The sulphur content of gasoil complies with the limit value in AGP Annex IV Table 2, in Serbia, Montenegro, Georgia and Moldova. For Kazakhstan and Armenia information was not sufficient to draw conclusions.

The VOC content in products is regulated in a similar way to AGP Annex VI, with the transposition of Directive 2004/42 in Serbia, Moldova, Montenegro and Georgia. Transposition is in progress in Armenia, and although some rules may exist in Kazakhstan, the information obtained was not sufficient to confirm alignment.

Directive 94/63/EC relating to the control of VOC emissions resulting from the storage of petrol and its distribution from terminals to service stations or Stage I (ELVs considered in Table 1 of AGP Annex VI) is at various stages of transposal in Serbia, Montenegro, Moldova and Georgia. Armenia has just begun transposition. There are no such rules in Kazakhstan.

Directive 2009/126/EC of 21 October 2009 on Stage II petrol vapour recovery during refuelling of motor vehicles at service stations (ELVs considered in Table 2 of AGP Annex VI) has only been transposed in Serbia and Montenegro, at different stages of progress.

For AGP Annex VIII, the situation may differ among the countries considered. For road transport, three groups of countries can be defined: Kazakhstan and Armenia are implementing EAEU regulations, and the latest for new vehicles produced or imported is based on the K5 standard equivalent to Euro 5/V; Georgia adopted a decree on June 2023, with at least a Euro 5b standard for first registration of vehicles; Serbia and Montenegro have transposed EU directives or regulations implementing Euro 6/VI as in the AGP, on time or with some delays. As far as Moldova is concerned, under the EU-Moldova Association Agreement, the EU directives or regulations introducing the Euro 6/VI standard (based on Tables 1 to 3 of AGP Annex VIII) implementing vehicle type-approval rules should have been aligned. However, no information was available to analyse the situation.

The petrol and gasoline specifications in Tables 13 and 14 on AGP Annex VIII are introduced in the legislative framework of Serbia, Montenegro, Georgia and Moldova. In Kazakhstan and Armenia, EAEU regulation 013/2011 prevails. The sulphur content of the K5 standard is 0.001% w/w, but other characteristics of the fuels may differ from those in Tables 13 and 14 of AGP Annex VIII.

1. Introduction and method used for this technical assessment

For each country: Serbia, Georgia, Kazakhstan, Moldova, Montenegro and Armenia, the method used is based on the following assessments:

- Situation in term of ratification of the CLRTAP and its Protocols[1] (Protocol on Long-term Financing of the Co-operative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe (EMEP), original and amended Protocol on heavy metals, original and amended Protocol on POPs and original or amended Gothenburg Protocol) and main strategic programmes developed,
- Assessment of air quality for SO_2, PM, NOx,
- Assessment of the main emission sources of SO_2, PM, NOx and VOC,
- Assessment of current regulations implemented for activities covered by Annexes IV (SO_2), V (NOx), VI (VOC), VIII (mobile sources), X (PM) and XI (VOC in products),
- Assessment of additional programmes to reduce air pollution and to develop policies and measures related to activities covered by Annex IV (SO_2), Annex V (NOx), Annex VI (VOC), VIII (mobile sources), X (PM) and XI (VOC in products),
- Recommendations for technological pathways.

The assessment has been completed in 2022 for first four countries and in 2024 for two additional countries and was carried out in full transparency with help of the country experts from the Ministries in charge of Environment most generally. Ad hoc literature surveys were carried.

At the 8th annual meeting of the Task Force on Techno-economic Issues (TFTEI), Rome 6-7 Oct, 2022, an informal session took place on the first day, focused on the first fourth case studies carried out by the TFTEI Techno scientific board, concerning the analysis of a possible technological pathways towards the ratification of the AGP, in 4 selected SEE and EECCA countries (Serbia, Georgia, Kazakhstan, and Moldova), with the participation of experts from those countries.

The subject was discussed in the perspective of the Thematic Session on Barriers, planned during the EB 42nd Session, with the aim of providing input to the discussions.

The summary of the first outcomes of the TFTEI analysis for these 4 countries is included in Section III of the GPG document "*Technical information for the review of the Gothenburg Protocol*" (*ECE/EB.AIR/2022/5*).

At the 9th annual meeting of the Task Force on Techno-economic Issues (TFTEI), Warsaw 11-12 June 2023, an informal session took place on the first day, focused on the fifth and sixth case studies carried out by the TFTEI Techno-scientific board (Montenegro and Armenia) with the participation of experts from those countries.

Case studies were also presented at the BAT workshop in Paris on 15-16 October, 2024, and at the informal Meeting of Delegates in Leuven on 21-24 October, 2024. The case studies will be key document for the preparatory work on the revision of the technical Annexes to the Amended Gothenburg Protocol and the discussions that will take place at the 44th session of the Executive Body in December 2024.

[1] The 1985 Protocol on the reduction of Sulphur emissions and their transboundary flux, the 1988 Protocol concerning the control of NOx or their transboundary fluxes, the 1991 Protocol concerning the Control of emissions of VOC or their transboundary fluxes and the 1994 Protocol for further reduction of Sulphur emissions have not been examined.

2. Republic of Serbia

This report has been developed with the kind support of Jasmina ĆURČIĆ-BOGDANOVIC, advisor for jobs related to the long-range transboundary air pollution at the Air and Ozone Layer Protection Department, Ministry of Environmental Protection.

2.1. Status of ratification of the CLRTAP and its Protocols and strategic programmes

Republic of Serbia (RS) succeeded to the Convention on Long-range Transboundary Air Pollution [1], on 12 March 2001 [2] (The former Yugoslavia had signed and ratified the Convention on 13 November 1979 and 18 March 1987 respectively). RS succeeded to the Protocol on Long-term Financing of the Co-operative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe (EMEP), also on 12 March 2001 [3] (The former Yugoslavia had acceded to the EMEP Protocol on 28 October 1987). Up to now, RS acceded to the original Protocol on heavy metals, on 26 March 2012 and the original Protocol on POPs, on 26 March 2016 but not the original Gothenburg Protocol [3]. RS did not ratify the other Protocols (Amended Protocol on heavy metals, amended Protocol on persistent organic compounds and original Protocol to abate acidification, eutrophication and ground level ozone) including the amended Gothenburg Protocol (AGP) subject of this assessment [3][2].

Serbia is engaged to reduce its air pollutant emissions and improve air quality since many years by implementation of national regulations, often translating EU Directives. These Serbian regulations are detailed hereafter. Serbia is an official candidate to join the EU [4], [5]. As some other countries of the Western Balkans, Serbia submitted its application for EU membership in December 2009 and was granted candidate country status in March 2012. Accession negotiations were formally opened on 21 January 2014 [4]. The sum of EU legislation (the acquis *communautaire*) is divided into more than 30 policy chapters. Currently, Chapter 27 on *environment and climate change* is one of these opened chapters. In this aim, Serbia is engaged in many programmes to align its legislation in terms of air pollution mitigation with EU policies in this area. The 4th multi-annual National Programme for the Adoption of the *Acquis* (NAAP) (2022-2025) was adopted recently [6], [8]. One key plan for reducing air pollutant emissions and improve air quality is the Air Protection Programme in the Republic of Serbia for the period from 2022 to 2030 with action plan, adopted in December 2022 [7], [8].

2.2. Main sources of emissions

This chapter presents emissions of SO_2, NOx, PM_{10} and $PM_{2.5}$ and VOC in the Republic of Serbia (RS). Specific data treatment was made by Citepa and all figures presented below, derive from the national emission inventory NFR tables as reported by the Republic of Serbia in 2022 to the UNECE LRTAP Convention [9]. The Informative Inventory Report (IIR) submission 2023 is available (the 2021 IIR report). However, it has to kept in mind that due to Covid pandemic, activity levels can have been impacted and reduced. The evolution of emissions from 2019 to 2020 may not be significative of a general trend. It has to be noticed that, except for SO_2 provided for the period 2000 - 2020, only the most recent years are presented for NOx,

[2] The 1985 Protocol on the reduction of Sulphur emissions and their transboundary flux, the 1988 Protocol concerning the control of NOx or their transboundary fluxes, the 1991 Protocol concerning the Control of emissions of VOC or their transboundary fluxes and the 1994 Protocol for further reduction of Sulphur emissions have not been examined.

PM_{10} and $PM_{2.5}$ and VOCs as emissions from road transport have been calculated with two different versions of the EU tool COPERT (version 5.5 from 2016 to 2017 and version 5 before) [10], making the series 2000-2020 not consistent enough. For those pollutant only 2017-2020 are presented consequently.

2.2.1. SO_2 emissions

Total emissions

The evolution of SO_2 emissions from the different sources from 2000 to 2020 is provided in Figure 2-1.

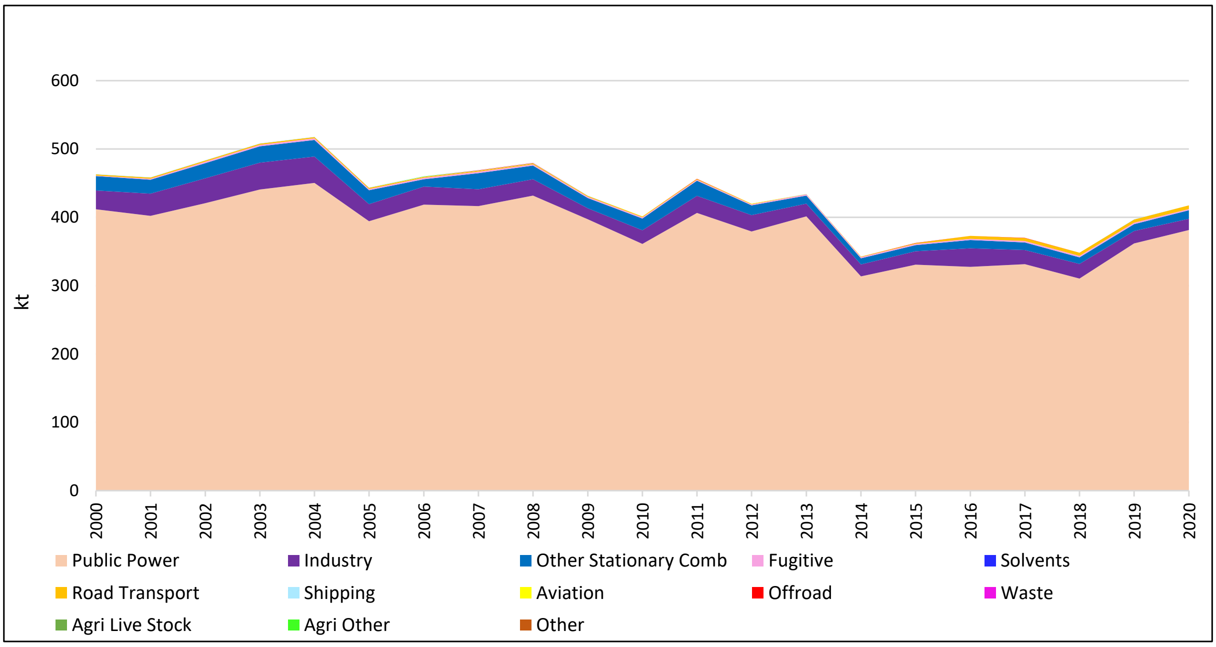


Figure 2-1: Trends in SO_2 emissions from 2000 to 2020 in Serbia

SO_2 emissions in 2020 are 418 kt [9]. The public power sector is the largest source of emissions with 91% of total emissions in 2019 and 2020. Emissions in 2019 and 2020 are similar to emissions in 2010. During all this period, large combustion plants from the power sector remained not equipped with efficient abatement techniques. SO_2 emissions remain proportional to the sulphur content of fuels used mainly coals and brown coals. Measures have been set up to limit SO_2 (as well as NOx and dust) emissions from LCPs but their impact is not yet visible in the emission inventory. The following chapters provide pieces of information on regulations implemented for LCPs and the National Emission Reduction Plan for old large combustion plants (NERP). According to the 2022 energy community report [11], an infringement procedure for non-compliance with the NERP ceilings for sulphur dioxide is open since March 2021 (see chapter 2.3.1). In 2022, SO_2 emissions from public power remain in the same magnitude as 2021 emissions and are a little bit lower than in 2020 [66].

Industrial sources

The evolution of SO_2 emissions from the different industrial sources is presented in Figure 2-2, from 2000 to 2020 [9]. Emission in 2020 are 12.2 kt. From 2009, the emissions remain in the same order of magnitude. The group “other industries” including all types of activities except those listed individually in the following figure, is the largest source representing 59% of emissions in 2020 from industry. Chemical industries and Paper and pulp industries represent around 10% and 11% of total emissions respectively.

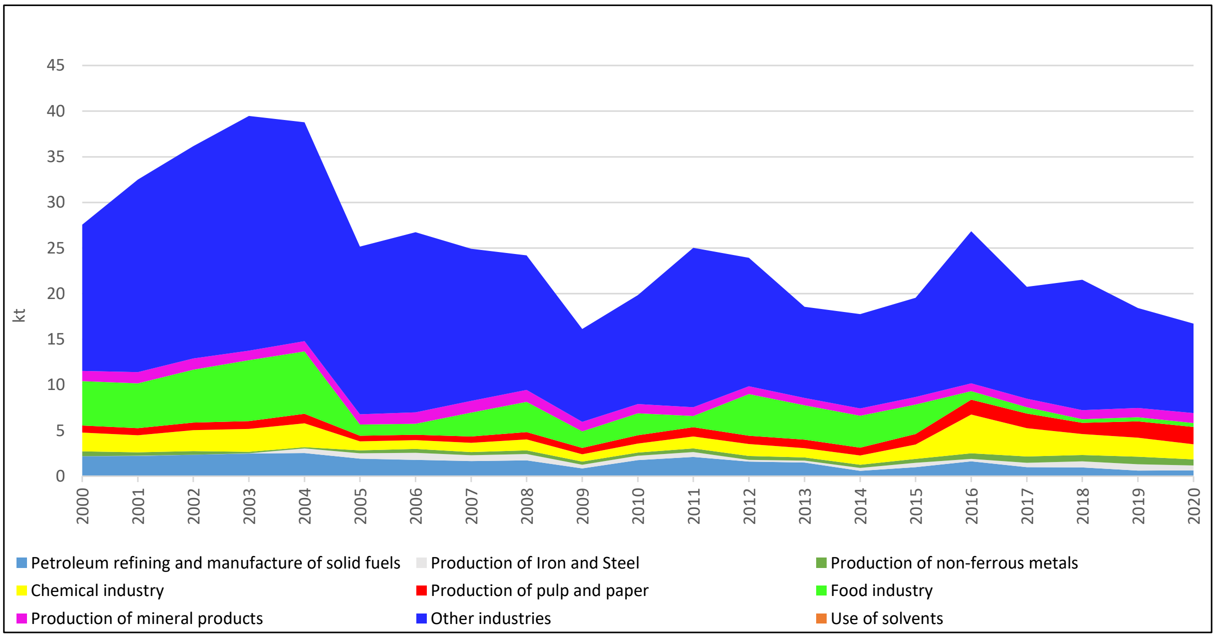


Figure 2-2: SO_2 emissions of manufacturing industry from 2000 to 2020 in Serbia

Road transport

The evolution of SO_2 emissions from road transport from 2016 to 2020 is provided in Figure 2-3 [9]. In 2020, with 5.2 kt, road transport represents 1.2 % of total SO_2 emissions in the Republic of Serbia. Passenger cars are the largest emitters (51%), followed by heavy duty vehicles (37%) and light duty vehicles (13%).

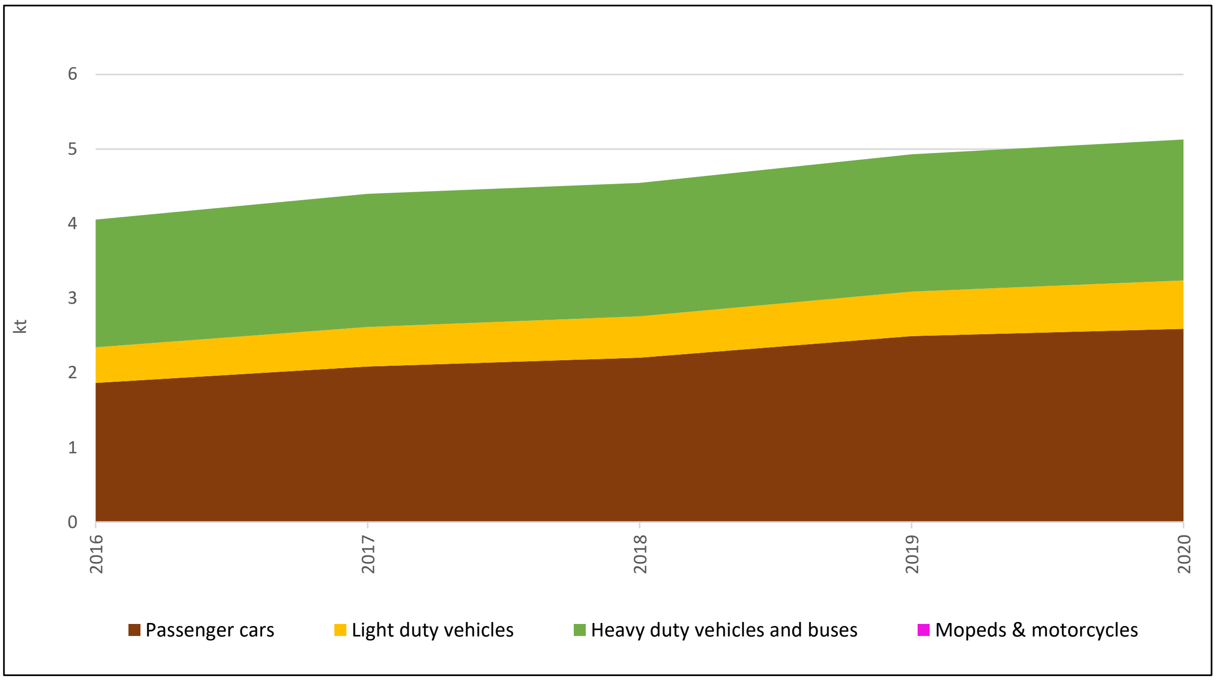


Figure 2-3: SO_2 emissions of road transport from 2016 to 2020 in Serbia

2.2.2. NOx emissions

Total emissions

The evolution of NOx emissions from the different sources is as in the following Figure 2-4, from 2016 to 2020 [9]. Emissions are 176 kt in 2020. In 2020, public power is the largest source of emissions, with 41.5% of total emissions followed by road transport with 38%. Industrial sources represent 6.5% of total emissions and other stationary combustion (residential and tertiary combustion) represents 4.5% of total emissions. In 2021 and 2022, NOx emissions continued to increase [66].

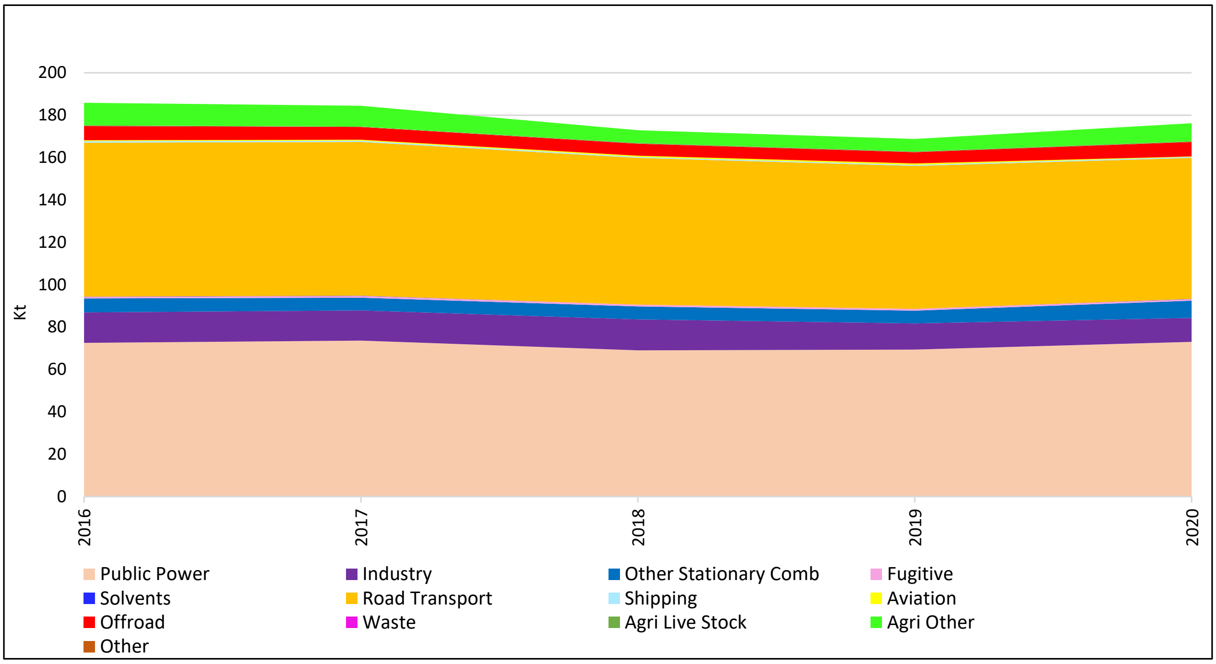


Figure 2-4: Trends in NOx emissions from 2016 to 2020 in Serbia

Industrial sources

The evolution of NOx emissions from the different industrial sources is as in the following Figure 2-5, from 2000 to 2020 [9]. Emissions in 2020 are 11 kt, after a recent peak of emissions in 2012 with 18.2kt. The production of mineral products is the largest source of NOx emissions in 2020 (31%). The group “other industries” including all types of activities except those listed individually in the following figure, is one of the largest sources with 29% of total emissions in 2020. Chemical industries, production of pulp and paper and iron and steel production represent around 7% of total emissions respectively.

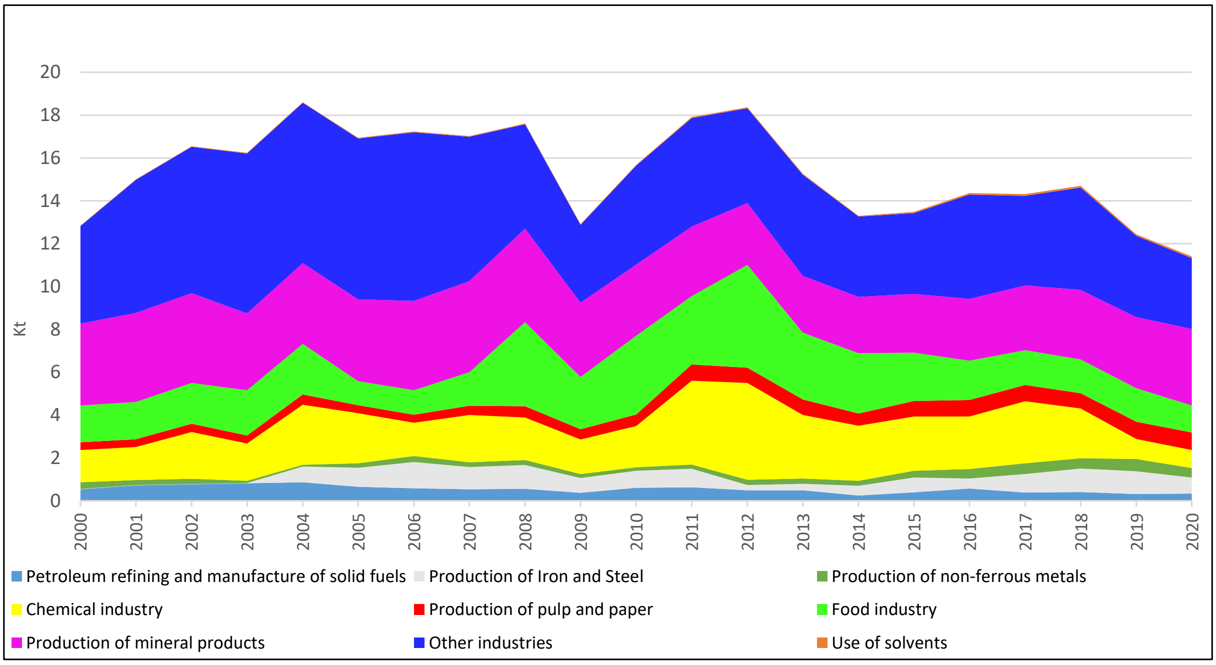


Figure 2-5: NOx emissions of industry from 2000 to 2020 in Serbia

Road transport

The evolution of NOx emissions from road transport is as in the following Figure 2-6, from 2016 to 2020 [9]. Emissions from road traffic are 67 kt in 2020 and represent 37.7% of total NOx emissions. Passenger cars and heavy-duty vehicles have similar contributions (around 44.5% of total emissions) followed by light duty vehicles (11%). In 2021 and 2022, no reduction of emissions is observed [66].

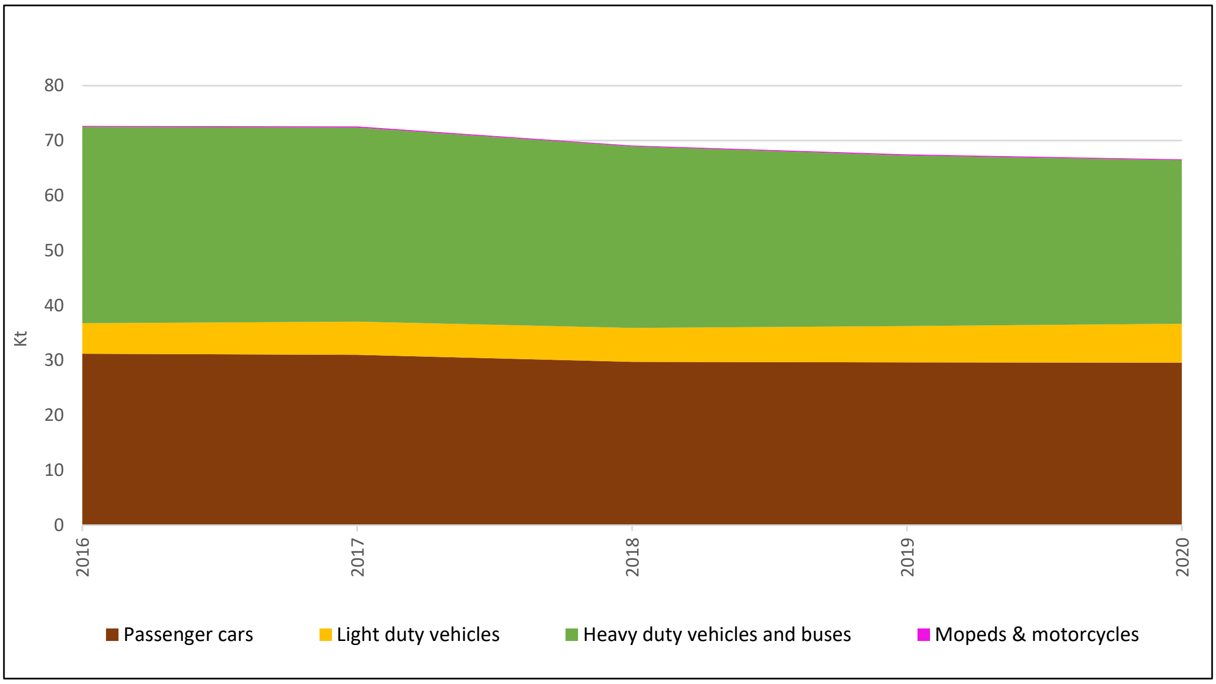


Figure 2-6: NOx emissions of road transport from 2016 to 2020 in Serbia

2.2.3. PM_{10} and $PM_{2.5}$ emissions

Total emissions

The evolutions of PM_{10} and $PM_{2.5}$ emissions from the different sources are presented in the following Figure 2-7 and Figure 2-8 respectively [9] for the years 2016 to 2020. 74.5 kt of PM_{10} and 58 kt of $PM_{2.5}$ are observed in 2020.

The emissions of PM_{10} and $PM_{2.5}$ are dominated by the impact of the sector "other stationary combustion" which groups combustion in tertiary activities and in domestic heating. Emissions from this sector represent 64% of total emissions of PM_{10} and 80% of total emissions of $PM_{2.5}$. Domestic heating represents 99% of the emission of this sector "other stationary combustion". These large emissions are due to high consumption of coal and wood in small domestic heating appliances and the low efficiency of combustion in these small appliances. Industry is the second largest source of PM_{10} (9.3%) followed by road transport (8.8%). For $PM_{2.5}$, the second largest source is the road transport (7.9%), followed by industry (5.5%). In 2021 and 2022, PM emissions remain on an upward trend [66].

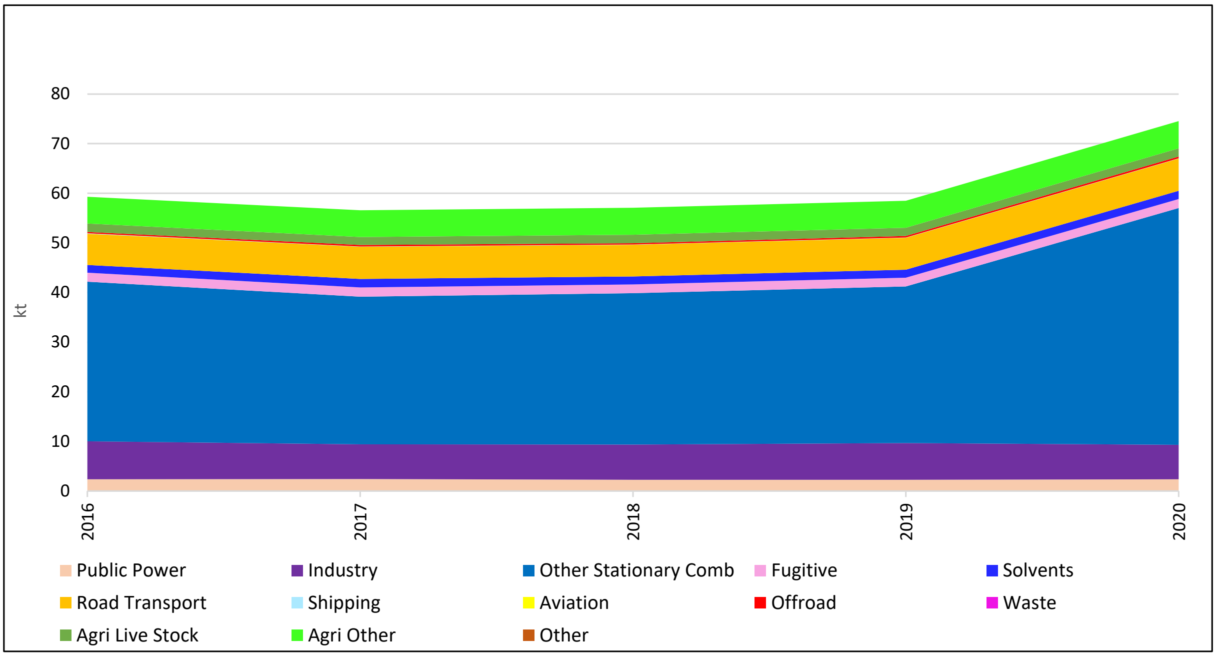


Figure 2-7: Trends in PM_{10} emissions from 2016 to 2020 in Serbia

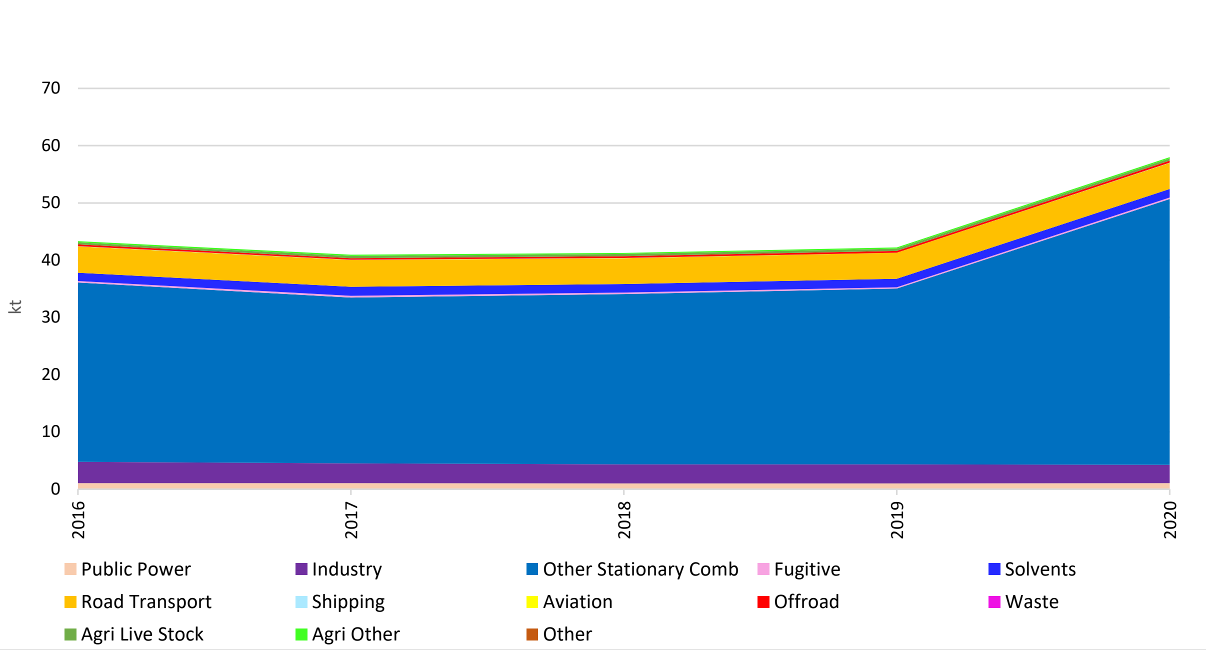


Figure 2-8: Trends in $PM_{2.5}$ emissions from 2016 to 2020 in Serbia

Industrial sources

The evolutions of PM_{10} and $PM_{2.5}$ emissions from different industrial sources are presented in Figure 2-9 and Figure 2-10, from 2000 to 2020 [9]. Total industrial PM_{10} and $PM_{2.5}$ emissions are respectively 7.0 kt and 3.2 kt. The group "other industries" is the largest sources of PM_{10} with 49% of total PM_{10} emissions in 2020 and represent 23% of total emissions of $PM_{2.5}$ in 2020. Mineral product production and food industry represent respectively 16.7% and 9.5% of total PM_{10} emissions. For $PM_{2.5}$, the following largest sources are the food industry with 20% of total emissions and the production of mineral products with 14% of emissions.

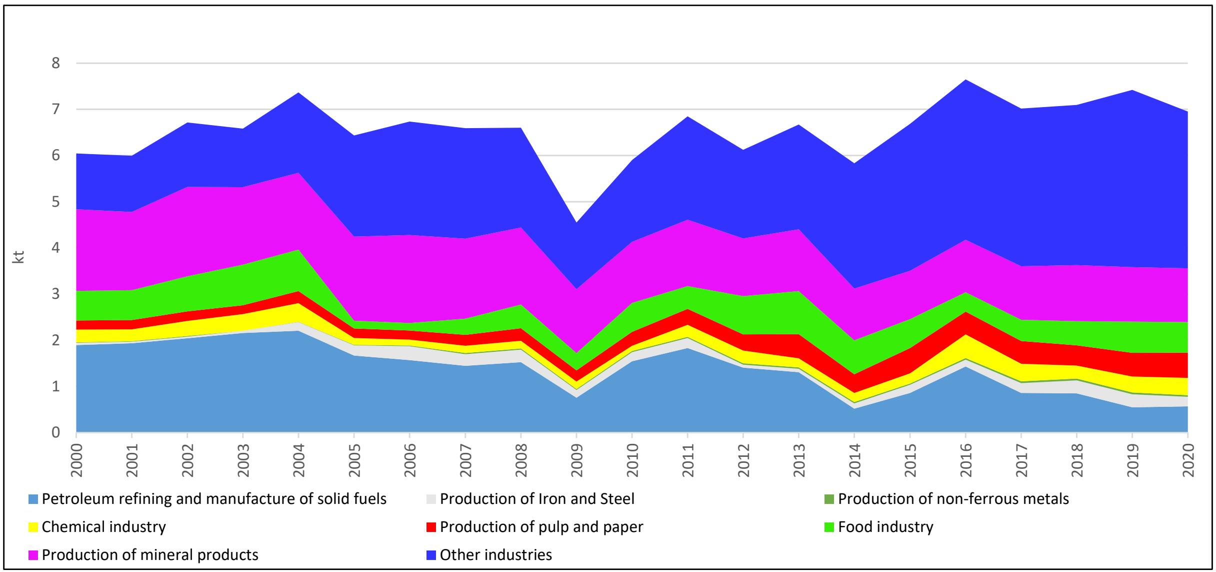


Figure 2-9: PM_{10} emissions of industry from 2000 to 2020 in Serbia

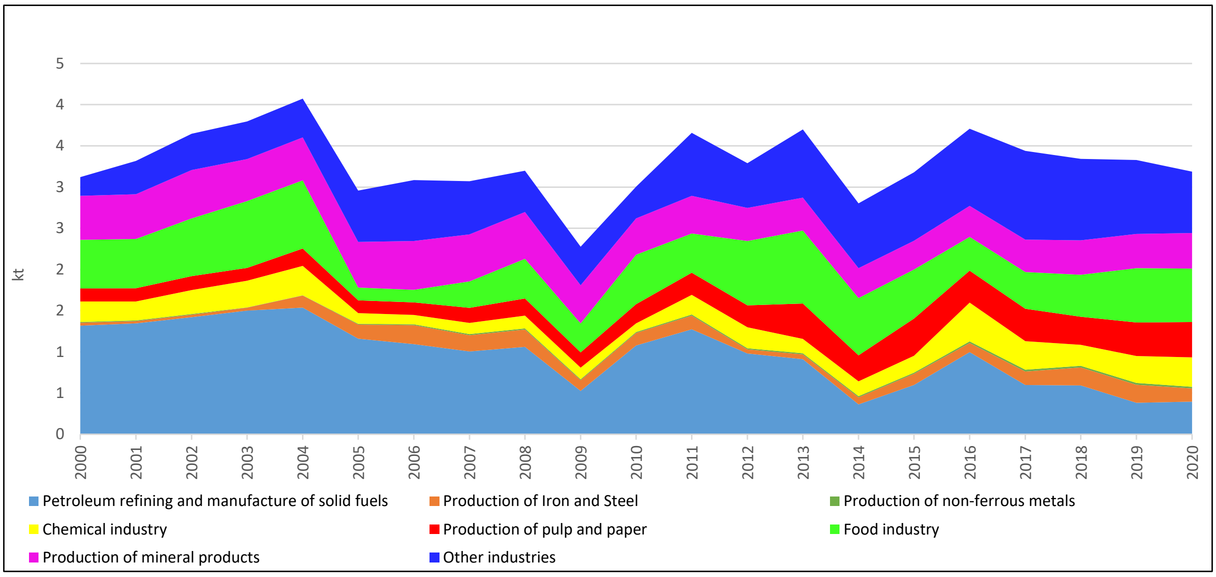


Figure 2-10: $PM_{2.5}$ emissions of industry from 2000 to 2020 in Serbia

Road transport

The evolutions of PM_{10} and $PM_{2.5}$ emissions from road transport are presented in Figure 2-11 and Figure 2-12, from 2016 to 2020 [9]. Total PM_{10} and $PM_{2.5}$ emissions from road traffic are respectively 6.5 kt and 4.6 kt. Passenger cars are the largest emitter in both cases with around (38% and 41% of PM_{10} and $PM_{2.5}$ emissions from road traffic). For PM_{10}, tyre and brake abrasion is the second largest source with 22% of total emissions. For $PM_{2.5}$, the second largest source is heavy duty vehicles with 22% of total emissions.

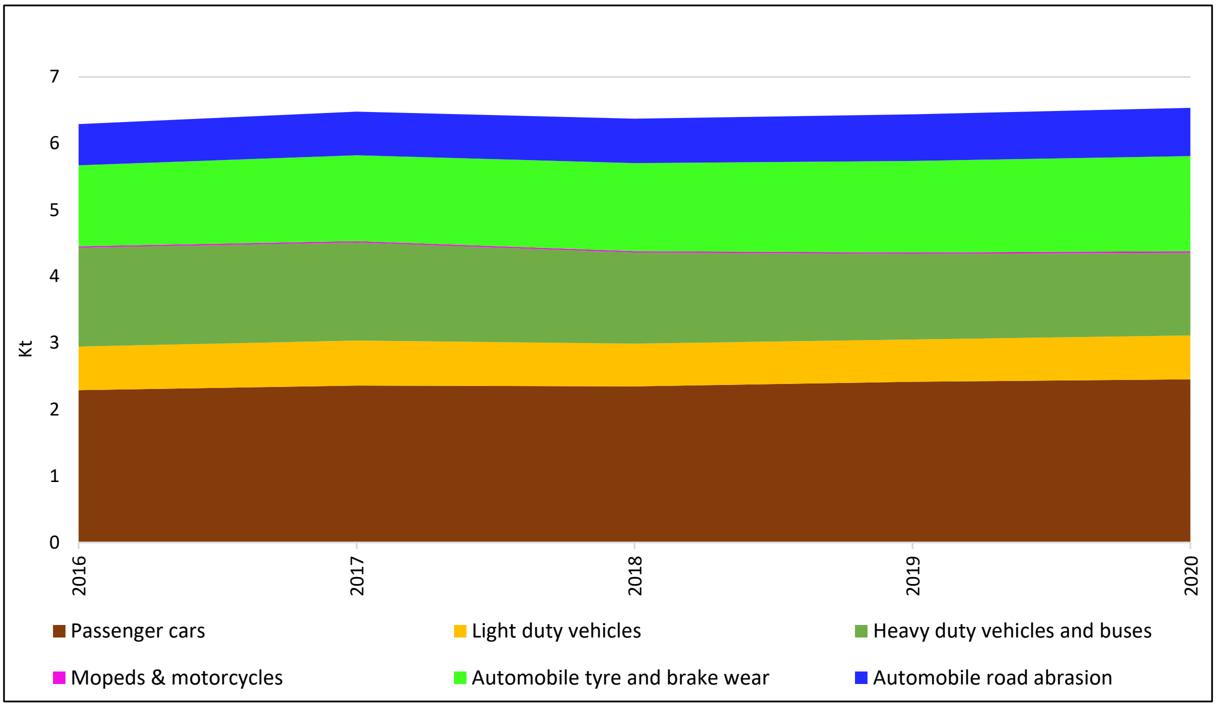


Figure 2-11: PM_{10} emissions of road transport from 2016 to 2020 in Serbia

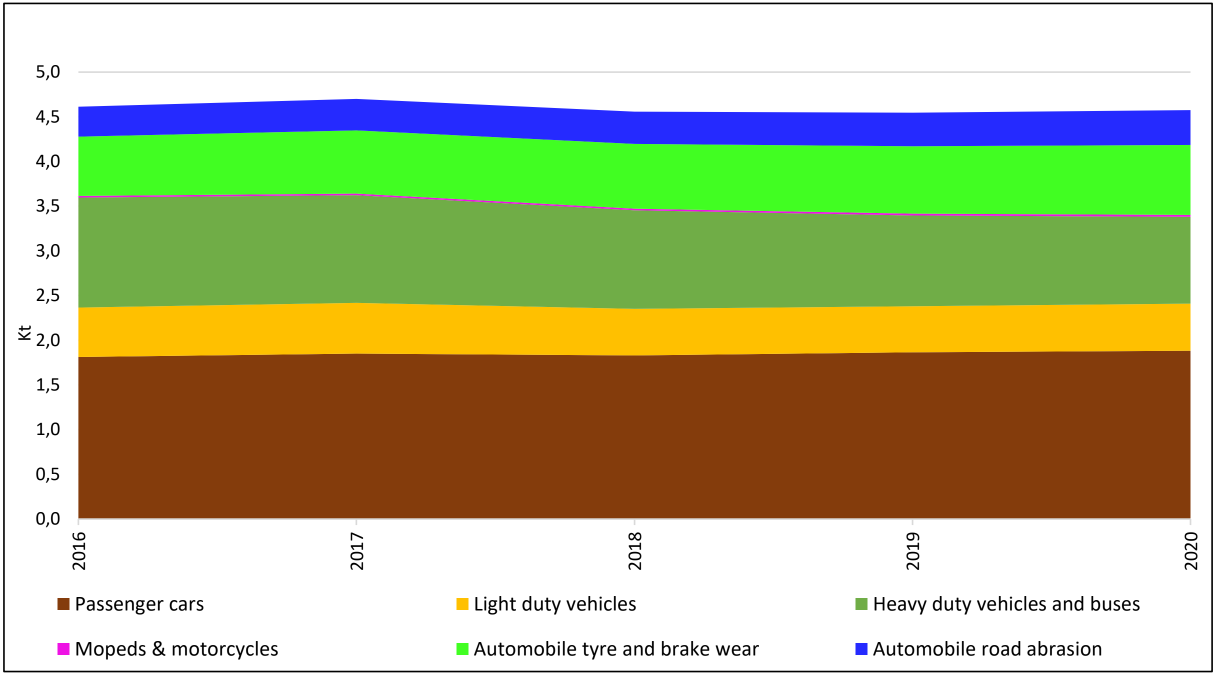


Figure 2-12: $PM_{2.5}$ emissions of road transport from 2016 to 2020 in Serbia

2.2.4. VOC emissions

<u>Total VOC emissions</u>

The evolution of VOC emissions of the different sources from 2016 to 2020 is presented in Figure 2-13 [9]. Emissions are 137 kt in 2020. The largest source is the sector other stationary combustion which groups combustion in tertiary activities and in domestic heating, with 29% of total VOC emissions and Fugitive emissions with 28% of total VOC emissions. The use of solvents represents 12% of total emissions and road transport 7%.

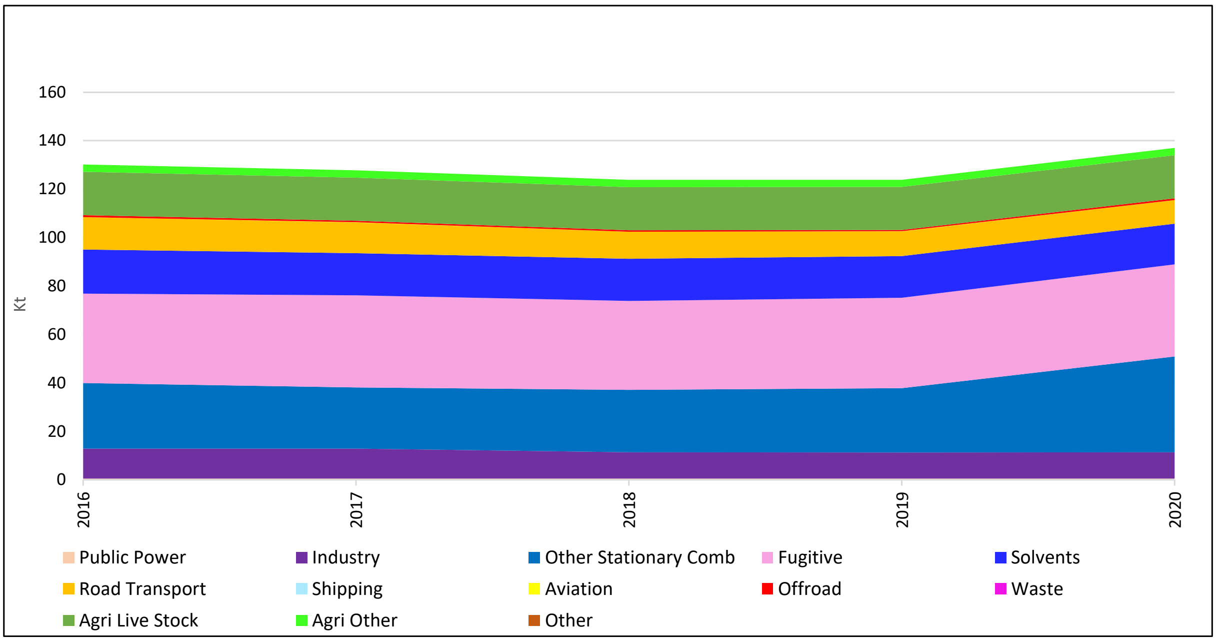


Figure 2-13: Trends in VOC emissions from 2016 to 2020 in Serbia

Industry (except industrial uses of solvents)

The Figure 2-14 presents the evolution of VOC emissions in industry (use of solvent are presented in the following subchapter) [9]. Total VOC emissions from industry are 11 kt in 2020. The food industry is by far the largest emitter with 78% of total VOC emissions from industry except solvent uses, followed by pulp and paper industry (11%) and chemical industry (9%).

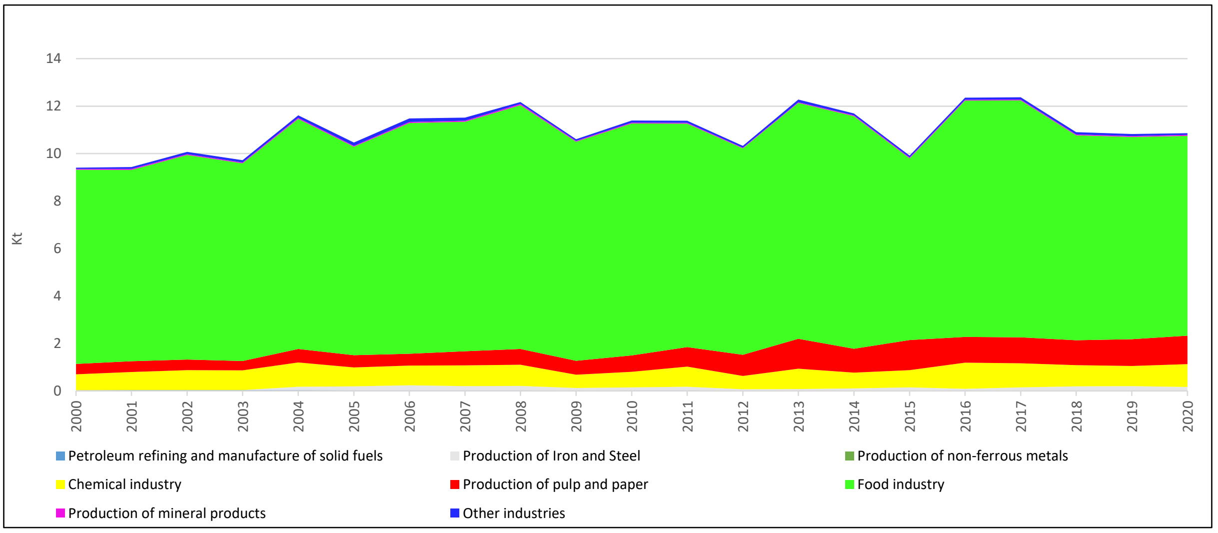


Figure 2-14: VOC emissions of industry (except use of solvents) from 2000 to 2020 in Serbia

Use of solvents and other products

Figure 2-15 presents the evolution of VOV emissions from the use of solvents and other products. Total VOC emissions from the uses of solvents are 16.8 kt in 2020. Domestic uses of solvents are, by far, the largest emitter with 8.2 kt representing 49.2% of total VOC emissions of the use of solvents. Printing industry is the second largest source with 4.5 kt representing 26.6 % of total VOC emissions of the use of solvents. Another important source is the group “other uses of solvents” which gather several activities with 2.7 kt and 16.4% of total VOC emissions of the use of solvents.

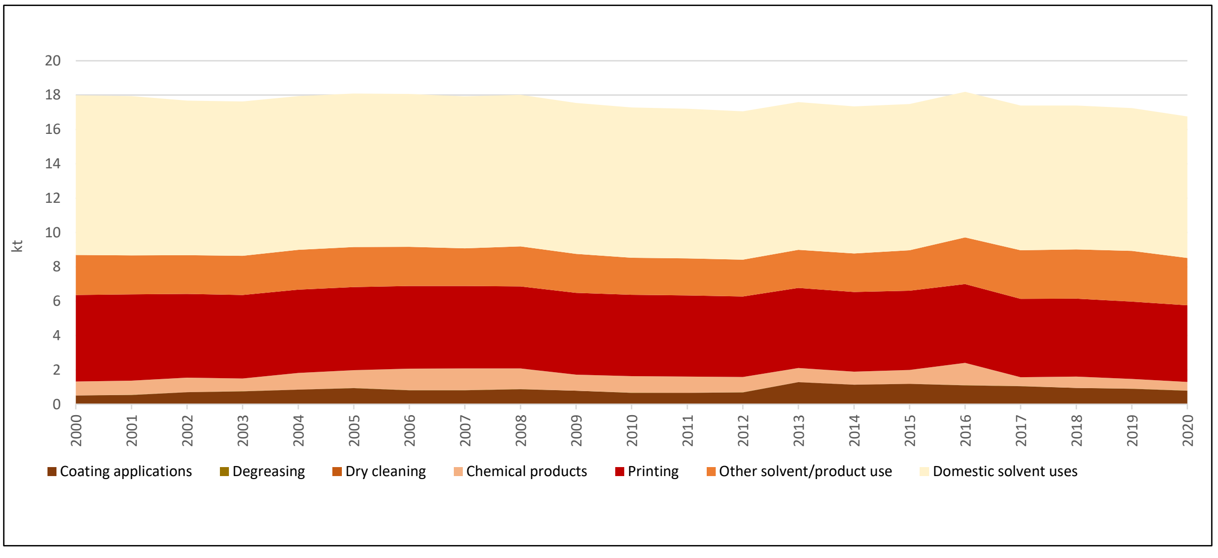


Figure 2-15: VOC emissions from the use of solvents from 2000 to 2020 in Serbia

Road transport

Figure 2-16 presents the evolution of emissions of VOC from road transport from 2016 to 2020. Total VOC emissions are 9.7 kt in 2020. End of pipe emissions from passenger cars are, by far, the largest emitter with 52% of total VOC emissions from road transport. Second source is the gasoline evaporation (22%). Heavy duty vehicles and mopeds have a similar contribution in total VOC emissions (around 10%).

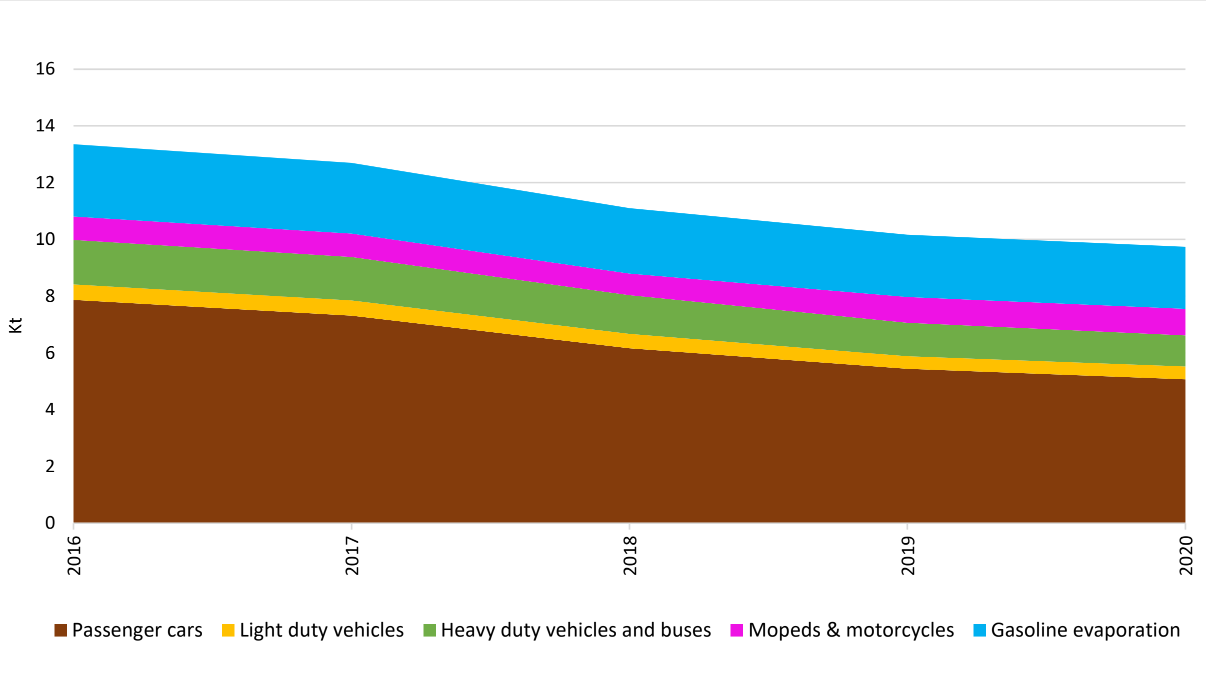


Figure 2-16: VOC emissions of road transport from 2016 to 2020 in Serbia

2.3. Situation in terms of air quality

The air quality report of 2021 developed by the Environmental Protection Agency [12] provides the following information. In the Republic of Serbia, zones and agglomerations are categorized into 3 categories numbered from "1" (pure or slightly polluted air) to "3" (too polluted) (Figure 2-17).

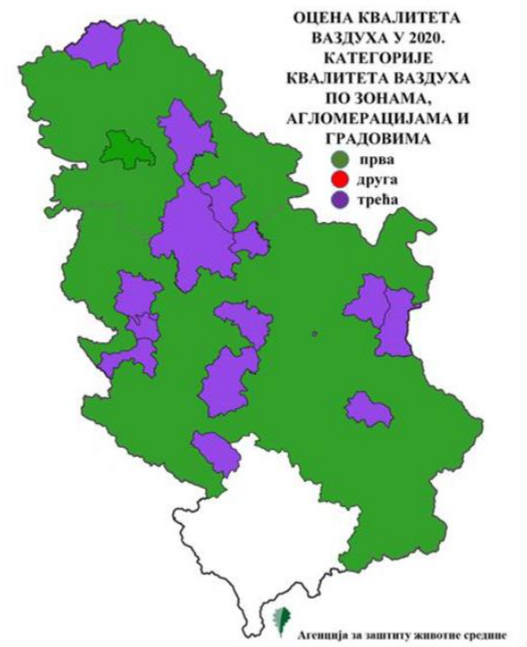


Figure 2-17: Zones of the Republic of Serbia in category 1 (in green) and in category 3 (in purple) [12] in term of air quality

Limit values in the Republic of Serbia for SO_2, NO_2, PM_{10} and $PM_{2,5}$ (other pollutants are not presented) are based on the EU directive 2008/50/EC of 21 May 2008 on ambient air quality and cleaner air for Europe [13] but may be stricter in some cases (daily limit value for NO_2 of 150 µg/m^3 instead of 200 µg/m^3 in the EU directive) [12]. In the following table, the limit values for the pollutants under the scope of this report are presented [12]:

Table 2-1: limit values for SO_2, NO_2, PM_{10} and $PM_{2.5}$

Pollutant	**Averaging period**	**Limit value**
SO_2	1 hour	350 µg/m^3 not to be exceeded more than 24 times per year
	1 day	125 µg/m^3 not to be exceeded more than 3 times per year
	annual	50 µg/m^3
NO_2	1 hour	150 µg/m^3 not to be exceeded more than 18 times per year
	1 day	85 µg/m^3
	annual	40 µg/m^3
PM_{10}	1 day	50 µg/m^3 not to be exceeded more than 35 times per year
	annual	40 µg/m^3
$PM_{2.5}$	annual	25 µg/m^3

In the zone Serbia (Serbia territory less the autonomous province of Vojvodina), except for the cities of Kragujevac, Valjevo, Kraljevo, Cacak, Zajecar, Novi Pazar, Paracin (Popovac) and Loznica, air quality was of the category I, i.e. clean or slightly polluted air.

In the zone Vojvodina (autonomous province of Serbia), except for the cities of Sremska Mitrovica, Subotica, Sombor and Zrenjanin, air quality was of the category I, i.e. clean or slightly polluted air.

In the agglomerations of Nis, Pancevo, Uzice, Smederevo and Kosjeric, air quality was of the category III, i.e. over-polluted air, due to concentrations that exceeded limit values of suspended particles $PM_{2.5}$ and PM_{10}.

In the agglomeration of Bor, air quality was of the category III, i.e. over-polluted air, due to concentrations that exceeded limit value of SO_2 and daily and annual limit values of PM_{10}.

In the agglomeration Novi Sad, air quality was of the category III, i.e. over-polluted air, due to concentrations that exceeded limit values of PM_{10}.

In the agglomeration Beograd, air quality was of the category III, i.e. over-polluted air, due to concentrations of suspended particles PM_{10} and $PM_{2.5}$ that exceeded limit values for these particles and too high concentrations of NO_2 exceeding the annual limit value.

In the cities Valjevo, Novi Pazar and Subotica, air was of the category III, over-polluted air, due to concentrations that exceeded limit values of suspended particles PM_{10} and $PM_{2.5}$,

In Kragujevac, Kraljevo, Loznica, Cacak, Zajecar, Paracin (Popovac), Sremska Mitrovica, Sombor and Zrenjanin, air quality was of the category III, due to concentrations that exceeded limit values of PM_{10}.

The states of exceedances is as follows for SO_2, NO_2, PM_{10} and $PM_{2.5}$:

SO_2

The mean annual value of SO_2 concentration above the limit value, 50 μg/m^3 did not occur at any station in 2021.

Exceedances of hourly limit value (350 μg/m^3) were registered more than 24 times at the station Bor Gradski park (156), at the station Bor Brezonik (67) and at the station Bor Institut (67).

Exceedances of daily limit value (125 μg/m^3) were registered more than 3 days at stations Bor Gradski park for 19 days and Bor Institut for 4 days.

NO_2

During 2021, the annual limit value for NO_2 of 40 μg/m^3 was exceeded in Beograd at station Despota Stefana (57 μg/ m^3).

Exceedances of daily limit value (85 μg/m^3) were registered at stations Beograd Despota Stefana GZZJZ (33), Beograd Mostar (5), Smederevo Carina (5), Bor Institut (4) and Valjevo (1).

Hourly limit value (150 μg/m^3) were exceeded more than 18 times at stations: Beograd Despota Stefana GZZJZ (178), Beograd Ovca (L) (27), Beograd Mostar (25) and Beograd Novi Beograd GZZJZ (24).

PM_{10}

In 2021, the annual limit value for PM_{10} (40 μg/m^3) was exceeded at the following stations: Valjevo ZZJZ (L) (64 μg/m^3), Zajecar (62 μg/m^3), Smederevo Radinac (56 μg/m^3), Novi Pazar (55 μg/m^3), Popovac (51 μg/ m^3), Valjevo (51 μg/m^3), Smederevo Carina (48 μg/m^3), Kosjeric (48 μg/m^3), Loznica (47 μg/m^3), Uzice (46 μg/m^3), Obrenovac Centar (45 μg/m^3), Pancevo Narodna basta (L) (44 μg/m^3), Cacak Kosta Novakovic (L) (42 μg/m^3), Kraljevo Policijska uprava (41 μg/m^3) and Beograd Vinca (L) (41 μg/m^3).

Exceedances of the daily limit value of 50 μg/m^3 were observed at all measuring points and their number was from three days at the station Kamenicki Vis till the 174 days recorded at the station Valjevo ZZJZ (L).

The highest daily concentrations of PM_{10} were measured on stations Valjevo ZZJZ (L) (317 μg/m^3) and Bor Gradski park (267 μg/m^3).

$PM_{2.5}$

The exceedances of annual limit value for $PM_{2.5}$ (25 μg/m^3) were recorded at the station Novi Pazar (48 μg/m^3), Valjevo (37 μg/m^3), Kosjeric (36 μg/m^3), Pancevo Narodna basta (L) (33 μg/m^3), Pancevo Vojlovica (L) (31 μg/m^3), Uzice (31 μg/m^3), Subotica Sonja Marinkovic (L) (29 μg/m^3), Obrenovac Centar (29 μg/m^3), Beograd Obrenovac GZZJZ (29 μg/m^3), Nis IZJZ Nis (29 μg/m^3), and Smederevo Centar (29 μg/m^3).

PM_{10} and $PM_{2.5}$ were in 2021, as in previous years, the dominant pollutants in the Republic of Serbia, impacting severely the air quality. Most of the agglomerations and cities faced too high concentrations of PM_{10} and $PM_{2.5}$ with exceedances of the limit values (both short term value for PM_{10} and annual limit values for PM_{10} and $PM_{2.5}$). For PM_{10}, both the annual limit value and the daily limit value not to be exceeded more than 35 days per year, were exceeded. Too high concentrations of SO_2 were also encountered in the industrial city (large copper production plant) of Bor [12].
From this analysis, it is obvious that efforts to reduce emissions of pollutants should focus in priority on PM emissions.

2.4. Regulations in place to limit emissions from stationary sources and programmes for their evolution

2.4.1. Existing regulations

The Serbian Law on Integrated Pollution Prevention and Control (IPPC) (official gazette of the Republic of Serbia (OGRS) n° 135/04, n° 25/15 and n° 109/21) [14] transposing the EU Directive 2008/1/EC concerning IPPC [15], was adopted in December 2004 and further amended in 2015 and 2021. This Law is associated to a set of by-laws adopted during the period 2005-2008. The EU directive 2008/1/EC was repealed in January 2014 when the new Directive 2010/75/EU on industrial emissions (IED) [16] began to apply and the Republic of Serbia started its transposal.

The process of transposition of the Industrial Emission Directive (IED) is not yet completely finalised and works for ensuring full alignment are still occurring (chapter 2.3.2.2.). The state of progress of the transposition is different from chapter to chapter of the Directive [8]. Certain chapters of the IED were transposed through transposition of the provisions of the IPPC Directive into the Law on IPPC (OGRS n° 135/04, n° 25/15 and n° 109/21) [14] and relevant by-laws.

- The chapter III of the IED related to large combustion plants (LCP) is partially transposed and regulated by Law on Air Protection (OGRS n° 36/09 and 10/13) [17] and by national by-laws: regulation “on emission limit values of pollutants in the air from combustion plants (OGRS, n° 6/16 and n° 67/21) [18] described in chapter 2.4.1.1 and regulation “on emissions of air pollutant measurements from stationary pollution sources (OGRS, n°5/16”) [19].

- The chapter IV of IED on waste incineration plants is partially transposed.
- The chapter V of IED related to the use of solvents in certain activities is also partially transposed. The regulation n°100/11 [20] is presented in chapters 2.4.1.3 and 2.4.2.

To support the finalisation of the transposition of the IED in national regulations, several projects were launched and finalised. A new project is ongoing. A project, supported by Swedish authorities, "IED Serbia" from 2018 to 2021 [21] developed the draft IED Specific Implementation Plan (DSIP) identifying the requirements of the IED, determining gaps between the current and desired situation regarding the implementation of the Directive and measures to eliminate them, clearly defining implementation activities and financial framework for their implementation. This work is continuing under other cooperation projects (refer to chapter 2.4.2.2.).

By 31st December 2024, installations defined as IED should have received an IPPC permit as defined in the amended law on Integrated Pollution Prevention and Control [14]. Full compliance of most industrial installations with chapter II of IED requirements will need a period of almost 10 years but more time for installations that will require extended implementation period. 2032 is foreseen according to draft IED DSIP developed by the project IED Serbia [21] but there are many challenges in this area that the competent authorities are currently facing.

The regulation "on limit values of emissions of pollutants in the air from combustion plants (OGRS, nº 6/16) [18] and regulation "on limit values of emissions of pollutants in the air from stationary sources (OGRS, nº 111/15) [26] are described in the following chapters 2.4.1.1. and 2.4.1.2. The limit values are compared with limit values prescribed by the technical Annexes IV, V, V and X of the Gothenburg Protocol in Annex 1 of the chapter.

2.4.1.1. Combustion installations

The limit values for combustion installations are prescribed by the regulation on limit values of emissions of pollutants from combustion plants adopted in 2016 (official gazette of the RS n°6/16) [18].

The regulation covers both large, medium and small combustion installations. For plants with a thermal power larger than 50 MW considered in the Gothenburg protocol Annexes IV for SO_2, V for NOx and X for PM, the regulation n°6/16 partially transposes the provisions of chapter III/Annex V of the IED [16] for large combustion plants.

ELVs are established for the following installations:

- Old large combustion plant means the combustion plant for which the operating permit was granted before 1 July 1992 or, in the absence of the operating permit, the construction permit, or the plant which was put into operation before 1 July 1992;
- Existing large combustion plant means the combustion plant for which the operating permit was granted on or after 1 July 1992 and before 1 January 2018 or, in the absence of the operating permit, the construction permit, or the plant which was put into operation on or after 1 July 1992 and before 1 January 2018;
- New large combustion plant means the combustion plant for which the operating permit was granted on or after 1 January 2018 or, in the absence of the operating permit, the construction permit, or the plant which was put into operation on or after 1 January 2018;

- Existing medium plant means the combustion plant for which the operating permit was granted before the date of entry into force of this Regulation or, in the absence of the operating permit, the construction permit or the plant which was put into operation before the date of entry into force of this regulation;
- New medium plant means the combustion plant for which the operating permit was granted before the date of entry into force of this Regulation or, in the absence of the operating permit, the construction permit or the which was put into operation before the date of entry into force of this regulation;
- Existing small plant means the combustion plant for which the operating permit was granted before the date of entry into force of this Regulation or, in the absence of the operating permit, the construction permit or the plant which was put into operation before the date of entry into force of this regulation;
- New small plant means the combustion plant for which the operating permit was granted after the date of entry into force of this Regulation or, in the absence of the operating permit, the construction permit or the plant which was put into operation after the date of entry into force of this regulation.

Small combustion plants according to the regulation n°6/16 [18], are the plants that produce thermal energy for heating households and sanitary water for households and whose thermal input is less than:

1) 1 MW_{th} when using solid fuels,

2) 5 MW_{th} when using liquid fuels,

3) 10 MW_{th} when using gaseous fuels.

Medium combustion plants according to the regulation n°6/16 [18], are defined as in the following:

1) Thermal energy is generated by solid fuels and whose thermal input is equal to or greater than 1 MWth and less than 50 MW_{th};

2) Thermal energy for heating households is generated by liquid fuels and whose thermal input is equal to or greater than 5 MW_{th} and less than 50 MW_{th};

3) Thermal energy is generated by gas fuels and is used for heating households and whose thermal input is equal to or greater than 10 MW_{th} and less than 50 MW_{th};

4) Thermal energy is generated by liquid or gaseous fuels and used for technological processes, the indirect drying or other procedures of processing objects or materials, power generation, provided that the thermal input is equal to or greater than 4 MW_{th} and less than 50 MW_{th};

The deadlines for compliance are as follows for combustion plants:

	Date of entering into force and limit values applied (From regulation n°6/16, [18])
New large combustion plants	From 01/01/2018, ELVs of Annex 1, part C
Old large combustion plants	Be included in the National Emission Reduction Plan (NERP) (described in the following paragraph) or apply specific ELVs of Annex 1,

	Date of entering into force and limit values applied (From regulation n°6/16, [18])
	part A and from the 01/01/2028, ELVs of Annex I, part B (as existing plants)
Existing large combustion plants	From 05/02/2016, ELVs of Annex 1, part B From 05/02/2021, ELVs of Annex 1, part C (as new plants)
New and existing medium combustion plants	From 05/02/2016, Existing plants, ELVs of Annex 2, part A New plants, ELVs of Annex 2, part B
New and existing small combustion plants	From 05/02/2016, Existing plants, ELVs of Annex 3, part A New plants, ELVs of Annex 3, part B

The ELVs prescribed for combustion installations by regulation n°6/16 [18] are presented in chapter 2.8.1. They are compared to ELVs implemented by the Gothenburg Protocol (Annex IV for SO_2, V for NOx and X for PM) [31].

ELVs and Comparison with ELVs of the Amended Gothenburg Protocol (Annexes IV, V and X)

Large Combustion Plants (Refer to chapter 2.8.1.1 for details on ELVs and comparison with ELVs from Gothenburg Protocol (Annex IV for SO_2, V for NOx and X for PM)

The ELVs of regulation n°6/16 for SO_2, NOx and PM, implemented for existing installations (plants which the operating permit was granted after 1 July 1992 or, in the absence of the operating permit, the plant which was put into operation after 1 July 1992) and new installations (respectively Annex 1 of the regulation n°6/16, part B and C), are equal to, or stricter than, ELVs implemented by the Gothenburg Protocol (Annex IV for SO_2, V for NOx and X for PM) [31] except NOx ELVs for existing plants using blast furnace gas, coke oven gas, low calorific gases or other gases (It has been identified that SO_2 ELVs of the Gothenburg Protocol for gasified refinery residues are not present in the Serbian regulation). It has indeed to be kept in mind that limit values of the Gothenburg Protocol present in Annex IV, V and X for large combustion installations were based on the Annex V on the IED Directive [16]. According to the information available, it is also the case of the Serbian regulation n°6/16 [18] for some categories of combustion plants.

For older combustion plants put into operation before the 1 July 1992, ELVs partly correspond to ELVs implemented by Directive 2001/80/EC of 23 October 2001, on the limitation of emissions of certain pollutants into the air from large combustion plants [22]. The plants are included in the NERP and should comply with limit values similar to those of the Amended Gothenburg Protocol from 1st January 2028.

According to the project IED Serbia "Further implementation of the Industrial Emissions Directive in Serbia" conducted by Sweden to support the implementation of the IED directive in Serbia [21], the status of implementation of limit values may be poor. It can be noticed that the emission inventory [9][10][66] does not observe significant reduction of emissions from these sources, but perhaps due to the type of inventory methods used. The work for further alignment is continuing (refer to chapter 2.4.2).

Old large combustion plants: National Emission Reduction Plan (NERP)

As a Contracting Party to the Energy Community Treaty, Serbia has the obligation to implement the EU energy acquis. Parallel to the adoption of secondary legislation, the implementation of the acquis gives rise to diverse reporting obligations [24].

In accordance with the Ministerial Council Decision D/2013/05/MC-EnC [23] on implementation of LCP Directive (Directive 2001/80), Republic of Serbia prepared its National Emission Reduction Plan (NERP) [25] containing only eligible old large combustion plants from the "network energy" sector (as well as preliminary list of old large combustion plants envisaged for "opt-out" mechanism).

The NERP has been prepared in accordance with the requirements of the Guidelines on the preparation of National Emission Reduction Plans developed by the Energy Community (EnC) Secretariat. NERP under the EnC is a combination of the NERP in sense of the LCP directive and the transitional national plan in sense of the Directive 2010/75/EU, Chapter 3, Article 32.

Final NERP list covered 12 emission sources (stacks), i.e. installations in accordance with LCP/IED that belong to the "network energy" sector.

Final list of old large combustion plants envisaged for "opt-out" mechanism, covered 4 installations in accordance with LCP/IED.

Also, Regulation on emission limit values of pollutants into the air from combustion plants (OGRS, n° 6/16 [18]) stipulates that the National Emission Reduction Plan for old large combustion plants shall apply in the period from 1 January 2018 to not later than 31 December 2027. For opt-out mechanism for the four old large combustion plants, the period is shorter 1 January 2018 until 31 December 2023.

For all plants covered with the NERP, it is envisaged through the Directive Specific Implementation Plan (DSIP) for IED [21], to comply with LCP BAT conclusions [27] after this period. For the industrial LCP technically connected to activities of Annex I of the IED, compliance has been assessed together with the primary Annex I activity. Compliance measures are also included in a single compliance plan with the request, if necessary, for a grace period.

The sum of total annual emissions of dust, SO_2 and NOx for all the plants included in NERP are listed in the next table.

Table 2-2: Annual emissions of dust, SO_2 and NOx for all the plants included in NERP [25]

t/y	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
SO_2	54,575	54,575	54 ,575	54 ,575	54,575	54,575	44,737	34,898	25,060	25,060
NOx	62,332	55,286	48,241	41,196	34,150	27,105	26,391	25,677	24,962	24,962
Dust	6,390	6,390	6,390	6,390	6,390	6,390	5,091	3,792	2,493	2,493

The NERP was adopted on the 30th of January 2020 by the Serbian Government.

Gas turbines (Refer to chapter 2.8.1.1 for details on ELVs and comparison with ELVs from Gothenburg Protocol (Annex V for NOx)

For combustion turbines (including Combined Cycle Gas Turbine CCGT) using natural gas or other gases, the NOx limit values prescribed by the regulation n°6/16 [18] are the same as limit values prescribed by technical Annex V of the amended Gothenburg Protocol [31]. No limit values have been noticed for gas turbines using liquid fuels.

Stationary engines (Refer to chapter 2.8.1.1 for details on ELVs and comparison with ELVs from Gothenburg Protocol (Annex V for NOx)

For existing stationary engines, limit values for NOx emissions are prescribed by the regulation n°6/16 [18]. The Protocol does not prescribe limit values for existing engines. For new engines, limit values are stricter than limit values prescribed by Annex V of the Gothenburg Protocol.

ELVs for small and medium size combustion installations (Refer to chapter 2.8.1.2 for details on ELVs and comparison with ELVs from Gothenburg Protocol (Annex X for PM)

Annex X of the AGP [31] introduces recommended limit values for combustion installation lower than 50 MWth, only for PM.

The ELVs prescribed by regulation n°6/16 [18] are presented in chapter 2.8.1.2. In most of the cases, regulation n°6/16 [18] prescribed less stringent ELVs for PM than the GP for small and medium size installations. It has to be noted that the MCP Directive [28] has not yet fully been transposed into national legislation of the Republic of Serbia.

2.4.1.2. Industrial installations

Regulation on limit values of emissions of air pollutants from stationary pollution sources, excluding combustion plants (Official gazette of the Republic of Serbia, n°111/15) [26]

Among other things, this regulation prescribes:

1) limit values for the emission of pollutants into the air from stationary sources of pollution, except for combustion plants;

2) the content of the emission balance report;

3) method of submission of emission data for the purposes of the information system and deadlines for data submission.

For the specific types of plants/stationary sources of air pollution, ELVs are prescribed (Annex 1 of the Regulation n°111/15 [26]) but also general emission limit values shall also apply to the stationary sources for the pollutants that based on the technological process, are expected in the waste gases, but are not stipulated in this Annex 1 for the related stationary sources of pollution.

Specific stationary sources are plants:

1) for the production and processing of coal;

2) for the production and processing of metals (iron and non-ferrous metallurgy);

3) in mineral industry;

4) in chemical industry;

5) for the surface treatment of metals;

6) for the production of lead-acid batteries;

7) for waste and other materials treatment, except for heat treatment;

8) for wastewater treatment;

9) for the production and processing of paper and wood products;

10) in food industry;

11) other activities.

ELVs and comparison with ELVs of the Gothenburg Protocol (Annexes IV, V and X)

A table comparing the ELVs prescribed by the technical Annexes IV, V and X of the AGP [31] to the ELVs prescribed by the Serbian regulation n°111/15 [26] has been prepared (Refer to chapter 2.8.1.2 for details on ELVs and comparison with ELVs from Gothenburg Protocol (Annex IV for SO_2, V for NOx and X for PM). ELVs implemented can be equal or in some cases, may be stricter than the ELVs of the Gothenburg technical Annexes (identified in green) or may be less stringent (identified in yellow).

The full alignment of the Regulation with limit values of the technical Annexes should be necessary. The ongoing projects to facilitate the implementation of the IED directive (refer to chapter 2.4.2) should reduce the existing gaps between ELVs.

2.4.1.3. Uses of solvents in industry

Regulation on the list of industrial installations and activities in which volatile organic compounds emissions are controlled, values of emission of volatile organic compounds under specific consumption of solvents and total permissible emissions, as well as emission reduction scheme (Official gazette of Republic of Serbia n°100/11) [20]

The regulation n°100/11 transposed Directive 1999/13/EC currently included in chapter V and Annex VII of the IED [16].

The Regulation n°100/11 [20] provides for a list of industrial installations and activities in which volatile organic compounds emissions are controlled, the VOC emission limit values, at a given solvent consumption, and the total permissible emissions of VOC from installations and activities, as well as schemes for reducing emissions of volatile organic compounds.

The list and description of the activities to which the provisions of the regulation n°100/11 apply [20], are given in its Annex 1 and the list of installations in which these activities are carried out and to which the provisions of regulation n°100/11 apply are given in its Annex 2.

It has also to be kept in mind that Annex VI of the AGP [31] introduces stricter VOC limit values for plants consuming more than 200 t solvent/year which are not considered in the regulation n°100/11. If Regulation n°100/11 prescribes limit values identical to the limit values in Annex VII of the IED, the limit values of the Annex VI of the AGP for plants with a consumption of more than 200 t/year of solvent, are not considered.

These lists and emission limit values are the same as the Annex of the Directive 1999/13/EC, now included in the IED [16], Annex VII.

According to the project IED Serbia “Further implementation of the Industrial Emissions Directive in Serbia” conducted by Sweden to support the implementation of the IED directive in Serbia [21], the status of implementation of the chapter V and Annex VII of IED (and consequently of regulation n°100/11!), was still very poor in 2018. The project “IED Serbia” recommended strengthening of the existing administrative capacities of the Ministry of the Environment Protection (MEP), the Serbian Environment Protection Agency (SEPA) and of environmental inspectors at all levels. Lack of adequate knowledge of environmental inspectors on the VOC/solvent issues, was identified.

A project “Further implementation of the EU regulation on Volatile Organic Compounds” [30] financially supported by the Royal Norwegian Embassy in Belgrade, was finalised by the end of 2022 (refer to chapter 2.4.2.2). Its general objective was to support the Ministry of

Environmental Protection of the Republic of Serbia and the Environmental Protection Agency of the Republic of Serbia in transposing Chapter V of the Industrial Emissions Directive into national legislation, as well as to support primarily, small and medium enterprises that use organic solvents in their production processes in fulfilling the requirements of the said Directive.

2.4.1.4. Sulphur content of gas oil

The AGP Annex IV [31] prescribes a limit value for the sulphur content of gasoil used in domestic heating and combustion installation (Annex IV, table 2) (the sulphur contents of fuel used in mobile engine and non-road mobile machinery are considered in Annex VIII of the AGP, mobile sources). The sulphur content is limited to 0.1% w/w.

Situation in Serbia and comparison with ELVs of the Gothenburg Protocol

In Serbia, the limit value for the Sulphur content of gasoil of 0.1% w/w is currently prescribed. The Republic of Serbia was working these last years, to further align its regulations related to the characteristics of liquid fuels with the fuel quality Directive 2009/30/EC on the specification of petrol, diesel and gasoil used in road transport, as well as to gasoil used in non-road-mobile machinery [32] and Directive 2016/802/EC relating to a reduction in the sulphur content of certain liquid fuels [33], which sets the conditions, as example, for the use of heavy fuel oil with a Sulphur content of more than 1% by weight (refer to chapter 2.4.2.1) [36].

2.4.1.5. Petrol storage and distribution from terminals to service stations and vehicle refuelling

The limit values prescribed by the AGP [31] in its Annex VI to control VOC emissions from the chain of distribution of petrol from terminals to the service stations and car refuelling were derived from limit values of the Directive 1994/63/EC of 20 December 1994 on the control of volatile organic compound (VOC) emissions resulting from the storage of petrol and its distribution from terminals to service stations (or Stage I petrol vapour recovery) [34] and Directive 2009/126/EC on Stage II petrol vapour recovery during refuelling of motor vehicles at service stations [35].

In Serbia, these Directives have been largely transposed and regulated by the Law on Air Protection, amended on 30 January 2013 (OGRS, n°36/09 and 10/13) [17] and by the Rulebook on technical measures and requirements in relation to allowed emission factors for VOCs resulting from the storage and transport of petrol (OGRS n°01/12, 25/12, 48/12 and 93/19).

Comparison with ELVs of the Annex VI of the Amended Gothenburg Protocol

The Directive 1994/63/EC [34] is transposed in large part in the Serbian regulation, but its implementation has been postponed. This is also the case for the directive 2009/126/EC [35]. The Republic of Serbia was working these last years to further align its regulations with these two EU directives (refer to chapter 2.4.2.1) and ensure full implementation of the requirements of the two Directives relating to the petrol distribution chain from the terminals to service stations and car refuelling [36].

2.4.1.6. Solvents in products

The limit values for the content of VOC of products prescribed by the AGP [31] in its Annex XI were derived from limit values of Directive 2004/42/EC on the limitation of emissions of VOCs due to the use of organic solvents in decorative paints and varnishes and vehicle refinishing products and amending Directive 1999/13/EC (Paints Directive) [67].

Main provisions of Directive 2004/42/EC were transposed, except for the provisions prescribed only for EU member states (e.g. reporting to the Commission) through amendments to the Law on chemicals and to the Rulebook on Bans and Restrictions of Production, placing on the Market and Use of Chemicals from 2010 to 2021. Some remaining requirements should be transposed by 2025.

Guidelines for inspection and control of chemicals placed on the market were developed, as well as guidelines on requirements of placing on market paints and varnishes intended to producers and importers of those chemicals with the support of an IPA twinning project "Assistance in establishing of Chemicals sound management system in the Republic of Serbia" during 2012.

The Ministry of Environmental Protection is the competent authority for the implementation of the Directive with its Department for Chemicals as the central administration. The environmental inspection is responsible for control of placing on the market, paints and varnishes for professional use. The sanitary inspection is responsible for control of placing on the market, paints and varnishes to general public.

2.4.2. Additional programmes to align the national regulations with EU Directives and reduce emissions of pollutants

This chapter presents some of recent or current projects and works of the Republic of Serbia to develop its programme for air protection, better align its regulations with the IED directive [16], several EU directives related to the fuel quality [32][33] and directives related to the petrol distribution [34][35].

2.4.2.1. Development of the air protection programme and its action plan and other implementation plans to further align the regulations with EU Directives

From 2019 to 2021, the Ministry of Environment Protection continued to work on the further alignment of its legislation with EU Directives and the development of the national Air Protection Programme for the period 2022-2030 with its action plan which was adopted in December 2022 [7].

The Project "Additional Development of EU Environment Approximation for Air, Chemicals and Horizontal Acquis (2019 – 2021) in Serbia or Environmental Approximation Strategy (EAS) III [36] was set up in this aim. The project was funded through the Instrument of Pre-Adhesion of the European Union (IPA. IPA projects support beneficiaries to implement the necessary political and economic reforms, preparing them for the rights and obligations that come with the EU membership). The project was carried by Expertise advisors, INERIS, Citepa and many country experts from the Beograd University.

The project aimed to support the implementation of the National Environmental Approximation Strategy (NEAS) and the upcoming EU negotiation process of the Republic of Serbia in three different sectors of the Chapter 27 - Environment and Climate Change (one of the 35 chapters related to different policy fields covered by the process) [4][5][6]:

- Ambient Air Quality
- Chemicals
- Horizontal (INSPIRE)

The project provided technical assistance to the Ministry of Environment Protection (MEP) and to other beneficiaries/stakeholders with preparation of strategic planning and programming documents, needed for the EU approximation and negotiation process.

The project focussed among other tasks related to INSPIRE and REACH, and ambient air quality through:

- Ambient Air Quality - Directive 2008/50/EC [13] including 4th Daughter Directive (2004/107/EC)[37];
- Reduction of national emissions of certain atmospheric pollutants - Directive (EU) 2016/2284 [38];
- Sulphur in fuels - Directive (EU) 2016/802 [33];
- Petrol and diesel fuels quality - Directive 98/70/EC [39];
- VOC I and VOC II - Directive 94/63/EC [34] and Directive 2009/126/EC [35].

The project aimed at strengthening capacities and capabilities of the MEP (air management) for planning the implementation of EU requirements for selected directives/regulations with the output documents as follows:

- National Air Protection Programme and the Action Plan,
- Directive/Regulation Specific Implementation Plans (DSIP/RSIP) for the seven directives cited above.

Air Protection Programme and the Action Plan

In order to prepare the future emission reduction pathways taking into account Serbia's national circumstances, different modelling tools were used. In order to assess different mitigation options, four air quality emission scenarios were developed (With Existing Measures (WEM), With Additional Measures (WAM) A, B and C (the three scenarios were developed to ensure step by step the improvement of air quality with the WAM C only enabling to avoid exceedances of aur quality limit values for PM_{10} and $PM_{2.5}$), while the Air Protection Programme determines the pathway until 2030.

The future effects of the mitigation potential of proposed policies and measures and the determination of possible national emission ceilings for 2030 and beyond, were assessed through these specific tools. The results then served as an input to CHIMERE multi-scale chemistry-transport model [40] which allows to translate future reduced emissions of air pollutants from different sectors and sources into the expected future concentrations of pollutants in ambient air.

The results regarding the ambient air quality then allowed for further adjustment of policies and measures to the level at which the modelling results show the acceptable level of air quality by 2030 and beyond.

The Action Plan, that is integral part of the Programme, is determining the activities for implementation of measures and achievement of goals set by the Programme and was prepared for a period of 5 years (up to 2026).

The development of the Programme and its Action plan was led by the Ministry of Environment Protection as responsible institution with a close cooperation and permanent consultations with relevant stakeholders (governmental, public, private and NGOs organisations).

One of the key measures of the plan, relates to domestic heating with solid fossil and biomass fuels. The proposed measures include the faster replacement of existing household heating appliances with new Eco-Design compliant appliances associated with financial incentives. Higher percentages of replacement of appliances in the cities of Kragujevac, Beograd, Nis, Valjevo and Užice (5 cities that are considered as PM hot spots) were also proposed. Further works are however still necessary for this source of PM. This includes activities such as additional work on full harmonisation of national legislation with the Eco-design Directive [41] and work on the transposition of the Regulation 2015/1189/EU [43] and the Regulation 2015/1185/EU [42] with regard to Eco-design requirements for solid fuel boilers and for solid fuel local space heaters respectively and establishment and implementation of a mechanism for financial incentives for the replacement of existing heating equipment in households with new appliances compliant with EU regulations and heat pumps. Institution responsible for the implementation is the Ministry of Mining and Energy.

The plan also considers the reduction of emissions from industry and large combustion plants through the IED implementation, the MCP implementation. For road transport, measures focus on the limitation of importations of old second-hand vehicles and the faster replacement of old vehicles.

From this work finalised in December 2021, the RS developed and adopted its national Air Protection Programme with an action plan for the period 2022-2030 on 8 December 2022 [7], [8].

Quality of fuels and sulphur in fuels

The Directive Specific Implementation Plans (DSIP) for Directive 2016/802 relating to a reduction in the sulphur content of certain liquid fuels [33] and for Directive 98/70/EC relating to the quality of petrol and diesel fuels [39] prepared during the EAS III project [36], consider all provisions of the Directives that have not have been transferred or have been only partially transferred to the legal system of the Republic of Serbia, as well as all measures and activities for full implementation and contain the following measures:

- measures for the harmonization of policies,
- measures for legal transposition,
- institutional development,
- implementation and enforcement.

The draft DSIPs prepared have not yet been officially approved and adopted by the Government of RS so they remain in draft form.

Distribution of petrol

One specific objective of the EAS III project [36], was to develop two DSIPs respectively for the Directive 94/63/EC on the control of VOC emissions resulting from the storage of petrol [34] and its distribution from terminals to service stations (VOC Petrol Stage I) and Directive 2009/126/EC on Stage II petrol vapour recovery during refuelling of motor vehicles at service stations (VOC Petrol Stage II) [35] in order to enable the Serbian authorities to identify legal, institutional and technical measures to provide valuable inputs for national negotiating position related to the compliance with the Directives.

The draft DSIPs prepared describe the current situation regarding relevant legal framework regarding emission of VOCs during the storage of petrol, its distribution and the refuelling of motor vehicles, transposition and implementation status, requirements of the VOCs directives Stage I [34] and Stage II [35], identify legal, institutional and technical gaps, specify the implementation of necessary technical measures, makes cost assessments, identify possible financial sources to close the gaps, and present recommendations on the investment schedule and transition period for the implementation of the two Directives.

By end of 2026, all technical measures to reduce the total annual loss of VOC resulting from the following sources or activities should be implemented:

- from loading and storage at each installation at terminals,
- from loading/unloading mobile containers at terminals,
- all road tanker loading gantries to meet the requirements of Annex IV of Directive 94/63/EC,
- from loading into storage installations at service stations.

By the end of 2028: all necessary technical measures at the petrol stations regarding vapour displaced from the fuel tank of a motor vehicle during refuelling at service stations, in order to ensure the petrol vapour capture efficiency of such systems should be implemented. This will be based on installation and establishment of in-service compliance of the active petrol vapour recovery system and automatic monitoring system, together with appropriate methodology for periodic checks of such systems.

The draft DSIPs prepared have not yet been officially approved and adopted by the Government of RS so they remain in draft form.

2.4.2.2. Works for better alignment of the Republic of Serbia regulations with the IED and its enforcement for industrial plants

The project “Further Implementation of the Industrial Emissions Directive in Serbia” was implemented by the Faculty of Technology and Metallurgy of the University of Belgrade in partnership with the Ministry of Environmental Protection of the Republic of Serbia. The project was funded by Sweden, for the period 2018-2021 [21].

The main goal of the project for the period 2018-2021 was to provide support to operators in the intensive farming and food and beverage (FDM) industry sectors, which together represent half of the total number of IPPC/IED installations in Serbia. Also, as part of the accession process of Serbia to the European Union, the project prepared a DSIP in cooperation with the Ministry of Environmental Protection, including all IPPC operators and its technical and financial analysis in accordance with the requirements of the IED Directive.

The general objective of the project “Further Implementation of the Industrial Emissions Directive in Serbia” was set up to support competent authorities and operators in Serbia in the implementation of the IED through a comprehensive analysis of measures that operators should implement in order to achieve full compliance with the requirements of the IED. A special focus was placed on reducing the environmental impact of operators in the food production chain through specific measures related to the efficient use of energy and resources and the reduction of waste generation. In addition, the project provided support to operators in improving existing and introducing new technologies with the aim of aligning their operations with Best Available Techniques (BAT).

The IED Serbia project was implemented within four main components and a series of different activities that involved all relevant stakeholders:

- Preparation of the DSIP and the legislative framework in the field of environment related to the implementation of IED.
- Technical support – direct technical assistance to competent authorities and operators in the food production chain in the process of obtaining integrated permits through the preparation of manuals, applications, and relevant plans and draft permits; constant support for operators (Help-desk).
- Promotion of technological improvement – promoting cooperation between companies and the University in order to promote environmental protection programmes, as well as help them to adopt innovative EU standards and develop new market opportunities; support in the preparation of project proposals related to technology transfer.
- Raising awareness and capacity building – organisation of workshops, seminars, and working groups.

In the frame of the first component, support to Serbia in the preparation of the legislative framework and a part of the negotiation position, pertaining to individual chapters of the Industrial Emissions Directive through the preparation of the DSIP for IED, was provided.

The aim of Component 2 was primarily to provide direct technical support to companies and competent authorities involved in the process of issuance and control of integrated permits for installations in food sector.

The main goal of Component 3 was to enhance the economic integration with the EU and development of market economy: to foster the cooperation between companies and the University in order to promote new technologies, as well as to adopt innovative EU standards and to develop new market opportunities. The activities were aimed at supporting operators and other stakeholders in the identification of funding opportunities and preparation of project proposals to foster innovation in the field of environmental protection.

A new project (following the IED Serbia project [21] carried out in 2018-2021 described here above) “Green Transition – Implementing Industrial Emissions Directive in Serbia 2021-2025” [29], represents the third phase of cooperation between the Ministry of Environmental Protection, the Cleaner Production Centre of the Faculty of Technology and Metallurgy, the University of Belgrade, and the Swedish International Development Cooperation Agency. It provides an extended support in the implementation of national regulations in the area of integrated pollution prevention and control, by promoting the transition of Serbian industry to green technologies.

The main objective of this new project is to provide assistance and support the competent authorities and companies in the implementation of the IED, which would reduce the impact of industrial emissions on the environment and human health. The project provides technical and administrative support to the Ministry of Environmental Protection and other competent authorities in the preparation of draft integrated permits for the selected companies, as well as in amending and preparing the regulations and part of the Negotiation Position in the field of industrial pollution.

The Project also supports the preparation of the DSIP for the EU ETS Directive, as support in achieving the national climate goals. The development of new business models should ensure support to industry in reducing their carbon footprint by applying cost-effective and clean technological solutions for the transition towards the European Green Deal.

The experience gained in the previous two phases of the project IED Serbia, enables the provision of support to Serbian institutions in introducing necessary changes into the legal and administrative framework, which would reduce the impact of the existing obstacles and bottlenecks to the regulatory cycle of integrated pollution prevention and control (IPPC).

Technical assistance planned by the new project is offered to competent authorities and other stakeholders involved in the implementation of the Law on IPPC at different levels. The first and most important beneficiary is the MEP through support and close cooperation with the selected expert team both in the theoretical part and in learning-by-doing in the field. Such an approach refers to every step of the regulatory cycle, from the preparation of legal documents and technical document analysis to thorough preparation and issuance of the integrated permits.

Cooperation with environmental inspectors ensures coverage of the entire regulatory cycle. The project will support the training of a core team of inspectors that will, at different administrative levels, gain experience in the control of installations that are subject to the issuance of integrated permits.

An Info Centre should be established within this new IED Serbia project. It should play an important role in the implementation of the Directive through permanent support to operators and competent authorities in the preparation of integrated permits, and in the provision of information to all stakeholders on the Best Available Techniques, regulations, available funds, and other related topics. Activities of the Info Centre includes the preparation of the manuals, brochures, and other educational materials which will make available necessary knowledge from target areas to all stakeholders.

For activities consuming organic solvents (Chapter V and Annex VII of the IED), the project “eVOC Serbia, further implementation of EU regulation on VOCs” [30] was set up for the period 2018-2022 with Norwegian funds. The general objective of the project was to support the Ministry of Environmental Protection of the Republic of Serbia and the Environmental Protection Agency of the Republic of Serbia in transposing Chapter V of the Industrial Emissions Directive into national legislation, as well as to support primarily small and medium enterprises that use volatile organic compounds in their production processes in fulfilling the requirements of the IED Directive, chapter V on VOC.

The project results were as follows:

- Harmonise National legislation with the requirements of the European directives,
- Establish control system for pollution resulting from VOC emissions,
- Develop database of operators subject to VOC Regulation,
- Establish information system for identification of sources, determination of quantities and monitoring of VOCs emissions within the National Register of Pollution Sources,
- Improve capacities in target small and medium enterprises, inspectorates and environmental consultants,
- Establish an Info Centre for the collection and dissemination of awareness about VOCs emissions for operators and other stakeholders,

- Improve cooperation of public, private and civil sectors through creation of a network of institutions and organisations interested in the improvement of environmental protection and air quality,
- Develop educational background for students at the final year of studies in the area of volatile organic compounds and their active involvement in project activities,
- Raise awareness of general public about the consequences of organic compounds volatility and importance of the control of production processes which use this type of compounds.

Currently, the IED plants with an integrated permit available were as in the following, by the end of 2022 [8]:

Table 2-3: Number of IED plants and number of IPPC permits issued [8]

No.		Total number of IPPC installations	Number of issued valid IPPC permits per installation
1.	Energy industries	29	2
2.	Production and processing of metals	21	7
3.	Mineral industry	25	10
4.	Chemical industry	12	5
5.	Waste management	13	2
6.	Other activities (6.1; 6.4; 6.5; 6.6a,b,c; 6.7)	119	18
	TOTAL	219	44

2.5. Regulations in place to limit emissions from mobile sources and programmes for their evolution

Annex VIII of the AGP [31] has been assessed by TFTEI in 2022 to prepare its possible update. An informal background document was published in August 2023 [47]. Most of limit values prescribed in the current Annex VIII of the AGP, were based on limit values of EU Directives adopted before 2012, date of the adoption of the Amended Gothenburg Protocol. From 2012, the European Commission implemented new Directives taking into account, as an example, more realistic certification cycles, real-driving emission measurements and prescribing more ambitious limit values for road vehicles. The TFTEI report [47] provides the synthesis of these new regulations and provides proposals for potential updates of Annex VIII.

To assess the situation of the Republic of Serbia in terms of regulations implemented for mobile sources, the limit values for the different types of vehicles currently prescribed by Annex VIII of the AGP were considered but also new EU regulations adopted since 2012.

2.5.1. Road vehicles

In the Republic of Serbia, in the field of motor vehicles in general, the Road Traffic Safety Agency (RTSA) is a competent authority for all issues referring to homologation of road vehicles (produced in Serbia or imported) [48]. Standards are prescribed through the Law on Road Traffic Safety and a set of different Rulebooks [64]. There are different requirements for domestically produced and imported vehicles and as an example, the approval provisions (homologation) shall be enforced two years after the date of adoption of these Rulebooks.

Different Rulebooks on division of motor vehicles and towed vehicles, and technical requirements for vehicles, transpose provisions of the EU directives related to passenger cars and light duty vehicles as well as heavy duty vehicles.

Regarding the content of exhaust gases for vehicles manufactured in the Republic of Serbia, the approval provisions (homologation) can be applied later than dates prescribed by the EU directives:

- For passenger cars and light duty vehicles (*limit values of table 1, Annex VIII of the AGP, corresponding to limit values for passenger cars and light-duty vehicles up to Euro 6, corresponds to limit values of the European Commission Regulation (EU) N°459/2012 of May 2012* [48]): application of the provisions of Euro 6 standards has been postponed for two years. Limit values for new vehicles produced in Serbia, consistent with Euro 6 standards of table 1, Annex VIII of the AGP entered in force in 2019.
- For heavy duty vehicles (*Limit values of tables 2 and 3, Annex VIII of the AGP corresponding to emission limit values up to EURO VI for heavy-duty vehicles under the test cycle specified by the World Heavy Duty Steady State Cycle (WHSC) and the World Heavy Duty Transient Cycle (WHTC). These limit values are based on the European Commission regulation 595/2009/EC of the European Parliament and of the Council of 18 June 2009 on type-approval of motor vehicles and engines with respect to emissions from heavy duty vehicles (EURO VI)* [50]): application of the provisions of EURO VI standards has been postponed for three years. Limit values for new vehicles produced in Serbia, consistent with Euro VI standards of tables 2 and 3, Annex VIII of the AGP entered in force in 2020.

At the EU level, regulations prescribing limit values for light duty vehicles evolved [47] and Euro 6c and 6d standards, based on real driving emissions, are now enforced. A set of commission regulations [68] to [70], [71] and [72] were adopted by the EU and the Commission Regulation (EU) 2018/1832 of 5 November 2018 amending Directive 2007/46/EC of the European Parliament and of the Council, Commission Regulation (EC) 692/2008 and Commission Regulation (EU) 2017/1151 for the purpose of improving the emission type approval tests and procedures for light passenger and commercial vehicles, including those for in-service conformity and real-driving emissions [51] is now applicable (regulation 2024/11257 implementing Euro 7 was published in April 2024).

The set of commission regulations [68] to [70], [71] and [72] and many other commission delegated or implementing regulations are being transposed or will be transposed through the Rulebook amending Rulebook as regards emissions from light passenger and commercial vehicles (Euro 6), the Rulebook for supplementing and amending Rulebook on type approval of motor vehicles with respect to emissions from light passenger and commercial vehicles (Euro 5 and Euro 6) and the Rulebook on access to vehicle repair and maintenance information, by the fourth quarter of 2025 [64]. Commission Regulation (EU) 2018/1832 seems not yet in the regulations covered [64] by end of 2025.

At the EU level, regulations prescribing limit values for heavy duty vehicles also evolved [47]. The Commission Regulation (EU) No 133/2014 of 31 January 2014 amending, for the purposes of adapting to technical progress as regards emission limits, Directive 2007/46/EC of the

European Parliament and of the Council, Regulation (EC) No 595/2009 of the European Parliament and of the Council and Commission Regulation (EU) No 582/201 was adopted in 2014 [73]**.**

This regulation will be transposed as Rulebook amending, for the purposes of adapting to technical progress as regards emission limits Rulebook on Establishing a Framework for the Approval of Motor Vehicles and their Trailers, and of Systems, Components and Separate Technical Units Intended for Such Vehicles and Rulebook on Requirements for Type approval of Motor vehicles and Engines with respect to Emissions from Heavy Duty Vehicles (EURO VI) and on access to vehicle repair and maintenance information [64].

Currently, passenger cars, light duty vehicles or heavy-duty vehicles produced in the Republic of Serbia comply with limit values of tables 1 to 3 of Annex VIII of the AGP at minimum, and the Republic of Serbia is transposing recent other EU regulations adopted after 2012.

The Air Protection Programme [7] should enforce minimum Euro standards for imported second-end vehicles: Euro 5/V from first January 2024 and Euro 6/VI from 1 January 2025 (imports of old Euro 3/III and Euro 4/IV vehicles were still existing in the first semester of 2024 [74]. Euro 3 and Euro 4 vehicles represented around 40% of imports). Some delays in adoption seem to be encountered.

2.5.2. Non road mobile machinery

In the Republic of Serbia, in the field of non-road mobile machines (NRMM), the Road Traffic Safety Agency (RTSA) is a competent authority for all issues referring to homologation of non-road vehicles [48].

The AGP Annex VIII limit values in tables 4 to 5 [31] correspond to Stage IIIB and Stage IV for diesel engines for NRMM, agricultural and forestry tractors. Table 6 [31] sets limit values for spark-ignition engines for NRMM.

Limit values for NRMM and agricultural and forestry tractors in Annex VIII of the AGP (tables 4 to 6) are based on limit values of the amended Directive 97/68/EC of 16 December 1997 [51] relating to measures against the emission of gaseous and particulate pollutants from internal combustion engines to be installed in NRMM. These limit values were adopted through different rule books for NRMM produced in Serbia.

These EU standards (amended Directive 97/68/EC) have evolved and were updated by Regulation (EU) 2016/1628 of the European Parliament and of the Council of 14 September 2016 on requirements relating to gaseous and particulate pollutant emission limits and type-approval for internal combustion engines for non-road mobile machinery [53]. Regulation 2016/1628 is an umbrella regulation for the homologation of an entire non road mobile machine. It repeals the amended Directive 97/68/CE.

Full compliance with EU Regulation 2016/1628 [53] is made possible by the adoption of amendments to the Road Traffic Safety Law as well as adopting appropriate by-laws that will further achieve full harmonization of the legislation in the field of motor vehicles and the emission of pollutants from the engines of non-road vehicles [8].

EU Regulation 2016/1628, amending EU regulations 2020/1040 and 2021/1068 and several other commission delegated or implementing regulations will be fully transposed as Rulebook on emission limit values of gaseous and particulate pollutants and homologation of internal combustion engines for non-road mobile machinery and several other rulebooks, by the fourth quarter of 2025 [64].

2.5.3. Locomotives and rail cars

Limit values for engines for propulsion of locomotives and railways are provided in tables 7 and 8 of Annex VIII of the AGP [31].

The current limit values are based on limit values of the amended Directive 97/68/EC of 16 December 1997 [51] relating to measures against the emission of gaseous and particulate pollutants from internal combustion engines to be installed in NRMM.

Regulation 2016/1628 [53] now applies to these engines (see above chapter 2.5.2) at the EU level. This regulation is scheduled to be transposed by the fourth quarter of 2025 by the Republic of Serbia [8]

2.5.4. Inland waterway vessels

Limit values for engines for propulsion of inland water ways are provided in Table 9 of Annex VIII of the AGP [31]. Limit values for engines for propulsion of inland waterway vessels of Annex VIII of the AGP (Table 9) are based on limit values of the amended Directive 97/68/EC of 16 December 1997 [51] relating to measures against the emission of gaseous and particulate pollutants from internal combustion engines to be installed to be installed in NRMM.

Regulation 2016/1628 [53] now applies to these engines (see above) at the EU level. This regulation is scheduled to be transposed by the fourth quarter of 2025 by the Republic of Serbia [64].

2.5.5. Recreational crafts

Limit values for recreational crafts are provided in Table 10 of Annex VIII of AGP [31].

The limit values were based on the amended Directive 94/25/EC of 16 June 1994 on the approximation of the laws, regulations and administrative provisions of the Member States relating to recreational craft [53].

The Directive 2013/53/EC of the European Parliament and of the Council of 20 November 2013 on recreational craft and personal watercraft and repealing Directive 94/25/EC [55] has been adopted by the EU in 2013.

Directive 2013/53/EC is fully transposed into the RS regulation on safety requirements for recreational crafts and jet-powered vessels [65].

2.5.6. Motorcycles and mopeds (L-category)

Limit values for motorcycles and mopeds are provided in tables 11 and 12 of Annex VIII of the AGP [31].

The limit values in tables 11 and 12 were based on the Directive 2002/51/EC of the European Parliament and of the Council of 19 July 2002 on the reduction of the level of pollutant emissions from two-and three-wheel motor vehicles and amending Directive 97/24/EC (implementing standards Euro 2 and 3 for motorcycles) [56].

EU regulation 2013/168 of 15 January 2013 on the approval and market surveillance of two- or three-wheel vehicles and quadricycles [57] was adopted by the EU. It repeals Directive 2002/51/EC.

The Regulation 2013/168 will be transposed through another Rulebook in the second quarter of 2025 [8].

Full compliance with EU Regulation 2013/168 [57] is made possible by the adoption of amendments to the Road Traffic Safety Law as well as adopting appropriate by-laws that will further achieve full harmonization of the legislation in the field of motor vehicles and the emission of pollutants from the engines of non-road vehicles [8].

EU Regulation 2013/13, amending EU regulations 2019/129 and several other commission delegated or implementing regulations will be fully transposed as Rulebook on the approval and market surveillance of two- or three-wheel vehicles and quadricycles and as several other Rulebooks, by the fourth quarter of 2025 by the Republic of Serbia [64].

2.5.7. Petrol and diesel fuel quality

The specifications for marketed fuels to be used in diesel and petrol as currently provided in tables 13 and 14 of Annex VIII of the AGP [31] were extracted from Directive 2009/30/EC of 23 April 2009 amending Directive 98/70/EC as regards the specification of petrol, diesel and gas-oil and introducing a mechanism to monitor and reduce greenhouse gas emissions and amending Council Directive 1999/32/EC as regards the specification of fuel used by inland waterway vessels and repealing Directive 93/12/EC [58]. As presented in chapter 2.4.2.7, the Republic of Serbia enhanced its legal framework to complete the transposition of this directive through the Project "Additional Development of EU Environment Approximation for Air, Chemicals and Horizontal Acquis (2019 – 2021) [36]. A Directive Specific Implementation Plan was developed.

The requirements of tables 13 and 14 for the Sulphur content of petrol and diesel can be considered implemented in the Republic of Serbia. However, it was not possible to obtain full characteristics of diesel and petrol to enable a comparison with all other characteristics of fuels set up by tables 13 and 14 of Annex VIII.

2.6. Technological pathways

In the Republic of Serbia, PM_{10} and $PM_{2.5}$ are by far, the main air quality problem with concentrations of PM_{10} and $PM_{2.5}$ in ambient air exceeding the current EU air quality limit values (refer to chapter 2.3).

Too high PM_{10} and $PM_{2.5}$ concentrations are widely spread over the territory [12]. Even if some unfavourable meteorological regional circumstances may explain the high observed concentrations in winter due to bad dispersion conditions and if the impact of transboundary air pollution can also be noticeable, this situation demonstrates that PM emissions are still too high. Policies should focus in priority on the main sources of PM and especially domestic heating with fossil or biomass solid fuels. In the emission inventory, the sector “other stationary combustion” which includes domestic heating small appliances represents 46 kt of $PM_{2.5}$ in 2020 or 80 % of total $PM_{2.5}$ emissions [9] (Figure 2-8).

NOx concentrations are less significant, and exceedances of limit values are observed in Beograd only, in 2021 [12].

Large combustion installations for the production of electricity are still, by far, the largest contributors in total emissions of SO_2 and NOx emissions in 2020 (respectively 91.3% and 41.5%) (chapter 2.2.1 and 2.2.2 respectively).

The Republic of Serbia is working for improving alignment of its national regulations concerning large combustion plants, industrial plants, use of solvents, the quality of fuels and petrol distribution with many EU directives or regulations. The EU directives adopted before 2012 in these domains were, in most cases, the basis for the definition of limit values prescribed by the technical Annexes IV, V, VI, X and XI of AGP [31] for stationary sources and Annex VIII for mobile sources.

The limit values of the Gothenburg Protocol present in Annex IV, V and X for large combustion installations were based on the Annex V on the IED Directive [16]. For combustion plants excluding gas turbines and stationary engines, the limit values prescribed by the Serbian regulation n°6/16 [18] are equal, or stricter, to limit values prescribed by the Gothenburg Protocol for plants which the operating permit was granted after 1 July 1992 or, in the absence of the operating permit, the plant which was put into operation after 1 July 1992 (comparison of limit values in chapter 2.8). For older plants put into operation before the 1 July 1992, limit values in the Serbian regulation have been adapted from the 2001 LCP directive [22]. Twelve old combustion plants are included in the National Emission Reduction Plan (NERP) [25] and should comply with limit values similar to those of the Amended Gothenburg Protocol from 1st January 2028. For combustion turbines (including Combined Cycle Gas Turbine CCGT), the limit values are the same. For stationary engines the limit values in Serbian regulation are stricter. In some cases, the limit values may be less stringent.

The Serbian regulation on limit values of emissions of air pollutants from stationary pollution sources, excluding combustion plants n°111/15 [26] prescribed ELVs for a set of industrial processes. ELVs implemented can be equal or in some cases, may be stricter than the ELVs of the Gothenburg technical Annexes or may be less stringent (comparison in chapter 2.8).

Several projects to develop the Serbian legislative framework for the implementation of the IED, increase capacity of environmental inspectors and develop integrated permits and controls for around 219 industrial plants (from 2018 to 2021 [21] and 2022-2025 [29]) should facilitate the reduction of emissions of these industrial plants. By 31st December 2024, installations defined as IED should have received an IPPC permit as defined in the amended law on Integrated Pollution Prevention and Control [14]. Full compliance of most industrial installations with chapter II of IED requirements will need a period of almost 10 years but more time for installations that will require extended implementation period. 2032 is foreseen according to draft IED DSIP developed by the project IED Serbia [21] but there are many challenges in this area that the competent authorities are currently facing.

Serbia also carried several projects to align its legislative framework for implementation of several EU Directives. The directives are as follows:

- Sulphur in fuels - Directive (EU) 2016/802 [33].
- Petrol and diesel fuels quality - Directive 98/70/EC [39];
- VOC I and VOC II - Directive 94/63/EC [34] and Directive 2009/126/EC [35].

The adoption of these directives through relevant rulebooks will enable the alignment of the national regulations with limit values present in the technical Annexes, which are based on the requirements of these directives.

The legal framework for adoption of EU standards for stationary sources (similar to limit values of the AGP technical Annexes and even stricter) could be fully finalised in a near term, however more time is needed for enforcement of the limit values and gradual compliance of installations.

In terms of mobile sources, Serbia adopts the EU directives and align its regulations in most of the cases for vehicles and engines produced in its territory. If Serbia adopts the EU directives for mobile sources produced in its territory, some delays may be considered. Limit values of Annex VIII of the AGP are applied for the new vehicles or new non road mobile engines produced in Serbia. Second-hand vehicles are imported and up to now (Regulation on import of motor vehicles ("Official Gazette of the Republic of Serbia", No. 23/10 and 5/18), the old vehicle (category M, category N) such vehicles can be imported if they are manufactured in accordance with the conditions prescribed by the "Euro 3" standard at minimum. With the newly adapted Air Protection Programme, imported second-hand vehicles follow the conditions of Euro 5/V from 1st January 2024 and will have to follow Euro 6/VI from 1st January 2025 [7].

Since 2012, date of adoption of the AGP [31], many new EU regulations were adopted and these new regulations could be considered to update the Annex VIII according to a TFTEI report published in August 2023 [47]. The AGP revision was adopted by decision 2023/5 at the 43rd EB meeting in December 2023.

A draft Air protection programme prepared in the scope of the EAS III project [36] (refer to chapter 2.4.2.1) proposed to gradually limit the age of imported second-hand vehicles. The Air Protection Programme of the Republic of Serbia for the period from 2022 to 2030 with action plan was adopted in December 2022 [7], [8].

The chapter 8 presents the techniques to comply with limit values introduced by Annexes IV for SO_2, V for NOx, VI for VOC, X for PM and XI for solvents in products, of the AGP [31]. In this technical pathway, the focus is only made on the largest emitters for which reduction measures would be rapidly necessary.

For large combustion plants, the reduction techniques available for abating SO_2 and NOx emissions are as in the following (chapter 8, sub chapters 8.1.; 8.2. and 8.4.):

The means to achieve SO_2 ELVs is the application of one or a combination of the following techniques [60], [63] according to the size of combustion installations, combined with the selection of low sulphur fuels and fuel substitution:

- boiler sorbent injection
- duct sorbent injection (DSI)
- spray dry absorption (SDA)

- circulating fluidised bed (CFB)
- wet flue-gas desulphurisation (FGD)
- seawater FGD

The means to achieve the NOx ELVs is the application of one or a combination of the following techniques [60], [63] according to the size of combustion installations:

- combustion optimisation
- air staging
- fuel staging
- flue-gas recirculation
- low-NOx burners (LNB)
- selective non-catalytic reduction (SNCR)
- selective catalytic reduction (SCR)

For **PM emissions from domestic heating appliances using coal or biomass,** the use of the most efficient appliances in terms of emissions and energy consumption is essential but technological solutions are not sufficient. The "Code of good practices for wood burning and small combustion installations" [45] developed by TFTEI, the report "Prioritizing reductions of particulate matter from sources that are also significant sources of black carbon - analysis and guidance" [44] developed by TFIAM and the report "Review on Black Carbon (BC) and Polycyclic Aromatic Hydrocarbons (PAHs) emission reductions induced by PM emission abatement" [61] developed by TFTEI provide excellent overview of policies to be implemented beyond the technical characteristics of appliances. The TFTEI report on the review of limit values of the AGP technical Annexes for stationary sources also provides information [46].The thematic session on residential wood combustion and air pollution of 56th WGSR in May 2018, is also useful for inspiring ideas in this field [62].

In terms of domestic appliances and combustion, the reduction of PM emissions can be pursued through optimisation of the combustion conditions, by several means, to ensure the best optimized conditions in terms of temperature, residence time (sufficient time is required) and turbulence (to ensure good mixing of flue gases) (the three T's rules), but also the geometry of the combustion chamber, air supply and reducing the user's intervention, by the combustion automated systems. The solutions for these three T's parameters can be applied in different types of appliances, especially stoves [46].

Temperature:

- Refractory lining in the combustion chamber,
- Shape and size of combustion chamber,
- Material and isolation of the door as well as size of window and its radiation coefficient or alternatively coated glasses or double/triple windows with air chambers in between,
- Windows should be of appropriate limited size.

Sufficient residence time:

- Gas volume flow,
- Distribution of flue gases over combustion chamber,
- Distribution of air,
- Height and width of the combustion chamber.

Turbulence or mixing of flue gasses:

- Distribution of purge air windows,
- Direction and geometry of additional inlet air,
- Velocities of flue gas and combustion air,
- Geometry of the main and the post combustion chamber,
- Geometry of deflection plate and the use of baffles in post combustion chamber,
- Avoidance of leakage streams (sealing),
- Avoidance of short-circuiting of the flue gas stream.

The Air Protection Programme of the Republic of Serbia for the period from 2022 to 2030 with its action plan was adopted in December 2022 [7]. One of the key measures of this plan relates to domestic heating with solid fossil and biomass fuels. The proposed measures include a programme for the faster replacement of existing household heating appliances with new Eco-Design compliant appliances associated to financial incentives. In the cities of Kragujevac, Beograd, Nis, Valjevo and Užice (5 cities that are considered as PM hot spots), a higher rate of replacement of oldest appliances is foreseen. These measures are also linked to an energy policy aiming at reducing the energy demand through better energy efficiency [7].

In order to have more efficient appliances in place rapidly, the programme includes activities for Serbia such as to complete the work for full harmonisation of its national legislation with the Eco-design Directive [41] and work on the transposition of the two EU regulations related to the emissions and energy efficiency of solid boilers and solid fuel local space heaters (Regulation 2015/1189/EU [43] and Regulation 2015/1185/EU [42]). The establishment and implementation of a mechanism for financial incentives for the replacement of existing heating equipment in households with new appliances compliant with EU regulations and heat pumps needs also to be set up.

For **industrial processes emitting SO_2, NOx and / or PM covered by Annexes IV, V and X,** the chapter 6 of this report (chapters 8.1, 8.2 and 8.4) presents the best available techniques to comply with the limit values prescribed.

For PM, best available techniques (chapter 8.4 of this report) to comply with limit values are electrostatic precipitators and bag filters. Other types of dedusters such as wet scrubbers are also available but are less used. The efficiency of these techniques is optimum when they are correctly dimensioned.

It may appear that in the national emission inventory (Figure 2-2), SO_2 emissions from industry are not significant at the national level, due to the importance of the public electricity sector.

However, industrial emissions may be particularly important at the local level. Exceedances of SO_2 air quality limit values are observed in the city of Bor due to the presence of large industrial emission sources in the local level (copper production and sulfuric acid plant).

Reduction of emissions of SO_2, can be done through:

- duct sorbent injection (DSI)
- spray dry absorption (SDA)
- wet flue-gas desulphurisation (FGD)

Reducing emissions from industrial plants is crucial and this is included in the Air protection Programme [7].

For the **uses of solvents in industry**, chapter 8.3 details the techniques available to comply with limit values for each activity covered by the Annex VI of the AGP. They are based on primary measures such as low solvent content or solvent free products, higher efficient means of application of products containing solvents and secondary measures such as thermal or catalytic oxidation, activated carbon adsorption and biological scrubbing. They are however different combination of primary and secondary measures according to the activity.

For **road transport vehicles**, the Republic of Serbia transposes the latest EU directives or regulations for application to domestic production of vehicles and new vehicles imported. However, the delay to align the Serbian regulations and the implementation of the regulations may be long. It could be examined if these delays could be shortened.

The Air Protection Programme [7] should have enforced minimum Euro standards for second-end vehicles: Euro 5/V from first January 2024 and Euro 6/VI from 1 January 2025. However imports of older Euro 3/III and Euro 4/IV vehicles were still possible in the first semester of 2024[74]). Some delays seem existing. Importing used vehicles compliant with recent Euro norms is crucial to reduce emissions from road traffic.

2.7. References of chapter 2 Republic of Serbia

[1] 1979 Convention on Long-Range Transboundary Air Pollution or Convention Air. https://unece.org/sites/default/files/2021-05/1979%20CLRTAP.e.pdf

[2] Convention on Long-Range Transboundary Air Pollution. Status of ratification: https://treaties.un.org/Pages/ViewDetails.aspx?src=TREATY&mtdsg_no=XXVII-1&chapter=27&clang=_en

[3] Protocols of the CLRTAP. Status of ratification: https://unece.org/protocols - Web site accessed in January 2023

[4] https://www.europarl.europa.eu/factsheets/en/sheet/167/the-enlargement-of-the-union

[5] Fact Sheets on the European Union – 2023. The enlargement of the European Union. André de Munter. October 2022

[6] NPAA. 4th multi-annual plan for the alignment of Serbian legislation with EU regulations (2022-2025) https://www.mei.gov.rs/upload/documents/nacionalna_dokumenta/npaa/NPAA_2022-2025_002.pdf

[7] Usvojen Program zaštite vazduha u Republici Srbiji za period od 2022. do 2030. godine sa akcionim planom | Ministarstvo zaštite životne sredine (ekologija.gov.rs)

[8] J. Curcic and all. Ministry for the Environmental Protection. Discussions with Citepa on July 2022, September 2022, first semester 2023

[9] Republic of Serbia - LRTAP Convention - NFR tables edition 2022 https://www.ceip.at/status-of-reporting-and-review-results/2022-submission

[10] https://cdr.eionet.europa.eu/rs/un/clrtap/iir/envzbgaw/CLRTAP_Serbia_IIR_2021.pdf

[11] Energy Community. Serbia. Annual implementation report. November 2022.

[12] Serbian Air Protection Agency. Annual air quality report of 2021. КВАЛИТЕТ ВАЗДУХА И АЛЕРГЕНИ ПОЛЕН У РЕПУБЛИЦИ СРБИЈИ 2021 . ГОДИНЕ

[13] Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on ambient air quality and cleaner air for Europe. https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A32008L0050 2004/107/

[14] Serbian Law on Integrated Pollution Prevention and Control (IPPC). Official gazette of the Republic of Serbia (OGRS) nº 135/04, n° 25/15

[15] Directive 2008/1/EC of the European Parliament and of the Council of 15 January 2008 concerning integrated pollution prevention and control

[16] European Commission, Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control)

[17] Republic of Serbia: Law on Air Protection (OGRS n° 36/09 and 10/13)

[18] Republic of Serbia: Regulation on limit values of emissions of pollutants from combustion plants implemented in 2016 (official gazette of the RS n°6/16)

[19] Republic of Serbia: Emissions of air pollutant measurements from stationary pollution sources (OGRS, nº5/16")

[20] Republic of Serbia: Regulation on the list of industrial installations and activities in which volatile organic compounds emissions are controlled, values of emission of volatile

organic compounds under specific consumption of solvents and total permissible emissions, as well as emission reduction scheme (Official gazette of Republic of Serbia n°100/11)

[21] IED Serbia 2018-2021. https://iedserbia.org/wp-content/uploads/think-bigger-ad-make-it-count.pdf

[22] Directive 2001/80/EC of the European Parliament and of the Council of 23 October 2001 on the limitation of emissions of certain pollutants into the air from large combustion plants. https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32001L0080&from=EN

[23] Decision of the Ministerial Council of the Energy Community of 24 October 2013 D/2013/05/MC-EnC: On the implementation of Directive 2001/80/EC of the European Parliament and of the Council of 23 October 2001 on the limitation of emissions of certain pollutants into the air from large combustion plants. https://www.energy-community.org/

[24] https://www.eea.europa.eu/data-and-maps/data/reported-information-on-large-combustion-2

[25] Republic of Serbia: National Emission Reduction Plan for old Large Combustion Plants https://www.srbija.gov.rs/vest/en/149736/

[26] Republic of Serbia: Regulation on limit values of emissions of air pollutants from stationary pollution sources, excluding combustion plants (Official gazette of the Republic of Serbia, n°111/15)

[27] European Commission. Commission Implementing Decision (EU) 2017/1442 of 31 July 2017 establishing best available techniques (BAT) conclusions, under Directive 2010/75/EU of the European Parliament and of the Council, for large combustion plants, 2017.

[28] Directive 2015/2193 on the limitation of emissions of certain air pollutants from medium-sized combustion installations (MCP)

[29] Project 2022- https://iedserbia.org/en/about-project/

[30] eVOC project https://evocs.org/en/about-project/

[31] Economic Commission for Europe, Executive Body for the Convention on Long-range Transboundary Air Pollution, 1999 Protocol to Abate Acidification, Eutrophication and Ground-level Ozone to the Convention on Long-Range Transboundary Air Pollution, as amended on 4 May 2012

[32] Directive 2009/30/EC of the European Parliament and of the Council of 23 April 2009 amending Directive 98/70/EC as regards the specification of petrol, diesel and gas-oil and introducing a mechanism to monitor and reduce greenhouse gas emissions and amending Council Directive 1999/32/EC as regards the specification of fuel used by inland waterway vessels and repealing Directive 93/12/EEC https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32009L0030

[33] Directive (EU) 2016/802 of the European Parliament and of the Council of 11 May 2016 relating to a reduction in the sulphur content of certain liquid fuels https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32016L0802

[34] European Parliament and Council Directive 94/63/EC of 20 December 1994 on the control of volatile organic compound (VOC) emissions resulting from the storage of petrol and its distribution from terminals to service stations. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:31994L0063

[35] Directive 2009/126/EC of the European Parliament and of the Council of 21 October 2009 on Stage II petrol vapour recovery during refuelling of motor vehicles at service stations, 2009

[36] Additional Development of EU Environment Approximation for Air, Chemicals and Horizontal Acquis (2019 – 2021) https://eas3.euzatebe.rs/en/about-us

[37] Directive 2004/107/EC of the European Parliament and of the Council of 15 December 2004 relating to arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons in ambient air. https://eur-lex.europa.eu/eli/dir/2004/107/oj

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

[39] Directive 98/70/EC of the European Parliament and of the Council of 13 October 1998 relating to the quality of petrol and diesel fuels and amending Council Directive 93/12/EEC. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A01998L0070-20181224

[40] Chimere A multi-scale chemistry-transport model for atmospheric composition analysis and forecast. https://www.lmd.polytechnique.fr/chimere/chimere.php

[41] European Commission, Directive 2009/125/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for the setting of Eco-design requirements for energy-related products, 2009

https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32009L0125

[42] Commission Regulation (EU) 2015/1185 of 24 April 2015 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to Eco-design requirements for solid fuel local space heaters. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32015R1185

[43] Commission Regulation (EU) 2015/1189 of 28 April 2015 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to Eco-design requirements for solid fuel boilers. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2015.193.01.0100.01.ENG

[44] Prioritizing reductions of particulate matter from sources that are also significant sources of black carbon - analysis and guidance, 2021. https://unece.org/sites/default/files/2021-10/ECE_EB.AIR_2021_6-2113500E.pdf

[45] Code of good practice for wood-burning and small combustion installations, 2019. https://unece.org/DAM/env/documents/2019/AIR/EB/ECE_EB.AIR_2019_5-1916518E.pdf

[46] TFTEI Techno-Scientific Board. TFTEI background informal technical document for the Review of the Gothenburg Protocol for Industrial Processes Annexes IV, V, VI, X and XI March 2022. Informal document to the 60th WGSR meeting. https://unece.org/sites/default/files/2022-03/TFTEI%20review%20of%20Annexes%20to%20the%20Gothenburg%20Protocol.pdf

[47] TFTEI Techno-Scientific Board. TFTEI background informal technical document for the Review of the Gothenburg Protocol for mobile sources, Annex VIII. August 2023. Informal document to the 61st WGSR in September 2023.

https://unece.org/sites/default/files/2023-08/TFTEI-%20Informal%20bakground%20document%20on%20review%20of%20Annex%20VIII%20-%20Mobile%20Sources%20of_0.pdf

[48] RTSA. Road Traffic Safety Agency. https://www.abs.gov.rs/en/homepage

[49] European Commission, *REGULATION (EC) N°459/2012 of 29 May 2012 amending Regulation (EC) No 715/2007 of the European Parliament and of the Council and Commission Regulation (EC) No 692/2008 as regards emissions from light passenger and commercial vehicles (Euro 6) (Text with EEA relevance),* **2012**

[50] European Commission (EU) *N°595/2009 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 18 June 2009 on type-approval of motor vehicles and engines with respect to emissions from heavy duty vehicles (Euro VI) and amending Regulation (EC) No 715/2007 and Directive 2007/46/EC and repealing Directives 80/1269/EEC, 2005/55/EC and 2005/78/EC,* **2009**

[51] Commission Regulation (EU) 2018/1832 of 5 November 2018 amending Directive 2007/46/EC of the European Parliament and of the Council, Commission Regulation (EC) No 692/2008 and Commission Regulation (EU) 2017/1151 for the purpose of improving the emission type approval tests and procedures for light passenger and commercial vehicles, including those for in-service conformity and real-driving emissions. **2018**

[52] Directive 97/68/EC of the European Parliament and of the Council of 16 December 1997 on the approximation of the laws of the Member States relating to measures against the emission of gaseous and particulate pollutants from internal combustion engines to be installed in non-road mobile machinery. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:31997L0068. **1997**

[53] European Commission (EU) *2016/1628 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 14 September 2016 on requirements relating to gaseous and particulate pollutant emission limits and type-approval for internal combustion engines for non-road mobile machinery, amending Regulations (EU) No 1024/2012 and (EU) No 167/2013, and amending and repealing Directive 97/68/EC* **2016**

[54] Directive 94/25/EC mended Directive 94/25/EC of the European Parliament and of the Council of 16 June 1994 on the approximation of the laws, regulations and administrative provisions of the Member States relating to recreational craft. https://eur-lex.europa.eu/legal-content/en/ALL/?uri=CELEX:31994L0025

[55] European Commission (EU) 2013/53/EU *OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 20 November 2013 on recreational craft and personal watercraft and repealing Directive 94/25/EC* **2013**

[56] Directive 2002/51/EC of the European Parliament and of the Council of 19 July 2002 on the reduction of the level of pollutant emissions from two-and three-wheel motor vehicles and amending Directive 97/24/EC (implementing standards Euro 2 and 3 for motorcycles) **2002**

[57] Consolidated text: Regulation (EU) No 168/2013 of the European Parliament and of the Council of 15 January 2013 on the approval and market surveillance of two- or three-wheel vehicles and quadricycles. ttps://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02013R0168-20201114

[58] European Commission (EU) *DIRECTIVE 2009/30/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 23 April 2009 amending Directive 98/70/EC as regards the specification of petrol, diesel and gas-oil and introducing a mechanism to monitor and reduce greenhouse gas emissions and amending Council Directive*

1999/32/EC as regards the specification of fuel used by inland waterway vessels and repealing Directive 93/12/EEC 2009

[59] Decision 2023/45 launching a process to revise the Protocol to Abate Acidification, Eutrophication and Ground-level Ozone, as amended in 2012, and to address other conclusions of its review. ECE/EB.AIR/154

[60] ECE/EB.AIR/154T. Lecomte, J.F. de la Fuente, F. Neuwahl, M. Canova, A. Pinasseau, I. Jankov, T. Brinkmann, S. Roudier, L. Delgado-Sancho, Best Available Techniques (BAT) Reference Document for Large Combustion Plants: Industrial Emissions Directive 2010/75/EU (Integrated Pollution Prevention and Control) 2017.

[61] B. Bessagnet, N. Allemand, Review on Black Carbon (BC) and Polycyclic Aromatic Hydrocarbons (PAHs) emission reductions induced by PM emission abatement, TFTEI 2019

[62] WGSR 56th. May 2018. Thematic session on residential wood combustion and air pollution. https://unece.org/info/Environmental-Policy/Air-Pollution/events/20267

[63] TFTEI Techno-Scientific Board. Guidance document on control techniques for emissions of sulphur, NOx, VOC, and particulate matter (including PM_{10}, $PM_{2.5}$ and black carbon) from stationary sources. ECE/EB.AIR/117. 2012. https://unece.org/gothenburg-protocol

[64] Draft action plan for harmonised area for motor vehicles and non-road mobile machinery emissions (chapter I – free movement of good) – Activities to be undertaken within the framework the plan for full harmonisation. July 2022. action plan for harmonised area for motor vehicles and non-road mobile machinery emissions (chapter I – free movement of good) Serbia negotiation - Recherche

[65] Information provided by the Ministry of transport in January 2024. (https://www.pravno-informacioni-sistem.rs/SlGlasnikPortal/eli/rep/sgrs/ministarstva/pravilnik/2019/88/4)

[66] EMEP Centre on emission inventories and projections. Data viewer – reported emission data. Accessed in October 2024.

[67] Directive 2004/42/CE of the European Parliament and of the council of 21 April 2004 on the limitation of emissions of volatile organic compounds due to the use of organic solvents in certain paints and varnishes and vehicle refinishing products and amending Directive 1999/13/EC

[68] Commission Regulation (EU) 2016/427 of 10 March 2016 amending Regulation (EC) No 692/2008 as regards emissions from light passenger and commercial vehicles (Euro 6)

[69] Commission Regulation (EU) 2016/646 of 20 April 2016 amending Regulation (EC) No 692/2008 as regards emissions from light passenger and commercial vehicles (Euro 6)

[70] Commission Regulation (EU) 2017/1154 of 7 June 2017 amending Regulation (EU) 2017/1151 supplementing Regulation (EC) No 715/2007 of the European Parliament and of the Council on type-approval of motor vehicles with respect to emissions from light passenger and commercial vehicles (Euro 5 and Euro 6) and on access to vehicle repair and maintenance information, amending Directive 2007/46/EC of the European Parliament and of the Council, Commission Regulation (EC) No 692/2008 and Commission Regulation (EU) No 1230/2012 and repealing Regulation (EC) No 692/2008 and Directive 2007/46/EC of the European Parliament and of the Council as regards real-driving emissions from light passenger and commercial vehicles (Euro 6)

[71] Commission Regulation (EU) 2017/1151 of 1 June 2017 supplementing Regulation (EC) No 715/2007 of the European Parliament and of the Council on type-approval of motor vehicles with respect to emissions from light passenger and commercial vehicles (Euro 5

and Euro 6) and on access to vehicle repair and maintenance information, amending Directive 2007/46/EC of the European Parliament and of the Council, Commission Regulation (EC) No 692/2008 and Commission Regulation (EU) No 1230/2012 and repealing Commission Regulation (EC) No 692/2008

[72] Commission Regulation (EU) 2017/1347 of 13 July 2017 correcting Directive 2007/46/EC of the European Parliament and of the Council, Commission Regulation (EU) No 582/2011 and Commission Regulation (EU) 2017/1151 supplementing Regulation (EC) No 715/2007 of the European Parliament and of the Council on type-approval of motor vehicles with respect to emissions from light passenger and commercial vehicles (Euro 5 and Euro 6) and on access to vehicle repair and maintenance information, amending Directive 2007/46/EC of the European Parliament and of the Council, Commission Regulation (EC) No 692/2008 and Commission Regulation (EU) No 1230/2012 and repealing Regulation (EC) No 692/2008

[73] Commission Regulation (EU) No 133/2014 of 31 January 2014 amending, for the purposes of adapting to technical progress as regards emission limits, Directive 2007/46/EC of the European Parliament and of the Council, Regulation (EC) No 595/2009 of the European Parliament and of the Council and Commission Regulation (EU) No 582/2011

[74] Serbia imports 65,275 used vehicles in H1 2024: Concerns over Euro 3 and Euro 4 engines persist - Doing Business in Serbia. 23 July 2024. https://serbia-business.eu/serbia-business-recent-vehicles-import-automotive-industry/

2.8. Limit values implemented by the regulations of the Republic of Serbia and comparison with the AGP limit values

2.8.1. Limit values implemented by the regulation n°6/16 for combustion plants of the Republic of Serbia

The following tables present ELVs prescribed by the regulation on limit value of emissions of pollutants from combustion plants implemented in 2016 (official gazette of the RS n°6/16).

They are compared to ELVs of the Gothenburg protocol in Annex IV for SO_2, Annex V for NOx and Annex X for PM.

A colour code is used to identify consistency and differences in ELVs: green in case of equal or stricter ELVs in the domestic regulation compared to ELVs of Annexes IV, V and VI of the AGP, yellow in case of less stringent ELVs.

2.8.1.1. Large combustion plants

Existing Large combustion plants

ELVs for SO_2 expressed in mg/Nm^3 applicable to the combustion plants using solid or liquid fuels other than gas turbines and gas engines are given in the following table:

Total thermal input (MWth)	Coal, lignite and other solid fuels	Biomass	Peat	Liquid fuels
50-100	400	200	300	350
100-300	250	200	300	250
>300	200	200	200	200

For combustion plants using solid fuels, which do not operate more than 1,500 operating hours per year in a five-year average, the emission limit value for SO_2 of 800 mg/normal m^3 shall apply.

For combustion plants using liquid fuels, which do not operate more than 1,500 operating hours per year in the five-year average, the emission limit value for SO_2 of 850 mg/normal m^3 shall apply in the case of plants with the total thermal input power of up to 300 MWth and the emission limit value for SO_2 of 400 mg/m^3 in the case of plants with the total thermal input higher than 300 MWth.

ELVs for SO_2 expressed in mg/Nm^3 applicable to combustion plants using gaseous fuels other than gas turbines and gas engines are given in the following table:

Type of fuel	Emission limit value
Gaseous fuels in general	35
Liquid oil gas	5
Coke oven low-calorific gases	400
Blast furnace low-calorific gases	200

For the combustion plants that fire low-calorific gases from the process of refinery residue gasification the emission limit value for SO_2 of 800 mg/normal m^3 shall apply.

ELVs for NOx expressed in mg/Nm^3 applicable to the combustion plants using solid or liquid fuels other than gas turbines and gas engines are given in the following table:

Total thermal input (MWth)	Coal, lignite and other solid fuels	Biomass and peat	Liquid fuels
50-100	300	300	450
100-300	200	250	200 (1)
>300	200	200	150 (1)
Note:			
(1) For combustion plants with a total thermal input power of up to 500 MWth, in which residues from distillation process or the oil process are combusted for their own consumption, the emission limit value of 450 mg/normal m^3 shall apply.			

For the combustion plants in chemical plants that use liquid production residues as a non-commercial fuel for own consumption, whose total thermal input power is less than 500 MWth, the emission limit value for NO_x (expressed as NO_2) of 450 mg/normal m^3 shall apply.

For the combustion plants in chemical plants that use solid or liquid fuels with a total thermal input power of less than 500 MWth and operate less than 1,500 hours per year in the five-year average, the emission limit value for NO_x (expressed as NO_2) of 450 mg/normal m^3 shall apply.

For the combustion plants that use solid fuels with a total thermal input power greater than 500 MWth and operate less than 1,500 hours per year in the five-year average, the emission limit value for NO_x (expressed as NO_2) of 450 mg/normal m^3 shall apply.

For the combustion plants that use liquid fuels with a total thermal input power greater than 500 MWth and operate less than 1,500 hours per year in the five-year average, the emission limit value for NO_x (expressed as NO_2) of 400 mg/normal m^3 shall apply.

For gas turbines (including gas turbines with combined cycle) using light and middle distillates as liquid fuels, the emission limit value for NO_x (expressed as NO_2) of 90 mg/normal m^3.

ELVs for NOx expressed in mg/Nm^3 applicable to the gas-fired combustion plants are given in the following table:

Type of plant	NO_x (NO_2)	Comments from TFTEI
Combustion plants that use natural gas, other than gas turbines and gas engines	100	
Combustion plants that use blast furnace gas, coke oven gas or low-calorific gases from the gasification of refinery residues, with the exception of gas turbines and gas engines	200 (4)	
Combustion plants that use other gases, with the exception of gas turbines and gas engines	200 (4)	
Gas turbines (including gas turbines with a combined cycle), which are fuelled by natural gas	50 (2) (3)	

Type of plant	NO_x (NO_2)	Comments from TFTEI
Gas turbines (including gas turbines with a combined cycle) fuelled by other gases	120	
Gas engines	100	The Protocol only prescribe ELVs for new engines

Note:

([1]) Natural gas is a mixture of hydrocarbon, of which the most common is methane containing up to 20% (by volume) of inert and other ingredients

([2]) Emission limit value is 75 mg/normal m^3 in cases where efficiency is determined in accordance with load conditions according to the stipulated Serbian standard:

1) gas turbines used in combined systems for heating and electricity production and whose overall efficiency is higher than 75%;

2) gas turbines used in combined cycle plants, with a production in which the overall annual average efficiency in the production of electricity is higher than 55%;

3) gas turbines for mechanical drives.

In the case of gas turbines with a single cycle, which are not covered by any of the categories listed under the note ([2]), but which have efficiency higher than 35% - determined in accordance with load conditions according to the stipulated Serbian standard – emission limit value for NO_x (expressed as NO_2) is calculated as $\frac{50\eta}{35}$ where η is the efficiency of the gas turbine in accordance with load conditions according to the stipulated Serbian standard, expressed in percent

([4]) Emission limit value is 300 mg/normal m^3 for the existing combustion plants whose total thermal input is less than 500 MWth.

For gas turbines (including gas turbines with a combined cycle) the emission limit values for NO_x (expressed as NO_2) and CO from the table in this item shall be applied only for loads above 70%.

For gas turbines (including gas turbines with a combined cycle) which do not operate more than 1,500 operating hours per year in the five-year average, the emission limit value for NO_x (expressed as NO_2) of 150 mg/normal m^3 shall apply if natural gas is used and the NO_x emission border value of 200 mg/normal m^3 when using other gases or liquid fuels.

For gas engines, no limit values are considered for existing engines in the Annex V.

ELVs for particulate matter expressed in mg/Nm^3 applicable to combustion plants using solid or liquid fuels, other than gas turbines and gas engines, are given in the following table:

Total thermal input (MWth)	Coal, lignite and other solid fuels	Biomass and peat	Liquid fuels ([1])
50-100	30	30	30
100-300	25	20	25
>300	20	20	20

(1) To combustion plants in which residues are fired for their own consumption from a distillation process or an oil process, the emission limit value of 50 mg/normal m^3 shall apply.

ELVs for particulate matter expressed in mg/Nm^3 applicable to combustion plants using gaseous fuels other than gas turbines and gas engines are given in the following table:

Type of fuel	Emission limit value
Gaseous fuels in general	5
Blast furnace gas	10
Gases produced in steel industry, which can be used elsewhere	30

New plants

ELVs for SO_2 expressed in mg/Nm^3 applicable to the combustion plants using solid or liquid fuels other than gas turbines and gas engines are given in the following table:

Total thermal input (MWth)	Coal, lignite and other solid fuels	Biomass	Peat	Liquid fuels
50-100	400	200	300	350
100-300	200	200	300 (250 in the case of fluidized bed combustion)	200
>300	150 200 in the case of combustion in circulating fluidised bed or a fluidized bed under pressure	150	150 200 in the case of fluidized bed combustion	150

ELVs for SO_2 expressed in mg/Nm^3 applicable to combustion plants using gaseous fuels other than gas turbines and gas engines are given in the following table:

Type of fuel	Emission limit value
Gaseous fuels in general	35
Liquid oil gas	5
Coke oven low-calorific gases	400
Blast furnace low-calorific gases	200

For the combustion plants that fire low-calorific gases from the process of refinery residue gasification the emission limit value for SO_2 not provided in the text.

ELVs for NOx expressed in mg/Nm^3 applicable to the combustion plants using solid or liquid fuels other than gas turbines and gas engines are given in the following table:

Total thermal input (MWth)	Coal, lignite and other solid fuels	Biomass and peat	Liquid fuels
50-100	300	250	300
50-100	400 in the case of combustion of pulverized lignite	250	300
100-300	200	200	150
>300	150	150	100
>300	200 in the case of combustion of pulverized lignite	150	100

For gas turbines (including gas turbines with a combined cycle) using light and middle distillates as liquid fuels, the emission limit value for NO_x (expressed as NO_2) of 50 mg/normal m^3 shall apply.

ELVs for NOx expressed in mg/Nm^3 applicable to the gas-fired combustion plants are given in the following table:

Type of plant	NO_x (NO_2)	Comments from TFTEI
Combustion plants other than gas turbines and gas engines	100	Annex V prescribes an ELV of 200 for other gaseous fuels
Gas turbines (including gas turbines with a combined cycle)	50 (1)	
Gas engines	75	Annex V prescribes ELVs more differentiated and ranging from 95 to 190 according to type of engines

(1) In the case of gas turbines with a single cycle which have efficiency greater than 35% - determined in accordance with load conditions according to the appropriate Serbian standard – emission limit value for NOx (expressed as NO2) is calculated as
, where ŋ is the efficiency of the gas turbine in accordance with load conditions according to the appropriate Serbian standard, expressed in percent

For gas turbines (including gas turbines with a combined cycle) the emission limit values for NO_x (expressed as NO_2) and CO from this paragraph shall be applied only for loads above 70%.

ELVs for particulate matter expressed in mg/Nm^3 applicable to combustion plants using solid or liquid fuels, other than gas turbines and gas engines, are given in the following table:

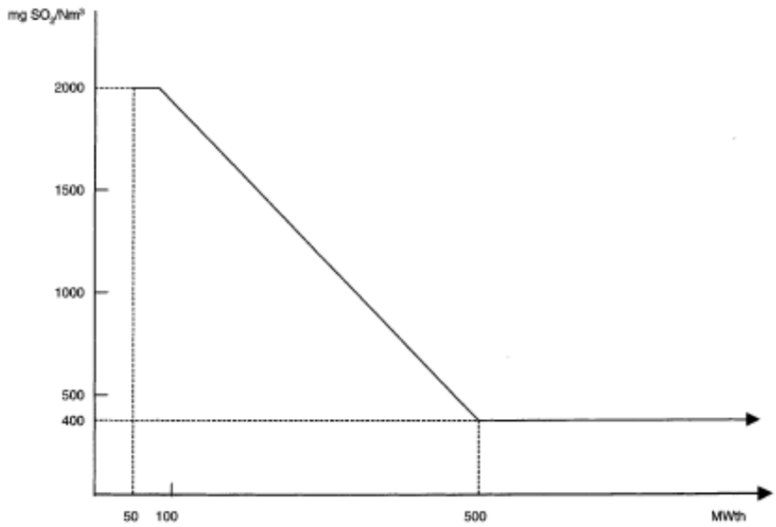
Total thermal input (MWth)	Emission limit value
50-300	20
>300	10 20 for biomass and peat

ELVs for particulate matter expressed in mg/Nm^3 applicable to combustion plants using gaseous fuels other than gas turbines and gas engines are given in the following table:

Type of fuel	Emission limit value
Gaseous fuels in general	5
Blast furnace gas	10
Gases produced in steel industry, which can be used elsewhere	30

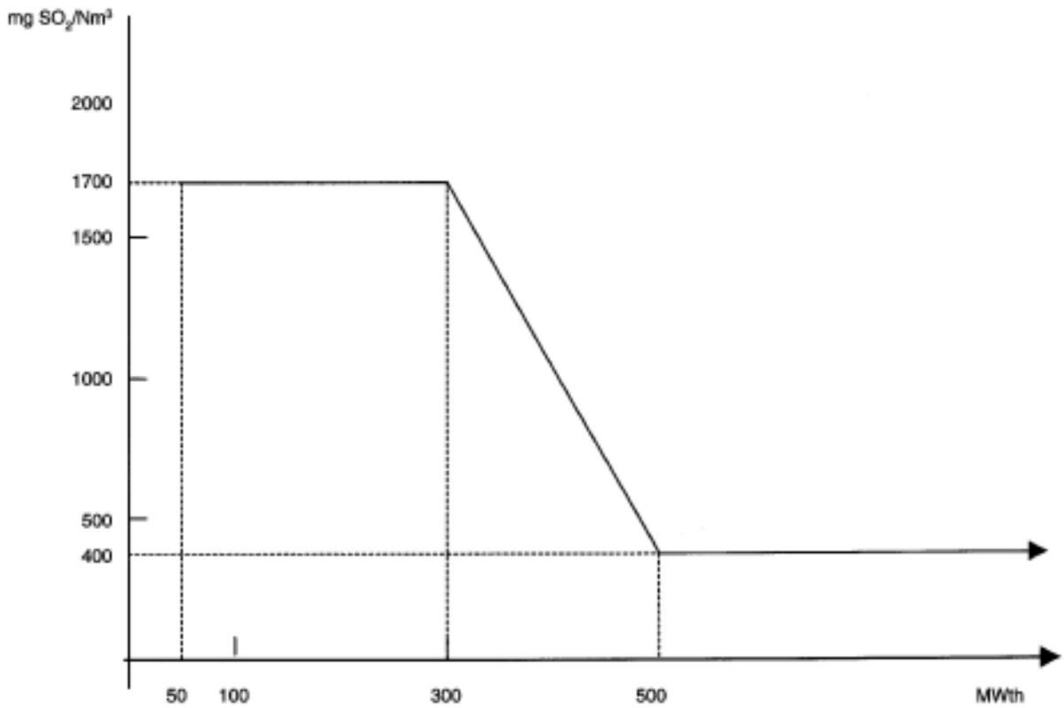
Old plants

ELVs for SO_2 expressed in mg/Nm^3 applicable to the combustion plants using solid fuels other than gas turbines and gas engines are given in the following table:



Note: If the above-mentioned emission limit values cannot be achieved due to fuel characteristics, a desulphurization degree of at least 60% must be achieved in plants with thermal input of 100 MWth or less, 75% for plants with thermal input of 100 MWth and less than or equal to 300 MWth and 90% for plants with thermal input higher than 300 MWth. For plants with thermal input higher than 500 MWth a desulphurization degree of at least 94% must be achieved.

ELVs for SO_2 expressed in mg/Nm^3 applicable to the combustion plants using liquid fuels other than gas turbines and gas engines are given in the following table:



ELVs for SO_2 expressed in mg/Nm^3 applicable to the combustion plants using gaseous and liquid fuels other than gas turbines and gas engines are given in the following table:

Type of fuel	Emission limit value
Gaseous fuels in general	35
Liquid oil gas	5
Low calorific gases from gasification of refinery residues, coke oven gas, blast furnace gas	800
Gas from the coal gasification process	(1) the value to be subsequently determined

ELVs for NOx expressed in mg/Nm^3 applicable to the combustion plants using solid fuels other than gas turbines and gas engines are given in the following table:

Type of fuel	Emission limit value
Solid fuels ([1]):	
to 500 MWth	600
>500 MWth	500
From 1 January 2018	
50 to 500 MWth	600
>500 MWth	200

ELVs for NOx expressed in mg/Nm^3 applicable to the combustion plants using liquid fuels other than gas turbines and gas engines are given in the following table:

Type of fuel	Emission limit value
Liquid fuels:	
50 to 500 MWth	450
>500 MWth	400

ELVs for NOx expressed in mg/Nm^3 applicable to the combustion plants using gaseous fuels other than gas turbines and gas engines are given in the following table:

Type of fuel	Emission limit value
Gaseous fuels:	
50 to 500 MWth	300
>500 MWth	200

ELVs for PM expressed in mg/Nm^3 applicable to the combustion plants using solid, liquid and gaseous fuels other than gas turbines and gas engines are given in the following table:

Type of fuel	Thermal input (MWth)	Emission limit value
Solid	≥500	50 (2)
	<500	100
Liquid (1)	All plants	50
Gaseous	All plants	5 (as a rule) 10 (for blast furnace gas) 50 (gas formed in the steel processing industry which can be used elsewhere)

(1) Emission limit value of 100 mg/normal m^3 can be applied to combustion plants with thermal input of 500 MWth if they use liquid fuel with a share of ash bigger than 0.06%

(2) Emission limit value of 100 mg/normal m^3 can be applied to the combustion plants with thermal input of 500 MWth that fire solid fuel whose calorific value is lower than 5800 kJ/kg (net calorific value), a moisture content higher than 45 mass %, the total mass fraction of moisture and ash bigger than 60% and the fraction of calcium oxide (CaO) bigger than 10%.

2.8.1.2. Medium combustion plants

The comparison with the limit values of the GP is only made for PM emissions, as the GP does not recommend ELVs for other pollutants than PM.

Existing plants

Emission limit values expressed in mg/Nm^3 for pollutants for existing medium combustion plants using solid fuels are given in the following table (O_2 content for coal, briquettes and coke from coal is 7%, and for other solid fuels, is 11%):

Pollutant	Type of fuels	Thermal input (MWth)	ELVs
Carbon monoxide-CO	All solid fuels		300

Natrium oxides NO_x expressed as NO_2	All solid fuels		650
Sulfur oxides expressed as SO_2	All solid fuels		1700
Particulate matter	All solid fuels	<5	
	Coal and other solid fuels		150 at 7% or 161 at 6% against 50 at 6 % in the GP
	Wood and other biomass		150 at 11% against 50 at 11 % in the GP
	All solid fuels	≥5	
	Coal and other solid fuels		50 at 7% or 54 at 6% against 30 at 6 % in the GP
	Wood and other biomass		50 at 11% against 30 at 11 % in the GP
Nitrous oxide – N_2O	For fluidized bed plants that use coal		150
Total organic carbon	Wood, briquettes or wood pellets		50

Emission limit values expressed in mg/Nm^3 for pollutants for existing medium combustion plants using liquid fuels are given in the following table (O_2 for liquid waste from the pulp production process is 6%, and for other liquid fuels, is 3%):

Pollutant	Types of fuel	ELVs
Carbon monoxide-CO	All solid fuels	170
Natrium oxides NO_x expressed as NO_2	medium fuel oil EURO S, fuel oil, low-sulfur fuel - special NSG-S	250
	Medium fuel oil S	350
Sulfur oxides expressed as SO_2	All solid fuels	1700
Particulate matter		50 (except for the plants that use medium fuel oil EURO S, fuel oil low-sulfur fuel - special NSG-S, medium fuel oil S, methanol, stanol, crude vegetable oils, methyl ester from vegetable oils whose emissions of particulate matter are not determined)

New plants

Emission limit values expressed in mg/Nm^3 for pollutants for existing medium combustion plants using solid fuels are given in the following table (O_2 content for coal, briquettes and coke from coal is 7%, and for other solid fuels, is 11%):

Pollutant	All fuels	Thermal input (MWth)	ELVs
Particulate matter	All solid fuels		20
	Coal and other solid fuels		20 at 7% or 24 at 6% against 20 at 6 % in the AGP, Annex X
	Wood and other biomass		20 at 11% against 20 at 11 % in the AGP, Annex X
CO	All solid fuels		150
Nitrogen oxides NO_x expressed as NO_2	Wood, briquettes, or wood pellets		250
	for plants with fluidized bed while using other solid fuels other than wood and wood briquettes and pellets		300
	Other solid fuels	≥10	400
		<10	500
N_2O	for plants with fluidized bed, which use coal		150
sulfur oxides expressed as SO_2	for plants with fluidized bed, provided that the emission factor, expressed as a ratio of the amount of sulfur in the waste gases and the amount of sulfur in the fuel is less than 25%		250
	For other plants when using coal		1300
	Other solid fuels		1000

Emission limit values expressed in mg/Nm^3 for pollutants for existing medium combustion plants using liquid fuels are given in the following table (O_2 for liquid waste from the pulp production process is 6%, and for other liquid fuels, is 3%):

Pollutant	Type of fuel	ELV (mg/normal m^3)
Particulate matter		50 (except for plants that use as fuel the medium fuel oil EURO S, fuel oil low-sulfur fuel - specially NSG-S, medium fuel oil S, methanol, stanol, crude vegetable oils, methyl ester from the vegetable oils whose emissions of particulate matter are not determined) (20 in the GP, table 14)
Carbon monoxide – CO	All liquid fuels	80
nitrogen oxides NO_x expressed as NO_2	for plants that use as fuel the medium EURO S fuel oil, fuel oil low-sulfur fuel - specially NSG-S, the medium S fuel oil at which the water temperature in the boiler is lower than 110 C°	180
	for plants that use as fuel the medium EURO S fuel oil and the low-sulfur fuel oil - specially NSG-S, the medium S fuel oil, at which the water temperature in the boiler is higher than 110 C° and lower than 210 C°	200
	for plants that use as fuel the medium EURO S fuel oil and the low-sulfur fuel oil - specially NSG-S, the medium S fuel oil, at which the water temperature in the boiler is higher than 210 C°	250
	for plants that use other liquid fuels or if the heat transfer medium in the boiler is not water	350
sulfur oxides expressed as SO_2	for plants that use as fuel the medium S fuel oil	1300

Pollutant	Type of fuel	ELV (mg/normal m^3)
	For plants that use other liquid fuels	850

2.8.1.3. Small combustion plants

The comparison with the limit values of the GP is only made for PM emissions, as the GP does not recommend ELVs for other pollutants than PM.

Existing plants

Emission limit values of pollutants for existing small combustion plants using solid fuels are given in the following table (O_2 content is for coal, briquettes and coke is 8%, for other er solid fuels is 13%).

Comparison is made with table 13 (non residential combustion installations from 100 kW to 1 MW) of Annex X of the GP and table 12 (new residential installations < 500 kW)

Pollutant	Type of fuel	Thermal input (kWth)	ELV (mg/normal m^3)
Carbon monoxide - CO	Coal, wood, briquettes, or wood pellets	50-150	4000
	Coal, wood, briquettes, or wood pellets	150-500	2000
	Coal, wood, briquettes, or wood pellets	≥500	1000
Particulate matter	Coal,		150 at 7% or 154 at 6 % against 150 at 6 % in the AGP Annex X in table 13.
	Wood		150 at 13% against 150 at 13 % in the AGP Annex X in table 13.

There is no limit value for PM for plants using liquid fuels.

New plants

Emission limit values of pollutants for existing small combustion plants using solid fuels are given in the following table (O_2 content is 13 % for solid fuels).

Pollutant	Type of fuel	Thermal input (kWth)	ELV
Particulate matter	coal	≥4	90 at 13% against 50 at 13% in AGP Annex X, table 12 and against 50 at 6% (or 27 at 13%) in table 13 for plant larger than 100 kW
	wood, except for briquettes or wood pellets	≥4	100 at 13% against 40 to 75 at 13% in table 12 and against 50 at 13% in table 13 for plant larger than 100 kW
	briquettes, or wood pellets	≥4	60 at 13% against 50 at 13% in table 12 and against 50 at 13% in table 13 for plant larger than 100 kW
Carbon monoxide - CO	Coal or wood, except for briquettes or wood pellets	4-500	1000
	briquettes or wood pellets	4-500	800
	Coal or wood, except for briquettes or wood pellets	≥500	500

There is no limit value for PM for plants using liquid fuels.

2.8.1.4. Limit values implemented by regulation n°111/15 and n°88/21 for industrial plants

In the following tables, only limit values for industrial processes present in the technical Annexes IV, V and X are highlighted and the ELVs prescribed by n°111/15 and n°88/21 are compared with those implemented by the technical Annexes of the AGP.

Table 2-4: Comparison of limit values for industriel processes prescribed by RS regulation n°111/15 and ELVs prescribed by the GP

	ELVs of technical Annexes of the GP	ELVs prescribed by the Serbian regulation
SO_2		
	Sulphur recovery units: for plants that produce more than 50 Mg of sulphur a day	New and existing plants for the production of sulfur (Claus Plant)

	ELVs of technical Annexes of the GP	ELVs prescribed by the Serbian regulation
	Minimum sulphur recovery rate of sulphur recovery units: new plants: 99.5 % existing plants: 98.5 %	New and existing plants for the production of sulfur > 50 t/day Emission level: 0.2 %
	Titanium dioxide production Sulphate process, total emission : 6 kg/t of TiO2 Chloride process, total emission : 1.7 kg/t of TiO2	Activity not existing In the Republic of Serbia
NOx		
	Cement clinker production General (existing and new installations): 500 mg/m3 Existing lepol and long rotary kilns in which no waste is co-incinerated: 800 mg/m3	Production of cement and cement clinker in rotary kilns by dry or wet processes New plants 500 mg/m3 Existing plants 1200 mg/m3
	Iron ore sinter plants New installation: 400 mg/m3 Existing installation: 400 mg/m3	Plants for the roasting, smelting and sintering of iron ore: New plants 400 mg/m3 Existing plants no information
	Nitric acid production excluding acid concentration units New installation: 160 mg/m3 Existing installation: 190 mg/m3	Production of nitric acid new and existing plants 200 mg/m3
Dust		
	Mineral oil and gas refineries FCC regenerators: 50 mg/m3	Catalytic cracking during the catalyst regeneration new and existing plants: 40 mg/m3
	Cement production Cement installations, kilns, mills and clinker coolers: 20 mg/m3	Production of cement and cement clinker in rotary kilns by dry or wet processes New plants 20 mg/m3 Existing plants 50 mg/m3
	Lime production Lime kiln firing: 20 mg/m3	No ELVs have been identified
	Primary iron and steel production Sinter plant: 50 mg/m3 Pelletization plant: 20 mg/m3for crushing, grinding 15 mg/m3 for all other process Blast furnace: Hot stoves (>2.5 t/hour): 10 mg/m3 Basic oxygen steelmaking and casting (>2.5 t/hour): 30 mg/m3 Electric steelmaking and casting (>2.5 t/hour):	Plants for the roasting, smelting and sintering of iron ore: New and existing plants 50 mg/m3 Pelletization plants: new and existing plants grinding, drying: 25 mg/m3 pelleting: 25 mg/m3 Blast furnace: New plants:10 mg/m3 Existing plant: 50 mg/m3 Basic oxygen steelmaking and casting: Not identified Electric steelmaking and casting:

	ELVs of technical Annexes of the GP	ELVs prescribed by the Serbian regulation
	15 mg/m3 for existing installations 5 mg/m3 for new installations	10 mg/m3 for existing installations 5 mg/m3 for new installations
	Iron foundries Iron foundries (>20 t/day): all furnaces (cupola, induction, rotary) all mouldings (lost, permanent) 20 mg/m3 Hot and cold rolling: 20 mg/m3 50 mg/m3 where a bag filter cannot be applied due to the presence of wet fumes	Foundries of gray cast iron (gray iron), alloy cast iron and steel <u>New installations</u> cupola furnaces with gas suction at the top 20 mg/m3 cupola furnaces with gas suction at the bottom 20 mg/m3 induction furnaces 20 mg/m3 electric ovens 20 mg/m3 Converters 20 mg/m3 other furnaces 20 mg/m3 facilities for the preparation of raw materials, processing, refrigeration and processing of raw materials (crushers, mills, screens, conveyor systems) 10 mg/m3 preparation and regeneration of the core 10 mg/m3 nodulation facilities 10 mg/m3 <u>Existing installations</u> cupola furnaces with gas suction at the top 20 mg/m3 cupola furnaces with gas suction at the bottom 50 mg/m3 induction furnaces 20 mg/m3 electric ovens 20 mg/m3 Converters 50 mg/m3 other furnaces 50 mg/m3
	Non-ferrous metals production Non-ferrous metal processing: 20 mg/m3	New plants for preparation of lead and alloys from secondary raw materials 5 mg/m3 Existing plants for preparation of lead and alloys from secondary raw materials 10 mg/m3 New and existing plants for obtaining ferro-alloys in electrothermal or metal-thermal processes 5 mg/m3 Plants for obtaining aluminum by electrolytic processes in electrolysis cells New plants storage and transportation of raw materials 5 mg/m3 screening, grinding, mixing and molding of anode mass 5 mg/m3

	ELVs of technical Annexes of the GP	ELVs prescribed by the Serbian regulation
		anode baking 5 mg/m3 Existing plants storage and transportation of raw materials 20 mg/m3 screening, grinding, mixing and molding of anode mass 20 mg/m3 anode baking 20 mg/m3 Plants for the production of aluminum from secondary raw materials new plants 10 mg/m3 Plants for the rolling of non-ferrous metals, furnaces for heating and thermal processing existing 50 mg/m3
	Glass production: New installation: 20 mg/m3 Existing installation: 30 mg/m3	Production of glass and glass fibers New plants 30 mg/m3 (half-hourly average value Existing plants 30 mg/m3
	Pulp production Auxiliary boiler 40 mg/m3when firing liquid fuels (at 3% oxygen content) 30 mg/m3 when firing solid fuels (at 6% oxygen content) Recovery boiler and lime kiln: 50 mg/m3	No specific limit values
	Waste incineration Municipal waste incineration plants (> 3 Mg/hour): 10 mg/m3 Hazardous and medical waste incineration (> 1 Mg/hour): 10 mg/m3	No waste incineration in Serbia

3. Georgia

This part of the report dedicated to Georgia was produced with the support Noe Megrelisvhili, head of Ambient Air Division at the Ministry of Environmental Protection and Agriculture.

3.1. Status of ratification of CLRTAP and its protocols and strategic programmes

Georgia accessed the Convention on Long-range Transboundary Air Pollution [2] on 11 February 1999 [2]. Georgia accessed the Protocol on Long-term Financing of the Co-operative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe (EMEP), on 7 February 2013 [3]. Up to now, Georgia did not sign, nor ratify the last three Protocols (heavy metals, persistent organic compounds and Protocol to abate acidification, eutrophication and ground level ozone) [5] including the amended Gothenburg Protocol (AGP) [3] subject of this assessment[3].

As a Party to the CLRTAP, Georgia is however determined to contribute to the overall aim of the Convention, i.e. to limit and, as far as possible, gradually reduce and prevent air pollution including long-range transboundary pollution [6]. A first draft plan for the ratification of the Protocols was prepared by the Ministry of Environment and Natural Resources Protection of Georgia in 2014. This plan was updated in 2018 in the scope of the UNECE assistance programme to support countries in Eastern Europe, the Caucasus and Central Asia (EECCA) with the aim to encourage ratification of the key Protocols to the Convention. The ratification of the Protocols requires implementation of various legal and administrative emission reduction measures [6]. In 2018, it was noticed in the action plan towards ratification [6], that Georgia was partially compliant with the provisions of the Protocols and though significant progress were achieved after signing the EU Association Agreement, some additional measures were required to fulfil the provisions and ensure ratification. A cost-benefit analysis of consequences and risks from ratification and implementation of the latest three Protocols to CLRTAP was also carried out, concluding benefits of the ratification on the reduction of emissions and health impact [7].

Georgia is currently engaged in an Association Agreement (AA) between the European Union and the European Atomic Energy Community and their Member States, of the one part, and the Republic of Georgia, of the other part. The aims of this Agreement are multiple but one of them is as follows (a, article 1): "*to promote political association and economic integration between the Parties based on common values and close links, including by increasing Georgia's participation in EU policies, programmes and agencies*" [8]**Erreur ! Source du renvoi introuvable.**.

The agreement entered into force on 1 July 2016 [8].

The agreement provides a road map for the implementation of key EU Directives. Among other ones, the chapter 3 of the AA relates to Environment and chapter 4 to the climate action [8].

Article 302, under chapter 3, provides the main objectives in terms of environment:

"Cooperation shall aim at preserving, protecting, improving and rehabilitating the quality of the environment, protecting human health, sustainable utilisation of natural resources and promoting

[3] The 1985 Protocol on the reduction of Sulphur emissions and their transboundary flux, the 1988 Protocol concerning the control of NOx or their transboundary fluxes, the 1991 Protocol concerning the Control of emissions of VOC or their transboundary fluxes and the 1994 Protocol for further reduction of Sulphur emissions have not been examined.

measures at international level to deal with regional or global environmental problems, including in the areas of:

(a) environmental governance and horizontal issues, including strategic planning, environmental impact assessment and strategic environmental assessment, education and training, monitoring and environmental information systems, inspection and enforcement, environmental liability, combating environmental crime, transboundary cooperation, public access to environmental information, decision- making processes and effective administrative and judicial review procedures;

(b) air quality;

(c) water quality and resource management, including flood risk management, water scarcity and droughts as well as marine environment;

(d) waste management;

(e) nature protection, including forestry and conservation of biological diversity;

(f) industrial pollution and industrial hazards, and

(g) chemicals management.

The AA is further detailed in the following chapters.

3.2. Main sources of emissions

The following figures present the emissions of atmospheric pollutants covered by the Amended Gothenburg Protocol (AGP). All figures have been elaborated by TFTEI from data available from NFR tables reported by Georgia to the UNECE Convention, submission 2022 [9] (Specific data treatment has been made by Citepa to provide the figures). Both the NFR tables reported by Georgia and the Informative Inventory Report (IIR) have been used to explain the emissions in 2019/2020. The evolution of emissions from 2000 to 2020 is presented. Indeed, emissions in the 90ies were quite larger than in 2000. As explained in the IIR, the general economic activity decreased in 1990s due to economic crisis caused by dissolution of Soviet Union. Subsequently, emissions of main pollutants declined sharply. Increased economic activity from the middle of 2000s led to increased emissions of most pollutants, but these trends were reduced in application of cleaner technologies that abated emissions from various sectors [9].

3.2.1. SO_2 emissions

Total SO_2 emissions

The evolution of SO_2 emissions from the different sources is provided in Figure 3-1. Emissions in 2019 are 5 kt. Industry (combustion plants and processes) is the largest source of emissions, with 95% and 94% of total emissions in 2019 and 2020 respectively. Significant decrease of SO_2 emissions after 2017, was caused by diminishing and up to zero consumption of coal for public electricity and heat production (2018-2020), iron and steel (2020), and food production (2020) [9]. For information in 1990, emissions of SO_2 were 106 kt [9].

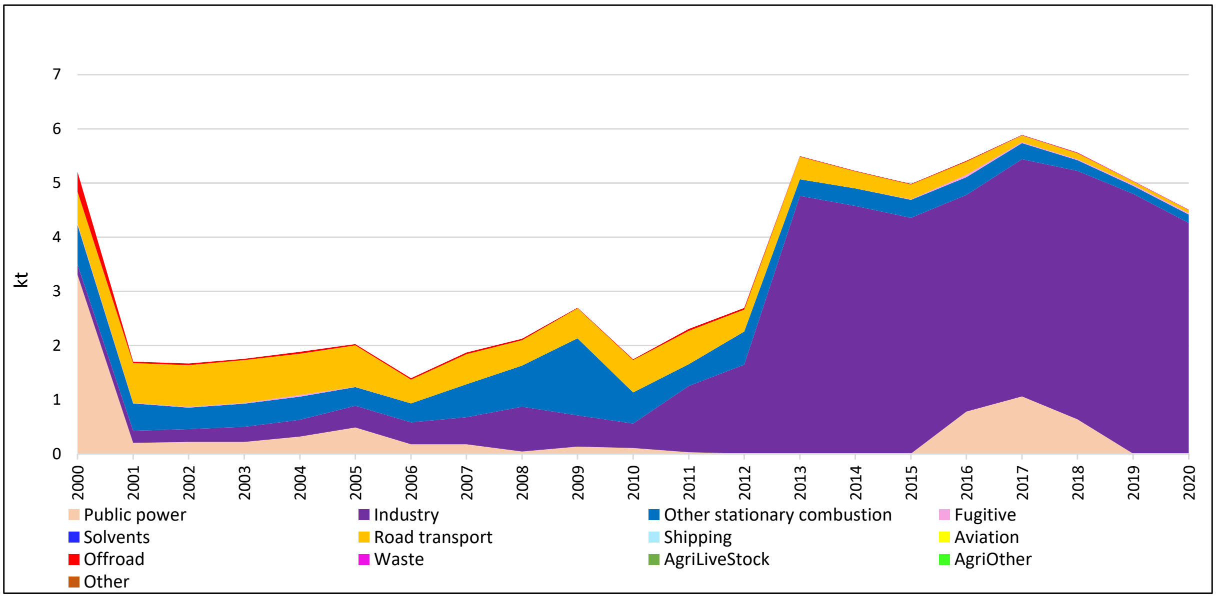


Figure 3-1: Trends in SO_2 emissions from 2000 to 2020 in Georgia

Industrial sources

The evolution of SO_2 emissions from the different industrial sources is provided in Figure 3-2 (emissions from combustion plants and processes included) [9]. Emissions are 4.25 kt in 2020 and represent 94.4% of total SO_2 of Georgia. Iron and steel production is the largest source of SO_2 emissions (82%) followed by production of mineral products (17%). According to the IIR [9], increasing trend of SO_2 emissions from 2011, resulted from increased coal fuel consumption in industry sector and mostly in iron and steel production and partially by rising cement production.

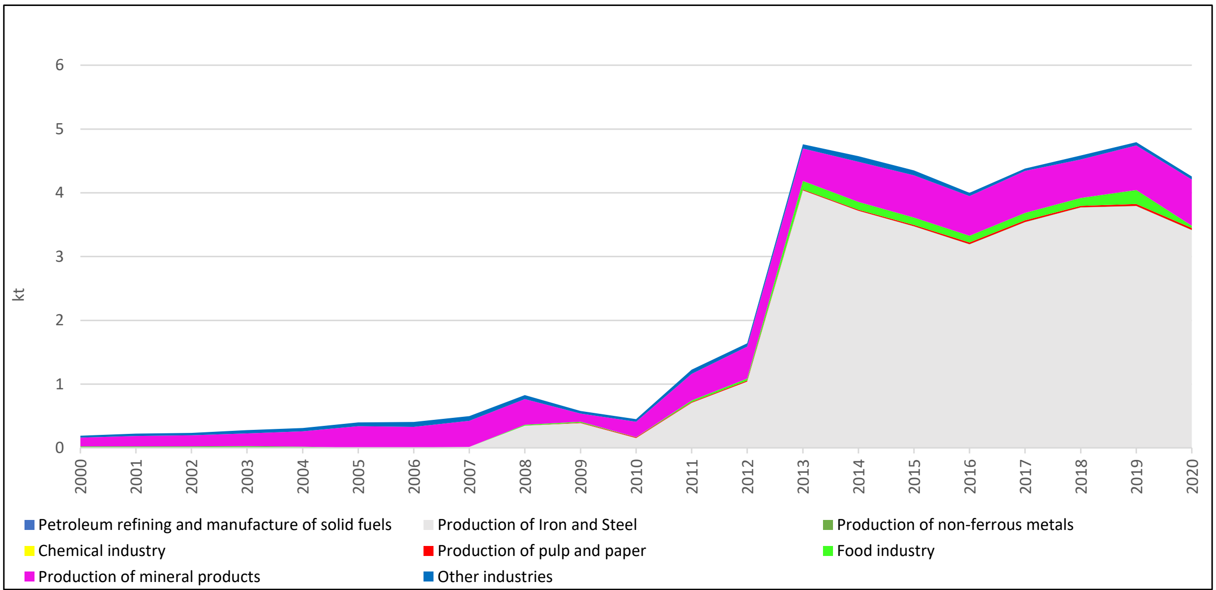


Figure 3-2: SO_2 emissions of manufacturing industry from 2000 to 2020 in Georgia

Road transport

The evolution of SO_2 emissions from road transport is provided in Figure 3-3. Road transport, with 0.06 kt SO_2 emissions in 2020, represents only 1.2% of total SO_2 emissions of Georgia in 2020.

According to the IIR [9], emissions of SO_2 are gradually decreasing in parallel with reduction of the sulphur content limits in national standards for petrol and diesel (for petrol: from 500 ppm to 10 ppm and for diesel: from 500 ppm to 50 ppm). In 2020, SO_2 emissions are 9 times less compared to 2007. It has to be noticed that from 1 January 2023, sulphur content of diesel is also 10 ppm.

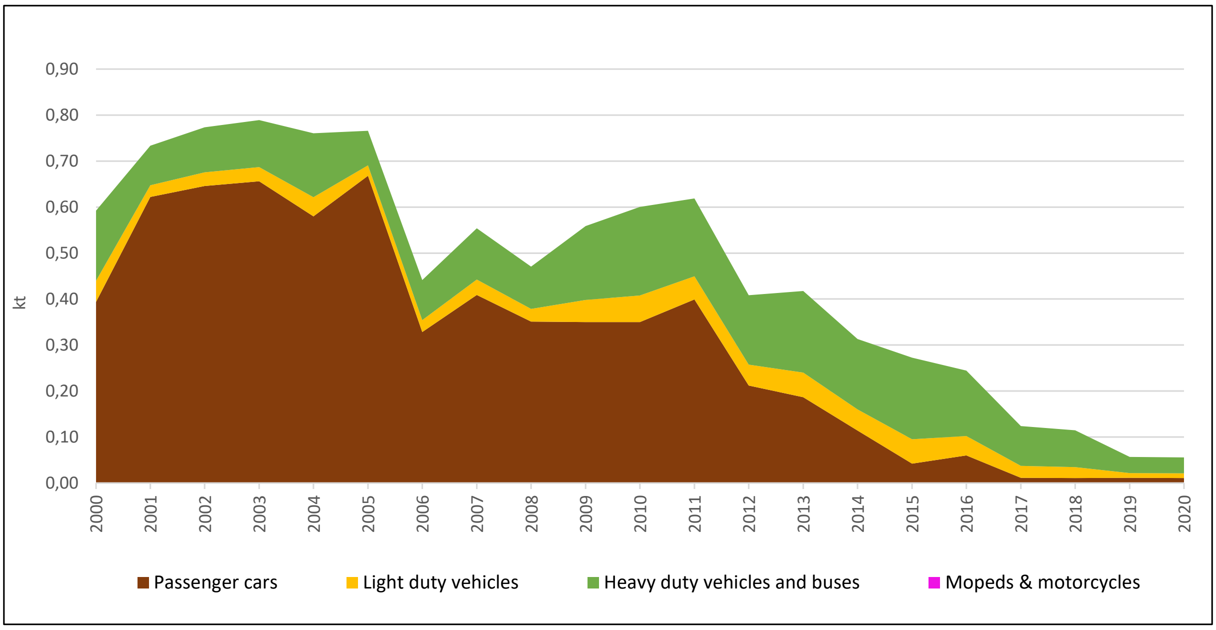


Figure 3-3: SO_2 emissions of road transport from 2000 to 2020 in Georgia

3.2.2. NOx emissions

Total NOx emissions

The evolution of NOx emissions from the different sources is provided in Figure 3-4. Emissions are 47.7 and 46.8 kt in 2019 and 2020 respectively. Road transport is the largest source of NOx emissions, with 19.2 kt in 2020, representing 41% of total emissions but its emissions are slightly decreasing from 2016 due to increasing share of new and clean vehicles in imports of vehicles and in the car fleet [9].

Growth of NOx emissions in 2018 from agriculture sector is related to application of larger amount of livestock manures to agricultural soils.

In 2020, emissions of NOx decreased slightly (by 2%) compared to previous year mainly due to Covid19 pandemic and its accompanied restrictions that resulted in less emissions from transport [9].

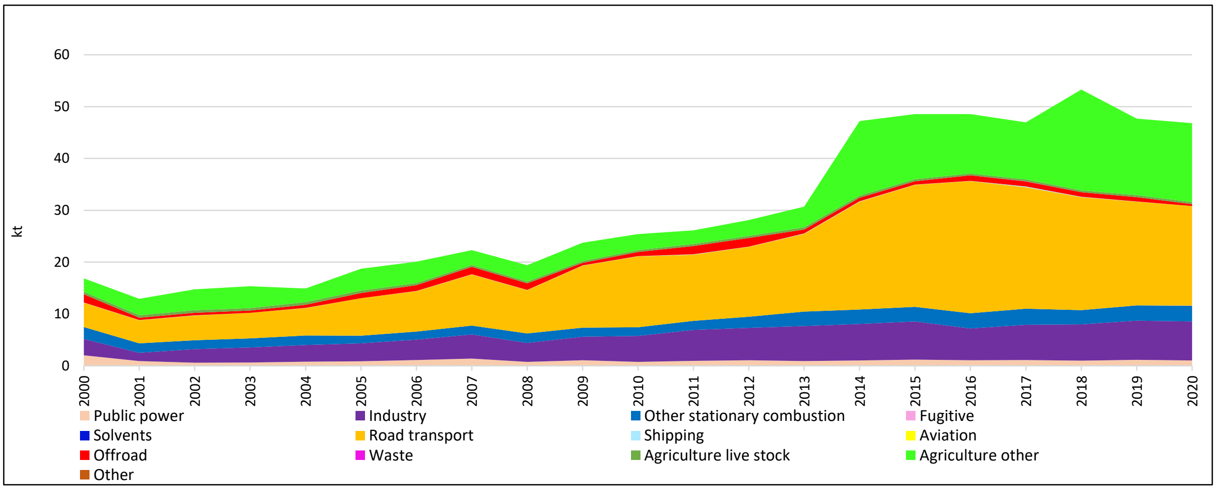


Figure 3-4: Trends in NOx emissions from 2000 to 2020 in Georgia

Industrial sources

The evolution of NOx emissions from industry is provided in Figure 3-5. Industry is the third largest source on NOx emissions in Georgia with 7.5 kt, and represents 16% of total NOx emissions of Georgia in 2020 [9]. Chemical industry is the largest source of NOx emission from industry (59%) followed by production of mineral products (30%).

The main source from the chemical is nitric acid production (4.19 kt). According to the IIR [9], significant decrease of emissions in 2016 was caused by switching to production data that is retrieved from state reporting system for stationary sources.

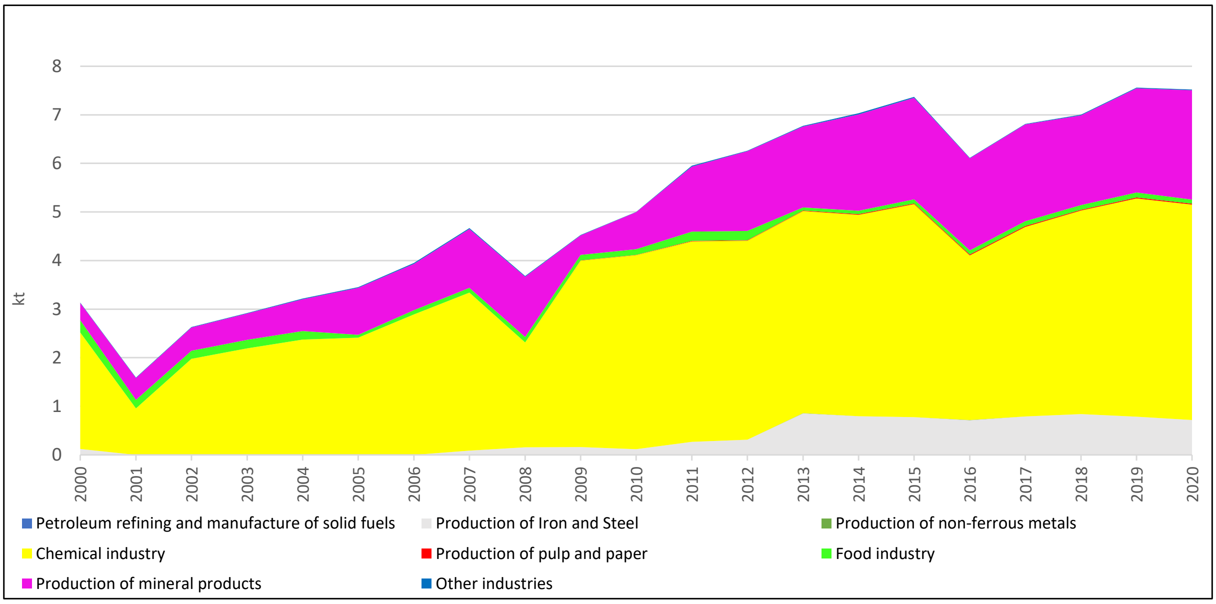


Figure 3-5: NOx emissions of industry from 2000 to 2020 in Georgia

Road transport

The evolution of NOx emissions from road transport is provided in Figure 3-6. Road transport with 19.2 kt NOx, represents 41% of total NOx emissions of Georgia in 2020.

Emissions of NOx from road transport have steady decreasing trend since 2016. According to the IIR [9], this is due to increase of new and clean vehicles share in import of vehicles and in the car fleet. The process was supported by increasing taxes for the import of fuels (petrol and diesel) and old cars and by reducing of excise duties for import of cleaner vehicles (electric/hybrid) in 2016-2017.

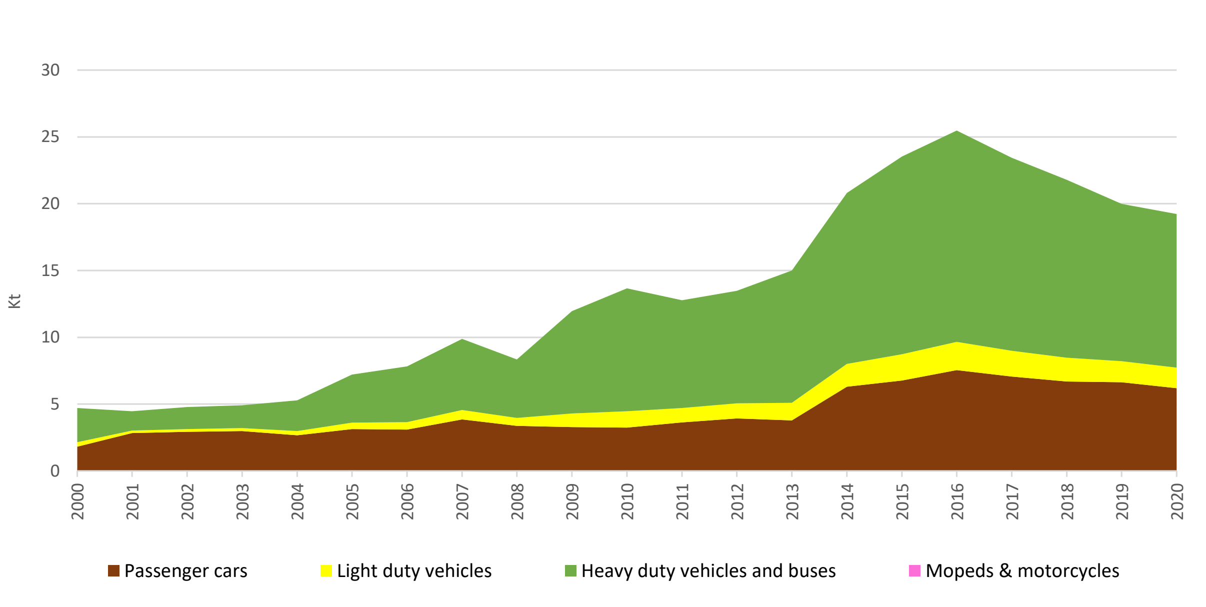


Figure 3-6: NOx emissions of road transport from 2000 to 2020 in Georgia

3.2.3. PM_{10} and $PM_{2.5}$ emissions

Total PM_{10} and $PM_{2.5}$ emissions

The evolutions of PM_{10} and $PM_{2.5}$ emissions from the different sources are provided respectively in Figure 3-7 and Figure 3-8. Emissions of PM_{10} are 12 kt in 2020. Emissions of $PM_{2.5}$ are 9.2 kt. Both for PM_{10} and $PM_{2.5}$ emissions, the largest source is the sector "other stationary combustion" which includes stationary combustion in commercial/institutional, residential and agriculture/forestry/fishing with respectively 60% and 77% of total emissions. Industry represents 22% of total PM_{10} emissions and 11% of total $PM_{2.5}$ emissions. Road transport represents both 8% of total PM_{10} and 8 $PM_{2.5}$ emissions.

The sudden growth of PM emissions in 2013, was caused by launching the national energy balance that provided slightly different and more precise activity data for residential stationary combustion compared to the data of the International Energy Agency, which was used for all previous years according the IIR [9]. The reduction trend since 2016 is caused by decreased consumption of firewood in households. The decrease of emissions from the sector "other stationary combustion" is linked to the reduction in biomass and coal consumption in residential sector [9]. Residential heating if the largest contributor to total emissions from this sector "other stationary combustion" with 61% and 77% of total emissions of PM_{10} and $PM_{2.5}$ respectively.

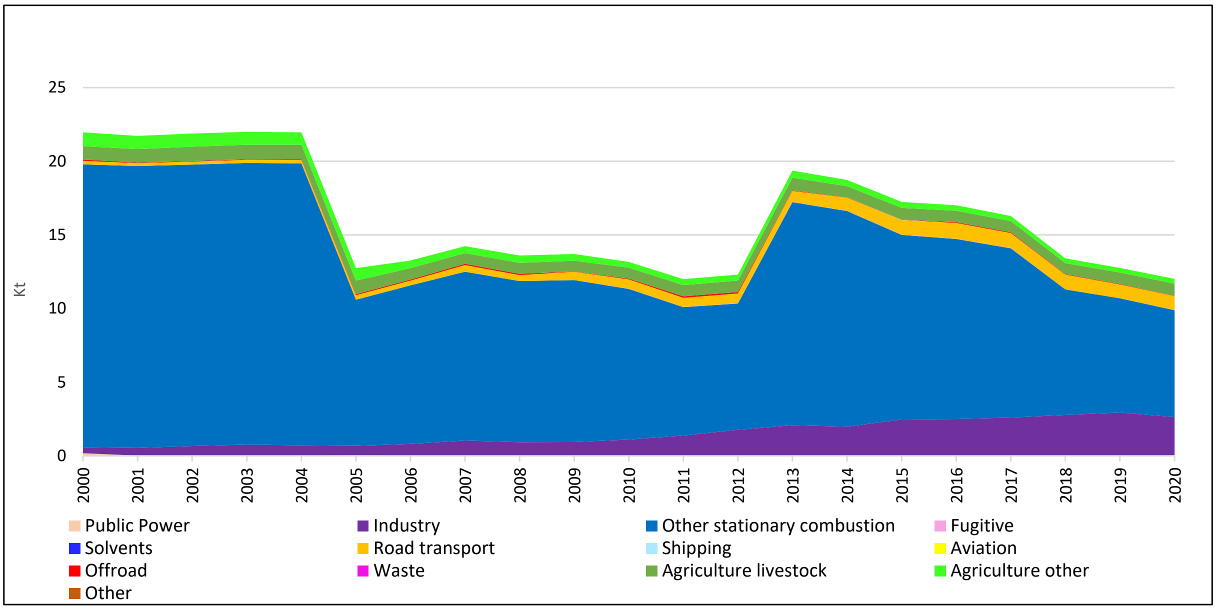


Figure 3-7: Trends in PM_{10} emissions from 2000 to 2020 in Georgia

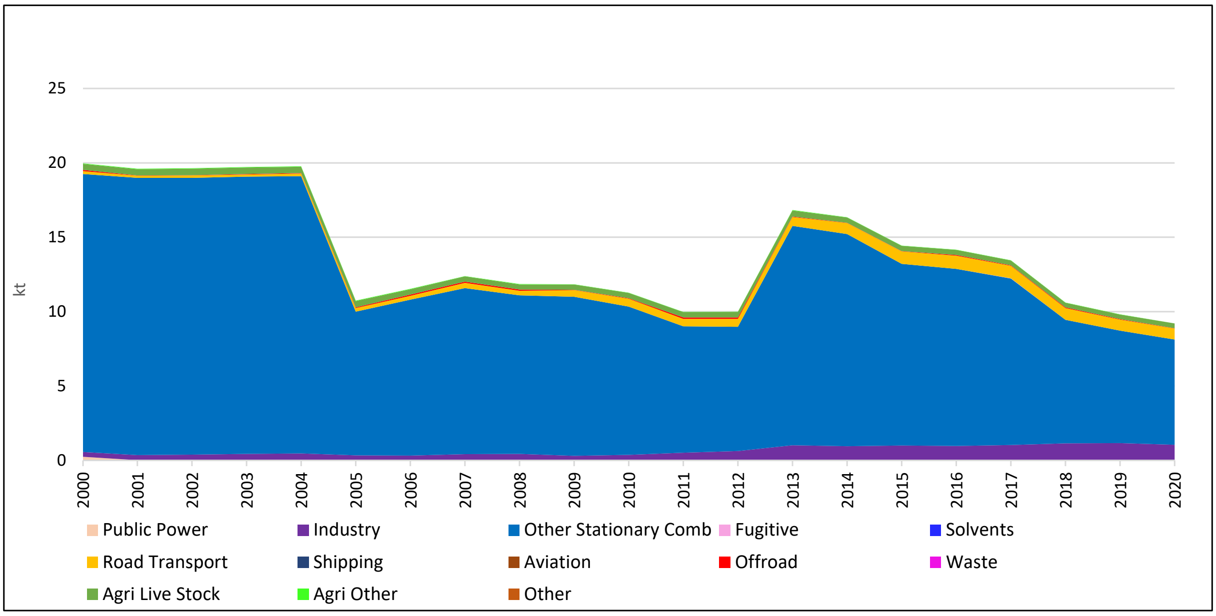


Figure 3-8: Trends in $PM_{2.5}$ emissions from 2000 to 2020 in Georgia

Industrial sources

The evolutions of PM_{10} and $PM_{2.5}$ emissions from industry are provided respectively in

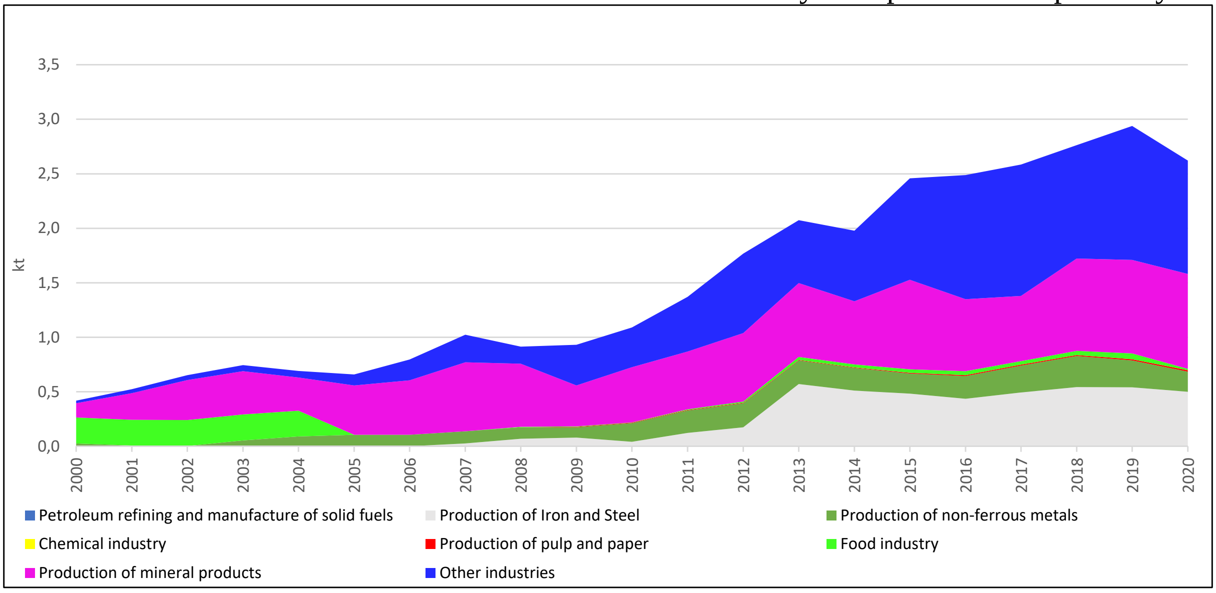


Figure 3-9 and Figure 3-10. In 2020, emissions of PM_{10} and $PM_{2.5}$ are respectively of 2.6 kt and 1.0 kt. For PM_{10}, the largest source of emissions is a group “other industry” (40% of total emissions), followed by production of mineral products (33%) and production of iron and steel (19%). For $PM_{2.5}$, the largest source of emissions is production of iron and steel (44% of total emissions), followed by production of mineral products (31%) and production of non-ferrous metals (13%).

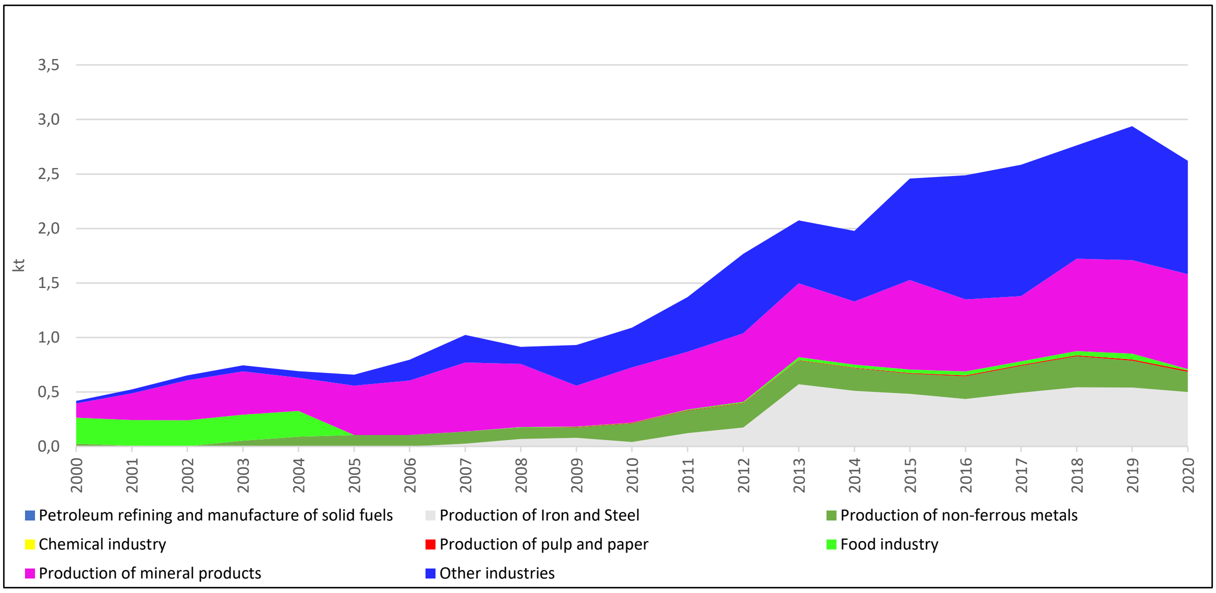


Figure 3-9: PM_{10} emissions of industry from 2000 to 2020 in Georgia

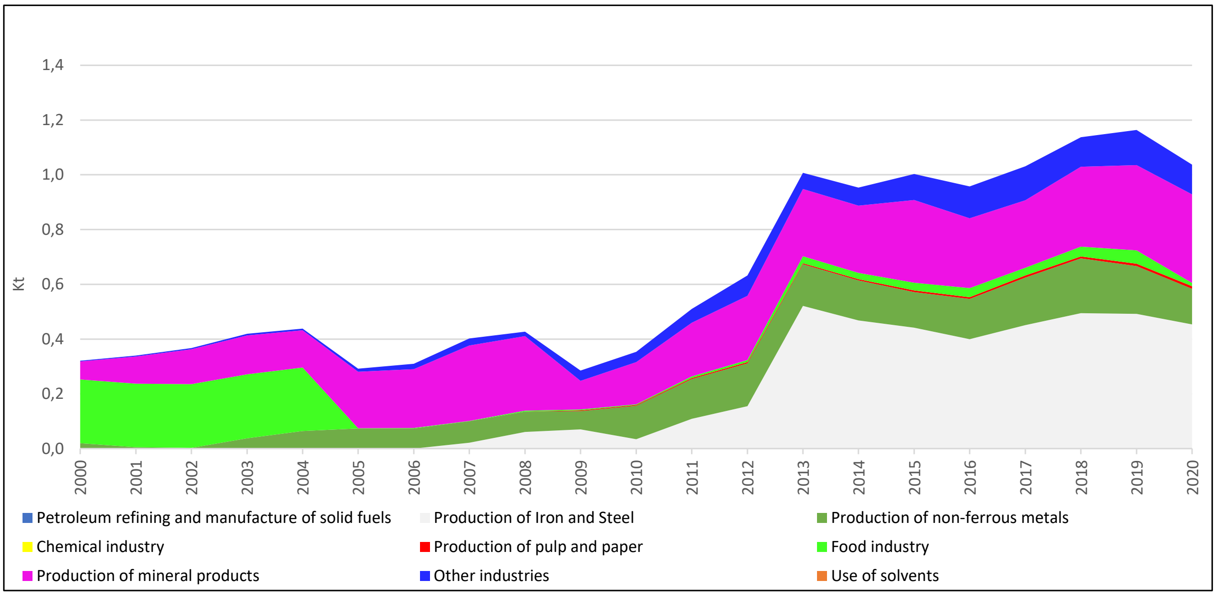


Figure 3-10: $PM_{2.5}$ emissions of industry from 2000 to 2020 in Georgia

Road transport

The evolutions of PM_{10} and $PM_{2.5}$ emissions from road transport are provided respectively in Figure 3-11 and Figure 3-12. In 2020, emissions of PM_{10} and $PM_{2.5}$ are respectively of 0.95 kt and 0.74 kt. Road transport represents 7.9% of total emissions of PM_{10} and 8.1% of total emissions of $PM_{2.5}$ in 2020. Emissions from tyre and brake wear and road abrasion are significant and represent together 48% of total PM_{10} emissions and around 33 % of $PM_{2.5}$ emissions. PM_{10} and $PM_{2.5}$ emissions from road transport have been steady decreasing trend since 2016. As already presented for NOx, according to the IIR [9], this is due to increasing share of new and clean vehicles in import of vehicles and in the car fleet. The chapter on NOx emissions provide additional details explaining the trends.

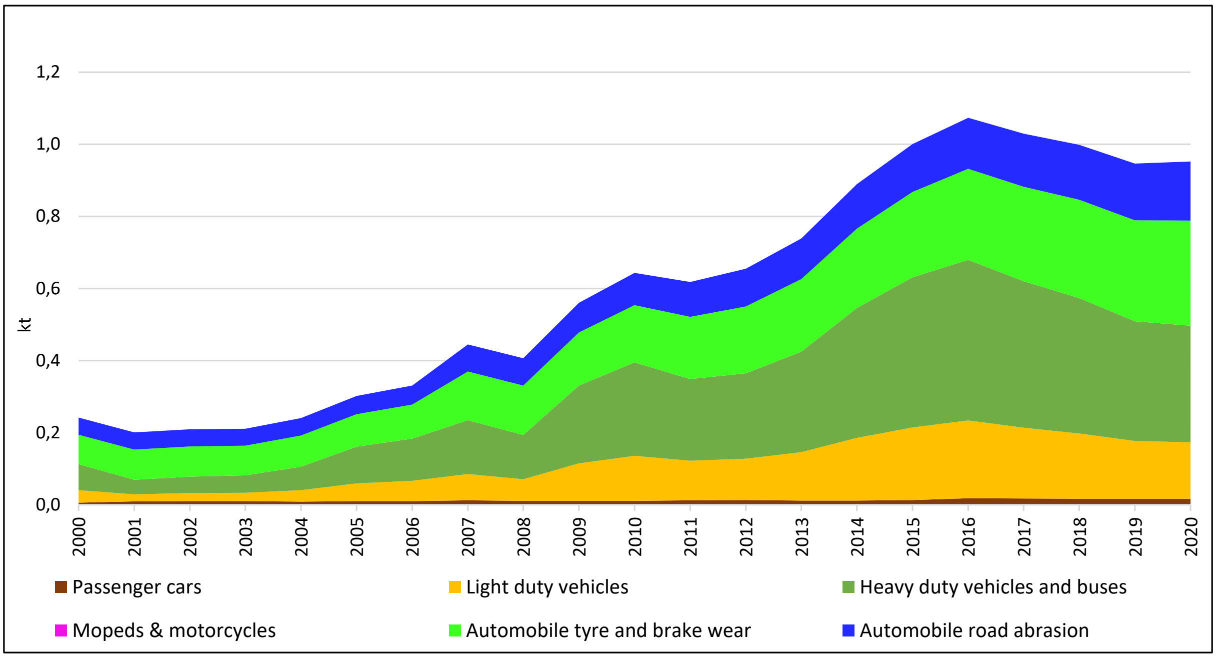


Figure 3-11: PM_{10} emissions of road transport from 2000 to 2020 in Georgia

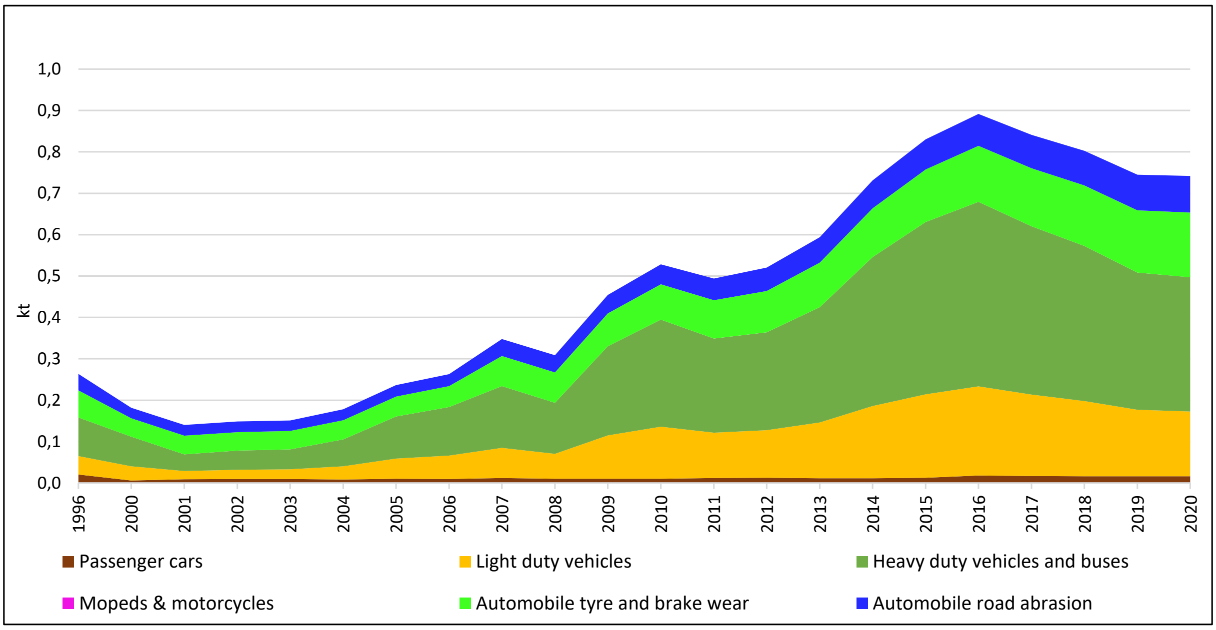


Figure 3-12: $PM_{2.5}$ emissions of road transport from 2000 to 2020 in Georgia

3.2.4. VOC emissions

Total VOC emissions

The evolution of VOC emissions from the different sources is provided in Figure 3-13. In 2020, emissions of VOC are 36.8 kt. Road transport is the largest source of emissions, with 26% of share in total emissions. Increased consumption of petrol by passenger cars caused rise in emissions of VOC in 2016. The second source of VOC emissions is the use of solvents by both domestic and industrial sources (24.5%). The IIR explains that rise in VOC emissions from the use of solvents in 2009 was related to application of paint (coating), for which activity data before 2009 were not available. Agriculture is also a significant source of VOC with 18.5% of total emissions. The sector “other stationary combustion” which includes stationary combustion in commercial/institutional, residential and agriculture/forestry/fishing represents 15.3% of total emissions.

Since 2016, VOC emissions have decreased by 12% due to reduced emissions in energy sector, in particular reduced consumption of biomass by households.

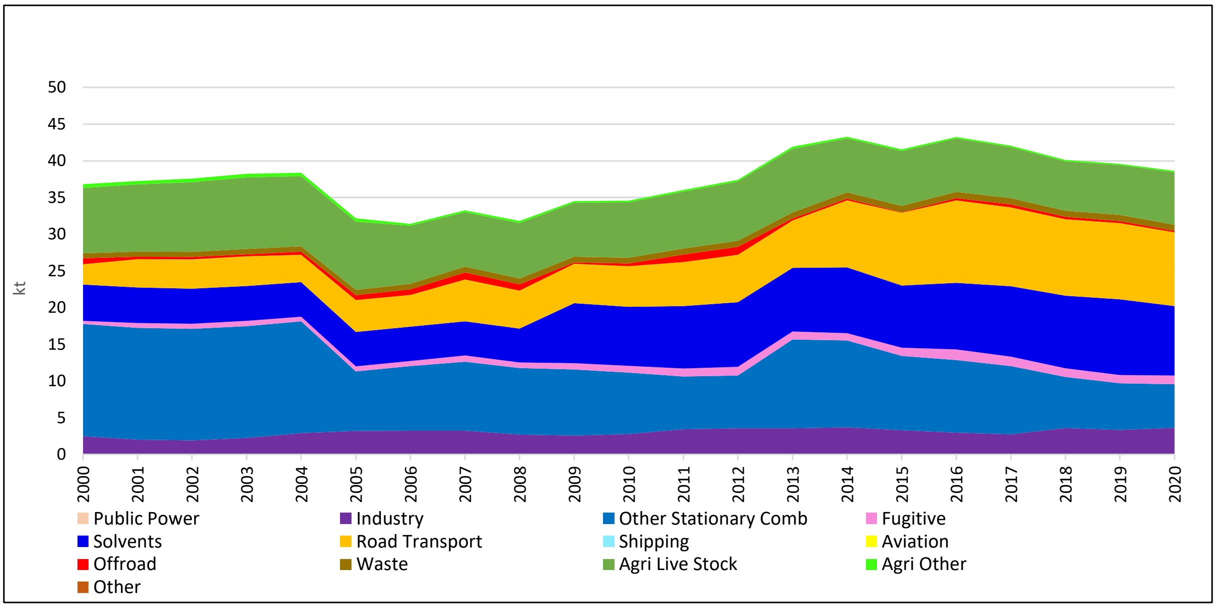


Figure 3-13: Trends in VOC emissions from 2000 to 2020 in Georgia

VOC emissions from industry (excluding solvents)

The evolution of VOC emissions from industry is provided in Figure 3-14. In 2020, emissions of VOC are 3.6 kt. Industry represents 9.3% of total VOC emissions of Georgia in 2020 [9]. The food industry is the largest source of VOC emissions from industry (87%).

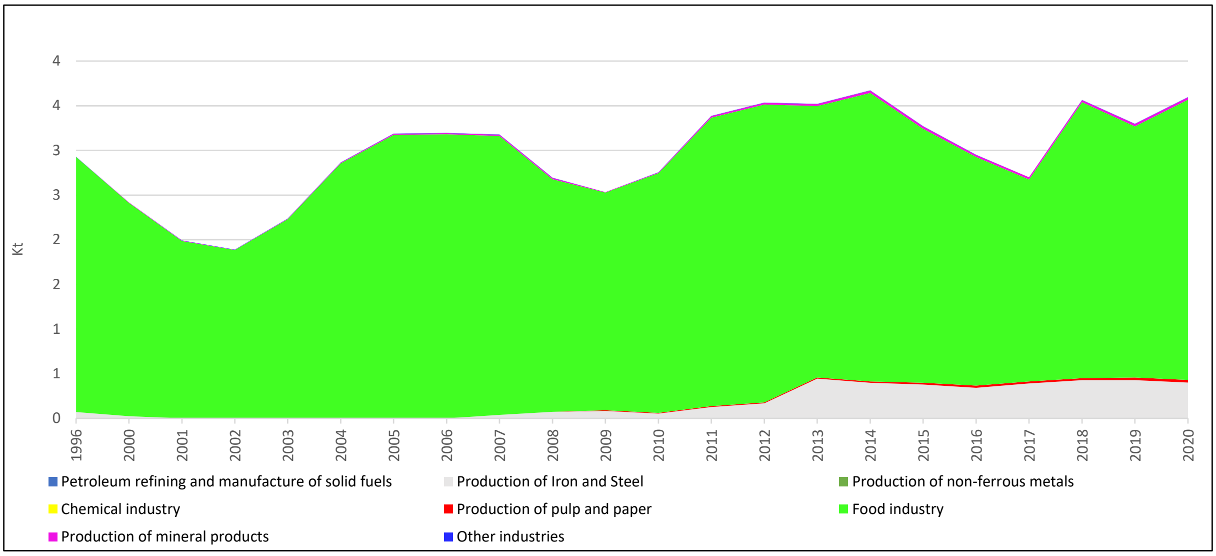


Figure 3-14: VOC emissions from industry (except solvent uses) from 2000 to 2020 in Georgia

VOC emissions from uses of solvents

The evolution of VOC emissions from solvent uses is provided in Figure 3-15. In 2020, VOC emissions are 9.5 kt. The use of solvents represents 24.6% of total VOC emissions of Georgia in 2020 [9]. Coating applications and domestic used of solvents have similar importance in total emissions (around 50/50%). Emissions from coating increase due to rising quantity of applied paints year-by-year. For VOC from solvents, the emission inventory is not yet complete as some sources using solvents are not yet estimated.

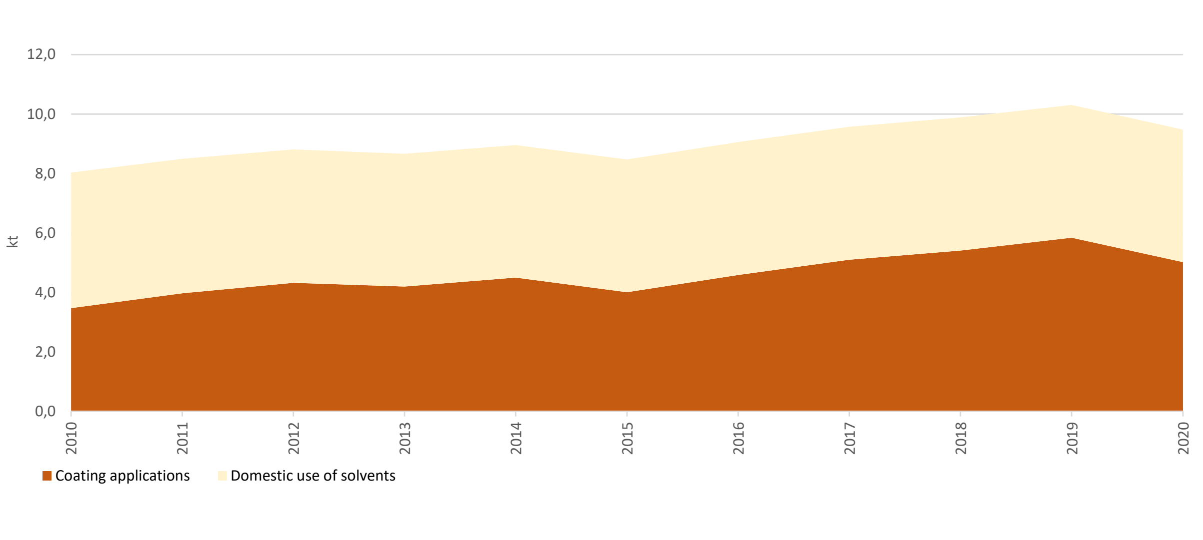


Figure 3-15: VOC emissions from solvent uses from 2010 to 2020 in Georgia

Road transport

The evolution of VOC emissions from road transport is provided in Figure 3-16. In 2020, VOC emissions are 10 kt. Road transport represents 26% of total VOC emissions of Georgia in 2020.

Increasing emissions since 2014 are related to growing petrol consumption in these years caused by increasing car fleet. Emissions of VOC from road transport have steady decreasing trend since 2016. According to the IIR [9], this is due to environmental policy in the transport sector, in particular, promotion of cleaner technologies (hybrid and electric vehicles) and increased environmental taxes for the import of fuels and old vehicles.

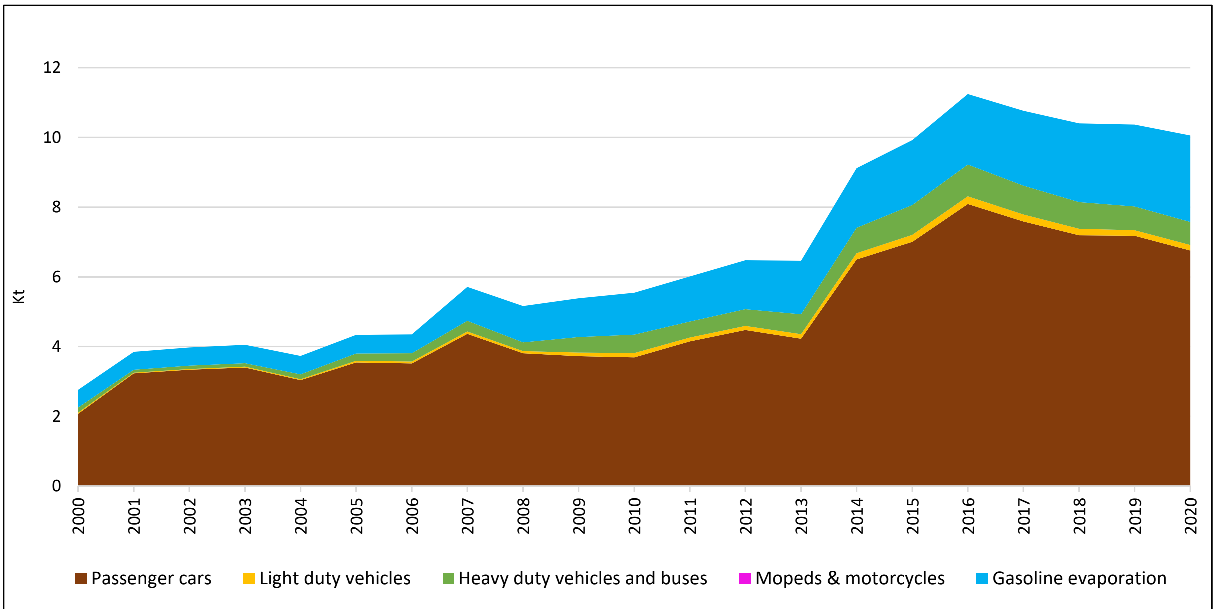


Figure 3-16: VOC emissions of road transport from 2000 to 2020 in Georgia

3.3. Situation in terms of air quality

In Georgia, ambient air monitoring is based on 8 automatic stationary stations, 1 mobile station [21] and on passive tube campaigns carried out in 25 cities. The limit values of the two EU air quality directives (EU directives 2008/50 on the Ambient Air Quality [10] and Cleaner Air for Europe and 2004/107/EC on Arsenic, Cadmium, Mercury, Nickel and Polycyclic Aromatic

Hydrocarbons in Ambient Air [37]) are in use [12] (Government Resolution n°383 (27.07.2018) on approval of European ambient air quality standards).

$PM_{2.5}$ and PM_{10} concentrations are monitored in the 8 stationary stations shared in four cities Tbilisi (5 stations), Batumi (1 station), Rustavi (1 station) and Kutaisi (1 station).

In 2019, $PM_{2.5}$ annual mean concentrations ranged from 17 µg/m^3 to 33 µg/m^3. The largest concentrations were observed in the most industrialised city of Georgia (Rustavi). PM_{10} annual mean concentrations ranged from 35 µg/m^3 in one station in Tbilisi to 62 µg/m^3 in the station of Rustavi.

In 2020, $PM_{2.5}$ annual mean concentrations ranged from 14 µg/m^3 to 31 µg/m^3 in these cities. The largest concentrations were observed in Rustavi. PM_{10} annual mean concentrations ranged from 30 to 58 µg/m^3 respectively in one station in Tbilisi and the station of Rustavi [14].

The annual limit value for $PM_{2.5}$ of 25 µg/m^3 was only exceeded in Rustavi, both in 2019 and 2020.

Average annual NO_2 concentrations from passive tube campaigns is 35 µg/m^3 with concentrations larger than the annual limit value in Tbilisi and some other cities.

With amendment to the Georgian Law on Ambient Air Protection of May 22, 2020 [15], air quality management framework is aligned with EU air quality Directive requirements [13]:

- Establishment and classification of zones and agglomerations;
- Development of ambient air quality management plans and short-term action plans in the zones and agglomerations where the problems of pollution or the risk of a problem arise;
- Continuous and timely access to information on ambient air quality data and its improvement measures for the public;

The information on air quality is publicly available from the following web site: https://www.air.gov.ge/en [16].

In 2020, a road map for development of the Air Quality Monitoring Network was elaborated in the scope of an UNDP programme and funds coming from the Swedish International Development Cooperation Agency (SIDA) [17]. It was recommended to extend the number of stations in the different zones and agglomerations to 28 to enable a better assessment of air quality. The first outline of the zones and agglomerations is ready within Air Quality Monitoring Network Development Plan (Roadmap) [17].

Zones & Agglomerations	Population
Agglomeration of Tbilisi	1.108.717
Black Sea Zone	635.480
West Zone	431.834
Central Zone	743.019
East Zone	287.122
High Zone	806.494
	4.012.666

Figure 3-17: First outline of zones and agglomerations defined for air quality management in Georgia

In terms of action plans for improving air quality, the situation is as in the following [18]:

Plans already addressed:

- State Program on Enabling Activities to Abate Ambient Air Pollution in Tbilisi, 2017-2020;
- Action Plan for Improving the Quality of Ambient Air in Rustavi, developed for the period 2020-2022.

New plans are foreseen and are as follows: Tbilisi Agglomeration 2024-2026; Central Zone 2023-2025 (including Rustavi and Marneuli), Black Sea Zone Batumi 2024-2026 (including Batumi and Poti); West Zone 2024-2026 (including Kutaisi, Zestaphoni and Chiatura).

According to the Association Agreement (AA) [8], the road map was as in the following:

For Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on ambient air quality and cleaner air for Europe, the target dates are as follows according to the articles of the directive:

- Adoption of national legislation and designation of competent authority/ies - 2020
- Establishment and classification of zones and agglomerations (Article 4) - 2022
- Establishment of a system for assessing ambient air quality in relation to air pollutants (Articles 5, 6 and 9) - 2022
- Establishment of air quality plans for zones and agglomerations where levels of pollutants exceed limit value/target value (Article 23) -2022
- Establishment of short-term action plans for zones and agglomerations in which there is a risk that alert thresholds will be exceeded (Article 24) - 2022
- Establishment of a system to provide information to the public (Article 26) - 2023

For Directive 2004/107/EC of the European Parliament and of the Council of 15 December 2004 relating to arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons in ambient air, the target dates are as follows according to the articles of the directive:

- Adoption of national legislation and designation of competent authority/ies - 2020
- Establishment and classification of zones and agglomerations (Articles 3.2) – 2024
- Establishment of an assessment regime with appropriate criteria for assessing ambient air quality in relation to air pollutants (Article 4) - 2024
- Taking measures in order to maintain/improve air quality in respect of the relevant pollutants (Article 3(1) and 3(3)) - 2025

3.4. Regulations in place to limit emissions of stationary sources and programmes for the evolution

3.4.1. Existing regulations

3.4.1.1. Industrial activities and large combustion plants

The source of information under analysis was provided by reference [14]. The regulatory framework for limitation of air emissions from industrial activities and large combustion installations is set by the Environmental Assessment (EA) Code of Georgia, hereafter EA Code [19].

A list of industrial activities subject to an Environmental Impact Assessment (EIA) as well as activities with significant effects on the environment are specifically defined in the Annex I of the EA Code [19]. The list of activities is provided in Annex II on this report.

ELVs are a significant part of the environmental decision after approval by the National Environmental Agency (NEA) and are mandatory for industrial installations.

For plants subject to an EIA:

- Emission limit values are set individually through the EIA procedure (an environmental decision made by Legal Entity of Public Law (LEPL) National Environmental Agency),
- Drafts for calculating threshold limit values of emissions (ELV) of harmful substances into the ambient air (but also other threshold limit values for the pollutants discharged in surface water along with wastewater) shall be attached to an application for obtaining a positive environmental decision,
- These ELVs are based on calculations taking into account different technical parameters such as stack height, flow rate (m^3/s), distance to the nearby settlement points, air quality standards, etc. and are set for each enterprise (installation) individually.

<u>The procedure is as in the following [14]:</u>

According to the EA Code, activities that are listed in the Annex I (Annex II of this report) or activities which are subject to the Environmental Impact Assessment (EIA) determined by the screening procedure, may only be carried out after the Environmental Decision has been made**.**

EIA procedure is implemented by the Legal Entity of Public Law (LEPL) National Environmental Agency (NEA) of the Ministry of Environmental Protection and Agriculture of Georgia.

If the implementation of the activity requires a license/permit provided for by the legislation of Georgia that depends on an Environmental Decision, and/or requires the completion of any stage of such license/permit. The license/permit may enter into force and/or the respective stage of such license/permit may be completed only after the Environmental Decision has been made. The licenses/permits provided by the legislation of Georgia may not prescribe terms and conditions which are in conflict with the Environmental Decision.

Hence, Environmental Decision is an act, which is a mandatory precondition for the implementation of activities that are subject to an EIA. Conduct of an activity subject to the Environmental Impact Assessment without an Environmental Decision or the conduct of an activity subject to a Screening procedure without a Screening Decision is fined in accordance with the Administrative Offenses Code of Georgia.

An EIA includes scoping, preparing an EIA report, public participation, carrying out consultations with competent administrative bodies, conducting site visits and preparing an expert opinion on the basis of the evaluation of the results obtained, taking account of the expert opinion during the issuance of an Environmental Decision under the EA Code and/or a respective enabling administrative act as provided by the legislation of Georgia. These stages are in line with the relevant EU Directive.

The main stages of EIA are as in the following:

- According to the EA Code, not earlier than the 26th day and not later than the 30th day after the registration of a scoping application, the Competent Authority (NEA) issues an individual administrative act on the issuance of a **scoping opinion** or, on the refusal of the carrying out of the activity. Scoping procedure defines the list of information that should be studied, as well as the means of incorporating this information in the Environmental Impact Assessment report, in order to have relevant information provided in the EIA report. EA Code determines the list of information to be provided by the developer for issuing Scoping Opinions. Moreover, public participation is ensured during the Scoping procedure.
- **Preparing an EIA report -** After issuance of the scoping opinion, the developer and/or a consulting company ensures the preparation of an EIA report. EA Code determines

the list of information to be provided in the EIA report. In addition, the methods applied in the preparation of the EIA report and the information included therein shall comply with the respective Scoping Opinion. The information required to be reflected in the EIA report is in line with the Directive 2011/92/EU of the European Parliament and of the Council of 13 December 2011 on the assessment of the effects of certain public and private projects on the environment [20].

- **Public participation -** The public has the right to, as envisaged by Article 30, EA Code participate in decision-making procedures and public participation shall be ensured in decision-making related to activities subject to an EIA. The EA Code sets out the means by which information should be disseminated on ongoing EIA procedures. The use of these mechanisms ensures effective informing of the public at an early stage and throughout the decision-making process, as required by the relevant Directives.

  According to the EA Code, information on ongoing procedures and planned public hearings are disseminated via the following means:

  - Official website of the competent authority (NEA);
  - Official website of the respective Municipality;
  - Information board of the respective Municipality;
  - Public places (bus stops, preschools, public schools, shopping centres, post offices, etc.)
  - A widely circulated newspaper.

- **Carrying out consultations with competent administrative Bodies and establishing Expert Commission** - According to the EA Code sufficient expertise is required to ensure that the information provided by the developer is complete and of a high level of quality. Within three days after an application for obtaining an Environmental Decision has been registered, NEA establishes an expert Commission to review the EIA report. A member of the expert Commission can be an expert of NEA or an institution within the Ministry's system and/or a public/independent expert provided by the legislation of Georgia. The involvement of the public experts in the decision-making process ensures the issuance of trustworthy and independent decisions. The expert Commission shall prepare and submit to NEA an expert opinion on the EIA report within 40 days after the establishment of the Commission. In issuing legal acts adopting environmental decisions, NEA reviews and if there are appropriate grounds, takes into account opinions and comments submitted by the public and any other administrative bodies in accordance with the EA Code. Furthermore, NEA ensures the involvement of the respective institutions in the administrative procedure if relevant.

- **Issuing an Environmental Decision -** According to the EA Code, not earlier than the 51st day and not later than the 55th day after the registration of an application for obtaining an environmental decision, the Competent Authority (NEA) issues an individual administrative act on the issuance of an environmental decision or, on the refusal of the carrying out of the activity. Within five days after an environmental decision or a legal act refusing the carrying out of activity has been issued, the competent authority ensures that information on the EIA report, the expert opinion, the issuance of the environmental decision or the legal act refusing the carrying out of the activity, and on the results of public participation, are published on its official website and on the notice board of the executive body and/or representative body of a respective municipality, and upon request, makes printed copies available under a procedure established by the legislation of Georgia. Unless the developer commences the activity provided for by such a decision within five years, the competent authority shall declare the environmental decision invalid.

Emission limit values are a significant part of the environmental decision after approval by National Environment Agency (NEA) and are obligatory for industrial installations to comply with.

The planned activities which are not subject to an EIA should comply with the requirements established by the environmental technical regulations and environmental standards applicable in Georgia.

The technical report on inventory of emissions of pollutants into the air from point sources shall be submitted to NEA for approval by operators (the emissions of pollutants from industrial sources are publicly available: Map of emissions of pollutants into the ambient air from stationary sources - Map.emoe.gov.ge [21]).

The governmental order n°325 (08.06.2018) of Georgia [22] on approval of the technical regulation on waste incineration and co-incineration conditions sets operational requirements and emission limit values (ELVs) for waste incineration and co-incineration plants in accordance with the chapter IV and Annex VI of the IED [25] entered partially into force on 1 September 2022. The requirements on continue self-monitoring and emission limit values will be entered into force from 1 Sept 2026 (in accordance with Eu-Georgia Association Agreement), as it is mentioned below. The technical regulation has been developed and approved on the basis of the Law of Georgia Waste Management Code [23].

It is very difficult to compare limit values implemented under this process in Georgia to limit values prescribed by technical Annexes IV, V, VI and X of the AGP as ELVs in Georgia are finally plant specific.

Nevertheless, this comparison is possible for large combustion plants (LCPs) as presented in Figure 3-18. Georgia has five gas-fired installations falling under the scope of the Large Combustion Plant Directive of 2001 [22] and Annex III of the IED [25], one of which started its operations in 2020. NOx emissions of the five LCPs are available in reference [27]. The emissions of the five plants are compliant with the provisions of the Directives, according to reference [27]: four plants with the Large Combustion Plant Directive of 2001 [22] and one plant with the IED [25].

The limit values for NOx emissions prescribed by Annex V of the AGP for LCPs were based on Annex V of the IED. The ELVs are of 100 mg/Nm^3 and are stricter than ELVs of the former EU LCP directive of 2001. The following figure presents the average concentrations in flue gases observed in the five plants compared to the limit values of the EU directives (or the LCP directive of 2001 or the IED) [27]. It seems that 3 plants on 5, comply with NOx concentrations of 100 mg/Nm^3 of Annex VIII (assuming the 0_2 content is 3% in figure 3-18.).

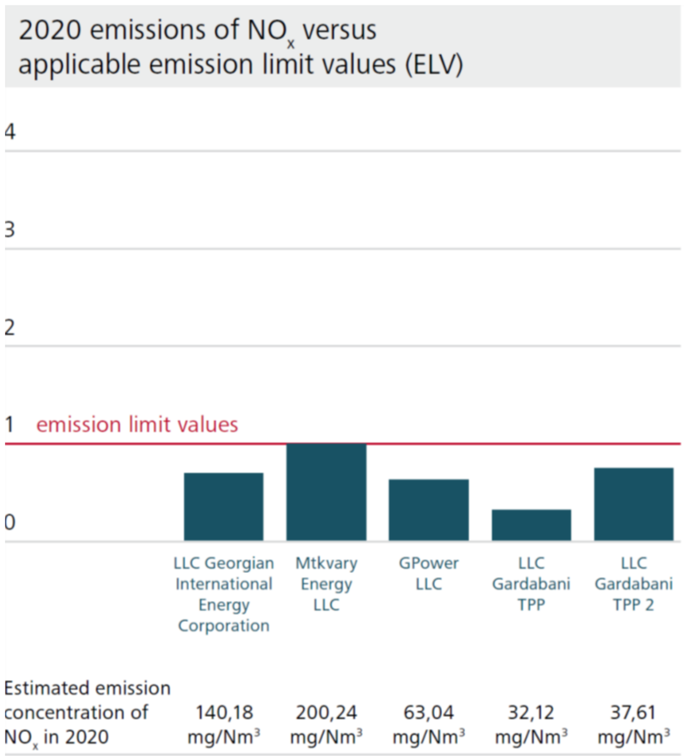


Figure 3-18: Concentrations in waste gases of the five LCPs using natural gas and comparison to limit values of the EU directives [27]

3.4.1.2. Sulphur content of gasoil and quality of fuels

With the Government Resolution n° 256 (25.03.2017) [24] on "Establishment of limit values of Sulphur content in certain liquid fuels" (such as heavy fuel, gas oil, and marine fuel) [24], the sulphur content of liquid fuels is limited as in the EU Directive 2016/802 of 11 May 2016 relating to a reduction in the sulphur content of certain liquid fuels [33].

The Sulphur content of gas oil is limited to 0.10% (per cent by weight) as in table 2 of Annex IV of the AGP [4].

3.4.2. Additional programmes to align the national regulations with several EU Directives and reduce emissions of pollutants

3.4.2.1. Industrial activities and large combustion plants

The source of the information under analysis is the one provided by the reference [14]. The concept of Best Available Techniques (BAT) is mentioned in the Laws of Georgia on Environment Protection and on Ambient Air Protection (AAP) [29], hereafter the AAP Law. According to the AAP Law, calculations of the limit values of harmful substances emissions for all industrial installations, which are also part of the environmental decision and obligatory for industrial installations to comply with, shall be based on the best available techniques, but emission limit values (ELV) are derived only from air quality parameters as described above. Therefore, the current system of the environmental decision-making does not fully correspond to the IPPC (Integrated Pollution Prevention and Control) approach and hence, to the integrated permitting system, Best Available Technique (BAT) concept and Emissions Limit Values (ELVs) established by the Directive 2010/75/EU on industrial emissions (IED) [25].

In the scope of an EU-funded Twinning project [30], a Law on Industrial Emissions and relevant by-laws were prepared. The Law on Industrial Emissions was adopted by the Parliament in June 2023 [14][53].

The Law on Industrial Emissions is fully in line with the provisions of the IED and sets a legal framework for their implementation: it introduces the IPPC principles and an integrated permit system, which is based on the concepts of BAT and emission limit values for industrial activities provided for by the Annex I of the Law (fully in line with the Annex I of IED).

The Law on Industrial Emissions defines the procedure of integrated permitting/combined procedure of EIA. NEA is responsible for integrated permitting considering the BAT conclusions as the integrated permit conditions. The Law sets requirements for monitoring/reporting and public participation.

The Law was discussed and agreed upon with relevant ministries and representatives of the business sector (approximately, 200 IED operators are identified) subject to regulation by the new IED requirements before being finally adopted in June 2023 [14].

By-laws on combustion plants, on waste incineration and co-incineration, on installations and activities using solvent shall be adopted by 1 September 2025 [55]. These by-laws include several special provisions, such as:

- For the large combustion plants: the draft by-law set operational conditions and ELVs for combustion plants with a total rated thermal input of 50 MW_{th} or more in accordance with the chapter III and Annex V of IED;
- For the installations and activities using organic solvents: the draft by-laws set solvent consumption thresholds and ELVs for installations and activities using organic solvents in accordance with the chapter V and Annex VII of IED.

Five EU BAT Conclusions have been translated into Georgian (LCPs, production of cement, lime and magnesium oxide, waste incineration, iron and steel plants and intensive rearing of poultry or pigs) [55]. A by-law on BAT conclusions shall be adopted by 1 September 2025 [55].

The Integrated permitting system will enter into force gradually from March 1, 2024 to September 1, 2026 for new installations with activities in Annex I of the Law on industrial emissions (similar to Annex I of the IED) [14][55].

Existing installations covered by the Law, will require an integrated permit, according to the following deadlines [55]:

- Energy production - until March 1, 2029
- Production and processing of metals - until September 1, 2029
- Processing of mineral raw materials - until March 1, 2030
- Chemical industry - until September 1, 2030
- Waste management, incineration and co-incineration plants - until March 1, 2031
- Other types of activity - until September 1, 2031.

The frequency of facility inspections is based on environmental risk assessment and should not exceed 1 year for the highest risk activities and 3 years for the lowest risk activities. In case of significant non-compliance with the conditions of the integrated permit during the inspection, inspection must be carried out again within 6 months of this inspection [55]. Several ministerial orders shall be issued by 1 January 2026 on templates for integrated permit application and for permit and on risk assessment for planning inspections.

It is likely that the full implementation of IEDs will be possible by 2031.

3.4.2.2. Petrol storage and distribution from terminals to service stations

Storage and distribution of petrol, excluding the loading of seagoing ships (stage I)

Programmes are currently being implemented to comply with the requirements of the EU regulation 94/63/EC on the control of VOC emissions resulting from the storage of petrol and its distribution from terminals to service stations (or Stage I) [31] (and consequently, Annex VI, table 1 of the AGP) [12][14]. The directive is indeed under the scope of the EU Georgia association agreement [8]:

- The inventory of petrol storage terminals has been conducted,
- The capacity of Georgia's existing petrol distribution system to fulfil new requirements on VOCs (based on EU Directive) has been assessed.

The introduction of legal requirements on petrol storage and distribution is currently ongoing. The dates foreseen for full implementation for service stations and terminals are as follows:

Stage I petrol vapour recovery at petrol stations:

- All new stations with a throughput larger than 100 m^3/y from 2024,
- At least 90% of existing stations equipped in 2029.

Relevant petrol vapour recovery systems in terminals:

- All new terminals from 2024,
- Existing terminals in with a throughput larger than 25,000 tonnes by 2029,
- All existing terminals in 2032.

Relevant petrol vapour recovery systems in tankers:

- All road tankers equipped properly from 2024,
- Rail tankers and vessels loading/unloading on terminals with a throughput larger than 25,000 tonnes in 2029,
- All rail tankers and vessels in 2032.

Car refuelling at petrol stations (stage II)

The introduction of legal requirements for car refuelling at petrol stations [35], or alignment with Directive 2009/126/EC of 21 October 2009 on Stage II petrol vapour recovery during refuelling of motor vehicles at service stations (considered in table 2 of Annex VI of the AGP) is not yet started [14]. The Stage II Directive is not under the scope of the EU Georgia association agreement [8].

3.4.2.3. Use of organic solvent in certain paints and varnishes

The limit values for VOC concentrations in certain paints and varnishes in Annex XI of the AGP were based on limit values prescribed by the directive 2004/42/EC on the limitation of emissions of volatile organic compounds due to the use of organic solvents in certain paints and varnishes and vehicle refinishing products [33]. The Directive is under the scope of the EU

Georgia association agreement [8]. Programme was implemented to transpose the requirements of the Directive 2004/42/EC [14] in the Georgian legal framework.

According to reference [14].

- The capacity of Georgia's existing paint production and distribution system to fulfil the requirements on VOCs of the EU Directive 2004/42/EC have been assessed.
- The introduction of legal requirements on use of organic solvents in paints and varnishes to reduce VOCs emissions based on EU Directive 2004/42/EC in the Georgian legal framework is finalised. The corresponding by-law on solvents in paints and varnishes was adopted by the Government of Georgia on 3 April 2024 and will be entered into force from 1 July 2025 [14] [56].

3.5. Regulations in place to limit emissions of mobile sources and programmes for the evolution

3.5.1. Road vehicles

Vehicles are not produced in Georgia. Thus, emission limit values have to regulate imports. The vast majority of vehicles in Georgia are imported from the USA, and almost all of them are second-hand cars. Up to now, limit values for mobile sources were not established in Georgia [14]. Studies have been carried to examine what policy options could be selected to reduce pollutant emissions from cars. In particular, to determine which limit values (Euro 5 or Euro 6) are feasible in Georgia, a related feasibility study was carried out with the support of UNEP, which showed that the introduction of the Euro 5 standards for passenger cars and heavy-duty vehicles is realistic and effective in Georgia. Georgia is currently working with the relevant state authorities (Ministry of Internal Affairs, LEPL, Land Transport Agency, Customs Department, etc.) to identify enforcement measures [14]. This project [34] "Phase II of the Sustainable Low Emissions Transport for Georgia" focused on the development of vehicle emission standards to promote a global transition to no-and low-emissions mobility for improved air quality and climate change mitigation. A cost-benefit analysis to assess the potential economic impacts of introducing import restrictions based on EU vehicle emission standards in Georgia has been carried out [35].

By the Government Decree N238 adopted on 28 June 2023 [40], EURO 5b equal emission standards have been established to first registration of vehicles (which is almost equal to imports, since Georgia does not produce cars). The requirements of the Decree entered into force from 1 January 2024 for M1 and M2 category vehicles and will be entered into force from 1 January 2025 for M3, N1, N2, N3 categories (This date could be postponed of one year according to [14]).

3.5.2. Non-road mobile machinery, locomotives and rail cars, inland waterways

At this stage, limit values for non-road mobile machinery are not established in Georgia. There are not yet activities in this direction [14].

3.5.3. Motor cycles and mopeds

At this stage limit values for motorcycles and moped are not established in Georgia. There are not yet activities in this direction [14].

3.5.4. Petrol and diesel fuel quality

Specifications of petrol and diesel from table 13 and 14 of Annex VIII of the AGP are derived from Directive 2009/30/EC of the European Parliament and of the Council of 23 April 2009 amending Directive 98/70/EC as regards the specification of petrol, diesel and gasoil [37].

Petrol:

Since 1 January 2017, in Georgia Euro 5 standard is required for petrol. The characteristics of petrol are as in the following [14]:

Research octane number	–	91	95	98
Aromatics	%	35		
Benzene	%	1		
Sulphur content	**mg/kg**	**10**		
Lead	mg/l	5		

From 1 January 2021, the national petrol standards were completed with further components, as in the following [14]:

Reid vapour pressure, summer period	kPa	80
Distillation:		
Evaporated at 100°C	% v/v	46
Evaporated at 150°C	% v/v	75

From 1 July 2021, additional components were added as in the following [14]:

Olefins	% v/v	18.0
Oxygen content	% m/m	3.7
Oxygenates:		
Sulphur content	mg/kg	10
Lead	mg/l	5
Methanol, stabilizing agents must be added	% v/v	3
Ethanol, stabilizing agents may be necessary	% v/v	5
Parameter:		
Iso-propyl alcohol	% v/v	10

Tert-butyl alcohol	% v/v	10
Iso-butyl alcohol	% v/v	7
Ethers containing 5 or more carbon atoms per molecule	% v/v	15
Other oxygenates	% v/v	10

To summarize, currently Georgian petrol quality standard is in line to the Euro 5 standard. There is one difference related to the Reid vapour pressure in summer period which is 80 kPa in Georgia and of 60 kPa in table 13 of Annex VIII of the AGP and allowed research octane number starts from 91 instead from 95.

Diesel

Since 1 January 2019, in Georgia Euro 4 standard was required for diesel fuel [38] . In particular [14]:

Cetane number	–	48
Density at 15°C	kg/m3	845
Polycyclic aromatic hydrocarbons	% m/m	11
Sulphur content	mg/kg	50

From 1 March 2021, additional components were added in the national diesel fuel standards, as in the following [14]:

Distillation point: 95%	°C	360
Flash point	°C	Above 55
Water content	mg/kg	200

From 1 January 2023, Euro 5 standard entered into force for diesel fuel as well, as prescribed in corresponding Governmental decree n°238 [40]. In particular [14]:

Cetane number	–	51
Density at 15°C	kg/m3	845
Distillation point: 95%	°C	360
Polycyclic aromatic hydrocarbons	% m/m	11
Sulphur content	**mg/kg**	**10**
Flash point	°C	Above 55
Water content	mg/kg	200

There is only one difference in PAH concentration which is 11 % m/m in Georgia and of 8 % m/m in table 14 of Annex VIII of the AGP.

From 1 January 2023, Georgia regulation for petrol and diesel is aligned with characteristics of petrol and diesel currently available in tables 13 and 14 of Annex VIII of the Gothenburg Protocol.

3.6. Technological pathways

In Georgia, PM_{10} and $PM_{2.5}$ are the main air quality problem with concentrations of PM_{10} and $PM_{2.5}$ in ambient air which exceed the air quality limit values in several cities. Georgia faces also high concentrations of NO_2 and exceedances of the average NO_2 annual limit value (40 $\mu g/m^3$) in several cities.

Policies to reduce air pollution and improve air quality should focus in priority on the main sources of PM and especially residential heating with fossil or biomass solid fuels. The sector "other combustion stationary sources" which include this type of source, represents 7.25 kt of $PM_{2.5}$ in 2020 or 77 % of total $PM_{2.5}$ emissions in Georgia [9]. In this sector, residential heating itself represents 77% of total $PM_{2.5}$ emissions (refer to chapter 3.2.3).

In terms of NOx emissions, road transport is the largest source and represents 41% of total NOx emissions in Georgia. Large combustion installations for the production of electricity use natural gas. The second largest source of NOx emissions is industry with 7.5 kt or 16 % of total emissions (refer to chapter 3.2.3).

As a Party to the CLRTAP, Georgia is however determined to contribute to the overall aim of the Convention, i.e. to limit and, as far as possible, gradually reduce and prevent air pollution including long-range transboundary pollution [6]. Georgia is working for the development of regulations and improvement of air quality. In this aim, Georgia is working for alignment of its national policies in link with the quality of fuels, petrol distribution and industries with many EU directives or regulations, which were in most cases, the basis for the definition of limit values prescribed by the technical Annexes IV, V, VI, X and XI. Georgia is currently engaged in an Association Agreement (AA) between the European Union and the European Atomic Energy Community and their Member States, of the one part, and the Republic of Georgia, of the other part [8]. The Agreement defines the road map for several key EU directives with among them:

a) Directive 2008/50/EC of 21May 2008 on ambient air quality and cleaner air for Europe,
b) Directive 2004/107/EC of 15 December 2004 relating to arsenic, cadmium, mercury, nickel, and polycyclic aromatic hydrocarbons in ambient air,
c) Directive 2010/75/EC of 24 November 2010, on Industrial Emissions (IED),
d) Directive 1994/63/EC of 20 December 1994 on the control of VOC emissions resulting from the storage of petrol and at distribution from terminals to service stations Stage I Petrol vapour recovery and Directive 2009/126/EC of 21 October 2009 on Stage II petrol vapour recovery during refuelling of motor vehicles at service stations,
e) Directive 1999/32/EC of 26 April 1999 relating to a reduction of sulphur content of certain liquid fuels,
f) Directive 2004/42 on the limitation of emissions of volatile organic compounds due to the use of organic solvents in certain paints and varnishes and vehicle refinishing products.

For stationary sources and petrol and diesel characteristics, the legal framework for adoption of EU standards similar to limit values of the technical Annexes or even stricter, is well advanced and key Laws and by-laws have been adopted or will be adopted soon:

- The Law on Industrial Emissions has been adopted by the Parliament in June 2023 [14], [55] which transposes the IED directive. Several bylaws shall be adopted by 1 September 2025 [55].
- For diesel, the sulphur content is limited to 0.001% from the first January 2023, by the Government Decree N238 adopted on 28 June 2023 [40] which imposes not only minimum euro 5b standards for imported vehicles but also characteristics of fuels.
- The introduction of legal requirements on use of organic solvents in paints and varnishes to reduce emissions of VOCs based on EU Directive 2004/42/EC was completed. The corresponding by-law was adopted by the end of 2023 and entered into force from 1 January 2024 [14].

The introduction of legal requirements on petrol storage and distribution is currently ongoing. The dates foreseen for enforcement for service stations, terminals and tankers range from 2024 to 2023.

The development of the legal framework is however, not yet started for car refuelling at service stations.

For mobile sources under the scope of Annex VIII of AGP, the situation is as follows:

- Georgia does not produce road vehicles but imports them. By the Government Decree N238 adopted on 28 June 2023 [40], EURO 5b equal emission standards have been established. That means to restrict imports of vehicles with lower standard emissions. The requirements of the Decree will be entered into force in two steps: from 1 Jan 2024 for M1 and M2 category vehicles; from 1Jan 2025 for M3, N1, N2, N3 categories [14].
- At this stage, limit values for non-road mobile machinery, motorcycles and mopeds and other engines installed on locomotives, inland water vessels or recreation crafts are not established in Georgia. There are not yet activities in this direction [14].

The chapter 8 presents the techniques to comply with limit values introduced by Annexes IV for SO_2, V for NOx, VI for VOC, X for PM and XI for solvents in products [4]. In this technical pathway, the focus is only made on the largest emitters for which reduction measures would be rapidly necessary.

<u>For large combustion plants using natural gas</u>, the reduction techniques available for abating NOx emissions are as in the following (chapter 8.2.).

The means to achieve the limit values are the application of one or a combination of the following techniques [51][52]:

- combustion optimisation
- low-NOx burners (LNB)
- air staging
- fuel staging
- flue-gas recirculation
- selective non-catalytic reduction (SNCR)

- selective catalytic reduction (SCR)

For **PM emissions from domestic heating appliances using coal or biomass**, the use of the most efficient appliances in term of emissions and energy efficiency is essential but technological solutions are not sufficient. The “Code of good practices for wood burning and small combustion installations” [45] developed by TFTEI, the report “Prioritizing reductions of particulate matter from sources that are also significant sources of black carbon - analysis and guidance” [44] developed by TFIAM and the report “Review on Black Carbon (BC) and Polycyclic Aromatic Hydrocarbons (PAHs) emission reductions induced by PM emission abatement” [61] developed by TFTEI provide excellent overview of policies to be implemented beyond the technical characteristics of appliances. The thematic session on residential wood combustion and air pollution of 56th WGSR in May 2018, is also useful for inspiring ideas in this field [62]. The last TFTEI report on the review of limit values of technical Annexes IV, V, VI, X and XI of the AGP also provides useful information [45].
Annex X of the AGP, recommends emission limits of PM for small appliances. These limit values could be a good starting point for the production of new appliances with improved performances and lower emissions. In terms of domestic appliances and combustion, the reduction of PM emissions can be pursued through optimisation of the combustion conditions, by several means, to ensure the best optimized conditions in terms of temperature, residence time (sufficient time is required) and turbulence (to ensure good mixing of flue gases) (the three T’s rules), but also the geometry of the combustion chamber, air supply and reducing the user’s intervention, by the combustion automated systems. The solutions for these three T’s parameters can be applied in different types of appliances, especially stoves [45].

Temperature:

- Refractory lining in the combustion chamber,
- Shape and size of combustion chamber,
- Material and isolation of the door as well as size of window and its radiation coefficient or alternatively coated glasses or double/triple windows with air chambers in between,
- Windows should be of appropriate limited size.

Sufficient residence time:

- Gas volume flow,
- Distribution of flue gases over combustion chamber,
- Distribution of air,
- Height and width of the combustion chamber.

Turbulence or mixing of flue gasses:

- Distribution of purge air windows,
- Direction and geometry of additional inlet air,
- Velocities of flue gas and combustion air,
- Geometry of the main and the post combustion chamber,

- Geometry of deflection plate and the use of baffles in post combustion chamber,
- Avoidance of leakage streams (sealing),
- Avoidance of short-circuiting of the flue gas stream.

The reduction of emissions from small domestic appliances is also dependent on energy efficiency of housing. Policies implemented to increase energy efficiency in housing have co-benefits in terms of air pollution by decreasing the fuel demand and consequently the emissions.

For **industrial processes emitting SO_2, NOx and or PM covered by Annexes IV, V and X,** Chapters 8.1 for SO_2 reduction techniques, 8.2 for NOx reduction techniques and 8.4 for PM reduction techniques present the BAT. For PM, BAT to comply with limit values of the AGP are electrostatic precipitators and bag filters. Other types of dedusters such as scrubbers are also available but are less used. The efficiency of these techniques is optimum when they are correctly dimensioned.

For the **uses of solvents in industry**, chapter 8.3. details the techniques available to comply with limit values. They are based on primary measures such as low solvent content, water borne or solvent free products, higher efficient means of application and secondary measures such as thermal or catalytic oxidation, activated carbon adsorption, biological scrubbing. Good solvent management systems with identification and quantification of the relevant solvent inputs and outputs are recommended. They can be used to set targets in terms of VOC emission reduction and track progress. Hazardous solvents should be substituted in priority by non-hazardous products

For **road vehicles**, significant progress has been made recently with the Government Decree N238 adopted on 28 June 2023 [40] establishing EURO 5b as minimum standard for first registration of used and new vehicles. This is an important steps. According to reference [36], 83% of registered cars (1.47 million) are 10 years or older; 23% are more than 30 years old.

It could be recommended to continue to develop the legal framework to go further (such as Euro 6c and 6d for light duty vehicles based on real driving condition test procedure (TFTEI review of limit values of Annex VIII [46]).

Many different approaches can also be implemented to reduce emissions from road transport. Measures such as development of public transport (insufficiently developed according to reference [36]), improvement of their attractiveness, incentives to use public transport, development of car sharing schemes, promotion of walking and cycling in cities with development of bike lanes, can be foreseen. These measures enable an integrated approach that can provide benefits for improving air quality and reducing GHG emissions. The use of new generation vehicles and development of electromobility in traffic can also be envisaged.

Non-Road Mobile Machinery (NRMM) represent 0.7 % of total NOx emissions and 0.2 % of total $PM_{2,5}$ emissions in 2020. Even if emissions are very low, limit values to regulate imports would be necessary. It can be recommended to start developing the legal framework for introducing of the standards of Annex VIII (corresponding to EU Directive 97/68/EC of 16 December 1997 on the approximation of the laws of the Member States relating to measures against the emission of gaseous and particulate pollutants from internal combustion engines to be installed in non-road mobile machinery) or possibly, develop the legal framework for introducing the newest standards of the EU Directive 2016/1628 of 14 September 2016 on requirements relating to gaseous and particulate pollutant emission limits and type-approval for internal combustion engines NRMM, amending Regulations (EU) 1024/2012 and (EU) 167/2013, and amending and repealing Directive 97/68/EC.

3.7. References of chapter 3 Georgia

[1] Convention on Long-Range Transboundary Air Pollution (CLRTAP). https://unece.org/sites/default/files/2021-05/1979%20CLRTAP.e.pdf

[2] Status of ratification of the Convention on Long-range atmospheric pollution.: https://treaties.un.org/Pages/ViewDetails.aspx?src=TREATY&mtdsg_no=XXVII-1&chapter=27&clang=_en

[3] EMEP Protocol. Status of ratification: https://treaties.un.org/Pages/ViewDetails.aspx?src=TREATY&mtdsg_no=XXVII-1&chapter=27&clang=_en

[4] Economic Commission for Europe, Executive Body for the Convention on Long-range Transboundary Air Pollution, 1999 Protocol to Abate Acidification, Eutrophication and Ground-level Ozone to the Convention on Long-Range Transboundary Air Pollution, as amended on 4 May 2012, 2012

[5] Protocols of the CLRTAP. Status of ratification: https://unece.org/protocols - Web site accessed in January 2023

[6] UNECE 2018. Georgian National Action Plan for ratification of CLRTAP protocols and fulfilment of corresponding commitments

[7] UNECE 2018. Georgia. Development of cost-benefit analysis of consequences and risks from ratification and implementation of the latest three protocols to CLRTAP. 2018

[8] Association Agreement between the European Union and the European Atomic Energy Community and their Member States, of the one part, and Georgia, of the other part. Last version of 15/11/2023. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:02014A0830(02)-20231115

[9] Georgia informative inventory report to LRTAP Convention for 1990-2020 and NFR tables 1990-2020 https://www.ceip.at/status-of-reporting-and-review-results/2022-submission

[10] Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on ambient air quality and cleaner air for Europe. https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A32008L0050 2004/107/

[11] 2004/107/EC of the European Parliament and of the Council of 15 December 2004 relating to arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons in ambient air. https://eur-lex.europa.eu/eli/dir/2004/107/oj

[12] Georgia - Government Resolution n°383 of 27.07.2018 on approval of the technical regulation on approval of ambient air quality standards

[13] Akhalaia, M. Arabidze. *Air Quality Data Policy in Georgia . Health-relevant air quality data informing policy and the public*. SEIS and the environmental dimension of the SDGs webinar series. Improved environmental monitoring and assessment in support of the 2030 Sustainable Development Agenda in South-Eastern Europe, Central Asia and the Caucasus, December 16, 2020

[14] N. Megrelishvili. Communication to Citepa July, September and November 2022 and first semester 2023

[15] Georgian Law on Amendments to the Georgian Law on Ambient Air Protection of May 22, 2020, N 5948-სს

[16] information on air quality https://www.air.gov.ge/en

[17] Giorgio Arduino. Georgia's air quality monitoring network development plan (Road map). UNDP, 2020

[18] Noe Megrelishvili. Developments of Georgia in Ambient Air Quality Management. UNECE Convention on Long-range Transboundary Air Pollution Joint Meeting of the EECCA Coordinating Group and the Task Force on Techno-Economic Issues (TFTEI). 26 April 2021

[19] Enterprise Georgia. Environmental impact assessment. 2019

[20] Directive 2011/92/EU of the European Parliament and of the Council of 13 December 2011 on the assessment of the effects of certain public and private projects on the environment.

[21] Lasha Akhalia. Overview of existing environmental monitoring an assessment system in Georgia and latest developments on this regard. UNECE Working Group on Environmental Monitoring and Assessment, 34th session. Geneva 11-12 April 2022

[22] Georgia. Governmental order n°325 of 08.06.2018 on approval of the technical regulation on waste incineration and co-incineration conditions

[23] Georgia. Georgian Law - Waste Management Code of 26 December 2014, N 2994-რს

[24] Georgia. Government Resolution n° 256 of 25.05.2017 on Establishment of limit values of Sulphur content in certain liquid fuels

[25] European Commission, Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control)

[26] Directive 2001/80/EC of the European Parliament and of the Council of 23 October 2001 on the limitation of emissions of certain pollutants into the air from large combustion plants. https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32001L0080&from=EN

[27] Energy Community. Georgia, Annual Implementation Report, 1 November 2021

[28] Directive (EU) 2016/802 of the European Parliament and of the Council of 11 May 2016 relating to a reduction in the sulphur content of certain liquid fuels https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32016L0802

[29] Law of Georgia on Ambient air protection. https://matsne.gov.ge/en/document/view/16210?publication=14

[30] Twinning project implemented by Spain, Netherlands and Czech Republic with Georgian Ministry of Environment and Natural Resources Protection to establish environmental permit and dangerous substance accident prevention systems. 2018-2019 https://www.eeas.europa.eu/node/32606_en

[31] European Parliament and Council Directive 94/63/EC of 20 December 1994 on the control of volatile organic compound (VOC) emissions resulting from the storage of petrol and its distribution from terminals to service stations. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:31994L0063

[32] Directive 2009/126/EC of the European Parliament and of the Council of 21 October 2009 on Stage II petrol vapour recovery during refuelling of motor vehicles at service stations, 2009

[33] Directive 2004/42/CE of the European Parliament and of the council of 21 April 2004 on the limitation of emissions of volatile organic compounds due to the use of organic solvents in certain paints and varnishes and vehicle refinishing products and amending Directive 1999/13/EC

[34] https://cennorg.w3i.app/towards-sustainable-low-emissions-transport-in-georgia/

[35] Cost benefit analysis for euro standard

[36] Heinrich-Böll-Stiftung. Air Pollution Regulation in Georgia: Current Needs and Policies. December 2022. https://ge.boell.org/en/2022/12/15/atmosperuli-haeris-dabindzurebis-kontroli-sakartveloshi-arsebuli-politika-da

[37] Directive 2009/30/EC of the European Parliament and of the Council of 23 April 2009 amending Directive 98/70/EC as regards the specification of petrol, diesel and gas-oil and introducing a mechanism to monitor and reduce greenhouse gas emissions and amending Council Directive 1999/32/EC as regards the specification of fuel used by inland waterway vessels and repealing Directive 93/12/EEC
https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32009L0030

[38] Georgia. Governmental Resolution n°238 of 28.12.2005 on diesel fuel composition norms, analysis methods and their implementation measures

[39] Georgia. Governmental Resolution n° 124 of 31.12.2004 on quality norms of motor petrol

[40] Georgia. Governmental Resolution n°238 of 28.06.2023 on approval of the maximum allowable norms for the emission of various types of transport and other mobile mechanical means polluting the atmospheric air with harmful substances in the territory of Georgia provided for by the European Union legislation

[41] Code of good practice for wood-burning and small combustion installations, 2019. https://unece.org/DAM/env/documents/2019/AIR/EB/ECE_EB.AIR_2019_5-1916518E.pdf

[42] Prioritizing reductions of particulate matter from sources that are also significant sources of black carbon - analysis and guidance, 2021. https://unece.org/sites/default/files/2021-10/ECE_EB.AIR_2021_6-2113500E.pdf

[43] B. Bessagnet, N. Allemand, Review on Black Carbon (BC) and Polycyclic Aromatic Hydrocarbons (PAHs) emission reductions induced by PM emission abatement, TFTEI 2019

[44] WGSR 56th. May 2018. Thematic session on residential wood combustion and air pollution. https://unece.org/info/Environmental-Policy/Air-Pollution/events/20267

[45] TFTEI background informal technical document for the Review of the Gothenburg Protocol for Industrial Processes Annexes IV, V, VI, X and XI. March 2022.

https://unece.org/environment/documents/2022/03/informal-documents/agenda-item-4-review-Annexes-iv-vi-x-xi-gothenburg

[46] TFTEI Techno-Scientific Board. TFTEI background informal technical document for the Review of the Gothenburg Protocol for mobile sources, Annex VIII. August 2023. Informal document to the 61st WGSR in September 2023. https://unece.org/sites/default/files/2023-08/TFTEI-

%20Informal%20bakground%20document%20on%20review%20of%20Annex%20VIII%20-%20Mobile%20Sources%20of_0.pdf

[47] T. Nussbaumer, Overview on technologies for biomass combustion and emission levels of particulate matter, prepared for the Swiss Federal office for the Environment and TFTEI, 2010

[48] European Commission, Directive 2009/125/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for the setting of Eco-design requirements for energy-related products, 2009

[49] European Commission, Commission regulation (EU) 2015/1185 of 24 April 2015 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to Eco-design requirements for solid fuel local space heaters, 2015.

[50] European Commission, Commission regulation 2015/1189 of 28 April 2015 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to Eco-design requirements for solid fuel boilers with a rated heat output of 500 kilowatt or less, 2015

[51] TFTEI background document Guidance document on control techniques for emissions of sulphur, NOx, VOC, and particulate matter (including PM_{10}, $PM_{2.5}$ and black carbon) from stationary sources. ECE/EB.AIR/117. 2012. https://unece.org/gothenburg-protocol

[52] T. Lecomte, J.F. de la Fuente, F. Neuwahl, M. Canova, A. Pinasseau, I. Jankov, T. Brinkmann, S. Roudier, L. Delgado-Sancho, Best Available Techniques (BAT) Reference Document for Large Combustion Plants: Industrial Emissions Directive 2010/75/EU (Integrated Pollution Prevention and Control) 2017

[53] goecohub.ge/en/2023/03/31/nino-tandilashvili-submitted-the-draft-law-on-industrial-emissions-for-consideration-in-parliament/

[54] https://parliament.ge/en/media/news/parlamentma-samretsvelo-emisiebis-shesakheb-kanonproekti-mesame-mosmenit-miigho

[55] V. Metreveli. Recent policy changes for combustion sectors and industrial sources and status of BAT application. BAT Workshop. Paris 15 to 16 October 2024.

[56] By-law N°127 on the solvents in paints and varnishes of 3 April 2024

4. Kazakhstan

This part of the report dedicated to Kazakhstan was produced with the support of local experts:

Dana Agybaeva, Chief Expert of the Department of State Metrological and Analytical Control of the Committee for Environmental Regulation and Control of the Ministry of Ecology, Geology and Natural Resources of the Republic of Kazakhstan

Botagoz Ibrayeva, former Head of the Analytical Department of Reference Books on BAT, Bureau of Best Available Techniques NJSC «International Green Technologies and Investment Projects Centre

Gaukhar Yensebayeva, Senior Manager of the Analytical Department of BAT Reference Books, Bureau of Best Available Techniques NJSC «International Green Technologies and Investment Projects Centre

Ekaterina Nikiforova, Eurasian GHG Management LLP, CLRTAP inventory compiler of Republic of Kazakhstan.

Kalmykov Dmitry, Development Director of Karaganda Regional Ecological Museum (NGO - public association), CLRTAP inventory compiler of Republic of Kazakhstan

Aigul Malikova, Director of Karaganda Regional Ecological Museum, CLRTAP inventory compiler of Republic of Kazakhstan

Alexander Cherednichenko, representative of Zhasyl Damu, former CLRTAP inventory compiler of Republic of Kazakhstan

They provided helpful information from June 2022 to January 2024 on industrial and transport emission sources, air quality, and emission regulations by responding to questionnaire, e-mail exchange and during several meetings [1].

4.1. Status of ratification of CLRTAP and its Protocols and strategic programmes

Kazakhstan is a Party to the Convention on Long-Range Transboundary Air Pollution (CLRTAP) with its ratification on 11 of January 2001 [2]. It has, however, neither signed nor ratified any of the Protocols to the CLRTAP [3]. Notwithstanding, Kazakhstan submits its emission inventories to the Centre on Emission Inventories and Projections (CEIP) [4],[5]. Since 2020, Kazakhstan submits the structured Informative Inventory Report (IIR) that explains the methodologies and activity data used in emissions reporting, as well as the associated uncertainties, quality assurance and quality control procedures implemented, and the NFR tables.

To enhance the country's capacity to adhere to the CLRTAP protocols and meet the corresponding commitments, a detailed draft "Kazakhstan National Action Plan for ratification of CLRTAP protocols and fulfilment of correspondent commitments" was developed by UNECE with the 31/12/2024 preliminary deadline [6]. It concerns, the 1998 Protocol on Persistent Organic Pollutants (POPs), the 2012 amended Protocol to Abate Acidification, Eutrophication and Ground-level Ozone, and the 1998 Protocol on Heavy Metals. However, up to now the action plan has not been approved by the competent authority of the Republic of Kazakhstan [1].

Several strategic documents were adopted by Kazakhstan during the last years to reduce air emissions. One of them is the strategy "Kazakhstan 2050: A New Political Course of the Established State" (hereafter "Kazakhstan 2050' strategy") adopted in 2012 [7]. It sets ambitious goals for sustainable development and Kazakhstan's transition to a low-carbon economy, providing, that by 2050:

- alternative and renewable energy sources (RES) should account for at least 50 % of total energy consumption;
- Kazakhstan should fully upgrade its production facilities and assets in line with the latest technological standards.
- In addition, all mining companies should practice environmentally responsible production.

And by 2025, the local market should provide transport fuels that meet the latest environmental standards.

In 2013, the Concept for Transition of the Republic of Kazakhstan to Green Economy (hereafter the Concept) was adopted [8]. The Concept builds on the "Kazakhstan 2050" strategy" and sets specific sectoral targets. Table 4-1 presents the energy and air emissions related targets included in the concept.

Table 4-1: Energy and air emissions related targets included in the Concept

Sector	Target description	2020	2030	2050
Energy efficiency	Reduction of energy intensity of GDP from 2008 levels	25%	30%	50%
Power sector	Share of alternative sources (solar, wind, hydropower, and nuclear) in electricity production	Solar and wind not less than 3%	30%	50%
	Share of gas power plants in electricity production, including switching of coal to gas in large cities provided that gas supply is secured at a reasonable price level	20%	25%	30%
	Gasification of regions	Akmola and Karaganda	Northern and eastern regions	
Air pollution	Reduction of SOx and NOx emissions		European levels of emissions	

To achieve the targets highlighted in Table 4-1, the Concept outlined areas of interventions, such as energy efficiency, cleaning of industrial processes, and so on. It estimates that the largest improvement in energy efficiency can be achieved in the residential sector through insulation of homes, among other measures. The second important sector for energy efficiency improvements and emission reduction is replacing old boilers in thermal power (TPPs) and combined heat and power (CHP) plants with new, more efficient ones.

In terms of increasing the share of RESs in energy generation, the concept projects commissioning of 4.6 GW of wind and 0.5 GW of solar capacity by 2030 so that solar and wind account for 10% of the electricity generation in Kazakhstan in 2030.

A key measure to reduce air pollution outlined in the Concept is the installation of dedusting and desulphurization equipment at coal power plants, as well as converting CHPs in large cities from coal to gas. In general, the Concept envisions developing and implementing emission standards and control mechanisms similar to the ones in the EU.

Since 2018 “Strategic Plan for Development until 2025” [9] features green economy and environmental protection as specific policies. It also lists the achievement of Kazakhstan’s commitments under the Paris Agreement, continuing work on decarbonizing the economy and promoting investment in green technologies and RES development, among specific tasks. Despite the outlined specific tasks, the plan includes only two indicators related to the environment, they are GDP energy intensity and share of RESs.

4.2. Main sources of emissions

This chapter presents the main sources of SO_2, NOx, PM_{10}, $PM_{2.5}$ and VOC emissions in the Republic of Kazakhstan. The dynamics of air pollutant emissions presented here, was built by TFTEI based on the emission data submitted by Kazakhstan under the CLRTAP in February 2022 for the period of 1990 to 2020 [10]. Since 2020, Kazakhstan has been submitting the structured Informative Inventory Report (IIR) that explains the methodologies and activity data used in emissions reporting, as well as the associated uncertainties, quality assurance and quality control procedures implemented [1].

The main source of information to compile the CLRTAP emission inventory in Kazakhstan is statistics on production of end-products and fuel used of the Bureau of National Statistics of the Republic of Kazakhstan. Since 2019, emissions are estimated based on the methodological document “EMEP/EEA air pollutant emission inventory guidebook 2019” using Tier 1 and, in some cases, Tier 2 methods [11].

Emissions dynamics are mainly related to differences in emission estimation methods and expert judgments of inventory teams. The main reason for the difference in emissions between 2018 and 2019 is that in 2019, the Office of National Statistics of the Republic of Kazakhstan presented data on emissions of categories that had not previously taken into account. For 2019, around ten new categories have been introduced, and their contribution is significant. For example, with regard to particulate matter (PM) emissions, until 2019, the reporting of PM emissions did not include emissions from residential heating and public electricity and heat production. The emissions reported for 2019 include these important sectors, which explains the increase in PM emissions levels in 2019. The differences in emissions are also explained by the fact that no adjustments were made for previous time series to include previously omitted sectors. From 2019 to 2020, due to Covid pandemic, activity levels have been affected and reduced, so emissions may not be indicative of a broader pattern.

When it comes to estimating emissions from transport, the results are highly uncertain, as the statistics used to compile the inventory are not broken down according to the characteristics required for calculating emissions, even within the framework of Tier 1 methodology (for example, no data available on fuel consumption by commercial vehicles, trucks, mopeds/motorcycles, let alone by "age", engine type and fuel consumed; no data on aircraft types and flight regimes). It was therefore decided to exclude analysis of transport emissions sources from this chapter.

4.2.1. SO_2 emissions

Total SO_2 emissions

The evolution of SO_2 emissions from 2010 to 2020 is shown in Figure 4-1. Between 2010 and 2018, SO_2 emission levels remained stable. In 2019, emissions tripled compared to 2018. In 2020, SO_2 emissions reached 1,576 kt.

In 2020, the main sources of SO_2 emissions were public power including electricity and heat production (66%), industry (24%), and other stationary combustion (10%). In this last category, residential heating accounted for 95%. Road transport emission were negligible, accounting for less than 1%. However, as mentioned above, road transport emissions had not been accurately estimated.

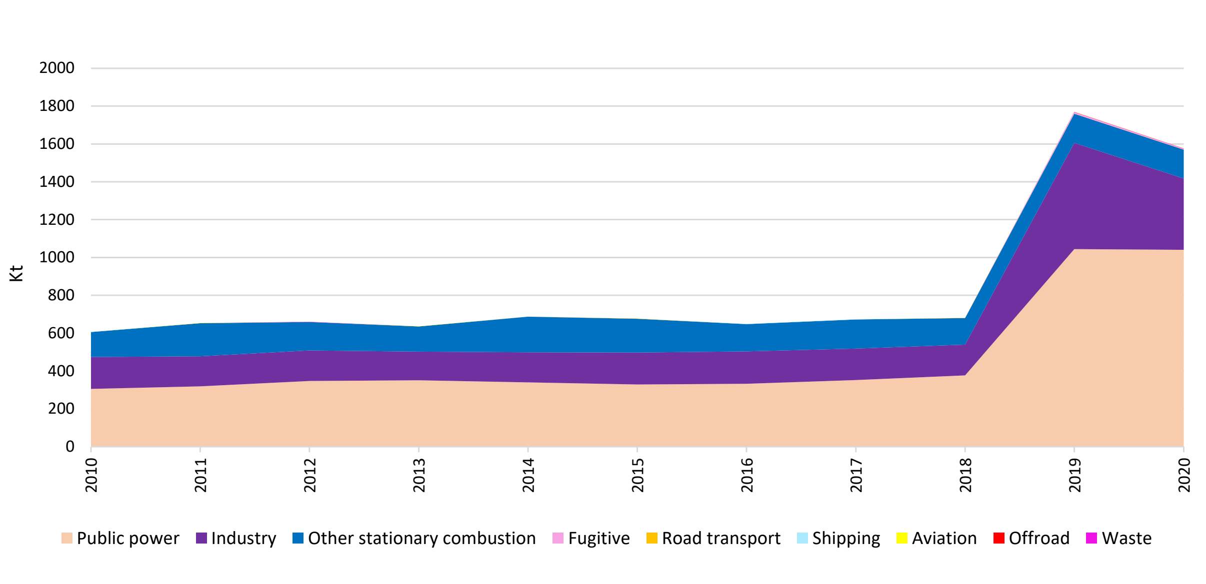


Figure 4-1: Trends in SO_2 emissions from 2010 to 2020 in Kazakhstan

Industrial sources

In 2020, total SO_2 emissions from industrial sources in Kazakhstan were 378 kt. The main industrial sectors emitting SO_2 were oil refining and manufacture of solid fuels (60%) and stationary combustion in iron and steel production (28%). Other sources such as the production of mineral products, the production of non-ferrous metals, and the chemical industry had a relatively minor impact on emissions (Figure 4-2).

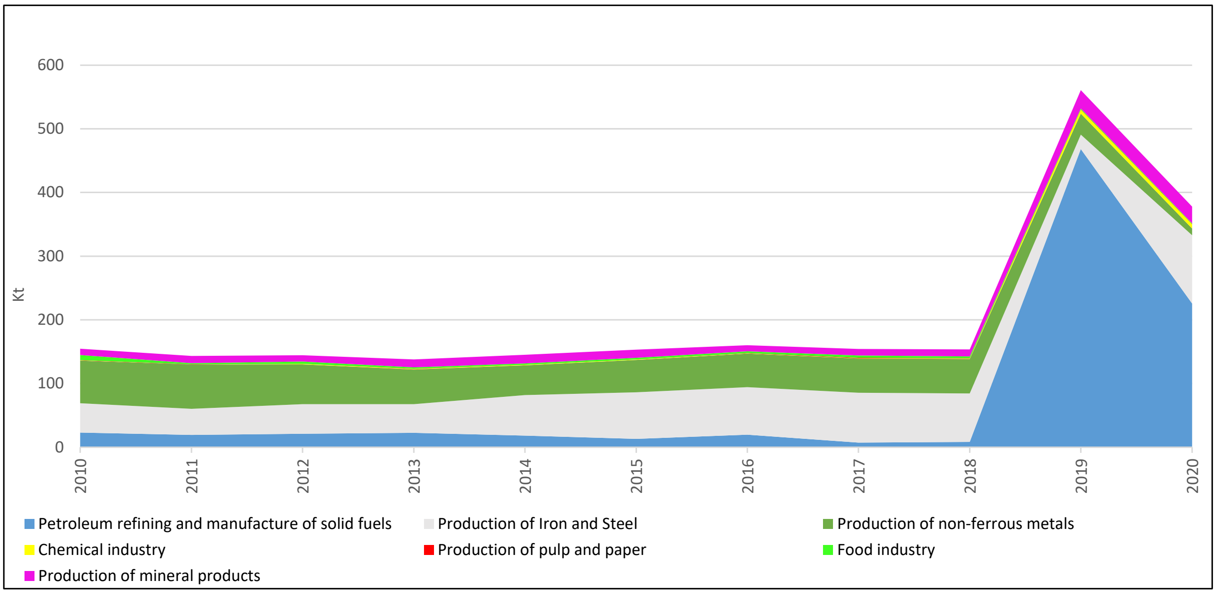


Figure 4-2: SO_2 emissions of industry from 2010 to 2020 in Kazakhstan

4.2.2. NOx emissions

Total NOx emissions

The trend in NOx emissions between 2010 to 2020 was as follows (Figure 4-3). NOx emissions have increased in recent years, but have fallen slightly since 2019 and were 646 kt in 2020.

Public power made a significant contribution to these emissions. In 2020, public power sources accounted for 48% of total emissions, industry 25%, off-road emissions 10%, fugitive emissions and other stationary combustion 9 and 7% respectively. The contribution of road transport emissions was negligible and accounted for less than 1%.

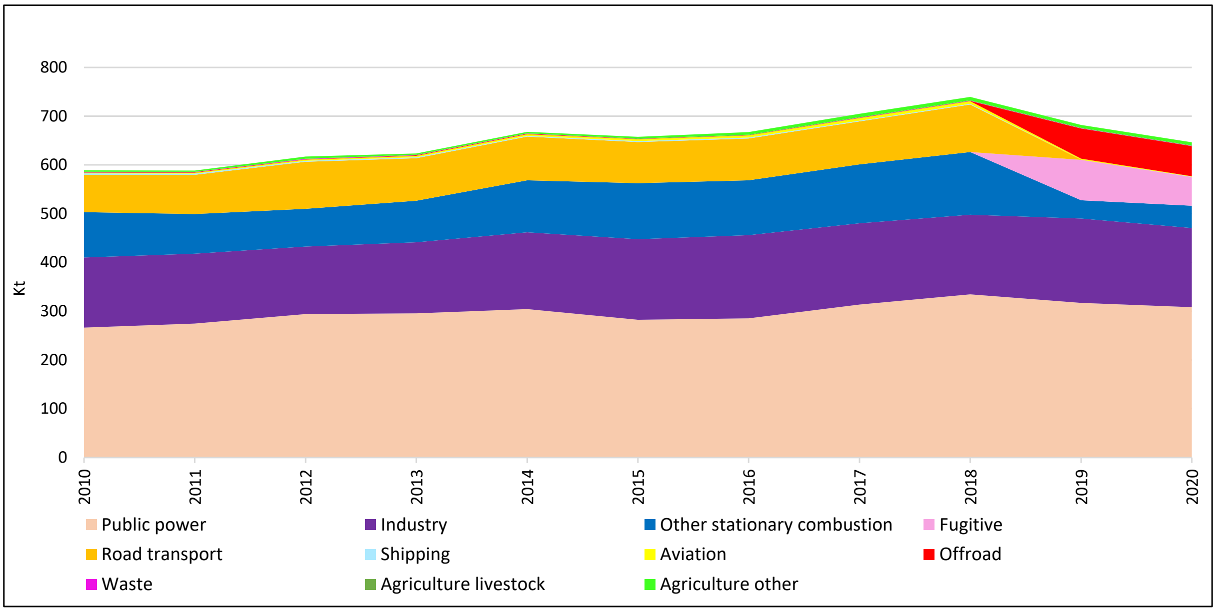


Figure 4-3: Trends in NOx emissions from 2010 to 2020 in Kazakhstan

Industrial sources

In 2020, total NOx emissions from industrial sources in Kazakhstan were 162 kt. The main industrial sectors contributing to NOx emissions, were oil refining and manufacture of solid fuels, which accounted for 66% of total industrial emissions. The solid fuels manufacturing sector and other energy industries accounted for 35% of these emissions, while oil refining contributed 31% of the remainder. Stationary combustion in production of iron and steel was another major source of NOx emissions, with a 22% share. The other sectors contributed to a lesser extent (Figure 4-4).

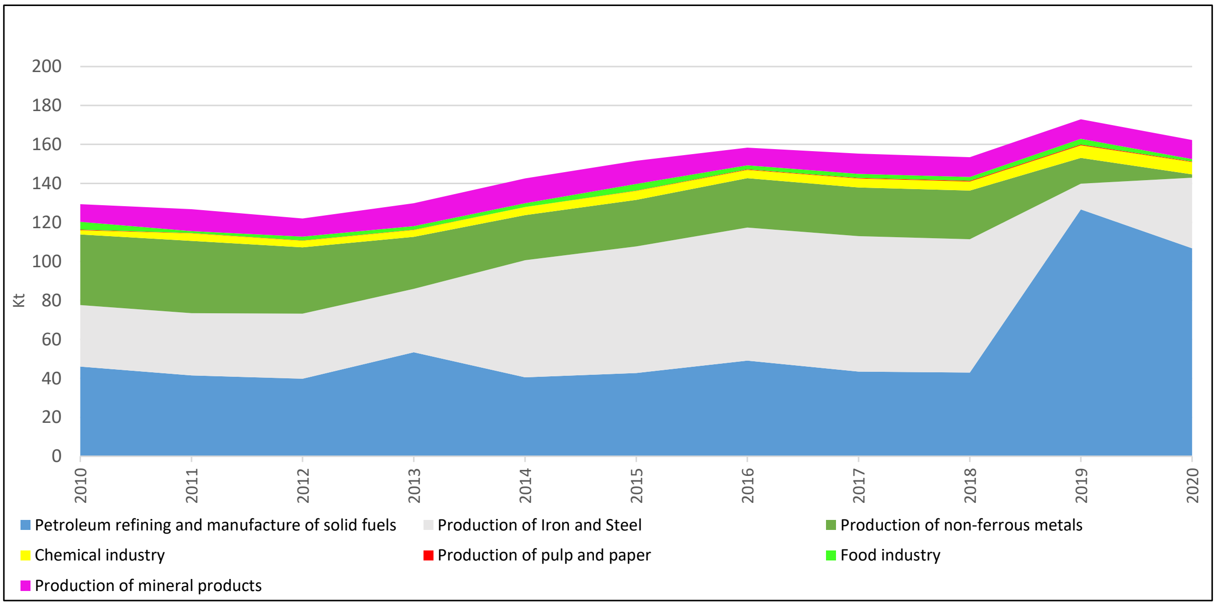


Figure 4-4: NOx emissions of industry from 2010 to 2020 in Kazakhstan

4.2.3. PM_{10} and $PM_{2.5}$ emissions

Total PM_{10} and $PM_{2.5}$ emissions

The evolution of PM_{10} and $PM_{2.5}$ emissions from 2010 to 2020 was as follows (Figure 4-5 and Figure 4-6). Overall PM_{10} emissions in 2020 were around 402 kt and $PM_{2.5}$ emissions were around 231 kt.

In 2020, the main contribution to PM_{10} emissions was from industry (37%) and fugitive emissions from fuels (28%). 95% of PM_{10} emissions from fugitive sources were due to oil and gas venting and flaring. Other stationary combustion was the third largest contributor with 16% of emissions, with residential heating accounting for 98% of the category. Surprisingly, public power share only accounted for 3% of total PM_{10} emissions. Road transport accounted for 5% of total emissions.

The main contribution to $PM_{2.5}$ emissions in 2020 was fugitive emissions from fuels (47%) and other stationary combustion (28%). 99% of fugitive $PM_{2.5}$ emissions were from oil and gas venting and flaring. Residential heating accounted for 98% of the other stationary combustion category. The share of industrial sources other than public power was 16%. The contribution of public power to $PM_{2.5}$ emissions was also minor (around 2%). Road transport accounted for 5% of total emissions.

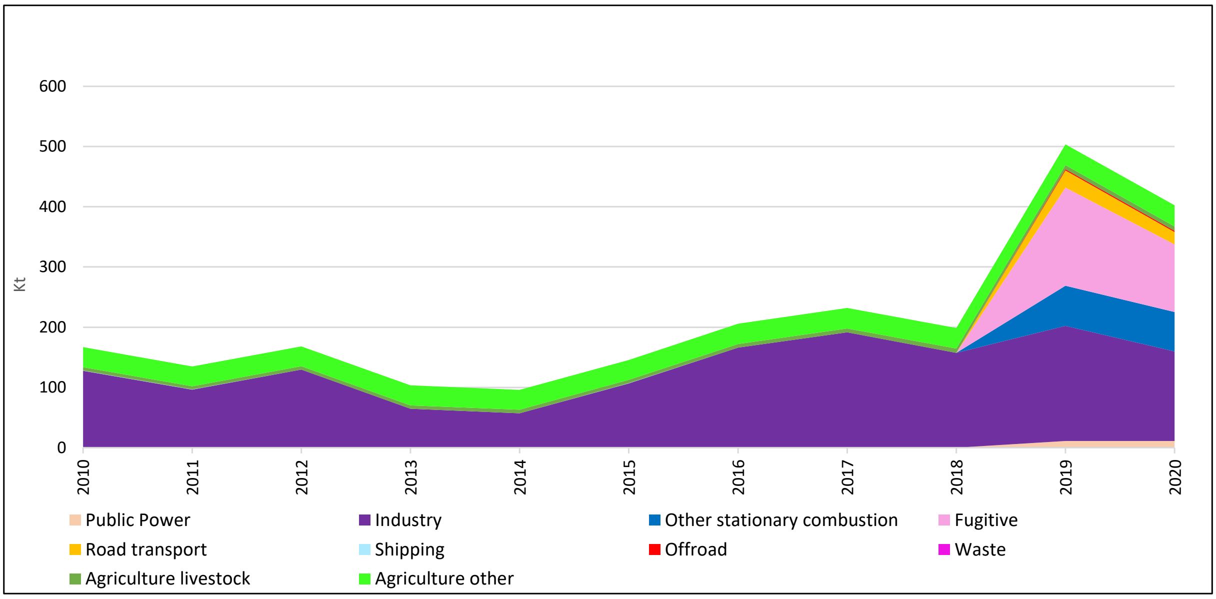


Figure 4-5: Trends in PM_{10} emissions from 2010 to 2020 in Kazakhstan

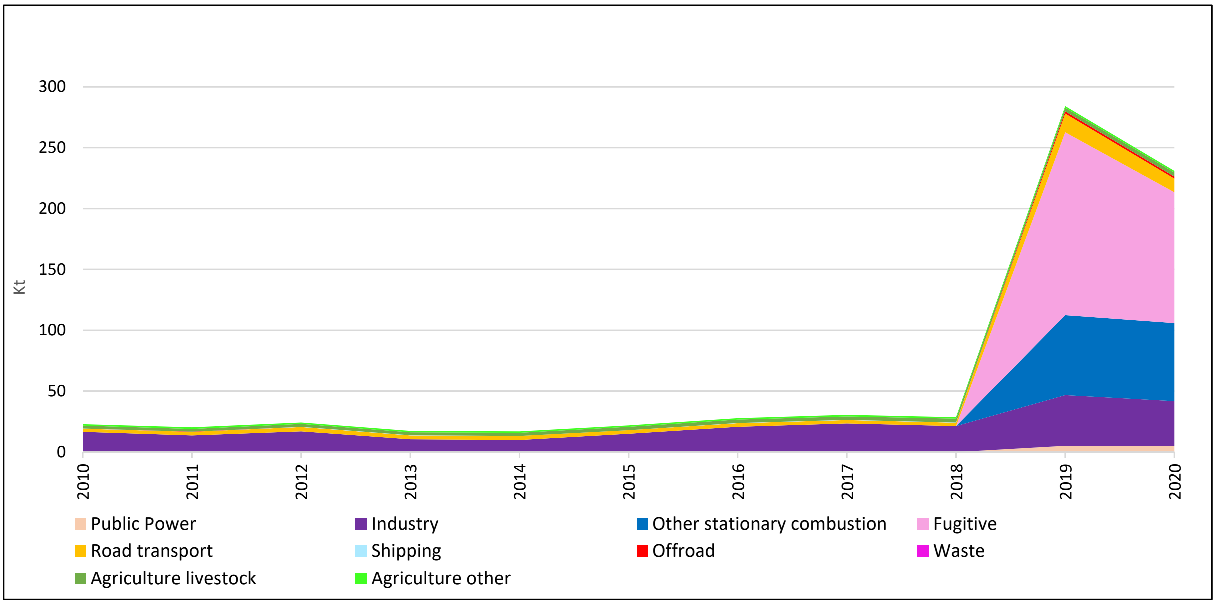


Figure 4-6: Trends in $PM_{2.5}$ emissions from 2010 to 2020 in Kazakhstan

Industrial sources

In 2020, total PM_{10} and $PM_{2.5}$ emissions from industrial sources in Kazakhstan were 149 and 37 kt respectively.

The main industrial sources of PM_{10} emissions were other industries (79%). The construction and demolition sector accounted for 89% of this category. Stationary combustion in iron and steel industry accounted for 10% of total emissions. Other sectors made only a marginal contribution (Figure 4-7).

The main industrial sources of $PM_{2.5}$ emissions were stationary combustion sources in production of iron and steel (36%), other industries (32%) (with 88% share from the construction and demolition sector), and production of non-ferrous metals (9%). Other sources made a minor contribution (Figure 4-8).

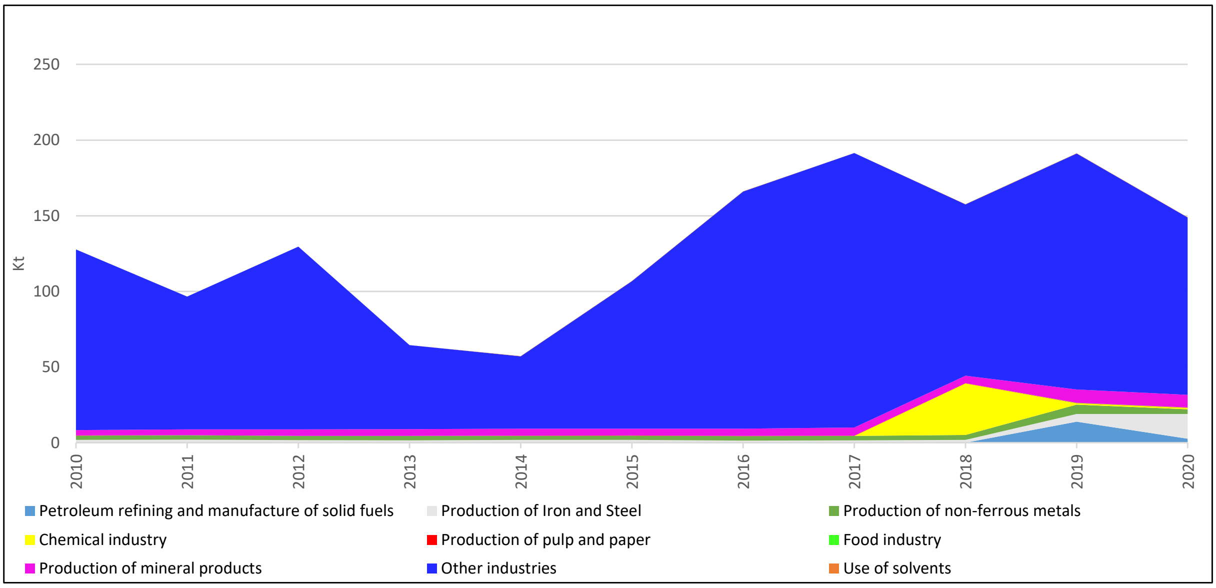


Figure 4-7: PM_{10} emissions of industry from 2010 to 2020 in Kazakhstan

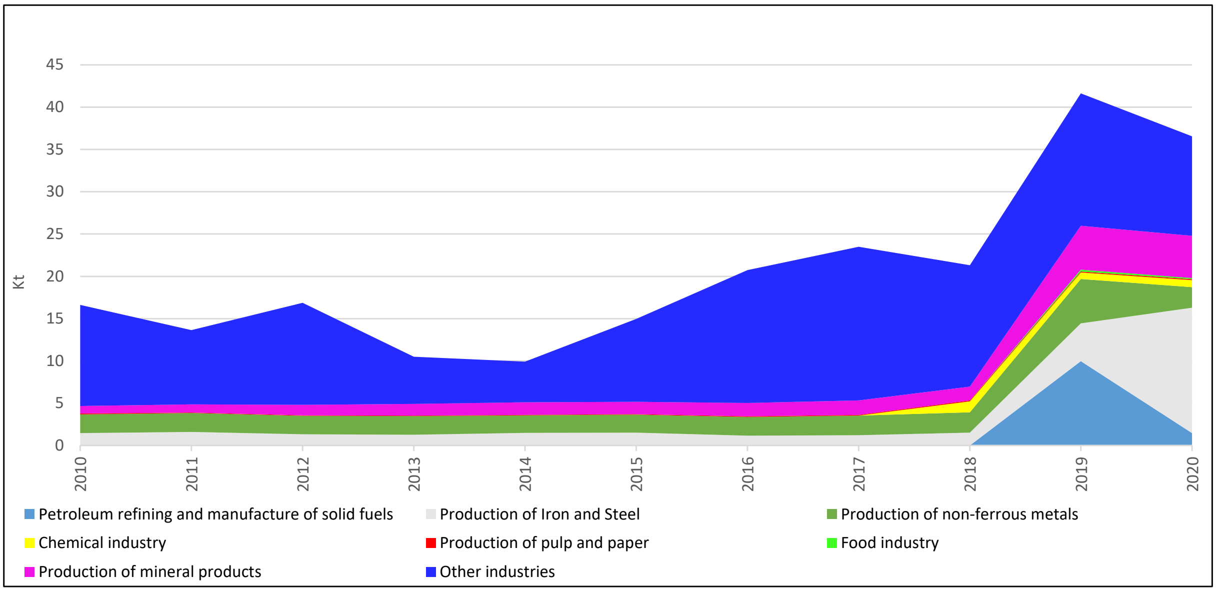


Figure 4-8: $PM_{2.5}$ emissions of industry from 2010 to 2020 in Kazakhstan

4.2.4. VOC emissions

Total VOC emissions

The evolution of VOC emissions in Kazakhstan between 2010 and 2020 was as follows (Figure 4-9). In 2020, overall VOC emissions were around 587 kt.

Fugitive emissions were the main contributor to VOC emissions in Kazakhstan in 2020 (33%), with a large share of solid fuels in the coal mining and handling with 46% of the overall fugitive emissions, and oil and gas venting and flaring (38%). Agricultural emissions accounted for 25% of all VOC. Use of solvents and other stationary combustion contributed 13% of total VOC emissions, 98% of which is due to residential heating. Industrial sources contributed 9% to total emissions. Road transport accounted for 1% of total emissions.

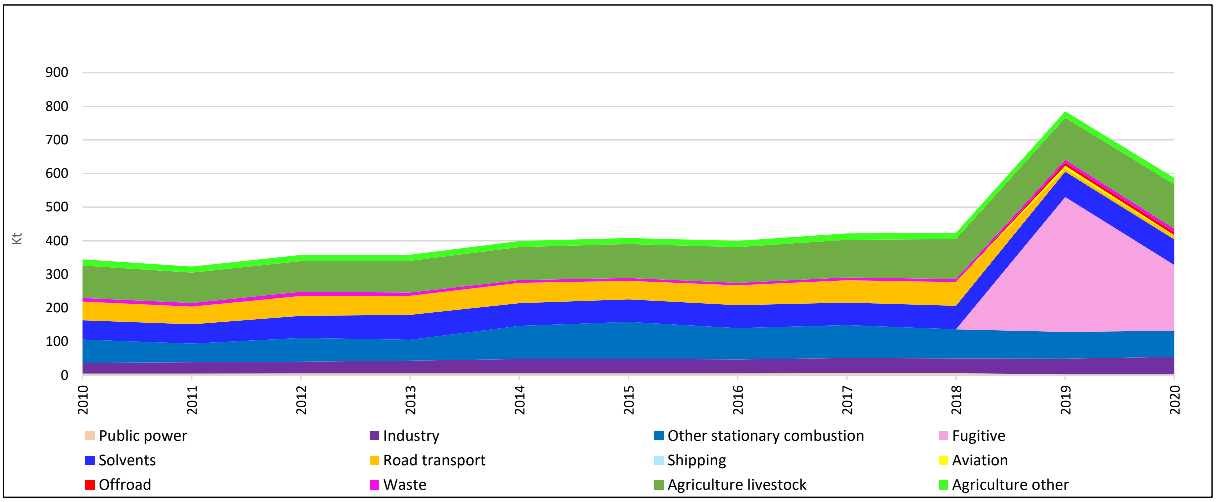


Figure 4-9: Trends in VOC emissions from 2010 to 2020 in Kazakhstan

Industry (except industrial uses of solvents)

The following figure shows the evolution of emissions in industry (the use of solvents is presented in the following subchapter) (Figure 4-10). In 2020, total VOC emissions from industry were 52 kt. The main industrial sources of VOC emissions were the chemical industry (38%), stationary combustion in iron and steel production (25%), and the food industry (27%).

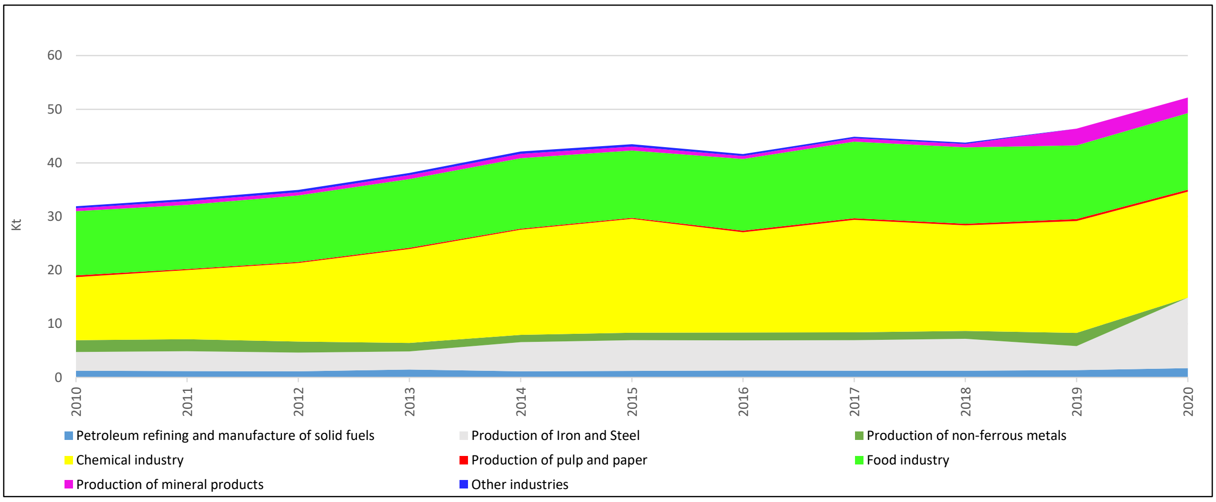


Figure 4-10: VOC emissions of industry (except industrial uses of solvents) from 2010 to 2020 in Kazakhstan

Use of solvents and other products

The following figure shows the evolution of VOC emissions from the use of solvents and other products (4-11). In 2020, total VOC emissions from the use of solvents were 53,4 kt.

Of the industrial use of solvents, the coating applications sector accounted for 97% (it should be noted that some domestic uses of solvents may be present in this category).

The other major source of solvents was domestic use. It represented 4% of the national total of VOC and 30% of the solvent category of emissions (Figure 4-11).

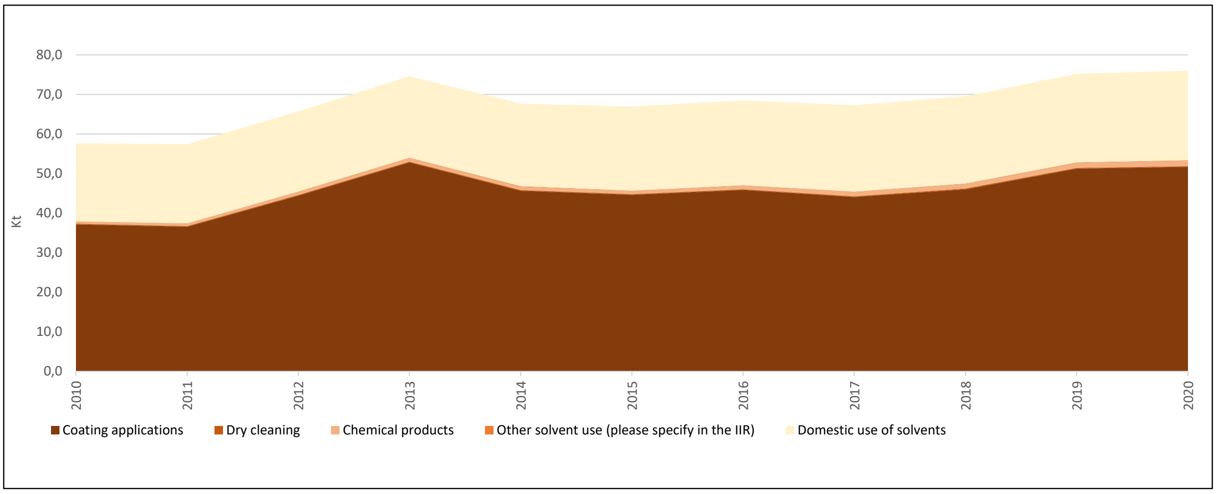


Figure 4-11: VOC emissions from the use of solvents from 2000 to 2020 in Kazakhstan

4.3. Situation in terms of air quality

Every year, 6,000–9,360 people in Kazakhstan are dying prematurely due to poor air quality. Moreover, a 2020 study prepared by the World Bank estimates that annually, particulate matter pollution alone causes 9,360 premature deaths and costs the economy more than $7.1 billion [12].

In 2021, ten cities in Kazakhstan has high air pollution levels Aktobe, Almaty, Atyrau, Balkhash, Karaganda, Nur-Sultan, Shymkent, Temirtau, Ust-Kamenogorsk, and Zhezkazgan. The concentrations of key air pollutants in the ambient air of the cities consistently exceeded the limit values of both Kazakhstan and the European Union (EU), especially in the winter. In some cases, the average annual concentrations were two or three times higher than the EU annual concentration limit values [12].

Most air quality-related diseases and premature deaths in Kazakhstan are linked to winter smog and fine particles. Concentrations of NO_2 and particles (PM_{10}, and $PM_{2.5}$) peak in winter months, exacerbated by local meteorological conditions such as temperature inversions which prevent air pollutant dispersion, leading to poor air quality. The greatest human exposure to $PM_{2.5}$ in Kazakhstan results from a relatively small mass of pollution emitted by dispersed small residential heating stoves and boilers [12]. The household survey conducted in 2018 [12] shows that only one-third of households in Kazakhstan use district heating, or gas or electricity for heating, and the remaining two-thirds burn solid fuels in their stoves and boilers integrated into the buildings (a mixture of fossil fuels (coal) and renewable energy (biomass, mainly wood)). The household survey suggests roughly equal proportions between coal and wood used for individual residential heating. These small stoves and boilers pose a major health hazard because their emissions are coming from low stacks and tend to condense in or close to densely populated urban centres, sometimes trapping smog near the ground by winter atmospheric inversion events during which pollutant dispersion is limited. The combustion processes in these installations are inefficient and extremely polluting per unit of useful energy [12].

According to information provided up to date, there is no programme in Kazakhstan focusing on the retrofitting of inefficient households' boilers and stoves [1].

Kazakhstan's air quality monitoring network includes both manual and automatic stations with continuous monitoring. In 2019, the network consisted of 84 automatic monitoring stations and

56 manual monitoring stations with a total of 140 monitoring stations, encompassing 45 settlements. There is one background air quality station – Borovoe. In addition, there were 14 mobile air quality monitoring stations. Air quality stations monitored a total of about 35 pollutants, including the key air quality pollutants covered by the AGP: PM (PM_{10} and $PM_{2.5}$), NOx, SO_2, and O_3 [12].

Kazakhstan has a legal and regulatory framework for air quality management (AQM). Basic ambient air quality standards have been established and are mandatory, although their levels and definitions need to be aligned with international best practices and enforced. Notwithstanding the needed modernization monitoring of ground-level ambient air quality is implemented in most cities which aids the identification of major hot spots where large populations are exposed to air pollution health hazards [12].

Approach to air quality limit values in Kazakhstan differs from the one of the European Union (EU) (Table 4-2). Maximum Allowed Concentrations (MACs) for 683 air quality pollutants are the main air quality limits settled, including a short-term maximum and a daily average. The short-term maximum is compared to the concentrations measured at 24-minute intervals at automatic monitoring stations with continuous monitoring. Every pollutant has a defined hazardous classification from class 1 to class 4, with class 1 being the most hazardous. The order does not prescribe actions if any of the MACs are exceeded as is the case in the European Union (EU), where exceedance of the air quality limit values (LVs) requires the development of local air quality action plans [12].

Table 4-2 : MACs in Kazakhstan and LVs in the EU of key air pollutants

Pollutant	**MACs in Kazakhstan**[a]		**LVs in EU**[b]		
	One-time ($\mu g/m^3$)	**24-hour ($\mu g/m^3$)**	**Concentration ($\mu g/m^3$)**	**Averaging period**	**Number of permitted exceedances per year**
$PM_{2.5}$	160	35	25	1 year	n.a.
PM_{10}	300	60	50	24 hours	35
			40	1 year	n.a.
NO_2	200	40	200	1 hour	18
			40	1 year	n.a.
SO_2	500	50	350	1 hour	24
			125	24 hours	3

a. MACs are given in milligram per cubic meter (mg/m^3) in the 2015 Order of the Minister of National Economy No. 168. For easier comparison with EU air quality standards, MACs are converted to $\mu g/m^3$.
b. EU LVs of key air pollutants are as under Directive 2008/50/EU [13].

Urban air quality in Kazakhstan is assessed using three indexes: the Standard Index (SI), Highest Frequency (HF), and Air Pollution Index (API_5) [12]. The most important and commonly used index is the API_5, which represents the sum of the average daily means of the five most important pollutants divided by the respective MAC values of the different pollutants and benchmarked by a factor related to the MAC value of SO_2. The SI is defined as the highest measured one-time concentration of a pollutant divided by the one-time MAC of the respective pollutant. The HF represents the share of concentrations that exceeded the MAC from the total number of concentrations.
The final assessment of air quality considers different ranges in the values of the API_5, SI, and HF and groups them into four classes of air pollution, ranging from low to very high as

described in Table 4-3 [12]. When there is a contradiction in the values among different indexes, the API_5 is the leading index used for air quality assessment.

Table 4-3: Air quality assessment in Kazakhstan based on different indexes

Class	Air pollution level	Air quality index	Annual assessment
I	Low	SI	0–1
		HF, %	0
		API_5	0–4
II	Increased	SI	2–4
		HF, %	1–19
		API_5	5–6
III	High	SI	5–10
		HF, %	20–49
		API_5	7–13
IV	Very high	SI	>10
		HF, %	>50
		API_5	≥14

The use of three different indexes individually and in combination complicates air quality assessment. The use of indexes also means that the actual measured values are rarely reported. Air quality information presented in such a way can be difficult to understand, not just for the average citizen but also, for air quality practitioners.

The National Hydrometeorological Service of the Republic of Kazakhstan (Kazhydromet) publishes monthly, quarterly, semi-annual, and annual reports on the state of the environment, including air quality. In addition, Kazhydromet supports an online platform on its website on which near real-time concentrations of different pollutants in each of the monitoring stations across the country are displayed [12].

4.4. Regulations in place to limit emissions from stationary sources and programmes for their evolution

4.4.1. Permitting system and its evolution

Legal framework for issuing integrating permits with emission limit values (ELVs) based on BATs has been in place in Kazakhstan since 2007. However, it has not been exercised due to the complexity of the process and the lack of relevant knowledge. Until first of January 2025, industrial facilities still apply for and receive conventional environmental permits for emissions based on practices pertaining from the past. The conditions for such permits are derived from capacity of installation, maximum allowable concentrations (MAC values), classes of environmental and sanitary exposure and sanitary zones [6].

Kazakhstan’s new Environmental Code effective since July 1, 2021, (hereinafter the 2021 Environmental Code) is the main legislating act that regulates industrial emission in the Republic of Kazakhstan [14]. It introduced mandatory integrated environmental permits (IEPs) since the first of January 2025 based on BAT for the most polluting enterprises, the Category I installations. The design of follow-up regulations and technical reference documents for BAT contributes to reduce air pollution and long-term phase-out of fossil fuels.

Pursuant to Kazakhstan’s legislation, every year, the permissible limits on total emissions from stationary sources are set. Nearly all point emission sources were subject to compliance with the permissible emission limits in 2019. Usually, the permissible emission limits significantly exceed the actual total emission levels indicating that the emission limits are set too high. For instance, the recent World Bank study [12] states that the actual total emissions from stationary sources in 2019 were 60 % of the permissible emission levels. Moreover, actual emissions from the industrial sector in 2019 were 66 % of the sector’s permissible emission limits. In 2019, the total actual emissions in the industrial sector with the highest emissions, namely the energy sector, were 73 % of the permissible emission levels [12].

The previous Environmental Code of Kazakhstan has been revised several times through the years and in 2018 a major redesign of the Environmental Code based on experiences in the Organisation for Economic Co-operation and Development (OECD) countries was initiated and adopted in January 2021. The 2021 Environmental Code provides a legal framework for strengthening efforts in a number of areas of environmental management, including air quality and air emissions.

The provisions on AQM are strengthened in a number of key areas in the 2021 Environmental Code, such as setting of average annual concentrations to be used as the limit values for certain pollutants and the process of emission inventories. For instance, emission inventories of industrial sources would be required for all settlements with more than 10,000 inhabitants, which will provide much more granular data than the current reporting of emissions on a regional level [12].

The 2021 Environmental Code divides all the industrial installations on four categories depending on their environmental impact. They are installations with significant negative environmental impact (Category I), with moderate (Category II), insignificant (Category III), and minimal (Category IV) negative environmental impact. Depending on the category of enterprises (I-IV), it establishes rules concerning the obligations of Environmental Impact Assessment (EIA). So, Category I enterprises are subject to mandatory EIA, whereas Category II enterprises are screened to determine whether an EIA is needed. Category III enterprises are required to submit environmental impact declarations. For example, warehouses, furniture workshops, concrete mortar units, or others whose activities are localised and might be sources of insignificant environmental pollution. Category IV enterprises are exempt from EIA regulation or environmental impact declarations as their environmental impact is deemed to be minimal. Category IV enterprises might include car washes, service stations, public catering facilities, or micro and small business facilities with low-power boilers for meeting their own energy needs [12].

The environmental impact of each stationary source is defined in one of four categories that relate to hazard classes according to the hygienic and sanitary classes described in new Kazakhstan’s legislation. Table 4-4 describes the four categories of environmental impact, with Category I having the greatest impact on the environment and Category IV having the least [1],[15].

Table 4-4: Categories of environmental impact of industrial stationary sources in Kazakhstan

Category of environmental impact	**Corresponding hygienic and sanitary class**
I	Class I of sanitary impact; sanitary protection zone of 1,000 m or more Class II of sanitary impact; sanitary protection zone between 500 m and 999 m
II	Class III of sanitary impact; sanitary protection zone between 300 m and 499 m
III	Class IV of sanitary impact; sanitary protection zone between 100 m and 299 m
IV	Class V of sanitary impact; sanitary protection zone between 0 m and 99 m

Annex I of the 2021 Environmental Code specifies the list of the industrial stationary sources of each category depending in some cases on the production capacity of the facility.

One of the key elements in the 2021 Environmental Code is the implementation of integrated environmental permits (IEPs) based on BATs. Two types of environmental permits are distinguished: integrated environmental permit (IEP) and environmental permit (EP).

IEPs are mandatory for Category I enterprises from 2025 onward. According to the legislation of the Republic of Kazakhstan, enterprises will receive at IEP based on the relevant BAT Conclusions that are approved based on Kazakhstan BREFs. The requirements for the mandatory availability of an integrated environmental permit are effective from January 1, 2025 and do not apply to Category I enterprises commissioned before July 1, 2021, or to Category I facilities not commissioned, but according to projects until July 1, 2021 a positive conclusion of the state environmental assessment or a comprehensive non-departmental examination was issued. Also, obtaining a EIP is mandatory in the case of the planned reconstruction of such facilities. All other enterprises may obtain an IEP on a voluntary basis.

EPs are issued by an authorized environmental protection agency and are valid indefinitely or until a change in the specified BAT conclusions and/or facility's conditions occurs [1].

An environmental permit (EP) is mandatory for the construction and (or) operation of Category II installations, as well as for the operation of Category I installations in the case the existing installations, the ones commissioned before 1 July 2021, and the ones not commissioned Category I installations that received a positive conclusion of the state environmental review or comprehensive non-departmental review before 1 July 2021 with some exceptions [14].

Nevertheless, an important consideration should be given to the reconciliation between the IEP and the previous emission permitting system. ELVs under the previous emission permitting system were based on historical emission levels and did not require implementation of cleaner technologies, whereas the IEP system is based on sector-specific BATs. Therefore, the coordination between the two systems should be carefully considered, along with the institutional capacities that need to be established to monitor compliance with the newly introduced IEP system [12].

To oversee the transition to BAT principles, the National Bureau on BAT has been established as part of the International Green Technologies and Investment Projects Centre (IGTIPC)[4].

Transition to the implementation of BAT principles involves development by July 1, 2023, of BAT Reference Books (BREFs) for the 50 most polluting enterprises in Category I by the Kazakhstan National Bureau on BAT. The BREFs will provide the competent authorities with a technical basis for establishing permit conditions for industrial facilities considering such facilities' technical characteristics, geographical location, and local environmental conditions.

Recently, several projects were carried out, aiming to help Kazakhstan to establish integrated permitting system based on the best available techniques. As an example, there were two projects supported by German Federal Environment Ministry's Advisory Assistance Programme (AAP) and German Environment Agency (UBA) "Development of sector specific ("vertical") Best Reference Document (BREF) for selected industry sector in the Republic of Kazakhstan for cement industry and energy sector (production of energy by combustion of fuel: coal, oil and gas)" [16] and "Further methodological support for the process to establish Best Available Techniques (BAT) in Kazakhstan" [17] were realised in 2021-2022. Another example is "European Union - Central Asia Water, Environment and Climate Change Cooperation (WECOOP)" project, that aimed to enhance environment, climate change and water policies in Central Asia through approximation to EU standards and to promote green investments in relevant sectors with the aim of contributing to measurable reductions in man-made pollution, including CO_2 emissions (2019-2023)[5].

In 2021-2023, Kazakhstan has developed 16 Best available techniques reference documents. They are: Petroleum and Gas Refining, Petroleum and Gas Production, Production of inorganic chemicals, Production of Cement and Lime, Lead Production, Production of Copper and Precious Metal Gold, Zinc and Cadmium Production, Extraction and Enrichment of Non-ferrous Metal Ores (incl. precious), Mining and Processing of Iron Ores (including other ferrous metal ores), Production of Ferroalloys, Energy Efficiency in Economic Operations and (or) other activities, Combustion of Fuels in Large Plants for Energy Production, Production of Iron and Steel, Aluminum Production, Further Processing of Ferrous Metals, Coal mining and preparation. Three of them were enacted at the end of 2023, namely BREF RK Production of inorganic chemicals, BREF RK Production of Cement and Lime, and BREF Zinc and Cadmium Production.

A further 17 BREFs are to be developed between 2024 and 2027. These include: Production of titanium and magnesium, Wastewater treatment of centralized wastewater disposal systems of settlements, Monitoring of pollutant emissions into atmospheric air and water bodies, Production of rare non-ferrous metals, Destruction and disposal of waste by thermal treatment, Waste neutralisation, Landfilling of waste, Intensive breeding of pigs and poultry, Slaughter of animals at meat processing plants, meat and cold slaughterhouses, Manufacture of food, beverages, milk and dairy products, Tanning, dyeing, dressing of hides and skins, Production of pulp from wood or other fibrous materials, Production of glass, ceramic products, Dyeing of textile fibres bleaching, dyeing of textile products [18].

---

[4] https://igtipc.org

[5] https://wecoop.eu

Rules for the development, implementation, monitoring and revision of best available techniques reference documents are established by the Resolution of 2021 “On Approval of the Rules for the Development, Application, Monitoring and Revision of Best Available Techniques reference documents” [19].

Before the Government of the Republic of Kazakhstan approves the Conclusions on the best available techniques, the operators of facilities when obtaining an EIP and justifying technological standards, are allowed to refer to the BREFs in the relevant areas of their application, developed within the framework of the European Integrated Pollution Prevention and Control Bureau, and also on the decisions of the European Commission on the approval of the conclusions on the best available techniques for the relevant areas of their application [14].

There are some transitional provisions or flexibilities for the stationary sources of Categories I and II in the case of non-compliance with the emission standards and (or) technological standards established in EIP in accordance with the 2021 Environmental Code.

In the case of Category I facility, a programme for improving environmental performance shall be developed for a period not exceeding ten years, so called environmental performance improvement programme (EPIP). It contains the time periods by which the technological standards and emission standards are to be achieved if the State introduces more stringent environmental quality standards or environmental quality targets, timed action plan for reconstruction, re-equipment, modernisation of the Category I installation to achieve technological standards and emission standards. If the technological and emission standards can be progressively met in accordance with the design solutions, a timetable is provided for achieving the indicators of progressive reduction of negative environmental impacts. The progressive reduction is determined on the basis of the completion dates of the plant's reconstruction, refitting and modernisation activities.

For certain Category I and II installations, an environmental action plan must be drawn up. During the period of implementation of the environmental action plan, the installation applies emission standards in accordance with the environmental permit and the conclusions of the national EIA (if applicable), in force on the date of submission of the application for the integrated environmental permit. The action plan shall contain indicators for the reduction of negative environmental impacts to be achieved by the operator of the installation during the period of validity of the action plan and a timetable for the progressive achievement of these indicators. When each indicator corresponding to a progressive reduction in negative environmental impact is achieved, it becomes a mandatory standard for the operator. The deadline for implementing the environmental action plan corresponds to the deadline for issuing the environmental permit and cannot be extended.

From January 1, 2023, Category I enterprises are required to implement automatic emission monitoring for the substances, including NOx, SO_2, dust (soot, suspended particles, $PM_{2.5}$, PM_{10}), hydrogen sulphide, and so called “marker substances” of the production process improving transparency of emissions reporting. In addition, the automated emission monitoring system shall be installed on the main stationary sources with gross emissions of pollutants into the atmosphere of 500 t/y or more from one stationary organized source and in sources at combustion plants operating on solid and liquid fuels, except for gas, with a total electric capacity of 50 MW or more, for boiler houses with a thermal capacity of 100 Gcal/h or more; for sources of power producing organizations operating on gas, with a total electric capacity of 500 MW or more, for boiler houses with a thermal capacity of 1200 Gcal/h or more [20].

The Order of the Minister of Ecology, Geology and Natural Resources of the Republic of Kazakhstan, 2021 № 63 determines that for the facilities in respect of which an integrated permit is issued, emission standards are set for individual stationary sources belonging to facilities of Categories I and II at levels not exceeding the relevant emission limit values of marker pollutants associated with the application of the best available techniques given in the conclusions on the best available techniques [21].

The 2021 Environmental Code foresees the development of pollutant release and transfer registers on the basis of methodological guidelines, which are to be developed by July 1, 2024 [6]. In 2021, an Order of the Minister of Ecology, Geology and Natural Resources of the Republic of Kazakhstan was established to approve the Rules for maintaining the register of emissions and transfer of pollutants [22] and the portal http://prtr.ecogosfond.kz/ was developed however is not yet well functioning.

4.4.2. Combustion installations

Up to now, in Kazakhstan the emission limits are established in Technical regulations: Requirements for emissions during combustion of various types of fuel in boiler plants of thermal stations dated December 14, 2007 N 1232 [6]. According to new Environmental Code of Kazakhstan, 2021 [14] starting with 2025, the emission limit values of integrated permits of new and existing large combustion plants in Kazakhstan should be based on the technological emission values associated with application of the best available techniques covered by the relevant BREF.

In 2021, BAT Bureau of IGTIPC supported by German Federal Environment Ministry’s Advisory Assistance Programme (AAP) and German Environment Agency (UBA) project [16], developed the draft BREF LCP of Kazakhstan [23] including the Conclusions. However, the lack of a strategy and programme for the development of the energy industry in the Republic of Kazakhstan as part of the broad economic policy guidelines has led to criticism from stakeholders regarding the emission limit values, which are not considered achievable in the near future. The draft BREF LCP is therefore currently being examined by the Minister of Ecology, Geology and Natural Resources of the Republic of Kazakhstan.

Comparison with ELVs of the Amended Gothenburg Protocol (Annexes IV, V and X)

The chapter 4.8.1 introduces the tables of comparison of LCP emission limit values in draft RK BREFs of the Republic of Kazakhstan [23] and the ones of the AGP.

The ELV of BREF RK “Combustion of fuels in large plants for energy production” for new installations are equal or below the ELV of large combustion plants within the AGP, with several important exceptions.

The emission limit values of SO_2 and NOx for new large combustion plants in the draft RK BREF “Combustion of fuels in large plants for energy production” [23] in some cases are close or equal to AGP Technical Annexes IV and V. However, dust ELVs of the draft RK BREF “Combustion of fuels in large plants for energy production”, compared with Annex X of the AGP, are equal only for liquid fuels. For solid fuels, dust ELVs for new LCPs are 3-3,5 times higher than in the AGP Annex X.

Concerning SO_2 ELVs of existing solid fuel LCPs, the draft LCP BREF of Kazakhstan introduces ELVs less stringent or equal, even stricter to the ones of AGP Annex IV. However, for liquid fuel LCPs, ELVs are 3 to 5 times higher than ELVs of AGP Annex IV.

Concerning NOx ELVs of existing solid fuel LCPs, the draft RK BREF "Combustion of fuels in large plants for energy production" introduces ELVs less stringent or equal to the ones of AGP Annex IV. For liquid and gaseous fuel LCPs, ELVs are less stringent and in some cases for 2.5 times higher than ELVs of AGP Annex V.

Concerning dust ELVs for existing liquid fuel LCPs, the draft RK BREF "Combustion of fuels in large plants for energy production" introduces ELVs stricter or equal than the ones of AGP Annex X. However, for existing solid fuel LCPs, ELVs are 2.5-10 times higher than in AGP Annex X.

The Republic of Kazakhstan has 183 operational combustion plants of over 50 MWh, with a preliminary estimate of around 392 fuel-burning boilers, with a unit capacity of over 50 MW, of which 100-300 MW units predominate. Around 50% of fuel-boilers are coal-fired, around 48% gas-fired, and 2% oil-fired. In 2019, thermal coal accounted for the majority (74 %) of the coal produced. More than half of the coal produced (52%) was used to generate electricity and heat. The main energy fuel used in Kazakhstan is the Ekibastuz coal, which has a sulphur content of around 0,5-0,7% [24]. Large combustion plants were the main source of SO_2 emissions in 2020.

The main source of PM emissions in Kazakhstan could be the widespread use of Ekibastuz coal, which has a particularly high ash content of (40-45%), and whose specific structural properties have made enrichment uneconomic to date [3]. In 2019, thermal coal accounted for the majority (74 %) of the coal produced. More than half of the coal produced (52 %) was used for electricity and heat generation, 79 % of which had a high ash content. Around 8 % of the coal produced was used by the general population [12].

ELVs for small and medium-sized combustion installations

Medium size combustion plants are considered as Category II enterprises and are covered by the Environmental code [14] and the Order of the Minister of Ecology, Geology and Natural Resources of the Republic of Kazakhstan, 2021 № 63 [21]. However, there were no elements available to conduct a comprehensive analysis of the medium-sized combustion plant ELVs.

The residential sector is a major contributor to PM emissions and concentrations across Kazakhstan. The key issues are burning of solid fuels (coal and biomass) in households, as well as inefficiencies in residential energy use. To reduce PM emissions coming from the residential heating, the Republic of Kazakhstan Government Decree of 4.11.2014 N № 1171 approved the "General scheme of gasification of the RK for 2015-2030", which provides for the gradual gasification of settlements [25]. There is also a standard on boiler requirements, that was developed as an analogue of the European one BS EN 303-1, 2:2017. It contains requirements for small boilers used in households, including the permissible dust limits, and applies to the manufacture of new boilers in the Republic of Kazakhstan [1].

According to experts interviewed, the legal framework for the sulphur content of gasoil (0.1%) has not been clearly identified, hence, analysing the current situation has been challenging.

The quality of coal used in the households heating corresponds to the technical conditions (national standards) which have been developed and approved for the relevant mining site. These national standards define the quality indicators of coal, including sulphur content [1].

One of other measures to reduce emissions from the residential heating is energy efficiency improvement in the sector. The Concept for Transition of the Republic of Kazakhstan to Green Economy [8] estimates that the largest improvement in energy efficiency can be achieved in the residential sector through insulation of homes. The main legal instrument that addresses energy issues in the residential sector is the 2012 Law on Energy Saving and Energy Efficiency Improvements [27]. The Law provides for mandatory energy efficiency assessments for new buildings and, in the case of expansion, existing buildings. As for existing buildings, the Law provides for support to dwelling owners to implement energy efficiency measures in their homes. Moreover, the Law introduces heat meters so that payments for heat energy can be based on actual consumption. Payment per use is an important step toward incentives to save energy and invest in thermal rehabilitation of buildings and more efficient appliances [12].

In addition to energy efficiency measures targeted at the building envelope, improved efficiency of heating systems should also be considered as a way to reduce emissions. Reduction of losses in the energy and heat networks is one of the objectives of the programme "Energy Saving 2020". The 2014 Concept for Development of the Energy and Heat Sector until 2030 envisions the modernization of energy-generating capacities. Moreover, the Concept for Transition of the Republic of Kazakhstan to Green Economy places a high importance on switching from coal to gas in urban TPPs and CHPs [12].

However, according to information provided by the local experts up to date, there is no programme in Kazakhstan focusing on the retrofitting of solid fuel inefficient households' boilers and stoves.

4.4.3. Industrial installations

The chapter 4.8.2 introduces the tables of comparison of the industrial plants emission limit values in draft BREFs of the Republic of Kazakhstan [1] and ELVs of AGP Technical Annexes.

Comparison with ELVs of Amended Gothenburg Protocol Annex IV

Mineral oil and gas refineries

Concerning sulphur recovery units, ELVs of the draft RK BREF Petroleum and gas processing [1], only information on minimum sulphur recovery rates of sulphur recovery units for existing installations were available for the analysis. They are more stringent than ELVs of AGP Annex IV (Table 3).

There are two sulphur recovery units in Kazakhstan and their sulphur recovery rate is equal or more 99% [1].

Titanium dioxide production

There is no titanium dioxide specific regulation, neither production of titanium dioxide in Kazakhstan. However, the BREF RK "Production of titanium and magnesium" is planned to be developed in 2024-2027.

Comparison with ELVs of Amended Gothenburg Protocol Annex V

Cement production

In 2021, BAT Bureau of IGTIPC supported by German Federal Environment Ministry's Advisory Assistance Programme (AAP) and German Environment Agency (UBA) project [16], developed the draft RK BREF Cement and Lime Production [28] including the Conclusions. It was finalised and enacted at the end of 2023. Concerning cement and clinker production, the BREF RK "Cement and Lime Production" sets NOx emission levels for new process lines as < 400 mg/Nm^3 , for cyclone kilns < 400 mg/Nm^3 that are stricter that the ones of Annex V (Table 3) of the AGP and for long rotary kilns in the wet process ELVs are the same (< 800 mg/Nm^3).

Cement is produced in 17 full-cycle plants including 11 modern dry process plants, 3 wet process plants, and 3 small plants with shaft kilns [1].

Iron ore sinter plants

Concerning iron ore sinter plants, the draft RK BREF "Production of iron and steel" was developed in 2023, but not available for analysis, so it was not possible to compare ELVs of AGP Annex V and ELVs of the draft RK BREF.

In the Republic of Kazakhstan, sinter production for the needs of the blast furnace shops is carried out in 3 sintering plants with a total sintering area of 1,008 sq.m. (Steel Department of JSC ArcelorMittal-Temirtau) [1].

Nitric acid production

The ELV for nitric acid production at an absorption tower in the RK BREF "Production of inorganic chemicals" [1] is of <180 mg/Nm^3, that is more stringent for existing installation and less stringent for new installations of AGP Annex V (Table 6).

Weak nitric acid, a semi-finished product used in technological processes as a reagent in the production of ammonium nitrate, is manufactured at KazAzot JSC (weak nitric acid workshop). Nitric acid production is designed as a combined process [1].

Comparison with ELVs of the Amended Gothenburg Protocol Annex X

Mineral oil and gas refineries

For mineral oil and gas refineries, in the draft RK BREF "Oil and Gas Refining", the dust ELV for the regenerator in the catalytic cracking process associated with the application of the BAT (monthly average) is established at 10-50 mg/Nm^3 [1]that is stricter or equal than ELV in AGP Annex X (Table 2).

The Republic of Kazakhstan has five major oil refineries (Atyrau Refinery LLP, Pavlodar Petrochemical Plant LLP, PetroKazakhstan Petroleum Products LLP, Joint Venture CASPI BITUM LLP, Condensate LLP) and around thirty smaller capacity producers, known as "mini-refineries".

Cement and lime production

For cement and lime production, dust emission limit values of the BREF RK "Cement and Lime Production" [28] are the same as of Annex X of the AGP (Tables 3 and 4).

As it was noted above, in Kazakhstan cement is produced in 17 full-cycle plants. Kazakhstan has also 26 registered producers of quicklime and hydrated air lime (2017) [1].

Primary iron and steel production, iron foundries

Dust ELVs for primary iron and steel production and iron foundries (Tables 5 and 6 of Annex X of the AGP) were not possible to compare with the ELVs applied in Kazakhstan, even though the draft BREF RK on iron and steel production was developed in 2023.

In Kazakhstan, primary iron and steel production is carried out at 4 full-cycle production sites in addition to 3 sintering plants mentioned above [1].

Non-ferrous metals production

Dust ELVs in the draft BREFs RK “Lead Production”, “Zinc and Cadmium Production”, “Copper and Precious Metal -– Gold Production”, for lead, zinc and cadmium production are 2-5 mg/Nm^3 [1], that is stricter than the ELVs of Annex X of the AGP (Table 7).

In total, non-ferrous metals in Kazakhstan are produced at 8 major industrial sites (Zhezkazgan Mining and Metallurgical Combine, Balkhashtsvetmet, Pavlodar Aluminium Smelter, Ust-Kamenogorsk Titanium and Magnesium Combine, Achisai Polymetallic Combine, Kazakhstan Electrolysis Plant, Balkhash Non-Ferrous Metals Processing Plant, Kairakta Mining and Metallurgical Combine)[1].

Glass production

Regarding glass production, there is no information on the ELVs to compare with those in Annex X of the AGP. However, the development of the RK BREF "Production of glass, ceramic products" is planned for the period 2024-2027.

Since 2021, one plant for the production of sheet glass has been in operation in the Republic of Kazakhstan. It is assumed that the production plant is not under Category I, so the up to now ELVs are developed in the case-by-case basis [1].

Pulp production

Regarding pulp production the development of the BREF RK “2025 Production of pulp from wood or other fibrous materials” is also planned for the period 2024-2027.

No information on activities in Kazakhstan was available [1].

Waste incineration

Regarding waste incineration, there is no specific regulation, neither the activities in Kazakhstan [1].

Titanium dioxide production

There is no titanium dioxide specific regulation, neither production of titanium dioxide in Kazakhstan. However, the BREF RK “Production of titanium and magnesium” is planned to be developed in 2024-2027.

4.4.4. Use of solvents in industry

Information relating to the regulation on the use of solvents in industry was not available to analyse.

4.4.5. Sulphur content of gasoil

The legal framework for the sulphur content of gasoil (0.1%) has not been clearly identified, hence, analysing the current situation has been challenging.

4.4.6. VOC contents of products

Law “About chemical product safety” from 21 July 2007 № 302-III [30][32] establishes the legal basis for ensuring the safety of chemical products for the protection of human life and health, environmental protection and consumer interests on the territory of the Republic of Kazakhstan.

Technical regulation on paints and varnishes №13 98 dated 29.12.2007 [31] establishes hygienic standards and toxicological indicators of main volatile organic compounds in the working area air and in the atmospheric air of populated areas. The requirements of this technical regulation apply to paint and varnish materials and solvents that are objects of technical regulation: varnishes, paints, enamels, primers, fillers, solvents and their wastes, classified in accordance with the codes of the Commodity Nomenclature of Foreign Economic Activities. The list of objects of technical regulation is set out in Annex 1 to this technical regulation [6].

It was not possible to compare the standards of the existing regulation in Kazakhstan and AGP Annex XI (Tables 1 and 2).

Transposition of AGP Annex XI (Tables 1 and 2) would be needed to be compliant with this Annex.

4.4.7. VOC Petrol storage and distribution from terminals to service stations

According to the available information [1], up to now, there is no programme in Kazakhstan to adopt VOC limit values for the storage and distribution of petrol prescribed by Table 1 of Annex VI of the AGP (which are based on Directive 1994/63/EC on Stage I petrol vapour recovery [32]) and no programme to adopt VOC limit values for car refuelling at service station presented prescribed by Table 2 of Annex VI of the AGP (which are based on Directive 2009/126/EC on Stage II petrol vapour recovery [33]).

4.5. Regulations in place to limit emissions from mobile sources and programmes for their evolution

4.5.1. Road transport

4.5.1.1. Vehicles

In Kazakhstan, the key issues in the transport sector with a significant impact on emissions are the old vehicle fleet (65 % of passenger vehicles over 10 years old), the use of low-quality fuels, and the low attractiveness of public transport use [12].

Kazakhstan moved to the new standard Euro-5 for most categories of motor vehicles in 2018. The Euro-5 standard is now valid for new vehicles produced in or imported into Kazakhstan (i.e., it does not apply to used vehicles) (Eurasian Economic Union (EAEU): Technical Regulation of the Eurasian Economic Union TR CU 018/2011 on the safety of wheeled vehicles (similar to Euro-5) [34]. In addition, Kazakhstan prohibits the import of cars that are below Euro-4 emission standards [1].

Periodic technical inspections are an important instrument to monitor the proper operation of vehicles, including their emission discharges. In June 2015, technical inspection of cars was made mandatory when the car reaches seven years of age. Cars older than seven years must pass the technical inspection check annually [12].

In April 2017, a road map for the development of electric cars' production and the necessary infrastructure was approved in Kazakhstan. The main pillars of the road map are development of local production of electric cars, development of charging infrastructures, and raising awareness to encourage purchase of electric vehicles by the population [12].

Comparison with ELVs of the Gothenburg Protocol

Since the AGP entered into force, technological development of engines occurred enabling them to comply with stricter standards of emissions (based on real driving conditions, EU Directives introducing standard 6c and 6d) [35]. However, in the Annex VIII, Table 1 for light duty vehicles and tables 2 and 3 for heavy duty vehicles of the AGP are the ELVs Euro 6 and Euro VI [35]. In addition, since 2018, import of vehicles that are below Euro 4 are prohibited in Kazakhstan. An important drawback to the minimum requirements of vehicles is that the rules introduced in 2018 are based on quite old state of the art of vehicles (Euro 5/V equivalent). The implementation on the requirements of Annex VIII introducing not only Euro 5/V but also Euro 6/VI, for passenger cars, light duty vehicles and heavy-duty vehicles is not yet achieved in the Republic of Kazakhstan and the evolution of the EAEU regulation TR CU 018/2011 is not known for TFTEI.

4.5.1.2. Petrol and diesel

Another major issue with renewing the vehicle fleet has been the availability of domestically produced fuel of adequate quality. Since 2017 the upgrade of the domestic oil refineries allowed them to produce K4 and K5 fuels. Until then, fuels of such quality were imported and hence more expensive than the locally produced fuels available on the market.

The regulation on sulphur content of petrol and diesel is the Technical Regulation of the Eurasian Economic Union 013/2011 "Requirements for automotive and aviation gasoline, diesel and marine fuel, jet fuel and fuel oil" [29]. According to this regulation, transition to release into circulation of diesel fuel of the ecological classes K4 and K5 (comparable with Euro-4 and -5) had to be carried out in the Republic of Kazakhstan no later than the 1st January 2016. However, according to the World Bank study [12] it was not until 2018 when the upgrade of the domestic oil refineries allowed them to produce K4 and K5 fuels.

The K4 and K5 ecological classes apply to both gasoline and diesel [1]. Sulphur content of petrol and diesel fuel standards in Kazakhstan is shown in the Table 4-5.

Table 4-5: Evolution of petrol and diesel fuel standards in Kazakhstan

Fuel standard	Year of introduction	Sulphur content, mg/kg	
		Petrol	Diesel
K3	2011	150	350
K4	2018	50	50
K5	2018	10	10

The characteristics of fuels are detailed in Table 4-6 and Table 4-7 [1] and compared to tables 13 and 14 of Annex VIII of the AGP. If the sulphur content may be equal, there are different parameters and different values.

Table 4-6: The limit values of different parameters for petrol in Kazakhstan and comparison with table 13, Annex VIII of the AGP

Parameter	Unit	K5 fuels
Mass fraction of sulphur, not more than	mg/kg	10
Volume fraction of benzene, not more than	%	1
Volume fraction of oxygen, not more than	%	2.7 (3.7 in table 13, ann VIII, AGP)
Volume fraction of hydrocarbons, not more than	%	
Aromatic		35
Olefinic		18
Octane number:		
By research method, not less than		80 (95 in table 13, ann VIII, AGP)
By motor method, not less than		76 (95 in table 13, ann VIII, AGP)
Saturated vapour pressure:	kPa	
Over the summer		35-80 (60 in table 13, ann VIII, AGP)
In winter		35-100 (no value in table 13, ann VIII, AGP)
Iron concentration, not more than	mg/dm^3	Absence (no value in table 13, ann VIII, AGP)
Concentration of manganese	mg/dm^3	Absence (no value in table 13, ann VIII, AGP)
Concentration of lead, not more	mg/dm^3	5 (lead is prohibited in table 13, ann VIII, AGP)
Volume fraction of monomethylaniline, max	%	Absence
Volume fraction of oxygenates, not more than:	%	In table 13, ann VIII of the AGP other oxygenated products are considered:
Methanol		1 (3 in table 13, ann VIII of the AGP)
Ethanol		5 (10 in table 13, ann VIII of the AGP)
Isopropanol		10 (12 in table 13, ann VIII, AGP)
Tretbutanol		7 (not in table 13, ann VIII of the AGP)
Isobutanol		10 (not in table 13, ann VIII of the AGP)
Esters containing 5 or more carbon atoms		15 (22 in table 13, ann VIII of the AGP)
Other oxygenates (with boiling point not exceeding 210°C)		10 (15 in table 13, ann VIII of the AGP)

In green values equal to value in table 13, Annex VIII of the AGP.

Table 4-7: The limit values of different parameters for diesel in Kazakhstan and comparison with Table 14, Annex VIII of the AGP

Parameter	Unit	K5 fuels
Mass fraction of sulphur, not more than	mg/kg	10
Flash point in closed crucible, not lower than	°C	(no value in table 14, ann VIII, AGP)
Summer and off season diesel fuel	%	55
Winter and artic diesel fuel	%	30
Fractional composition – 95 % by volume distilled at a temperature, not higher than	°C	360

Parameter	Unit	K5 fuels
Mass fraction of polycyclic aromatic hydrocarbons, max	%	8
Cetane number for summer fuel, at least	-	51 (no distinction of season in table 14, ann VIII, AGP)
Cetane number for winter and artic fuel, at least	-	47
Lubricity, not more	micrometer	460 (no value in table 14, ann VIII, AGP)
Filterability limit temperature, not higher	°C	(no value in table 14, ann VIII, AGP)
Summer diesel fuel		Undefined
Winter diesel fuel		Minus 20
Arctic diesel fuel		Minus 38
Off season fuel		Minus 15

In green values equal to value in table 14, Annex VIII of the AGP

Development and implementation of amendments to the existing product standards (2022) could bring Kazakhstan in compliance with the Directive 98/70/EC of the European Parliament and of the Council of 13 October 1998 relating to the quality of petrol and diesel fuels, as amended [36].

4.5.2. Non road mobile machinery, mopeds and motorcycles

Specific emission limit values or standards are in place for non-road machinery, which is a significant source of emissions [6]. However, no additional information was available to analyse the situation with non-road mobile machinery, mopeds and motorcycles and associated ELVs.

4.6. Technological pathways

Kazakhstan stepping up its efforts to reduce air pollution, which imposes high health costs on its citizens. According to the Concept for Transition to a Green Economy of Kazakhstan [8] and a study carried out in 2021 by the World Bank [12], every year, up to 6,000–9,360 people in Kazakhstan die prematurely as a result of poor air quality.

As a Party to the Convention on the Long-Range Transboundary Air Pollution, however, Kazakhstan has not ratified any of the Protocols to the Air Convention. To enhance the country’s capacity to adhere to the CLRTAP protocols and meet the corresponding commitments, a detailed draft “Kazakhstan National Action Plan for ratification of CLRTAP protocols and fulfilment of correspondent commitments” was developed by UNECE with the 31/12/2024 preliminary deadline [6]. It concerns, the 1998 Protocol on Persistent Organic Pollutants (POPs), the 2012 amended Protocol to Abate Acidification, Eutrophication and Ground-level Ozone, and the 1998 Protocol on Heavy Metals. However, up to now the action plan has not been approved by the competent authority of the Republic of Kazakhstan [1]

However, Kazakhstan submits its emission inventories to the Centre on Emission Inventories and Projections (CEIP) [4],[5]. And since 2020, Kazakhstan submits the structured Informative Inventory Report (IIR) that explains the methodologies and activity data used in emissions reporting, as well as the associated uncertainties, quality assurance and quality control procedures implemented, and the NFR tables.

In 2021, 10 cities in Kazakhstan had high air pollution levels. These are Aktobe, Almaty, Atyrau, Balkhash, Karaganda, Nur-Sultan, Shymkent, Temirtau, Ust-Kamenogorsk, and Zhezkazgan. Air quality monitoring data provided for these cities showed that concentrations of the key air quality pollutants covered by the AGP (PM (PM_{10} and $PM_{2.5}$), NOx, SO_2, and O_3) in the ambient air consistently exceeded the limit values of both Kazakhstan and the European Union, especially in winter. In some cases, annual average concentrations exceeded the EU limit values for annual concentrations by two to three times. Kazakhstan has a legal and regulatory framework for air quality management. Basic ambient air quality standards have been established and are mandatory, although their levels and definitions need to be aligned with international best practices and enforced.

The main sources of air emissions in Kazakhstan are public power plants, including electricity and heat production. It is a major source of SO_2 and NOx emissions, with share of around 66% and 48% respectively in 2020, followed by the industrial sectors with shares of 24% and 25% respectively. The main industrial sector emitting SO_2 are oil refining and the manufacture of solid fuels (60%) and stationary combustion in the iron and steel industry (28%).

For NOx emissions, the contribution of industrial sectors is due to the solid fuels manufacturing and other energy industries (35%), oil refining (31%), and stationary combustion in the iron and steel industry (22%). The contribution of road transport emissions is negligible at less than 1%. However, according to local experts, when it comes to estimating emissions from transport, the results are highly uncertain, as the statistics used to compile the inventory are not broken down according to the characteristics required for calculating emissions, even under the Tier 1 methodology.

The main sources of PM_{10} emissions are industrial processes, which accounted for 37% of national totals in 2020, due to emission in the construction and demolition sector (70%) and stationary combustion in the iron and steel industry (10%).

Fugitive sources are another major source of particulate matter, both PM10 and PM2.5, and VOCs, accounting for 28%, 47%, and 33% respectively of total national emissions in 2020. PM10 and PM2.5 emissions are due to oil and gas venting and flaring, in proportions of 95% and 99% respectively. VOC emissions fugitive sources are two sectors, coal mining and handling (46%) and oil and gas venting and flaring (38%).

The residential sector is also a major source of air pollutant emissions in Kazakhstan, accounting for 9% of SO_2, 16% of PM_{10}, 28% of $PM_{2.5}$, and 13% of VOCs emissions.

Surprisingly, public power share only accounted for 3% of total PM_{10} emissions and around 2% of $PM_{2.5}$ emissions.

In some places and cities, large emission sources can contribute disproportionally to background pollution throughout the year and to pollution peaks during winter smog, particularly when industrial emissions are trapped by temperature inversion phenomena that are more frequent during cold seasons [12].

There are significant gaps in existing air quality monitoring data and emission source inventories, which provide strong rationale for improving knowledge and taking action to make progress on the attribution of air emission sources and emission reduction measures.

Three strategic documents of the Republic of Kazakhstan, namely the strategy “Kazakhstan 2050: A New Political Course of the Established State”[7], the Concept for Transition of the

Republic of Kazakhstan to Green Economy [8], and ”Strategic Plan for Development until 2025”[9] are dealing with the measures that directly or un-directly could reduce emissions of pollutants (SO_2, NOx, PM, and NMVOC). These include increasing the share of RES, bringing production facilities and transport fuels into line with the latest technological standards, reducing SOx and NOx emissions, improving energy efficiency, etc.

Legal framework for issuing integrating permits with emission limit values (ELVs) based on BATs has been in place in Kazakhstan since 2007. However, it has not been exercised due to the complexity of the process and the lack of relevant knowledge. Until first of January 2025, industrial facilities still apply for and receive conventional environmental permits for emissions based on practices pertaining from the past. The conditions for such permits are derived from capacity of installation, maximum allowable concentrations (MAC values), classes of environmental and sanitary exposure and sanitary zones.

In addition, Kazakhstan’s new Environmental Code effective since July 1, 2021, is an important step toward bringing environmental management in line with global best practice. It introduced mandatory integrated environmental permits (IEPs) based on BAT for the most polluting enterprises. The design of follow-up regulations and technical reference documents for BAT contributes to reduce air pollution and long-term phase-out of fossil fuels [2], [12].

The coordination between the two systems should be carefully considered, along with the institutional capacities that need to be established to monitor compliance with the newly introduced IEP system.

For the period 2021-2023, sixteen Best available techniques reference documents (BREF) were developed in Kazakhstan, and tree of them were enacted at the end of 2023, namely Production of inorganic chemicals, Production of Cement and Lime, and Zinc and Cadmium Production. In addition, 17 BREFs are planned to be developed between 2024 and 2027 [18].

The developed draft BREFs in Kazakhstan cover fuel combustion at large energy-producing installations, oil and gas processing, production of inorganic chemicals, cement and lime production, energy efficiency, lead production, zinc and cadmium production, copper and precious metal-gold production, mining of oil and gas, ferrous metals mining and beneficiation, production of ferroalloys, and non-ferrous metals mining and beneficiation (including precious metals) and others. The BREFs to be developed in 2024-2027 cover among others monitoring of air pollutants, production of pulp from wood or other fibrous materials, production of glass, ceramic products, and dyeing of textile fibres bleaching, dyeing of textile products. The largest sources of industrial pollution in Kazakhstan, Category I enterprises, must obtain an IEP based on BAT starting in 2025.

Chapter 8 lists the techniques for complying with the limit values introduced by AGP Technical Annexes IV for SO_2, V for NOx, VI for VOC and X for PM.

Large combustion plants

The Republic of Kazakhstan has 183 operational combustion plants of over 50 MWh, with a preliminary estimate of around 392 fuel-burning boilers, with a unit capacity of over 50 MW, of which 100-300 MW units predominate. Around 50% of fuel-boilers are coal-fired, around 48% gas-fired, and 2% oil-fired. In 2019, thermal coal accounted for the majority (74 %) of the coal produced. More than half of the coal produced (52%) was used to generate electricity and heat. The main energy fuel used in Kazakhstan is the Ekibastuz coal, which has a sulphur content of around 0,5-0,7%, a particularly high ash content of around 40-45%, and whose specific structural properties have made enrichment uneconomic to date [3], [24].

The emission limit values (ELV) in the draft RK BREF “Combustion of fuels in large plants for energy production” for new installations are equal to or more stringent than the ELVs for large combustion plants within the AGP, with several important exceptions. For existing plants, the ELVs may be close to, equal to or less stringent depending on the fuels and pollutants considered.

Chapter 4.4.2 summarises the differences between the ELVs of the RK BREF “Combustion of fuels in large plants for energy production” and the ELVs of Annexes IV, V and X of the AGP and chapter 4.8.1 details these differences by type of installations and fuels.

For **large combustion plants**, the reduction techniques available to reduce SO_2 and NOx emissions are described in chapters 8.1.1 and 8.2.1.

The means of achieving the SO_2 ELVs of Annex IV of the AGP for LCP, is the application of one or a combination of the following techniques, combined with the selection of low sulphur fuels:

- boiler sorbent injection,
- duct sorbent injection (DSI),
- spray dry absorber (SDA),
- circulating fluidised bed (CFB) dry scrubber,
- wet scrubbing,
- wet flue-gas desulphurisation (FGD),
- seawater FGD.

The means of achieving the NOx limit values of Annex V of the AGP for LCP is the application of one or a combination of the following techniques:

- combustion optimisation,
- low-NOx burners (LNB),
- air staging,
- fuel staging,
- flue-gas recirculation,
- selective non-catalytic reduction (SNCR),
- selective catalytic reduction (SCR).

Industrial activities emitting SO_2, NOx and or PM covered by Annexes IV, V and X of the AGP

The Republic of Kazakhstan has five major oil refineries (Atyrau Refinery LLP, Pavlodar Petrochemical Plant LLP, PetroKazakhstan Petroleum Products LLP, Joint Venture CASPI

BITUM LLP, Condensate LLP) and around thirty smaller capacity producers, known as "mini-refineries”. Two sulphur recovery units also operate in oil refineries.

In the Republic of Kazakhstan, primary iron and steel production is carried out at four full-cycle production sites and sinter production for the needs of the blast furnace shops is carried out in 3 sintering plants (Steel Department of JSC ArcelorMittal-Temirtau).

Cement is produced in seventeen full-cycle plants including eleven modern dry process plants, three wet process plants, and three small plants with shaft kilns. Kazakhstan has also twenty-seven registered producers of quicklime and hydrated air lime (2017).

Non-ferrous metals in Kazakhstan are produced at eight major industrial sites (Zhezkazgan Mining and Metallurgical Combine, Balkhashtsvetmet, Pavlodar Aluminium Smelter, Ust-Kamenogorsk Titanium and Magnesium Combine, Achisai Polymetallic Combine, Kazakhstan Electrolysis Plant, Balkhash Non-Ferrous Metals Processing Plant, Kairakta Mining and Metallurgical Combine).

There is weak nitric acid production in Kazakhstan at KazAzot JSC (weak nitric acid workshop). Nitric acid production is designed as a combined process.

Since 2021, one plant for the production of sheet glass has been in operation in the Republic of Kazakhstan.

No information on Pulp production activities in Kazakhstan was available to analyse.

Regarding waste incineration and titanium dioxide production, up to now there is no such activities in Kazakhstan [1].

For **industrial processes emitting SO_2, NOx and or PM covered by Annexes IV, V and X of the AGP,** chapters 8.1, 8.2 and 8.4 present the best available techniques for complying with the prescribed limit values. They may be specific to a process or generic, as presented above for LCPs. For PM, best available techniques for complying with the limit values are electrostatic precipitators and bag filters. Other types of dedusters, such as scrubbers, are also available but are less widely used. These techniques are most efficient when correctly sized.

Chapter 4.4.3 summarises the differences between the ELVs of the BREFs developed or under development by Kazakhstan and the ELVs of the AGP, Annexes IV, V and X, and chapter 4.8.2 details these differences by type of activity.

For the **uses of solvents in industry**, chapter 8.3, details the techniques available to comply with the limit values of AGP Annex VI. These techniques are based on primary measures such as low solvent content or solvent free products, more efficient means of application and secondary measures such as thermal or catalytic oxidation, adsorption on activated carbon and biological purification. With regard to the regulation of the VOC content of products, only limited information was available to compare the standards of the existing regulations in Kazakhstan and Annex XI of the AGP (Tables 1 and 2).

In Kazakhstan, priority measures to improve air quality in cities could also concern small residential stoves and boilers using coal and biomass for heating. Although in some regions electricity and industry can play a major role, residential heating using solid fuels is one of the main contributors to the health effects associated with winter smog in Kazakhstan’s cities.

District heating plants operate in several cities in Kazakhstan. However, they are generally old and use coal to produce heat. To date, one of the main sources of exposure of the population to particulate pollution in Kazakhstan's cities is residential heating using solid fuels in individual dwellings [12].

With regard to **PM emissions from domestic heating appliances using coal or biomass,** the use of the most efficient appliances in terms of emissions and energy consumption is essential, but technological solutions are not enough. The “Code of good practices for wood burning and small combustion installations” [37] developed by TFTEI, the report “Prioritizing reductions of particulate matter from sources that are also significant sources of black carbon - analysis and guidance” [38] developed by TFIAM and the report “Review on Black Carbon (BC) and Polycyclic Aromatic Hydrocarbons (PAHs) emission reductions induced by PM emission abatement” [39] developed by TFTEI provide an excellent overview of the policies to be implemented beyond the technical characteristics of appliances. The thematic session on residential wood combustion and air pollution of 56th WGSR in May 2018, is also useful for inspiring ideas in this field [40].

One of the key measures that could be applied to domestic heating using solid fossil and biomass is to replace existing domestic heating appliances with new, improved appliances and to raise awareness among users of these appliances.

The “Code of good practice for wood-burning and small combustion installations” was developed and adopted in 2019 [37]. This document responds to the needs to inform the general public of the impact of wood heating on air pollution and human health and how the end-users can contribute to reducing PM emissions, which come from multiple sources. The following main topics were addressed in the document: a) the best practices available for domestic wood heating in order to minimize emissions and increase efficiency, reducing expenditure due to reduced wood use and storage requirements, while reducing the negative impact on the environment and human health; b)the best heating appliances currently available on the market; c) the proper origin and characteristics of wood biomass, emphasising the need to burn dry, clean wood and therefore avoid the use of composite, treated and/or contaminated wood.

As far as appliances and combustion are concerned, the reduction of PM emissions is pursued through optimising combustion conditions, by several means, to ensure the best optimized conditions in terms of temperature, residence time (sufficient time is required) and turbulence (to ensure good mixing of flue gases) (the three T’s rules), but also the geometry of the combustion chamber, the air supply and the reduction of user intervention, through automated combustion systems. Solutions for these three T’s parameters can be applied to different types of appliances, including stoves [41].

Temperature:

- Refractory lining in the combustion chamber,
- Shape and size of combustion chamber,
- Material and isolation of the door as well as size of window and its radiation coefficient or alternatively coated glasses or double/triple windows with air chambers in between,
- Windows should be of appropriate limited size.

Sufficient residence time:

- Gas volume flow,
- Distribution of flue gases over combustion chamber,
- Distribution of air,
- Height and width of the combustion chamber.

Turbulence or mixing of flue gasses:

- Distribution of purge air windows,
- Direction and geometry of additional inlet air,
- Velocities of flue gas and combustion air,
- Geometry of the main and the post combustion chamber,
- Geometry of deflection plate and the use of baffles in post combustion chamber,
- Avoidance of leakage streams (sealing),
- Avoidance of short-circuiting of the flue gas stream.

Financial incentives can increase the replacement rate for domestic appliances. In the cities of Aktobe, Almaty, Atyrau, Balkhash, Karaganda, Nur-Sultan, Shymkent, Temirtau, Ust-Kamenogorsk, and Zhezkazgan, a higher rate of replacement of older appliances could be foreseen.

These measures are also linked to an energy policy aimed at reducing the energy demand through better energy efficiency.

Nevertheless, implementation energy efficiency measures in practice also requires behavioural incentives through appropriate price levels that reflect the full costs of using fuels, including the cost of damages imposed on victims of pollution. Where access to finance or affordability impede the behavioural response to price signals, additional financial support for targeted homeowners may be required to maintain energy comfort and invest in energy efficiency [12].

Regarding mobile sources, the following recommendations can be made:

Passenger cars, light and heavy-duty vehicles:

In Kazakhstan, the highest ecological class for vehicles currently in force is K5 (comparable to Euro 5/V in the EU). In addition, since 2018, fuels produced in the country have complied with K4 and K5 standards (comparable to Euro 4 and Euro 5). However, in accordance with the requirements of the amended Gothenburg Protocol, the transition to Euro-6 and Euro-VI standards is necessary. To date, regulations have not been aligned to allow the implementation of Euro 6/VI standards for vehicles produced in Kazakhstan (tables 1 to 3 of Annex VIII of the AGP) or for new imported vehicles.

The sulphur content of diesel and petrol is aligned with Annex III of the AGP, (10 mg/kg) from 2018.

The legislative framework can be improved to ensure that the latest Euro 6/Euro VI standards are implemented for new vehicles imported and manufactured in Kazakhstan.

Many different approaches can also be used to reduce emissions from road transport. Measures such as developing public transport, making it more attractive, encouraging the use of public transport, developing car-sharing schemes, and encouraging walking and cycling in cities, can be envisaged. These measures provide an integrated approach that can benefit both air quality and climate change.

Non-Road Mobile Machinery:

Information was not available to analyse, but it is unlikely that new engines produced in Kazakhstan comply with the limit values of Tables 4 to 9 of Annex VIII of the AGP. Engine technology has evolved, and emissions may even be below than the Annex VIII limit values.

A study could be conducted to determine the state of the art in Kazakhstan for non-road mobile Machinery and assess whether the engines currently produced comply with Tables 4 to 9 of Annex VIII of the AGP.

Final conclusions

The implementation of the 2021 Environmental Code and supporting regulations, the definition of BAT and the introduction of integrating permit system will allow the legal framework in Kazakhstan to be consistent with some of the provisions of AGP Technical Annexes IV, V and X, for the LCPs and industrial sources covered, but only if the technological emission values associated with application of the best available techniques implemented are the same as or more stringent than BAT-AELs in AGP Technical Annexes. It was noted that some BAT-AELs may be less stringent than the ELVs in AGP Technical Annexes for PM emissions from LCPs.

Evolution of the regulatory framework for LCP and Category I industrial sources can be achieved in 2026-2028, according to TFTEI, through intensive work on BAT definition and BREF development. Implementation of BATs for LCPs and industrial processes will reduce of SO_2, NOx en PM emissions, but emissions reduction will be effective if the measures are enforced.

For Annexes VI and XI of the AGP, there was insufficient reliable information to assess the legal framework for VOC limit values for industrial processes or related products.

Annex VIII of the AGP sets Euro 5/V standards only for road vehicles (passenger cars and duty vehicles). For all other vehicles covered by Annex VIII such as non-road mobile machinery, there was insufficient reliable information to access the legal framework.

Studies could be envisaged to know better the status of engine performance and to assess whether the engines currently produced comply with the limit values specified in Tables 4 to 9 of Annex VIII of the AGP.

4.7. References of chapter 4. Kazakhstan

[1] The Department of State Metrological and Analytical Control of the Committee for Environmental Regulation and Control of MENR RK, Eurasian GHG Management, Karaganda Regional Environmental Museum, and International Centre for Green Technologies and Investment Projects communications with Citepa, from June 2022 to January 2024

[2] Convention on Long-range atmospheric pollution. Status of ratification: https://treaties.un.org/Pages/ViewDetails.aspx?src=TREATY&mtdsg_no=XXVII-1&chapter=27&clang=_en

[3] Protocols of the CLRTAP. Status of ratification: https://unece.org/protocols - Web site accessed in January 2023

[4] UNECE On the way of clean air The Capacity-Building Programme under the Convention on Long-range Transboundary Air Pollution in Eastern Europe, the Caucasus and Central Asia, 2019 https://unece.org/sites/default/files/2021-06/20191003-CAPACITY-BUILDING-DIGITAL-PAGE-EN.pdf

[5] Status of Reporting, EMEP https://www.ceip.at/status-of-reporting-and-review-results/2023-submission - Web site accessed in July 2023

[6] Kazakhstan National Action Plan for ratification of CLRTAP protocols and fulfilment of correspondent commitments, 2021

[7] Kazakhstan 2050: A New Political Course of the Established State, 2012

[8] Concept for the transition of the Republic of Kazakhstan to a "green economy", 2013, https://policy.asiapacificenergy.org/node/133

[9] Strategic Development Plan of the Republic of Kazakhstan until 2025, 2018

[10] The Republic of Kazakhstan NFR tables for 2022 https://www.ceip.at/status-of-reporting-and-review-results/2022-submission

[11] EMEP/EEA air pollutant emission inventory guidebook 2019. Technical guidance to prepare national emission inventories: https://www.eea.europa.eu/publications/emep-eea-guidebook-2019Reg

[12] Vasil Zlatev, Janusz Cofala, Grzegorz Peszko, Qing Wang. 2021. Clean Air and Cool Planet – Cost-Effective Air Quality Management in Kazakhstan and Its Impact on Greenhouse Gas Emissions. The World Bank: Washington DC

[13] Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on ambient air quality and cleaner air for Europe. http://data.europa.eu/eli/dir/2008/50/oj

[14] Environmental code of the Republic of Kazakhstan, 2021: https://adilet.zan.kz/rus/docs/K2100000400

[15] Sanitary and epidemiological requirements for sanitary protection zones of facilities which are objects of impact on habitat and human health, of the Republic of Kazakhstan Order No. 26447, 11 January, 2022: https://adilet.zan.kz/rus/docs/V2200026447#z6

[16] Development of sector specific (“vertical”) Best Reference Document (BREF) for selected industry sector in the Republic of Kazakhstan for cement industry and energy sector (production of energy by combustion of fuel: coal, oil and gas) project, 2021-2022

[17] Further methodological support for the process to establish Best Available Techniques (BAT) in Kazakhstan” project, 2022

[18] Communication of Kairat Massenov, IGTIPC "Best available techniques as a tool for sustainable development", 8th Meeting of the Expert Group on Best Available Techniques 9 and 10 November 2023, Seville, Spain

[19] Resolution of the Government of the Republic of Kazakhstan dated 28 October 2021 No. 775 “On Approval of the Rules for the Development, Application, Monitoring and Revision of Best Available Techniques reference documents” https://adilet.zan.kz/rus/docs/P2100000775

[20] Rules for maintaining an automated system for monitoring emissions into the environment during industrial environmental control of the Republic of Kazakhstan, 2021: https://adilet.zan.kz/rus/docs/V2100023659

[21] Order of the Minister of Ecology, Geology and Natural Resources of the Republic of Kazakhstan dated 10 March 2021 № 63 “On Approval of the Methodology for Determination of Environmental Emission Standards” https://adilet.zan.kz/rus/docs/V2100022317

[22] Order of the Minister of Ecology, Geology and Natural Resources of the Republic of Kazakhstan dated 31 August 2021 No. 346. On approval of the Rules for maintaining the register of emissions and transfer of pollutants https://adilet.zan.kz/rus/docs/V2100024214

[23] Draft BREF LCP of Kazakhstan (Version of 16th of September, 2021)

[24] Kazakhstan Environmental Performance Reviews. Third review. United Nations. Geneva, 2019

[25] Decree of the Government of the Republic of Kazakhstan No. 1171 of 4 November 2014 “On approval of the General Scheme of Gasification of the Republic of Kazakhstan for 2015 – 2030”: https://adilet.zan.kz/rus/docs/P1400001171

[26] GOST 32511-2013 (EN 590:2009) "Diesel fuel EURO. Technical conditions". Interstate standard GOST 32511-2013 was enacted as a national standard of the Republic of Kazakhstan from July 15, 2017 by Order of the Committee for Technical Regulation and Metrology No. 186-OD of July 1, 2017.

[27] On Energy Saving and increase of Energy Efficiency. The Law of the Republic of Kazakhstan, No. 541-IV, 13 January 2012. https://adilet.zan.kz/eng/docs/Z1200000541

[28] Draft BREF RK “Cement and Lime Production” (Version of 16th of September, 2021)

[29] Technical Regulation of the Eurasian Economic Union 013/2011 “Requirements for automotive and aviation gasoline, diesel and marine fuel, jet fuel and fuel oil” https://meganorm.ru/Data2/1/4293800/4293800288.pdf

[30] Law “About chemical product safety” from 21 July 2007 № 302-III https://online.zakon.kz/Document/?doc_id=30113861&doc_id2=36231433#pos=91;-104.33332824707031&pos2=3;-101.33332824707031

[31] Technical regulation on paints and varnishes №13 98 dated 29.12.2007 https://adilet.zan.kz/rus/docs/P070001398_

[32] Directive 94/63/EC of 20 December 1994 on the control of volatile organic compound (VOC) emissions resulting from the storage of petrol and its distribution from terminals to service stations http://data.europa.eu/eli/dir/1994/63/oj

[33] Directive 2009/126/EC of the European Parliament and of the Council of 21 October 2009 on Stage II petrol vapour recovery during refuelling of motor vehicles at service stations http://data.europa.eu/eli/dir/2009/126/oj

[34] Technical Regulation Customs Union. Eurasian Economic Union. TR CU 018/2011 on the safety of wheeled vehicles.

[35] TFTEI Techno-Scientific Board. TFTEI background informal technical document for the Review of the Gothenburg Protocol for mobile sources, Annex VIII. August 2023. Informal document to the 61st WGSR in September 2023.

https://unece.org/sites/default/files/2023-08/TFTEI-%20Informal%20bakground%20document%20on%20review%20of%20Annex%20VIII%20-%20Mobile%20Sources%20of_0.pdf

[36] Directive 98/70/EC of the European Parliament and of the Council of 13 October 1998 relating to the quality of petrol and diesel fuels and amending Council Directive 93/12/EEC http://data.europa.eu/eli/dir/1998/70/2018-12-24

[37] Code of good practice for wood-burning and small combustion installations, 2019. https://unece.org/DAM/env/documents/2019/AIR/EB/ECE_EB.AIR_2019_5-1916518E.pdf

[38] Prioritizing reductions of particulate matter from sources that are also significant sources of black carbon - analysis and guidance, , 2021. https://unece.org/sites/default/files/2021-10/ECE_EB.AIR_2021_6-2113500E.pdf

[39] B. Bessagnet, N. Allemand, Review on Black Carbon (BC) and Polycyclic Aromatic Hydrocarbons (PAHs) emission reductions induced by PM emission abatement, TFTEI 2019

[40] Thematic session on residential wood combustion and air pollution of 56th WGSR in May 2018. https://unece.org/info/Environmental-Policy/Air-Pollution/events/20267.

[41] T. Nussbaumer, Overview on technologies for biomass combustion and emission levels of particulate matter, prepared for the Swiss Federal office for the Environment and TFTEI, 2010

4.8. Comparison of limit values in the regulations of Kazakhstan with the limit values of the AGP

4.8.1. Limit values in draft BREF LCP for large combustion plants

The following tables present ELVs in draft BREF LCP of Kazakhstan (the version of 16th September 2021 [23]). They are compared to ELVs of the Gothenburg protocol in Annex IV for SO_2, Annex V for NOx and Annex X for PM.

A colour code is used to identify consistency and differences in ELVs: green in case of equal or stricter ELVs, yellow in case of less stringent ELVs.

Table 4-8: Emission limit values for solid fuel combustion in draft BREF LCP of Kazakhstan and AGP

Type of combustion plant Total rated thermal power, MW of thermal energy	Substance	Draft BREF LCP of Kazakhstan		ELVs of technical Annexes of the AGP	
		New installation mg/m^3	Existing installation, mg/m^3	New installation mg/m^3	Existing installation, mg/m^3
< 100	NOx	155-200	330-450	300 (coal, lignite and other solid fuels) 450 (pulverized lignite) 250 (biomass, peat)	300 (coal, lignite and other solid fuels) 450 (pulverized lignite) 300 (biomass, peat)

100 – 300		80-130	200-210	200 (coal, lignite and other solid fuels) 200 (biomass, peat)	200 (coal, lignite and other solid fuels) 250 (biomass, peat)
≥ 300		80-125	200-210 (excluding pulverized coal)	150 (coal, lignite and other solid fuels) (general) 150 (biomass, peat) 200 (pulverized lignite)	200 (coal, lignite and other solid fuels) 200 (biomass, peat)
< 100	SOx	170-220	400 400 400	400 (coal, lignite and other solid fuels) 300 (peat) 200 (biomass)	
100 – 300		135-200	220-250 220-250 220-250	200 (coal, lignite and other solid fuels) 300 (peat) 200 (biomass)	250 (coal, lignite and other solid fuels) 300 (peat) 200 (biomass)
≥ 300		25-110 (pulverized coal plant and fluidized bed boiler)	165-200 (excluding fluidized bed boiler)	150 (coal, lignite and other solid fuels) (FBC: 200) 150 (peat) (FBC: 200) 150 (biomass)	200 (coal, lignite and other solid fuels) 200 (peat) 200 (biomass)
< 100	Dust	35-60	70-200	20 (coal, lignite and other solid fuels) 20 (biomass, peat)	30 (coal, lignite and other solid fuels) 30 (biomass, peat)
100 – 300		35-60	70-200	20 (coal, lignite and other solid fuels) 20 (biomass, peat)	25 (coal, lignite and other solid fuels) 20 (biomass, peat)
300 – 1000		35-60	70-200	10 (coal, lignite and other solid fuels) 20 (biomass, peat)	20 (coal, lignite and other solid fuels) 20 (biomass, peat)
≥ 1000		35-70	70-200		

Table 4-9: Emission limit values for liquid fuel combustion in draft BREF LCP of Kazakhstan and AGP

Type of combustion plant Total rated thermal power, MW of thermal energy	Substance	Draft BREF LCP of Kazakhstan		ELVs of technical Annexes of the AGP	
		New installation mg/m³	Existing installation, mg/m³	New installation mg/m³	Existing installation, mg/m³
< 100	NOx	100-215 (in boilers)	450-500	300	450
100 – 300		85-100 (in boilers)	450-500	150 50 (light and medium distillates)	200 (general) Existing plants within refineries and chemical installations: 450 (for firing of distillation and conversion residues from crude oil refining for own consumption in combustion plants and for firing liquid production residue as non-commercial fuel) 90 (general for light and medium distillates) 200 (plants operating less than 1,500 hours a year)
≥ 300				100	150 (general) Existing plants within refineries and chemical installations: 450 (for firing of distillation and conversion residues from crude oil refining for own consumption in combustion plants and for firing liquid production residue as non-commercial fuel (< 500 MWth))
< 100	SOx	100-250 85-100 (in boilers)	750-1400	350	
100 – 300				200	250
≥ 300		75-200 85-100 (in boilers)	600-950	150	200
< 100	Dust	7-18	7-25	20	30 (in general) 50 (for the firing of distillation and conversion residues within refineries from the refining of crude oil for own consumption in combustion plants)
100 – 300				20	25 (in general) 50 (for the firing of distillation and conversion residues within refineries from the refining of crude oil for own consumption in combustion plants)
≥ 300		7-10	7-15	10	20 (in general) 50 (for the firing of distillation and conversion residues within refineries from the refining of crude oil for own consumption in combustion plants)

Table 4-10: Emission limit values for gaseous fuels combustion in draft BREF LCP of Kazakhstan and AGP

Type of combustion plant Total rated thermal power, MW of thermal energy	**Substance**	**Draft BREF LCP of Kazakhstan**		**AGP**	
		New installation mg/m³	**Existing installation, mg/m³**	**New installation mg/m³**	**Existing installation, mg/m³**
Open-cycle gas turbines (GTP)					
≥ 50	NOx	25-50	100-150	100 (natural gas)	100 (natural gas)
Combined cycle gas turbines (CCGT)					
50–600	NOx	15-40	75-120	50 (general for natural gas)	50 (general for natural gas), 150 (plants working on natural gas and operating less than 1,500 hours per year) 120 (general for other gases) 200 (for other gases, for plants operating less than 1,500 hours a year)
>600		15-40	50-100		
Natural gas combustion in boilers and engines					
Boiler <100	NOx	50-100	100-200	100 (natural gas)	100 (natural gas)
Boiler ≥100-300		50-100	100-200		
Boiler ≥ 300		50-100	100-200		
Engine		55-85	100-175		

4.8.2. Limit values in draft BREF for industrial plants

The following tables present ELVs in draft BREFs of Kazakhstan [1]. They are also compared to ELVs of the Gothenburg protocol in Annex IV for SO_2, Annex V for NOx and Annex X for PM.

The same colour code is used in the following tables.

Table 4-11: Comparison of ELV for industrial processes in draft BREFs of the Republic of Kazakstan and ELVs prescribed by the AGP

ELVs of technical Annexes of the AGP		**ELVs prescribed by the Kazakhstan regulation**
SO_2		
Table 3	Sulphur recovery units: for plants that produce more than 50 Mg of sulphur a day Minimum sulphur recovery rate of sulphur recovery units: new plants: 99.5% existing plants: 98.5%	There are two sulphur recovery units operating in the Republic of Kazakhstan at refineries Minimum sulphur recovery rate of sulphur recovery units for existing installations Sulfuric acid plants – 2 units >99% Oil refinery plants 5 units >99.95% Gas refinery plants 3 units >99.7%
Table 4	Titanium dioxide production Sulphate process, total emission:	Activity not existing in the Republic of Kazakhstan

ELVs of technical Annexes of the AGP		ELVs prescribed by the Kazakhstan regulation
	6 kg/t of TiO_2 Chloride process, total emission: 1.7 kg/t of TiO_2	
NOx		
Table 3	Cement clinker production General (existing and new installations): 500 mg/m³ Existing lepol and long rotary kilns in which no waste is co-incinerated: 800 mg/m³	BREF RK "Cement and Lime Production" sets NOx emission levels for new process lines : < 400 mg/Nm³ For existing - cyclone kilns: < 400 mg/Nm³ for long rotary kilns in the wet process: < 800 mg/Nm³
Table 5	Iron ore sinter plants New installation: 400 mg/m³ Existing installation: 400 mg/m³	draft BREF RK on iron and steel production was developed in 2023, however was not available for analysis.
Table 6	Nitric acid production excluding acid concentration units New installation: 160 mg/m³ Existing installation: 190 mg/m³	The draft BREF RK "Production of inorganic chemicals" (was not precised for new or existing installations): for nitric acid production at an absorption tower of <180 mg/Nm³ for ammonia production of <230 mg/Nm³.
Dust		
Table 2	Mineral oil and gas refineries FCC regenerators: 50 mg/m³	In the draft BREF RK "Oil and Gas Refining", For the regenerator in the catalytic cracking process associated with the application of the BAT (monthly average) at 10-50mg/Nm³
Table 3	Cement production Cement installations, kilns, mills and clinker coolers: 20 mg/m³	BREF RK "Cement and Lime Production" for kiln gases from cement production at < 20 mg/Nm³ regardless of the production method
Table 4	Lime production Lime kiln firing: 20 mg/m³	BREF RK "Cement and Lime Production" for kiln gases from lime production at < 20 mg/Nm³ regardless of the production method
Table 5	Primary iron and steel production Sinter plant: 50 mg/m³ Pelletization plant: 20 mg/m³ for crushing, grinding 15 mg/m3 for all other process	Draft BREF RK on iron and steel production was developed in 2023. however, was not available for analysis

ELVs of technical Annexes of the AGP		ELVs prescribed by the Kazakhstan regulation
	Blast furnace: Hot stoves (>2.5 t/hour): 10 mg/m^3 Basic oxygen steelmaking and casting (>2.5 t/hour): 30 mg/m3 Electric steelmaking and casting (>2.5 t/hour): 15 mg/m^3 for existing installations 5 mg/m^3 for new installations	
Table 6	Iron foundries Iron foundries (>20 t/day): all furnaces (cupola, induction, rotary) all mouldings (lost, permanent) 20 mg/m^3 Hot and cold rolling: 20 mg/m^3 50 mg/m3 where a bag filter cannot be applied due to the presence of wet fumes	Draft BREF RK on iron and steel production was developed in 2023.however, was not available for analysis
Table 7	Non-ferrous metals production Non-ferrous metal processing: 20 mg/m^3	According to the draft BREFs RK “Lead Production”, “Zinc and Cadmium Production”, “Copper and Precious Metal – Gold Production”, for lead production are 2-5 mg/Nm^3, for copper production 2-5 mg/Nm^3, for zinc and cadmium production 2-5 mg/Nm^3.
Table 8	Glass production: New installation: 20 mg/m^3 Existing installation: 30 mg/m^3	Since 2021, one production plant for the production of sheet glass has been in operation in the Republic of Kazakhstan BREF RK on Production of glass, ceramic products is scheduled for 2024-2027
Table 9	Pulp production Auxiliary boiler 40 mg/m^3 when firing liquid fuels (at 3% oxygen content) 30 mg/m^3 when firing solid fuels (at 6% oxygen content) Recovery boiler and lime kiln: 50 mg/m^3	There is no pulp production in Kazakhstan. However, BREF RK Production of pulp from wood or other fibrous materials is scheduled for 2024-2027
Table 10	Waste incineration Municipal waste incineration plants (> 3 Mg/hour): 10 mg/m^3	There is no waste incineration in Kazakhstan

ELVs of technical Annexes of the AGP		ELVs prescribed by the Kazakhstan regulation
	Hazardous and medical waste incineration (> 1 Mg/hour): 10 mg/m^3	

5. Moldova

This part of the report dedicated to Kazakhstan was produced with the support of Moldovian experts:

Stela Drucioc, head of Air and Climate Change Policies Division of the Ministry of Environment of Moldova

Norocea Galina, senior Advisory Officer of the Ministry of Environment of Moldova

Elena Bicova, team leader on energy sector for UNFCCC and CLRTAP reporting, Institute of Power Engineering of Moldova

Tatiana Kirillova, expert in energy for UNFCCC and CLRTAP reporting, Institute of Power Engineering of Moldova

Elena Mosanu, team leader on industry and solvents sector for CLRTAP reporting, Institute of Ecology and Geography of Moldova

Irina Vasiliev, researcher at the Institute of Power Engineering of Moldova

Iordanca-Rodica Iordanov, Executive Director at P.A. Eco Contact Moldova

They provided helpful information from June 2022 to October 2023 on industrial and transport emission sources, air quality, and emission regulations by responding to questionnaire, e-mail exchange and during several meetings [1].

5.1. Status of ratification of CLRTAP and its protocols and strategic programmes

Moldova is Party to the Convention on the Long-Range Transboundary Air Pollution (CLRTAP) (Accessed on 5th of January 1995 [2]) and also accessed to the Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe (EMEP) on 26 July, 2016. On 1st October, 2002 Moldova ratified the 1998 original Protocol on Heavy Metals and the 1998 original Protocol on Persistent Organic Pollutants (POP) [3]. Moldova signed but did not ratify Gothenburg Protocol 23 of May 2000 [3][6].

In 2014, the Republic of Moldova signed an Association Agreement between the European Union and the European Atomic Energy Community and their Member States, of the one part, and the Republic of Moldova, of the other part (hereafter Association Agreement EU – Republic of Moldova) [4]. It has been in force since July 1, 2016.

Chapter 16th of the Association Agreement EU – Republic of Moldova [4] is devoted to strengthening cooperation in the field of environment including air quality and industrial pollution. This chapter also stipulates that the Republic of Moldova shall approximate its legislation to the EU acts and international instruments referred to in Annex XI to this Agreement, in accordance with the provisions of that Annex (Article 19).

Annex XI of the Association Agreement EU – Republic of Moldova outlines provisions on air quality and industrial pollution and industrial hazards. Here is the updated information [1]:

[6] The 1985 Protocol on the reduction of Sulphur emissions and their transboundary flux, the 1988 Protocol concerning the control of NOx or their transboundary fluxes, the 1991 Protocol concerning the Control of emissions of VOC or their transboundary fluxes and the 1994 Protocol for further reduction of Sulphur emissions have not been examined.

1. Air quality

The Directive 2008/50/EC [5] has been partially transposed in Law no. 98/2022 regarding ambient air quality [6]. Concerning:

- adoption of national legislation and designation of competent authority/authorities scheduled to 2020, will be realised by entering into force on April 13, 2024, Law no. 98/2022 regarding atmospheric air quality.
- establishment and classification of zones and agglomerations scheduled to 2021, will be implemented from 2024.
- establishment of an assessment regime with appropriate criteria for assessing ambient air quality in relation to air pollutants to be implemented to 2025.
- establishment of air quality plans for zones and agglomerations where levels of pollutants exceed limit value/target value to be implemented to 2025. The plans will be developed based on the Methodology for developing air quality plans and air quality maintenance plans approved by the national government.
- establishment of short-term action plans for zones and agglomerations in which there is a risk that alert thresholds will be exceeded scheduled to 2025, will start in 2024.
- establishment of a system to provide information to the public is implemented to 2021. The Ministry of Environment provides information to the public and interested institutions.

The Directive 2004/107/EC [7] has also been partially transposed in Law no. 98/2022. Concerning:

- adoption of national legislation and designation of competent authority/authorities (to be implemented to 2020) both Law no. 98/2022 as well as other normative acts designate the competent authorities for atmospheric air protection.
- establishment and classification of zones and agglomerations (to be implemented to 2021) will be implemented starting in 2024.
- establishment of an assessment regime with appropriate criteria for assessing ambient air quality in relation to air pollutants to be implemented to 2025.
- making measures in order to maintain/improve air quality in respect of the relevant pollutants (to be implemented to 2025), until the entry into force of Law no. 98/2022, Law no. 1422/1997 on atmospheric air protection establishes measures to maintain and improve air quality [8].
- establishment of a system to provide information to the public to be implemented to 2021.

Concerning Council Directive 1999/32/EC of 26 April 1999 relating to a reduction of sulphur content of certain liquid fuel[7] to be implemented according to the timeline agreed within the framework of the Energy Community Treaty:

- adoption of national legislation and designation of competent authority/authorities.

[7] Directive 1999/32/EC of 26 April 1999 was repealed by Directive (EU) 2016/802 of the European Parliament and of the Council of 11 May 2016 relating to a reduction in the sulphur content of certain liquid fuels [9]

- establishment of an effective sampling system and appropriate analytical methods of analysis.
- prohibition of use of heavy fuel oil and gas oil with a sulphur content greater than established limit value.
- application of limit values for the sulphur content of marine fuels.

Concerning Council Directive 94/63/EC of 20 December 1994 on the control of volatile organic compound (VOC) emissions resulting from the storage of petrol and its distribution from terminals to service stations [10]:

- adoption of national legislation and designation of competent authority/authorities (to be implemented to 2020) Government Decision No. 587/2020 is in force for the approval of the Regulation on the control of emissions of volatile organic compounds resulting from the storage and distribution of gasoline from terminals to fuelling stations with oil products transposes Directive 94/63/EC [11].
- identifying all terminals for storing and loading petrol scheduled to 2019, was completed.
- establishment of technical measures to reduce loss of petrol from storage installations at terminals and service stations and during loading/unloading mobile containers at terminals (to be implemented to 2019) are implemented from 2020. The technical measures have been established in GD no. 587/2020 at Cap. VI. Requirements for the design and operation of gasoline loading and storage facilities at oil product service stations [11]. Owners or administrators of oil terminals report the results of volatile organic compound emissions measurements each year, no later than April 30 of the year preceding the reporting year, in the automated information system "National Register of Emissions and Transfer of Pollutants", in accordance with the provisions of the Government Decision no. 373/2018 [12].
- requiring all road tanker loading gantries and mobile containers to meet the requirements (to be implemented to 2021) Government Decision no. 587/2020 [11] establishes the requirements for loading and unloading facilities for mobile containers at terminals.

Directive 2004/42/EC of the European Parliament and of the Council of 21 April 2004 on the limitation of emissions of volatile organic compounds due to the use of organic solvents in certain paints and varnishes and vehicle refinishing products [13] was transposed by Government Decision no. 914/2020 of 16 December 2020 on the approval of the Regulation on the limitation of emissions of volatile organic compounds due to the use of organic solvents in certain paints and varnishes and vehicle refinishing product [14]. Concerning:

- adoption of national legislation and designation of competent authority/authorities was scheduled to 2021. The placing on the market of paints, varnishes and refinishing products for motor vehicles is regulated by Law no. 277/2018 regarding chemical substances [15] and the normative acts approved pursuant to it, the provisions of Law no. 7/2016 regarding market surveillance in relation to the sale of non-food products [16], as per Law no. 105/2003 on consumer protection [17].
- setting up maximum VOC content limit values for paints and varnishes scheduled to 2026, maximum VOC limit values were set up by the Regulation on the limitation of emissions of volatile organic compounds caused by the use of organic solvents in certain paints, varnishes and in automotive refinishing products [14].

- establishment of requirements ensuring labelling of products placed on the market and placing on the market of products complying with relevant requirements to be implemented to 2026.

Concerning Directive 2001/81/EC of the European Parliament and of the Council of 23 October 2001[8] on national emission ceilings for certain atmospheric pollutants:

- adoption of national legislation and designation of competent authorities to fulfil the requirement of reporting of emission inventories and reporting under the directive scheduled to 2020 is still in progress. By Government Decision no. 373/2018 [12], the National Register of Pollutant Emissions and Transfer is established for the purpose of collecting information on pollutant emissions and their transfer, and the Automated Information System "National Register of Pollutant Emissions and Transfer" is approved.
- development of national programmes to meet national ceilings scheduled to 2022, is in the process of developing the normative framework regarding national emission ceilings for certain atmospheric pollutants.
- meeting all other obligations, including national emission ceilings to be implemented to 2026.

So, to 2026, national emission ceilings shall apply as established in the original 1999 Gothenburg Protocol to Abate Acidification, Eutrophication and Ground-level Ozone. Furthermore, within that period the Republic of Moldova shall endeavour to ratify the Gothenburg Protocol, including the amendments adopted in 2012.

2. Industrial pollution and industrial hazards

Concerning Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control) [19]:

- adoption of national legislation and designation of competent authority/authorities was scheduled to 2020. Law no. 227/2022 on industrial emissions [20] will enter into force in September 2024 transposing Directive 2010/75/EU.
- identification of installations that require a permit (Annex I) scheduled to 2019, will be implemented from 2024.
- implementation of BAT taking into account the BAT conclusions of the BREFs to be implemented to 2026.
- establishment of an integrated permit system scheduled to 2022, will be implemented from 2024.
- establishment and implementation of a compliance monitoring mechanism to be implemented to 2024.
- establishment of emission limit values for combustion plants scheduled to 2020, to be implemented from 2024. The Environment Agency sets the emission limit values.

[8] Directive 2001/81/EC was repealed by Directive (EU) 2016/2284 of the European Parliament and of the Council of 14 December 2016 on the reduction of national emissions of certain atmospheric pollutants [18].

- preparation of a transitional national plan to reduce total annual emissions from existing plants (optional to setting emission limit values for existing plants) scheduled to 2022, to be implemented from 2024.

Annex VII of Association Agreement EU – Republic of Moldova [4] also provides the specifications for approximation of the Republic of Moldova legislation to Chapter 17 (Climate action) of title IV.

They include among others the specification to fuel quality to be implemented to 2021.

Concerning Directive 98/70/EC of the European Parliament and of the Council of 13 October 1998 relating to the quality of petrol and diesel fuels [21], the Republic of Moldova is in the process of developing the normative framework to insure:

- adoption of national legislation and designation of competent authority/authorities,
- carrying out an assessment of national fuel consumption,
- establishment of a system for monitoring fuel quality,
- prohibition of marketing of leaded petrol,
- permitting the marketing of unleaded petrol, diesel fuel and gas oils intended for non-road mobile machinery and agricultural and forestry tractors only if these meet relevant requirements,
- establishment of a regulatory system to cover exceptional circumstances and of a system to collect national fuel quality data.

Concerning road transport means, Annex XVI of the Association Agreement EU – Republic of Moldova covers the approximation of Moldova legislation:

to 2015:

- Directive 2002/24/EC of the European Parliament and of the Council of 18 March 2002 relating to the type-approval of two or three-wheel motor vehicles[9].
- Directive 94/25/EC of the European Parliament and of the Council of 16 June 1994 on the approximation of the laws, regulations and administrative provisions of the Member States relating to recreational craft[10].

to 2016:

- Directive 2003/37/EC of the European Parliament and of the Council of 26 May 2003 on type-approval of agricultural or forestry tractors, their trailers and interchangeable towed machinery, together with their systems, components and separate technical units and repealing Directive 74/150/EEC [24], Directive 77/537/EEC of 28 June 1977 on the approximation of the laws of the Member States relating to the measures to be taken against the emission of pollutants from diesel engines for use in wheeled agricultural or forestry tractors [25], and Directive 2000/25/EC of the European Parliament and of the

[9] Directive 2002/24/EC was repealed by Regulation (EU) No 168/2013 of the European Parliament and of the Council of 15 January 2013 on the approval and market surveillance of two- or three-wheel vehicles and quadricycles

[10] Directive 94/25/EC was repealed by Directive 2013/53/EU of the European Parliament and of the Council of 20 November 2013 on recreational craft and personal watercraft and repealing Directive 94/25/EC [23]

Council of 22 May 2000 on action to be taken against the emission of gaseous and particulate pollutants by engines intended to power agricultural or forestry tractors and amending Council Directive 74/150/EEC[11].

to 2018:

- Commission Regulation (EC) No 692/2008 of 18 July 2008 implementing and amending Regulation (EC) No 715/2007 of the European Parliament and of the Council on type-approval of motor vehicles with respect to emissions from light passenger and commercial vehicles (Euro 5 and Euro 6) and on access to vehicle repair and maintenance information[12],
- Regulation (EC) No 715/2007 of the European Parliament and of the Council of 20 June 2007 on type approval of motor vehicles with respect to emissions from light passenger and commercial vehicles (Euro 5 and Euro 6) and on access to vehicle repair and maintenance information [29].
- Regulation (EC) No 595/2009 of the European Parliament and of the Council of 18 June 2009 on type-approval of motor vehicles and engines with respect to emissions from heavy duty vehicles (Euro VI) and on access to vehicle repair and maintenance information [30].

In addition, in 2018, Moldova adopted two important documents: the Programme on the Promotion of Green Economy for 2018-2020 which focused on reducing air pollution by targeting solutions in specific sectors, such as sustainable transport, green construction, and energy efficiency and The national development strategy "European Moldova 2030", approved by Law no. 315/2022 [31], that provides a strategic vision related to four pillars: Sustainable and inclusive economy; strong human and social capital; fair and efficient institutions; and a healthy environment, Low-emission development program until 2030 [32].

The country has expressed its intention to ratify the three most recent protocols of CLRTAP as amended. At the request of the Government, workshops on gridded emission data and projections were carried out in 2014 and 2018. Gridded emissions were calculated for road transport and power generation, the two key sectors in the national emission inventory. As a result, the Republic of Moldova submitted its first Informative Inventory Report in 2015 [33].

5.2. Main sources of emissions

This chapter presents the main sources of SO_2, NOx, PM_{10}, $PM_{2.5}$ and VOC emissions in the Republic of Moldova. The dynamics of air pollutant emissions presented here, was built by TFTEI based on the emission data submitted by Moldova under the CLRTAP in October 2022 for the period of 1990 to 2020 [34] and Informative Inventory Report submitted in 2022 [35].

---

[11] Directive 74/150/EEC was repealed by the Regulation (EU) No 167/2013 of the European Parliament and of the Council of 5 February 2013 on the approval and market surveillance of agricultural and forestry vehicles [27]

[12] Commission Regulation (EC) No 692/2008 was repealed by Commission Regulation (EU) 2017/1151 of 1 June 2017 supplementing Regulation (EC) No 715/2007 of the European Parliament and of the Council on type-approval of motor vehicles with respect to emissions from light passenger and commercial vehicles (Euro 5 and Euro 6) and on access to vehicle repair and maintenance information, amending Directive 2007/46/EC of the European Parliament and of the Council, Commission Regulation (EC) No 692/2008 and Commission Regulation (EU) No 1230/2012 and repealing Commission Regulation (EC) No 692/2008 [28].

The main source of information to compile the CLRTAP emission inventory in Moldova is activity data officially published (national statistical publications, reports of central public authorities, public sector, scientific literature, and private sector). Emissions are estimated based on the methodological document “EMEP/EEA air pollutant emission inventory guidebook 2019”[36] using Tier 1 method. From 2019 to 2020, due to Covid pandemic, activity levels have been affected and reduced, so emissions may not be indicative of a broader pattern.

5.2.1. SO_2 emissions

Total SO_2 emissions

The evolution of SO_2 emissions from 2000 to 2020 is shown in Figure 5-1.

Sulphur dioxide (SO_2) emissions from 2000 to 2020 range from 3.2 to 5.8 kt, except 2013 when emissions SO_2 reached 12.5 kt, due to abnormally high contribution of public electricity and heat production sector (7.1 kt). This is due to an increase in coal consumption at the Moldavian Thermal Power Station in 2013 [35].

In 2020, SO_2 emissions reached 4.5 kt. In 2020, the main sources of SO_2 emissions were other stationary combustion (62%) mainly residential heating (71% of the category) and stationary combustion in industry (36%). The road transport sector accounts for less than 1%.

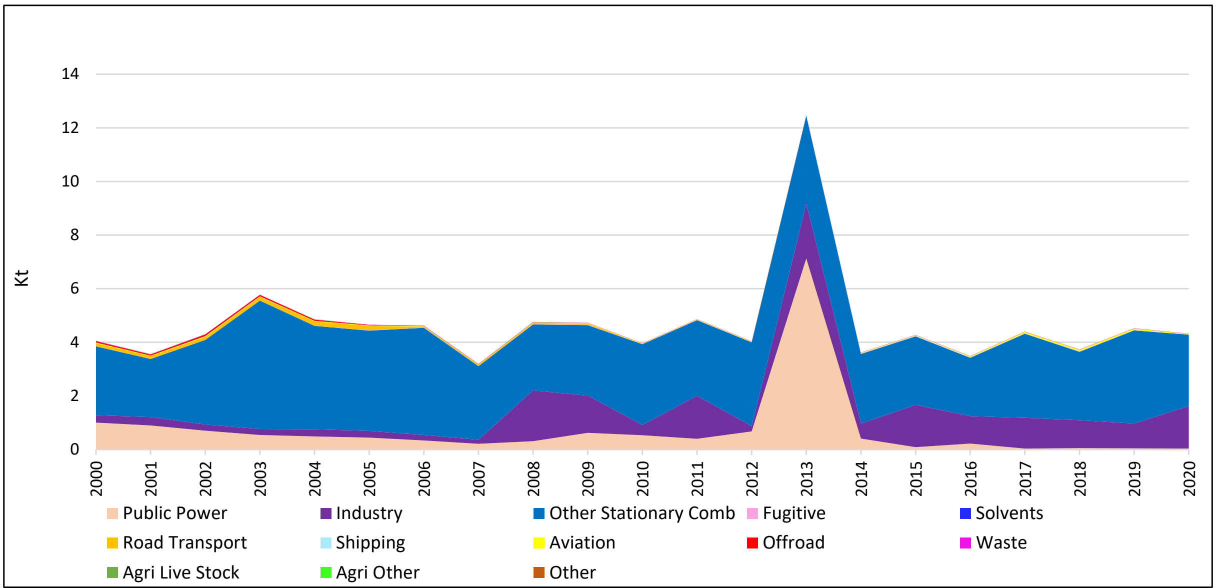


Figure 5-1: Trends in SO_2 emissions from 2000 to 2020 in Moldova

Industrial sources

In 2020, industrial sources of SO_2 emissions were 1,6 kt. The main sources of SO_2 emissions were the production of mineral products (95%), due to stationary combustion sources of non-metallic minerals (100%). Other sources make a minor contribution (Figure 5-2).

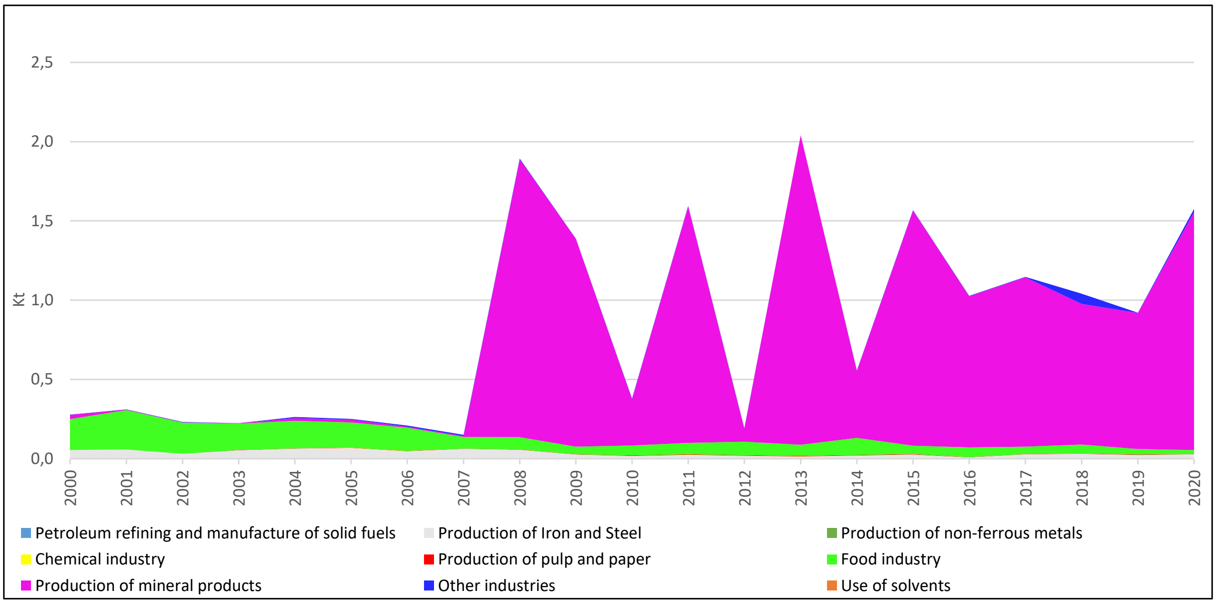


Figure 5-2: Trends in SO_2 emissions of industry from 2000 to 2020 in Moldova

5.2.2. NOx emissions

Total NOx emissions

The evolution of NOx emissions from 2000 to 2020 is shown in Figure 5-3.

From 2000 onward, NOx emissions in the Republic of Moldova were steadily growing. In 2020, NOx emissions were accounted for about 34.2 kt.

In 2020, road transport accounted for 48% of total emissions. In the structure of contributions by category, the share of road transport was increasing (mainly heavy-duty vehicles and buses (N2-N3 trucks, and M2-M3 buses)) [35]. Public power 17% and agriculture emissions accounted for 10%. Other stationary combustion sources accounted for 9%, due to stationary combustion (83%). Industrial sources accounted for only 4% of national totals.

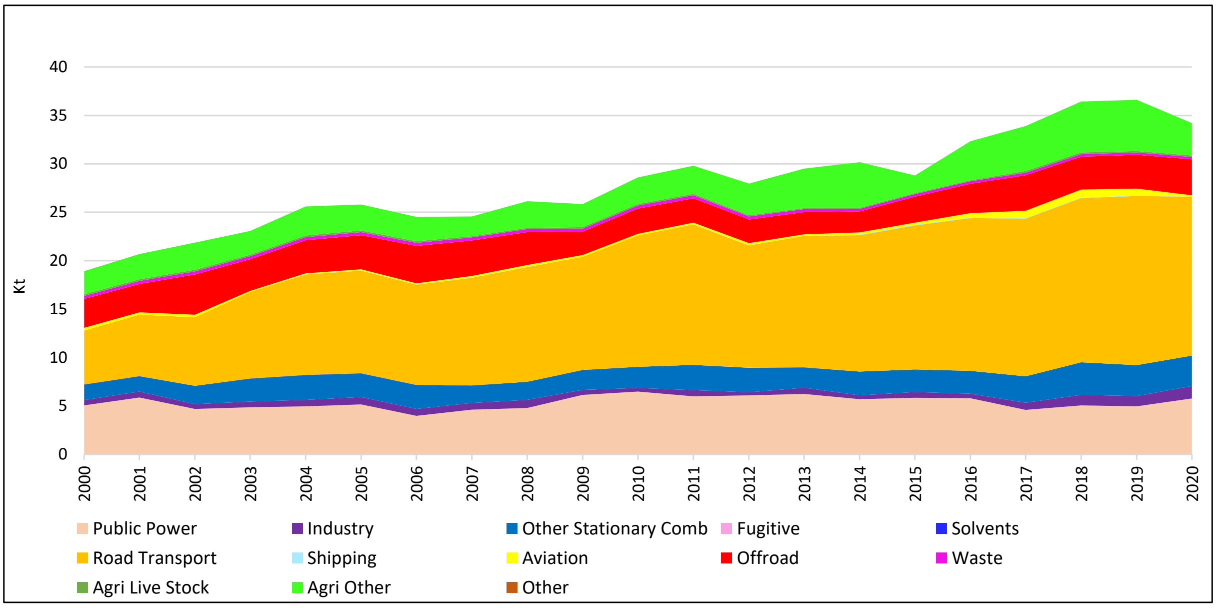


Figure 5-3: Trends in NOx emissions from 2000 to 2020 in Moldova

Industrial sources

In 2020, NOx emissions in Moldova was 1.3 kt. Among industrial sources, the main contribution to NOx emissions was from other industries (56%) due to stationary combustion in manufacturing industries and construction (100%). The production of mineral products was the second largest industrial source (33%), due to the stationary combustion of non-metallic minerals (100%). Other sources make a minor contribution (Figure 5-4).

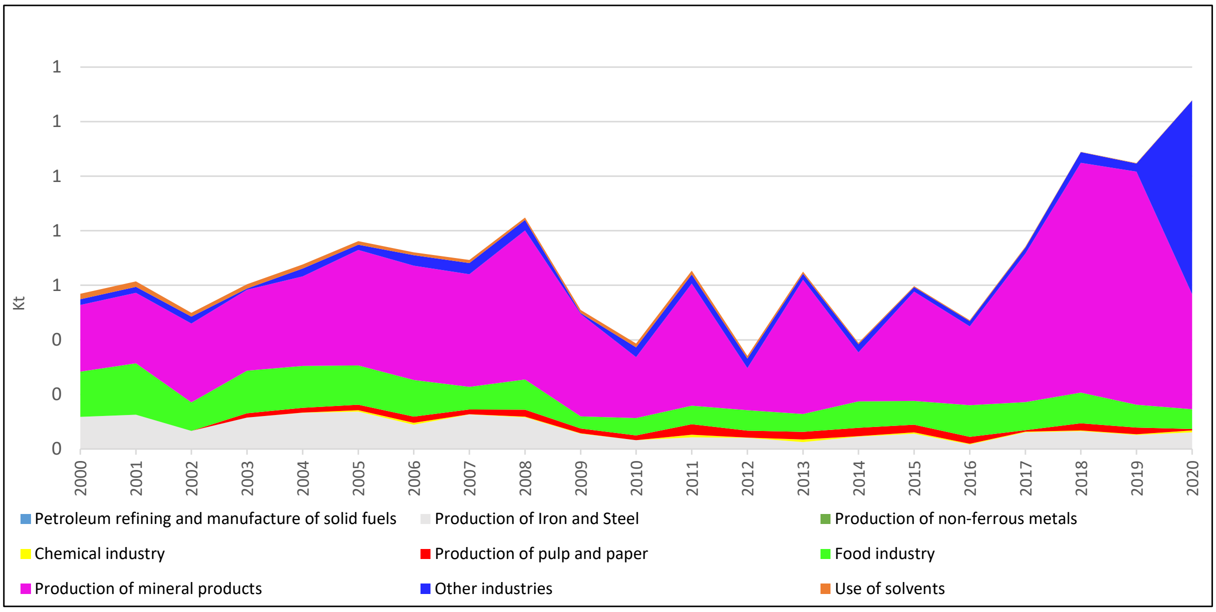


Figure 5-4: NOx emissions of industry from 2000 to 2020 in Moldova

Road transport

The trend in NOx emissions from the transport sector coincided with the trend in total NOx emissions. In 2020, NOx emissions from the transport sector was amount to around 16.4 kt, mainly from heavy-duty vehicles and busses (67%), passenger cars (19%), and light-duty vehicles (14%) (Figure 5-5).

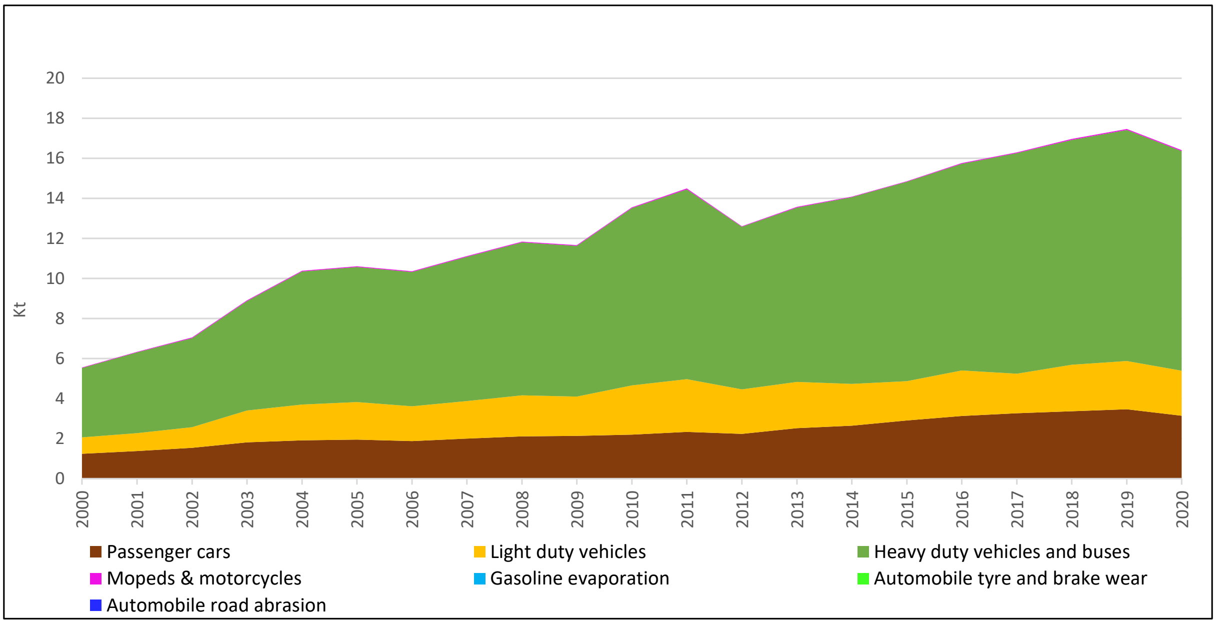


Figure 5-5: NOx emissions of transport from 2000 to 2020 in Moldova

5.2.3. PM_{10} and $PM_{2.5}$ emissions

Total PM_{10} and $PM_{2.5}$ emissions

The trend in PM_{10} and $PM_{2.5}$ emissions from 2000 to 2020 is shown in Figure 5-6 and Figure 5-7.

PM_{10} and $PM_{2.5}$ emissions remained stable before 2013, increased from 2013 to 2018, decreased in 2019 and grown in 2020. In 2020, overall PM_{10} emissions were approximately 28.4 kt and $PM_{2.5}$ emissions were around 22.5 kt.

In 2020, the main contribution to PM_{10} emissions was from other stationary combustion (72%), due to residential heating (99% of the category). Industrial processes contribute 14% to total PM_{10} emissions. Road transport accounts for only 3% of total emissions in 2020.

In 2020, the main contribution to $PM_{2.5}$ emissions was also due to other stationary combustion (88%), due residential heating (99% of the category). Industrial processes generated minor emissions (4%). $PM_{2.5}$ emissions from road transport accounted for 4% of total emissions.

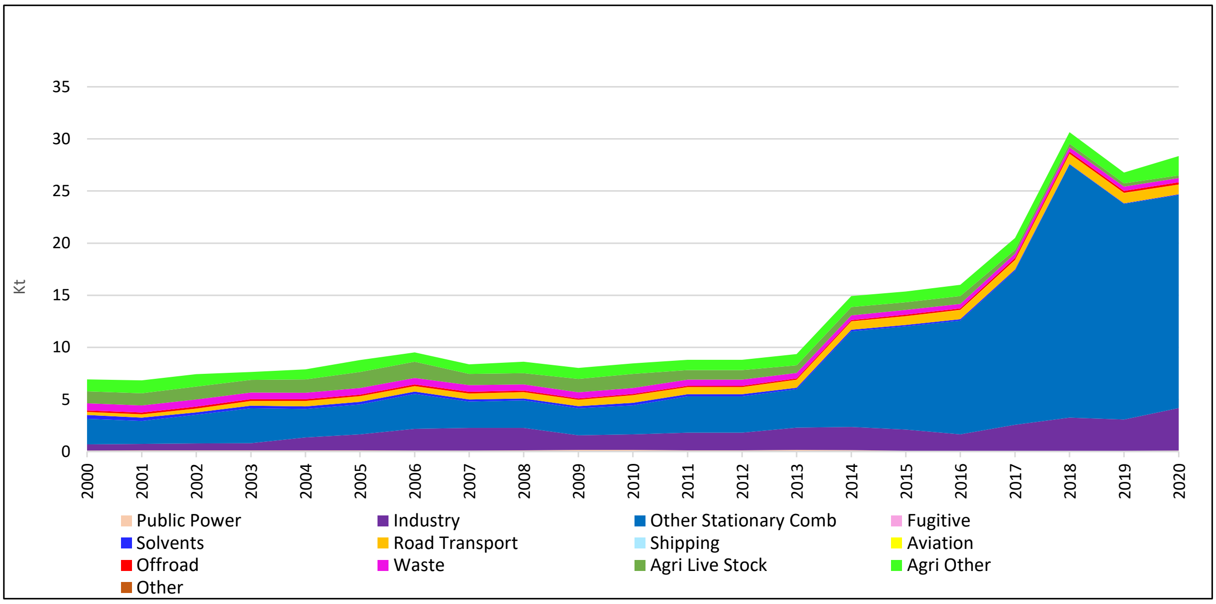


Figure 5-6: Trends in PM_{10} emissions from 2000 to 2020 in Moldova

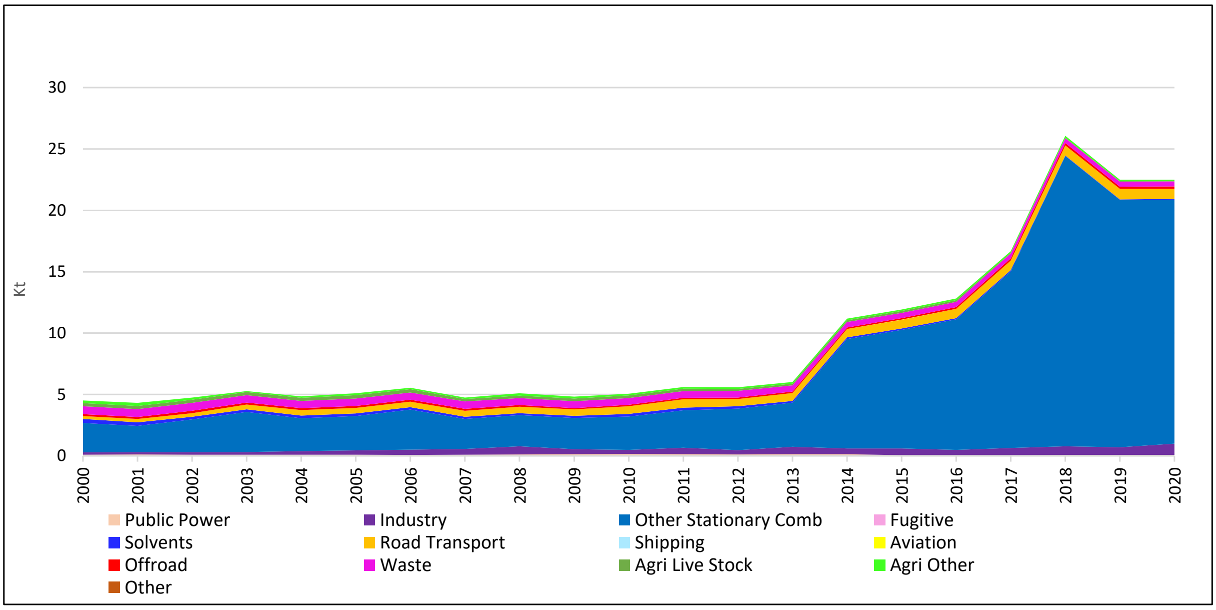


Figure 5-7: Trends in $PM_{2.5}$ emissions from 2000 to 2020 in Moldova

Industrial sources

In 2020, PM_{10} emissions from industrial sources represented around 4.2 kt. The main industrial sources of PM_{10} emissions were other industries (84%), mainly due to the sector of road paving with asphalt (72%), quarrying and mining of minerals other than coal (14%), and construction and demolition (10%). 13% of PM_{10} emissions in 2020 was due to the production of mineral products (38%), cement production and stationary combustion in non-metallic minerals manufacturing industries and construction (36%). The other sectors made minor contribution (Figure 5-8).

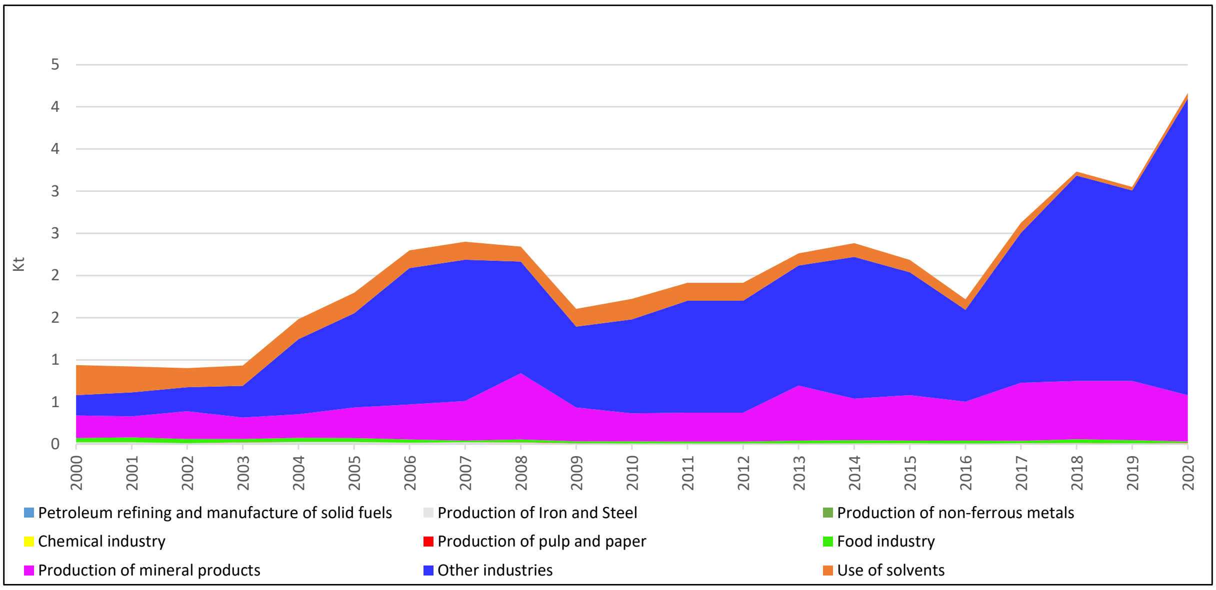


Figure 5-8: PM_{10} emissions of industry from 2020 to 2020 in Moldova

In 2020, $PM_{2.5}$ emissions from industrial sources accounted for around 1kt. The main industrial source of $PM_{2.5}$ emissions was other industries (55%), due to road paving with asphalt (65% of the category). The other major source of $PM_{2.5}$ emissions was the production of mineral products (38%), due to stationary combustion in manufacturing industries and construction of non-metallic minerals (50% of the category) and cement production (32% of the category). The other sources made minor contribution (Figure 5-9).

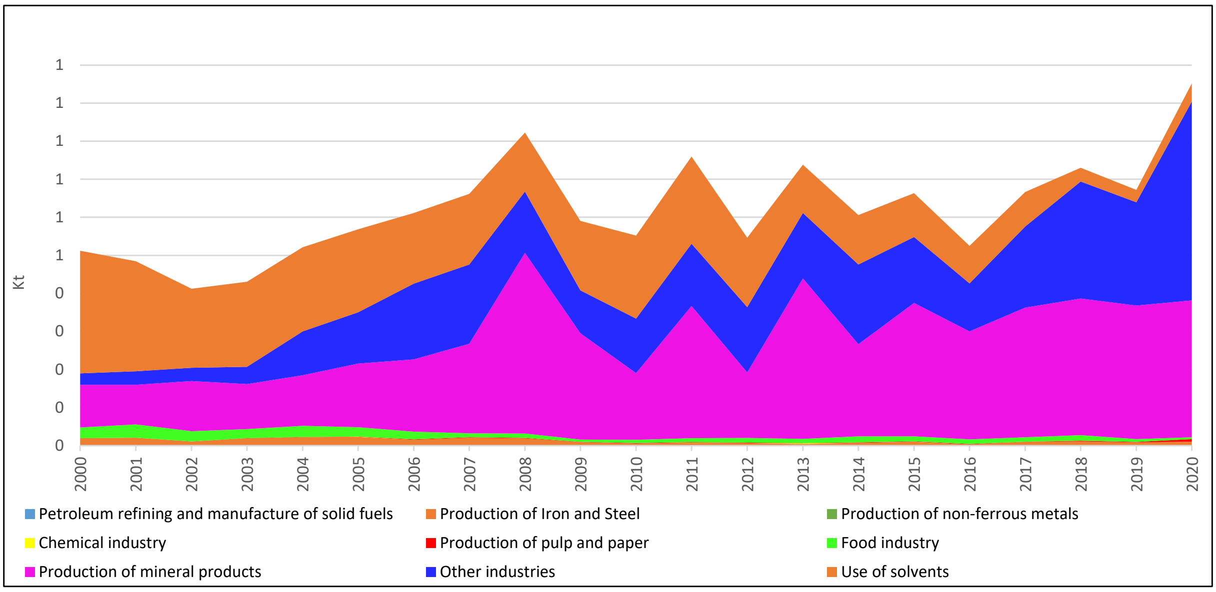


Figure 5-9: $PM_{2.5}$ emissions of industry from 1990 to 2019 in Moldova

Road transport

Trends in PM_{10} and $PM_{2.5}$ emissions from the road transport sector were similar. Emissions of these two pollutants had been gradually increasing since 2000, reaching around 1kt of PM_{10} and 0,9kt of $PM_{2.5}$ emissions. In 2020, PM_{10} and $PM_{2.5}$ emissions were mainly emitted by heavy-duty vehicles and busses (34% and 40% respectively), by light-duty vehicles (18% and 22% respectively), by automobile tyre and break wear (19% and 12% respectively) and by passenger cars (16% and 18% respectively) (Figure 5-10 and Figure 5-11).

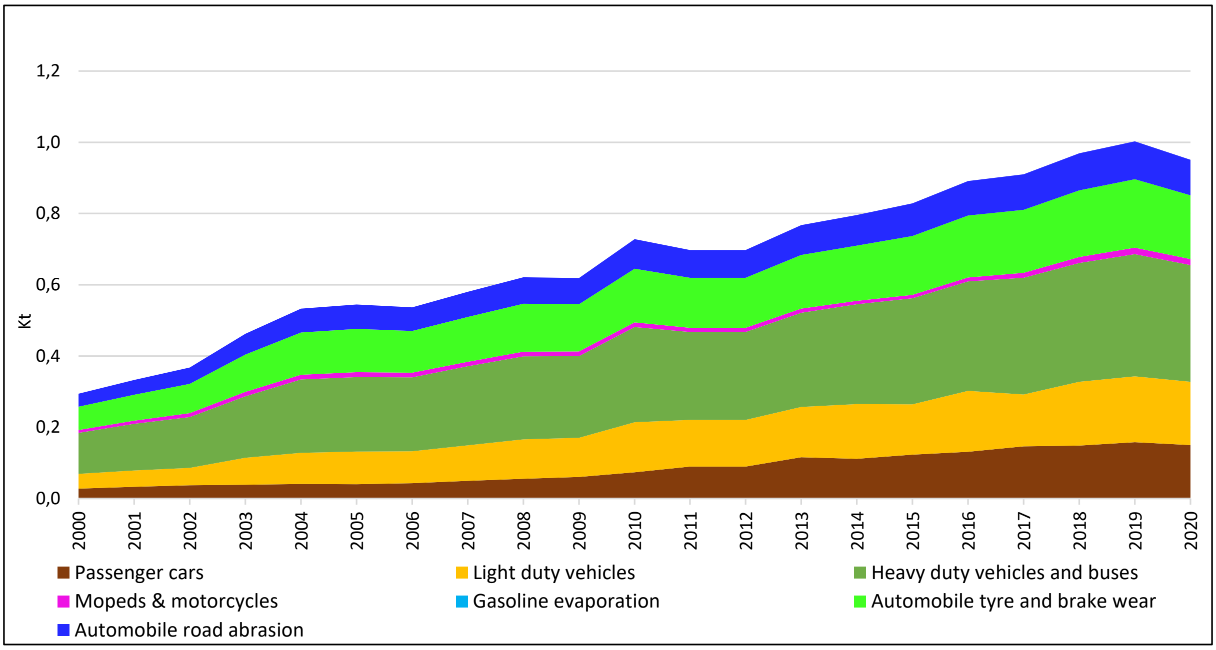


Figure 5-10: PM_{10} emissions of road transport from 2000 to 2020 in Moldova

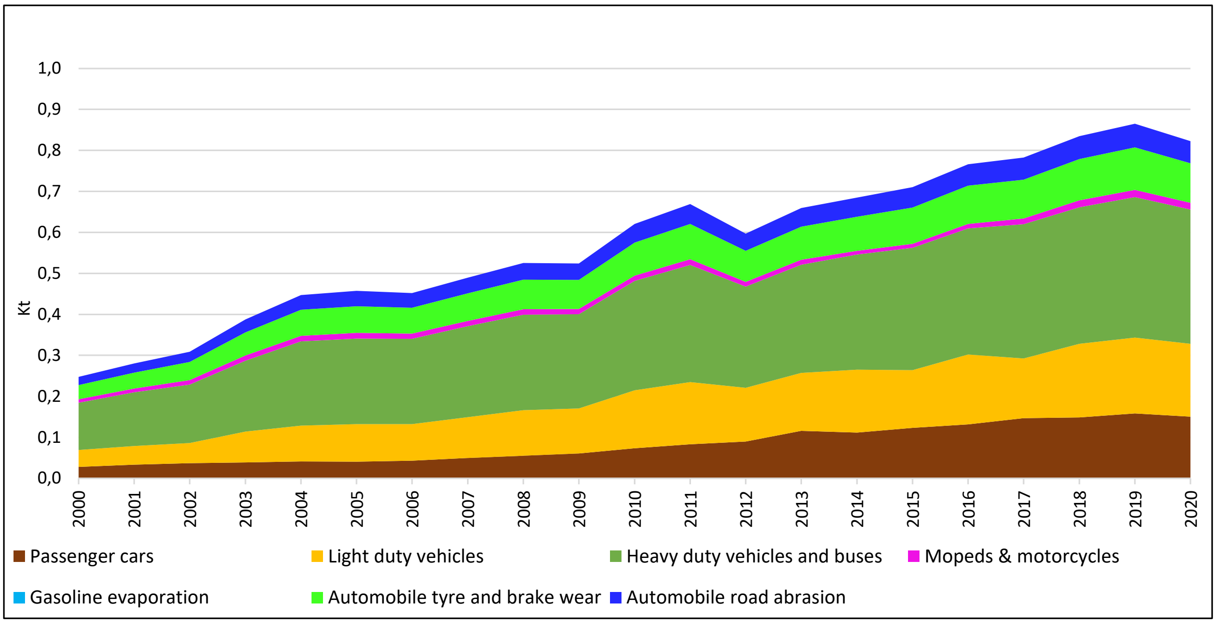


Figure 5-11: $PM_{2.5}$ emissions of road transport from 2000 to 2020 in Moldova

5.2.4. VOC emissions

Total VOC emissions

The evolution of VOC emissions from 2000 to 2020 is shown in Figure 5-12.

VOC emissions tend to increase in 2005, decrease from 2006 to 2013 and increase from 2014 onward. In 2020, VOC emissions represented around 69.3 kt. In 2020, the main contributors to VOC emissions were solvents (49%), followed by other stationary combustion (24%), due to residential heating (98% of the category). Industry makes a minor contribution (7%). Road transport contributes 9% of total VOC emissions.

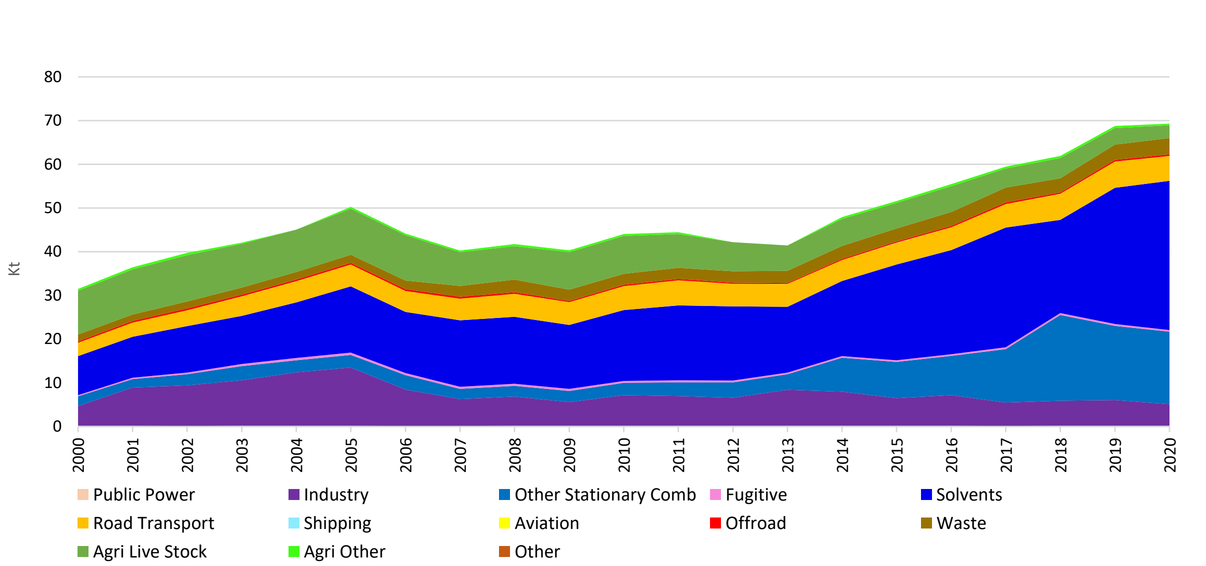


Figure 5-12: Trends in VOC emissions from 2000 to 2020 in Moldova

Industry (except industrial uses of solvents)

Figure 5-13 shows the evolution of VOC emissions in industry (the use of solvent is presented in the following sub-chapter). In 2020, total VOC emissions from industry, excluding industrial uses of solvents were 4.9kt. The main industrial source of VOC emissions was the food industry (87%). The other sources make a minor contribution.

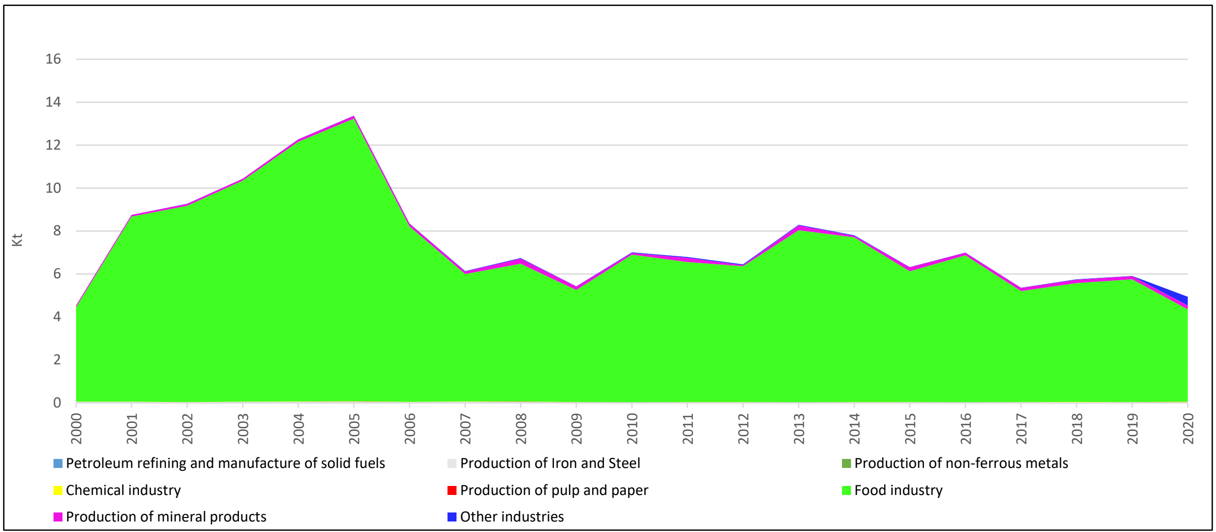


Figure 5-13: VOC emissions of industry (except industrial uses of solvents) from 2000 to 2020 in Moldova

Use of solvents and other products

Figure 5-14 shows the evolution of VOC emissions from the use of solvents and other products. In 2020, total VOC emissions from the uses of solvents were 30,4 kt. The other solvent use was the most contributing category to the use of solvents and other products (61%), followed by the coating application (25%), and chemical products (13%).

The other major source of VOC emissions in the use of solvents was their domestic use. It accounted for 5% of the national total VOC emissions and 11% share of the other solvent use category.

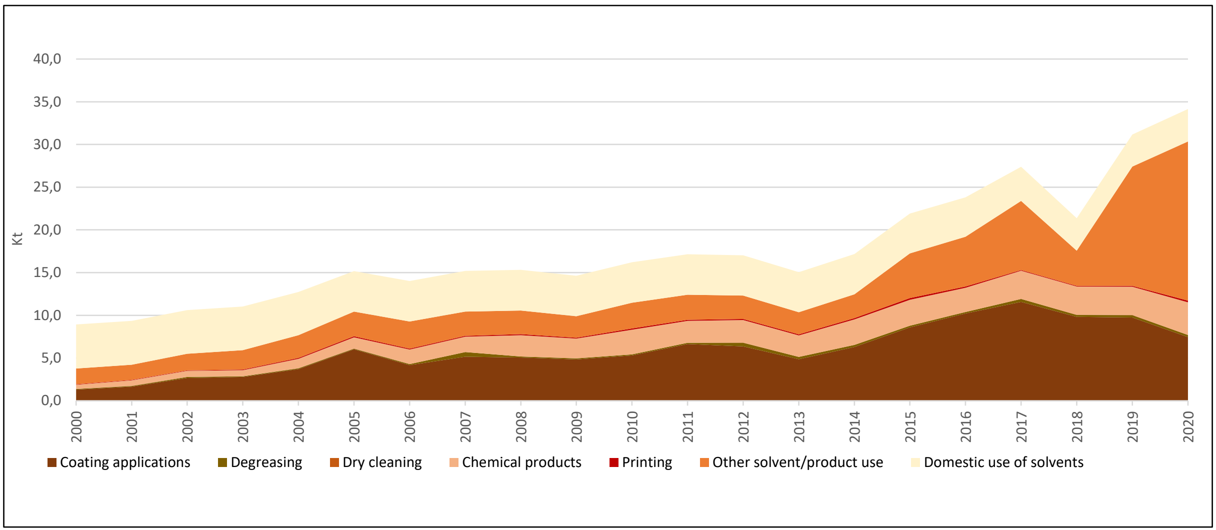


Figure 5-14: VOC emissions from the use of solvents from 2000 to 2020 in Moldova

Road transport

In 2020, the trend of VOC emissions in the road transport sector was similar to that for PM, representing 5.7kt. The main contribution to VOC emissions were split between gasoline evaporation (29%), passenger cars (29%), and mopeds and motorcycles (29%) (Figure 5-15).

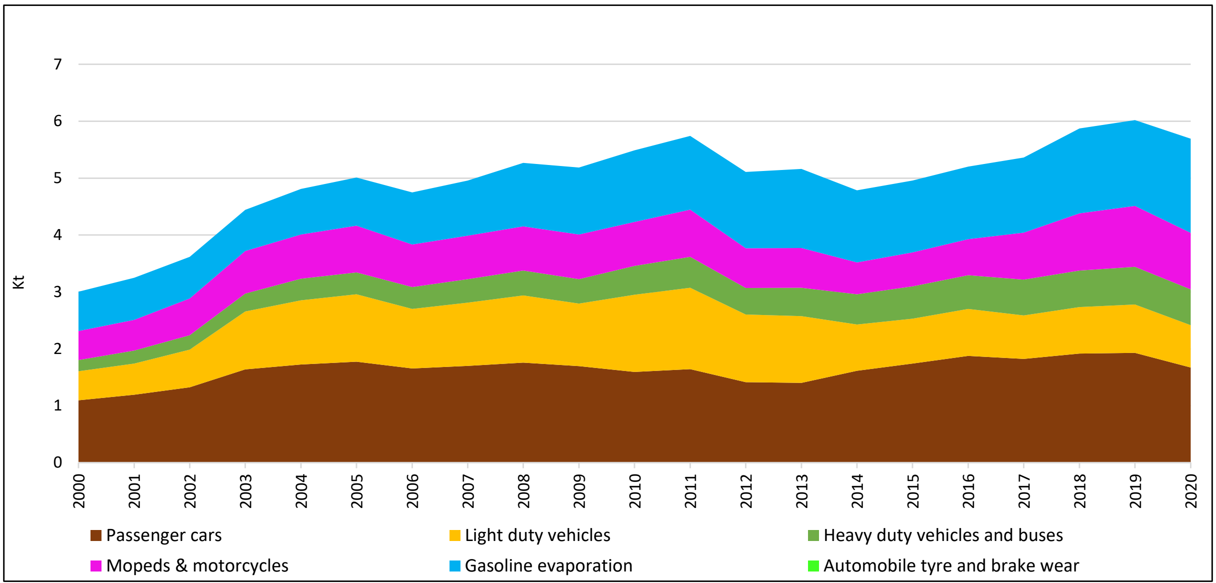


Figure 5-15: VOC emissions of transport from 2000 to 2020 in Moldova

5.3. Situation in terms of air quality

Over the last ten years, the Republic of Moldova has undertaken the actions to align its policies and regulations with those of the EU and has transposed several EU Directives.

To date, the following Directives have been transposed:

- Directive 2008/50/EC on ambient air quality and cleaner air for Europe [5].
- Directive 2004/107/EC relating to arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons in ambient air [7].

These two Directives have been transposed into the Law on ambient air quality of the Republic of Moldova and will come into force on April 13 of 2024 [6]. The main objective of the law is to develop air quality monitoring network and to carry out analyses and assessments based on reliable data regarding air pollutants, and share information and air quality indicators to the population in real time.

This law establishes regulations, assessment and management regimes for ambient air quality, criteria for dividing the territory of the Republic of Moldova into zones (parts of the national territory delimited for the purposes of air quality monitoring, assessment and management) and agglomerations (the zones with 250,000 or more inhabitants), as well as protection measures to maintain ambient air quality in line with European Union standards through air quality plans that define measures to achieve emission limits or other targets.

The law also establishes air quality standards taking into account human health Table 5-1. The table shows that Moldova's air quality standards are the same as the EU for PM_{10}, NO_2, and SO_2. However, Moldova adopted 20 µg/m^3 as annual average for $PM_{2.5}$.

Table 5-1: Air quality standards in Moldova and LVs in the EU of key air quality pollutants

Pollutant	Air quality standards in Moldova			LVs in EU[a]		
	Concentration (µg/m^3)	**Averaging period**	**Number of permitted exceedances per year**	**Concentration (µg/m^3)**	**Averaging period**	**Number of permitted exceedances per year**
$PM_{2.5}$	20	1 year	n.a	25	1 year	n.a.
	25	24 hours	n.a			
PM_{10}	50	24 hours	35	50	24 hours	35
	40	1 year	n.a.	40	1 year	n.a.
NO_2	200	1 hour	18	200	1 hour	18
	40	1 year	n.a.	40	1 year	n.a.
SO_2	350	1 hour	24	350	1 hour	24
	125	24 hours	3	125	24 hours	3

a. EU LVs of key air pollutants are as under Directive 2008/50/EU.

Air quality monitoring in the Republic of Moldova is currently performed by a network of 17 fixed stations, installed between 1970 and 1978. They operate according to schedule, 3 times/24h, and air samples are taken manually for several pollutants (solid suspensions, SO_2, CO, NO_2, NO, soluble sulphates, phenol, and formaldehyde). The stations are located in 5 industrialized centres of the Republic of Moldova (Chisinau-6 posts, Balti-2 posts, Bender-4 posts, Tiraspol-3 posts, Ribnita-2 posts).

It should be noted that the results of air samples collected at existing stations do not reflect the actual air quality situation, as the stations and analysis methods used are obsolete and the margin of error is high. Sampling results are published one day late. They are not recognized and cannot be shared in the European data system. EU standards stipulate that monitoring of atmospheric emissions must be carried out continuously on the basis of automatic stations. This requirement is based on the fact that significant emissions of air pollutants, which disperse rapidly, cannot be monitored and taken into account in the daily air quality assessment, and may occur between the sampling hours.

The first step in setting up the air quality monitoring network was the installation and commissioning of the first traffic station on June 24, 2022. The station is located in the city of Chisinau. The station was donated by the German Government, the Environment Agency of Saxony, as part of the GIZ programme "Capacity Building for Climate Policy Implementation in the Western Balkans, Central and Eastern Europe and Central Asia" [37]. This is an automatic station equipped with 5 gas analysers to monitor 5 air pollutants: NOx, SO_2, O_3, CO, and PM_{10}.

It is proposed to submit and discuss, at the External Assistance Council meeting, the provision of financial support for the creation of the national air quality monitoring network, namely, the acquisition and installation of 18 atmospheric air quality monitoring stations (traffic, industrial, and background monitoring stations). According to the study conducted by GIZ described in the Informative note on the need of establishment of the national air quality monitoring network [37], Moldova, draft Strategy for the implementation of monitoring and management of ambient air quality, the location of the stations was proposed on the basis of delimited agglomerations, namely: 5 stations in Chisinau (2-traffic, 2 background, 1-industrial) and 13 stations in the localities: Bălți (2 stations), Comrat - 1 station, Soroca - 1 station, Cahul (2 stations), Orhei - 1 station, Ungheni - 1 station, Mateuți - 1 station, Leova - 1 station, Tiraspol (2 stations) and Râbnița - 1 station.

5.4. Regulations in place to limit emissions of stationary sources and programmes for the evolution

5.4.1. Existing regulations

To date, the following EU Directives transposed with regard to the air pollutant emissions:

- Directive 2004/42/EC on the limitation of emissions of VOC due to the use of organic solvents in certain paints and varnishes and vehicle refinishing products [13] which served as basis of Annex XI limit values of the AGP.

- Directive 94/63/EC, Stage I on the control of VOC emissions resulting from the storage of petrol, and its distribution, from terminals to the service stations [10]which was the basis for definition of limit values in Annex VI, table 1.

- Directive 1999/32/EC of 26 April 1999 relating to a reduction in the sulphur content of certain liquid fuels and amending Directive 93/12/EEC (repealed in 2016 by the Directive 2016/802 on reduction in the sulphur content in fuels [9]).

- Directive 98/70/EC of the European Parliament and of the Council of 13 October 1998 relating to the quality of petrol and diesel fuels and amending Council Directive 93/12/EEC (Table 13 and Table 14 of Annex VIII of the AGP comes from limit values implemented by this directive) [21].

The Directive 2010/75/EU on Industrial Emissions (IED) [19] is currently under transposition via Law no. 227/2022 on industrial emissions [20] will enter into force in September 2024. Concerning Directive 2016/2284 on the reduction of national emissions of certain atmospheric pollutants [18]. The Republic of Moldova is in the process of developing the normative framework to transpose Directive 2016/2284 [1].

However, no information on the transposition of the Directive 2009/126/EC on Stage II petrol vapour recovery during refuelling of motor vehicles at service stations [38] is available.

The Law no. 227/2022 on industrial emissions of the Republic of Moldova was adopted 30 of September 2022 [20]. It partly transposes Directive 2010/75/EC on industrial emissions and Directive (EC) 2015/2193 on the limitation of emissions of certain air pollutants from medium-sized combustion installations [39].

The Law on industrial emissions of the Republic of Moldova establishes the approach of public participation in decision making, the criteria to define BAT, the general list of pollutants in air and water, the conditions for obtaining integrated environmental permits, the conditions for determining emission limits, and emission limits themselves for existing and new installations, as well as baseline report prior to the launch of activity. It also defines the rules for periodic and continuous industrial monitoring of emissions.

The Law divides all activities in three categories: industrial and economic activities with significant environmental risks, activities with low environmental risk and those with minor environmental impact.

- Industrial and economic activities with significant environmental risks include energy industries (e.g., fuel combustion in plants with an installed thermal capacity equal to or greater than 50 MWth), as well as main metal production and processing, mining, chemical industry, waste management, and other activities (Annex 1 of the Law).
- Industrial and economic activities with low environmental risk include energy industry (e.g., medium-sized combustion plants with an installed thermal capacity equal to or greater than 5 MW and less than 50 MW), metal production and processing, mining, the chemical industry, waste treatment wastewater/waste treatment, agriculture and aquaculture, the extractive industry, the food industry, the textile, leather, the wood and paper industry, and other activities (Annex 2 of the Law).
- Industrial and economic activities with minor environmental impact (Annex 3 of the Law)

The Law also defines Best Available Techniques (BAT) as “the most efficient and advanced stage in the development of activities and practices, indicating the practical suitability of certain technologies to meet emission thresholds and other permit conditions aimed at preventing or, where this is not feasible, reducing emissions and environmental impacts in general” and BAT Conclusions as “a document containing parts of the BAT guides, through which conclusions on best available techniques, their description, information on assessing their applicability, emission levels approved according to best available techniques, appropriate monitoring, appropriate consumption levels and, if necessary, appropriate remediation measures for the site are established”.

The BAT reference document (BREF) is defined as “a document resulting from an exchange of information organised by the European Commission for certain activities, describing the technologies used, the current level of emissions and consumption, the methodologies used to determine the best available technologies, and the BAT conclusions and any emerging technologies, taking into account the same criteria as in the Annex III of IED”.

Annex 6 lists of pollutants (air and water) covered by the law.

Emission limit values for pollutants apply at the point at which the emissions are released from the installation, and any dilution up to that point is not taken into account in determining such values. The Environment Agency sets emission thresholds so that, under normal operating conditions, emissions do not exceed emission levels approved in accordance with Best Available Techniques, as stated in BAT conclusions. Annex 5 of the law sets up the criteria for determining the best available techniques.

Industrial and economic activities subject to Annex 1 shall be carried out on the basis of an integrated environmental permit, and industrial and economic activities subject to Annex 2 on the basis of an environmental permit issued by the Environment Agency. Conditions and procedure for issuing integrated environmental and environmental permits are précised in the Articles 13 and 15 of the Law. Annex 15 gives an example of Integrated Environmental Permit and Annex 16 an example of Environmental permit. Annex 10 describes emission limit values for the permits issued for large combustion plants before the entry into force of the Law on industrial emissions or whose operators submitted a fully completed application for a permit. Annex 7 covers information that shall be submitted by the operator for the issuance of an environmental permit for medium-sized combustion plants (MCP). Annex 8 covers emission limit values for MCP. Annex 9 covers emissions monitoring and compliance verification for low-risk industrial and economic activities low-risk industrial and economic activities to the environment.

Annex 11 describes an example of Plan of Alignment of the installation in accordance with a permit.

Annex 12 describes technical provisions concerning activities and installations using organic solvents.

Annex 13 set up Technical provisions for plants producing titanium dioxide.

Annex 14 lists prohibited building and chemical products.

An integrated environmental permit shall be issued for a period of 12 years and an environmental permit for a period of 6 years with the right of suspension, revocation and withdrawal in case of non-compliance with permit conditions or non-compliance.

An operator of an installation whose activities fall within the list of activities according to Annexes 1 and 2 and who holds an environmental permit issued prior to the entry into force of this Law shall apply for an integrated environmental permit/environmental protection permit upon expiry of the existing permit, but no later than 5 years after the entry into force of this draft law.

Holders of a permit for the emission of pollutants into the atmosphere from stationary sources of pollution, issued pursuant to Act No. 1422/1997 on ambient air protection [8], prior to the entry into force of this Law shall:

a) Comply with the emission limits of pollutants (PDV[13]);

b) Observe the schedule and procedures for checking emissions into the ambient air, agreed upon with the Environmental Agency;

c) Implement pollution mitigation and environmental protection measures.

The inspections of the industrial and economic activities with significant and low environmental risk are previewed by the Environmental Protection Inspectorate and could be distinguished on announced and unannounced inspections. Scheduled environmental inspections are carried out on the basis of an annual inspection plan prepared by the Environmental Inspectorate in accordance with the provisions of Act No. 131/2012 on state control of business activities. Unannounced environmental controls shall be carried out in accordance with Article 19 of Act No. 131/2012 on the State Control of Business Activities. It shall be conducted to investigate as soon as possible and, if necessary, before issuing, revising or renewing the permit, relevant environmental complaints, industrial accidents, serious incidents, when emission thresholds are exceeded, and serious cases of non-compliance are recorded.

Annex 5 sets out the criteria for determining the best available technologies are established. Annex 6 lists pollutants in various media, including air. These include pollutants such as SO_2, NOx, NMVOCs and dust, including fine particulate matter.

Within 24 months of the law's publication date, the Ministry of the Environment approves BREFs, guidelines for the preparation of the baseline report, and guidelines for issuing an integrated environmental permit, environmental permit and business registration (Article 60 (3)).

Since 2018, a National Pollutant Release and Transfer Registry to collect information on pollutant releases and transfers was established in the Republic of Moldova [12].

5.4.1.1. Combustion installation

Comparison with ELVs of the Amended Gothenburg Protocol (Annex IV, V and X)

As it was outlined earlier, until late 2024, emission of pollutants into the atmosphere from stationary sources, including permits is regulated by Law No. 1422/1997 on ambient air protection [8]. The new Law on industrial emissions [20] will regulate industrial installations including LCP and MCP since September 2024. In addition, EU BREFs published in Romanian language in the Official Journal of the European Union, by order of the Minister of Environment, are recognised as national BREFs and published in the Official Gazette of the Republic of Moldova. The Environment Agency of Moldova shall apply the BREF Conclusions when setting permit conditions [1].

Emission limit values for LCP (Annex 10) of the Law on industrial emissions [20] correspond to IED Annex V (Parts 1-3).

For installations with thermal capacity larger than 50 MWth considered in Annexes IV, V and X, of the Gothenburg protocol, the Law on industrial emissions (Annex 10) [20] transposes

[13] Here PDV of pollutants - maximum permissible emission of pollutants established by calculating the dispersion into the surface layer of the atmosphere by a source or group of emission sources, which do not exceed the air quality standards established for the population, fauna and flora [8]

Annex V of the IED [19], including ELV for large combustion plants. The Republic of Moldova has recognised BREFs published in Romanian language in the Official Journal of the European Union as national BREFs and shall apply the conclusions of the BAT when setting permit conditions [1], the ELVs considered in Moldova and applied for LCPs are lower than or equal to those specified in the Annexes VI, V, and X of the AGP.

Continuous monitoring of SO_2, NOx, and dust (TSP) is mandatory for large combustion plants with a total thermal capacity of 100 MWth or more. In addition, for large combustion plants with a total thermal capacity of 100 MWth or more using gaseous fuel, continuous CO measurements are also mandatory, with some exceptions.

If continuous monitoring is not performed at a large combustion plant, periodic measurements of SO_2, NOx, TSP, and, in the case of gas turbines CO, at least once every six months are mandatory. For large coal or lignite combustion plants using, emissions of total mercury are to be measured at least once a year [20].

The Law on industrial emissions [20] also establishes transitional provisions for large combustion plants, which are defined as plants with a total installed thermal capacity greater than or equal to 50 MWth, regardless of the type of fuel used, in operation on the date of entry into force of the Law, compliance with which shall be ensured from 31 December 2028.

Among LCP in Moldova, there are three CHPP operating on natural gas with a fuel oil as a reserve fuel. They are CHPP-166 MW (12, 12, 10, 27.5 MW - 5 blocks of different capacity), CHPP-2 (3 blocks of 80 MW each, total nominal capacity of 240 MW)[14] and Balti CHPP (24 MW)[15] in addition using gas pistons of 13,2 MW with 4 identical blocks working on natural gas [1]. According to local experts [1], 97% of LCP use natural gas. There is also a small coal and biomass boiler house in Molodovo belonging to Balti CHPP [1].

ELVs for small and medium size combustion installations

Annex X (Table 14) of the AGP [40] introduces recommended limit values for combustion installations of 1 to 50 MWth using solid and liquid fuels for PM only. The Law on industrial emissions (Annex 8) [20] transposes the ELVs for medium sized combustion plants from the MCP Directive [39]. They are equal to the values of Table 14 of Annex X, of the AGP. There is no systematised information on the MCPs in the Republic of Moldova [1].

Regarding small combustion installation, there is no systematised information or legislative information available for analysis. According to experts, small combustion appliances operate mainly on wood, and wood consumption has been increasing over the last 7 years [1].

5.4.1.2. Industrial installations

The Law on industrial emissions [20], which regulates industrial activities in the Republic of Moldova, is enacted from September 2024. Annex 1 to the Law on industrial emissions lists the industrial activities covered by the law. These are energy industries, as well as production and processing of ferrous and non-ferrous metals, mining industry (production of cement, lime and

[14] https://termoelectrica.md/transparenta/indicatori-tehnico-economici/

[15] www.cet-nord.md

magnesia, glass production, melting of minerals, production using roasting), chemical industry, waste management, pulp and wood panel production, pretreatment of textile and some others.

Chapter VI of the Law on industrial emissions [20] deals with the special conditions applicable to waste incineration installations. It applies to waste incineration and co-incineration plants that incinerate or co-incinerate solid or liquid wastes. They are subject to an integrated environmental or environmental permit, however, no emission limit values are outlined within the law.

Chapter VIII of the Law on industrial emissions [20] deals with the special conditions for installations producing titanium dioxide with emission limit in Annex 13. They correspond to Annex VIII of the IED. For the sulphate process, the ELV are the same as for the AGP (Annex IV, Table 3).

Comparison with ELVs of Amended Gothenburg Protocol

Regarding the ELV in the AGP (Annex IV, Annex V and Annex X) of industrial processes, they should be in line with the relevant EU BREF, since the BREFs published in Romanian language in the Official Journal of the European Union, by order of the Minister of Environment are accepted as national BREFs and published in the Official Gazette of the Republic of Moldova [1].

Mineral oil and gas refineries

As far as oil and gas refineries are concerned, there is only one small refinery in the town of Comrat, built to process oil extracted from the Valeni field in the south of the country. It produces between 7,000 and 17,000 tonnes of oil products per year, mainly diesel fuel and fuel oil. The fuel is mainly exported to Romania. In the energy balance, data on oil production and production of by-products have been available since 2004, when oil production began [1].

To now, there is no sulphur recovery units in the Republic of Moldova [1].

Titanium dioxide production

To date there are no incineration installations in the Republic of Moldova [1].

Cement and lime production

There are two major clinker producers in Moldova: Lafarge Ciment (Moldova) S.A. from Rezina and Cement Slate Plant from Ribnitsa [1].

Iron ore sinter plants

The Rybnitsa Metallurgical Combine is located on the left bank of the River Dniester. The plant operates on scrap metal. On the right bank of the Nistru River there are four small enterprises with electric arc furnaces of low capacity (less than 50 tonnes/year). Steel production at these enterprises, compared to the plant in Ribnita, is insignificant.

Nitric acid production

To now, there is no nitric acid production in the Republic of Moldova [1].

Glass production

There are four glass factories in the Republic of Moldova: the Î.S. Glass Factory in the Chisinau and the Î.M. Glass Container Company are operational, while the Cristal-Flor Glass Factory in Floresti and the Glass Factory in Tiraspol are currently inactive [1].

Pulp production

To now, there is no pulp production in the Republic of Moldova [1].

Waste incineration

To date there are no incineration installations in the Republic of Moldova [1].

Non-ferrous metals production, lime production

Concerning secondary non-ferrous metals and lime production, there are activities in the Republic of Moldova, however, there is limited information about was available to the analysis.

5.4.1.3. Uses of solvents in industry

Chapter VII of the Law on industrial emissions [20] deals with special conditions for installations and activities using organic solvents. Annex 12 describes technical conditions for installations and activities with the use of organic solvents, their ELVs correspond to Annex VII of the IED. Thus, it can be concluded that the ELV are similar to Annex VI of the AGP (Tables 3-15).

Among the activities listed in Annex VI of the AGP, only limited information is available on the industries present in Moldova. According to local experts [1], there are more than 100 economic entities specializing in sunflower oil production in Moldova, the largest of which is the S.A. plant "Sunflower" from the city of Balti. There are also around 13 producers of pharmaceutical products. Other activities covered by Annex VI of the AGP, are present in Moldova, however detailed information on these activities was not available for analysis. There are no activities related to coating in the automotive industry and various industrial sectors, roll coating or processing of natural or synthetic rubber [1].

5.4.1.4. Sulphur content of gasoil

The Regulation on reducing the sulphur content of certain liquid fuels [41] transposes Council Directive 1999/32/EC of 26 April 1999 relating to the reduction in the sulphur content of certain liquid fuels and amending Directive 93/12/EEC (and repealed in 2016) [9]. The Regulation aims to reduce the sulphur content of certain liquid fuels to reduce SO_2 emissions resulting from their combustion, to reduce the negative effects of such emissions on public health and the environment and introduces emission limit values for the sulphur content of these fuels for their use in the Republic of Moldova, including the exclusive economic zone and pollution control zones. The Regulation is in force from 15 July 2016, and for some items from 1 January 2020.

Comparison with ELVs of the Annex VI of the Amended Gothenburg Protocol

Annex IV of the AGP [40] prescribes a limit value for the sulphur content of gasoil used in domestic heating and combustion installation (Annex IV, Table 2) (the sulphur contents of fuel used in mobile engines and non-road mobile machinery is dealt with Annex VIII of the AGP, mobile sources). The sulphur content is limited to 0.1% w/w, so is in the Regulation of the Republic of Moldova on reducing the sulphur content of certain liquid fuels [41] stipulating (point 6) that gas oil, with a sulphur content exceeding 0.1% by mass cannot be placed on the market.

5.4.1.5. Storage and distribution of petrol from terminals to service stations

The Regulation on the control of emissions of volatile organic compounds from the storage and distribution of petrol from terminals to service stations of the Republic of Moldova [11] transposes Directive 1994/63/EC on Stage I on the control of volatile organic compound (VOC) emissions resulting from the storage of petrol and its distribution from terminals to service stations. The Regulation applies to procedures, installations, vehicles and vessels used for the storage, loading/unloading and transportation of petrol from one terminal to another or from a terminal to a station by refuelling with oil products, with the aim of limiting emissions of volatile organic compounds from these operations. The Regulation is in force since 31 January 2021.

No information was available on the transposition of Directive 2009/126/EC of the European Parliament and of the Council of 21 October 2009 on Stage II petrol vapour recovery during refuelling of motor vehicles at service stations [38].

Comparison with ELVs of the Amended Gothenburg Protocol

Directive 1994/63/EC provisions was transposed via the mentioned above Regulation [11] were considered in Table 1 of Annex VI of the AGP.

5.4.1.6. VOC content of products

The Regulation on the limitation of emissions of volatile organic compounds due to the use of organic solvents in certain paints and varnishes and vehicle refinishing product [14] transposed the Directive 2004/42/EC on the limitation of emissions of volatile organic compounds due to the use of organic solvents in certain paints and varnishes and vehicle refinishing products [13]. The Regulation was adopted on 16 December 2020. It aims to limit the total content of volatile organic compounds in some paints, varnishes and products used for car finishing, to prevent and reduce air pollution caused by the contribution of volatile organic compounds to the formation tropospheric ozone. The Regulation is in force from 15 of January 2022.

Comparison with ELVs of the Amended Gothenburg Protocol

The provisions of the Directive [13] were considered in Annex XI of the AGP (Tables 1 and 2).

5.5. Regulations in place to limit emissions of mobile sources and programmes for the evolution

5.5.1. Road vehicles

At the moment, we don’t have enough information to judge whether the emission limit values for most mobile sources, including the passenger cars and light-duty vehicle standards of Table 1 (Euro 4, 5, and 6) and for heavy-duty vehicles of Tables 2 and 3 (Euro IV, V, and VI) of Annex VIII of the AGP are implemented in the current regulation. However, according to the Association Agreement EU – Republic of Moldova, the EU regulation introducing Euro 5 and Euro 6 [4] should have been transposed within 2015-2018.

In 2018, Moldova completed the Fuel Economy Database for new registered vehicles with the help of the Coalition's Heavy-Duty Vehicles Initiative. This gave the country a baseline for vehicle fuel consumption and emissions from the incoming vehicle fleet. "Developing a more complete picture of the fuel quality and vehicle emissions situation in Moldova is key for planning future policy and projecting both CO_2 and other emissions reductions. Moldova's steps in adopting cleaner, more efficient vehicles will allow consumers to choose and access the best technology available on the market – including electric vehicles [32].

5.5.2. Motorcycles and mopeds

The Association Agreement EU – the Republic of Moldova [4] includes legislation with which the Republic of Moldova should aligned with. These include the Regulation (EU) 168/2013 on the approval and market surveillance of two- or three-wheel vehicles and quadricycles [22]. This requires the elaboration of a draft law on the homologation of road vehicles and a draft Regulation on the homologation of motor vehicles and the certification of their components. Currently, some provisions regarding approval are included in Law no. 131/2007 regarding road traffic safety [1].

Tables 11 and 12 of Annex VIII of the AGP are based on Euro 2 and Euro 3 limit values, which are based on Directive 2002/51/EC of the European Parliament and of the Council of 19 July 2002 on the reduction of the level of pollutant emissions from two- and three-wheel motor vehicles and amending Directive 97/24/EC. Directive 168/2013 limit values were identified by TFTEI during the review of Annex VIII of the AGP. This directive introduces the Euro 4 and 5 standards for motorcycles. Thus, Moldova should adopt the following Euro standards after Euro 2 and 3, considered in Annex VIII of the AGP. The TFTEI report was published in 2023 [42].

The draft Law on the approval and market supervision of road vehicles and their component parts partially transposed to the provisions of Directive 2007/46/EC, which establishes the framework for the approval of motor vehicles and their trailers, as well as systems, components and separate technical units intended for these vehicles and the Regulation (EU) 168/2013 [22].

5.5.3. Non-Road Mobile machinery

The Association Agreement EU – Republic of Moldova includes the Regulation (EU) 167/2013 of the European Parliament and of the Council of 5 February 2013 on the approval and market surveillance of agricultural and forestry vehicles) [27], as currently amended. This requires the development of a draft Law on approval and market surveillance for non-road mobile machinery including agricultural and forestry vehicles and the proposals for amendment of the Governmental Decision (GD) 607/199 on the State Inspectorate for Technical Supervision "Intehagro" of the Ministry of Agriculture Food Industry in order to reorganize the State Inspectorate for Technical Supervision for the assignment of market surveillance functions.

It is also planned to transpose the additional regulations to implement the Regulation (EU) 167/2013:

- Commission Implementing Regulation (EU) 2015/504 of 11 March 2015 implementing Regulation (EU) 167/2013 of the European Parliament and of the Council with regard to the administrative requirements for the approval and market surveillance of agricultural and forestry vehicles.

- Commission Delegated Regulation (EU) 2015/208 of 8 December 2014 supplementing Regulation (EU) 167/2013 of the European Parliament and of the Council with regard to vehicle functional safety requirements for the approval of agricultural and forestry vehicles.
- Commission Delegated Regulation (EU) 2015/68 of 15 October 2014 supplementing Regulation (EU) 167/2013 of the European Parliament and of the Council with regard to vehicle braking requirements for the approval of agricultural and forestry vehicles.
- Commission Delegated Regulation (EU) 1322/2014 of 19 September 2014 supplementing and amending Regulation (EU) 167/2013 of the European Parliament and of the Council with regard to vehicle construction and general requirements for the approval of agricultural and forestry vehicles.

At the moment, these elements are not implemented.

The transposal of Directive 2013/53/EC of the European Parliament and of the Council of 20 November 2013 on recreational craft and personal watercraft and repealing Directive 94/25/EC [23] is also included in the Association Agreement EU – the Republic of Moldova, however not transposed yet.

5.5.4. Petrol and diesel quality

Regarding petrol and diesel quality, Directive 98/70/EC on the quality of gasoline and diesel has been partially transposed. Namely, Articles 2,3,4,8 and Annexes 1 and 2 of the Directive, which establish environmental specifications of diesel fuel and petrol. Thus, since February 2019, high-quality fuel with low content of sulphur are imported that into the territory of the Republic of Moldova. The implementation of the transposed provisions, namely ensuring fuel quality control, - upon entering the country and – at the distribution station /at the refuelling station, it is made according to the standards SM EN 14274 standards; SM EN 14275; SM EN 228 and SM EN 590, which are to be implemented. Currently, customs control regarding the fuel quality is ensured, through qualitative and quantitative checks based on Law no. 461/2001 on the oil products market [1].

5.6. Technological pathways

Moldova is a Party to the Convention on the Long-Range Transboundary Air Pollution (CLRTAP) (Accessed on January 5, 1995 [2]) and also accessed the Co-operative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe (EMEP) on July 26, 2016. In addition, on October 01, 2002, Moldova ratified the original 1998 Protocol on Heavy Metals and the original of 1998 Protocol on Persistent Organic Pollutants (POP) on April 25, 2002, and signed Gothenburg Protocol on May 23, 2000 [3].

In the Republic of Moldova, air quality is currently monitored by a network of 17 obsolete fixed stations, installed during the period 1970-1978. These stations are not internationally recognized, and their results are not shared with the European data system. It is therefore difficult to draw conclusions about air quality in the country.

Residential heating is a major source of SO_2 emissions (44% of total emissions), PM_{10} emissions (71%), $PM_{2.5}$ emissions (88%), and VOC emissions (24%). Residential heating emissions are driven by the solid fuel consumption.

VOC emissions come mainly from the solvent sectors (49%).

Road transport is the main source of NOx emissions with contribution of 48%, mainly due to emissions from heavy-duty vehicles and buses (N2-N3 trucks, and M2-M3 buses). Public power is another major source of NOx emissions accounting for 17% of total NOx emissions.

Industry is also the main source of SO_2 emissions, mainly due to stationary combustion (36% of total emissions), mainly due sources of non-metallic minerals (95% of stationary combustion sources). Industry also have a significant share of PM_{10} emissions (14% of total emissions) mainly due to the sector of road paving with asphalt (62% of industrial sources).

Knowledge of the sources of air emissions and measures to reduce them needs to be significantly increased.

Since over ten years, Moldova has been aligning its policies and regulations with EU Directives, through transposition. In 2014, the Republic of Moldova signed an Association Agreement between the European Union and the European Atomic Energy Community and their Member States, of the one hand, and the Republic of Moldova, of the other [4]. It entered into force on July 01, 2016.

Under this Association Agreement, Moldova must align its legal framework with that of the EU with regard to air quality, industrial emissions, road transport and many other sectors. National emission ceilings must also be applied as provided for in the original 1999 Gothenburg Protocol to Abate Acidification, Eutrophication and Ground-level Ozone. In addition, before 2026, the Republic of Moldova shall endeavour to ratify the Gothenburg Protocol, including the amendments adopted in 2012[4].

To date, the following Directives have been transposed:

- Directive 2004/42/EC on the limitation of emissions of VOC due to the use of organic solvents in certain paints and varnishes and vehicle refinishing products (limit values of Annex XI of the AGP),
- Directive 1994/63/EC, Stage I on the control of VOC emissions resulting from the storage of petrol, and its distribution, from terminals to the service stations (limit values in Table 1, Annex VI of the AGP),
- Directive 2016/802 on reduction in the sulphur content in fuels.

Moldova has transposed Directive 2008/50/EC on Ambient Air Quality and Cleaner Air for Europe and Directive 2004/107/EC on Arsenic, Cadmium, Mercury, Nickel and PAH in ambient air. The corresponding legislation will be implemented in Moldavia from 2024.

The recent Law n. LP227/2022 on industrial emissions adopted on September 30, 2022, partially transposes Directive 2010/75/EC on industrial emissions and Directive (EC) 2015/2193 on the limitation of emissions of certain air pollutants from large combustion installation, medium-sized combustion installations, industrial activities using organic solvents, other industrial activities and defines the rules for periodic and continuous industrial monitoring of emissions. The ELV of activities using organic solvents are similar to Annex VI of the AGP

(Tables 3-15). EU BREFs published in Romanian language in the Official Journal of the European Union, by order of the Minister of Environment, are recognised as national BREFs and published in the Official Gazette of the Republic of Moldova. The Environment Agency of Moldova shall apply the BREF Conclusions when setting permit conditions.

Directive 2016/2284 on the reduction of national emissions of certain atmospheric pollutants is currently being transposed.

Chapter 5.8 introduces tables comparing the emission limit values implemented by the regulations of the Republic of Moldova and comparison with the AGP limit values for large combustion plants and industrial sources.

Domestic heating

Domestic heating with solid fuels such as coal or biomass is key sector **emitting PM** in Moldova, for which recommended limit values are provided by the AGP. The use of the most efficient appliances in term of PM emissions and energy efficiency is essential, but technological solutions are not sufficient. The "Code of good practices for wood burning and small combustion installations" [43] developed by TFTEI, the report "Prioritizing reductions of particulate matter from sources that are also significant sources of black carbon - analysis and guidance" [44] developed by TFIAM and the report "Review on Black Carbon (BC) and Polycyclic Aromatic Hydrocarbons (PAHs) emission reductions induced by PM emission abatement" [45] developed by TFTEI provide an excellent overview of policies beyond the technical characteristics of appliances. The thematic session on residential wood combustion and air pollution of the 56th WGSR in May 2018 is also useful for inspiring ideas in this field [46]. In addition, the latest TFTEI report on limit values updates to the technical Annexes also provides information [47].

One of the key measures relating to domestic heating with solid fossil and biomass fuels could be the development of a programme to replace existing household heating appliances with new eco-design compliant ones, combined with financial incentives. In "hot spots" of PM pollution from household heating, higher rates of replacement of older appliances could be foreseen. These measures are also linked to an energy policy aimed at reducing energy demand through greater energy efficiency.

In order to rapidly introduce more efficient appliances, the programme could include activities for Moldova such as aligning its national legislation with the Eco-design Directive [48] and work on transposing the two EU regulations on emissions and energy efficiency of solid boilers and solid fuel local space heaters (Regulation 2015/1189/EU [49] and Regulation 2015/1185/EU [50]). The implementation mechanism for financial incentives for the replacement of existing heating equipment in households with new appliances compliant with EU regulations and heat pumps must also be put in place.

For industrial processes emitting SO_2, NOx and/or PM covered by Annexes IV, V and X, the Chapter 8. Techniques available to comply with limit values of the Amended Gothenburg Protocol (sub-chapters 8.1, 8.2 and 8.4) presenting the best available techniques to comply with the prescribed emission limit values.

For PM, the best available techniques (sub-chapters 8.4.2 to 8.4.10) to comply with emission limit values are electrostatic precipitators and bag filters. Other types of dedusters, such as wet scrubbers, are also available but are less widely used. These techniques are most efficient when correctly dimensioned.

For the **uses of solvents in industry**, the sub-chapter 8.3 details the techniques available to comply with emission limit values. These techniques are based on primary measures such as low solvent content or solvent-free products, higher efficient application methods and secondary measures such as thermal or catalytic oxidation, activated carbon adsorption, biological scrubbing.

Emissions from transport (Annex VIII of the AGP):

Moldova is taking steps to control road transport emissions. Thus, in 2018, the country completed the Fuel Economy Database of newly registered vehicles with the help of the Coalition’s Heavy-Duty Vehicles Initiative. The draft development of regulations, after an Association Agreement EU – the Republic of Moldova is foreseeable, including the draft Law on the homologation of road vehicles and the draft Regulation on the homologation of motor vehicles and the certification of their components, after Regulation (EU) 168/2013.

With regard to fuel quality, Directive 98/70/EC on the quality of petrol and diesel has been partially transposed and provides for environmental specifications for diesel and petrol, i.e. the same level of sulphur content as in Tables 13 and 14, Annex VIII of the AGP.

Under the Association Agreement EU – the Republic of Moldova, the EU directives or regulations introducing Euro 6/VI (based on Tables 1 to 3 of Annex VIII of the AGP) implementing vehicle type-approval rules should have been approximated. However, no information was available to analyse the situation.

In addition, the latest EU directives or regulations concerning Euro standards for light- and heavy-duty vehicles as well as for other types of vehicles are recommended.

One efficient measure could be a ban on import of old second-hand vehicles, however more information on the existing fleet is needed to analyse the situation.

Many different approaches can also be implemented to reduce emissions from road transport. Measures such as developing public transport, making it more attractive, encouraging the use of public transport, developing car-sharing schemes, promoting walking and cycling in cities can be foreseen. These measures provide an integrated approach that can benefit both air quality and climate change.

Since 2014, Moldova has been developing the legislative framework to bring it in line with EU norms, mainly within the framework of the Association Agreement EU – Republic of Moldova. With further harmonization of the legislative framework with EU ones, Moldova's legislative framework could meet the provisions of the five AGP Technical Annexes IV, V, VI, X and XI in particular their ELVs, tentatively by 2030-35. For mobile source, additional research is needed.

5.7. References of chapter 5 Moldova

[1] The Ministry of Environment of Moldova, the Institute of Power Engineering of Moldova, the Institute of Ecology and Geography of Moldova, P.A. EcoContact communications with Citepa, from June 2022 to October 2023communications with Citepa, from June 2022 to October 2023

[2] Convention on Long-range atmospheric pollution. Status of ratification: https://treaties.un.org/Pages/ViewDetails.aspx?src=TREATY&mtdsg_no=XXVII-1&chapter=27&clang=_en - Web site accessed in July 2023

[3] Protocols of the CLRTAP. Status of ratification: https://unece.org/protocols - Web site accessed in July 2023

[4] Association Agreement between the European Union and the European Atomic Energy Community and their Member States, of the one part, and the Republic of Moldova, of the other part https://investmentpolicy.unctad.org/international-investment-agreements/treaties/bit/3483/eu---moldova-association-agreement-2014-

[5] Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on ambient air quality and cleaner air for Europe. http://data.europa.eu/eli/dir/2008/50/oj

[6] On ambient air quality, Law of the Republic of Moldova, No. LP98/2022, 14 April 2022

[7] Directive 2004/107/EC of the European Parliament and of the Council of 15 December 2004 relating to arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons in ambient air. http://data.europa.eu/eli/dir/2004/107/oj

[8] On the ambient air protection, Law of the Republic of Moldova, No. LP1422/1997, 17 December 1997

[9] Directive (EU) 2016/802 of the European Parliament and of the Council of 11 May 2016 relating to a reduction in the sulphur content of certain liquid fuels. http://data.europa.eu/eli/dir/2016/802/oj

[10] Directive 94/63/EC of 20 December 1994 on the control of volatile organic compound (VOC) emissions resulting from the storage of petrol and its distribution from terminals to service stations http://data.europa.eu/eli/dir/1994/63/oj

[11] On the approval of the Regulation on the control of emissions of volatile organic compounds resulting from the storage and distribution of petrol from terminals to service stations, Government decision No. HG 587/2020, 31 July 2020 https://www.legis.md/cautare/getResults?doc_id=122611&lang=ru

[12] On the National Register of Emissions and transfer of pollutants. Government decision no. HG 373/2018, 24 April 2018 https://www.legis.md/cautare/getResults?doc_id=122933&lang=ru

[13] Directive 2004/42/EC of the European Parliament and of the Council of 21 April 2004 on the limitation of emissions of volatile organic compounds due to the use of organic solvents in certain paints and varnishes and vehicle refinishing products and amending Directive 1999/13/EC http://data.europa.eu/eli/dir/2004/42/2021-07-16

[14] On the approval of the Regulation on the limitation of emissions of volatile organic compounds due to the use of organic solvents in certain paints and varnishes and vehicle refinishing product, Government decree No. HG914/2020, 16 December 2020

[15] On chemical substances, Law of the Republic of Moldova, No. LP277/2018, 29 November 2018

[16] On market surveillance in relation to the sale of non-food products, Law of the Republic of Moldova, No. LP7/2016, 26 February 2016

[17] On consumer protection, Law of the Republic of Moldova, No. LP105/2003, 13 Mars 2003

[18] Directive (EU) 2016/2284 of the European Parliament and of the Council of 14 December 2016 on the reduction of national emissions of certain atmospheric pollutants, amending Directive 2003/35/EC and repealing Directive 2001/81/ECE. http://data.europa.eu/eli/dir/2016/2284/oj

[19] Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control) (Recast) http://data.europa.eu/eli/dir/2010/75/2011-01-06

[20] On industrial emissions, Law of the Republic of Moldova No. LP227/2022, 30 September 2022

[21] Directive 98/70/EC of the European Parliament and of the Council of 13 October 1998 relating to the quality of petrol and diesel fuels and amending Council Directive 93/12/EEC http://data.europa.eu/eli/dir/1998/70/2018-12-24

[22] Regulation (EU) No 168/2013 of the European Parliament and of the Council of 15 January 2013 on the approval and market surveillance of two- or three-wheel vehicles and quadricycles http://data.europa.eu/eli/reg/2013/168/2020-11-14

[23] Directive 2013/53/EU of the European Parliament and of the Council of 20 November 2013 on recreational craft and personal watercraft and repealing Directive 94/25/EC http://data.europa.eu/eli/dir/2013/53/2013-12-28

[24] Directive 2003/37/EC of the European Parliament and of the Council of 26 May 2003 on type-approval of agricultural or forestry tractors, their trailers and interchangeable towed machinery, together with their systems, components and separate technical units and repealing Directive 74/150/EEC http://data.europa.eu/eli/dir/2003/37/2014-04-09

[25] Directive 77/537/EEC of 28 June 1977 on the approximation of the laws of the Member States relating to the measures to be taken against the emission of pollutants from diesel engines for use in wheeled agricultural or forestry tractors http://data.europa.eu/eli/dir/1977/537/1997-10-30

[26] Directive (EU) 2016/802 of the European Parliament and of the Council of 11 May 2016 relating to a reduction in the sulphur content of certain liquid fuels. http://data.europa.eu/eli/dir/2016/802/oj

[27] Regulation (EU) No 167/2013 of the European Parliament and of the Council of 5 February 2013 on the approval and market surveillance of agricultural and forestry vehicles http://data.europa.eu/eli/reg/2013/167/2019-04-18

[28] Commission Regulation (EU) 2017/1151 of 1 June 2017 supplementing Regulation (EC) No 715/2007 of the European Parliament and of the Council on type-approval of motor vehicles with respect to emissions from light passenger and commercial vehicles (Euro 5 and Euro 6) and on access to vehicle repair and maintenance information, amending Directive 2007/46/EC of the European Parliament and of the Council, Commission Regulation (EC) No 692/2008 and Commission Regulation (EU) No 1230/2012 and repealing Commission Regulation (EC) No 692/2008 http://data.europa.eu/eli/reg/2017/1151/2023-09-01

[29] Regulation (EC) No 715/2007 of the European Parliament and of the Council of 20 June 2007 on type approval of motor vehicles with respect to emissions from light passenger

and commercial vehicles (Euro 5 and Euro 6) and on access to vehicle repair and maintenance information http://data.europa.eu/eli/reg/2007/715/2020-09-01

[30] Regulation (EC) No 595/2009 of the European Parliament and of the Council of 18 June 2009 on type-approval of motor vehicles and engines with respect to emissions from heavy duty vehicles (Euro VI) and amending Regulation (EC) No 715/2007 and Directive 2007/46/EC and repealing Directives 80/1269/EEC, 2005/55/EC and 2005/78/EC http://data.europa.eu/eli/reg/2009/595/2020-09-01

[31] On amending certain regulatory acts, Law of the Republic of Moldova No. LP356/2022, 29 December 2022

[32] Moldova, CCAC partner since 2016, https://www.ccacoalition.org/en/partners/moldova

[33] UNECE On the way of clean air The Capacity-Building Programme under the Convention on Long-range Transboundary Air Pollution in Eastern Europe, the Caucasus and Central Asia. 2019

[34] The Republic of Moldova NFR tables for 2022 https://www.ceip.at/status-of-reporting-and-review-results/2022-submission

[35] Informative Inventory Report of the Republic of Moldova, 1990-2020 / Stela Drucioc, Elena Bykova, Irina Vasiliev, Sergei Burtev, Tatiana Kirillova, Elena Kuznetsov, Elena Mosanu, Anatol Tarita, 2022 https://www.ceip.at/status-of-reporting-and-review-results/2022-submission

[36] EMEP/EEA air pollutant emission inventory guidebook 2019. Technical guidance to prepare national emission inventories: https://www.eea.europa.eu/publications/emep-eea-guidebook-2019Reg

[37] Informative note on the need of establishment of the National Air Quality Monitoring Network, Ministry of Environment of Moldova communication with Citepa, July 2022

[38] Directive 2009/126/EC of the European Parliament and of the Council of 21 October 2009 on Stage II petrol vapour recovery during refuelling of motor vehicles at service stations http://data.europa.eu/eli/dir/2009/126/oj

[39] Directive (EU) 2015/2193 of the European Parliament and of the Council of 25 November 2015 on the limitation of emissions of certain pollutants into the air from medium combustion plants http://data.europa.eu/eli/dir/2015/2193/oj

[40] 1999 Protocol to Abate Acidification, Eutrophication and Ground-level Ozone to the Convention on Long-range Transboundary Air Pollution, as amended on 4 May 2012 https://unece.org/sites/default/files/2021-10/ECE.EB_.AIR_.114_ENG.pdf

[41] On the approval of the Regulation on reducing the sulphur content of certain liquid fuels, Government decree No. HG414/2016, 8 April 2016

[42] TFTEI Techno-Scientific Board. TFTEI background informal technical document for the Review of the Gothenburg Protocol for mobile sources, Annex VIII. August 2023. Informal document to the 61st WGSR in September 2023.

https://unece.org/sites/default/files/2023-08/TFTEI-%20Informal%20bakground%20document%20on%20review%20of%20Annex%20VIII%20-%20Mobile%20Sources%20of_0.pdf

[43] Code of good practice for wood-burning and small combustion installations, 2019. https://unece.org/DAM/env/documents/2019/AIR/EB/ECE_EB.AIR_2019_5-1916518E.pdf

[44] Prioritizing reductions of particulate matter from sources that are also significant sources of black carbon - analysis and guidance, 2021. https://unece.org/sites/default/files/2021-10/ECE_EB.AIR_2021_6-2113500E.pdf

[45] B. Bessagnet, N. Allemand, Review on Black Carbon (BC) and Polycyclic Aromatic Hydrocarbons (PAHs) emission reductions induced by PM emission abatement, TFTEI 2019

[46] WGSR 56th. May 2018. Thematic session on residential wood combustion and air pollution. https://unece.org/info/Environmental-Policy/Air-Pollution/events/20267

[47] TFTEI Techno-Scientific Board. TFTEI background informal technical document for the Review of the Gothenburg Protocol for Industrial Processes Annexes IV, V, VI, X and XI March 2022. Informal document to the 60th WGSR meeting. https://unece.org/sites/default/files/2022-03/TFTEI%20review%20of%20Annexes%20to%20the%20Gothenburg%20Protocol.pdf

[48] Directive 2009/125/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for the setting of eco-design requirements for energy-related products http://data.europa.eu/eli/dir/2009/125/2012-12-04

[49] Commission Regulation (EU) 2015/1185 of 24 April 2015 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to eco-design requirements for solid fuel local space heaters http://data.europa.eu/eli/reg/2015/1185/oj

[50] Commission Regulation (EU) 2015/1189 of 28 April 2015 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to eco-design requirements for solid fuel boilers http://data.europa.eu/eli/reg/2015/1189/oj

5.8. Limit values implemented by the regulations of the Republic of Moldova and comparison with the AGP limit values

5.8.1. Combustion installations

The following tables present ELVs prescribed by the regulation on emission limit value of pollutants from combustion plants shall be ensured from 31 December 2028 [20]. They are compared to ELVs of the Gothenburg protocol in Annex IV for SO_2, Annex V for NOx and Annex X for PM (Table 5-2, Table 5-3, and Table 5-4).

A colour code is used to identify consistency and differences in ELVs: green in case of equal or stricter ELVs, yellow in case of less stringent ELVs.

Table 5-2: Emission limit values for solid fuel combustion in Law on industrial emissions of Moldova and AGP

Type of combustion plant/ Total rated thermal power, MW of thermal energy	Substance	Law on industrial emissions of Moldova		ELVs of technical Annexes of the AGP	
		New installation mg/m³	Existing installation, mg/m³	New installation mg/m³	Existing installation, mg/m³
< 100	NOx	300 (coal, lignite and other solid fuels) 400 (pulverized lignite) 250 (biomass, peat)	300 (coal, lignite and other solid fuels) 450 (pulverized lignite) 300 (biomass, peat)	300 (coal, lignite and other solid fuels) 450 (pulverized lignite) 250 (biomass, peat)	300 (coal, lignite and other solid fuels) 450 (pulverized lignite) 300 (biomass, peat)
100 - 300		200	200 (coal, lignite and other solid fuels) 250 (biomass, peat)	200	200 (coal, lignite and other solid fuels) 250 (biomass, peat)
≥ 300		150 200 when combustion of pulverized lignite	200	150 (coal, lignite and other solid fuels) (general) 150 (biomass, peat) 200 (pulverized lignite)	200
< 100	SOx	400 (coal, lignite and other solid fuels) 300 (peat) 200 (biomass)	400 (coal, lignite and other solid fuels) 300 (peat) 200 (biomass)	400 (coal, lignite and other solid fuels) 300 (peat) 200 (biomass)	
100 - 300		200 (coal, lignite and other solid fuels) 200 (biomass) 300 (peat) (FBC:250)	250 (coal, lignite and other solid fuels) 300 (peat) 200 (biomass)	200 (coal, lignite and other solid fuels) 300 (peat) 200 (biomass)	250 (coal, lignite and other solid fuels) 300 (peat) 200 (biomass)
≥ 300		150 (coal, lignite and other solid fuels) (FBC: 200)	200 (coal, lignite and other solid fuels) 200 (peat)	150 (coal, lignite and other solid fuels) (FBC: 200) 150 (peat) (FBC: 200) 150 (biomass)	200 (coal, lignite and other solid fuels) 200 (peat) 200 (biomass)

Type of combustion plant/ Total rated thermal power, MW of thermal energy	Substance	Law on industrial emissions of Moldova		ELVs of technical Annexes of the AGP	
		New installation mg/m³	Existing installation, mg/m³	New installation mg/m³	Existing installation, mg/m³
		150 (peat) (FBC: 200) 150 (biomass)	200 (biomass)		
< 100			30	20 (coal, lignite and other solid fuels) 20 (biomass, peat)	30
100 - 300	Dust		25 (coal, lignite and other solid fuels) 20 (biomass, peat)	20 (coal, lignite and other solid fuels) 20 (biomass, peat)	25 (coal, lignite and other solid fuels) 20 (biomass, peat)
≥ 300			20	10 (coal, lignite and other solid fuels) 20 (biomass, peat)	20

Table 5-3: Emission limit values for liquid fuel combustion in Law on industrial emissions of Moldova and AGP

Type of incineration plant/ Total rated thermal power, MW of thermal energy	Substance	Law on industrial emissions of Moldova		ELVs of technical Annexes of the AGP	
		New installation mg/m³	Existing installation, mg/m³	New installation mg/m³	Existing installation, mg/m³
< 100		300	450	300	450
100 - 300	NOx	150	200 (general) Existing plants within refineries and chemical installations	150 50 (light and medium distillates)	200 (general) Existing plants within refineries and chemical installations: 450 (for firing of distillation and conversion residues from crude oil refining for own consumption in combustion plants and for firing liquid production residue as non-commercial fuel) 90 (general for light and medium distillates) 200 (plants operating less than 1,500 hours a year)

Type of incineration plant/ Total rated thermal power, MW of thermal energy	Substance	Law on industrial emissions of Moldova		ELVs of technical Annexes of the AGP	
		New installation mg/m^3	Existing installation, mg/m^3	New installation mg/m^3	Existing installation, mg/m^3
≥ 300		100	150 (general) Existing plants within refineries and chemical installations: 450 (when distillation and conversion residues of distillation of crude oil for own use in combustion plants with an aggregate rated thermal capacity exceeding 500 MW, for which a permit was issued before the entry into force of this Law or whose operators have submitted a fully executed application for a permit before that date, provided that such plants are put into operation no later than the date of entry into	100	150 (general) Existing plants within refineries and chemical installations: 450 (for firing of distillation and conversion residues from crude oil refining for own consumption in combustion plants and for firing liquid production residue as non-commercial fuel (< 500 MWth))

Type of incineration plant/ Total rated thermal power, MW of thermal energy	Substance	Law on industrial emissions of Moldova		ELVs of technical Annexes of the AGP	
		New installation mg/m^3	Existing installation, mg/m^3	New installation mg/m^3	Existing installation, mg/m^3
			force of this Law)		
< 100	SOx	350	350	350	
100 - 300	SOx	200	250	200	250
≥ 300	SOx	150	200	150	200
< 100	Dust	20	30 50 (for the firing of distillation and conversion residues within refineries from the refining of crude oil for own consumption in combustion plants)	20	30 (in general) 50 (for the firing of distillation and conversion residues within refineries from the refining of crude oil for own consumption in combustion plants)
100 - 300	Dust	20	25 (in general) 50 (for the firing of distillation and conversion residues within refineries from the refining of crude oil for own consumption in combustion plants)	20	25 (in general) 50 (for the firing of distillation and conversion residues within refineries from the refining of crude oil for own consumption in combustion plants)
100 - 300	Dust	10		10	20 (in general)

Type of incineration plant/ Total rated thermal power, MW of thermal energy	Substance	Law on industrial emissions of Moldova		ELVs of technical Annexes of the AGP	
		New installation mg/m^3	Existing installation, mg/m^3	New installation mg/m^3	Existing installation, mg/m^3
≥ 300			20 (in general) 50 (for the firing of distillation and conversion residues within refineries from the refining of crude oil for own consumption in combustion plants)		50 (for the firing of distillation and conversion residues within refineries from the refining of crude oil for own consumption in combustion plants)

Table 5-4: Emission limit values for gaseus fuel combustion in Law on industrial emissions of Moldova and AGP

Type of incineration plant/ Total rated thermal power, MW of thermal energy	Substance	Law on industrial emissions of Moldova		AGP	
		New installation mg/m^3	Existing installation, mg/m^3	New installation mg/m^3	Existing installation, mg/m^3
Open-cycle gas turbines (GTP)					
≥ 50	NOx	-	-	100 (natural gas)	100 (natural gas)
Combined cycle gas turbines (CCGT)					
50–600 >600	NOx	50 (For simple cycle gas turbines with an efficiency greater than 35%, determined on the basis of the ISO reference operating mode, the emission threshold for NOx is 50 xη / 35, where η is the gas turbine efficiency, determined on	50 (general for natural gas) 75 mg/Nm^3 in (natural gas) the following cases where the efficiency of the gas turbine is determined on the basis of the basic operating mode according to ISO 120 (general for other gases)	50 (general for natural gas)	50 (general for natural gas), 75 mg/m3 in the following cases, where the efficiency of the gas turbine is determined at ISO base load conditions 150 (plants working on natural gas and operating less than 1,500 hours per year)

Type of incineration plant/ Total rated thermal power, MW of thermal energy	**Substance**	**Law on industrial emissions of Moldova**		**AGP**	
		New installation mg/m³	**Existing installation, mg/m³**	**New installation mg/m³**	**Existing installation, mg/m³**
		the basis of the ISO reference operating mode and expressed as a percentage.)			120 (general for other gases) 200 (for other gases, for plants operating less than 1,500 hours a year)
Natural gas combustion in boilers and engines					
Boiler	NOx	100	100	100 (natural gas)	100 (natural gas)
Engine		75	100		

5.8.2. Industrial plants

The following tables present ELVs prescribed by the regulation on emission limit value of pollutants from industrial plants.

Table 5-5: Comparison of limit values for industrial processes prescribed by the Republic of Moldova regulation and ELVs prescribed by the AGP

	ELVs of technical Annexes of the AGP	ELVs prescribed by Moldova regulation
SO_2		
	Sulphur recovery units: for plants that produce more than 50 Mg of sulphur a day Minimum sulphur recovery rate of sulphur recovery units: new plants: 99.5 % existing plants: 98.5 %	Minimum sulphur recovery rate should be in line with the EU BREF, as BREFs published in Romanian in the Official Journal of the European Union, by order of the Minister of Environment are accepted as national BREFs and published in the Official Gazette of the Republic of Moldova. There is no sulphur recovery units in Moldova.
	Titanium dioxide production Sulphate process, total emission : 6 kg/t of TiO_2 Chloride process, total emission: 1.7 kg/t of TiO_2	Titanium dioxide production For gaseous sulphur dioxide and sulphur trioxide emitted during decomposition and calcination, including acid drops calculated as SO_2 equivalents: (a) 6 kg/t of titanium dioxide produced as annual average; (b) 500 mg/Nm^3 as an hourly average for waste acid concentration plants. 4. For chlorine, for plants using the chloride process: (a) 500 mg / nm^3 as a daily average; (b) 40 mg/Nm^3 at any time. (Annex 13) of the Law on industrial emissions, 2022 [20] There is no titanium dioxide production plants in Moldova.
NOx		
	Cement clinker production General (existing and new installations): 500 mg/m^3 Existing lepol and long rotary kilns in which no waste is co-incinerated: 800 mg/m^3	ELV should be in line with the EU BREF, as BREFs published in Romanian in the Official Journal of the European Union, by order of the Minister of Environment are accepted as national BREFs and published in the Official Gazette of the Republic of Moldova. There are two major clinker producers in Moldova: "Lafarge Ciment (Moldova)" S.A. from Rezina and Cement Slate Plant from Ribnita (UATSN).
	Iron ore sinter plants New installation: 400 mg/m^3	ELV should be in line with the EU BREF, as BREFs published in Romanian in the Official Journal of the European Union, by order of the Minister of Environment are accepted as national

	ELVs of technical Annexes of the AGP	ELVs prescribed by Moldova regulation
	Existing installation: 400 mg/m^3	BREFs and published in the Official Gazette of the Republic of Moldova. There are ferrous metal production in Moldova, however data is limited on it [34].
	Nitric acid production excluding acid concentration units New installation: 160 mg/m^3 Existing installation: 190 mg/m^3	ELV should be in line with the EU BREF, as BREFs published in Romanian in the Official Journal of the European Union, by order of the Minister of Environment are accepted as national BREFs and published in the Official Gazette of the Republic of Moldova. There is no nitric acid production plants in Moldova.
Dust		
	Mineral oil and gas refineries FCC regenerators: 50 mg/m^3	ELV should be in line with the EU BREF, as BREFs published in Romanian in the Official Journal of the European Union, by order of the Minister of Environment are accepted as national BREFs and published in the Official Gazette of the Republic of Moldova There are mineral oil and gas refineries production in Moldova, however data is limited on it [1].
	Cement production Cement installations, kilns, mills and clinker coolers: 20 mg/m^3	ELV should be in line with the EU BREF, as BREFs published in Romanian in the Official Journal of the European Union, by order of the Minister of Environment are accepted as national BREFs and published in the Official Gazette of the Republic of Moldova. There are two major clinker producers in Moldova: "Lafarge Ciment (Moldova)" S.A. from Rezina and Cement Slate Plant from Ribnita (UATSN).
	Lime production Lime kiln firing: 20 mg/m^3	ELV should be in line with the EU BREF, as BREFs published in Romanian in the Official Journal of the European Union, by order of the Minister of Environment are accepted as national BREFs and published in the Official Gazette of the Republic of Moldova. There are lime production in Moldova, however data is limited on [1]
	Primary iron and steel production Sinter plant: 50 mg/m^3 Pelletization plant: 20 mg/m^3 for crushing, grinding 15 mg/m^3 for all other process Blast furnace: Hot stoves (>2.5 t/hour):	ELV should be in line with the EU BREF, as BREFs published in Romanian in the Official Journal of the European Union, by order of the Minister of Environment are accepted as national BREFs and published in the Official Gazette of the Republic of Moldova. There are ferrous metal production in Moldova, however data is limited on it [34].

	ELVs of technical Annexes of the AGP	ELVs prescribed by Moldova regulation
	10 mg/m^3 Basic oxygen steelmaking and casting (>2.5 t/hour): 30 mg/m^3 Electric steelmaking and casting (>2.5 t/hour): 15 mg/m^3 for existing installations 5 mg/m^3 for new installations	
	iron foundries Iron foundries (>20 t/day): all furnaces (cupola, induction, rotary) all mouldings (lost, permanent) 20 mg/m^3 Hot and cold rolling: 20 mg/m^3 50 mg/m^3 where a bag filter cannot be applied due to the presence of wet fumes	ELV should be in line with the EU BREF, as BREFs published in Romanian in the Official Journal of the European Union, by order of the Minister of Environment are accepted as national BREFs and published in the Official Gazette of the Republic of Moldova. There are ferrous metal production in Moldova, however data is limited on it [34].
	Non-ferrous metals production Non-ferrous metal processing: 20 mg/m^3	ELV should be in line with the EU BREF, as BREFs published in Romanian in the Official Journal of the European Union, by order of the Minister of Environment are accepted as national BREFs and published in the Official Gazette of the Republic of Moldova. There are secondary non-ferrous metal production in Moldova, however data is limited on [1]
	Glass production: New installation: 20 mg/m3 Existing installation: 30 mg/m^3	ELV should be in line with the EU BREF, as BREFs published in Romanian in the Official Journal of the European Union, by order of the Minister of Environment are accepted as national BREFs and published in the Official Gazette of the Republic of Moldova. There is no glass production plants in Moldova.
	Pulp production Auxiliary boiler 40 mg/m^3 when firing liquid fuels (at 3% oxygen content) 30 mg/m^3 when firing solid fuels (at 6% oxygen content) Recovery boiler and lime kiln: 50 mg/m^3	ELV should be in line with the EU BREF, as BREFs published in Romanian in the Official Journal of the European Union, by order of the Minister of Environment are accepted as national BREFs and published in the Official Gazette of the Republic of Moldova. There is no pulp production plants in Moldova.
	Waste incineration Municipal waste incineration plants (> 3 Mg/hour): 10 mg/m^3	ELV should be in line with the EU BREF, as BREFs published in Romanian in the Official Journal of the European Union, by order of the Minister of Environment are accepted as national BREFs and published in the Official Gazette of the Republic of Moldova.

	ELVs of technical Annexes of the AGP	ELVs prescribed by Moldova regulation
	Hazardous and medical waste incineration (> 1 Mg/hour): 10 mg/m^3	There is limited information available on waste incineration in Moldova [23]

6. Montenegro

This part of the report dedicated to Montenegro was produced with the support of a Montenegrin expert:

Olivera Kujundzic, senior advisor, Directorate for Ecology and Climate Change of the Ministry of Ecology, Spatial Planning and Urbanism of Montenegro.

She provided detailed information on the air quality situation, sources of emissions from industry, road transport and residential heating as well as relevant policy documents and legislation on which TFTEI analysis is based. The interviews and document exchange took place from April to October 2023 [1].

6.1. Status of ratification of CLRTAP and its protocols and strategic programmes

The former Yugoslavia had signed and ratified the Convention on 13 November 1979 and 18 March 1987 respectively [2]. CLRTAP and EMEP Protocol, were taken over by the Montenegro by means of succession it with the date of effect of 23 October 2006 [1], [4]. Montenegro acceded the original Protocol on Heavy Metals on 30 December 2011 [4], and the original Protocol on Persistent Organic Pollutants 9 February 2012 [5].

In 2011, Montenegro adopted a Law on the approval of original protocol of 1999 [6], however, it didn't set emission ceilings. To date, Montenegro has not signed nor ratified amended Gothenburg protocol [7].

Air pollutant emission inventories in Montenegro were developed and submitted for the period 2010-2013 with the assistance of Italian Ministry of Environment. There was no national emission inventory for seven years, and since 2020 Montenegro has been developing and submitting the emission inventories with the support of the Environment Agency Austria [1].

The draft Montenegro Air quality management strategy for the period 2021-2029 (hereinafter the Strategy 2021-2029), was developed in 2021 as a continuation of the previous National Air Quality Management Strategy 2013, implemented by two Action plans (2013-2016 and 2017-2020) [8], however up to now it was not adopted [1].

The Strategy 2021-2029 combines air quality plans for the three established air quality zones (Northern, Central and Southern) and replaces the plans prepared for the Municipality of Pljevlja (2013), the Municipality of Nikšić (2014) and the Capital City of Podgorica (2015). In addition, the Strategy 2021-2029 includes the Plan of measures for pollution control, which has been prepared in accordance with the requirements of the relevant EU regulations and the final benchmark for the negotiation Chapter 27, considering their overall goal and objectives related to the improvement of air quality, environmental protection and human health. The Strategy 2021-2029 has been developed for 9 years with air pollution reduction targets set until 2030 [8].

As part of the negotiations between Montenegro and the European Union, the EU Joint Position for Chapter 27 - environment and climate change are the final benchmarks for closing the chapter, requires Montenegro to fully comply with the revised EU Directive on the reduction of national emissions of certain atmospheric pollutants (hereafter NECD II) [9]. Thus, the proposed new Strategy 2021-2029 presents an analysis of economically viable emission control strategies for the period of 2020-2029, which will serve as a basis for a final agreement between the EU and Montenegro on its emission reduction commitments. These commitments are in addition to regular annual emissions reporting under NECD II [9], CLRTAP, and the establishment of the National Pollution control programme for air. In addition, Montenegro is expected to improve the implementation of the acquis of the EU in this area, through regular measures to reduce air pollution at the national level, especially in areas where air quality limit values set by the EU are exceeded, and by establishing or updating air quality plans in accordance with Directive 2008/50/EC on ambient air quality and cleaner air for Europe [10].

A number of activities related to air quality are planned within the strategic framework of Montenegro:

- expansion and improvement of the national air quality monitoring network and the IHMS (Institute for Hydrometeorology and Seismology) laboratory for air quality testing in accordance with EU standards;
- improvement of intercity line-haul transportation of passengers in road;
- supporting the technological modernization of the processing industry sector;
- stopping the degradation of the value of renewable natural resources: biodiversity, water, air, land by applying the best available practices and available clean and innovative technologies, significantly reducing air, water and land pollution;
- improving control of air, water and land pollution due to emissions from industry and transportation;
- prioritizing measures to address air pollution, especially pollution with PM from various sources;
- improving data on air conditions in line with the needs and effective control of air pollution;
- continuous and comprehensive monitoring of air quality, identifying cause-and-effect links between pollution and the effectiveness of actions by competent institutions, especially with regard to consistent application of regulations;
- increasing the number of measuring points for air quality monitoring;
- developing the air quality modelling system to reduce the cost of real-time data monitoring and increase the coverage of air quality data;
- implementation of horizontal measures for air protection by integrating air quality policy into other sectoral policies [8].

Other strategic documents of Montenegro that take into account air quality issues are mentioned in the Strategy 2021-2029. Such as, the Innovative Strategy of Montenegro (2020-2029), that is fully in line with the stated goals [8].

Within the global Sustainable Development Goals, which came into force on January 1, 2016, it was determined that a significant reduction in the number of illnesses and deaths due pollutants in air, water and by 2030 (sub-goal 3.9) is needed, as well as reduction of the negative impact of pollutants in cities, focusing on air quality and waste management (sub-goal 11.6) [8].

Furthermore, one of the priorities of the National Strategy of Sustainable Development until 2030 of Montenegro is the protection and improvement of air quality, especially in urban areas. The Strategy tackled drafting Air Quality Management Plan for Podgorica focused on measures to reduce PM_{10} emissions. For industry and energy installations, regulations and economic instruments were developed to enable a shift to lower emissions technologies and processes. In the road transport sector, the age and quality of vehicles were addressed. The public network of air quality monitoring stations was also tackled. However, work is currently underway to update the strategy [1].

The Energy Development Strategy of Montenegro until 2030 is also a key document in this area. In the process of alignment with the strategic framework, numerous issues have been identified that link the two documents, both in the field of air pollution protection, greenhouse gas emissions and other issues related to mitigation of the negative effects of climate change and air pollution [8]. Currently, the country is preparing the updated National Energy and Climate Plan in line with EU requirements and is expected to adopt it by the end of 2024 [1].

The Montenegro Traffic Development Strategy 2019-2035 includes among the defined goals the protection of the environment from the negative impacts of traffic. In the field of road traffic, efforts to free Montenegro from dependence on fossil fuels and negative environmental impact by promoting alternative fuels and electromobility are recognized.

The National Climate Change Strategy until 2030 makes a very important link between the climate change policies and the air protection policies, lies in the provisions of the NECD II [9]. SO_2, NOx, NH_3, volatile organic compounds (VOCs) are also gases affecting climate change. This document contains the goal of reducing emissions of these pollutants at the national level, indicating the necessity of synergy between the two policies [8]. A revision of the strategy is also under way and is planned to be completed by the end of 2024 [1].

The key strategic goals of the draft Montenegro Air quality management strategy for the period 2021-2029 are to improve air quality and further improve air quality monitoring and management [8]. These strategic goals are to be achieved through the following operational goals:

- for air quality improvement, they are reducing SO_2 concentrations in the Northern air quality zone, reducing PM concentrations in the Northern and Central air quality zones, and reducing pollutant emissions (NOx, SO_2, VOC, NH_3 and $PM_{2.5}$);
- to further improve air quality monitoring and management, they are improving the quality of data on air quality and air pollutant emissions and to improve cooperation between relevant institutions, local government units, the civil sector and enterprises.

The following have been identified as key activities for the implementation of the operational goals of the Strategy 2021-2029:

- reduction of SO_2 concentrations in the Northern air quality zone through ecological reconstruction of the Pljevlja Thermal Power Plant (PTPP), carried out by the Electric Power Company of Montenegro. The completion deadline for the installation of the waste gas desulphurization system was 2023.
- reduction of PM concentrations in the Northern and Central air quality through long-term synergistic actions on parallel implementation of the proposed activities:
    - improving household heating by reducing coal consumption, wet wood to firewood, using more efficient heating appliances, switching to more environmentally friendly fuels, improving energy efficiency of residential buildings, introducing central heating systems, etc.;
    - preventive measures related to forest fires and tightening of criminal policy related to the prohibition of open burning of waste, including agricultural waste.
- reduction of pollutant emissions (NOx, SO_2, VOCs, NH_3 and $PM_{2.5}$) stipulated by NECD II [9].
- improving the data quality on air quality and air pollutant emissions through the following activities:
    - regular maintenance and calibration of measuring instruments and other air quality monitoring equipment;

- regular updating and improvement of the inventory of air pollutant emissions;
- establishment of cross-border air pollution monitoring in accordance with the EMEP programme at the measuring point in Velimlje;
- development of mathematical air quality modelling methods to obtain data supplemented with indicative data for areas where measurements are not carried out.

- Improving cooperation between relevant institutions, local government units, civil sector and professional public in the field of air protection through more intensive meetings and joint activities aimed at implementing the strategy, solving ad hoc issues and promoting air protection [8].

The draft programme of air pollution control measures within the Strategy 2021-2029

The draft programme of Air Pollution Control Measures (2021-2029) has been prepared as part of the Strategy 2021-2029, in accordance with the requirements of NECD II [9], the Guide for the Development of National Air Pollution Control Programs under the above mentioned Directive, and by the Commission implementing decision (EU) 2018/1522 laying down a common format for national air pollution control programmes under Directive (EU) 2016/2284 of the European Parliament and of the Council on the reduction of national emissions of certain atmospheric pollutants, to the extent possible in relation to the available data [8].

Taking into account that national legislation stipulates that programmes are adopted for a maximum of three years, and that the specific programme by its nature and the mentioned EU acts covers a longer period (2020-2029), and that the programme must be developed in line with the goals and existing measures and plans to improve air quality, this programme was included in the updated Strategy 2021-2029 [8]. However, as the Strategy 2021-2029 has not been adopted to date, there has been no subsequent development of this draft programme of air pollution control measures [1]. Nevertheless, progress in the implementation of the regulations to date is evident and is in line with the technological pathway of AGP for Montenegro.

Measures to reduce SO_2 emissions for the period 2020-2029, covered by the draft programme of air pollution control measures, are as follows:

- Installation of waste gas desulphurization system at the Pljevlja Thermal Power Plant

Significant SO_2 emission reduction is expected in the energy production sector after completion of the ecological reconstruction of the Pljevlja Thermal Power Plant, i.e. when the technological process of coal combustion will be improved using secondary measure. When it is implemented, SO_2 emissions from the PTPP, i.e. in the energy production sector, will be reduced by 90%, which represents a reduction of more than 80% of total national emissions. The conceptual design for the ecological reconstruction of the PTPP has been completed and the project is currently in the tendering process for the selection of material and equipment suppliers and contractors. Funds for the implementation of the measure were provided by EPCG[16].

The reconstruction of the Pljevlja Thermal Power Plant will ensure compliance with the strictest environmental protection parameters stipulated by the latest EU Decision 2017/1442, establishing best available techniques (BAT) conclusions, under Directive 2010/75/EU of the European Parliament and of the Council, for large combustion plants [11]. The PTPP operator submitted a request to the Secretariat of the Energy Community for the application of the

[16] Elektroprivreda Crne Gore AD Nikšić (EPCG) is a national energy company established by the decision about transformation of JEP Elektroprivreda Crne Gore Nikšić, No. 1001-2772/1 dated October 16th, 1998 for the purpose of carrying out energy activity, i.e. electricity generation and supply: https://www.epcg.com/en/about-us/about-us

exemption mechanism for the Directive on large combustion plants in accordance with the decision of the Ministerial Council of the Energy Community ("Opt-out" mechanism) and received approval. According to this decision, the PTPP can operate for a total of 20,000 hours between 2018 and 2024, which will reduce air emissions by around 50% over the same period, and after this period it can only operate if the operation of the plant is adapted to the requirements of the Industrial Emissions Directive [12].

The project documentation published by EPCG AD Nikšić on July 11, 2019, for the works and equipment for the ecological reconstruction of the PTPP defines the best available technological emission limit values for the existing unit, which it will achieve after new and subsequent flue gas treatment installations and have limit values for SO_2 130 mg/Nm^3 [8].

- Reduction of sulphur content in liquid fuels of oil origin and fuel replacement

SO_2 emissions from the production processes sector and product use sector have already decreased, in the period after 2011, when the Regulation on limit values of the content of polluting substances in liquid fuels of oil origin was adopted, prescribing a reduced sulphur content in diesel fuel, oil and marine fuels [13].

The implementation of this Regulation led not only to a reduction of SO_2 emissions from the transport sector, but also to a transition to the use of low-sulphur fuels in production processes [8].

The Regulation on limit values of the content of polluting substances in liquid fuels of oil origin [13] further tightened the limit values of sulphur content in marine fuels in accordance with Directive (EU) 2016/802 on the reduction of content of sulphur in certain liquid fuels [14]. According to this regulation, vessels sailing in the territorial waters of Montenegro and the exclusive economic zone must not exceed 0.5% m/m the sulphur content in marine fuels, as of January 1, 2020. Although according to NECD II emissions from international maritime traffic are not taken into account in determining the emission reductions achieved, the initiative to declare the Mediterranean Sea or parts thereof as Emission Control Areas (ECAs) for sulphur oxides (SOx) under Annex VI of the MARPOL Convention [8].

- Other measures applied or to be applied to SO_2 emission reduction for the period 2020-2029

Kombinat aluminum Podgorica (KAP), the largest industrial plant in Montenegro, has been using liquefied natural gas instead of oil fuel in its technological process since 2019. Between 2005 and 2018, SO_2 and NOx emissions at KAP decreased even without taking into account the switch to liquefied natural gas, but also due to production cuts and some improvements implemented in the technological processes.

Željezara Nikšić, an iron and steel plant, is also planning to replace its boiler plant, which will use liquefied natural gas as fuel, in order to bring emissions from this plant in line with the integrated permit.

The Energy Development Strategy until 2030 includes plans for constructing a gas pipeline network in the country in 2021. This development is part of two regional gas pipeline projects, which, following the establishment of the distributive gas network, will initiate widespread use of natural gas.

The Strategy 2021-2029 establishes a goal to reduce SO_2 emissions in the period 2020-2029 via the environmental reconstruction of the Pljevlja Thermal Power Plant, which represents the most important source of emissions. According to the Action Plan for the Environmental Protection Programme of this plant, a wet scrubber system will be installed in the PTPP, the efficiency of which is estimated at 90%. At best, this will reduce around 80% of the total current national SO_2 emissions.

However, considering that emission reductions, according to NECD II [9], must be achieved in relation to emissions in the base year 2005, it is necessary to pay attention to the increase in SO_2 emissions over the past period, according to the available data from the emission inventory. Thus, according to Article 5 of NECD II, the most optimistic estimate of SO_2 emission reduction compared to 2005 is 50% [8].

Measures to reduce NOx emissions for the period 2020-2029, envisaged by the draft programme of air pollution control measures are as follows:

- Installation of a waste gases denitrification system in the Pljevlja Thermal Power Plant

As part of the environmental reconstruction of the Pljevlja Thermal Power Plant, it is also planned to install a waste gases denitrification system by 2023, by improving the coal combustion technological process using selective catalytic reduction (SCR) technique, which will reduce emissions from this source by up to 70%, representing a reduction of more than 35% of the country's total emissions.

The project documentation published by EPCG on July 11, 2019, for the works and equipment for the environmental reconstruction of the PTPP, defines the compliance of the new flue gas treatment installations with the limit value for NOx 150 mg/Nm^3 [8].

- Increasing the use of alternative fuels, new generation vehicles and electromobility in road traffic

In Podgorica, increased NOx concentrations are the result of intensive traffic and in the coming period, increased concentrations can be expected at the new measuring point that has been established to monitor the impact of traffic (Zabjelo roundabout).

According to the study about situational analysis of legal, institutional and financial framework for e-mobility in Montenegro, in 2035 the total number of passenger vehicles is expected to increase to around 284,000 (in the realistic scenario), i.e. around 329,000 passenger vehicles (in the optimistic scenario), and in the same period the expected number of registered electrically driven vehicles could be about 60,000 (in the realistic scenario), or about 96,000 (in the optimistic scenario). In 2017, around 198,500 passenger vehicles were registered in Montenegro. To assess the effect of this measure, data of the realistic scenario of the mentioned study for the period 2020-2029 were used. Thus, in 2029, the total number of passenger vehicles is expected to increase to 246,695 units, of which 26,881 will be registered for the first time. During the observed period, the number of diesel-powered cars decreases continuously, followed by an increase in petrol engine vehicles, hybrid, and electric vehicles, while the number of LPG passenger vehicles remains roughly constant. The proposed measure can contribute to a 75% reduction in NOx emissions in the road transport sector, while VOC emissions will increase by 12%, due to the significant increase in the use of motor gasoline compared to diesel fuel.

The implementation of this measure is ongoing. NOx emissions from road traffic (trucks and passenger vehicles) have already been partially reduced due to the introduction of catalysts in cars, as well as the introduction of increasingly strict emission standards for the import of used and new cars compared to 2005. Within the project "Development of low-carbon tourism in Montenegro", a certain number of electric tourist vehicles were procured. The dynamics of the implementation of this measure will be dictated by the market, and for it to be implemented faster and lead to better results in terms of emission reduction, appropriate regulatory and fiscal instruments need to be developed.

For the transport sector, where there is a continuous trend of energy consumption growth and increasing share of diesel vehicles in the fleet, studies on the potential of biofuel production and use, the potential of introducing other alternative fuels in the transport sector, the potential of energy efficiency in transport, and an action plan for sustainable use of energy in traffic have been prepared. In addition to the increased use of biofuels, the use of alternative fuels (Liquefied Petroleum Gas-LPG and Compressed Natural Gas-CNG) and electricity in traffic, including infrastructure development, is expected to increase. In the framework of the project "Development of Sustainable use of energy", financed from EU support (through IPA 2011), activities on the preparation of the "Study on potentials for improving energy efficiency in the transport sector", have been finalized. The study analyses for the first time the transport sector in terms of energy consumption, identifies the potential for energy efficiency improvements, identifies existing barriers and proposes measures and activities to overcome them in accordance with the practice in developed countries. In addition to this study, two other case studies were prepared under the project: "Study on the potential of biofuels and the potential to produce second-generation biofuels" and "Study on the possibility of introducing other alternative fuels in the transport sector". Based on these three studies, an "Action Plan for renewable energy sources and energy efficiency measures in the transport sector" was drawn up, which identifies key priorities and measures to be implemented in the coming period, some of which are directly related to energy efficiency. To date, some of the measures in the action plan contribute to the development of energy efficiency in the transport sector, have been implemented.

The Rulebook on marking the energy efficiency of vehicle tires and other parameters adopted in 2017, was updated in 2022 [15]. Together with the Regulation on technical requirements for vehicles imported or first placed on the market in Montenegro [16] they prescribe conditions regarding the limit values of exhaust emissions and noise level for EURO 6 standard for new vehicles, and EURO 4 standard for second-hand vehicles.

In addition, some initial activities have been implemented over the past three-year to support projects that can be linked to energy efficiency improvements in the transport sector. In particular, UNDP and the Ministry of Sustainable Development and Tourism are implementing an innovative project "Development of low-carbon tourism in Montenegro", funded by GEF. The project aims to reduce GHG emissions in the tourism sector, which will also contribute to the reduction of air pollution. The programme supported projects aimed at introducing sustainable solutions in the transport sector.

One of the key measures for sustainable transport is the development of Sustainable Urban Mobility Plans (SUMP), which aim to improve air quality by reducing pollutant and GHG emissions through lower final energy consumption and increased use of RES in road traffic, with a focus on improving the quality of life of citizens. In the previous period, a Polycentric Sustainable Urban Mobility Plan (Poly-SUMP) was prepared for Boka Kotorska and Cetinje. Activities are planned to develop a SUMP for the capital city of Podgorica and to support other SUMPs in Montenegro in developing sustainable urban mobility solutions.

Podgorica has already over 12 km of existing infrastructure, and with the construction of the last of the five projected corridors, will have around 15 km. Two cycle paths with a total length of around 30 km, designed for more experienced cyclists, are currently under construction.

The combined installation of the waste gas denitrification system at the Pljevlja Thermal Power Plant and the increased use of alternative fuels, new-generation vehicles and electromobility in traffic could result in a total reduction of NOx emissions by 55%, while emissions from the key sources (energy production, road traffic) should be reduced by 70-75%. While the reduction of NOx emissions from energy production is certain, the reduction of NOx emissions from transport by renewing and modifying the structure of the vehicle fleet is an expensive and long-term process that can hardly be achieved over the next 10 years.

Given that the share of new passenger vehicles registered for the first time in the total number of passenger vehicles registered in 2018 was only 1.1%, on the basis of available data, reductions in NOx emission of up to 15% can be expected by 2030 [8].

Before 2021, **to reduce PM emissions**, the following measures in industry and energy production were implemented:

- Commissioning of a new electric arc furnace with a built-in system for dedusting gases in the Nikšić Ironworks and disconnection of the old furnace from the production system (2012);
- At the PTPP, the electrostatic filter used to control particulate emissions was overhauled (2013). The values measured after the filter overhaul were within the prescribed limits. As part of the environmental reconstruction of the Pljevlja Thermal Power Plant, it is planned to further optimise the electrostatic filter to comply with the requirements of the new BAT for large combustion plants.
- By changing the fuel (from oil to natural gas) in the anode baking furnace and in the Bertrams boiler plants in KAP, PM emissions were reduced by 100% in 2018, according to the Strategy 2021-2029 [8]. Further planned investments in this facility will significantly reduce suspended particle emissions in the electrolysis facility.

Measures to reduce $PM_{2.5}$ and VOC emission reduction for the 2020-2029 period covered by the draft programme of air pollution control measures are as follows [8].

- Replacement of heating appliances and energy efficiency measures in individual residential buildings

By applying the measure of replacing inefficient heating stoves with efficient ones and the measures to improve the energy characteristics of the building envelope (installation of thermal insulation on the facade walls of the residential building and installation of energy-efficient carpentry) in all individual buildings used for housing, built before 2010 by early 2030, significant thermal energy savings would be achieved, and at the same time, a 35% reduction in $PM_{2.5}$ emissions from the housing sector is expected, ultimately leading to a 25% reduction in $PM_{2.5}$ emissions at national level. In addition, by applying this measure, the reduction in VOC emissions would amount to 35%, which in the end, at national level represents 9%. The measure is currently being implemented.

The Ministry of Economy has been implementing several programmes such as “Energy Wood”, “Energy Efficient Home” and others of a similar nature for many years.

Here are more details on the projects mentioned so far:

- “Energy Wood”: interest-free loans for the installation of heating systems using modern forms of biomass. Under this programme, citizens were able to apply for loans of up to €3,500, with a repayment period of up to five years and an interest rate of 0% for the installation of heating system, i.e. stoves and boilers, using modern forms of biomass. Three phases of the “Energy Wood” programme were yet implemented. More than 1,000 households took part in the programme.
- “Energy Efficient Home”: interest-free loans for the installation of modern forms of biomass heating systems and carrying out work to improve the energy characteristics of the building envelope. In 2018, the Ministry of Economy provided funding amounting of €120,000 for the implementation of the “Energy Efficient Home” programme, which began in October 2018. This programme is a continuation of the “Energy Wood” programme, which has been supplemented by other energy efficiency measures. The aim of the” Energy Efficient Home” programme is to offer households, through interest-

free loans (up to €8,000, with a repayment period of up to 6 years), the possibility to make economic and energy savings by using a biomass heating system and financing works to improve the energy characteristics of the building envelope (installation of thermal insulation on the facade walls of the residential building and installation of energy-efficient joinery). In the first phase of this project, €33,339 was spent and energy efficiency (EE) measures were implemented in 93 households. For the implementation of this project in 2019, budget funds in the amount of €100,000 have been provided, which are intended for the implementation and the interest rate at commercial banks. Further financial support for the project will be implemented through the launch of the GEFF residential project. As part of the EU support, some funds have been earmarked to support the household sector in implementing energy efficiency measures through the Western Balkans Residential Green Economy Financing Facility (GEFF-Residential) project, which is being implemented by the EBRD bank. To realize the project, the EBRD needs to establish cooperation with Montenegro's commercial banks (one or more), which would be obliged to set up credit lines dedicated to energy efficiency. If citizens implement energy efficiency measures using funds from these credit lines, they acquire the right to subsidies, from designated EU funds, of between 15% and 30% of the amount of the investment.

- Subsidized procurement of briquettes and pellets in Pljevlja: with budgetary support from the Government of Montenegro, the municipality of Pljevlja provided citizens with a 50% subsidy for more environmentally friendly energy sources (briquettes, pellets) during the 2015-2019 heating seasons. On average, 500-1,000 households took part in the project each season. Municipality of Pljevlja continued the activity [1].
- In the previous period, several local government authorities continued to implement the subsidy programme for the installation of solar systems in new buildings, through the reduction of communal fees (costs for equipping communal land) in the amount of €50-200 per square meter of solar panel installed and depending on the local self-government units. The activities of certain local government authorities were also noted, such as, for example, municipality of Tivat, which has established a support programme for citizens (interest-free loans), in cooperation with commercial banks, to implement energy efficiency measures in households within the municipality's territory.
- Eco-design of products

By 2019, the Ministry of Economy adopted 17 regulations transposing EU regulations for the introduction of eco-design requirements and 6 regulations transposing EU regulations for the energy efficiency marking of products affecting energy consumption. For most products, application began on January 1, 2019, except for light bulbs, for which application began in 2018. In this context, the regulations governing requirements for space heating appliances are of particular importance.

- Construction the system for district heating in Pljevlja

Pljevlja is a municipality in northern Montenegro with a population of 27,531, or 4.42% of the population of Montenegro. During the winter months, particularly under unfavourable meteorological conditions (days without wind or precipitations, stable atmospheric pressure, temperature inversions), high concentrations of PM and a large number of days when limit values of PM concentrations are exceeded, are recorded in Pljevlja. In this municipality, there are significant coal consumption in household heating (due to the presence of the Pljevlja Coal Mine) and the impact of the Pljevlja Thermal Power Plant activities. Annual average concentrations of PM_{10} and $PM_{2.5}$ in Pljevlja in 2021 were above the prescribed limit value. In addition, one-hour limit concentrations of SO_2 were also above the prescribed limit value [17].

As a part of the environmental reconstruction project of the Pljevlja Thermal Power Plant, a central source of thermal energy with a capacity of 87 MWth is to be provided, along with a main heat pipe. For the implementation of the construction of the district heating infrastructure in Pljevlja, some funds have already been allocated from the capital budget, which have been used to create project documentation for the construction of a mini heating plant to be used as a backup source of thermal energy. However, the municipality of Pljevlja, has decided not to go ahead with the mini-heating plant project.

In the coming period, it is necessary to plan the construction of the district heating network and the infrastructure for connecting the hot water pipe to the source of the thermal power plant, as well as the connection of households to the network.

In 2016-2017, as part of the project "Development of sustainable energy use", which was financed with the support of IPA 2011, the Ministry of Economy of Montenegro prepared a study for the assessment of the potential for the application of high-efficiency cogeneration and the introduction of district heating and cooling systems, and based on the study, prepared a draft action plan for the development and use of district heating and/or cooling and high-efficiency cogeneration. The action plan was due to be finalised and adopted in 2019.

The heating and cooling technologies used in the study include biomass micro-cogeneration, efficient biomass boilers, biomass stoves, efficient heat pumps and solar water heating. The study concludes that the economic potential of district heating and cogeneration is concentrated in municipalities in the north of the country. This potential is estimated at around 95 GWh per year in 2015 and represents final consumption for heating needs in the residential and service sectors, from district heating and cogeneration. It is estimated that this potential will increase to around 100 GWh by 2027, representing around 3% of total heating consumption in the residential and tertiary sectors by 2027. Most of this potential can be expected to be gradually realised over the next ten years. As indicated in the study, a feasibility study will have to be carried out at facility level to determine the specific characteristics of each of the municipalities in climate zone 3, as provided for in the action plan of the Energy Development Strategy (2016-2020).

The introduction of a biomass district heating system (wood chips, pellets and briquettes) for space heating in several northern municipalities was addressed by the results of a feasibility study aimed at identifying biomass potential and assessing the possibility of implementing district heating in 10 municipalities in northern Montenegro.

Of the 10 municipalities observed, projects to implement a biomass-based district heating system development in 4 municipalities were selected as sustainable and special studies were prepared for them in Kolašin, Nikšić, Bijelo Polje and Rožaje.

Although the effects of this measure will not have a significant impact on total emissions at the national level, the measure is extremely important when it comes to local air quality, especially in the northern air quality zone, which is burdened with increased concentrations of PM due to long and harsh winters and the predominant use of solid fuels (coal or firewood) for households heating. Assuming that the project will be fully implemented in the next 10 years and that 4,000 households will be connected to the heating network by 2030, by applying this measure, i.e. extinguishing small fireplaces in households, the annual emission of $PM_{2.5}$ would decrease by 75t, SO_2 emissions by 168t, NOx emissions by 20t and VOC compounds by 90t.

EPCG, as part of the ecological reconstruction of the PTPP, has planned construction works for the city's base, peak, and reserve heating sources, as well as exchange substations within the PTPP with a capacity of up to 50MW. These developments will significantly accelerate the implementation of this project. EPCG has committed to financing the construction of the heat pipe from the Pljevlja Thermal Power Plant gate to its final location in Pljevlja. Certain funds have already been allocated from the capital budget for the construction of district heating infrastructure in Pljevlja. In the upcoming period, it is essential to plan the construction of the district heating network and the infrastructure for connecting households to the network [8].

- Energy efficiency measures in public sector (heating)

The Government of Montenegro, with a €6.5 million loan from the International Bank for Reconstruction and Development (IBRD), implemented “Energy efficiency in Montenegro” project from 2009 to 2014. Energy efficiency measures were applied to health and educational facilities, many of which used oil or solid fuel boilers for heating. For instance, in two city schools in Pljevlja, the heating sources were replaced, and pellet boilers were installed to replace coal-fired ones, with a total capacity of about 1.2 MWth. These successful outcomes led the Government of Montenegro to decide to secure a new €5 million loan to continue the project from 2014 to 2017, primarily in health facilities across Montenegro.

In July 2018, a new Loan Agreement of €6 million was signed with IBRD or the subsequent phase of the project. This phase aimed to further implement energy efficiency measures in healthcare facilities and establish a sustainable financing system for energy efficiency projects in the public sector. A sustainable financing system will allow funding for energy efficiency measures in other buildings to come from the savings realized in retrofitted structures. The project is scheduled to run until December 31, 2023.

The “Energy Efficiency Programme in Public Buildings” was implemented in two phases, in cooperation with the German Development Bank KfW, from January 2012 to December 2015. The Programme’s implementation was financed through loans and financial contributions from KfW Bank, totalling €13.44 million. In the first phase of the Programme, energy efficiency measures were applied, and working conditions were improved in 20 primary and secondary schools and one student dormitory.

The second phase of the programme was carried out with a loan of €20 million and donations of €2,743 million. It commenced in January 2015 and was completed by the end of 2020. The project aimed to enhance the energy efficiency and living and working conditions in administrative facilities related to education, employment, social welfare, and public administration.

In 2018, the “Beautiful Cetinje” project, valued at approximately USD7 million, was successfully completed. This project was executed in collaboration between the UNDP office, the Capital of Cetinje, and the Ministry of Culture. Its primary objective was the economic revitalization of the Capital City through the urban restoration of cultural heritage sites, incorporating energy efficiency measures, providing professional training, supporting small businesses, and fostering green ideas and innovations in overall urban development.

Within the scope of the project's activities, a central focus was on promoting low-carbon development by revitalizing public spaces and preserving and enhancing historical and cultural heritage buildings through the implementation of energy efficiency measures. The ultimate goal was to make these buildings and infrastructure more environmentally friendly and energy efficient.

Building upon this collaboration, in 2018, the project "Improving the Cultural Heritage Management System" was initiated. Among its objectives is the enhancement of the cultural heritage management system by renovating selected cultural heritage sites. As part of this project, ten energy inspections were conducted on publicly used buildings, and energy efficiency assessments were carried out for buildings slated for reconstruction in the near future.

As part of EU support under IPA 2019, around €2.4 million has been allocated for the creation of a financial assistance program aimed at enhancing energy efficiency in facilities under the jurisdiction of local authorities [8].

- Use of renewable energy sources

The increased utilization of RES in the domestic electricity production market in recent years, with significant investment funds having been allocated and continuous investing in new renewable sources, has also contributed to a reduction in air pollutant emissions. The largest ongoing project is the Briska Gora solar power plant, boasting an installed capacity of 250 MW, which is being constructed in phases (Phase I: 50 MW, Phase II: 200 MW). The wind power plants Krnovo (72 MW) and Možura (46 MW) are already operational, while VE Gvozd (55 MW) and SE Velje Brdo (50 MW) are in the preliminary analysis phase, and VE Brajiÿi, with a total installed capacity of 100 MW, is in the phase of tender announcements. Furthermore, in recent years, existing hydroelectric plants and small hydroelectric plants have undergone revitalization, 11 new small hydroelectric plants have been built, and there are plans for the construction of one large and several small hydroelectric plants in the near future.

The increase in the utilization of RES to produce electricity and heat in both new and existing residential buildings, as well as in the commercial and public sectors, represents a significant step towards achieving goals related to the incorporation of renewable energy sources into the total final consumption. In February 2018, the Secretariat of the Energy Community of Southeast Europe published guidelines for the integration of buyer-producers (prosumers) into the network. As part of the Montenegro Energy Efficiency Action Plan for the period 2019-2021, a specific measure known as 'Development of decentralized energy production by prosumers' was introduced. The primary objective of this measure was to promote the concept of decentralized energy production.

The Ministry of Economy of Montenegro, in collaboration with the UNDP office, initiated specific activities between 2018 and 2019. These activities were designed to analyse the current legal framework and procedures relevant to the implementation of the buyer-producer concept and to prepare appropriate guidelines and recommendations. Additionally, UNDP has started work on the preparation of technical documentation for the construction of photovoltaic power plants on various public buildings, including the roof of the Business Centre building in Cetinje, the roof of the Technopolis building in Nikšić, the Parking service Podgorica and the Martiniÿi farm [8].

- Prohibition of burning of residues harvests and agricultural waste

The measure is recommended by NECD II. The ban on open burning of waste is prescribed by the Law on Waste Management [18], although it does not explicitly mention the burning of harvest residues and agricultural waste. Additionally, this measure is recommended through the Code of Good Agricultural Practices (MPRR, 2013), which stipulates that plant residues from the harvest (straw and stubble) should not be burned in the field, except in cases where it is very challenging to incorporate the waste into the soil through plowing or when necessary for weed, disease, and pest control.

Considering that agricultural activities are conducted on relatively small areas (approximately 2.2 thousand hectares of arable crops were harvested in 2017), the burning of crop residues contributes only minimally to total emissions. This measure involves providing adequate information and launching a promotional campaign to familiarize individuals with the regulations and motivate compliance. These activities require certain investments to ensure proper implementation and achieve the desired outcomes. The implementation of this measure is ongoing.

While due attention should be also be given to the prevention of forest fires, this can be considered a preventive measure rather than an emission reduction measure. It is obvious that the sector where the most significant results can be achieved is the domestic heating sector. Unfortunately, transitioning to more energy-efficient homes, more energy-efficient heating systems, and environmentally friendlier fuels represents a substantial financial burden for households. Therefore, it will require an extended period and the continuation and expansion of currently available subsidy programmes.

Considering the economic analysis prepared for the proposed set of measures, as well as the fact that almost all the proposed measures are already in various stages of implementation, Montenegro will implement these measures in the coming period to the extent that financial resources allow.

Special measures to reduce the emissions of VOC are outlined as follows:

- The enforcement of regulations on VOC emissions resulting from the use of paints and varnishes, as specified in the Regulation on the prohibition and restriction of the use, placing on the market and production of chemicals that represent an unacceptable risk to human health and the environment [19]. This regulation stipulates prohibited or permitted methods for using, producing and placing on the market chemicals or specific products that pose an unacceptable risk to human health and the environment.
- The implementation of the Regulation on technical conditions for air protection from emissions of volatile organic compounds resulting from the storage, transfer and distribution of petrol [20]. This rulebook sets technical environmental protection standards for gasoline storage and transfer equipment at terminals and gas stations, as well as for tankers used to transport gasoline between terminals or from a terminal to a gas station, along with the associated deadlines for compliance.

Considering the economic analysis prepared for the proposed set of measures and the fact that nearly all the proposed measures are already at various stages of implementation, Montenegro is moving forward with these measures to the extent that financial resources permit. This set of measures will be incorporated into the updated Air Quality Management Strategy [1].

6.2. Main sources of emissions

This chapter presents the main sources of SO_2, NOx, PM_{10}, $PM_{2.5}$ and VOC emissions in Montenegro. The evolution of air emissions in Montenegro was developed by TFTEI using emission data submitted under the CLRTAP in March 15, 2021, covering the period from 2010 to 2019 [21] and the Informative Inventory Report (IIR) submission 2021 [22]. More recent NFR tables and the IIR report submitted in 2023, which are available on the web platform for CLRTAP submissions [23], were not utilized due to observed inconsistencies in the emission data. The local expert of the Ministry of Ecology, Spatial Planning and Urbanism Montenegro emphasized the need for further improvements in the emissions inventory to accurately reflect the air emissions situation in Montenegro and facilitate the ratification of the AGP.

6.2.1. SO_2 emissions

This section presents the evolution of SO_2 emissions from 2010 to 2019, starting with total SO_2 emissions and ending with the contribution of industrial sources other than public power. SO_2 emissions from road transport vehicles were not estimated in 2021 NFR tables submission [21].

Total SO_2 emissions

The evolution of SO_2 emissions from 2010 to 2019 is shown in Figure 6-1.

In 2019, SO_2 emissions in Montenegro reached 24.9 kt. There is a trend of decreasing SO_2 emissions from 2010 to 2019. In 2019, the main source of SO_2 emissions was public power (98.4%), specifically the coal fired Pljevlja Thermal Power Plant [8]. This thermal power plant generates approximately one-third of Montenegro's electricity, with hydropower plants contributing to the remaining two-thirds [1].

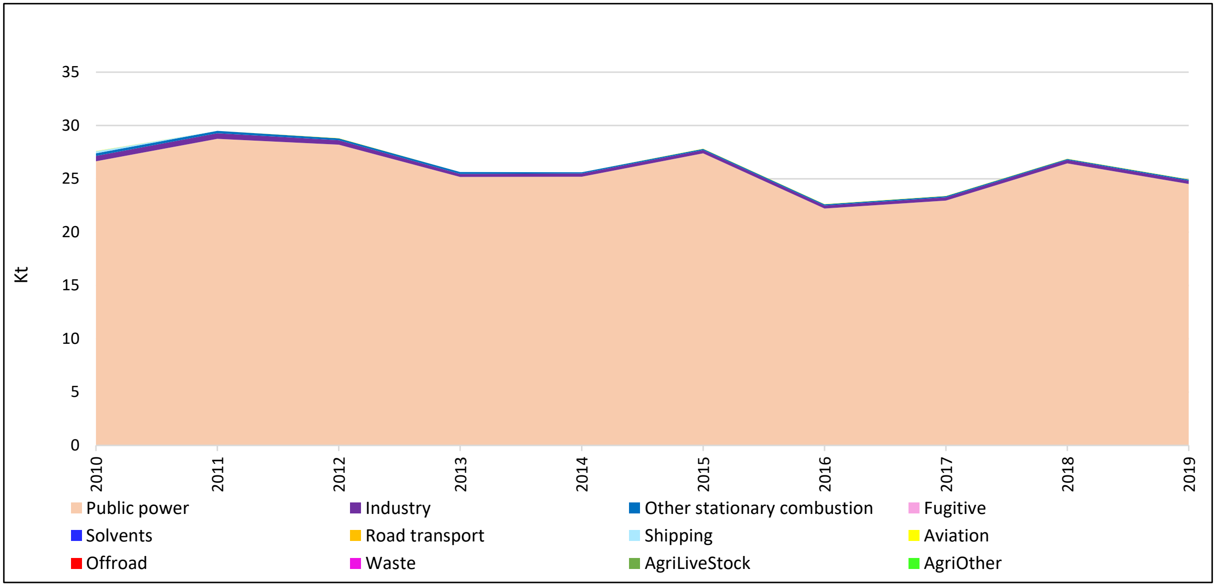


Figure 6-1: Trends in SO_2 emissions from 2010 to 2019 in Montenegro

Industrial sources

The evolution of SO_2 emissions from the industrial sources during the period from 2010 to 2019, is presented in Figure 6-2. SO_2 emissions from Production of non-ferrous metals, namely aluminium production, have decreased by 61% from 2010 to 2019. However, Other industries and Food industry categories have seen increases of 97% and 93%, respectively, from 2013 to 2019.

Total SO_2 emissions from industrial sources in Montenegro in 2019 amounted to 0.3 kt. The major sources of SO_2 emissions in 2019 were the Production of non-ferrous metals (60%), Other industries through Stationery combustion in manufacturing industries and construction (25%), and Food industry (12%).

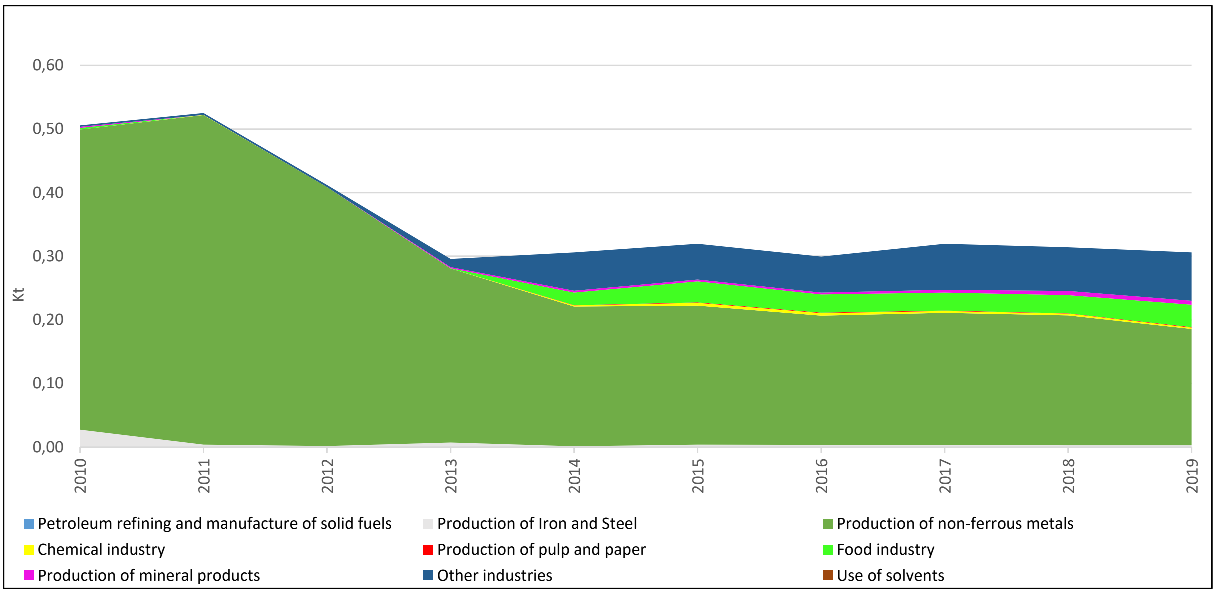


Figure 6-2: SO_2 emissions of manufacturing industry from 2010 to 2019 in Montenegro

6.2.2. NOx emissions

This section outlines the evolution of NOx emissions from 2010 to 2019, beginning with the total NOx emissions, followed by the contribution of industrial sources other than public power, and concluding with emissions from road transport vehicles.

Total NOx emissions

The evolution of NOx emissions from 2010 to 2019 is depicted in Figure 6-3. In 2019, the total NOx emissions amounted to 12,7 kt.

According to data from the emissions inventory [22], in 2019, the key contributor to NOx emissions was road transport with 56% share, while energy production (the PTPP Pljevlja) contributed 28%. The processing industry contributed 10% to NOx emissions due to manufacturing processes, while all other sectors contributed approximately 6%, including a 3% contribution from Other stationary combustion, mainly due to Residential heating.

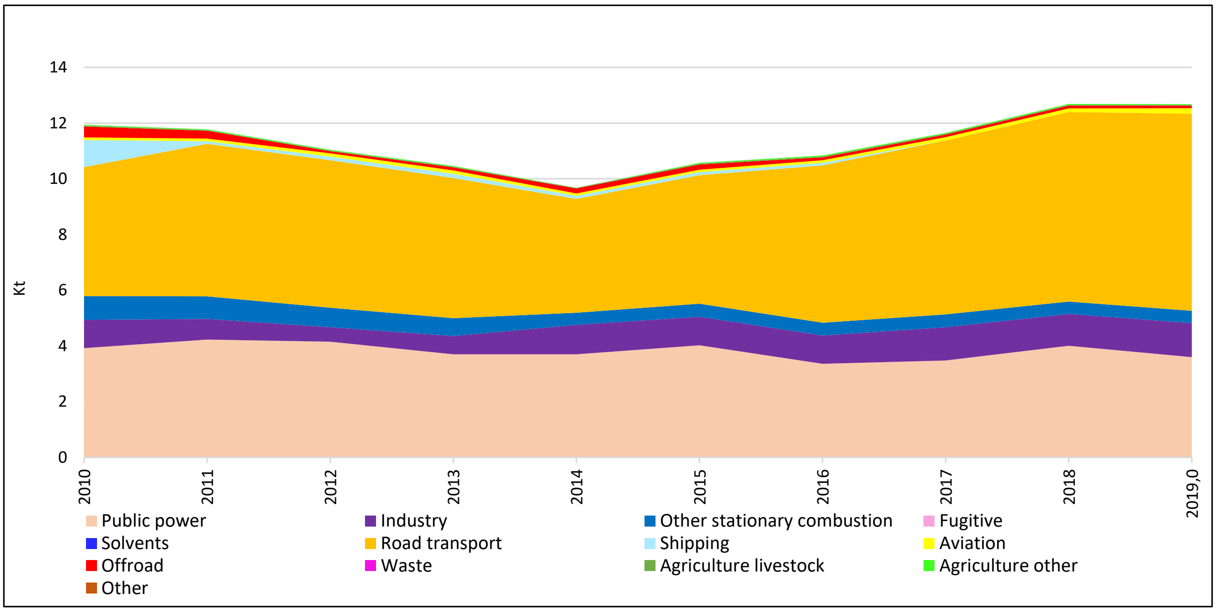


Figure 6-3:Trends in NOx emissions from 2010 to 2019 in Montenegro

Industrial sources

The evolution of NOx emissions from industrial sources is presented in Figure 6-4 for the period from 2010 to 2019. In 2019, NOx emissions from industrial sources totalled 1,2 kt.

The Other industries category made the most significant contribution (69%), with NOx emissions of this category increasing from 2013, primarily due to the rise in the liquid fuel used [1]. The other significant sources of NOx emissions are Food industry (18%), Production of mineral products (6%) and Production of non-ferrous metals (4%).

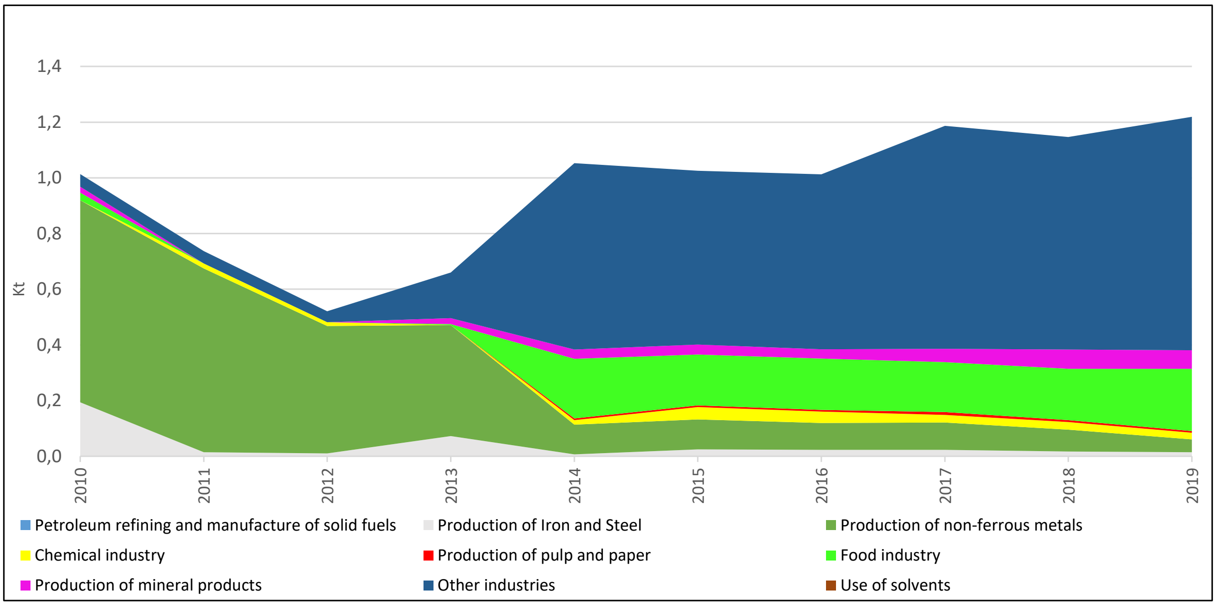


Figure 6-4: NOx emissions of manufacturing industry from 2010 to 2019 in Montenegro

Road transport

The trend in NOx emissions from road transport is as in Figure 6-5, covering the period from 2019 to 2020. In 2019, emissions from road traffic were 7 kt, accounted for 56% of Montenegro's total NOx emissions. Among these emissions, heavy-duty vehicles contributed 90% of the total NOx emissions, with passenger cars making up the remaining 10%.

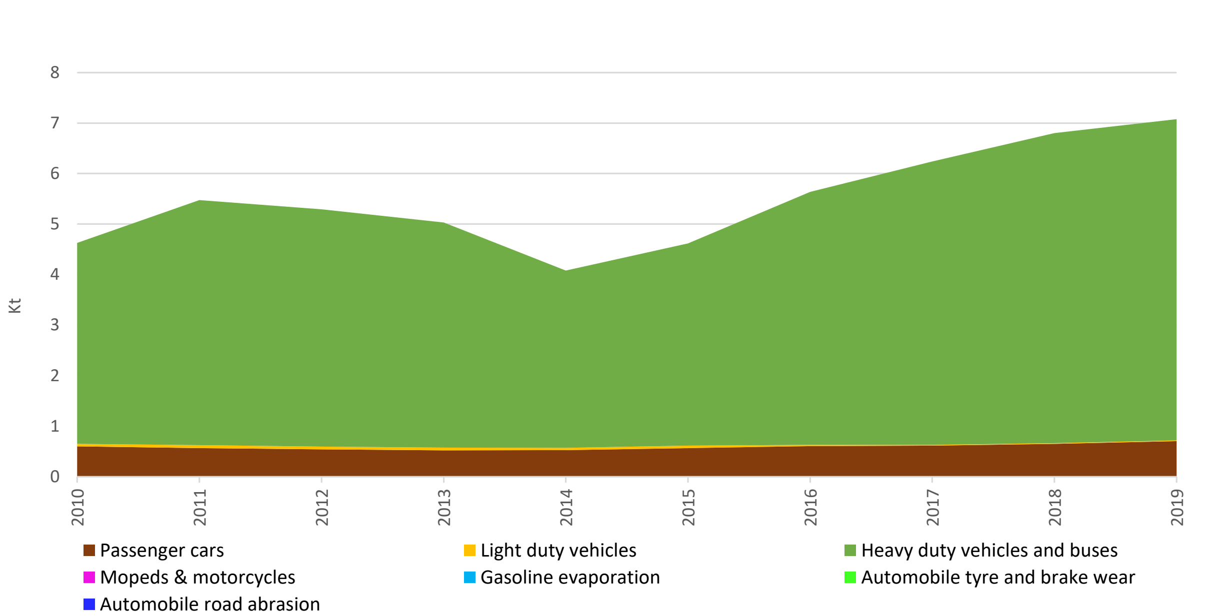


Figure 6-5: NOx emissions of road transport from 2010 to 2019 in Montenegro

6.2.3. PM_{10} and $PM_{2.5}$ emissions

This section presents the evolution of emissions from 2010 to 2019, starting with total PM_{10} and $PM_{2.5}$ emissions. Subsequently, the contribution of industrial sources, other than public power is presented, followed by the display of emissions from road transport.

Total PM_{10} and $PM_{2.5}$ emissions

The trends in PM_{10} and $PM_{2.5}$ emissions from various sources are provided in Figure 6-6 and Figure 6-7 for the period from 2010 to 2019. In 2019, the total PM_{10} and $PM_{2.5}$ emissions were 4,9 and 4,7 kt respectively.

According to the emissions inventory [22], in 2019 the key contribution to PM_{10} and $PM_{2.5}$ emissions (accounting for 85% for both pollutants) came from Other stationary combustion sources, primarily associated with Residential heating (99% for both pollutants). Road transport contributed 6% to PM_{10} and 10% to $PM_{2.5}$ total emissions.

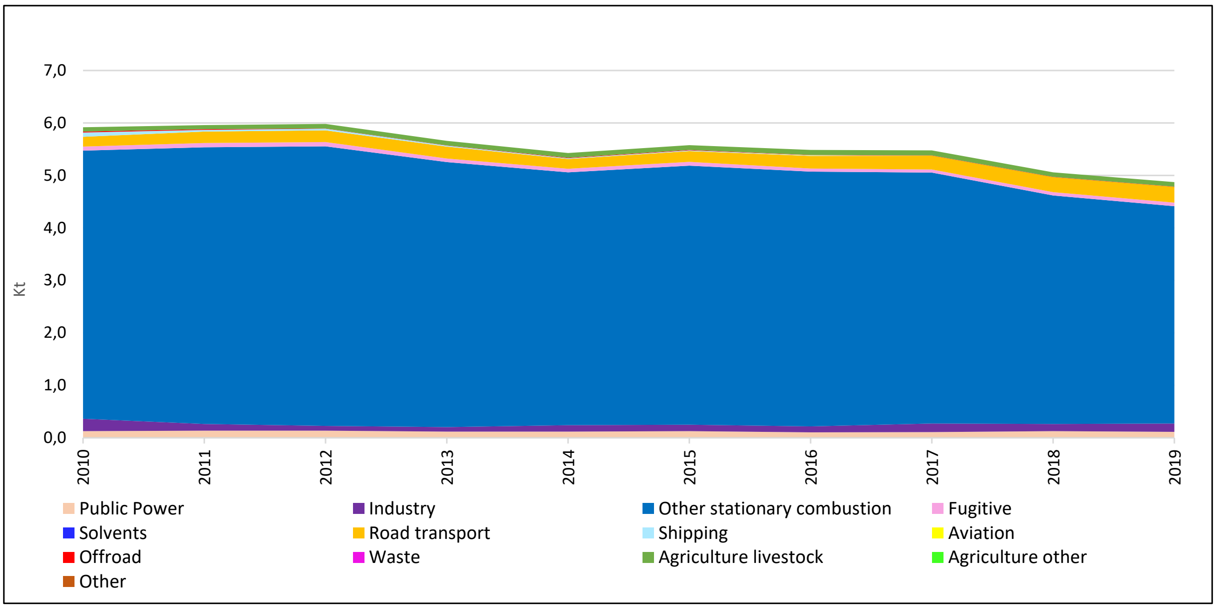


Figure 6-6:Trends in PM_{10} emissions from 2010 to 2019 in Montenegro

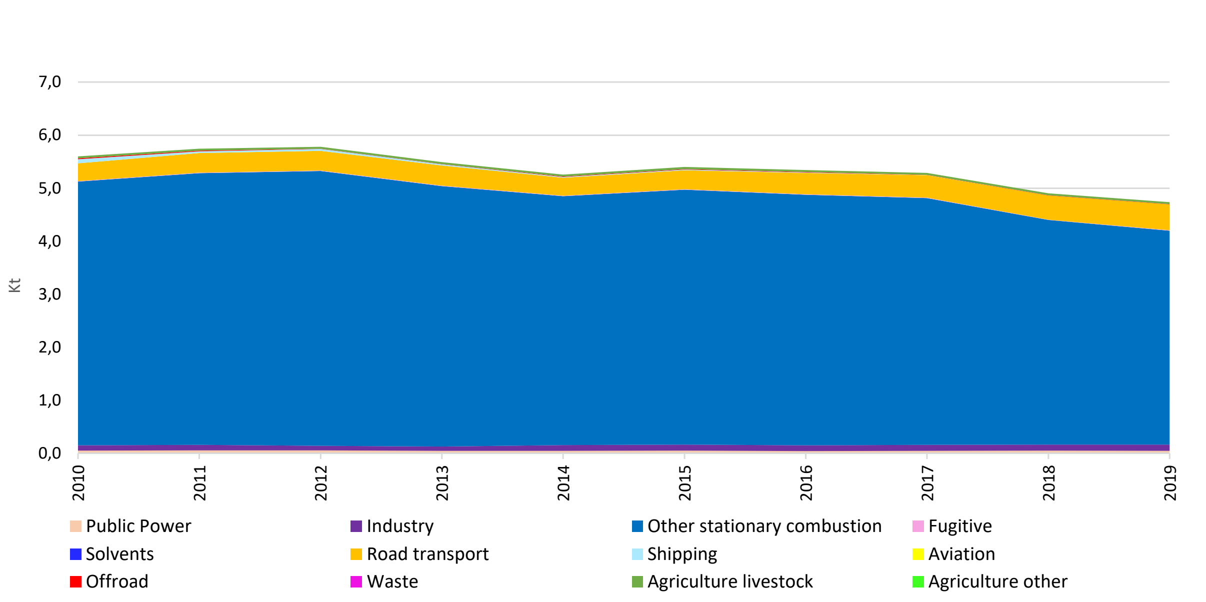


Figure 6-7:Trends in $PM_{2.5}$ emissions from 2010 to 2019 in Montenegro

Industrial sources

The trends in PM_{10} and $PM_{2.5}$ emissions from the industrial sources are provided in Figure 6-8 and Figure 6-9, respectively, for the period from 2010 to 2019. In 2019, PM_{10} and $PM_{2.5}$ emissions from industrial sources were 0.16 and 0.12 kt.

For PM_{10} emissions, the Other industries category had the highest contribution (48%), followed by the Food industry with 33% of the share. Emissions from the Production of non-ferrous metals accounted for 12% of the total industrial emissions, and the Chemical industry contributed 5%.

Regarding $PM_{2.5}$ emissions, the Food industry had the highest contribution (43%), while the Other industries category was the second-largest contributor, accounting for 35% of the share. Emissions from the Production of non-ferrous metals emissions constituted 13% emissions of the total industrial emissions, and the Chemical industry with 7%.

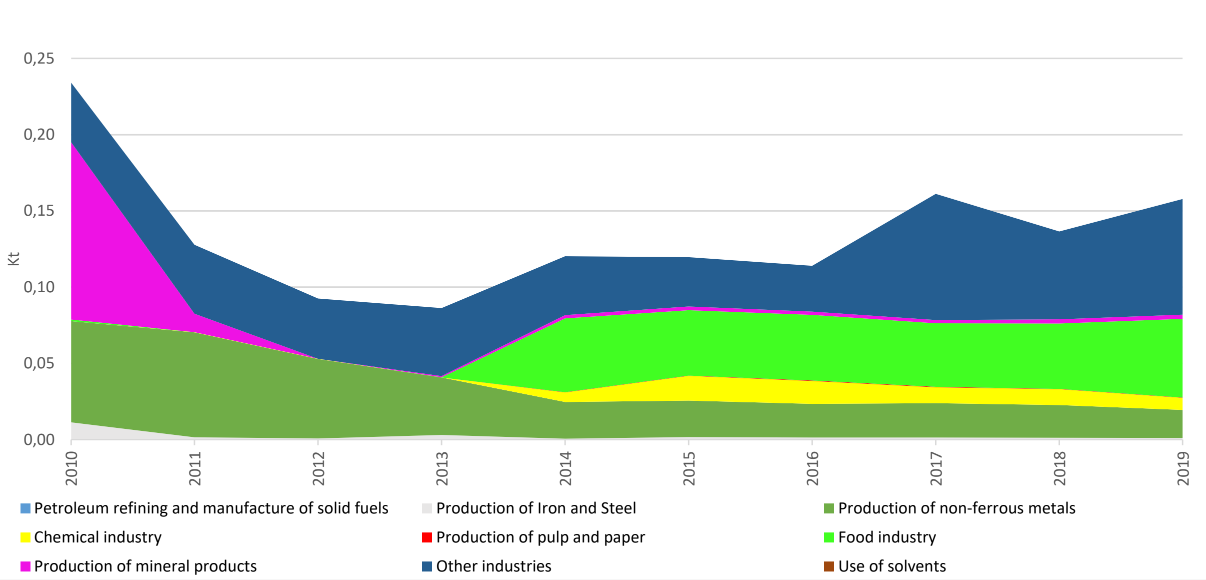


Figure 6-8: PM_{10} emissions of manufacturing industry from 2010 to 2019 in Montenegro

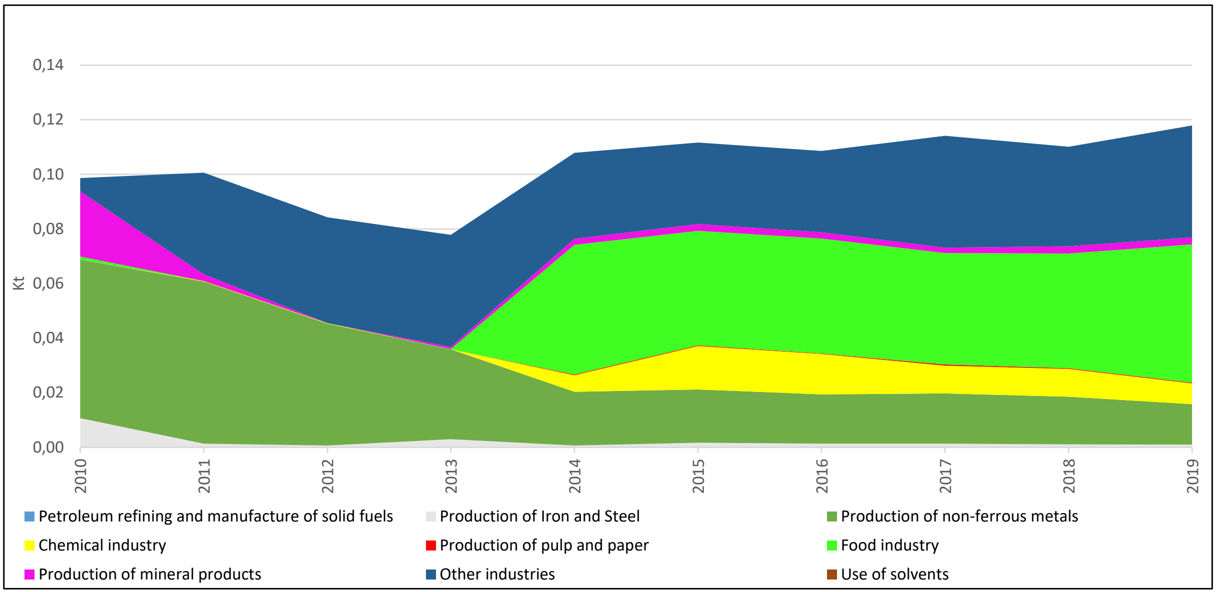


Figure 6-9: $PM_{2.5}$ emissions of manufacturing industry from 2010 to 2019 in Montenegro

Road transport

The trends in PM_{10} and $PM_{2.5}$ emissions from road transport are provided in Figure 6-10 and Figure 6-11, respectively, for the period from 2010 to 2019. In 2019, PM_{10} and $PM_{2.5}$ emissions from road traffic were 0,3 kt and 0,49 kt, respectively.

PM_{10} emissions were primarily attributed to heavy-duty vehicles, constituting 57% of the emissions, followed by automobile tyre and brake wear (22%), passenger cars (12%), and automobile road abrasion (9%).

For PM_{10} emissions, the majority (53%) was attributed to tyre and brake wear, followed by heavy-duty vehicles (35%), passenger cars (7%), and automobile road abrasion (4%).

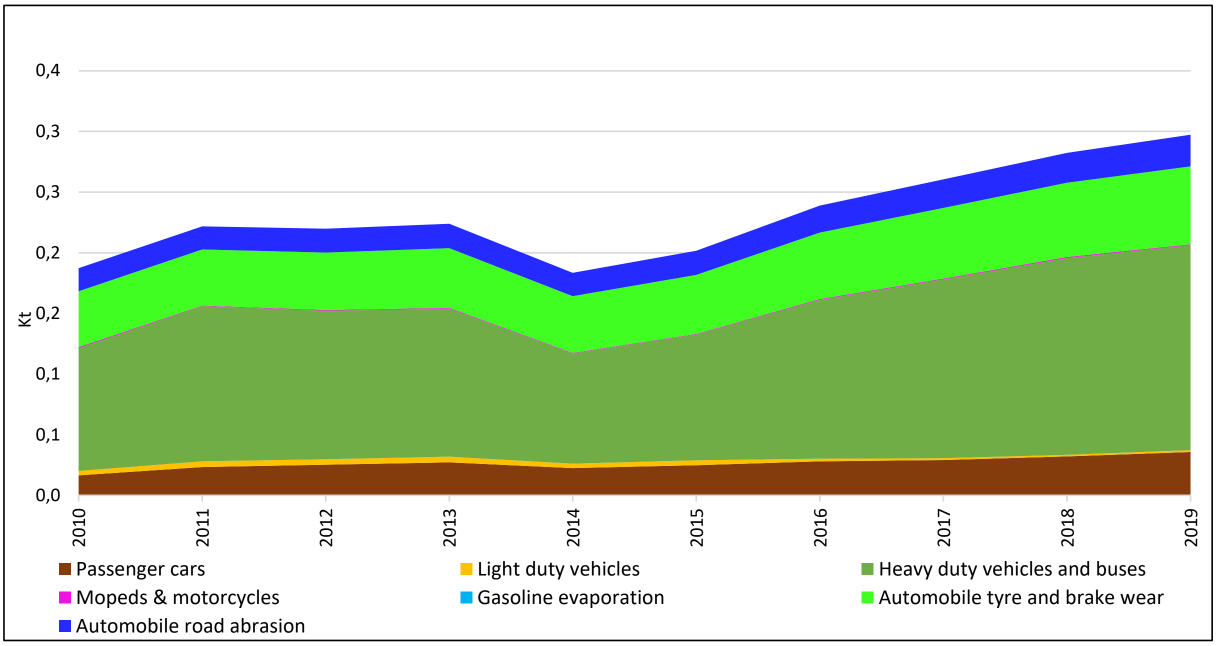


Figure 6-10: PM_{10} emissions of road transport from 2010 to 2019 in Montenegro

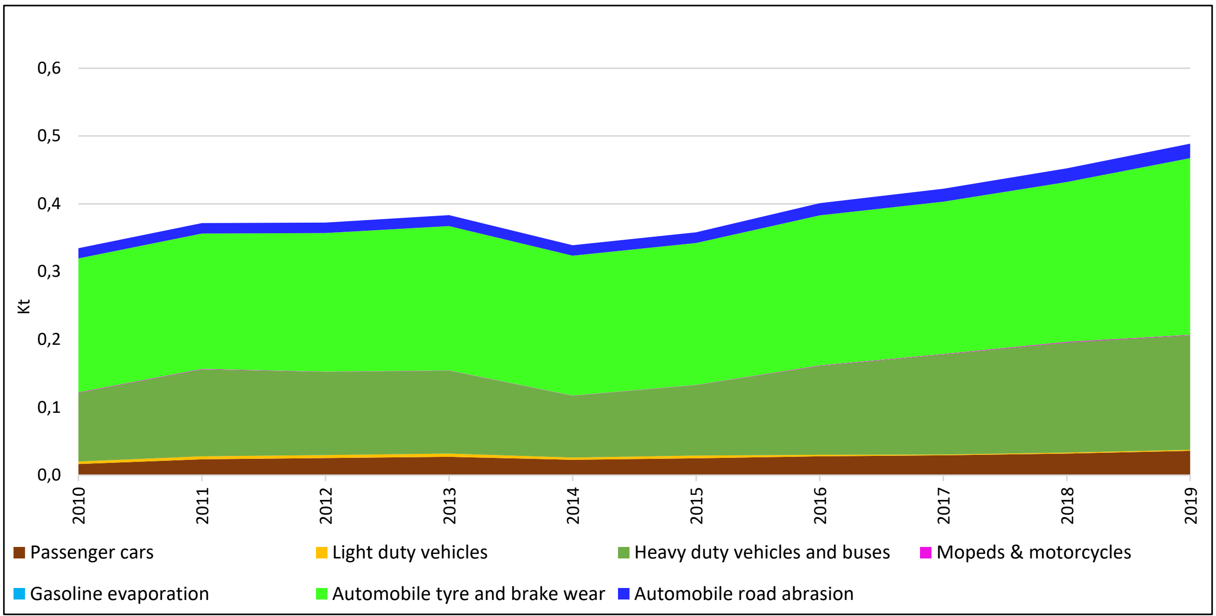


Figure 6-11: $PM_{2.5}$ emissions of road transport from 2010 to 2019 in Montenegro

6.2.4. VOC emissions

This section presents the evolution of VOC emissions from 2010 to 2019, starting with total VOC emissions. Subsequently, the contribution of industrial sources other than public power is presented, followed by the display of emissions from road transport vehicles.

Total VOC emissions

The trends in VOC emissions from various sources are provided in Figure 6-12, for the period from 2010 to 2019. In 2019, the total VOC emissions were 8,6 kt.

According to data from the emissions inventory [22], in 2019, the key contributor to VOC emissions (accounting for 39%) was Other stationary combustion, mainly related to Residential heating (97%). Road transport contributed 16%, while Fugitive emissions made up 15% of the total VOC emissions. Fugitive emissions were entirely attributed to emissions from solid fuels, specifically Coal mining and handling. Solvents, offroad and agriculture livestock each accounted for 9% of the total VOC emissions. The manufacturing industry represented only 4% in the total VOC emissions.

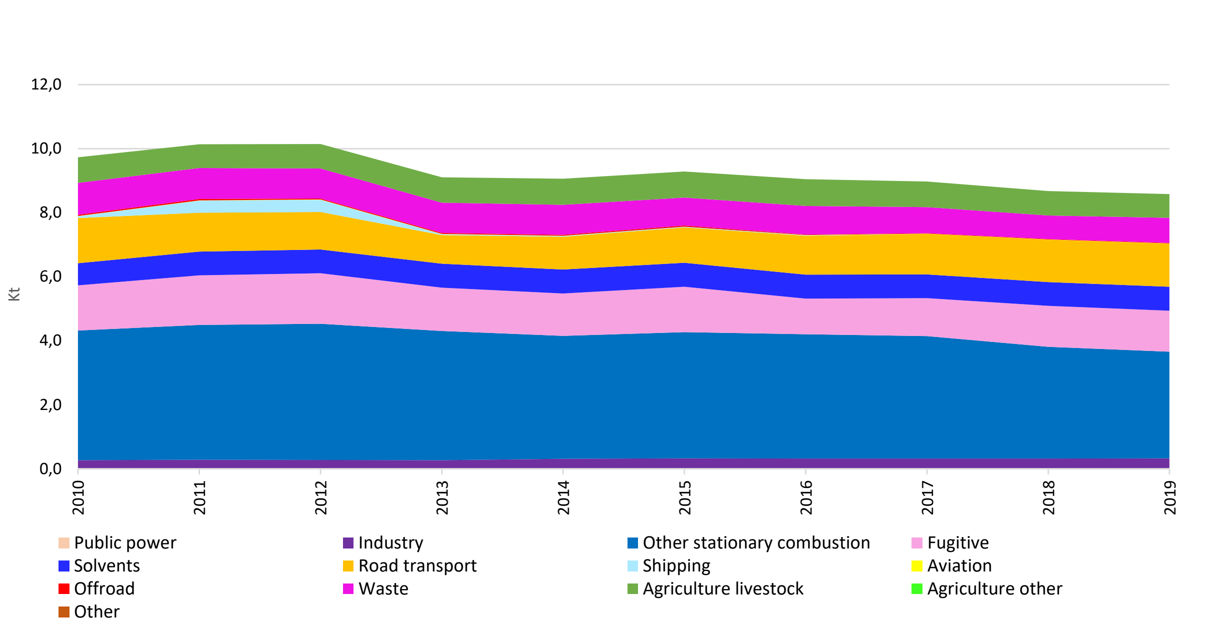


Figure 6-12: Trends in VOC emissions from 2010 to 2019 in Montenegro

Current data indicates a relatively stable level of these emissions throughout the entire period [8].

The primary sources of VOC emissions included individual fireplaces used for burning firewood in households. In certain urban areas, these sources could be partially replaced with the introduction of central heating systems and district heating systems utilizing modern forms of biomass. However, it's worth noting that for most local governments in the northern part of the country, the construction of such systems presents significant challenges, both in terms of finances and technical aspects.

Another major source of VOC emissions is road traffic. To mitigate air pollution, the introduction of electric vehicles is planned, although the implementation of this initiative is also quite challenging, primarily due to the substantial financial requirements.

Industry (except industrial uses of solvents)

The trends of VOC emissions from the industrial sources are provided in Figure 6-13, for the period from 2010 to 2019. In 2019, VOC emissions from industrial sources amounted to 0.31 kt.

In terms of VOC emissions, the Food industry made the largest contribution (74%), followed by the Other industry with 18% of the share. The Chemical industry represented 5% of the total share.

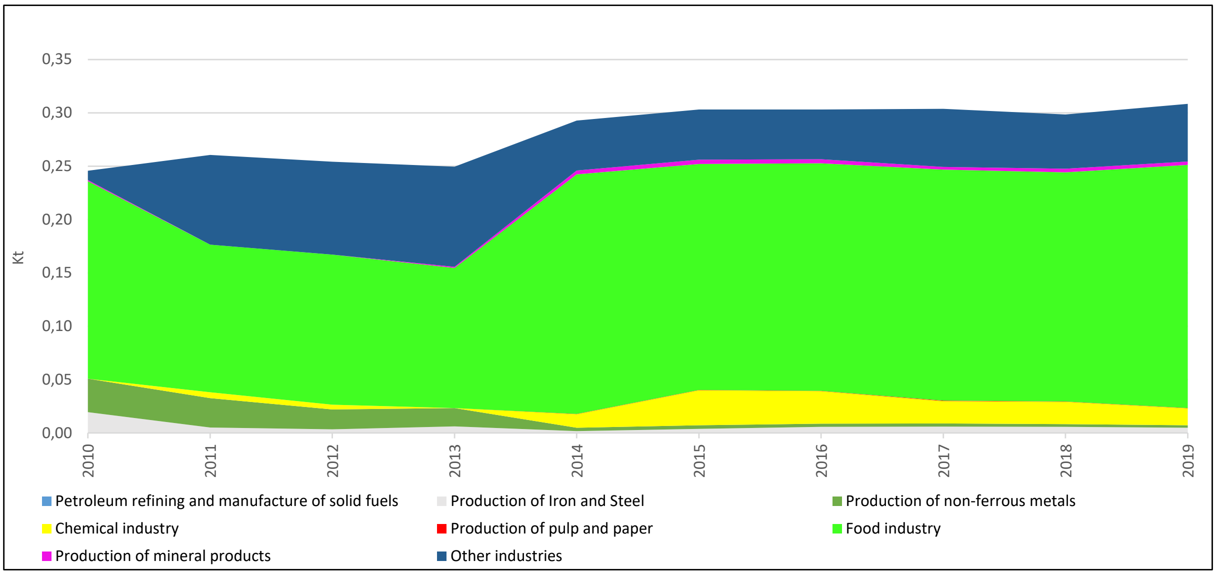


Figure 6-13: VOC emissions of industry (except industrial uses of solvents) from 2010 to 2019 in Montenegro

Use of solvents and other products

Figure 6-14 illustrates the evolution of VOC emissions from the use of solvents and other products. In 2019, the total VOC emissions from the uses of solvents was 0,75 kt. Domestic uses of solvents were the sole estimated source of emissions in Montenegro in 2019.

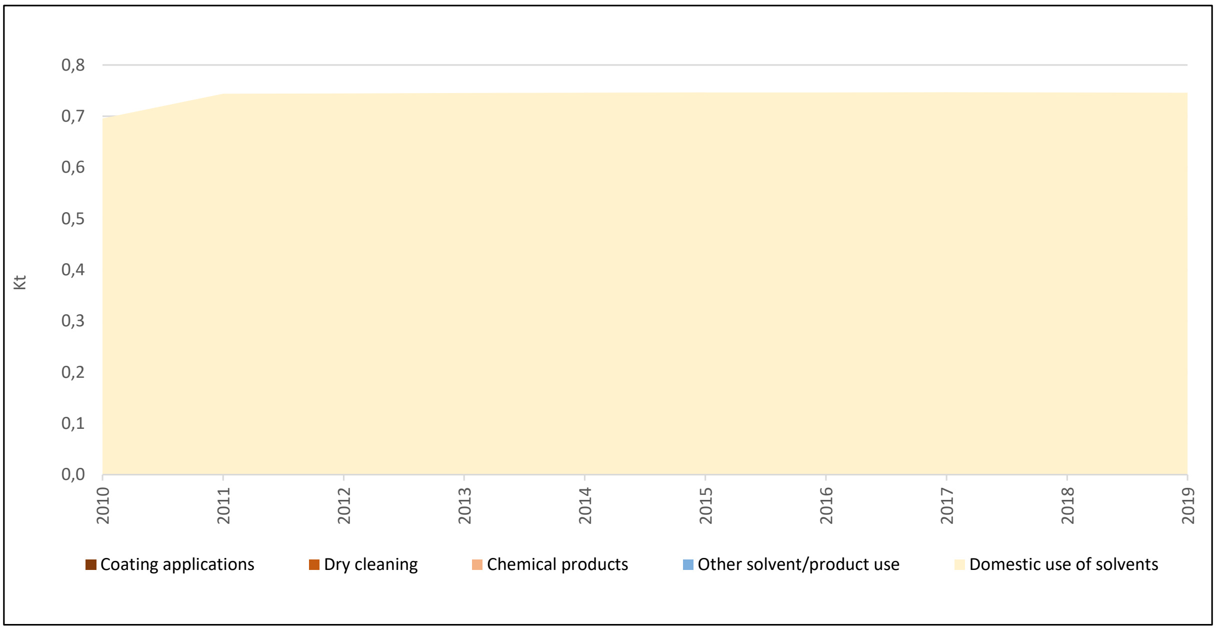


Figure 6-14: VOC emissions from the use of solvents from 2010 to 2019 in Montenegro

Road transport

The trends in VOC emissions from road transport are as in Figure 6-15, covering the period from 2010 to 2019. In 2019, VOC emissions from road traffic amounted to 1,34 kt.

VOC emissions were primarily attributed to heavy-duty vehicles, accounting for 55% of emissions, followed by passenger cars (26%), gasoline evaporation (15%), and mopeds & motorcycles (3%).

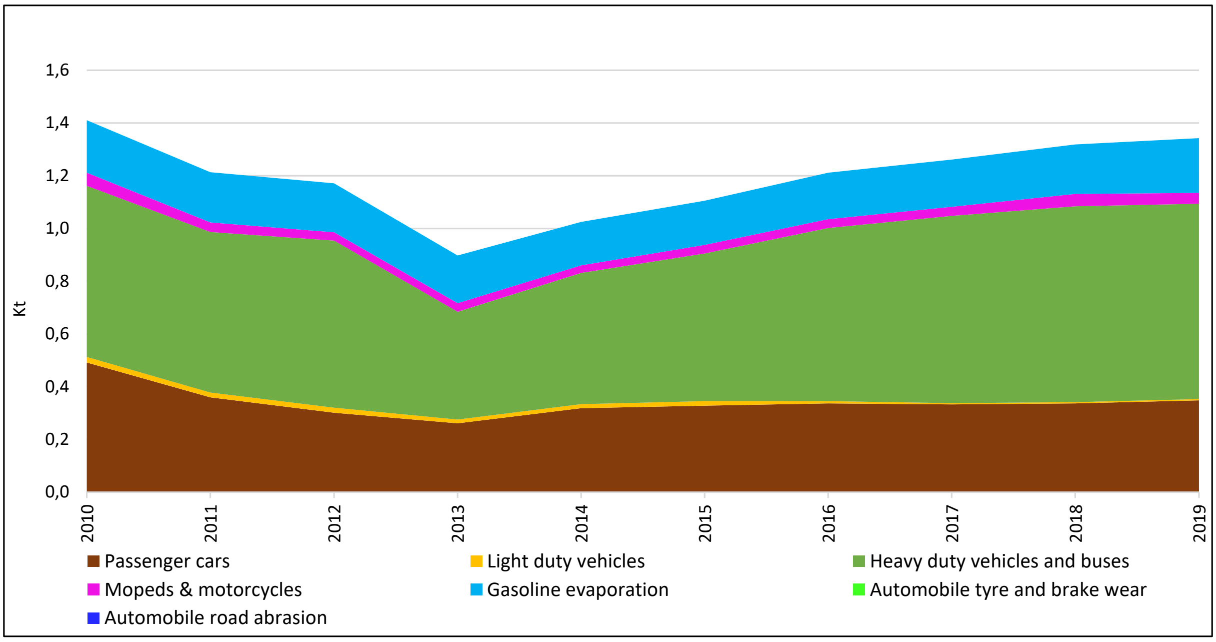


Figure 6-15: VOC emissions of road transport from 2010 to 2019 in Montenegro

6.3. Situation in terms of air quality

Air quality in Montenegro has been monitored in accordance with European standards since 2009. Over the past 10 years, the number of automatic air quality monitoring stations has been gradually increased. By repositioning them within the state network, an optimal level of representativeness of the measuring points has been achieved [8].

The assessment of air quality is carried out in accordance with the Law on Air Protection, 2010 as amended in 2019 [24], as well as the following regulations and rulebooks:

1. Regulation on activities that affect or may affect air quality, 2012 [25],
2. Regulation on the establishment of a network of measuring points for air quality monitoring, 2018 [26],
3. Regulation on the determination of types of pollutants, limits values and other air quality standards, 2012 [27],
4. Rulebook on the manner and conditions for monitoring the quality of air, 2016 [28],
5. Rulebook on the content and method of making annual air quality information, 2012 [29],

and in accordance with the relevant European legislation, including Directive 2008 /50/EC [10] and Directive 2004/107/EC [30].

The territory of Montenegro is divided into three air quality zones (Table 6.1 and Table 6-1: Air quality zones in Montenegro Figure 6-16). These air quality zones are determined based on a preliminary assessment of air quality, available data on pollutant concentrations, and by modelling of existing data. The boundaries of the air quality zones align with the external administrative boundaries of the municipalities that are part of those zones [17].

Table 6-1: Air quality zones in Montenegro

Air quality zone	Municipalities in the zone
Northern air quality zone	Andrijevica, Berane, Bijelo Polje, Gusinje, Pljevlja, Kolašin, Mojkovac, Petnjica, Plav, Plužine, Rozaje, Šavnik and Zabljak
Central air quality zone	Podgorica, Nikšić, Danilovgrad and Cetinje
Southern air quality zone air quality	Bar, Budva, Kotor, Tivat, Ulcinj and Herceg Novi

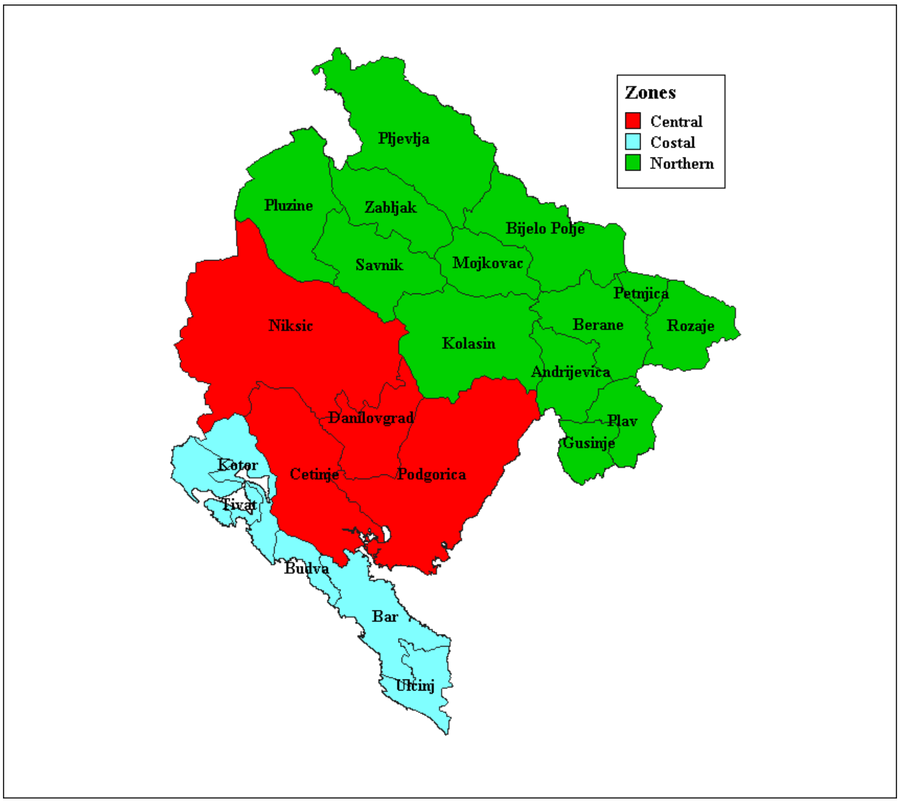


Figure 6-16: Current configuration of Air quality zones [8]

There are 9 continuous monitoring stations and 1 additional EMEP station designed to measure background concentrations. The data from these monitoring stations are made available to the public and other stakeholders through the website of the Environment protection Agency of Montenegro – EPA Montenegro (http://www.epa.org.me/vazduh/) [8].

Air quality monitoring is mandatory in all zones, but not necessary in all municipalities in Montenegro. This European model is employed to reduce the costs associated with air quality monitoring, as it demands costly and sensitive measurement instruments. Therefore, 10 automatic air quality monitoring stations is considered sufficient. However, it remains necessary to develop mathematical modelling systems to complement measurement-based data with indicative data. Regular assessments of the monitoring station positions are also essential to identify the unique characteristics of specific locations where air quality may deviate from the expected norms [8].

Air quality monitoring in the state network covers several categories of pollutants, such as SO_2, NO_2, ground O_3, CO, PM_{10} and $PM_{2.5}$[17], as well as heavy metals (Cd, As, Ni, Pb), PAH (b(a)p), Hg[18] [8].

Since 2019, an EMEP continuous monitoring station was established in Velimlje, with continuous measurements of SO_2, NOx, PM_{10}, and $PM_{2.5}$ among others. However, the data collected and stored in the station's PC memory are in an inadequate user format. The procurement of software for data transfer from the station to the PC, as well as data validation, have not been implemented yet. Consequently, the data cannot be published and shared with the public [17]. Moreover, the Institute for Hydrometeorology and Seismology does not have an accreditation for EMEP measurements [1].

Air quality monitoring data indicates exceedances of air quality standards in the Northern air quality zone during winter months, specifically during the heating season. Despite a slight improvement in air quality in the Pljevlja basin in terms of SO_2 and $PM_{2.5}$ in 2021 compared to the previous year, air quality data still show significant pollution of the lower atmospheric layer for nearly 7 months (January-April / October- December). The situation is similar in other parts of the Northern air quality zone, with the measuring station in Bijelo Polje serving as a reference point. The worst air quality levels were recorded during the period of January-March and late October-December, which coincide with the period when individual and collective fireplaces are most actively used, that is, during the heating season [17].

In 2021, compared to 2020, air quality in the Central air quality zone improved. However, this improvement was not sufficient, as the number of days with exceedances of the average daily concentration of PM_{10} in the air was still significantly higher than the air quality standard. For instance, at the measuring station Podgorica, Zabjelo roundabout, the number of days with exceedances was twice as high as the threshold) [17].

In 2021, measured concentrations of SO_2, PM_{10} and $PM_{2.5}$ in the Southern air quality zone remained below the annual limit values [17].

According to the Law on Air Protection [24], a local government has the authority to establish an air quality monitoring network within its jurisdiction. In line with this practice, during 2021, the Capital City of Podgorica conducted air quality monitoring at 4 locations within the city using a mobile station (SO_2, NOx, and PM_{10} among others). Analysis of the measurement results revealed that poor air quality was influenced by the occasional presence of increased concentrations of PM_{10} in the air, largely attributable to household heating. Other monitored pollutants remained within prescribed limit values.

The state of exceedances for SO_2, NO_2, PM_{10} and $PM_{2.5}$ in Montenegro is as follows.

SO_2

SO_2 concentrations have been monitored in continuous monitoring stations since 2009 in Bar and Nikšić, and since 2012 in Pljevlja, Gradina, Golubovci and Tivat. Average annual concentrations of SO_2 in the southern and central air quality zones are below 10 µg/m^3. However, in the northern zone, concentrations range up to 50 µg/m^3, exceeding this level during 2015, 2016, 2017 and 2019, at the measuring site in Pljevlja [8].

In 2021, SO_2 was measured at five stations: two in the Northern (Pljevlja and Gradina), two in the Central zone (Podgorica and Nikšić), and one in the Southern air quality zone (Kotor). In

[17] Data on concentrations of $PM_{2.5}$ are available since 2012.

[18] From 2019 gaseous mercury is also monitored

2021, only the two stations in the Northern air quality zone recorded SO_2 one-hour threshold violation (350 µg/m^3), but there were no daily threshold violations (125 µg/m^3)[17].

NO_2

NO_2 Air quality monitoring is running at all 10 monitoring stations. For the period of 2009-2019, average annual concentrations of NO_2 at all measuring points were below the threshold (40 µg/m^3) [8][8].

In 2021, NO_2 was measured at eight stations, namely Podgorica Zabjelo, Nikšić, Pljevlja, Gradina, Bijelo Polje, Gornje Mrke, Bar and Kotor [8]. In 2021, at all stations except Podgorica, concentrations were below the one-hour and annual thresholds (200 and 40 µg/m^3 respectively) [17].

PM_{10}

The measurement of PM_{10} concentrations in ambient air has been significantly improved after the expansion and improvement of the state monitoring network. In addition to the measurements already established in Podgorica, Bar, Nikšić and Pljevlja, since October 2019, measurements of PM_{10} concentrations have also been carried out in Kotor and Bijelo Polje. At most measuring points, measurements are performed using two methods: an automatic method, which allows results to be available on the website of the Agency for Environmental Protection in real-time, and a reference, gravimetric method, based on which reports with validated data are prepared.

Average annual concentrations of PM_{10} during the period 2009-2018 in the southern air quality zone (measuring site Bar) were below the limit value (40 µg/m^3) throughout the entire measurement period, while in Podgorica, they slightly exceeded the average annual limit value in 2015 (about 42 µg/m^3) and 2018 (40.3 µg/m^3). At all measuring points, during 2009-2018, there was a noticeable trend of decreasing concentrations, except in Podgorica, where there was a slight increase, which can be explained by the significant expansion of the Capital City in the last ten years (e.g., the number of inhabitants increased by about 11%). Compared to 2009, in 2018, the concentrations of PM_{10} in Pljevlja decreased by 28%, in Nikšić by 42%, and in Bar by 30% The average annual limit value was exceeded during all ten years in Pljevlja (Northern zone) and Nikšić (Central zone) [8].

In 2021, measurements of PM_{10} were being carried out at seven measuring stations, namely in Pljevlja, Bijelo Polje, Podgorica Zabjelo, Podgorica Block V, Nikšić, Bar and Kotor. All stations have daily threshold violations (50 µg/m^3). Annual thresholds were violated only at two out of seven stations (Pljevlja and Bijelo Polje) [17].

$PM_{2.5}$

During 2012, with the acquisition of new equipment for sampling $PM_{2.5}$, monitoring of this pollutant was established at four measuring points in the urban area: Bar, Tivat, Nikšić and Pljevlja. Since October 2019, monitoring of the $PM_{2.5}$ concentration has been established at the measuring point in Podgorica and the measuring point in Bijelo Polje. The results of the measurements indicate a high concentration of $PM_{2.5}$, especially during the winter months, when solid fuels are predominantly used for heating dwellings. The average annual limit value (25 µg/m^3) was exceeded in Pljevlja (Northern zone) for seven years from 2012 to 2018, while in Nikšić (Central zone), it was below the annual threshold in 2014 and 2017, and slightly above the limit value in 2016 and 2018 (25.04 µg/m^3). In Bar, during 2014, the average annual concentration of $PM_{2.5}$ was 25.33 µg/m^3; however, considering that due to instrument failure, measurements were performed only during 72 days in the first quarter of that year, the result cannot be considered valid in terms of mean annual value. No exceedances were recorded in Tivat during the observed period. From 2012 to 2018, the average annual limit value for $PM_{2.5}$

concentration was exceeded in two air quality zones (Northern and Central), while no exceedances were recorded in the Southern zone. In accordance with the Regulation on determination of types of pollutants, limit values and other air quality standards [27], the limit value of 20 μg/m^3 entered into force in Montenegro on 1 January 2020 [8].

In 2021, measurements of $PM_{2.5}$ were carried out at five stationary monitoring stations, namely Pljevlja, Bijelo Polje, Nikšić and Podgorica 2 Block V. In four out of five stations (except Bar), the average annual concentration of $PM_{2.5}$ was above the prescribed limit value of 20 μg/m^3 [17].

The national Montenegro air quality monitoring network was expanded during 2019. This expansion involved relocating numerous measuring points and introducing the monitoring of several parameters at each measuring point. Therefore, the data for the next decade will represent a new step in air quality monitoring in Montenegro [8].

6.4. Regulations in place to limit emissions of stationary sources

6.4.1. Existing regulations

In 2019, Montenegro adopted a new Law on industrial emissions [31], transposing Directive 2010/75/EU on Industrial Emissions (IED) [32] into Montenegrin legislation, followed by the Implementation Plan for the Industrial Emissions Directive [25]. This law regulates a set of measures aimed at preventing and controlling emissions from industrial plants located within Montenegro, encompassing rules and topics for the integrated prevention and control of industrial environmental pollution.

It transposes Chapters I and II of the IED, which cover the main definitions, including the definitions of best available techniques, integrated permits, and inspections of permit conditions. Chapter II of the Regulation [31] doesn't include the list of specific industrial activities. Chapter III of the Regulation covers large and medium combustion plants with exemptions for LCP, Chapter IV waste incineration and co-incineration plants, Chapter V installations and activities where organic solvents are used, Chapter VI plants producing titanium dioxide, and Chapter VII annual reporting provisions for large combustion plants and penal provisions.

In addition, the Law [31] covers mercury, mercury compounds, and mixtures in industrial plants. The adopted principles of integrated pollution prevention and control are as follows:

- general environmental protection-precautionary principle;
- principle of integrated approach;
- principle of sustainable development;
- principle of waste hierarchy;
- polluter pays principle;
- principle of access to information and public participation.

The Law on industrial emissions [31] stipulates that plants can start performing activities only if they have an integrated permit, issued for a period of up 10 years or more. The permit includes, among others, emission limit values of polluting substances, methods of monitoring emissions, and requirements for regular maintenance and control of measures taken to prevent emissions. The permit establishes conditions based on conclusions about the best available techniques (BAT). If environmental quality standards require stricter conditions than those achievable by applying the BAT, the permit shall establish additional measures. The criteria for establishing the best available techniques are prescribed by the Ministry. Conclusions about the BAT are translated and published by the Ministry on its website [31].

The Law covers large and medium combustion plants, establishing rules to determine emission limit values based on the total input thermal power. The administrative body is responsible for preparing an annual inventory of SO_2, NOx, PM emissions, as well as energy consumption for each combustion plant [31].

Furthermore, the Law on industrial emissions [31] specifies exemptions from complying with the SO_2 ELVs. Combustion plants using domestic solid fuel, including those co-incinerating waste, which exceed the prescribed ELVs for SO_2 due to the characteristics of the fuel, can employ desulphurization techniques to achieve the prescribed minimum desulphurization rates. Regular control of the sulphur content in the fuel used by the combustion plant is mandated.

In areas where air quality standards are exceeded, stricter ELVs may be applied to individual intermediate combustion plants, provided that such application would effectively contribute to a significant improvement in air quality. These emission values are determined by the permit for each individual facility.

The operator of combustion plants with a total nominal thermal input power of 100 MW or more is required to provide continuous monitoring of SO_2, NOx and PM of emissions in the outflows gases.

The requirement for continuous measurement can be waived under a permit for combustion plants in the following cases:

- For combustion plants whose lifespan is less than 10,000 working hours.
- For SO_2 and PM emissions from combustion plants that use natural gas.
- For SO_2 from combustion plants that use liquid fuel with a known sulphur content, in cases where there is no desulphurization equipment.
- For SO_2 from combustion plants that use biomass, if the operator can demonstrate that SO_2 emissions will not exceed the prescribed emission limit values.

In case of non-compliance with the emission limit values, the operator is obliged to immediately reduce the volume of work or completely stop the operation of the plant until implementing measures that will bring the operation of the plant to normal operating conditions without exceeding the prescribed emission limit values under any conditions.

The operator of the existing large combustion plant, which is exempted from the application of emission limit values by the Decision of the Council of the Energy Community until December 31, 2023, is obliged to:

1) Submit records of the number of working hours to the state administration body responsible for energy by March 31 of the current year for the previous year, for the period to which the exemption applies;

2) Suspend the operation of the plant after 20,000 working hours, which can be used from January 1, 2018, until December 31, 2023, at the latest.

The Law [31] also covers waste incineration and co-incineration, facilities using organic solvents, plants producing titanium dioxide, and mercury, mercury compounds and mixtures. It establishes a ban on traditional gold mining and processing. The facilities for waste incineration and co-incineration covered by the law include those for waste reception, storage, on-site pre-treatment, waste, fuel and air supply systems, boilers, waste gas treatment, on-site residue and wastewater treatment or storage, chimneys, devices and systems for controlling incineration or co-incineration, and those for recording and monitoring incineration and co-incineration conditions. According to the law, waste incineration or co-incineration plants must have a permit to operate. This permit must specify, among other requirements, the limit values for emissions of polluting substances into the air.

For plants using organic solvents, registration in the register of plants that use organic solvents or products containing volatile organic compounds is required. In plants where two or more activities are carried out, each surpassing the solvent consumption threshold, the plant operator must comply with the prescribed emission limit values for substances or mixtures marked with warning signs, for each individual activity, or for other substances or mixtures. Exceeding the limit values of fugitive and/or total emissions from the plant is permissible if it does not endanger human health and the environment. The Ministry prescribes the limit values for emissions of volatile organic compounds and fugitive emissions and/or total emissions, as well as the method of assessing compliance with these limit values.

The supervision over the implementation of this law and the regulations adopted under it is carried out by the Ministry. Joint inspection supervision is performed by the administrative body responsible for inspection supervision, in accordance with this law and the law regulating inspection supervision. The prescription of fines is possible in certain cases noted by the Law.

The Law [31] includes a transitional provision which stipulates that regulations for the implementation of this law will be adopted within two years from its date of entry into force, which will be in 2025. Until then, regulations adopted under the Law on Integrated Prevention and Control of Environmental Pollution, 2018 [33] and the Law on Air Protection [24] shall be applied.

The Rulebook on the form of integrated permit, 2021 [34], describes the form of the permit, while the Rulebook on Content and Method of Application for an integrated permit, 2020 [35], prescribes the detailed content and method of submitting a request for the issuance of an integrated permit.

Table 6-2 shows the industrial plants for which the permits was issued by 2021 and Table 6-3 provides a review of submitted applications for operating permits for existing plants [12].

Table 6-2: Review of the plants for which permit was issued

Overview of the issued permits for the existing plants					
Operator-plant	**Location of activity**	**Type of activity**	**Date of permit issuing/ permit validity**	**Date of permit revision**	**Competent authority**
„FAB LIVE“ **Podgorica**	Mahala bb. Podgorica	2.6 Plants for surface treatment of metals and plastic materials using electrolytic or chemical processes, where the volume of the bathtub for treatment exceeds 30 m^3	13.12.2013, permit revision: 10/2018/validity period- 5 years	2023	City of Podgorica
„Alu-line“ **Vojislava Šćepanovića, bb** **Mojkovac**	In the part of the flotation plant of the old mine „Brskovo“ in Mojkovac	2.6 Plants for surface treatment of metals and plastic materials using electrolytic or chemical processes, where	31.07.2014/5	2019 „Aluline“ Mojkovac has ceased to operate so there	Municipality Mojkovac

		the volume of the bathtub for treatment exceeds 30 m^3		will be no revision of the permit.	
„ Montenegrin Electric Enterprise “ AD Nikšić	Kalušići bb, Pljevlja	1.1 Thermal power plants with a thermal input exceeding 50 MW	22.03.2018/ 5	2023	Agency for Nature and Environment Protection
„Deponija“ Podgorica	Ul. Španskih boraca bb Podgorica	5.3 Facility for the disposal of non-hazardous waste with a capacity exceeding 50 t per day	13.03.2013/ 5 25.03.2018 (extended permit)/ 6 years	03/2024	Agency for Nature and Environment Protection
Overview of new plants for which integrated permit was issued					
„Možura“, Bar	Bulevar Revolucije br. 1 Bar	5.4 Landfills receiving more than 10 tonnes of waste per day or total capacity exceeding 25 000 t, excluding landfills of inert waste	04.04.2013/ 5 29.04.2018 (extended permit)/ 5 years	04/2023	Agency for Nature and Environment Protection

Table 6-3: Review of submitted applications for issuing operating permits for existing plants

Operator-plant	Operator’s address	Type of activity	Application date	Permit status	Competent authority
TOSCELIK NIKŠIĆ Steel, Nikšić	VUKA KARADŽIĆA BB Nikšić	2.2 i 2.3	27.12.2018/ 5 18.04.2019 / 5 years	04/2023	Agency for Nature and Environment Protection
KAP, aluminum factory Podgorica AD	DAJBABE B.B., Podgorica	2.5	30.12.2016.	Ministry issued a conclusion on suspension of the proceedings until determining who the operator plant and the taxpayer to obtain integrated work permit.	Agency for Nature and Environment Protection
POLIEX AD, **Explosives factory**	Police bb, Berane	4.6	Poliex AD submitted the request to the ANEP for int. permit on 29.10.2018, which was returned for amending on	ongoing procedure	Agency for Nature and Environment Protection

Operator-plant	Operator's address	Type of activity	Application date	Permit status	Competent authority
			October 30, 2018, and afterwards requested an extension of the deadline, which was granted. After the expiry of the request was rejected as incomplete.		

The Rulebook on method and procedure for monitoring of emissions from stationary sources, 2013 [36], prescribes the method for measuring emissions from stationary sources. It covers the measurement procedures, method for verifying the accuracy and calibration of measuring devices, procedures for evaluating results, and methods for submitting data to the environmental protection information system.

The Rulebook on emission limit values, technical measures for exemption of application of limit values, and monitoring methods, 2020 [37], sets out the limit values for polluting substances from industrial plants. It also details technical measures for exemption from these limits and the methods for monitoring emissions. This Rulebook specifies that the emission limit values for polluting substances from industrial plants are determined in accordance with a prescribed list of polluting substances. These values are established based on the best available techniques and other substances that can be emitted from the plants, which have the characteristics of industrial emissions, depending on their nature and potential for transfer from one part of the environment to another.

The limit values of emissions of polluting substances from an industrial plant, as specified in the integrated permit for normal operating conditions of facilities, are determined by:

- Establishing the limit value of emissions of polluting substances that shall not exceed the levels of emissions established in accordance with the best available techniques and conclusions; or
- Basing them on average values for a certain period of time and reference conditions. If these differ from the limit values specified in the first sub-paragraph of this paragraph, it is stipulated that they must not lead to the exceeding of those limit values [37].

Emission limit values can be adjusted through equivalent parameters or technical measures, that ensure the same level of environmental protection. These equivalent parameters might include parameters of other emissions, processes, or conditions, that are associated with industrial emissions and can be supplemented or replaced by the equivalent parameters. Both equivalent parameters and technical measures must be grounded in the best available techniques. The monitoring of the limit values of emissions of polluting substances from industrial plants is conducted through direct control of emissions or equivalent parameters, and by verifying the reliability of the technical measures applied when modifying the indicators of the limit values of emissions of polluting substances [37].

The Rulebook on criterions for determination of the best available techniques for environment protection and the list of pollutants from industrial installations, 2019 [38], establishes the criteria for determining the best available techniques for environmental protection and provide a list of polluting substances from industrial plants for an integrated permit. The list includes SO_2 and sulphur compounds, NOx and other nitrogen compounds, VOCs, and dust from industrial facilities to ambient air.

6.4.1.1. Large combustion plants

The Regulation on limit values of emissions from combustion plants and method of calculating emission limit values for plants using multiple types of fuels [39] establishes the emission limit values for combustion plants and outlines the method for calculating these limit values for those plants in Montenegro. This regulation applies to both large and medium combustion plants. The limit values of pollutant emissions for existing and new large combustion plants are detailed in Annex 2 of the Regulation.

Comparison of Large Combustion Plants ELVs with ELVs of the Amended Gothenburg Protocol (Annex IV, V and X)

It is observed that for plants with a thermal power larger than 50 MW, as considered in the Annexes IV, V and X of the Gothenburg protocol, the Law on industrial emissions of Montenegro [31] transposes Chapter III, and the Regulation [39] transposes Annex V of the IED [32], including ELVs for large combustion plants. Additionally, Montenegro has translated into Montenegrin language the Commission Implementing Decisions, concerning large combustion plants (LCP) [40], with ELVs for LCP that are equal to or lower than those in Annexes VI, V, and X of the AGP.

The limit values for emissions of polluting substances into the air from existing and new large combustion plants have been applied since the end of 2021. The minimum rates of waste gas desulphurisation from combustion plants are specified in Annex 4 of the Regulation on limit values of emissions from combustion plants and method of calculating emission limit values for plants using multiple types of fuels [39]. Table 6-4 presents a comparison of the limit values for the rates of desulphurization for LCP as outlined in Annex IV of the AGP and in Regulation [39]. This table demonstrates, that for existing LCPs, the desuperization rate is more stringent in Montenegro's Regulation [39], while for new LCPs, it aligns with the AGP ones.

Table 6-4: Limit values for the rates of desulphurization for LCP of Annex IV AGP and Regulation 129/21 dated 15.12.2021 [39]

Total rated thermal power, MW of thermal energy	Regulation 129/21 dated 15.12.2021, %		Annex IV of AGP, %	
	New installations	Existing installations	New installations	Existing installations
50-100	93	92	93	80
100-300	93	92	93	90
> 300	97	96	97	95

Continuous monitoring of SO_2, NOx, and dust (TSP) is mandatory for large combustion plants with a total thermal input of 100 MW or more. Additionally, for large combustion plants with a total thermal input of 100 MW or more that use gaseous fuel, continuous measurements of CO are also mandatory, with some exceptions.

If continuous monitoring is not conducted at a large combustion plant, periodic measurements of SO_2, NOx, TSP, and, in the case of gas turbines, CO, are required at least every six months. For large combustion plants using coal or lignite, emissions of total mercury must be measured at least annually.

Currently, there is only one LCP in Montenegro, the Thermal Power Plant "Pljevlja" with a total heat output of 580 MWth. The operating hours of the plant from 2018 to 2023 to be reduced to a total of 20,000 h, so-called "Opt Out" option, in accordance with the decision of the Ministerial Council of the Energy Community no. 2016/19 / MC-ENC. The PTPP Pljevlja will be exempted from compliance with the emission limit values in air referred to Article 4 (3) of Directive 2001/80/EC, as per the aforementioned decision.

The operator has planned to implement a project for the environmental reconstruction of the PTPP Pljevlja within the period from 2018 to 2022. This plan aligns with the Programme of measures for adjusting the operation of an existing plant or activity under specific conditions and action plan. Following this reconstruction, the plant is expected to operate in accordance with the requirements of the Directive on Industrial Emissions 2010/75 EU. Initially, the plant did not plan to request an additional period for compliance with the Best Available Techniques (BAT) [12]. However, due to the pandemic, the reconstruction plans were delayed and only commenced in 2022. The reconstruction process is still ongoing, and there is an infringement procedure in front of Energy community[19].

6.4.1.2. ELVs for small and medium size combustion installations

Annex X (Table 14) of the AGP [7] introduces recommended limit values for combustion installations smaller than 50 MW, but only for PM. The Regulation on limit values of emissions from combustion plants and method of calculating emission limit values for plants using multiple types of fuels [39] transposes ELV for medium-sized combustion plants of MCP Directive [41], thereby aligning with the AGP (Annex X, Table 14).

By 2019, the Ministry of Economy passed 17 regulations transposing EU regulations for the introduction of eco-design requirements, as well as 6 regulations transposing EU regulations for marking the energy efficiency of products that affect energy consumption. Notably, regulations on the eco-design of space heating devices were adopted, including those considering emission limit values for PM emissions in solid fuel heating appliances, namely:

- The Rulebook on the technical requirements of eco-design for devices for solid fuel local space heating [42] transposes Commission Regulation (EU) 2015/1185 of 28 April 2015 implementing Directive 2009/125/EC with regard to eco-design requirements for solid fuel local space heaters [43].
- The Rulebook on the technical requirements of eco-design for boilers using solid fuels [44] transposed Commission Regulation (EU) 2015/1189 of 28 April 2015 implementing Directive 2009/125/EC with regard to eco-design requirements for solid fuel boilers [45].

Comparison with ELVs of the Gothenburg Protocol

The emission limit values of PM for small-sized heating appliances are, so far, in compliance with the ELVs for small solid fuel combustion installations as outlined in the AGP (Annex X, Tables 12-13).

6.4.1.3. Industrial installations

The Regulation on emission limit values of air pollutants from stationary sources, 2021 [46], prescribes the limit values for emissions of pollutants, as well as other air protection measures, applicable to emission from both point and diffuse stationary sources in Montenegro. This regulation also addresses activities that result in the emission of pollutants into the air. The specific list of these activities is outlined in Annex I. However, Annex I was not accessible in English for further analysis.

The Regulation [46] provides detailed rules on how emissions from stationary sources should be measured. Additionally, it sets a general total dust emission limit value as 20 mg/m^3 for mass

[19] Case ECS-15/21, Montenegro https://www.energy-community.org/legal/cases/2021/case1521MN.html

concentrations when the mass flow greater than or equal to 200g/h, and 150 mg/m^3 for mass concentrations when the mass flow is less than 200g/h. The Regulation also established general total limit values for other substances.

In the event that emission limit values from stationary sources are exceeded, the Regulation mandates the operator to undertake the following measures to reduce emissions to ambient air:

- sealing the plant;
- collection of waste gases at the place of origin;
- closing the circular flow of the process of creating waste gases;
- material recycling and heat recovery;
- reuse of waste gases;
- increasing the degree of utilization of raw materials and energy;
- improving of work efficiency in the periods of switching on and off the plant and other extraordinary periods of plant operation;
- preventing the increase in emissions of inorganic powdery substances and carcinogenic substances containing lead;
- regular plant maintenance.

The Rulebook on the method of performing monitoring of emissions in water and air from plants that produce titanium dioxide, 2020 [47], prescribes the methods for monitoring and the limit values of emissions into water and air from plants producing titanium dioxide, transposing Annex VIII of the IED [32], which pertains to technical provisions for installations producing titanium dioxide. However, it is noted that there is no production of titanium dioxide within Montenegro [1],[10].

Similarly, the Rulebook on the limit values of the emissions of pollutants, method of performing monitoring and operating conditions of the plant for incineration and co-incineration of waste, 2020 [48], outlines the limit values of emissions of polluting substances in waste gas and wastewater at waste incineration and co-incineration plants. It also details the method of monitoring, reporting on monitoring results, assessing compliance of emissions with limit values, and the operating conditions of waste incineration and co-incineration plants. The Annex of this Rulebook [48] transposes Annex VI of the IED, concerning technical provisions relating to waste incineration plants and waste co-incineration plants including emission limit values. However, it is noted that there is no waste incineration plants within Montenegro [1].

Montenegro has also translated in Montenegrin relevant Commission Implementing Decisions, concerning:

- Cement, lime and magnesium oxide industry [49];
- Iron and steel production [50];
- Non-ferrous metal industries [51];
- Production of cellulose paper and cardboard [52];
- Surface treatment using organic solvents including protection of wood and products from wood with chemicals [53];
- Food industry, the beverage industry and the milk industry [54];
- Waste treatment [55];
- Poultry and pig farming [56].

In Montenegro, there is only one iron and steel plant: TOSCELIK NIKŠIĆ Steel Ltd, Nikšić. This installation is for the production of raw iron or steel (primary or secondary melting) including continuous casting, with a capacity exceeding 2,5 t/h. According to the adjustment plan submitted by the steel plant, which is currently under assessment by the Agency, the Ironworks will request a transition period during negotiations with the EU. According to the dynamic plan of alignment, the plant aims to achieve complete compliance with measures by the end of 2024 [12].

The only aluminium production plant, Aluminum Plant Podgorica (KAP), is currently in bankruptcy and carries out activities of aluminium production at the location Dajbabe b.b. A dynamic adaptation plan, including a cost estimate, has not been drafted or submitted with an application for an integrated permit. As it is anticipated that this plant will be a subject of negotiation for transition periods, with the year 2030 set as a predetermined deadline based on the review of necessary measures, an initial cost estimate for harmonization was made, taking 2019 as the starting year of adjustment [12].

These two enterprises are exempted from the application of Article 11 (conditions contained in the permit) and Article 18 (environmental quality standards) of the IED, specifically regarding measures related to emission limit values, equivalent parameters, or technical measures based on the best available techniques. Initiatives to satisfy the issuance of licenses for existing plants in Montenegro with a deadline of 1 January 2030 will be undertaken [12].

Comparison with ELVs of the Gothenburg Protocol

Emission limit values for air emissions in the sectors mentioned above are in line with the relevant EU Commission Implementing Decisions. The ELVs of BATs for industrial sources are either lower than or equal to those specified in the Annexes of IV, V, and X of the AGP.

Regarding other sectors covered in the AGP for industrial installation emissions, such as sulphur recovery units, nitric acid production (excluding acid concentration units), mineral oil and gas refineries (including FCC regenerators), glass production, titanium dioxide production, pulp production, and waste incineration plants, these are not relevant in Montenegro as there are no such activities currently in operation [1].

6.4.1.4. Use of solvents in industry

The Rulebook on the type of activities, emission limit values and methods performing monitoring in plants using organic solvents, 2020 [57], outlines the types of activities in plants that use organic solvents in Montenegro. It includes the consumption limits of organic solvents, the procedure for submitting an application for registration in the plant register of plants that use organic solvents or products containing volatile organic compounds, and the method of managing the register. Additionally, it sets out the limit values for emissions of volatile organic compounds and fugitive emissions and/or total emissions. The Rulebook also details the method of assessing compliance of emissions with limit values, the method of monitoring, and the detailed content of the report on the annual consumption of organic solvents.

The activities covered by the Rulebook [57] includes:

1) application of glue (adhesive) is a process in which glue (adhesive) is applied to a surface, except for adhesive coatings and production

2) coating process is any activity in which coating layers are applied once or repeatedly to:

a. On the following vehicles: new vehicles from category M1, and category N1 if they are coated in the same plant as vehicles of category M1; - truck cabins for accommodating drivers, as well as all integrated accommodation spaces for technical equipment of vehicles of category N2 and N3; vans and trucks of categories N1, N2 and

N3, but not truck cabins; buses of vehicle category M2 and M3; trailers of categories O1, O2, O3 and O4;

b. Metal and plastic surfaces, including surfaces of airplanes, ships, trains, and others;

c. wooden surfaces;

d. textiles, bags, foil and paper surfaces;

e. the skin.

There are two industrial plants using solvents in Montenegro covered by the Rulebook. One of them is "FAB LIVE" Ltd, located in Podgorica, engages in activities related to the plasticization of aluminium profiles. This is done using powder coating colours which are electrostatically applied to the profiles, employing the latest surface treatment technology for aluminium in accordance with the RAL standard and RAL's colour map. The enterprise is fully compliant with the IED harmonization plan. The second enterprise is 'ALULINE' Ltd, based in Mojkovac, which primarily engages in the anodizing and lamination of aluminium profiles [12]. However, the company ceased the activities [1].

Comparison with ELVs of the Gothenburg Protocol

The Rulebook transposes emission limit values of the Annex VII of IED [32], which pertains to technical provisions related to installations and activities using organic solvents. As a result, the ELV are the same or lower than those specified in the AGP (Annex VI).

Additionally, Montenegro has translated the text of the BAT on air and water emissions monitoring, as outlined in the JRC Reference Report on Monitoring of Emissions to Air and Water from IED Installations [58].

6.4.1.5. Sulphur content of gas oil

The Regulation on limit values of the content of polluting substances in liquid fuels of oil origin, 2017 [13], prescribes a reduced sulphur content in diesel fuel, fuel oil and marine fuels in Montenegro. This regulation specifies the types of liquid fuels of oil origin, which include gasoline, diesel fuels, fuels used in NRMM, vessels, and other gas oils. It sets limit values for polluting substances, the content of metal-based additives, and other fuel characteristics that must meet environmental protection standards. These standards are applicable to fuels placed on the market, fuel used on vessels in ports, territorial waters, exclusive economic zones, and sulphur oxide emissions control zones. The regulation also prescribes methods for determining and monitoring fuel characteristics, reducing emissions of pollutants into the air, and reporting on compliance with limit values for pollutant content.

According to this Regulation, gas oils that are intended or used as fuel for construction and other machinery, agricultural tractors, river vessels and vessels used for sports, recreation, and leisure may be placed on the market if their sulphur content does not exceed 0.01g/kg (0.001% w/w). Additionally, gas oil can be marketed if its sulphur content does not exceed 10g/kg (0.1% w/w).

Exceptionally, fuel oil with a sulphur content exceeding 1% w/w may be placed on the market only for use in:

- LCP whose emissions of SO_2 comply with the air pollutant limit values, and for which an integrated permit is issued. This is conditional on the measurement of pollutant emissions being carried out by a legal entity that holds a permit for measuring emissions from stationary sources;
- Plants with combustion chambers where the average monthly emission of SO_2 is equal to or less than 1700 mg/Nm^3 at a content of 3% vol of oxygen in dry exhaust

gas, and for which a permit on the permitted emissions of pollutants into the air has been issued.

Comparison with ELVs of the Gothenburg Protocol

Annex IV of the AGP [7], sets a limit value for the sulphur content of gasoil used in domestic heating and combustion installation (Annex IV, Table 2). The sulphur contents of fuel used in mobile engines and non-road mobile machinery are addressed in Annex VIII of the AGP, which pertains to mobile sources. The sulphur content is limited to 0.1% w/w, so is in the Montenegro Regulation on limit values of the content of polluting substances in liquid fuels of oil origin [13].

Additionally, the limit values for the content of sulphur in marine fuels have been tightened in accordance with Directive (EU) 2016/802 on the reduction of content of sulphur in certain liquid fuels [14]. According to this regulation, for vessels sailing in the territorial waters of Montenegro and the exclusive economic zone, the sulphur content in marine fuels must not exceed 0.5% w/w as of January 1, 2020.

6.4.1.6. Storage and distribution of petrol from terminals to service stations

The Regulation on technical conditions for air protection from emissions of volatile organic compounds resulting from the storage, transfer and distribution of petrol [20] sets out technical environmental protection standards for gasoline storage and transfer systems at terminals and gas stations, as well as for tankers used to transport gasoline from one terminal to another or from a terminal to a gas station in Montenegro. It also specifies the deadlines for achieving these standards. This Regulation transposes two key EU directives: Directive 94/63/EC of 20 December 1994 on the control of volatile organic compound (VOC) emissions resulting from the storage of petrol and its distribution from terminals to service stations [59], and Directive 2009/126/EC of the European Parliament and of the Council of 21 October 2009 on Stage II petrol vapour recovery during refuelling of motor vehicles at service stations [60].

Comparison with ELVs of the Gothenburg Protocol

The ELV of the Regulation [20] have been transposed, aligning them with the ELVs of the AGP, specifically as outlined in Annex VI.

6.4.1.7. VOC contents of products

The regulation on VOC emissions from the use of paints and varnishes is enforced in Montenegro through the Regulation on the prohibition and restriction of the use, placing on the market and production of chemicals that represent an unacceptable risk to human health and the environment, 2022 [19]. This regulation stipulates the prohibited or permitted methods of use, production, and placing on the market of chemicals or certain products that pose an unacceptable risk to human health and the environment.

To date, “FAB LIVE" Ltd from Podgorica is only enterprise in Montenegro subject to integrated permitting that is concerned by the abovementioned regulation. The Ltd for processing and coating of metals “ALULINE” from Mojkovac ceased its activities [12].

Comparison with ELVs of the Gothenburg Protocol

In comparison with the ELVs of the AGP, the ELVs for VOC content in coatings (paints and varnishes) are addressed in the Regulation [19], specifically in Annex 3, phase I (since 01.12.2013) and phase II (since 01.12.2014). The ELV of phase II of the AGP (Annex XI, Tables 1 and 2) are completely transposed to the mentioned Regulation.

6.5. Regulations in place to limit emissions of mobile sources

The Regulation on technical requirements for vehicles imported or first placed on the market in Montenegro, 2021 [61], prescribes technical requirements and conditions regarding safety features for motor vehicles and trailers, along with their parts, devices, and equipment that are imported, or put on the market for the first time in Montenegro. This regulation details the requirements and technical documentation, the method of conducting vehicle homologation, the content and appearance of vehicle homologation certificate for vehicle types, as well as homologation certificate for individual vehicles. It also outlines the method for issuance, the content and method of maintaining records on vehicle homologation, and the conditions in terms of personnel, equipment, and space required for a legal entity that performs homologation tasks.

The regulation specifies, among other things, safety and technical requirements and conditions for vehicles that are imported or put on the market for the first time in Montenegro, including both new and second-hand vehicles. These vehicles must meet the safety and technical requirements and conditions in accordance with Annex 2 (Part 1) of the regulation.

Annex 2 describes safety-technical requirements and conditions for environmental and human health protection, including air emissions standards applicable to both new and old vehicles, in line with UNECE regulations.

So far, new vehicles imported into Montenegro are required to comply with the minimum standard EURO 6 and EURO VI (factory production) and must meet relevant requirements related to the limit values of exhaust emissions.

Second-hand vehicles imported into Montenegro should meet at least the EURO 4 and EURO IV standard (factory production) and meet relevant requirements concerning the limit values of exhaust emissions.

The Agreement on the adoption of uniform technical regulations for vehicles with wheels, equipment and parts, which can be installed and / or used on wheeled vehicles, and the conditions for mutual recognition of approvals granted pursuant to these regulations, has been in force in Montenegro since October 16, 1995 [62].

Additionally, the Regulation on marking the energy efficiency of vehicle tires and other parameters [15] sets out requirements for marking the energy efficiency of vehicle tires and other parameters.

Up to now, there has been no production of passenger cars, light and heavy-duty vehicles, motorcycles, non-road mobile machinery in Montenegro [1].

Comparison with ELVs of the Gothenburg Protocol

The specifications for marketed fuels to be used in diesel and petrol engines, as currently provided in Tables 13 and 14 of Annex VIII of the AGP [7], were derived from Directive 2009/30/EC of April 23, 2009. This Directive amends Directive 98/70/EC as regards the specification of petrol, diesel and gas-oil and introducing a mechanism to monitor and reduce greenhouse gas emissions and amending Council Directive 1999/32/EC as regards the specification of fuel used by inland waterway vessels and repealing Directive 93/12/EC [63]. Montenegro has fully transposed the provisions of AGP Tables 13 and 14 into its Regulation on limit values of the content of polluting substances in liquid fuels of oil origin, 2017 [13].

6.6. Technological pathways

The former Yugoslavia had signed and ratified the Convention on 13 November 1979 and 18 March 1987 respectively [2]. CLRTAP and EMEP Protocol, were taken over by the Montenegro by means of succession it with the date of effect of 23 October 2006 [1], [3]. Montenegro acceded the original Protocol on Heavy Metals on 30 December 2011 [4], and the original Protocol on Persistent Organic Pollutants 9 February 2012 [5].

In 2011, Montenegro adopted a Law on the approval of original protocol of 1999 [6], however, it didn't set emission ceilings. To date, Montenegro has not signed nor ratified amended Gothenburg protocol [7].

Air pollutant emission inventories in Montenegro were developed and submitted for the period 2010-2013 with the assistance of Italian Ministry of Environment. There was no national emission inventory for seven years, and since 2020 Montenegro has been developing and submitting the emission inventories with the support of the Environment Agency Austria [1].

The draft Montenegro Air quality management strategy for the period 2021-2029 (hereinafter the Strategy 2021-2029), was developed in 2021 as a continuation of the previous National Air Quality Management Strategy 2013, implemented by two Action plans (2013-2016 and 2017-2020) [8], however up to now it was not adopted [1]. The Strategy 2021-2029 combines air quality plans for the three established air quality zones (Northern, Central and Southern) and replaces the plans prepared for the Municipality of Pljevlja (2013), the Municipality of Nikšić (2014) and the Capital City of Podgorica (2015). In addition, the Strategy 2021-2029 includes the Plan of measures for pollution control, which has been prepared in accordance with the requirements of the relevant EU regulations and the final benchmark for the negotiation Chapter 27, considering their overall goal and objectives related to the improvement of air quality, environmental protection and human health. The Strategy 2021-2029 has been developed for 9 years with air pollution reduction targets set until 2030 [8].

The Strategy 2021-2029 establishes a goal to reduce SO2 emissions in the period 2020-2029 via the environmental reconstruction of the Pljevlja Thermal Power Plant, which represents the most important source of emissions. According to the Action Plan for the Environmental Protection Programme of this plant, a wet scrubber system will be installed in the PTPP, the efficiency of which is estimated at 90%. At best, this will reduce around 80% of the total current national SO2 emissions. However, considering that emission reductions, according to NECD II [9], must be achieved in relation to emissions in the base year 2005, it is necessary to pay attention to the increase in SO2 emissions over the past period, according to the available data from the emission inventory. Thus, according to Article 5 of NECD II, the most optimistic estimate of SO2 emission reduction compared to 2005 is 50% [8].

Regarding measures to reduce NOx emissions, the Strategy 2021-2029 stipulates the combined installation of the waste gas denitrification system at the Pljevlja Thermal Power Plant and the increased use of alternative fuels, new-generation vehicles and electromobility in traffic. These measures could result in a total reduction of NOx emissions by 55%, while emissions from the key sources (energy production, road traffic) should be reduced by 70-75%. While the reduction of NOx emissions from energy production is certain, the reduction of NOx emissions from transport by renewing and modifying the structure of the vehicle fleet is an expensive and long-term process that can hardly be achieved over the next 10 years. Given that the share of new passenger vehicles registered for the first time in the total number of passenger vehicles registered in 2018 was only 1.1%, on the basis of available data, reductions in NOx emission of up to 15% can be expected by 2030 [8].

Considering the economic analysis prepared for the proposed set of measures to reduce PM and VOC emissions under the Strategy 2021-2029, there are several measures applied for several years. They target replacement of heating appliances and energy efficiency measures in individual residential buildings, eco-design of products, construction the system for district heating in Pljevlja, energy efficiency measures in public sector (heating), use of renewable energy sources, prohibition of burning of residues harvests and agricultural waste, and a set of measures to reduce VOC emissions. All the measures are already at various stages of implementation and Montenegro is moving forward with these measures to the extent that financial resources permit.

Air quality in Montenegro has been monitored in accordance with European standards since 2009. Over the past 10 years, the number of automatic air quality monitoring stations has been gradually increased. By repositioning them within the state network, an optimal level of representativeness of the measuring points has been achieved.

In terms of air quality, the main concerns in Montenegro are PM_{10} and $PM_{2.5}$ concentrations in all the territory, and SO2 in the Northern air quality zone during winter months, specifically during the heating season. It remains crucial to develop mathematical modelling systems to augment measurement-based data with indicative data. Regular evaluations of the monitoring station locations are also vital to discern the unique characteristics of specific locales where air quality may diverge from expected standards.

The main source of SO_2 emissions in Montenegro is public power, accounting for 98.4%, specifically the coal fired Pljevlja Thermal Power Plant. The key contribution to NOx emissions is road transport, responsible for 56%, while energy production (at TEP Pljevlja) contributes 28%. The key source of PM_{10} and $PM_{2.5}$ emissions, accounting for 85% of the emissions for both pollutants, is other stationary combustion, predominantly residential heating, which accounts for 99% for both pollutants. The main source of VOC emissions is also other stationary combustion with the 39% share, mainly from residential heating, which accounts for 97% for both pollutants. Road transport comprises 16%, fugitive emissions 15% (solid fuels, notably coal mining and handling), and solvents, off-road activities, and agriculture livestock each contributing 9% to the total VOC emissions. The local expert of the Ministry of Ecology, Spatial Planning and Urbanism Montenegro emphasized the need for further improvements in the emissions inventory to accurately reflect the air emissions situation in Montenegro and facilitate the ratification of the AGP.

In 2019, Montenegro enacted a new Law on industrial emissions [31] transposing the Directive 2010/75/EU on Industrial Emissions (IED) [32] into Montenegrin legislation, followed by the Implementation Plan for Industrial Emissions Directive [12].

The Law on industrial emissions in Montenegro prescribes the set of measures for prevention and control of emissions from industrial plants within the country. It transposes Chapters I and II of the IED, which cover the main definitions, including the definitions of best available techniques, integrated permits, and inspections of permit conditions. Chapter II of the Regulation [31] doesn’t include the list of specific industrial activities. Chapter III of the Regulation covers large and medium combustion plants with exemptions for LCP, Chapter IV waste incineration and co-incineration plants, Chapter V installations and activities where organic solvents are used, Chapter VI plants producing titanium dioxide, and Chapter VII annual reporting provisions for large combustion plants and penal provisions.

It is observed that for plants with a thermal power larger than 50 MW, as considered in the Annexes IV, V and X of the Gothenburg protocol, the Law on industrial emissions of Montenegro [31] transposes Chapter III, and the Regulation [39] transposes Annex V of the IED [32], including ELVs for large combustion plants. Additionally, Montenegro has translated into Montenegrin language the Commission Implementing Decisions, concerning large combustion plants (LCP) [40], with ELVs for LCP that are equal to or lower than those in

Annexes VI, V, and X of the AGP. The ELV for MCP comply with those in AGP Annex X (Table 14).

To date, there is only one LCP in Montenegro, the Thermal Power Plant "Pljevlja", with total heat output of 580 MWth.

For large combustion plants, the reduction techniques available to reduce SO_2 and NOx emissions are described in chapters 8.1.1 and 8.2.1.

The means of achieving the SO_2 ELVs of Annex IV of the AGP for LCP, is the application of one or a combination of the following techniques, combined with the selection of low sulphur fuels [64], [65]:

- boiler sorbent injection,
- duct sorbent injection (DSI),
- spray dry absorption (SDA),
- circulating fluidised bed (CFB),
- wet flue-gas desulphurisation (FGD),
- seawater FGD.

The means of achieving the NOx ELVs of Annex V of the AGP for LCP is the application of one or a combination of the following techniques [64], [65]:

- combustion optimisation,
- air staging,
- fuel staging,
- flue-gas recirculation,
- low-NOx burners (LNB),
- selective non-catalytic reduction (SNCR),
- selective catalytic reduction (SCR).

Montenegro has also transposed EU provisions and ELVs for small heating appliances, such as solid fuel boilers [45] and local space heating [43].

With regard to **PM emissions from domestic heating appliances using coal or biomass,** the use of the most efficient appliances in term of emissions and energy efficiency is essential. . The emission limit values of PM for small-sized heating appliances in Montenegro are in compliance with the ELVs for small solid fuel combustion installations as outlined in the AGP (Annex X, Tables 12-13).

However, technological solutions are not sufficient. The “Code of good practices for wood burning and small combustion installations” [66] developed by TFTEI, the report “Prioritizing reductions of particulate matter from sources that are also significant sources of black carbon - analysis and guidance” [67] developed by TFIAM and the report “Review on Black Carbon (BC) and Polycyclic Aromatic Hydrocarbons (PAHs) emission reductions induced by PM emission abatement” [68] developed by TFTEI provide an excellent overview of the policies to be implemented beyond the technical characteristics of appliances. The thematic session on residential wood combustion and air pollution of 56th WGSR in May 2018, is also useful for inspiring ideas in this field [69]. The latest TFTEI report on the updates of limit values of technical Annexes also provides information [70].

In Montenegro, the sulphur content in gas oil is limited to 0.1% w/w, as stipulated in the Montenegrin Regulation on limit values of the content of polluting substances in liquid fuels of oil origin [13]. Furthermore, the country has tightened the limit values for sulphur content in marine fuels in accordance with Directive (EU) 2016/802 on the reduction of content of sulphur in certain liquid fuels [14]. Under this regulation, on vessels sailing in the territorial waters of Montenegro and the exclusive economic zone, the sulphur content in marine fuels, as of January 1, 2020, must not exceed 0.5% w/w.

ELVs for **industrial activities** in Montenegro are covered by the Regulation on emission limit values of air pollutants from stationary sources [46]. Additionally, eight BREFs have been translated in Montenegrin language. These include the Cement, lime and magnesium oxide industry [49], Iron and steel production [50], Non-ferrous metal industries [51], Production of cellulose paper and cardboard [52], Surface treatment using organic solvents including protection of wood and products from wood with chemicals [53], Food industry, beverage, and milk industries [54], Waste treatment [55], and Poultry and pig farming [56]. There is also the Rulebook on the type of activities, emission limit values and methods performing monitoring in plants using organic solvents [57]. In addition, there are Rulebooks, covering ELVs of titanium dioxide production plants [47], and the plants for incineration and co-incineration of waste [48]. Emission limit values for air emissions in the sectors mentioned above are in line with the relevant EU Commission Implementing Decisions. The ELVs of BATs for industrial sources are either lower than or equal to those specified in the Annexes of IV, V, and X of the AGP.

Among the main industrial activities in Montenegro, we could distinguish an iron and steel plant TOSCELIK NIKŠIĆ Steel Ltd, Nikšić, Aluminum Plant Podgorica (KAP), Dajbabe b.b. currently in bankruptcy.

Regarding the next sectors: sulphur recovery, nitric acid production (excluding acid concentration units), mineral oil and gas refineries (including FCC regenerators), glass production, titanium dioxide production, pulp production, and waste incineration plants, there are no such activities currently in operation in Montenegro [1].

Emission limit values concerning the sectors described above for air emissions are in line with the relevant EU Commission Implementing Decisions. The ELVs of the BATs for industrial sources are equal to or lower than those in the Annexes IV, V, and X of the AGP.

For **industrial processes emitting SO_2, NOx and / or PM covered by Annexes IV, V and X,** the chapters 8.1, 8.1.2 and 8.4 present the best available techniques to comply with the prescribed limit values. For PM, best available techniques (sub chapters 8.4.2 to 8.4.10 of this report) for complying with the limit values are electrostatic precipitators and bag filters. Other types of dedusters, such as wet scrubbers, are also available but are less widely used. These techniques are most efficient when correctly sized.

For **the uses of solvents in industry**, chapter 8.3 details the techniques available to comply with limit values of AGP Annex VI. These techniques are based on primary measures such as low solvent content or solvent free products, more efficient means of application and secondary measures such as thermal or catalytic oxidation, adsorption on activated carbon and biological purification. However, there are various combinations of primary and secondary measures applicable depending on the specific industrial activity.

The Regulation on technical conditions for air protection from emissions of volatile organic compounds resulting from the storage, transfer and distribution of petrol [20] transposes Stage I [59] and Stage II [60], so far the ELV of AGP (Annex VI). There is also a Rulebook addressing plants using organic solvents [57]. There are two industrial plants using solvents in Montenegro: "FAB LIVE" Ltd, Podgorica and 'ALULINE' Ltd, Mojkovac (ceased the activities).

Over several decades, Montenegro has developed additional measures to reduce emissions from households heating and road transport, as well as from Large Combustion Plants (LCPs) and industrial sources. These measures include district heating and incentives, among others, to enhance air quality within the country [8].

Regarding **VOC content of products**, the ELVs for VOC content in coatings (paints and varnishes) are addressed in the Regulation [19], specifically in Annex 3, phase I (since 01.12.2013) and phase II (since 01.12.2014). The ELV of phase II of the AGP (Annex XI, Tables 1 and 2) are completely transposed to the mentioned Regulation.

For **road transport vehicles**, the Republic of Montenegro transposes the latest EU directives and regulations for application to domestically produced vehicles and new vehicles imported.

The fuel specifications for marketed diesel and petrol fuels are currently provided in Tables 13 and 14 of Annex VIII of the AGP [7], are derived from Directive 2009/30/EC of 23 April 2009. This Directive amends Directive 98/70/EC as regards the specification of petrol, diesel and gas-oil and introducing a mechanism to monitor and reduce greenhouse gas emissions and amending Council Directive 1999/32/EC as regards the specification of fuel used by inland waterway vessels and repealing Directive 93/12/EC [63]. Montenegro fully transposed the provisions of AGP Tables 13 and 14 in the Regulation on limit values of the content of polluting substances in liquid fuels of oil origin, 2017 [13].

Various approaches can be implemented to reduce emissions from road transport. Measures such as the development of public transport, enhancing its attractiveness, incentives for public transport use, car-sharing schemes, and promotion of walking and cycling in cities, can be considered. These measures provide an integrated approach, offering benefits for air quality and climate change mitigation.

Through the implementation of key provisions from EU Directives into its legislative framework, the Emission Limit Values (ELVs) transcribed into Montenegro's legal framework could align with the provisions of the AGP Technical Annexes IV, V, VI, X, VIII, and XI, around 2025-28.

6.7. References of chapter 6 Montenegro

[1] Ministry of Ecology, Spatial Planning and Urbanism Montenegro communications with Citepa, from April to October 2023

[2] Law on CLRTAP Ratification (“Official Gazette of the SFRY” no. 11/86)

[3] Law on Ratification of the Protocol to the 1979 Convention on Long-Range Transboundary Air Pollution on long-term financing of the Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe (EMEP) (“Official Gazette of Montenegro – International Agreements 11/86”)

[4] Law on Ratification of the Protocol to the 1979 Convention on Long-Range Transboundary Air Pollution on heavy metals (“Official Gazette of Montenegro – International Agreements 8/11”)

[5] Law on the Confirmation of the Protocol on POPs with the 1979 Convention on Long-Range Transboundary Air Pollution (“Official Gazette of Montenegro – International Agreements 8/11”)

[6] Law on the approval of the protocol on GP 1999 ("Official Gazette of Montenegro - International Agreements", No. 08/11 dated 01.07.2011)

[7] 1999 Protocol to Abate Acidification, Eutrophication and Ground-level Ozone to the Convention on Long-range Transboundary Air Pollution, as amended on 4 May 2012 https://unece.org/sites/default/files/2021-10/ECE.EB_.AIR_.114_ENG.pdf

[8] Air quality management strategy of Montenegro for the period 2021-2029, 2021

[9] Directive (EU) 2016/2284 of the European Parliament and of the Council of 14 December 2016 on the reduction of national emissions of certain atmospheric pollutants, amending Directive 2003/35/EC and repealing Directive 2001/81/ECE. http://data.europa.eu/eli/dir/2016/2284/oj

[10] Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on ambient air quality and cleaner air for Europe. http://data.europa.eu/eli/dir/2008/50/oj

[11] Commission Implementing Decision (EU) 2017/1442 of 31 July 2017 establishing best available techniques (BAT) conclusions, under Directive 2010/75/EU of the European Parliament and of the Council, for large combustion plants (notified under document C (2017). http://data.europa.eu/eli/dec_impl/2017/1442/oj

[12] Implementation Plan for Industrial Emissions Directive, 2019

[13] Regulation on limit values of the content of polluting substances in liquid fuels of oil origin ("Official Gazette of Montenegro", no. 17/17)

[14] Directive (EU) 2016/802 of the European Parliament and of the Council of 11 May 2016 relating to a reduction in the sulphur content of certain liquid fuels. http://data.europa.eu/eli/dir/2016/802/oj

[15] Regulation on marking the energy efficiency of vehicle tires and other parameters ("Official Gazette of Montenegro", 119/22 of 26.10.2022).

[16] Regulation on technical requirements for vehicles imported or first placed on the market in Montenegro ("Official Gazette of Montenegro", no. 05/15 of 30.01.2015, 63/18 of 28.09.2018, 10/19 of 13.02.2019, 68/20 of 08.07.2020, 16/21 of 17.02.2021)

[17] Information on the state of the environment in Montenegro for 2021, 2022

[18] Law on Waste Management ("Official Gazette of Montenegro" no. 064/11 and 039/16)

[19] Regulation on the prohibition and restriction of the use, placing on the market and production of chemicals that represent an unacceptable risk to human health and the environment ("Official Gazette of Montenegro", No. 070/18 dated 31.10.2018, 076/20 dated 28.07.2020, 134/22 dated 07.12.2022)

[20] Regulation on technical conditions for air protection from emissions of volatile organic compounds resulting from the storage, transfer and distribution of petrol ("Official Gazette of the Republic of Montenegro" no. 07/14, 008/19 from 06.02.2019)

[21] Montenegro - LRTAP Convention - tables edition 2021 https://www.ceip.at/status-of-reporting-and-review-results/2021-submission/#M

[22] Montenegro - LRTAP Convention - Informative inventory report of 2021 https://cdr.eionet.europa.eu/me/un/clrtap/iir/envyetx8q/

[23] Montenegro - LRTAP Convention - Informative inventory report of 2023 https://www.ceip.at/status-of-reporting-and-review-results/2023-submission

[24] Law on Air Protection ("Official Gazette of Montenegro", number 25/10 dated 05.05.2010, 040/11 dated 08.08.2011, 043/15 dated 31.07.2015, 73/19 from 27.12.2019)

[25] Regulation on activities that affect or may affect air quality ("Official Gazette of the Republic of Montenegro", no. 61/2012 of 7 December 2012)

[26] Regulation on the establishment of a network of measuring points for air quality monitoring, (“Official Gazette of Montenegro", no. 44/10 of 30.07.2010, 13/11 of 04.03.2011, 064/18 of 04.10. 2018)

[27] Regulation on the determination of types of pollutants, limits values and other air quality standards ("Official Gazette of the Republic of Montenegro", no. 25/12 from 11.5.2012)

[28] Rulebook on the manner and conditions for monitoring the quality of air ("Official Gazette of Montenegro", No. 21/2011, 032/16 dated 20.05.2016)

[29] Rulebook on the content and method of making annual air quality information (“Official Gazette of Montenegro”, No. 27/2012)

[30] Directive 2004/107/EC of the European Parliament and of the Council of 15 December 2004 relating to arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons in ambient air. http://data.europa.eu/eli/dir/2004/107/oj

[31] Law on Industrial Emissions ("Official Gazette of the Republic of Montenegro", no. 17/19 and 3/23)

[32] Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control) (Recast) http://data.europa.eu/eli/dir/2010/75/2011-01-06

[33] Law on Integrated Prevention and Control of Environmental Pollution, ("Off. Gazette RCG", No. 080/05 from 28.12.2005, Off. Journal CG", No. 054/09, 040/11, 042/15,55/18)

[34] Rulebook on the form of integrated permit (“Official Gazette of Montenegro”, No. 059/19 dated 23.10.2019, 060/21 dated 08.06.2021)

[35] Rulebook on content and method of application for an integrated permit (“Official Gazette of Montenegro”, No. 055/20 od 12.06.2020)

[36] Rulebook on method and procedure for monitoring of emissions from stationary sources (“Official Gazette of Montenegro”, No. 039/13 dated 07.08.2013)

[37] Rulebook on emission limit values, technical measures for exemption of application of limit values and monitoring methods (“Official Gazette of Montenegro”, No. 061/20 od 24.06.2020)

[38] Rulebook on criterions for determination of the best available techniques for environment protection and the list of pollutants from industrial installations (“Official Gazette of Montenegro”, No. 035/19 od 24.06.2019)

[39] Regulation on limit values of emissions from combustion plants and method of calculating emission limit values for plants using multiple types of fuels ("Official Gazette of Montenegro", No. 129/21 dated 15.12.2021)

[40] Conclusions about the best available technics (BAT) for large combustion plants. Adapted for Montenegro Commission Implementing Decision (EU) 2017/1442 of 31 July 2017 establishing best available techniques (BAT) conclusions, under Directive 2010/75/EU of the European Parliament and of the Council, for large combustion plants (notified under document C (2017) 5225)

[41] Directive (EU) 2015/2193 of the European Parliament and of the Council of 25 November 2015 on the limitation of emissions of certain pollutants into the air from medium combustion plants http://data.europa.eu/eli/dir/2015/2193/oj

[42] Rulebook on the technical requirements of eco-design for devices for solid fuel local space heating ("Official Gazette of Montenegro", No. 035/19 od 24.06.2019)

[43] Commission Regulation (EU) 2015/1185 of 24 April 2015 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to eco-design requirements for solid fuel local space heaters http://data.europa.eu/eli/reg/2015/1185/oj

[44] Rulebook on the technical requirements of eco-design for boilers using solid fuels ("Official Gazette of Montenegro", No. 035/19 od 24.06.2019)

[45] Commission Regulation (EU) 2015/1189 of 28 April 2015 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to eco-design requirements for solid fuel boilers http://data.europa.eu/eli/reg/2015/1189/oj

[46] Regulation on emission limit values of air pollutants from stationary sources ("Official Gazette of Montenegro", 10/2011 of 11 February 2011, 129/21 of 15 December 2021)

[47] Rulebook on the method of performing monitoring of emissions in water and air from plants that produce titanium dioxide ("Official Gazette of Montenegro", No. 070/20 of 15 July 2020)

[48] Rulebook on the limit values of the emissions of pollutants, method of performing monitoring and operating conditions of the plant for incineration and co-incineration of waste ("Official Gazette of Montenegro", No. 079/20 of 02.08.2020)

[49] The best available technics (BAT) for cement, lime and magnesium oxide industries. Adapted for Montenegro 2013/163/EU: Commission Implementing Decision of 26 March 2013 establishing the best available techniques (BAT) conclusions under Directive 2010/75/EU of the European Parliament and of the Council on industrial emissions for the production of cement, lime and magnesium oxide (notified under document C (2013) 1728)

[50] Conclusions about the best available technics (BAT) for production of iron and steel. Adapted for Montenegro Commission Implementing Decision (EU) 2017/1442 of 31 July 2017 establishing best available techniques (BAT) conclusions, under Directive 2010/75/EU of the European Parliament and of the Council, for large combustion plants (notified under document C (2017) 5225)

[51] Conclusions about the best available technics (BAT) for non-ferrous metal industries. Adapted for Montenegro Commission Implementing Decision (EU) 2016/1032 of 13 June 2016 establishing best available techniques (BAT) conclusions, under Directive 2010/75/EU of the European Parliament and of the Council, for the non-ferrous metals industries (notified under document C (2016) 3563)

[52] Best available technics (BAT) for the production of cellulose, paper and cardboard. The document has been adapted for use in Montenegro. Commission Implementing Decision of 26 September 2014 establishing the best available techniques (BAT) conclusions, under Directive 2010/75/EU of the European Parliament and of the Council, for the production of pulp, paper and board (notified under document C (2014) 6750)

[53] Best available technics (BAT) for surface treatment using organic solvents including preservation of wood and wood products with chemicals. The document has been adapted for use in Montenegro. Commission Implementing Decision (EU) 2020/2009 of 22 June 2020 establishing the best available techniques (BAT) conclusions, under Directive 2010/75/EU of the European Parliament and of the Council on industrial emissions, for surface treatment using organic solvents including preservation of wood and wood products with chemicals (notified under document C (2020) 4050)

[54] Conclusions on the best available technics (BAT) for the food, drink and milk industries. Adapted for Montenegro Commission Implementing Decision (EU) 2019/2031 of 12 November 2019 establishing best available techniques (BAT) conclusions for the food, drink

and milk industries, under Directive 2010/75/EU of the European Parliament and of the Council (notified under document C (2019) 7989)

[55] Best available technics (BAT) for waste treatment. Adapted for Montenegro Commission Implementing Decision (EU) 2018/1147 of 10 August 2018 establishing best available techniques (BAT) conclusions for waste treatment, under Directive 2010/75/EU of the European Parliament and of the Council (notified under document C (2018) 5070)

[56] Best available technics (BAT) for rearing of poultry or pigs. Adapted for Montenegro Commission Implementing Decision (EU) 2017/302 of 15 February 2017 establishing best available techniques (BAT) conclusions, under Directive 2010/75/EU of the European Parliament and of the Council, for the intensive rearing of poultry or pigs (notified under document C (2017) 688)

[57] Rulebook on the type of activities, emission limit values and methods performing monitoring in plants using organic solvents ("Official Gazette of Montenegro", No. 030/20 od 07.04.2020)

[58] Monitoring of pollutants in the air from the industrial facilities. Adapted for Montenegro JRC Reference Report on Monitoring of Emissions to Air and Water from IED Installations

[59] Directive 94/63/EC of 20 December 1994 on the control of volatile organic compound (VOC) emissions resulting from the storage of petrol and its distribution from terminals to service stations http://data.europa.eu/eli/dir/1994/63/oj

[60] Directive 2009/126/EC of the European Parliament and of the Council of 21 October 2009 on Stage II petrol vapour recovery during refuelling of motor vehicles at service stations http://data.europa.eu/eli/dir/2009/126/oj

[61] Regulation on technical requirements for vehicles imported or first placed on the market in Montenegro ("Official Gazette of Montenegro", no. 05/15 of 30.01.2015, 63/18 of 28.09.2018, 10/19 of 13.02.2019, 68/20 of 08.07.2020, 16/21 of 17.02.2021).

[62] Agreement on the adoption of uniform technical regulations for vehicles with wheels, equipment and parts which can be installed and / or used on wheeled vehicles and conditions for mutual recognition of granted approvals pursuant to these regulations, which entered into force on October 16, 1995, ("Official Gazette of Montenegro - International Treaties", No. 5/2014)

[63] Directive 2009/30/EC of the European Parliament and of the Council of 23 April 2009 amending Directive 98/70/EC as regards the specification of petrol, diesel and gas-oil and introducing a mechanism to monitor and reduce greenhouse gas emissions and amending Council Directive 1999/32/EC as regards the specification of fuel used by inland waterway vessels and repealing Directive 93/12/EEC http://data.europa.eu/eli/dir/2009/30/oj

[64] T. Lecomte, J.F. de la Fuente, F. Neuwahl, M. Canova, A. Pinasseau, I. Jankov, T. Brinkmann, S. Roudier, L. Delgado-Sancho, Best Available Techniques (BAT) Reference Document for Large Combustion Plants: Industrial Emissions Directive 2010/75/EU (Integrated Pollution Prevention and Control) 2017

[65] Commission Implementing Decision (EU) 2017/1442 of 31 July 2017 establishing best available techniques (BAT) conclusions, under Directive 2010/75/EU of the European Parliament and of the Council, for large combustion plants (notified under document C (2017). http://data.europa.eu/eli/dec_impl/2017/1442/oj

[66] Code of good practice for wood-burning and small combustion installations, 2019. https://unece.org/DAM/env/documents/2019/AIR/EB/ECE_EB.AIR_2019_5-1916518E.pdf

[67] Prioritizing reductions of particulate matter from sources that are also significant sources of black carbon - analysis and guidance, 2021. https://unece.org/sites/default/files/2021-10/ECE_EB.AIR_2021_6-2113500E.pdf

[68] B. Bessagnet, N. Allemand, Review on Black Carbon (BC) and Polycyclic Aromatic Hydrocarbons (PAHs) emission reductions induced by PM emission abatement techniques, TFTEI 2020 https://drupal-main-staging.unece.org/sites/default/files/2020-12/Review%20on%20BC%20and%20PAH%20emission%20reductions%20.pdf

[69] WGSR 56th. May 2018. Thematic session on residential wood combustion and air pollution. https://unece.org/info/Environmental-Policy/Air-Pollution/events/20267

[70] TFTEI Techno-Scientific Board. TFTEI background informal technical document for the Review of the Gothenburg Protocol for Industrial Processes Annexes IV, V, VI, X and XI March 2022. Informal document to the 60th WGSR meeting. https://unece.org/sites/default/files/2022-03/TFTEI%20review%20of%20Annexes%20to%20the%20Gothenburg%20Protocol.pdf

7. Armenia

This report has been developed with the kind support of Gayane Shahnazaryan, Deputy Director of the Department of Atmospheric Policy of the Ministry of Environment and her team [9].

7.1. Status of ratification of CLRTAP and its protocols and strategic programmes

Armenia accessed the 1979 Convention on Long-range Transboundary Air Pollution [1] (CLRTAP) in 1997, February 21st [2] and the 1984 Geneva Protocol on Long-term Financing of the Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe (EMEP) in 2014, 21st January [3] but not yet, one of the Protocols aiming at reducing pollutants and especially the Gothenburg Protocol [4].

A first draft of "National Action Plan for ratification of CLRTAP protocols and meeting of correspondent commitments" was prepared by the Ministry of Environment of the Republic of Armenia in 2014 within the framework of a project "Assessment and enhancement of national capacities for joining CLRTAP Protocols and meeting corresponding commitments" which was a regional pilot project implemented within the framework of the EU funded project "Air Quality Governance in ENPI East Countries" [5]. A reviewed and updated plan was prepared by international consultants to the United Nations under the assistance programme to support countries in Eastern Europe, the Caucasus and Central Asia (EECCA) with the aim to encourage ratification of the key Protocols to the CLRTAP [6], taking in to account the bilateral agreement with the EU.

Armenia is currently engaged in a Comprehensive and Enhanced Partnership Agreement (CEPA) between the European Union and the European Atomic Energy Community and their Member States, of the one part, and the Republic of Armenia, of the other part. The aims of this Agreement are multiple but one of them is as follows (a, article 1): "*to enhance the comprehensive political and economic partnership and cooperation between the Parties, based on common values and close links, including by increasing the participation of the Republic of Armenia in policies, programmes and agencies of the European Union"* [7].

The agreement entered into force on first March 2021. CEPA provides a framework for the EU and Armenia to work together on a wide range of areas: strengthening democracy, the rule of law and human rights; creating more jobs and business opportunities, improving legislation, public safety, a cleaner environment, as well as better education and opportunities for research. It is based in four pillars: better living standards, fairer and safer society, cleaner environment and education [8].

The agreement provides a road map for the implementation of key EU directives.

Among other ones, the chapter 3 of CEPA is related to Environment and chapter 4 to the climate action [7]. Article 48 under chapter 3, provides the main objectives:

(a) the development of a general national environmental strategy for the Republic of Armenia, covering:

> *(i) planned institutional reforms (with timetables) for ensuring implementation and enforcement of environmental legislation;*
>
> *(ii) the division of competence for environmental administration at national, regional and municipal levels;*
>
> *(iii) procedures for decision-making and the implementation of decisions;*

(iv) procedures for the promotion of the integration of the environment into other policy areas;

(v) the promotion of green economy measures and eco-innovation, the identification of the necessary human and financial resources and a review mechanism; and

(b) the development of sector-specific strategies for the Republic of Armenia (including clearly defined timetables and milestones for implementation, administrative responsibilities, as well as financing strategies for investments in infrastructure and technology) on:

(i) ***air quality;***

(ii) water quality and resource management;

(iii) waste management;

(iv) biodiversity, nature conservation and forestry;

(v) ***industrial pollution and industrial hazards****; and*

(vi) chemicals.

The CEPA is further detailed in the following chapters.

With this agreement, Armenia is currently working actively for the establishment of an enhanced air protection programme.

Armenia is Member of the Eurasian Economic Union (EEU) from 2015. In some areas, regulations developed by the EEU apply in Armenia (especially for mobile sources and quality of fuels) [45].

7.2. Main sources of emissions

7.2.1. Emissions of SO_2, NOx, PM_{10} and $PM_{2.5}$ and VOC in 2021

In 2021, emissions are estimated to [11]:

SO_2: 0.86 kt

NOx: 23.7 kt

PM_{10}: 3.1 kt

$PM_{2.5}$: 2.8 kt

VOCs: 183 kt

The main sources of pollutants are presented in the following figure (TFTEI treatment from the NFR tables of Armenia [11]):

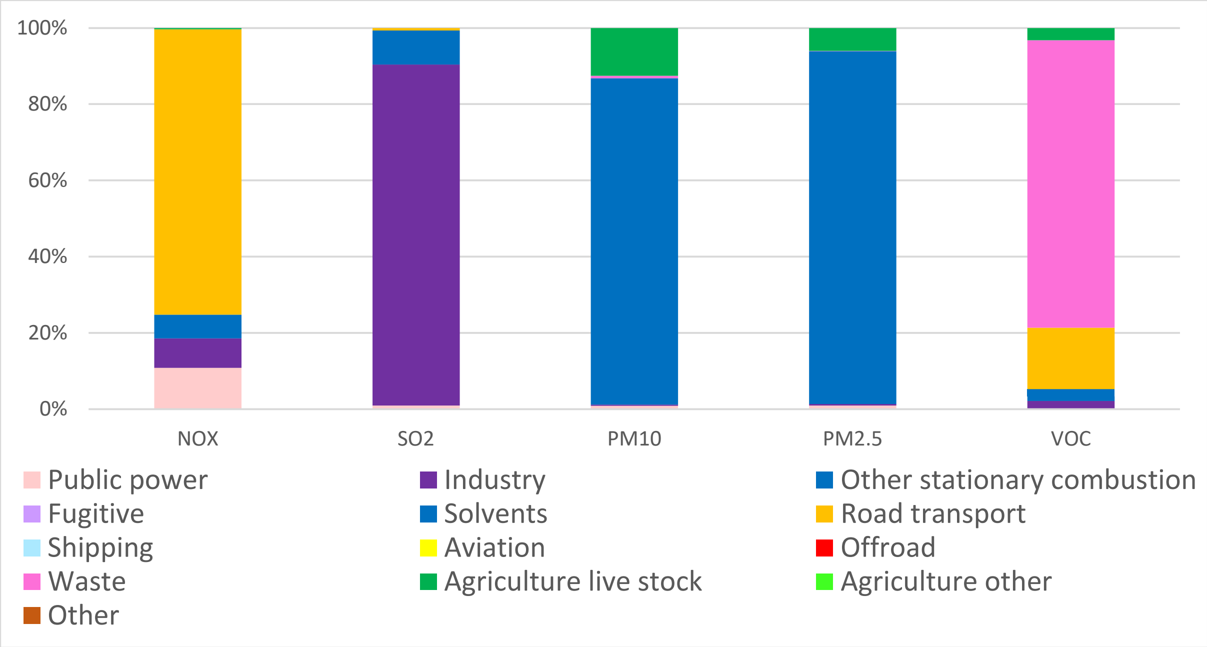


Figure 7-1: Share of emissions of SO_2, NOx, PM_{10}, $PM_{2.5}$ and VOC in Armenia in 2021 [11]

Industry is the main source of SO_2 emissions with 89% of national SO_2 emissions and represents 8% of national NOx emissions. It has to be kept in mind the low proportion of oil products in the energy consumption from fossil fuels (refer to chapter 7.2.2).

Road transport represents 75% of national NOx emissions and 16 % of national VOC emissions.

Public power represents 11% of national NOx emissions.

Other stationary combustion (including domestic heating) is the largest source of PM_{10} and $PM_{2.5}$ emissions, representing 86 and 93% of total national emissions respectively.

The waste sector could be the major source of VOCs but its contribution is rather quite inexplicable. Some wrong estimates could exist in the emission inventory (unit problem). This should be checked by the Republic of Armenia in the next inventory submission.

7.2.2. Energy balance

To better understand the characteristics of the energy consumption in Armenia, the energy balance report [12] provides useful information as well as the IEA report for Armenia [13].

The main domestic sources of primary energy production are nuclear energy and hydro energy with shares of 60.4% and 22.0% correspondingly in 2021, as presented in the following figure [12]:

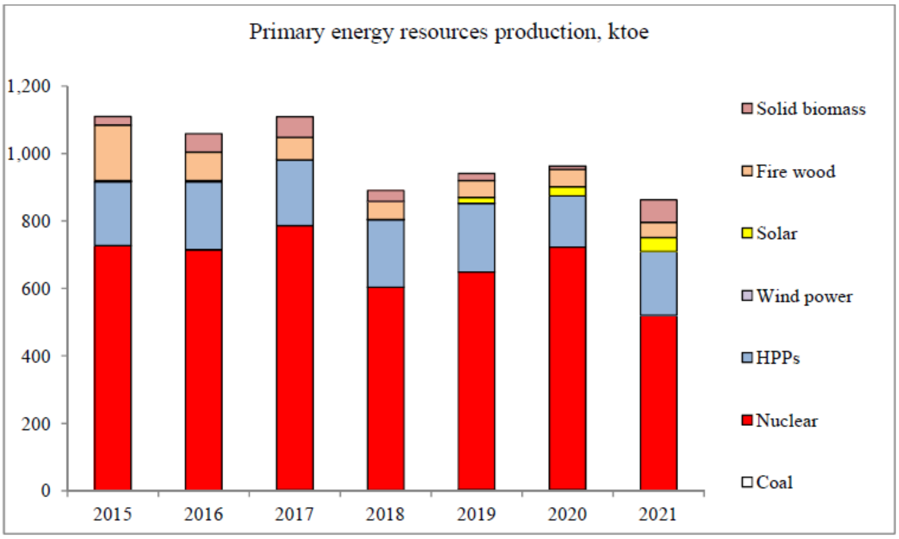


Figure 7-2: Evolution of the primary energy ressources production [12]

Armenia does not produce fossil fuels. There is no refinery. Natural gas and oil products used in the country have to be imported (figure 4). Armenia imports 81.2% of its energy resources (in the total primary supply of energy). Imports of oil products and natural gas are the largest ones, as presented in the following figure [12]:

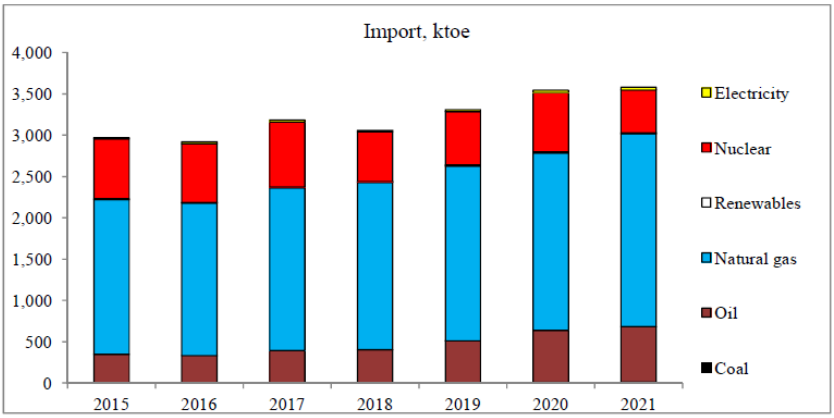


Figure 7-3: Evolution of imported energy resources [12]

Transport is the main sector for consumption of oil products as presented in the following figure [13].

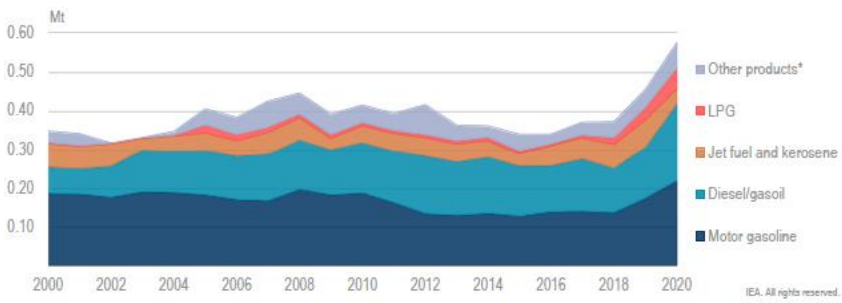


Figure 7-4: Uses of oil products in Armenia [13]

There are **four large thermal power plants** in Armenia for the production of electricity, all using natural gas [12], [13].

- “Yerevan TPP” CJSC, 228.6 MW, which although is combined cycle production unit, operated in condensation mode during 2021 and produced 1652.7 GWh of electricity.
- “Hrazdan TPP” OJSC, 410 MW, is a condensing power unit, owned by “Gazprom Armenia” CJSC, produced 1576.9 GWh of electricity (Five oil and gas boilers are used to power four co-generation turbines).
- “Hrazdan-5” CJSC, 467 MW, condensing power unit owned by “Gazprom Armenia” was not operated in 2021.
- A new 254 MW combined cycle production unit has been operated by “ArmPower” CJSC since 29 November, 2021 with 148.1 GWh electricity production.

The share of energy consumption is presented below. In 2021, the largest energy consumer was the household sector which share was 34.7% against the total amounts of the final consumption for energy purposes. The transport share was 32.5%. The share of service sector was 15.7%, and industry 13.4% [12].

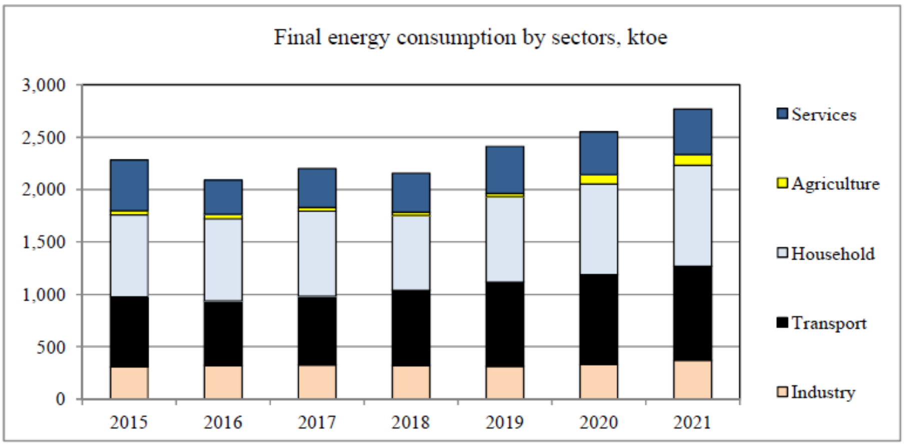


Figure 7-5: final energy consumption per sector, ktoe [12]

In industry, the main fuel used is natural gas. Oil is also used but in a smaller proportion.

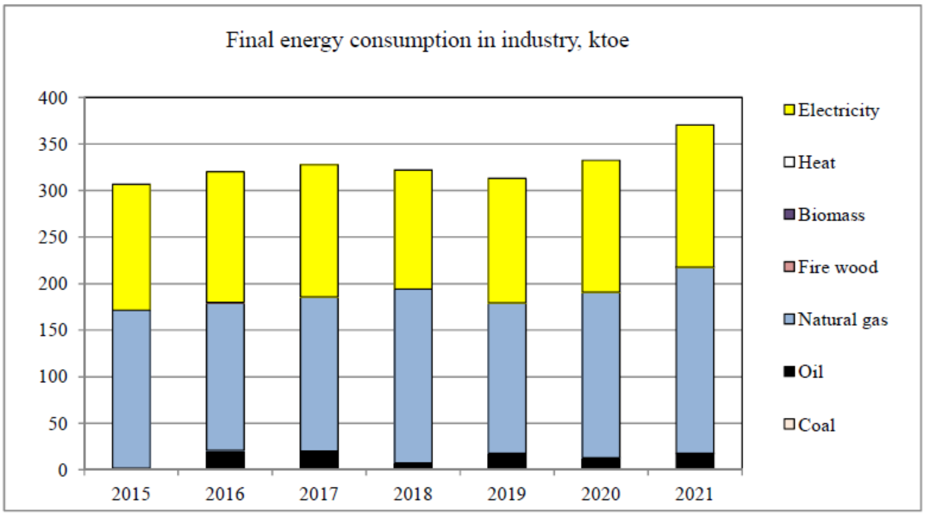


Figure 7-6: Final energy consumption in industry, ktoe [12]

Household is the second largest gas consumer of natural gas, accounting for 28% of gas demand in 2020 according to reference [13]. 96% of the communities have access to pipeline gas. Gas is used in the residential sector for both cooking and heating. Most residential heating now consists of small, individual gas boilers.

On contrary to the past, district heating systems are not used as they were shut down [13].

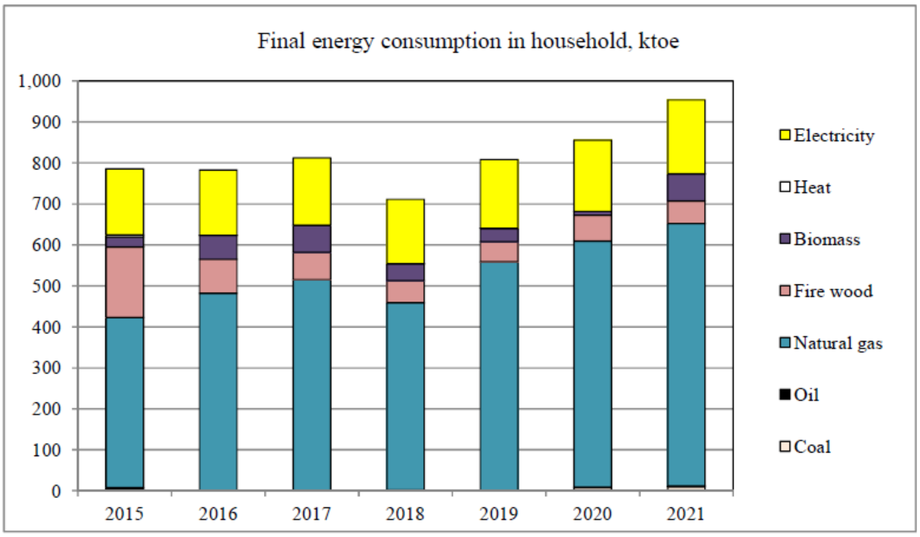


Figure 7-7: Final energy consumption in household, ktoe [12]

Armenia has one of the world's highest levels of gasification in the transport sector. Over 70% of vehicles run on natural gas, with a higher rate in Yerevan. Most use gas in the form of compressed natural gas (CNG), though some vehicles are designed to run on LNG [13] (figure 7.8).

There are 384 CNG filling stations, one for approximately every 38 km of road. Nearly all vehicles running on CNG are also able to use motor gasoline, providing flexibility in case of a gas supply disruption [13].

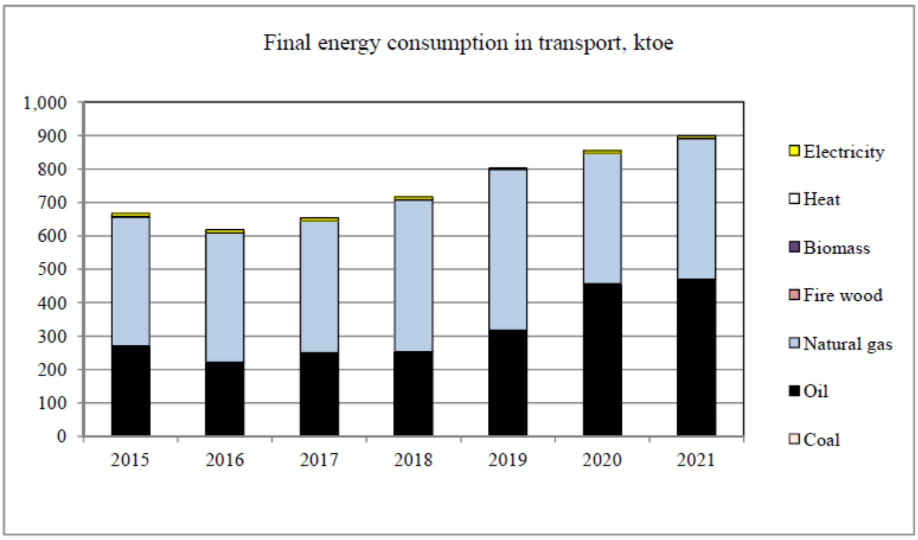


Figure 7-8: Final energy consumption in transport, ktoe [12]

7.2.3. Improvement plans for emission inventories

According to experts from the Environment Ministry, the emission inventories would require improvements [10][9]. The situation is as in the following [10]:

- Emissions from registered (permitted) stationary sources are estimated based on annual statistical forms,
- Emissions from mobile sources are calculated based on the consumption of fuels, taking into account the composition of vehicle fleet,
- Agricultural sector is calculated based on the EMEP/CORINAIR methodology.

The emission inventory needs improvements on the following topics [10]:

- The road transport inventory is not detailed,
- Fugitive emissions from diffused sources are not yet estimated,
- Emissions from the waste ate not yet estimated,
- Missing self-monitoring of emissions with automatic measurements by the operators of large installations (However, the monitoring of emissions is not yet in practices. Operators carry out atmospheric air quality monitoring in the vicinity of the plant and adjacent aeras [9]),
- Emission inventories are only reported only for the current year and the timeseries are not presented,
- Absence of a national data base of methodologies for emission estimation and the inability of direct application of European methodologies as the result of the differences in technologies used,
- Absence of the complete set of activity data. The main gap is related to statistics for carrying out the emission inventory of road traffic (no detailled data of the type of vehicles, split per fuel, per technology and Euro standard).

In the scope of an UNDP-GEF project “Building Armenia’s National Transparency Framework under Paris Agreement” [10], the emission inventory for GHG emission and pollutants should be improved with two main objectives, impacting also air pollutant emission inventory:

- Setting an institutional organisation for GHG emission inventory,
- Reconcile LRTAP reporting and GHG inventory data for common database.

7.3. Situation in terms of air quality

7.3.1. Organisation of air quality monitoring and limit values

Air quality monitoring in the Republic of Armenia is carried out by the Hydrometeorology and Monitoring Centre (Armhydromet), which is State Non-Commercial Organization "HMC". The Armhydromet was established by the N 81-N decree (January 30, 2020 [14]) of the Government of the Republic of Armenia. Armhydromet merges the former "Environmental Monitoring and Information Centre", "Forest Monitoring Center" and the "Hydrometeorology and Atmospheric Impact Services" SNCOs. Armhydromet is the legal successor of these centres [15][16]. http://meteomonitoring.am/page/5

In 2023, air quality monitoring in Armenia is done in 11 settlements of the Republic [8]: Yerevan, Gyumri, Vanadzor, Alaverdi, Hrazdan, Ararat, Tsaghkadzor, Charentsavan, Kapan, and Kajaran cities, as well as in the Amberd station of the regional first level of transboundary air pollution monitoring. In total, there are 16 stationary observation stations and 215 non-stationary observation stations in the above-listed settlements.

Pollutants measured are as follows [16][15]:

- Total dust (TSP),
- Sulphur dioxide (SO_2),
- Nitrogen dioxide (NO_2),
- Ground level ozone (O_3),
- Heavy metals in dust.

The following table presents the pollutants monitored by automated stations, non-automated stations, as well as passive samplers [15].

Table 7-1: Parameters monitored by automated stations, non-automated stations, as well as passive samplers [15]

Non-automated method (active sampling and chemical analysis)	Passive sampling method
Total dust (TSP)	Sulphur dioxide (SO_2)
Sulphur dioxide (SO_2)	Nitrogen dioxide (NO_2)
Nitrogen dioxide (NO_2)	
Ground level ozone (O_3)	
Heavy metals in dust	

The ambient air quality standards were established by the RA Government decision, N 160, 2006 [17]. Limit values are as in the following:

Table 7-2: Air quality limit values (maximum permissible concentrations or MPC)) currently applied in Armenia [17]

Air pollutants	Ambient air quality standard (maximum permissible concentration)
SO_2	24 hour mean: 0.05 mg/m³ Max. Daily: 0.5 mg/m³
NO_2	24 hour mean: 0.04 mg/m³ Max. Daily: 0.085 mg/m³
NO	24 hour mean: 0.06 mg/m³ Max. Daily: 0.4 mg/m³
CO	24 hour mean: 3 mg/m³ Max. Daily: 5 mg/m³
Dust	24 hour mean: 0.15 mg/m³ Max. Daily: 0.5 mg/m³
O_3	24 hour mean: 0.03 mg/m³ Max. Daily: 0.16 mg/m³

7.3.2. Concentrations of pollutants observed

The concentrations of pollutants measured in 2021 and 2022 are as in the following [8]:

Nitrogen dioxide

The following figure presents NO_2 annual average concentrations monitored in 10 cities of Armenia [8].

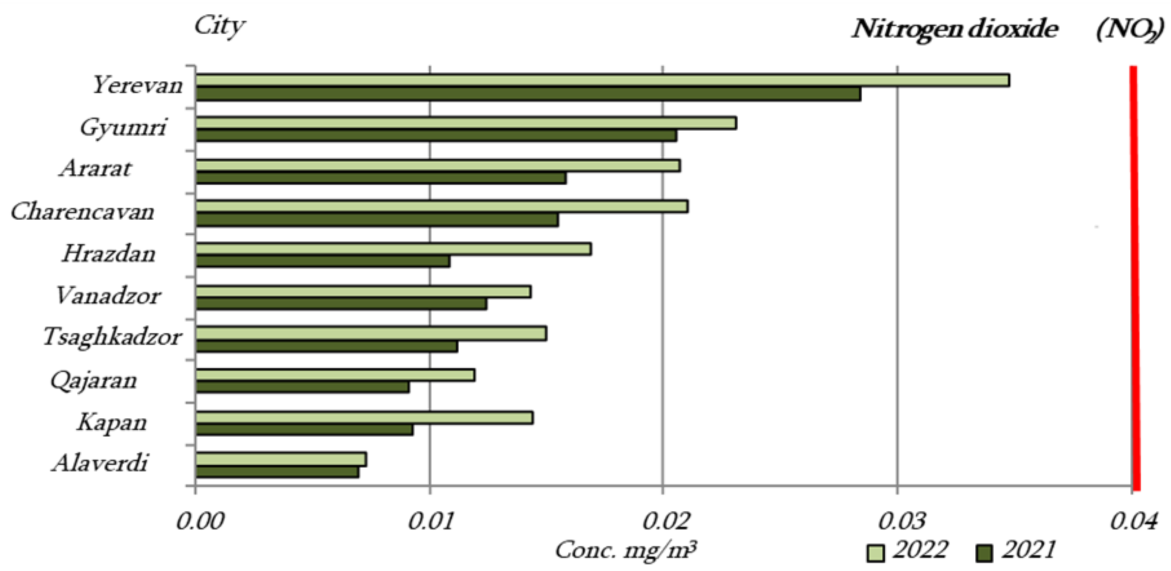


Figure 7-9: Concentrtaions of NO_2 in 10 cities of Armenia in 2021 and 2022 [8]

On average, the annual NO_2 concentraions are below the maximum permissible concentrations expressed as daily average of 40 µg/m^3.

Sulphur dioxide

The following figure presents SO_2 average annual concentrations monitored in 10 cities of Armenia [8].

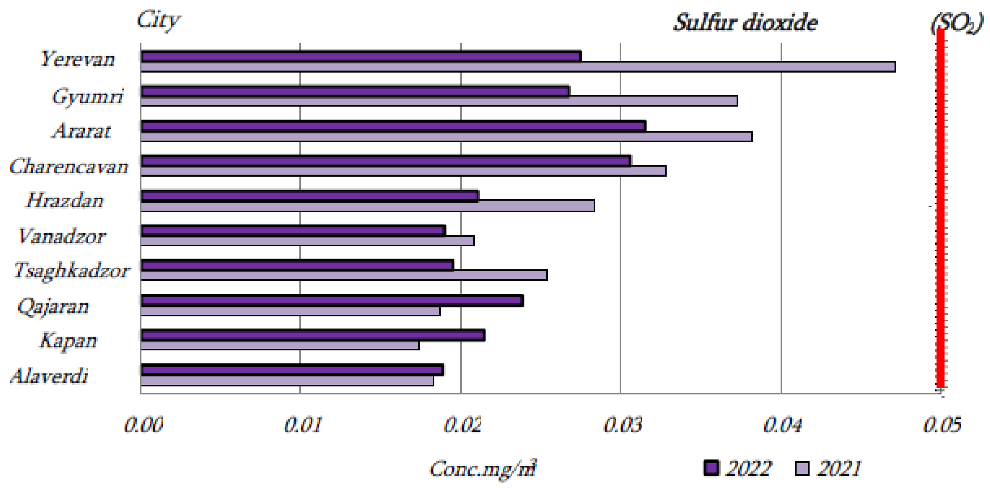


Figure 7-10: Concentrations of SO_2 in 10 cities of Armenia in 2021 and 2022 [8]

Dust

The following figure presents annual dust concentrations monitored in some cities of Armenia [8]. The MPC for dust in Tsaghkadzor, Hrazdan, and Ararat cities is 0.1 mg/m^{3}and 0.15 mg/m^3 in other cities.

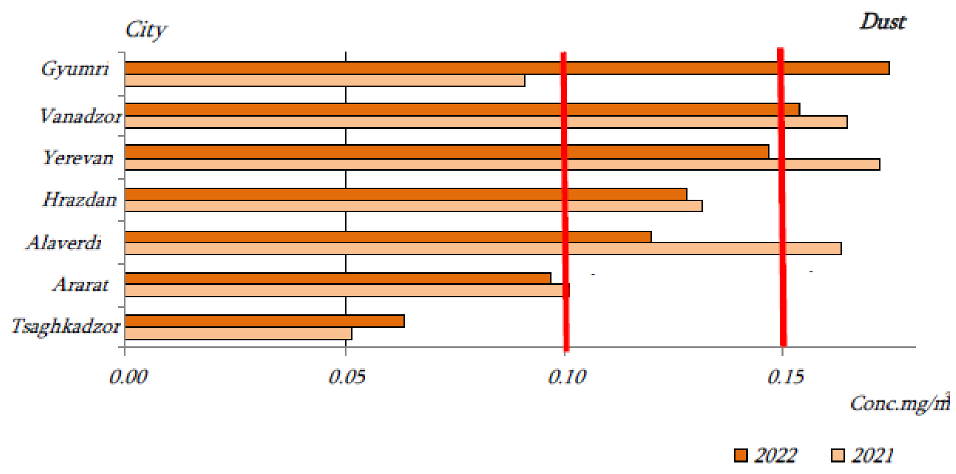


Figure 7-11: Concentrations of dust in 7 cities of Armenia in 2021 and 2022 [8]

In Yerevan, the concentrations of dust in 2021 and 2022 are as follows:

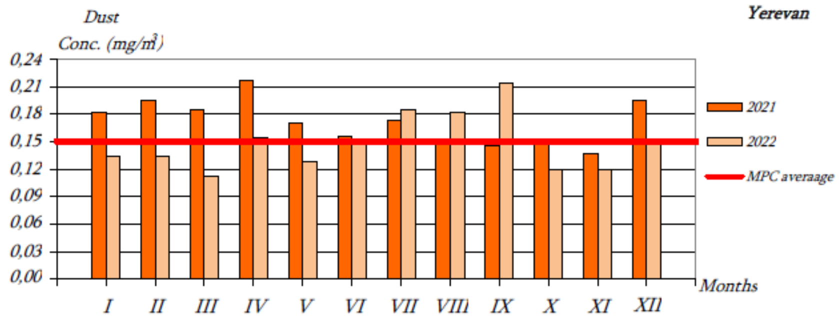


Figure 7-12: Concentrations of dust in Yerevan as monthly average in 2021 and 2022 [8]

The following table presents the evolution of annual concentrations of dust, NO_2, SO_2 and ozone (mg/m^3).

Table 7-3: Annual concentrations of dust, NO_2, SO_2 and ozone (mg/m^3) in Yerevan from 2018 to 2022 [8]

Pollutant name	Characteristic	Date				
		2018	2019	2020	2021	2022
Dust	Average annual concentration	0.110	0.128	0.117	0.172	0.147
Sulfur dioxide		0.028	0.018	0.013	0.017	0.022
Nitrogen dioxide		0.020	0.015	0.032	0.027	0.029
Ground-level ozone		0.007	0.006	0.004	0.005	0.006

Ongoing works to improve the air quality monitoring network

According to reference [10], consistently with the CEPA, approximation of the two EU air quality directives is scheduled from 2021 to 2027.

- Directive 2008/50/EC of the European Parliament and of the Council of 21May 2008 on ambient air quality and cleaner air for Europe [18].
- Directive 2004/107/EC of the European Parliament and of the Council of 15 December 2004 relating to arsenic, cadmium, mercury, nickel, and polycyclic aromatic hydrocarbons in ambient air [19].

Armenia is engaged to improve air quality assessment in accordance with the requirements of the Protocols and EU legislation [6][10] and fulfilment of correspondent commitments:

- Introduction and implementation of air quality standards (Critical levels of O_3, PM, NH_3; Critical loads of acidity and nutrient nitrogen);
- Ambient concentrations and depositions of sulphur and nitrogen compounds;
- Ambient concentrations of O_3, VOCs and PM;
- Estimation of exposure to O_3 and PM;

The current issues and steps for improvements are as in the following [16]:

- Modernize existing air quality monitoring system in accordance with international requirements,
- Provide real-time data to the public and for better management of air pollution,
- Improve access to data,
- Introduce air pollution modelling and forecasting system, linkage to the satellite data,
- Develop or adapt cross-sectoral assessment tools,
- Accreditation of the reference laboratory,
- Connect local data to the global networks, portals.

The road map is as follows according to the CEPA:

For Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on ambient air quality and cleaner air for Europe, the target dates are as follows according to the articles of the directive:

- Adoption of national legislation and designation of competent authority/ies - 2025
- Establishment and classification of zones and agglomerations (Articles 4 and 5) - 2028
- Establishment of upper and lower assessment thresholds and limit values (Article 5 and 13) - 2028
- Establishment of a system for assessing ambient air quality in relation to air pollutants (Articles 5, 6 and 9) - 2029
- Establishment of air quality plans for zones and agglomerations where levels of pollutants exceed limit value/target value (Article 23) -2029
- Establishment of short-term action plans for zones and agglomerations in which there is a risk that alert thresholds will be exceeded (Article 24) - 2029
- Establishment of a system to provide information to the public (Article 26) - 2027

For Directive 2004/107/EC of the European Parliament and of the Council of 15 December 2004 relating to arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons in ambient air, the target dates are as follows according to the articles of the directive:

- Adoption of national legislation and designation of competent authority/ies - 2026
- Establishment of upper and lower assessment thresholds (Article 4(6)) and target values (Article 3) - 2027
- Establishment and classification of zones and agglomerations (Articles 3 and 4(6)) - 2027
- Establishment of a system for assessing ambient air quality in relation to air pollutants (Article 4) - 2029
- Taking measures in order to maintain/improve air quality in respect of the relevant pollutants (Article 3) – 2029

Within the "EU4Climate" project, the Environment Agency Austria has developed a report "Concept for improving air quality monitoring in Armenia" [15] based on requirements arising from the Comprehensive and Enhanced Partnership Agreement (CEPA) between the European Union and the Republic of Armenia.

7.4. Regulations in place to limit emissions of stationary sources and programmes for the evolution

7.4.1. Strategic programmes

Some strategic documents have been presented in chapter 7.1. The following EU Directives related to specific sources of emissions, are in the scope of the CEPA [7]:

- Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control) [16]
- Directive 2004/42/EC of the European Parliament and of the Council of 21 April 2004 on the limitation of emissions of volatile organic compounds due to the use of organic solvents in certain paints and varnishes and vehicle refinishing products and amending Directive 1999/13/EC [21]
- European Parliament and Council Directive 94/63/EC of 20 December 1994 on the control of volatile organic compound (VOC) emissions resulting from the storage of petrol and its distribution from terminals to service-stations [26]
- Council Directive 1999/32/EC of 26 April 1999 relating to a reduction in the sulphur content of certain liquid fuels and amending Directive 93/12/EEC [23].

In the following paragraphs, the road map fixed by the CEPA is further detailed for the different Directives.

7.4.2. Industrial sources and large combustion plants

Regulations set out emission thresholds for which media-specific permits are required, as well as maximum allowable concentrations (MAC) for certain pollutants.

According to article 13 of the 1994 Law on Atmospheric Air Protection [24], permits are required for entities that exceed 2 billion m^3 of the required volume of air use per year (or 2 000 m^3 per second). Entities – such as small and medium-sized enterprises – with emissions below the established thresholds may operate without a permit or might be required to provide a notification of their operations instead [26].

In addition, legislation also sets out maximum allowable concentrations (MACs) of certain pollutants in ambient air. The 2006 government resolution sets out MACs for 389 atmospheric pollutants, also indicating their level of toxicity [27]. Additional information is expected later.

The permissible limit values of the pollutant emissions are calculated on the basis of the annual production [9]. If, as a result of the calculations, the company's emissions considering the background pollution of the given location, do not exceed the maximum allowable concentration (MAC) of pollutants, no plan of measures to reduce the emissions is planned. And if, in the case of any pollutant, the maximum allowable concentration is exceeded, then a plan of measures to reduce the emissions is planned [9].

Armenia's current approach to permitting industrial installations retains elements from its Soviet-era regulatory framework, emphasizing maximum allowable concentrations (MAC) of pollutants and the establishment of sanitary protection zones. This methodology is comparable to practices in Kazakhstan and other former Soviet republics. The process involves ensuring that pollutant concentrations, expressed in mg/m^3, remain below the maximum allowable concentration (MAC). Emission dispersion is calculated to determine pollutant levels at key locations: the emitting organization's boundary, the perimeter of the sanitary protection zone, and the nearest residential areas. If dispersion calculations show that ground-level concentrations do not exceed the MAC in these areas, the emission limits are considered acceptable, and permits are issued accordingly. However, if concentrations exceed the MAC, a mitigation program must be developed to reduce emissions and ensure compliance with MAC standards. This process aims to protect public health and the environment while regulating industrial activities

The following table presents emissions of SO_2, NOx and PM of some large plants covered by the Arminian regulation and enables to compare the level of emissions according to the permit and emissions reported by plants [9].

Table 7-4: Emissions of SO_2, NOx and PM of some plants covered by the Arminian regulation [9]

Production type	Plant	According to the emission reporting	According to the permit
		SO2, tonne	
Ferromolybdenum	Plant FM1	356.08	376.35
Ferromolybdenum	Plant FM2	346.78	631.1
		NOx, tonne	
Electricity	Combustion plant 1	409.59	2557.408
Electricity	Combustion plant 2	277.37	290.599
Electricity	Combustion plant 3	49.91	472.54
cement	Cement plant 1	153.70	509.35
cement	Cement plant 2	31.2	182.5
glass	Glass plant 1	39.31	64.7
steel	Steel plant 1	21.6	57.1
		PM, tonne	
cement	Cement plant 1	688.50	1347.98
cement	Cement plant 2	233.60	1128.7
glass	Glass plant 1	43.77	72
steel	Steel plant 1	17.5	21.6

According to reference [26], operators apply for permits to local offices of the Ministry of Environment through paper applications. The digitisation of the permit application procedure is ongoing. Permitting is single media based, with a separate application required for each environmental medium. Applicants must pay a small fee for permit applications.

The Environmental Protection and Mining Inspection Body (EPMIB) is responsible for inspections in enterprises. The EPMIB was established in 2017, according to the Law on inspection Bodies of 2014 [28].

The frequency of inspections depends on a risk-based parameter. The Methodology and General Description of Criteria Determining Risks-Based Decree on the Risk Assessment Conducted by the Environmental Protection and Mining Inspection Body of Armenia was adopted in

August 2019 [29]. This document defines risk as the probability of harming the environment. It establishes three categories of risk for economic entities. This methodology allows the Inspection Body to [30]:

1) Analyse, evaluate and classify economic entities according to the risk groups of the impact on the environment as a result of their activities,

2) Create a database according to the fields of activity and the economic entities,

3) Create a database of environmental impact and consequences, which will give the opportunity to strengthen the analytical skills of the inspection body,

4) Increase the distribution efficiency of available resources (human, material and financial) focusing them on riskier fields.

5) Develop and implement more optimal and effective inspection mechanisms.

The corresponding frequency of inspection depends on the Risk class: high risk (once a year); medium risk (once in three years); and low risk (once in five years).

The Law on inspection Bodies of 2014 [28] defines the system of risk-based inspections in the Republic of Armenia and inspection planning, according to which [31]:

- The risk-based inspection system is a set of measures taken by inspection bodies to plan its inspections.
- Through the system of risk-based inspections, the inspection body targets the areas and the objects of control that are most at risk.

Evolution of the regulation:

According to the roadmap for the implementation of the commitments of CEPA [7], the legislative framework for adopting the EU Directive 2010/75/EU of 24 November 2010 on industrial emissions [16] (integrated pollution prevention and control) should be implemented from 2025 to 2027 for new installations and 2034 for existing ones with, among other:

- Adoption of national legislation and designation of competent authority(ies) (2025)
- Determination of structures for which a permit is required (Appendix I) (2027)
- Establishment of a combined permit system (Articles 4 to 6, 12, 21 and 24 and Annex IV) (2027)
- Establishing a compliance monitoring mechanism (Articles 8, 14(1)(d) and 23(1)) (2027)
- Implementation of Best Available Technologies (BAT), taking into account the BAT conclusions of the BAT reference documents (Articles 14(3) to (6) and 15(2) to (4)), (new plants 2027, existing plants 2034)
- Establishment of emission limit values for combustion plants (Article 30 and Annex V) (new plants 2027, existing plants 2034)[20],
- Preparation of programmes to reduce the total volume of annual emissions from existing plants (alternative to setting emission limit values for existing plants) (Article 32) (2034)

[20] remark: Annex V of the directive 2010/75/EU [16] was used to develop Annexes IV, V and X for limit values for LCP of the AGP [33]

Limit values for large combustion plants (all LCPs for electricity production use natural gas) which are implemented by the technical Annex V (Table 1: Limit values for NOx emissions from combustion plants and table 2: Limit values for NOx emissions released from onshore combustion turbines (including Combined Cycle Gas Turbine CCGT)) and the technical X (Table 1: Limit values for dust emissions from combustion plants) of the AGP [33] which are based on Annex V of the IED [16], should be applied in the Republic of Armenia according to this road map in 2027 at the latest for new plants and before 2034 for existing plants.

It was noticed that Annex VII of the IED [16], related to limit values of VOCs from certain activities using solvents is not covered by the CEPA. However, according to CEPA, Directive 2010/75/EC must be fully implemented, but not all measures were listed in the current roadmap. In the near future, it is planned to make a change in the road map and include all measures [7]. At present, the work of approximating the directive 2010/75/EC is underway within the project UNDP Climate Promise 2 [47]. Some activities using solvents are not present in Armenia: vehicle manufacturing, coal coating, conversion of rubber, manufacture of coatings, extraction of vegetable oil [9].

The concept of BAT was introduced in the amended Law on Air protection adopted in 2022 [25]. The framework for introduction of BATs and ELVs associated with them, are provided in the new Law and introduced as part of integrated permitting system.

7.4.3. Residential heating

According to energy statistics [12][13], natural gas and electricity are the main sources of energy for Residential heating. Bioenergy represents 8% of total energy consumption (figure 7.7).

There is not yet legal framework focussing on the reduction of emissions of PM emissions from domestic appliances.

According to its National Determined Contribution (NFC), Armenia should reduce its GHG emissions by 40% in 2030 compared to 1990 levels. In this aim, the following actions are defined [34]:

- Provisions of the EU-Armenia CEPA [7] roadmap with 12 actions on climate change and 34 actions on energy efficiency, renewable energy, and energy security;
- A national Energy Efficiency and Renewable Energy Programme 2021-2030, which will define new sectoral targets.

Evolution of regulations:

According to the roadmap for the implementation of the commitments of CEPA [7], the legislative framework for adopting the EU Directive 2009/125/EC of the European Parliament and of the Council of 21 October 2009 on establishing a framework for the setting of Eco-design requirements for energy-related products [41] shall be implemented by 2026.

The CEPA [7] precises that for the two following regulations related to solid fuel local space heaters and solid fuel boilers, the Partnership Council will regularly assess the possibility of setting specific timelines for the implementation of those Regulations and Directive.

- Commission Regulation (EU) 2015/1185 of 24 April 2015 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to Eco-design requirements for solid fuel local space heaters [42],

- Commission Regulation (EU) 2015/1189 of 28 April 2015 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to Eco-design requirements for solid fuel boilers [43].

In absence of plan to transpose these two regulations, it is difficult for TFTEI to determine if, possibly for the time bieng, the recommended PM limit values of table 12 for dust emissions released from new solid fuel combustion installations with a rated thermal input < 500 kWth to be used with product standards and table 13 of Annex X of the AGP [33] for dust emissions released from boilers and process heaters with a rated thermal input of 100 kWth –1 MWth could be implemented in Armenia.

7.4.4. Sulphur content of gasoil

The AGP in its Annex IV introduces the following limit value for gasoil.

Table 7-5: Limit value for gasoil according to Annex IV of the AGP [33]

Table 2
Limit values for the sulphur content of gas oil[a]

	Sulphur content (per cent by weight)
Gas oil	< 0.10

[a] "Gas oil" means any petroleum-derived liquid fuel, excluding marine fuel, falling within CN code 2710 19 25, 2710 19 29, 2710 19 45 or 2710 19 49, or any petroleum-derived liquid fuel, excluding marine fuel, of which less than 65% by volume (including losses) distils at 250°C and of which at least 85% by volume (including losses) distils at 350°C by the ASTM D86 method. Diesel fuels, i.e., gas oils falling within CN code 2710 19 41 and used for self-propelling vehicles, are excluded from this definition. Fuels used in non-road mobile machinery and agricultural tractors are also excluded from this definition.

As presented in figures 7.6 and 7.7, oil products are used in small amount in industry and households. Oil products are imported from Russia and Iran [8].

According to the regulation of Eurasian Economic Union, TR CU 013/2011 [40] about requirements to automotive and aviation gasoline, diesel and marine fuel, jet fuel engines and oil, the limit values of sulphur content in gasoil (used for mobile machine) are based on the following ecological classes (refer to chapter 7.5.1):

K4-50 mg/kg in force from 31 December 2015

K5-10 mg/kg not limited.

It was not possible to confirm that heating gasoil is covered by this regulation.

According to the roadmap for the implementation of the commitments of CEPA [7], the legislative framework for adopting the Directive 93/32/EEC relating to the sulphur content of certain liquid fuels [23] should be implemented from 2020 to 2023, with, among other:

- Adoption of national legislation and designation of competent authority(ies).
- Definition of an effective fuel sampling system and appropriate analytical methods for sulfur content determination (Article 6)
- Prohibition of the use of fuel oil and oil distillate (gas oil) in the event that the sulfur content during their application to the soil exceeds the specified limit values (Article 3(1), unless the exceptions specified in Articles 3(2) and 4(1) are applicable)

Remark: The Directive 99/32/EEC relating to the sulphur content of certain liquid fuels [23] is no longer into force in the EU. It has been repealed by Directive (EU) 2016/802 of the European Parliament and of the Council of 11 May 2016 relating to a reduction in the sulphur content of certain liquid fuels [32]. It is probable that this last directive will be considered by Armenia in the scope of the CEPA. According to article 4 of the directive 1999/32, gas oil cannot be used if its sulphur content exceeds 0,10 % by mass. It can be considered the gas oil in Armenia has a sulphur content less than 0.1%).

7.4.5. Storage of petrol from terminals to service stations

Oil products only represent around 50% of the energy consumption in transport in Armenia (figure 7.8). There is currently no regulation limiting VOC emissions from the petrol distribution [8].

According to reference [13], there were over 480 filling stations in Armenia selling petrol and/or diesel in 2017.

According to the CEPA [7], the programme to adopt VOC limit values for the storage and distribution of petrol prescribed by table 1 of Annex VI of the AGP [33] (which are based on Directive 1994/63/EC on Stage I petrol vapour recovery [26]) has been set up. There is not programme to adopt VOC limit values for car refuelling at service station presented prescribed by table 2 of Annex VI of the AGP (which are based on Directive 2009/126/EC on Stage II petrol vapour recovery [38]).

Evolution of regulations:

According to the roadmap for the implementation of the commitments of CEPA [7], the legislative framework for adopting the Directive 94/63/EC on the control of volatile organic compound (VOC) emissions resulting from the storage of petrol and its distribution from terminals to service stations [26] should be implemented from 2026 to 2029, with, among other:

- Adoption of national legislation and designation of competent authority(ies),
- Detection of all gasoline storage and transfer stations (Article 2),
- Determination of technical measures aimed at reducing the loss of gasoline during loading/unloading of mobile containers from storage facilities and loading stations at transfer stations and filling stations (Articles 3, 4 and 6 and Annex III),
- Establishing compliance requirements for loading docks and portable containers for all tank cars (Articles 4 and 5).

With this programme to adapt its legal framework, the Republic of Armenia will be able to implement the limit values of table 1 “Limit values for VOC emissions from the storage and distribution of petrol, excluding the loading of seagoing ships (stage I)” of Annex VI related to VOC emissions of the AGP [33].

7.4.6. VOC content of products

Currently the solvent content of coatings for domestic application is not yet controlled.

Evolution of regulations:

According to the roadmap for the implementation of the commitments of CEPA [7], the legislative framework for adopting the Directive 2004/42/EC [21] of the European Parliament and of the Council of 21 April 2004 on the limitation of emissions of volatile organic compounds due to the use of organic solvents in certain paints and varnishes and vehicle refinishing products and amending Directive 1999/13/EC, should be implemented from 2021 to 2026 (5 years after the date of entering into force of CEPA), with, among other:

- Adoption of national legislation and designation of competent authority(ies),
- Setting up maximum VOC content limit values for paints and varnishes (Article 3 and Annex II) (remark: Annex II of the directive 2004/42 was used to develop Annex XI of the AGP [33]),
- Establishment of requirements ensuring labelling of products placed on the market and placing on the market of products complying with relevant requirements (Article 3 and 4).

With this work, the legislative framework of the Republic of Armenia will be updated and consequently, the Republic of Armenia will be able to implement the limit values of table 1 “maximum VOC content for pains and varnishes ” and table 2 Maximum VOC content for vehicle refinishing products of Annex XI related to “Limit values for volatile organic compounds content of products” of the AGP [33].

7.5. Regulations in place to limit emissions from mobile sources and projects for their evolution

7.5.1. Quality of petrol and diesel

The Technical Regulation of the Eurasian Economic Union 013/2011 “On the requirements for automotive and aviation gasoline, diesel and marine fuel, jet fuel and fuel oil” [40][41] is applied in the Republic of Armenia. This technical regulation was developed in accordance with the Agreement on Uniform Principles and Rules of Technical Regulation in the Republic of Belarus, the Republic of Kazakhstan and the Russian Federation.

The sulphur content evolved as follows, both for petrol and diesel [40]:

K2: 500 mg/kg

K3: 150 mg/kg

K4: 50 mg/kg

K5: 10 mg/kg

According to the regulation 013/2011, the use of the different fuels has been regulated as follows in the Russian Federation [40]:

Table 7-6: Dates of entering into force of the limit values of sulphr for petrol and diesel [40]

Fuel quality	Petrol	Diesel
K3	December 31, 2014	December 31, 2015
K4	December 31, 2015	December 31, 2015
K5	Not limited	Not limited

The K3 quality is not more allowed in Armenia.

The characteristics of fuels are as follows [40]:

Table 7-7: Limit values of different parameters for petrol [40] and comparison with table 13, Annex VIII of the AGP

Parameter	Unit	K5 fuels
Mass fraction of sulfur, not more than	mg/kg	10
Volume fraction of benzene, not more than	%	1
Volume fraction of oxygen, not more than	%	2.7 (3.7 in table 13, ann VIII, AGP)
Volume fraction of hydrocarbons, not more than	%	
Aromatic		35
Olefinic		18
Octane number:		
By research method, not less than		80 (95 in table 13, ann VIII, AGP)
By motor method, not less than		76 (95 in table 13, ann VIII, AGP)
Saturated vapour pressure:	kPa	
Over the summer		35-80 (60 in table 13, ann VIII, AGP)
In winter		35-100 (no value in table 13, ann VIII, AGP)
Iron concentration, not more than	mg/dm^3	Absence (no value in table 13, ann VIII, AGP)
Concentration of manganese	mg/dm^3	Absence (no value in table 13, ann VIII, AGP)
Concentration of lead, not more	mg/dm^3	5 (lead is prohibited in table 13, ann VIII, AGP)
Volume fraction of monomethylaniline, max	%	Absence
Volume fraction of oxygenates, not more than:	%	In table 13, ann VIII of the AGP other oxygenated products are considered: Tert-butyl alcohol Iso-butyl alcohol
Methanol		1 (3 in table 13, ann VIII of the AGP)
Ethanol		5 (10 in table 13, ann VIII of the AGP)
Isopropanol		10 (12 in table 13, ann VIII, AGP)

Parameter	Unit	K5 fuels
Tretbutanol		7 (not in table 13, ann VIII of the AGP)
Isobutanol		10 (not in table 13, ann VIII of the AGP)
Esters containing 5 or more carbon atoms		15 (22 in table 13, ann VIII of the AGP)
Other oxygenates (with boiling point not exceeding 210°C)		10 (15 in table 13, ann VIII of the AGP)

In green values equal to value in table 13, Annex VIII of the AGP

Table 7-8: Limit values of different parameters for diesel [40] and comparison with table 14, Annex VIII of the AGP (In green values equal to value in table 13, Annex VIII of the AGP)

Parameter	Unit	K5 fuels
Mass fraction of sulfur, not more than	mg/kg	10
Flash point in closed crucible, not lower than	°C	(no value in table 13, ann VIII, AGP)
Summer and off-season diesel fuel	%	55
Winter and artic diesel fuel	%	30
Fractional composition – 95 % by volume distilled at a temperature, not higher than	°C	360
Mass fraction of polycyclic aromatic hydrocarbons, max	%	8
Cetane number for summer fuel, at least	-	51 (no distinction of season in table 14, ann VIII, AGP)
Cetane number for winter and artic fuel, at least	-	47
Lubricity, not more	micrometer	460 (no value in table 14, ann VIII, AGP)
Filterability limit temperature, not higher	°C	(no value in table 14, ann VIII, AGP)
Summer diesel fuel		Undefined
Winter diesel fuel		Minus 20
Arctic diesel fuel		Minus 38
Off season fuel		Minus 15

7.5.2. Road vehicles

There is no production of road vehicles in the Republic of Armenia. All types of vehicles are imported.

From January 1, 2018, all types of new vehicles, including freight and passenger vehicles, produced or imported into the countries of the Eurasian Economic Union (EAEU), had to comply with the fifth ecological class according to the Technical Regulation of the Eurasian Economic Union TR CU 018/2011 on the safety of wheeled vehicles (similar to Euro-5) adopted by Armenia [42], [9] [48] [49] (This technical regulation TR CU 018/2011 does not regulate the prohibition of types of vehicles, it simply defines what technical requirements the vehicles in production and operation must meet).

According to the reference [42], the links between the TR CU 018/2011 and UNECE norms are as follows (Citepa has added links with EU norm based on information provided by reference [43]. Only data related to limit values are provided in the following table:

Table 7-9: Technological requirements for vehicles according to TR CU 018/2011

Ecological class	**Categories and subgroups of vehicles and internal combustion engines**	**Technical requirements for vehicles and engines of internal combustion**
4	M1, M2, N1, N2 (according to scope of regulation UNECE No. 83) with forced ignition and diesels	UNECE Regulation No. 83-05 (Emission Tier B) *This corresponds to Euro 4 according to ref [43]*
	M1 maximum weight over 3.5 t, M2, M3, N1, N2, N3 with gas and diesel engines	UNECE Regulation No. 49-05 ((emission level B1, requirement level in onboard diagnostics, durability and serviceability, NOx control - "C") *This corresponds to Euro IV according to ref [43]*
	M1 maximum weight over 3.5 t, M2, M3, N2, N3 with gasoline engines	Clause 12 of Annex No. 3 to this technical regulation *Refer to Annex 1 of the chapter*
	Diesel and gas engines, for installation in vehicles category M1 maximum weighing over 3.5 tons, M2, M3, N1, N2, N3	UNECE Regulation No. 49-05 (Emission level B1, intended the level of requirements in onboard diagnostics, durability and serviceability, NOx control - "C") *This corresponds to Euro IV according to ref [43]*
5	M1, M2, N1, N2 (according to scope of UNECE Regulation No. 83-06) with engines with forced ignition and diesel	UNECE Regulation No. 83-06 *This corresponds to Euro 5 according to ref [43]*
	M1 maximum mass 3.5 t, M2, M3, N1, N2, N3 with gas and diesel engines	UNECE Regulation No. 49-05 (emission level B2, C, over requirement level with respect to onboard diagnostics, durability, NOx control – "G", "K") *This corresponds to Euro V according to ref [43]*

Ecological class	Categories and subgroups of vehicles and internal combustion engines	Technical requirements for vehicles and engines of internal combustion
	Diesel and gas engines designed for installations on transport means of categories M1 maximum weight over 3.5t, M2, M3, N1, N2, N3	UNECE Regulation No. 49-05 (Emission Level B2, C, level of requirements in terms of onboard diagnostics, durability, NOx control - "G", "K") *This corresponds to Euro V according to ref [43]*
	M, N hybrid (according to the scope of this technical UNECE Regulation No. 49) and engines designed for installation on vehicles	Clause 13 of Annex No. 3 to this technical regulation *Refer to Annex 1 of the chapter*

According to Annex VIII of the AGP [33], tables 1 to 3, minimum standards required were Euro 5/V and Euro 6/VI with different dates of implementation, ranging from 01/01/2014 for Euro 5 and 01/09/2015 or 2016 for Euro 6 for passenger cars and light duty vehicles (table 1 of Annex VIII of the AGP); from 01/10/2009 for Euro V and 31/12/2013 for Euro VI for heavy duty vehicles steady-state cycle load-response tests (table 2 of Annex VIII of the AGP) and from 01/10/2009 for Euro V and 31/12/2013 for Euro VI for heavy duty vehicles transient cycle tests (table 3 of Annex VIII of the AGP [33]).

The implementation on the requirements of Annex VIII introducing Euro 5/V, for passenger cars, light duty vehicles and heavy-duty vehicles is not yet achieved in the Republic of Armenia and the evolution of the EAEU regulation TR CU 018/2011 is not known from TFTEI.

7.5.3. Engines installed on NRMM or locomotives, rail cars, inland water ways

In the Republic of Armenia, there is no production of:

- non-road mobile machinery (covered by tables 4, 5 and 6 of Annex VIII of the AGP [33]).
- engines for the propulsion of locomotives, railcars, inland water way vessels, recreational crafts (tables 7 to 10 of Annex VIII of the AGP [33]).

The Technical Regulation of the Eurasian Economic Union TR CU 018/2011 on the safety of wheeled vehicles [42] is applied in Armenia [49]. It introduces limit values for some engines (class 4 vehicles) as presented in the following table:

Table 7-10: Technological requirements for engines according to TR CU 018/2011 [42]

Ecological class	Categories and subgroups of vehicles and internal combustion engines	Technical requirements for vehicles and engines of internal combustion
4	M1G and M2G maximum weighing over 3.5 tons, M3G, N2G, N3G with all-wheel drive, including with switchable driven by one of the axles, with diesel engines	UNECE Regulation No. 96-02
	Diesel engines for installations on transport means of categories M1G and M2G with a maximum mass of over 3.5t, M3G, N2G, N3G, with four-wheel drive,	UNECE Regulation No. 96-02

Ecological class	Categories and subgroups of vehicles and internal combustion engines	Technical requirements for vehicles and engines of internal combustion
	including those with disconnectable all-wheel drive	

The UNECE regulation 96-02 corresponds to Stage IIIA limit values of EU regulation 97/68 [44] (Annex 4, appendix 3 of regulation TR CU 018/2011 [44]). The implementation of the provisions of Annex VIII for NRMM based on stage IIIB and IV [33] can be considered not yet achieved in the Republic of Armenia and the evolution of TR CU 018/2011 is not known from TFTEI.

7.5.4. Mopeds and motorcycles

In the Republic of Armenia, there is no production of:

- mopeds and motorcycles (tables 11 to 12 of Annex VIII of the AGP).
-

7.6. Technological pathways

In Armenia, dust is the main air quality problem with concentrations in ambient air which exceed the national air quality limit values (daily average of 100 µg/m^3 in some cities or 150 µg/m^3 in other cities) in several cities (figure 7.11). The national limit value for NO_2 (daily average of 40 µg/m^3) is not exceeded and average daily concentrations range from less than 10 µg/m^3 Alaverdi to around 35 µg/m^3 in Yerevan in 2022 (figure 7.9).

The sector “other combustion stationary sources” which includes this residential heating represents 86 % of total PM_{10} and 93% of $PM_{2.5}$ emissions in Armenia (refer to figure 7.1 and chapter 7.2.1).

In terms of NOx emissions, road transport is the largest source and represents 75% of total NOx emissions in Armenia. Large combustion installations for the production of electricity use natural gas. They are the second largest source of NOx emissions with 11 % of total emissions (refer to chapter 7.2.1, figure 7.1).

SO_2 emissions are low as the consumption of coal or heavy fuel oil is very low in Armenia. Large combustion plants for electricity production use natural gas; in industry, natural gas is the first fuel consumed, and liquid fuels are used in a very small proportion. In transport sector, Armenia has one of the world’s highest levels of gasification. Over 70% of vehicles run on natural gas.

Policies to reduce air pollution and improve air quality should focus in priority on the main sources of PM and especially residential heating with biomass (wood is used and manure in rural area). As a Party to the CLRTAP, Armenia is engaged to reduce its emissions and improve air quality. Armenia is working for the development of regulations and improvement of air quality. In this aim, Armenia is working for alignment of its national policies in link with the quality of fuels, petrol distribution and industries with many EU directives or regulations, which were in most cases, the basis for the definition of limit values prescribed by the technical Annexes IV, V, VI, X and XI. Armenia is currently engaged in an Association Agreement (AA) between the European Union and the European Atomic Energy Community and their Member States, of the one part, and the Republic of Armenia, on the other part [7]. The Agreement entered into force on 1 March 2021, defines the road map for several key EU directives, with among them:

a) Directive 2008/50/EC of 21May 2008 on ambient air quality and cleaner air for Europe,

b) Directive 2004/107/EC of 15 December 2004 relating to arsenic, cadmium, mercury, nickel, and polycyclic aromatic hydrocarbons in ambient air,
c) Directive 1999/32/EC of 26 April 1999 relating to a reduction in the sulphur content of certain liquid fuels and amending Directive 93/12/EC,
d) Directive 1994/63/EC of 20 December 1994 on the control of VOC emissions resulting from the storage of petrol and at distribution from terminals to service stations Stage I Petrol vapour recovery and Directive 2009/126/EC of 21 October 2009 on Stage II petrol vapour recovery during refuelling of motor vehicles at service stations,
e) Directive 2004/42 on the limitation of emissions of volatile organic compounds due to the use of organic solvents in certain paints and varnishes and vehicle refinishing products,
f) Directive 2010/75/EC of 24 November 2010, on Industrial Emissions (IED).

Armenia is Member of the Eurasian Economic Union (EAEU) from 2015. In several areas, regulations developed by the EAEU apply in Armenia (especially for mobile sources and quality of fuels) [45].

For stationary sources the legal framework for adoption of EU standards similar to limit values of the technical Annexes or even stricter is in progress:

- For Industrial Emissions, the CEPA provides a road map from 2021 to 2034 with adoption of a national legislation by 2025 and establishment of an integrated permit system by 2027 and implementation of BAT by 2027 for new plants and 2034 for existing ones.

- The introduction of legal requirements on use of organic solvents in certain products to reduce emissions of VOCs based on EU Directive 2004/42/EC is ongoing. The time frame defined by CEPA is 5 years to complete the alignment of the legislative framework.

- The introduction of legal requirements for alignment of the national legislation on EU Directive 1994/63/EC on the control of VOC emissions resulting from the storage of petrol and its distribution from terminals to service stations is ongoing. The time frame defined by CEPA is 9 years to complete the alignment of the legislative framework.

The development of the legal framework is not yet scheduled for car refuelling at service stations.

For road transport, Armenia adopts regulations from the Eurasian Economic Union EAEU and from January 1, 2018, all types of new vehicles, including freight and passenger vehicles, produced or imported into the country had to comply with the fifth ecological class according to the Technical Regulation of the Eurasian Economic Union TR CU 018/2011 on the safety of wheeled vehicles (similar to Euro-5). (Requirements of tables 1 to 3 of Annex VIII of AGP are based on Euro 5/V and Euro 6/VI [33]).

For Non-Road Mobile Machinery, the EAEU regulation TR CU 018/2011 [44] based on the UNECE regulation 96-02 corresponds to Stage IIIA limit values of EU regulation 97/68 [44] (provisions of Annex VIII for NRMM are based on stage IIIB and IV [33]).

The chapter 8 presents the techniques to comply with limit values introduced by Annexes IV for SO_2, V for NOx, VI for VOC, X for PM and XI for solvents in products [33]. In this technical pathway, the focus is only made on the largest emitters for which reduction measures would be rapidly necessary.

For combustion plants using natural gas, the reduction techniques available for abating NOx emissions are as in the following (chapter 8.2.).

The means to achieve the limit values are the application of one or a combination of the following techniques [56][57]:

- combustion optimisation
- low-NOx burners (LNB)
- air staging
- fuel staging
- flue-gas recirculation
- selective non-catalytic reduction (SNCR)
- selective catalytic reduction (SCR)

For **PM emissions from domestic heating appliances using coal or biomass**, the use of the most efficient appliances in term of emissions and energy efficiency is essential but technological solutions are not sufficient. The "Code of good practices for wood burning and small combustion installations" [50] developed by TFTEI, the report "Prioritizing reductions of particulate matter from sources that are also significant sources of black carbon - analysis and guidance" [51] developed by TFIAM and the report "Review on Black Carbon (BC) and Polycyclic Aromatic Hydrocarbons (PAHs) emission reductions induced by PM emission abatement" [54] developed by TFTEI provide excellent overview of policies to be implemented beyond the technical characteristics of appliances. The thematic session on residential wood combustion and air pollution of 56th WGSR in May 2018, is also useful for inspiring ideas in this field [55]. The last TFTEI report on the review of limit values of technical Annexes IV, V, VI, X and XI of the AGP also provides useful information [52].

The Annex X of the AGP, recommends emission limits of PM for small domestic appliances (table 12, Annex X). These limit values could be a good starting point for the production of new appliances with improved performances and lower emissions. In terms of domestic appliances and combustion, the reduction of PM emissions can be pursued through optimisation of the combustion conditions, by several means, to ensure the best optimized conditions in terms of temperature, residence time (sufficient time is required) and turbulence (to ensure good mixing of flue gases) (the three T's rules), but also the geometry of the combustion chamber, air supply and reducing the user's intervention, by the combustion automated systems. The solutions for these three T's parameters can be applied in different types of appliances, especially stoves [52].

Temperature:

- Refractory lining in the combustion chamber,
- Shape and size of combustion chamber,
- Material and isolation of the door as well as size of window and its radiation coefficient or alternatively coated glasses or double/triple windows with air chambers in between,
- Windows should be of appropriate limited size.

Sufficient residence time:

- Gas volume flow,
- Distribution of flue gases over combustion chamber,

- Distribution of air,
- Height and width of the combustion chamber.

Turbulence or mixing of flue gasses:

- Distribution of purge air windows,
- Direction and geometry of additional inlet air,
- Velocities of flue gas and combustion air,
- Geometry of the main and the post combustion chamber,
- Geometry of deflection plate and the use of baffles in post combustion chamber,
- Avoidance of leakage streams (sealing),
- Avoidance of short-circuiting of the flue gas stream.

The reduction of pollutants emissions both PM, VOC from small domestic appliances is also dependent on energy efficiency of housing. Policies implemented to increase energy efficiency in housing have co-benefits in terms of air pollution by decreasing the fuel demand and consequently the emissions.

For **industrial processes emitting SO_2, NOx and or PM covered by Annexes IV, V and X,** Chapters 8.1 for SO_2 reduction techniques, 8.2 for NOx reduction techniques and 8.4 for PM reduction techniques present the best available techniques to comply with the limit values prescribed. For PM, best available techniques to comply with limit values are electrostatic precipitators and bag filters. Other types of dedusters such as scrubbers are also available but are less used. The efficiency of these techniques is optimum when they are correctly dimensioned.

For the **uses of solvents in industry**, the chapter 8.3. details the techniques available to comply with limit values. They are based on primary measures such as low solvent content or solvent free products, higher efficient means of application and secondary measures such as thermal or catalytic oxidation, activated carbon adsorption, biological scrubbing.

For **road vehicles**, it could be recommended to develop the legal framework to introduce stricter standards such as Euro 6c and 6d for new light duty vehicles based on real driving condition test procedure (review of limit values of Annex VIII [53].
Many different approaches can also be implemented to reduce emissions from road transport. Measures such as development of public transport, improvement of their attractiveness, incentives to use public transport, development of car sharing schemes, promotion of walking and cycling in cities, can be foreseen. These measures enable an integrated approach that can provide benefits for air quality and climate change.

For Non-Road Mobile Machinery (NRMM), the introduction of stricter standards could be foreseen for new engines introduced on the market.

7.7. References of chapter 7 Armenia

[1] Convention on Long-Range Transboundary Air Pollution (CLRTAP). https://unece.org/sites/default/files/2021-05/1979%20CLRTAP.e.pdf

[2] Status of the ratification of Convention on Long-Range Transboundary Air Pollution (CLRTAP). https://treaties.un.org/Pages/ViewDetails.aspx?src=TREATY&mtdsg_no=XXVII-1&chapter=27&clang=_en

[3] Emep Protocol. Status of ratification: https://treaties.un.org/Pages/ViewDetails.aspx?src=TREATY&mtdsg_no=XXVII-1&chapter=27&clang=_en

[4] Protocols of the CLRTAP. Status of ratification: https://unece.org/protocols - Web site accessed in April 2023

[5] “National Action plan for ratification of CLRTAP protocols and meeting of correspondent commitments”

[6] Olga Melnicenko. National Action Plan for ratification of the Conventions key Protocols. UNECE. 2019

[7] Comprehensive and Enhanced Partnership Agreement (CEPA) between the European Union and the European Atomic Energy Community and their Member States, of the one part, and the Republic of Armenia, of the other part. Official Journal of the European Union. 26 January 2018. https://www.eeas.europa.eu/armenia/european-union-and-armenia_en?s=216

[8] Leaflet CEPA

[9] Information provided to Citepa by Gayane Shahnazaryan and hear team, Deputy Director Hydrometeorology and Monitoring Center, Ministry of Environment in 2023

[10] G. Shahnazaryan. Thematic session on barriers towards ratification and implementation of the AGP for Armenia. EB meeting of December 2022.

[11] IIR and NFR of Armenia, submission 2023. https://www.ceip.at/status-of-reporting-and-review-results/2023-submission

[12] Scientific Research Institute of Energy. Energy balance of the Republic of Armenia for 2021. 2022

[13] IEA, Armenia 2022, Energy Policy review. 2023

[14] RA Government decision N 81-N decree (January 30, 2020)

[15] EU4Climate project. Concept for improving air quality monitoring in Armenia.

[16] Air quality monitoring and data management in Armenia, G. Shahnazaryan 2020. 1st webinar on health and air quality data informing policy and the public

[17] RA Government decision, N 160, 2006

[18] Directive 2008/50/EC of the European Parliament and of the Council of 21May 2008 on ambient air quality and cleaner air for Europe

[19] Directive 2004/107/EC of the European Parliament and of the Council of 15 December 2004 relating to arsenic, cadmium, mercury, nickel, and polycyclic aromatic hydrocarbons in ambient air

[20] European Commission, Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control)

[21] Directive 2004/42/EC of the European Parliament and of the Council of 21 April 2004 on the limitation of emissions of volatile organic compounds due to the use of organic solvents in certain paints and varnishes and vehicle refinishing products and amending Directive 1999/13/EC

[22] European Parliament and Council Directive 94/63/EC of 20 December 1994 on the control of volatile organic compound (VOC) emissions resulting from the storage of petrol and its distribution from terminals to service stations. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:31994L0063

[23] Council Directive 1999/32/EC of 26 April 1999 relating to a reduction in the sulphur content of certain liquid fuels and amending Directive 93/12/EEC

[24] 1994 Law on Atmospheric Air Protection

[25] Amended Law on Atmospheric air protection - 2022

[26] EU4Environment (2022), The Environmental Compliance Assurance System in Armenia: Current Situation and Recommendations.

[27] Government of Armenia (2006), *Resolution of the Government of Armenia on the Limit of Permissible Concentrations of Atmospheric Pollutants*, Government of Armenia.

[28] Government of Armenia (2014), *Law on Inspection Bodies*, Government of Armenia

[29] Government of Armenia (2019), Methodology and General Description of Criteria Determining Risks-Based Decree on the Risk Assessment Conducted by the Environmental Protection and Mining Inspection Body of Armenia.

[30] V. Galoyan, Environmental Protection and Mining Inspection Body, Sharing experience on benefits and challenges of risk base approaches. EU4Environment. 25 November 2020

[31] V. Galoyan, Policies and tools for enforcement of environmental compliance – a regional seminar with Eastern Partner countries. EU4Environment.17 November 2021

[32] Government of Armenia (2005), Law on Environmental Control, Government of Armenia

[33] Economic Commission for Europe, Executive Body for the Convention on Long-range Transboundary Air Pollution, 1999 Protocol to Abate Acidification, Eutrophication and Ground-level Ozone to the Convention on Long-Range Transboundary Air Pollution, as amended on 4 May 2012, 2012

[34] Decision of the government of the republic of Armenia of 22 April 2021 n 610 – l on approval of the nationally determined contribution 2021-2030 of the Republic of Armenia to Paris agreement

[35] European Commission, Directive 2009/125/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for the setting of Eco-design requirements for energy-related products, 2009

https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32009L0125

[36] Commission Regulation (EU) 2015/1185 of 24 April 2015 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to eco-design requirements for solid fuel local space heaters. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32015R1185

[37] Commission Regulation (EU) 2015/1189 of 28 April 2015 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to eco-design requirements for solid fuel boilers. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2015.193.01.0100.01.ENG

[38] Directive 2009/126/EC of the European Parliament and of the Council of 21 October 2009 on Stage II petrol vapour recovery during refuelling of motor vehicles at service stations, 2009

[39] Directive (EU) 2016/802 of the European Parliament and of the Council of 11 May 2016 relating to a reduction in the sulphur content of certain liquid fuels https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32016L0802

[40] Technical Regulation of the Eurasian Economic Union 013/2011 “Requirements for automotive and aviation gasoline, diesel and marine fuel, jet fuel and fuel oil” https://docs.cntd.ru/document/902307833

[41] RA Government Decision on “The regulation of use of motor fuel”, №1592-N, 11.11.2004

[42] Technical Regulation Customs Union. Eurasian Economic Union. TR CU 018/2011 on the safety of wheeled vehicles.

[43] François Cuenot. Mechanical engineer. UNECE. Information provided to Citepa on 24 July 2023

[44] Regulation UNECE Consolidated Resolution on the Construction of Vehicles (R.E.3) Revision 7. Consolidated Resolution on the Construction of Vehicles (R.E.3) Revision 7 | UNECE

[45] Directive 97/68/EC of the European Parliament and of the Council of 16 December 1997 on the approximation of the laws of the Member States relating to measures against the emission of gaseous and particulate pollutants from internal combustion engines to be installed in non-road mobile machinery (currently repealed). https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:31997L0068

[46] Eurasian Economic Union (EAEU). https://www.gov.kz/memleket/entities/mfa/press/article/details/583?lang=en - Web site accessed in July 2023

[47] https://climatepromise.undp.org/what-we-do/where-we-work/armenia

[48] https://www.arlis.am/documentview.aspx?docID=141635

[49] https://www.arlis.am/documentview.aspx?docID=115020

[50] Code of good practice for wood-burning and small combustion installations, 2019. https://unece.org/DAM/env/documents/2019/AIR/EB/ECE_EB.AIR_2019_5-1916518E.pdf

[51] Prioritizing reductions of particulate matter from sources that are also significant sources of black carbon - analysis and guidance, 2021. https://unece.org/sites/default/files/2021-10/ECE_EB.AIR_2021_6-2113500E.pdf

[52] TFTEI Techno-Scientific Board. TFTEI background informal technical document for the Review of the Gothenburg Protocol for Industrial Processes Annexes IV, V, VI, X and XI March 2022. Informal document to the 60th WGSR meeting. https://unece.org/sites/default/files/2022-03/TFTEI%20review%20of%20Annexes%20to%20the%20Gothenburg%20Protocol.pdf

[53] TFTEI Techno-Scientific Board. TFTEI background informal technical document for the Review of the Gothenburg Protocol for mobile sources, Annex VIII. August 2023. Informal document to the 61st WGSR in September 2023.

https://unece.org/sites/default/files/2023-08/TFTEI-%20Informal%20bakground%20document%20on%20review%20of%20Annex%20VIII%20-%20Mobile%20Sources%20of_0.pdf

[54] Bessagnet, N. Allemand, Review on Black Carbon (BC) and Polycyclic Aromatic Hydrocarbons (PAHs) emission reductions induced by PM emission abatement, TFTEI 2019

[55] WGSR 56th. May 2018. Thematic session on residential wood combustion and air pollution. https://unece.org/info/Environmental-Policy/Air-Pollution/events/20267

[56] T. Lecomte, J.F. de la Fuente, F. Neuwahl, M. Canova, A. Pinasseau, I. Jankov, T. Brinkmann, S. Roudier, L. Delgado-Sancho, Best Available Techniques (BAT) Reference Document for Large Combustion Plants: Industrial Emissions Directive 2010/75/EU (Integrated Pollution Prevention and Control) 2017.

[57] TFTEI Techno-Scientific Board. Guidance document on control techniques for emissions of sulphur, NOx, VOC, and particulate matter (including PM_{10}, $PM_{2.5}$ and black carbon) from stationary sources. ECE/EB.AIR/117. 2012. https://unece.org/gothenburg-protocol

7.8. Annex related to regulation TR CU 018/2011

Annex 3

Clause 12. Emission requirements for vehicles of categories M1 with a maximum mass exceeding 3.5 tonnes, M2, M3, N2, N3 with petrol engines.

The emission levels for the individual environmental classes are set in accordance with Table 12.1:

Environmental class	**Emission levels**
3	CO - 20 g/kWh, HC - 1.1 g/kWh, NOx - 7 g/kWh (at tests according to UNECE Regulation No. 49-04 (ESC test cycle))
4	CO - 4 g/kWh, HC - 0.55 g/kWh, NOx - 2 g/kWh (in case of tests according to UNECE Regulation No. 49-05 (ESC test cycle))

Clause 13. Emission requirements for hybrid vehicles with a reference mass exceeding 2,610 kg and the power units fitted to them power plants.

Note: For the emissions of vehicles with a reference mass of 2610 kg or less, the requirements of UNECE Regulation No. 83 shall apply.

the requirements of UNECE Regulation No. 83 shall apply.

13.1. The emissions of hybrid vehicles and their power packs shall comply with the emission limit values given in Table 13.1 for individual ecological classes when testing complete power plant assemblies in accordance with the UNECE Regulation No. 49-05 methodology using the ETC cycle.

Table 13.1:

Environmental class	Emission and smokiness limit values				
	CO g/kWh	NMHC g/kWh	CH4 g/kWh	NOX g/kWh	PM g/kWh
4	4,0	0,55	1,1[1)]	3,5	0,03[2)]
5	4,0	0,55	1,1[1)]	2,0	0,03[2)]

Notes:

[1)] For Compressed Natural Gas (CNG) fueled engines only Compressed natural gas (CNG) engines only;

[2)] For diesel fueled engines only;

13.2 Vehicles and their installed power plant shall fulfil the requirements for on-board diagnostics and reliability in accordance with the requirements of UNECE Regulation No. 49-05. UNECE Regulation No. 49-05.

4.1 Emission requirements of vehicles of categories M and N

The vehicle shall be deemed to comply with the requirements of this technical regulation and ecological class 4 when fulfilment of at least the following conditions:

4.1.1. The year of manufacture (model year) of the vehicle is not earlier than 2007 г.

Note: A vehicle of an earlier year of manufacture (model year) shall be deemed to comply with the requirements of this technical regulation. (model year) shall be deemed to comply the requirements of this technical regulation and ecological class 4 in the presence of a notification of type approval report or certificate of conformity issued by a member State of the Customs Union on the basis of the results of the Customs Union on the basis of the results of tests according to the UNECE Regulations specified in Table 3 of Annex No. 1 of this technical regulation Table 3 of Annex No. 1 of this technical regulation of this technical regulation.

4.1.2. For vehicles of categories M1 with a gross vehicle mass of not more than 3.5 tonnes and N1 M1 vehicles with a gross vehicle mass not exceeding 3.5 tonnes and N1 vehicles, it is mandatory to have the on-board diagnostic system (with regard to environmental performance) in a serviceable condition. for environmental indicators) in a serviceable condition.

4.1.3. For vehicles of categories M1 with a gross vehicle mass of more than 3.5 tonnes, M2, M3, N2, N3 of 2008 and later years of manufacture with diesel engines and of 2010 and later years of manufacture with diesel engines. 2010 and later years of manufacture with gas engines -. mandatory availability of on-board diagnostics system in operable condition.

4.1.4 Equipping with toxicity reduction devices and systems in good working order, as a minimum:

vehicles of categories M1 with a gross vehicle mass up to 3.5 tonnes and N1 with forced-ignition engines - catalytic converter;

vehicles of categories M1 up to 3.5 t GVW and N1 with diesel engines - exhaust gas recirculation system and (or) catalytic converter and/or particle filter;

vehicles of categories M1 with a gross vehicle mass exceeding 3.5 tonnes, M2, M3, N2, N3 with diesel engines - exhaust gas recirculation system and particle filter (catalytic converter and (or) particle filter exhaust gas recirculation system and particle filter (catalytic converter) or a catalytic converter and particle filter or selective converter nitrogen oxides (using urea solution); vehicles of all categories with petrol engines - with a hydrocarbon trap from the petrol tank (absorber).

4.1.5. The on-board diagnostic system (if any) shall confirm completeness and operability of the systems ensuring the level of emissions.

4.1.6. The design of the power system, exhaust system and systems, emissions systems have not been modified. modifications.

8. Techniques available to comply with limit values of the Amended Gothenburg Protocol

The following tables summarize the current emission limit values (ELVs) implemented by the AGP, and describe the techniques applicable to achieve similar or lower levels of emissions.

In the Amended Gothenburg Protocol (AGP), large combustion plants are defined as installations with a rated thermal power input capacity higher than 50 MWth. The rated thermal input of the combustion plant is calculated as the sum of the input of all units connected to a common stack. Individual units below 15 MWth shall not be considered when calculating the total rated thermal input (ELV are applied to all unit even those bellow 15 MWth).

For large combustion plants, in the light of the current regulations, this analysis is presented per pollutant, fuel type, thermal input power range and installation status (new or existing). For the latter, a “new” stationary source is considered as an installation for which construction or modification was initiated before the expiry of one year from the date of entry into force of the AGP for the Party (Chapters 8.1.1, 8.2.1 and 8.3.1).

8.1. Annex IV of the GP, SOx emissions

8.1.1. Limit values for SO_2 emissions released from combustion plants

Table 8-1: Table 1, Annex IV, limit values for emissions of sulphur from combustion plants andtechniques available for compliance

Pag.	Limit values	Reduction techniques available	Potential Applicability (%)
37-38	Table 1: Limit values for SO_2 emissions released from combustion plants		
	Coal, lignite and other solid fuels: Combustion plant with a thermal input capacity between 50 and 100 MW New and existing plants: 400 mg/m^3 at 6 % O_2 Combustion plant with a thermal input capacity between 100 and 300 MW: New plants: 200 mg/m^3 at 6 % O_2 Existing plants: 250 mg/m^3 at 6 % O_2 Combustion plant with a thermal input capacity exceeding 300 MW: New plants: 150 mg/m^3 at 6 % O_2 (200 mg/m^3 at 6 % O_2 if fluidised bed boiler) Existing plants: 200 mg/m^3 at 6 % O_2	The means to achieve ELVs is the application of one or a combination of the following techniques [1] [2][3]: - boiler sorbent injection - duct sorbent injection (DSI) - spray dry absorber (SDA) - circulating fluidised bed (CFB) dry scrubber - wet scrubbing - wet flue-gas desulphurisation (FGD) - seawater FGD	Almost 100 %. Some limitations may exist for FGD if: - the plant operates less than 500 hours per year, - it is for retrofitting on existing combustion plant operating less than 1,500 hours per year, - the combustion plant is less than 300 MW_{th}, there may be technical and economic restrictions

Pag.	Limit values	Reduction techniques available	Potential Applicability (%)
	Solid biomass and peat: Combustion plant with a thermal input capacity between 50 and 100 MW – New and existing plants: Peat: 300 mg/m^3 at 6 % O_2 Biomass: 200 mg/m^3 at 6 % O_2 Combustion plant with a thermal input capacity between 100 and 300 MW – New and existing plants: Peat: 300 mg/m^3 at 6 % O_2 Biomass: 200 mg/m^3 at 6 % O_2 Combustion plant with a thermal input capacity exceeding 300 MW: New plants: Peat: 150 mg/m^3 at 6 % O_2 (200 mg/m^3 at 6 % O_2 if fluidised bed boiler) Biomass: 150 mg/m^3 at 6 % O_2 Existing plants: Peat: 200 mg/m^3 at 6 % O_2 Biomass: 200 mg/m^3 at 6 % O_2	The means to achieve the associated environmental levels is the application of one or a combination of the following techniques [1][2][3]: - boiler sorbent injection - duct sorbent injection (DSI) - spray dry absorber (SDA) - circulating fluidised bed (CFB) dry scrubber - wet scrubbing - flue gas condenser - wet flue-gas desulphurisation (FGD)	Almost 100 %. Some limitations may exist for FGD if: - the plant operates less than 500 hours per year, - it is for retrofitting on existing combustion plant operating less than 1,500 hours per year, there may be technical and economic restrictions
	Liquid fuels: Combustion plant with a thermal input capacity between 50 and 100 MW – New and existing plants: 350 mg/m^3 at 3 % O_2 Combustion plant with a thermal input capacity between 100 and 300 MW: New plant: 200 mg/m^3 at 3 % O_2 Existing plant: 250 mg/m^3 at 3 % O_2 Combustion plant with a thermal input capacity exceeding 300 MW: New plant: 150 mg/m^3 at 3 % O_2 Existing plants: 200 mg/m^3 at 3 % O_2	The means to achieve the associated environmental levels is the application of one or a combination of the following techniques [1][2][3]: - duct sorbent injection (DSI) - spray dry absorber (SDA) - flue-gas condenser - wet flue-gas desulphurisation (FGD) - seawater FGD	Almost 100 %, except FGD for plants operating less than 500 hours per year. Some limitations may exist for FGD if: - it is for retrofitting on existing combustion plant operating less than 1,500 hours per year, - the combustion plant is less than 300 MW_{th}, there may be technical and economic restrictions.
	Gaseous fuels:		

Pag.	Limit values	Reduction techniques available	Potential Applicability (%)
	Combustion plant with a thermal input capacity exceeding 50 MW – New and existing plants: Gaseous fuels in general: 35 mg/m^3 at 3 % O_2 Liquefied gas: 5 mg/m^3 at 3 % O_2 Iron and steel process gas Coke oven gas: 400 mg/m^3 at 3 % O_2 Blast furnace gas: 200 mg/m^3 at 3 % O_2 Gasified refinery residues new plant: 35 mg/m^3 at 3 % O_2 existing plant: 800 mg/m^3 at 3 % O_2	For iron and steel process gases only [1] [2][3]: The means to achieve the ELVs is the application of one or a combination of the following techniques: - process gas management system and auxiliary fuel choice (use low sulphur content auxiliary fuels), - desulphurisation by absorption systems, - wet oxidative desulphurisation	For iron and steel process gases only: Desulphurisation by absorption and wet oxidative desulphurisation are only applicable to cove-oven gas combustion plants.
	Chemical industry process fuels: [for boilers in the chemical industry; no distinction		

8.1.2. Limit values for the sulphur content of gas oil

Table 8-2: Table 2, Annex IV, ELVs for the Sulphur content of gas oil and techniques available for compliance

Page	Limit values	Reduction techniques available	Applicability (%)
38	Annex IV Table 2: Limit values for the sulphur content of gas oil Sulphur content (per cent by weight) Gas oil < 0.10%	Sulphur reduction in the oil refining process through refinery fuel oil (RFO) desulphurisation by hydro-treatment in addition to selection of low-sulphur crude [4][5]	Almost 100 %.

8.1.3. Limit values for SO_x for Sulphur recovery units in oil and gas refineries

Table 8-3: Table 3, Annex IV, Sulphur recovery rate in sulphur recovery units for off-gas treatment

Page	Limit values	Reduction techniques available	Potential Applicability (%)
39	Annex IV Table 3: Limit value ed as a minimum sulphur recovery sulphur recovery units New plant: 99.5 %	Specific unit that generally consists of a Claus process for sulphur removal of hydrogen sulphide (H_2S)-rich gas streams from amine treating units and sour water strippers. SRU is generally followed by a tail gas treatment unit (TGTU) for remaining H_2S removal [4][5]	Almost 100 %
	Existing plant: 98.5 %		Almost 100 %

In mineral oil and gas refineries, the sulphur from the fuels has to be removed. This mainly ends up as H_2S in acid by-product gases from which sulphur is removed and recovered. These sulphur recovery units (SRUs) generally consist of a Claus process for sulphur removal of hydrogen sulphide (H_2S)-rich gas streams from amine treating units and sour water strippers.

The multi-step Claus process recovers sulphur from the gaseous hydrogen sulphide found in raw natural gas and from the by-product gases derived from refining crude oil and other industrial processes. Main chemical reactions taking place in the Claus process are as follows:

$$2\ H_2S + 3\ O_2 \rightarrow 2\ SO_2 + 2\ H_2O \text{ (thermal step)}$$

$$4\ H_2S + 2\ SO_2 \rightarrow 3\ S_2 + 4\ H_2O \text{ (catalytic step)}$$

SRU is generally followed by a tail gas treatment unit (TGTU) for remaining H_2S removal. TGTU is family of techniques, additional to the SRU in order to enhance the removal of sulphur compounds. They can be divided into four categories according to the principles applied [5]:

- direct oxidation to sulphur
- continuation of the Claus reaction in multiple reactors (multistage Claus process)
- oxidation to SO_2 and recovering sulphur from SO_2
- reduction to H_2S and recovery of sulphur from this H_2S (e.g. through an amine process)

8.1.4. Limit values for SO_x emissions released from titanium dioxide production

Table 8-4: Table 4, Annex IV, ELVs for SOx emissions from TiO_2 production and techniques available for compliance

Page	Limit values	Reduction techniques available	Potential Applicability (%)
39	Sulphate process: ELV for SO_x (expressed as SO_2) (kg/t of TiO_2): total emission: 6 kg/t as yearly average	Multi-stage scrubbing [6]: 1. scrubbed with recycled waste water 2. quenched and then scrubbed with caustic soda solution. 3. quenched, passed through an electrostatic precipitator (removing SO_3 aerosols) 4. Removal of SO_2 via oxidation with aqueous H_2O_2 to produce sulphuric acid which is re-used Removing H_2S by absorption in an aqueous suspension of ZnO	Almost 100 %
	Chloride process: ELV for SOx (expressed as SO_2) (kg/t of TiO_2): total emission: 1.7 kg/t as yearly average	Specific configurations of a multistage waste gas treatment unit based on liquid scrubbing with caustic soda or water → sulphur is removed for sale	Almost 100 %

Titanium dioxide (TiO_2) is an inorganic compound currently produced using two distinct processing routes:

1. In the chloride process, the ore is treated with chlorine and carbon to give titanium tetrachloride, a volatile liquid that is further purified by distillation. The $TiCl_4$ is treated with oxygen to regenerate chlorine and produce the titanium dioxide.
2. In the sulphate process, ilmenite concentrate (45-60% TiO_2) is treated with sulphuric acid to extract iron (II) sulphate pentahydrate. The resulting synthetic rutile is further processed according to the specifications of the end user, i.e. pigment grade.

8.2. Annex V of the GP, NOx emissions

8.2.1. Limit values for NOx emissions released from combustion plants

Table 8-5: Table 1, Annex V, ELVs for emissions of nitrogen oxides from combustion plants and and techniques available for compliance

Pag.	Limit values	Reduction techniques available	Potential Applicability (%)
42-43	Annex V, Table 1: Limit values for NO_x emissions released from combustion plants		
	Coal, lignite and other solid fuels: Combustion plant with a thermal input capacity between 50 and 100 MW – New and existing plants: Coal, lignite and other solid fuels: 300 mg/m^3 at 6 % O_2 Pulverised lignite: 450 mg/m^3 at 6 % O_2 Combustion plant with a thermal input capacity between 100 and 300 MW – New and existing plants: 200 mg/m^3 at 6 % O_2 Combustion plant with a thermal input capacity exceeding 300 MW: New plants: Coal, lignite and other solid fuels: 150 mg/m^3 at 6 % O_2 [Pulverised lignite: 200 mg/m^3 at 6 % O_2 Existing plants: 200 mg/m^3 at 6 % O_2	The means to achieve the associated environmental levels is the application of one or a combination of the following techniques [1] [2][3]: - combustion optimisation - combination of primary techniques for NO_x reduction such as air or fuel staging, flue-gas recirculation, low-NO_x burners (LNB) - selective non-catalytic reduction (SNCR) - selective catalytic reduction (SCR)	Almost 100 %, except for SCR for combustion plant less than 100 MW_{th}. Some limitations may exist for SNCR if the plant operates less than 1,500 hours per year with highly variable loads and/or if the cross-sectional area is large enough to prevent homogeneous mixing of NH_3 and NO_x. SCR is not applicable for plants smaller than 300 MW_{th} which operate less than 500 hours per year. Technical and economic barriers can exist for retrofitting on plants operating less than 1,500 hours per year.
	Solid biomass and peat: Combustion plant with a thermal input capacity between 50 and 100 MW: New plants: 250 mg/m^3 at 6 % O_2 Existing plants: 300 mg/m^3 at 6 % O_2 Combustion plant with a thermal input capacity between 100 and 300 MW – New and existing plants: New plants: 200 mg/m^3 at 6 % O_2 Existing plants: 250 mg/m^3 at 6 % O_2	The means to achieve the limit values is the application of one or a combination of the following techniques [1] [2][3]: - combustion optimisation - low-NO_x burners (LNB) - air staging - fuel staging - flue-gas recirculation - selective non-catalytic reduction (SNCR) - selective catalytic reduction (SCR)	Almost 100 %, except for SCR and SNCR if the plant operates less than 500 hours per year, and for SCR for combustion plant less than 100 MW_{th}. Some limitations may exist for SNCR if the plant operates less than 1,500 hours per year with highly variable loads. There may be technical and economic barriers for retrofitting of SCR on plants smaller than 300 MW_{th}.

Pag.	Limit values	Reduction techniques available	Potential Applicability (%)
	Combustion plant with a thermal input capacity exceeding 300 MW: New plants: 150 mg/m^3 at 6 % O_2 Existing plants: 200 mg/m^3 at 6 % O_2		

Pag.	Limit values	Reduction techniques available	Potential Applicability (%)
	Liquid fuels: Combustion plant with a thermal input capacity between 50 and 100 MW: New plants: 300 mg/m^3 at 3 % O_2 Existing plants: 450 mg/m^3 at 3 % O_2 Combustion plant with a thermal input capacity between 100 and 300 MW: New plants: 150 mg/m^3 at 3 % O_2 Existing plants: Liquid fuels in general: 200 mg/m^3 at 3 % O_2 Plant within refineries and chemical installations: Distillation and conversion residues from crude oil refining: 450 mg/m^3 at 3 % O_2 Combustion plant with a thermal input capacity exceeding 300 MW: New plants: 100 mg/m^3 at 3 % O_2 Existing plants: Liquid fuels in general: 150 mg/m^3 at 3 % O_2 Existing plants: Distillation and conversion residues from crude oil refining within refineries and chemical installations: 450 mg/m^3 at 3 % O_2 For process fuels in boilers in the chemical industry: No specific ELVs	The means to achieve the associated environmental levels is the application of one or a combination of the following techniques [1][2][3]: - air staging, - fuel staging, - flue-gas recirculation, - low-NO_x burners (LNB), - water/steam addition, - selective non-catalytic reduction (SNCR), - selective catalytic reduction (SCR), - advanced control system.	Almost 100 %, except for SCR and SNCR if the plant operates less than 500 hours per year, and for SCR for combustion plant less than 100 MW_{th}. Some limitations may exist for SNCR if the plant operates less than 1,500 hours per year with highly variable loads. There may be technical and economic barriers for retrofitting SCR on plants operating less than 1,500 hours per year.

Pag.	Limit values	Reduction techniques available	Potential Applicability (%)
	Gaseous fuels: Combustion plant with a thermal input capacity exceeding 50 MW: Natural gas – New and existing plants: 100 mg/m^3 at 3 % O_2 Other gaseous fuels New plants: 200 mg/m^3 at 3 % O_2 Existing plants: 300 mg/m^3 at 3 % O_2 Process gas in the iron and steel industry No specific ELVs Process gas in the chemical industry No specific ELVs Refineries, gas firing No specific ELVs	The means to achieve the associated environmental levels is the application of one or a combination of the following techniques [1] [2][3]: - combustion optimisation, - air or fuel staging, - flue-gas recirculation, - low-NO_x burners (LNB), - advanced control system, - reduction of combustion temperature, - selective non-catalytic reduction (SNCR), - selective catalytic reduction (SCR).	Almost 100 %, except for SNCR and SCR for plants operating less than 500 hours per year, and for SCR for combustion plant smaller than 100 MW_{th}. Advanced control system application may be limited for retrofitting on old combustion plants. Some limitations may exist for SNCR if the plant operates less than 1,500 hours per year with highly variable loads. Technical and economic barriers can exist for retrofitting of SCR on plants operating less than 1,500 hours per year.

8.2.2. Limit values for NOx emissions released from gas turbines

Table 8-6: Table 2, Annex V, limit values for emissions of nitrogen oxides from gas turbines and and techniques available for compliance

Pag.	Limit values	Reduction techniques available	Potential Applicability (%)
44	Table 2: Limit values for NO_x emissions released from onshore combustion turbines (including Combined Cycle Gas Turbine CCGT) Combustion plant with a thermal input capacity exceeding 50 MW Liquid fuels (light and medium distillates): New plants: 50 mg/m^3 at 15 % O_2 Existing plants: 90 mg/m^3 at 15 % O_2 (200 mg/m^3 at 15 % O_2 if operating less than 1,500 hours a year)	The means to achieve the associated environmental levels is the application of one or a combination of the following techniques [1] [2][3]: - low-NO_x burners (LNB), - water/steam addition, - selective catalytic reduction (SCR).	LNB are applicable only for turbine models for which they are available on the market. SCR is not applicable if the plant operates less than 500 hours per year. There may be technical and economic barriers for retrofitting SCR on plants operating less than 1,500 hours per year. Moreover, retrofitting may be constrained by space availability.
44	Table 2: Limit values for NO_x emissions released from onshore combustion turbines (including Combined Cycle Gas Turbine CCGT)	The means to achieve the associated environmental levels is the application of one or a combination of the following techniques [1] [2][3]:	Advanced control system application is limited for old combustion plants. DLN application is limited in the presence of water/steam addition systems.

Pag.	Limit values	Reduction techniques available	Potential Applicability (%)
	Combustion turbines with a thermal input capacity exceeding 50 MW – New: Natural gas: 50 mg/m^3 at 15 % O_2 Other gases: 50 mg/m^3 at 15 % O_2 [Update Index 2] Combustion turbines with a thermal input capacity exceeding 50 MW – Existing: Natural gas: 50 mg/m^3 at 15 % O_2 (150 mg/m^3 at 15 % O_2 if operating less than 1,500 hours a year) Other gases: 120 mg/m^3 at 15 % O_2 (200 mg/m^3 at 15 % O_2 if operating less than 1,500 hours a year)	- advanced control system, - water/steam addition, - dry low-NO_x burners (DLN) - low-load design concept, - low-NO_x burners (LNB), - selective catalytic reduction (SCR).	LNB are generally applicable to supplementary firing for heat recovery steam generators (HRSGs) in the case of combined- cycle gas turbine (CCGT) combustion plants. SCR is not applicable if the plant operates less than 500 hours per year or for plants smaller than 100 MW_{th}. There may be technical and economic barriers for retrofitting SCR on plants operating less than 1,500 hours per year. Finally, SCR retrofits may be constrained by space availability.

8.2.3. Limit values for NOx emissions released from cement clinker production

In cement production, NOx emissions are influenced by different parameters such as the type of fuel, the type of combustion, the combustion air-ratio and the flame temperature [1]. Thus, to reduce NOx emissions, several primary measures can be implemented as a first step, while additional secondary end-of-pipe measures such as Selective Non-Catalytic Reduction (SNCR) or Selective Catalytic Reduction (SCR) are necessary to meet the emission levels summarized in [7][8]. Both primary and secondary measures and related ELVs are described below.

Table 8-7: Table 3, Annex V, ELVs for NOx emissions from cement clinker production and techniques available for compliance

Pag.	Limit values	Reduction techniques available	Potential Applicability (%)
44	Annex V Table 3: Limit values for NOx emissions released from cement clinker production General (existing and new plants): 500 mg/m^3 at 10 % O_2	The techniques are advanced primary measures (e.g. low NOx burners) associated with SNCR and/or SCR [7][8]	Almost 100 %. Some limitations may exist if the primary measures are not able to reach concentrations below 1000 mg/m^3.
	Existing Lepol and Long Rotary Kilns in which no waste is co in-incinerated 800 mg/m^3 at 10 % O_2	The technique are advanced primary measures (low NOx burners, mid-kiln firing) associated with SNCR and/or SCR [7][8]	Almost 100 %

8.2.4. Limit values for NOx emissions released from new stationary engines

Reference [1] provides a good overview of techniques which may be applied. Primary measures that can be applied for liquid fuel-fired diesel engines, include a base engine optimized for low NOx, fuel injection retards, and the addition of water (such as water injection directly into the combustion space, water-in-fuel emulsion, or humidification of the combustion air). These primary measures are however not efficient enough to abate emissions effectively and the classical end-of-pipe technique for NOx reduction from stationary engines, particularly from diesel engines, is selective catalytic reduction (SCR). A further concept to reduce NO_x in diesel engines is the “Low-NO_x combustion concept”. This technique consists of a combination of internal engine modifications, e.g. combustion and fuel injection optimisation (the very late fuel injection timing in combination with early inlet air valve closing), turbocharging or the so called “Miller cycle”. In the Miller case, the engine leaves the intake valve open during part of the compression stroke, so that the engine is compressing against the pressure of the supercharger rather than the pressure of the cylinder walls. This reduces NO_x formation in diesel engines. Further measures to reduce NO_x are exhaust gas recirculation or water/steam addition [3]. Water or steam is used as a diluent for reducing the combustion temperature in gas turbines, engines or boilers and thus the thermal NO_x formation. It is either premixed with the fuel prior to its combustion (fuel emulsion, humidification or saturation) or directly injected in the combustion chamber (water/steam injection).

For spark ignited Otto engines fuelled by natural gas, propane or gasoline, three-way catalytic converters are effective in preventing air pollution. In this case, the oxidation of carbon monoxide (CO) and hydrocarbons (HC) as well as the reduction of nitrogen oxides (NO_x) occur simultaneously to form the harmless products; carbon dioxide (CO_2), water (H_2O) and nitrogen (N_2).

Table 8-8: Table 4, Annex V, ELVs for NOx emissions from stationary engines and techniques available for compliance

45	Annex V Table 4: Limit values for NOx emissions released from new stationary engines		
	Gas engines > 1 MWth Spark ignited (= Otto) engines all gaseous fuels: ELV (mg/m³)		
	Spark ignited (= Otto) engines: 95 mg/m³ (enhanced lean burn)	The usual abatement technique for CO is through three-way catalysts which also remove NOx, further techniques for lean-burn engines are selective catalytic reduction (SCR) processes [9]	100%
	All gaseous fuels: 190 mg/m³ (Standard lean burn or rich burn with catalyst)	Three-way catalysts, SCR.	100%
	Dual fuel engines > 1 MWth: ELV (mg/m³)		
	In gas mode (all gaseous fuels): 190 mg/m³	Three-way catalysts, SCR.	100%
	In liquid mode (all liquid fuels): 225 mg/m³	Exhaust-gas recirculation, water/steam addition, SCR	100%
	Diesel engines > 5 MWth (compression ignition) Slow (< 300 rpm)/medium (300 rpm–1,200 rpm)/ speed, ELV (mg/m³)		
	5 MWth–20 MWth: Heavy fuel oil and bio oils: 225 mg/m³; Light fuel oil and natural gas: 190 mg/m³	Selective catalytic reduction (SCR)	100%
	20 MWth and high speed (> 1200 rpm): 190 mg/m³ for all fuels	Selective catalytic reduction (SCR)	100%

8.2.5. Limit values for NOx emissions released from iron ore sinter plants

Reference [1] provides a good overview of techniques which may be applied. Beside primary measures such as low NOx burners and waste gas recirculation, NOx reduction is achieved through a Regenerated Activated Carbon Process with additional NH_3 injection or through Selective Catalytic Reduction (SCR) [10][11]. The RAC process as a secondary reduction measure which is mainly applied for desulphurisation but which may additionally reduce NO_x through ammonia injection.

Table 8-9: Table 5, Annex V, ELVs for NOx emissions from iron ore sinter plants and techniques available for compliance

Pag.	Limit values	Reduction techniques available	Potential Applicability (%)
46	Annex V Table 5: Limit values for NOx emissions released from iron ore sinter plants New installations, ELV for NOx (mg/m^3): 400 measured as average values over a longer period of time	Primary measures such as waste gas recirculation and low NOx burners in combination with regenerated activated carbon process (RAC) or selective catalytic reduction (SCR) [10][11]	Almost 100%
	Existing installations, ELV for NOx (mg/m^3): 400 measured as average values over a longer period of time	Primary measures such as waste gas recirculation and low NOx burners in combination with regenerated activated carbon process (RAC) or selective catalytic reduction (SCR) [10][11]	Depending on process specification and space → site specific

8.2.6. Limit values for NOx emissions released from the production of nitric acid

Nitric acid is a key industrial chemical for the production of fertilizers. The current production route of nitric acid is known as “the Ostwald process” in which nitric acid is produced by oxidation of ammonia. The tail gases of the process containing high levels of NO_x is treated in a DeNOx unit before being discharged. The DeNOx unit is normally based on selective catalytic reduction process (SCR) with an additional H_2O_2 absorption in the last stage [1][30]. An established DeNOx process that outperforms the emission levels summarized in [31] is the so called EnviNOx® process.

Table 8-10: Table 6, Annex V, ELVs for NOx emissions from nitric acid production and techniques available for compliance

Pag.	Limit values	Reduction techniques available	Potential Applicability (%)
46	Annex V Table 6: Limit values for NOx emissions released from nitric acid production New installations, ELV for NOx (mg/m^3): 160	Different primary measures and combined NO_x and N_2O abatement in tail gases, selective catalytic reduction (SCR), addition of H_2O_2 to the last absorption stage (EnviNOx) [1] [30][31]	Almost 100%
	Existing installations, ELV for NOx (mg/m^3): 190	Different primary measures and combined NOx and N_2O abatement in tail gases, selective catalytic reduction SCR, addition of H_2O_2 to the last absorption stage (EnviNOx [1] [30][31]	Almost 100%

8.3. Annex VI: limit values for emissions of VOC from stationary sources

Reference [1] provides a good overview of techniques which may be applied. From the date of publication of this UNECE guidance document in 2015, several Reference Documents from the EU have been published, such as:

- Best Available Techniques (BAT) Reference Document on Surface Treatment Using Organic Solvents including Preservation of Wood and Wood Products with Chemicals or STS BREF [13] and the associated decision [14]. The scope of this reference document covers the largest industrial solvent consumers with a solvent consumption higher than 200 tons.
- Best Available Techniques (BAT) Reference document for the Tanning of Hides and Skins of 2013[15],
- Commission implementing Decision of 11 February 2013 establishing the best available techniques (BAT) conclusions under Directive 2010/75/EU of the European Parliament and of the Council on industrial emissions for the tanning of hides and skins of 2013[16],
- Best Available Techniques (BAT) Reference Document for the Food, Drink and Milk Industries of 2019 [18],
- Commission implementing Decision (EU) 2019/2031 of 12 November 2019 establishing best available techniques (BAT) conclusions for the food, drink and milk industries, under Directive 2010/75/EU of the European Parliament and of the Council of 2019 [19].
- Best available techniques (BAT) reference document for Common waste gas management and treatment systems in the chemical sector, 2023 [20].

8.3.1. Limit values for VOCs classified as CMR

Article 5 in Annex VI of the current GP is as in the following:

> 5. The following ELVs apply for waste gases containing substances harmful to human health:
>
> (a) 20 mg/m^3 (expressed as the mass sum of individual compounds) for discharges of halogenated VOCs, which are assigned the following risk phrases: “suspected of causing cancer” and/or “suspected of causing genetic defects”, where the mass flow of the sum of the considered compounds is greater than or equal to 100 g/h; and
>
> (b) 2 mg/m^3 (expressed as the mass sum of individual compounds) for discharges of VOCs, which are assigned the following risk phrases: “may cause cancer”, “may cause genetic defects”, “may cause cancer by inhalation”, “may damage fertility”, “may damage the unborn child”, where the mass flow of the sum of the considered compounds is greater than or equal to 10 g/h.

Chemical substances can have various harmful effects on human health. They can be characterised as "CMR", for carcinogenic, mutagenic or toxic for reproduction. The Classification, Labelling and Packaging regulation (CLP) in the EU [32]introduces hazard categories that define the level of evidence of the observed CMR effects. Two categories are defined:

- Category 1 which is divided into 2 sub-categories:
  - 1A which includes the substances that are known of being CMR to humans and carrying the hazard statements H340, H350, H360.

- 1B which includes the substances that are presumed of being CMR to humans and carrying the hazard statements H340, H350, H360.

- Category 2 which covers the substances that are suspected of being CMR to humans and the hazard statements H341, H351, H361.

When a CMR substance is identified, it should be eliminated or replaced whenever technically possible. Moreover, a chemical management system that includes an inventory of all the hazardous substances and substances of very high concern used in the process(es) is a method for managing this type of products [20]. The potential for substitution of the substances that are listed in this inventory, focusing on those substances other than raw materials, can be analysed periodically (e.g. annually) in order to identify possible new available and safer alternatives, with no or lower environmental impacts [20].

According to the BREF WGC [20], the Best Available Technique are as in the following:

- A chemical management system that includes an inventory of the hazardous substances and substances of very high concern used in the process(es) can be developed for managing this type of products.
- The potential for substitution of the substances that are listed in this inventory, focusing on those substances other than raw materials, is analysed periodically (e.g. annually) in order to identify possible new available and safer alternatives, with no or lower environmental impacts [20].
- Common VOC emission reduction techniques are also used.

Reference [1] provides a good overview of techniques which may be applied.

8.3.2. Limit values for VOC emissions released from storage and distribution of petrol, excluding the loading of seagoing ships

The current limit values are as in the following table 1 of Annex VI of the GP:

Limit values for VOC emissions from the storage and distribution of petrol, excluding the loading of seagoing ships (stage I)

Activity	Threshold value	ELV or reduction efficiency
Loading and unloading of mobile container at terminals	5,000 m^3 petrol throughput annually	10g VOC/m^3 including methane[a]
Storage installations at terminals	Existing terminals or tank farms with a petrol throughput of 10,000 Mg/year or more New terminals (without thresholds except for terminals located in small remote islands with a throughput less than 5,000 Mg/year)	95 wt-%[b]
Service stations	Petrol throughput larger than 100 m^3/year	0.01wt-% of the throughput

[a] The vapour displaced by the filling of petrol storage tanks shall be displaced either into other storage tanks or into abatement equipment meeting the limit values in the table above.

[b] Reduction efficiency expressed in % compared to a comparable fixed-roof tank with no vapour-containment controls, i.e., with only a vacuum/pressure relief valve.

[c] Vapours displaced by the delivery of petrol into storage installations at service stations and in fixed-roof tanks used for the intermediate storage of vapours must be returned through a vapour-tight connection line to the mobile container delivering the petrol. Loading operations may not take place unless the arrangements are in place and properly functioning. Under these conditions, no additional monitoring of the compliance with the limit value is required.

Reference [1] provides a good overview of techniques which may be applied from the terminal to the service stations.

Stage I controls mainly consist of vapour balance lines and vapour recovery units (VRU) to recover petrol. Modified loading, e.g. bottom loading of road tankers, results in a smaller vapour loss than top loading. Bottom loading enables reduced VOC emissions compared to top loading and importantly permits more efficient vapour collection than with modified top loading arms. Vapours collected at service stations from the discharge of petrol from road tankers can be returned via the road tankers and recovered in the terminal VRU. The VRU unit is based on adsorption on activated carbon, absorption, membrane separation or hybrid systems combining cooling/absorption and compression/absorption/membrane separation. The overall efficiency of VRU ranges from 95% to more than 99%. Stage I controls also mean modifications to road and rail tankers and to ships and barges. In the latter cases, extra care must be taken to maintain safety standards particularly to prevent propagation of ignition and over- or under-pressurisation of cargo tanks.

8.3.3. Limit values for VOC emissions released from car refuelling at service stations

The current limit values are as in the following table 2 of the Annex VI of the GP:

Limit values for VOC emissions for car refuelling at service station (stage II)

Threshold values	Minimum vapour capture efficiency wt-% [a]
New service station if its actual or intended throughput is greater than 500 m^3 per annum Existing service station if its actual or intended throughput is greater than 3,000 m^3 per annum as of 2019 Existing service station if its actual or intended throughput is greater than 500 m^3 per annum and which undergoes a major refurbishment	Equal to or greater than 85 wt-% with a vapour/petrol ratio equal to or greater than 0.95 but less than or equal to 1.05 (v/v)

[a] The capture efficiency of the systems has to be certified by the manufacturer in accordance with relevant technical standards or type approval procedures.

The Directive 2009/126/EC of the European Parliament and of the Council of 21 October 2009 on Stage II petrol vapour recovery during refuelling of motor vehicles at service stations consolidated by the Commission Directive 2014/99/EU of 21 October 2014 amending, for the purposes of its adaptation to technical progress, Directive 2009/126/EC on Stage II petrol vapour recovery during refuelling of motor vehicles at service stations is well represented in the table 2 of the Annex VI of the GP [22][23].

Reference [1] provides a good overview of techniques which may be applied. VOC emissions from car refuelling can be controlled by vapour balancing systems, so-called stage II controls, or by an enlargement of the on-board canister already installed on automobiles to capture fuel system hot soak losses. Stage II controls are technically capable of achieving a 85–92% recovery (depending on the capture efficiency). Active vapour recovery systems or stage II controls are based on the following principle: the petrol air vapour mixture escaping from the vehicle tank during filling is sucked off at the vapour spout of the nozzle and vapours are returned back to the storage tank. The air/vapour mixture is returned proportionally to the flow rate of petrol delivered.

8.3.4. Limit values for VOC emissions released from adhesive coating

Reference [1] provides a good overview of techniques which may be applied. The solvent management plan which is an essential tool to determine the solvent consumptions and emissions, especially fugitive VOCs emissions, and define the abatement strategy if necessary is described in reference [33]. Both primary and secondary abatement techniques are available to comply with limit values as described in the following:

Table 8-11: Annex VI, table 3, ELVs for VOC emissions from adhesive coating and techniques available for compliance

Pag.	Limit values	Reduction techniques available	Potential Applicability (%)
54	Table 3: Limit values for adhesive coating Footwear manufacture (solvent consumption > 5 Mg/year) 25 g VOC / pair of shoes Other adhesive coating (solvent consumption 5 Mg/year–15 Mg/year) ELVc = 50 mg C/m^3 (150 mg C/m^3 if techniques enabling solvent recovery) ELVf = 25 wt-% or less of the solvent input. Or total ELV of 1.2 kg or less of VOC/kg of solid input Other adhesive coating (solvent consumption 15 Mg/year–200 Mg/year) ELVc = 50 mg C/m^3 (150 mg C/m3 if techniques enabling solvent recovery) ELVf = 20 wt-% or less of the solvent input. Or total ELV of 1 kg or less of VOC/kg of solid input Other adhesive coating (solvent consumption > 200 Mg/year) ELVc = 50 mg C/m^3 (100 mg C/m^3 if techniques enabling solvent recovery) ELVf = 15 wt-% or less of the solvent input. Or total ELV of 0.8 kg or less of VOC/kg of solid input	Reduction of VOC emissions is based on a series of BAT related to raw materials (such as high solids coatings, varnishes…) and their optimal uses (reduced consumption through adequate application techniques…), minimising the use of solvent-based cleaning agents, the reduction of fugitive emissions by applying principles of good housekeeping, use of secondary flue gas reduction techniques [1][13][14] The associated monitoring for total VOC emissions and fugitive emissions is to monitor total and fugitive VOC emissions by compiling, at least once every year, a solvent mass balance of the solvent inputs and outputs of the plant [13][14] [32][33]. For VOC emissions in waste gases BAT is to monitor emissions in waste gases with at least the frequency given below and in accordance with EN standards. If EN standards are not available, BAT is to use ISO, national or other international standards that ensure the provision of data of an equivalent scientific quality) [13][14] [33]. In order to reduce the energy consumption of the VOC abatement system, BAT is to use one or a combination of the following techniques: (a) maintaining the VOC concentration sent to the off-gas treatment system by using variable-frequency drive fans; (b) internal concentration of solvents in the waste gases; (c) external	.

Pag.	Limit values	Reduction techniques available	Potential Applicability (%)
		concentration of solvents in the waste gases through adsorption; (d) plenum technique to reduce waste gas volume [13][14].	

8.3.5. Limit values for VOC emissions released from coating activities in the vehicle industry

Reference [1] provides a good overview of techniques which may be applied. The solvent management plan which is an essential tool to determine the solvent consumptions and emissions, especially fugitive VOCs emissions, and define the abatement strategy if necessary is described in reference [33]. Both primary and secondary abatement techniques are available to comply with limit values as described in the following:

The techniques available to comply with limit values are as in the following:

Table 8-12: Table 5, Annex VI, ELVs of VOC emissions from coating activites in the vehicle industry and techniques available for compliance

Pag.	Limit values	Reduction techniques available	Potential Applicability (%)
54/55	Table 5: Limit values for coating activities in the vehicle industry 1/ Manufacture of cars (M1, M2) Solvent consumption > 15 Mg/year and ≤ 5,000 coated items a year or > 3,500 chassis built: 90 g VOC/m² or 1.5 kg/body + 70 g/m² (yearly) Solvent consumption 15 Mg/year – 200 Mg/year and > 5,000 coated items a year: Existing installations: 60 g VOC/m² or 1.9 kg/body + 41 g/m² (yearly) New installations: 45 g VOC/m² or 1.3 kg/body + 33 g/m² (yearly) Solvent consumption > 200 Mg/year and > 5,000 coated items a year): 35 g VOC/m² or 1 kg/body + 26 g/m² (yearly) 2/ Manufacture of truck cabins (N1, N2, N3) Solvent consumption > 15 Mg/year and ≤ 5,000 coated items/year Existing installations: 85 g VOC/m² New installations: 65 g VOC/m² Solvent consumption 15 to 200 Mg/year and > 5,000 coated items/year Existing installations: 75 g VOC/m² New installations: 55 g VOC/m²	VOCs are reduced through use of one or a combination of the coating systems given in below in order to reduce the consumption of solvents, other raw materials and energy, as well as to reduce VOC emissions: (a) mixed (SB-mix) coating; (b) water-based (WB) coating; (c) integrated coating process; (d) three-wet process [1][13][14] BAT is to monitor total and fugitive VOC emissions by compiling, at least once every year, a solvent mass balance of the solvent inputs and outputs of the plant, as defined in Part 7(2) of Annex VII to Directive 2010/75/EU and to minimise the uncertainty of the solvent mass balance data by using all of the techniques [13][14] [32][33]	For (a) mixed (SB-mix) coating; (b) water-based (WB) coating; (c) integrated coating process; (d) three-wet process: only applicable to new plants or major plant upgrades of existing ones.

Pag.	Limit values	Reduction techniques available	Potential Applicability (%)
	Solvent consumption > 200 Mg/year and > 5,000 coated items a year: 55 g VOC/m² (yearly) 3/ Manufacture of trucks and vans Solvent consumption > 15 Mg/year and ≤ 2,500 coated items/year Existing installations: 120 g VOC/m² New installations: 90 g VOC/m² Solvent consumption 15 to 200 Mg/year and > 2,500 coated items/year Existing installations: 90 g VOC/m² New installations: 70 g VOC/m² Solvent consumption > 200 Mg/year and > 2,500 coated items a year: 50 g VOC/m² (yearly) 4/ Manufacture of buses Solvent consumption > 15 Mg/year and ≤ 2,000 coated items/year Existing installations: 290 g VOC/m² New installations: 210 g VOC/m² Solvent consumption 15 to 200 Mg/year and > 2,000 coated items/year Existing installations: 225 g VOC/m² New installations: 150 g VOC/m² Solvent consumption > 200 Mg/year and > 2,000 coated items a year): 150 g VOC/m² (yearly)		

According to information provided by the STS BREF [13], solvent-based paints have been replaced with solvent-free or water-based equivalents or more efficient solvent-based technologies and, additional off-gas treatment units have been installed. These new or upgraded technologies implemented in this sector have reduced VOCs emissions per car by 21 % and total VOCs emissions of the sector by 16% from 2008 to 2017 in the EU. Mixed (SB-mix) coating, water-based (WB) coatings, integrated coating process and three-wet process and their combination are among the BATs available for this sector [13][14].

8.3.6. Limit values for VOC emissions released from coating activities in various industrial sectors

8.3.6.1. Coating of wooden surfaces, metal and plastic surfaces

Reference [1] provides a good overview of techniques which may be applied. The solvent management plan which is an essential tool to determine the solvent consumptions and emissions, especially fugitive VOCs emissions, and define the abatement strategy if necessary is described in reference [33]. Both primary and secondary abatement techniques are available to comply with limit values as described in the following:

Table 8-13: Table 6, Annex VI, ELVs of VOC emissions from coating activities in various industrial sectors techniques available for compliance

Pag.	Limit values	Reduction techniques available	Potential Applicability (%)

56	Table 6: Limit values for coating activities in various industrial sectors
	
	1/ Wood coating
	
	Solvent consumption 15 to 25 Mg/year: ELVc = 100 mg C/m³ (daily); ELVf = 25 wt-% or less of the solvent input (yearly). Or total ELV of 1.6 kg or less of VOC/kg of solid input (yearly)
	
	Solvent consumption 25 to 200 Mg/year: ELVc = 50 mg C/m³ (daily) for drying and 75 mg C/m³ (daily) for coating; ELVf = 20 wt-% or less of the solvent input (yearly). Or total ELV of 1 kg or less of VOC/kg of solid input (yearly)
	
	Solvent consumption > 200 Mg/year: ELVc = 50 mg C/m³ (daily) for drying and 75 mg C/m³ (daily) for coating; ELVf = 15 wt-% or less of the solvent input (yearly). Or total ELV of 0.75 kg or less of VOC/kg of solid input (yearly)
	
	2/ Coating of metal and plastics
	Solvent consumption 5 Mg/year–15 Mg/year: ELVc = 100 mg C/m³ (daily); ELVf = 25 wt-% or less of the solvent input (yearly). Or total ELV of 0.60 kg or less of VOC/kg of solid input (yearly)
	
	3/ Other coating, including textile, bag film and paper (excluding web screen printing for textiles, see printing)
	
	Solvent consumption 5 Mg/year–15 Mg/year: ELVc = 100 mg C/m³ (daily); ELVf = 25 wt-% or less of the solvent input (yearly). Or total ELV of 1.6 kg or less of VOC/kg of solid input (yearly)
	
	Solvent consumption > 15 Mg/year: ELVc = 50 mg C/m³ (daily) for drying and 75 mg C/m³ (daily) for coating; ELVf = 20 wt-% or less of the solvent input (yearly). Or total ELV of 1.0 kg or less of VOC/kg of solid input (yearly)
	
	4/ Coating of plastic workpieces
	
	Solvent consumption 15 to 200 Mg/year: ELVc = 50 mg C/m³ (daily) for drying and 75 mg C/m³ (daily) for coating; ELVf = 20b wt-% or less of the solvent input (yearly). Or total ELV of 0.375 kg or less of VOC/kg of solid input (yearly)
		Reduction of VOC emissions is based on a series of BAT related to raw materials (such as high solids coatings, varnishes…) and their optimal uses (reduced consumption through adequate application techniques…), minimising the use of solvent based cleaning agents, the reduction of fugitive emissions by applying principles of good housekeeping, use of secondary flue gas reduction techniques [1][13][14]
		
		The associated monitoring for total VOC emissions and fugitive emissions is to monitor total and fugitive VOC emissions by compiling, at least once every year, a solvent mass balance of the solvent inputs and outputs of the plant, [13][14] [32][33].
		
		For VOC emissions in waste gases BAT is to monitor emissions in waste gases with at least the frequency given below and in accordance with EN standards. If EN standards are not available, BAT is to use ISO, national or other international standards that ensure the provision of data of an equivalent scientific quality) [13][14] [32][33].
		In order to reduce the energy consumption of the VOC abatement system, BAT is to use one or a combination of the following techniques: (a) maintaining the VOC concentration sent to the off-gas treatment system by using variable-frequency drive fans; (b) internal concentration of solvents in the waste gases; (c) external concentration of solvents in the waste gases through adsorption; (d) plenum technique to reduce waste gas volume [13][14].
			For (a) maintaining the VOC concentration sent to the off-gas treatment system by using variable-frequency drive fans: only applicable to central thermal off-gas treatment systems in batch processes such as printing.
			
			For (b) internal concentration of solvents in the waste gases: the applicability may be limited by health and safety factors such as the LEL, and product quality requirements.
			
			For (c) external concentration of solvents in the waste gases through adsorption: the applicability may be restricted where the energy demand is excessive due to the low VOC content.
			
			For (d) plenum technique to reduce waste gas volume: generally applicable.

Pag.	Limit values	Reduction techniques available	Potential Applicability (%)
	Solvent consumption > 200 Mg/year): ELVc = 50 mg C/m^3 (daily) for drying and 75 mg C/m^3 (daily) for coating; ELVf = 20b wt-% or less of the solvent input (yearly). Or total ELV of 0.35 kg or less of VOC/kg of solid input (yearly) 5/ Coating of metal surfaces Solvent consumption 15-200 Mg/year: ELVc = 50 mg C/m^3 (daily) for drying and 75 mg C/m^3 (daily) for coating ELVf = 20 wt-% or less of the solvent input (yearly). Or total ELV of 0.375 kg or less of VOC/kg of solid input (yearly). Exception for coatings in contact with food: Total ELV of 0.5825 kg or less of VOC/kg of solid input (yearly) Solvent consumption >200 Mg/year: ELVc = 50 mg C/m^3 (daily) for drying and 75 mg C/m^3 (daily) for coating ELVf = 20 wt-% or less of the solvent input (yearly). Or total ELV of 0.33 kg or less of VOC/kg of solid input (yearly). Exception for coatings in contact with food: Total ELV of 0.5825 kg or less of VOC/kg of solid input (yearly)		

8.3.6.2. Leather coating

Reference [1] provides a good overview of techniques which may be applied. The solvent management plan which is an essential tool to determine the solvent consumptions and emissions, especially fugitive VOCs emissions, and define the abatement strategy if necessary is described in reference [33]. Both primary and secondary abatement techniques are available to comply with limit values as described in the following:

Table 8-14: Table 7, Annex VI, ELVs for VOC emissions from leather coating techniques available for compliance

Pag	Limit values	Reduction techniques available	Potential Applicability (%)
57	Table 7: Limit values for leather and winding wire coating 1/ Leather coating in furnishing and particular leather goods used as small consumer goods like bags, belts, wallets, etc. (solvent consumption > 10 Mg/year): Total ELV of 150 g/m² (yearly) 2/ Other leather coating (solvent consumption 10 Mg/year–25 Mg/year): Total ELV of 85 g/m² (yearly) 3/ Other leather coating (solvent consumption > 25 Mg/year):	In order to reduce the airborne emissions of halogenated volatile organic compounds, BAT is to replace halogenated volatile organic compounds used in the process with substances that are not halogenated [15][16] In order to reduce airborne emissions of volatile organic compounds (VOC) from finishing, BAT is to use one or a combination of the techniques given below, priority being given to the first one: (a) The use of water-borne coatings in combination with an efficient application system; (b) The use of extraction ventilation and an abatement system [15][16] [1]	Applicability: does not apply to the dry degreasing of sheepskins carried out in closed cycle machines

Pag	Limit values	Reduction techniques available	Potential Applicability (%)
	Total ELV of 75 g/m² (yearly)		

8.3.6.3. Winding wire coating

Reference [1] provides a good overview of techniques which may be applied. The solvent management plan which is an essential tool to determine the solvent consumptions and emissions, especially fugitive VOCs emissions, and define the abatement strategy if necessary is described in reference [33]. Both primary and secondary abatement techniques are available to comply with limit values as described in the following:

Table 8-15: Table 7, Annex VI, limit values for VOC emissions from winding wire coating

Pag.	Limit values	Reduction techniques available	Potential Applicability (%)
57	Table 7: Limit values for leather and winding wire coating Winding wire coating (solvent consumption > 5 Mg/year): Total ELV of 10 g/kg (yearly) applies for installations where average diameter of wire ≤ 0.1 mm Total ELV of 5 g/kg (yearly) applies for all other installations	Reduction of VOC emissions is based on a series of BAT related to raw materials (such as high solids coatings, varnishes…) and their optimal uses (reduced consumption through adequate application techniques…), minimising the use of solvent based cleaning agents, the reduction of fugitive emissions by applying principles of good housekeeping, use of secondary flue gas reduction techniques [1][13][14] The associated monitoring for total VOC emissions and fugitive emissions is to monitor total and fugitive VOC emissions by compiling, at least once every year, a solvent mass balance of the solvent inputs and outputs of the plant [13][14] [32][33]. For VOC emissions in waste gases BAT is to monitor emissions in waste gases with at least the frequency given below and in accordance with EN standards. If EN standards are not available, BAT is to use ISO, national or other international standards which ensure the provision of data of an equivalent scientific quality) [13][14]. According to the STS decision [14], BAT are one of the following techniques or a combination of them: process-integrated VOC oxidation, solvent free lubricants, self-lubricant coatings and high solid enamels.	

8.3.7. Limit values for VOC emissions released from coil coating

Reference [1] provides a good overview of techniques which may be applied. The solvent management plan which is an essential tool to determine the solvent consumptions and emissions, especially fugitive VOCs emissions, and define the abatement strategy if necessary is described in reference [33]. Both primary and secondary abatement techniques are available to comply with limit values as described in the following:

Table 8-16: Table 8, Annex VI, ELVs for VOC emisisons from coil coating techniques available for compliance

Pag.	Limit values	Reduction techniques available	Potential Applicability (%)

57/58	Table 8: Limit values for coil coating
	Existing installations
	Solvent consumption > 25 Mg/year: ELVc = 50 mg C/m^3 ELVf = 10 wt-% or less of the solvent input. Or total ELV of 0.45 kg or less of VOC/kg of solid input. If techniques are used which allow reuse of recovered solvent, the limit value shall be 150 mg C/m^3.
	New installations
	Solvent consumption > 25 Mg/year:
	ELVc = 50 mg C/m^3 (daily); If techniques are used which allow reuse of recovered solvent, the limit value shall be 150 mg C/m^3. ELVf = 5 wt-% or less of the solvent input (yearly). Or total ELV of 0.3 kg or less of VOC/kg of solid input (yearly).
		Reduction of VOC emissions is based on a series of BAT related to raw materials (such as high solids coatings, varnishes…) and their optimal uses (reduced consumption through adequate application techniques…), minimising the use of solvent based cleaning agents, the reduction of fugitive emissions by applying principles of good housekeeping, use of secondary flue gas reduction techniques [1][13][14].
		The associated monitoring for total VOC emissions and fugitive emissions is to monitor total and fugitive VOC emissions by compiling, at least once every year, a solvent mass balance of the solvent inputs and outputs of the plant. [13][14] [32][33].
		For VOC emissions in waste gases BAT is to monitor emissions in waste gases with at least the frequency given below and in accordance with EN standards. If EN standards are not available, BAT is to use ISO, national or other international standards that ensure the provision of data of an equivalent scientific quality) [13][14]
		In order to reduce the energy consumption of the VOC abatement system, BAT is to use one or a combination of the following techniques: (a) maintaining the VOC concentration sent to the off-gas treatment system by using variable-frequency drive fans; (b) internal concentration of solvents in the waste gases; (c) external concentration of solvents in the waste gases through adsorption; (d) plenum technique to reduce waste gas volume [13][14]
			For (a) maintaining the VOC concentration sent to the off-gas treatment system by using variable-frequency drive fans: only applicable to central thermal off-gas treatment systems in batch processes such as printing.
			For (b) internal concentration of solvents in the waste gases: the applicability may be limited by health and safety factors such as the LEL, and product quality requirements.
			For (c) external concentration of solvents in the waste gases through adsorption: the applicability may be restricted where the energy demand is excessive due to the low VOC content.
			For (d) plenum technique to reduce waste gas volume: generally applicable.

8.3.8. Limit values for VOC emissions released from dry cleaning

The techniques available to comply with limit values are as in the following:

Table 8-17: Table 9, Annex VI, limit values for VOC emisisons from dry cleaning techniques available for compliance

Pag.	Limit values	Reduction techniques available	Potential Applicability (%)
58	Table 9: Limit value for dry cleaning Total ELV of 20 g VOC/kg (yearly)	Perchloroethylene is the most common solvent used for dry cleaning. It is “suspected of causing cancer” There are alternatives to the use of this solvent but the potential for these alternatives to harm human health and the environment is not always well-understood yet	Almost 100% for the ELV. Many of the alternative solvents are relatively new products with no established occupational exposure limits.

Perchloroethylene (PER) was one of the most used solvents in dry cleaning machines. It is a halogenated solvent which is classified as a CMR substance (C2: suspected of being a carcinogenic substance) according to [32].

In many countries, the use of PER is declining and even more, forbidden in dry cleaning applications.

Wet-based cleaning is one of the alternatives to perchloroethylene. The other alternatives are based on the use of other solvents [34]:

- n-Propyl Bromide which is a brominated hydrocarbon, and considered by reference [34] as a regrettable substitution,
- Solvon K4 or dibutoxymethane, or Butylal, which is an oxygenated hydrocarbon,
- Decamethylcylclopentasiloxane (called D5),
- Glycol ethers: dipropylene glycol tert-butyl ethers (DPTB), dipropylene glycol, n-butyl ether (DPNB), and propylene glycol t-butyl ether (PGtBE),
- High-flashpoint hydrocarbons which are oil-based solvents and have relatively high flammability and volatility,
- Liquid carbon dioxide which is a technology that combines carbon dioxide with specialised detergents under high pressure.

Other alternative solvents are identified:

- Hi-Glo, which is a solvent mixture based on an oxygenated hydrocarbon,
- KTEX, which is a combination of hydrocarbons associated with a glycol ether.

According to reference [34], dry cleaning machines have evolved through several “generations” to minimize PER release.

According to the current situation and efficiency of newest machines (5^{th} generation) [34], the emissions can be as low as 10 g VOC/kg cleaned garment)

8.3.9. Limit values for VOC emissions released from manufacturing of coatings, varnishes and adhesives

Reference [1] provides a good overview of techniques which may be applied. The solvent management plan which is an essential tool to determine the solvent consumptions and emissions, especially fugitive VOCs emissions, and define the abatement strategy if necessary is described in reference [33]. Both primary and secondary abatement techniques are available to comply with limit values as described in the following:

Table 8-18: Table 10, Annex VI, limit values for VOC emissions from manufacturing of coatings, varnishes and adhesives techniques available for compliance

Pag.	Limit values	Reduction techniques available	Potential Applicability (%)
58	Table 10: Limit values from manufacturing of coatings, varnishes, inks and adhesives New and existing installations with solvent consumption between 100 Mg/year–1,000 Mg/year: ELVc = 150 mg C/m^3, ELVf = 5 wt% or less of the solvent input. Or total ELV of 5 wt% or less of the solvent input. New and existing installations with solvent consumption > 1,000 Mg/year: ELVc = 150	In the production of coatings, process modifications are possible by switching to low organic solvent containing paints and glues. Process controls for reducing emissions, such as covering vessels or reducing storage tank breathing losses can be implemented. Further VOC abatement options are condensation, adsorption, thermal and catalytic oxidation. The techniques are as follows [1]:	

Pag.	Limit values	Reduction techniques available	Potential Applicability (%)
	mg C/m^3, ELVf = 3 wt % or less of the solvent input. Or total ELV of 3 wt % or less of the solvent input.	Recovery of solvent vapours during raw material distribution, Unloading of the barrels with fork lifts to avoid leakages, Coverage of mobile vessels, Use of solvents with lower volatility to reduce fugitive emissions, Use of cleaning agents containing less solvents, Use of automatic cleaning devices whenever possible, Recycling of cleaning solutions, Upgrading of the condensation or carbon adsorption units and solvent recovery	

8.3.10. Limit values for VOC emissions released from printing activities

Reference [1] provides a good overview of techniques which may be applied. The solvent management plan which is an essential tool to determine the solvent consumptions and emissions, especially fugitive VOCs emissions, and define the abatement strategy if necessary is described in reference [33]. Both primary and secondary abatement techniques are available to comply with limit values as described in the following:

Table 8-19: Table 11, Annex VI, ELV for VOC emissions from printing activities techniques available for compliance

Pag.	Limit values	Reduction techniques available	Potential Applicability (%)
58/59/60	1/ Heat-set offset Solvent consumption 15 – 25 Mg/year: New and existing presses: ELVc = 150 mg C/m^3, ELVf = 30 wt % or less of the solvent input. Solvent consumption 25 – 200 Mg/year: New and existing presses: ELVc = 20 mg C/m^3, ELVf = 30 wt % or less of the solvent input. Solvent consumption > 200 Mg/year): New and upgraded presses: Total ELV = 10 wt-% or less of the ink consumption (yearly). Existing presses: Total ELV = 15 wt-% or less of the ink consumption (yearly). 2/ Publication gravure	Primary measures (reduction of solvent content of inks and other coatings) and secondary techniques van be combined to achieved such limit values [1][13][14]. VOC emissions by compiling, at least once every year, a solvent mass balance of the solvent inputs and outputs of the plant , [13][14][33]. For VOC emissions in waste gases BAT is to monitor emissions in waste gases with at least the frequency given below and in accordance with EN standards. If EN standards are not available, BAT is to use ISO, national or other international standards that ensure the provision of data of an equivalent scientific quality) [13][14]. In order to reduce the energy consumption of the VOC abatement system, BAT is to use one or a combination of the following techniques: (a) maintaining the VOC concentration sent to the waste gas treatment system by using variable-frequency drive fans; (b)	

Pag.	Limit values	Reduction techniques available	Potential Applicability (%)
	Solvent consumption 25-200 Mg/year: New installations: ELVc = 75 mg C/m^3 ELVf = 10 wt-% or less of the solvent input Or total ELV of 0.6 kg or less of VOC/kg of solid input (yearly) Existing installations: ELVc = 75 mg C/m^3 ELVf = 15 wt-% or less of the solvent input Or total ELV of 0.8 kg or less of VOC/kg of solid input (yearly) Solvent consumption > 200 Mg/year: New installations: Total ELV = 5 wt-% or less of the solvent input (yearly). Existing installations: Total ELV = 7 wt-% or less of the solvent input (yearly) 3/ Packaging rotogravure and flexography Solvent consumption 15-25 Mg/year: New and existing installations: ELVc = 100 mg C/m^3 ELVf = 25 wt-% or less of the solvent input Or total ELV of 1.2 kg or less of VOC/kg of solid input (yearly) Solvent consumption 25-200 Mg/year: New and existing installations: ELVc = 100 mg C/m^3 ELVf = 20 wt-% or less of the solvent input Or total ELV of 1.0 kg or less of VOC/kg of solid input (yearly) Solvent consumption > 200 Mg/year: For plants with all machines connected to oxidation: Total ELV = 0.5 kg VOC/kg of solid input (yearly) - For plants with all machines connected to carbon adsorption: Total ELV = 0.6 kg VOC/kg of solid input (yearly) - For existing mixed plants where some existing machines may not be attached to an incinerator or solvent recovery: Emissions	internal concentration of solvents in the waste gases; (c) external concentration of solvents in the waste gases through adsorption; (d) plenum technique to reduce waste gas volume [13][14].	

Pag.	Limit values	Reduction techniques available	Potential Applicability (%)
	from the machines connected to oxidizers or carbon adsorption are below the emission limits of 0.5 or 0.6 kg VOC/kg of solid input respectively. - For machines not connected to gas treatment: use of low solvent or solvent free products, connection to waste gas treatment when there is spare capacity and preferentially run high solvent content work on machines connected to waste gas treatment. Total emissions below 1.0 kg VOC/kg of solid input (yearly).		

8.3.10.1. Heatset web offset printing

According to the STS BREF [13], all installations use thermal off-gas treatment techniques which is the general rule in the sector due to the offensive smell of waste gases. Most installations in this sector apply integrated dryer-oxidisers at each press specifically designed for heatset web offset printing.

Techniques specifically used in heatset web offset to reduce VOC emissions are [13].

- low-IPA (isopropanol) or IPA-free additives for dampening solutions.
- use of waterless offset plates.
- automatic cleaning systems for blanket cylinders, capture and routing of solvent emissions from cleaning to the off-gas treatment system.
- web offset dryer integrated with thermal off-gas treatment.

8.3.10.2. Publication rotogravure printing

According to the STS BREF [13], all publication rotogravure printing plants nowadays have toluene recovery installations. In spite of the toluene recovery, part of the toluene input is still emitted. The main sources of VOC emissions are:

- the printing process and its cleaning operations,
- the solvent recovery system,
- the printed product.

In order to minimise toluene emissions to air, various techniques have been identified:

- direct piping of inks,
- closed-loop distiller system at the toluene recovery for recovering the toluene residue from decanted water,
- use of retention inks,
- connection to the toluene recovery system of all potential toluene-emitting activities/processes: print units, toluene washing machines, dryers, press room air at units.

According to the STS BREF [13], total emissions of VOCs as a percentage of the solvent input are below 3 % in all cases and close to or lower than 1 % when non-solvent-based cleaning agents are used.

8.3.10.3. Flexography and non-publication rotogravure printing

According to the STS BREF [13], almost all of the reported values for fugitive emissions of VOCs are below the IED limit value of 20 % of the solvent input and more than the half of reported values are below 10 % of the solvent input.

The main reported techniques for the minimisation of fugitive emissions are:

- safe storage of hazardous substances and measures to prevent unplanned releases.
- handling and use of hazardous materials.
- air extraction from drying processes.
- enclosed application zones with air extraction.
- hall ventilation partly used as dryer input, treated in RTO.
- air recirculation in dryers.
- overpressure management with installed waste air pipes to minimise leakages caused by overpressure.
- ink management techniques that include an automatic ink mixing system and management of ink residues.
- automatic hardener dosing using enclosed piping system (two-component systems).
- air extraction from washing machines, adhesive mixing and ink mixing area.
- automatic parts cleaning machine (solvent-based, connected to ‘smoothener’ and common waste gas extraction for treatment in a RTO).
- solvent-free adhesives (hot melts).
- ultrasonic cleaning machine for anilox rollers.

8.3.11. Limit values for VOC emissions released from manufacturing of pharmaceutical products

Reference [1] provides a good overview of techniques which may be applied. The solvent management plan which is an essential tool to determine the solvent consumptions and emissions, especially fugitive VOCs emissions, and define the abatement strategy if necessary is described in reference [33]. Both primary and secondary abatement techniques are available to comply with limit values as described in the following:

Table 8-20: Table 12, Annex VI, ELVs for VOC emissions from manufacturing of pharmaceutical products techniques available for compliance

Pag.	Limit values	Reduction techniques available	Potential Applicability (%)
60	Table 12: Limit values for manufacturing of pharmaceutical products New installations	One or a combination of techniques can be applied as a recovery/abatement system for a whole site, an individual production building, or an individual process. This depends on the particular situation and affects the number of point sources. BAT is to select VOC	Almost 100%

	Solvent consumption > 50 Mg/year: ELVc = 20 mg C/m^3 (a,b) and ELVf = 5 wt-% or less of the solvent input (b) Existing installations Solvent consumption > 50 Mg/year): ELVc = 20 mg C/m^3 (a,c) and ELVf = 15 wt-% or less of the solvent input (c). (a) If techniques are used which allow reuse of recovered solvents, the limit value shall be 150 mg C/m^3 (b) A total limit value of 5% of solvent input may be applied instead of applying ELVc and ELVf (c) A total limit value of 15% of solvent input may be applied instead of applying ELVc and ELVf.	recovery and abatement techniques according to an in depth assessment of possible use of techniques [1] [17] [20]. According to Reference [20], BAT is to incorporate the following features: - Implementation of an inventory of channelled and diffuse emissions to air, maintenance of such an inventory and regular review, as part of the environmental system [33] - Reduce the frequency of other than normal operating conditions (OTNO), development of a management plan for emissions to air - An integrated waste gas management and treatment strategy for channelled emissions based on the combination of waste gas streams with similar characteristics, limit thus optimise minimising the number of emission points and the correct design and maintenance of abatement systems (considering the maximum flow rate and concentrations) to ensure optimal availability, effectiveness and efficiency of the equipment.	

8.3.12. Limit values for VOC emissions released from conversion of natural or synthetic rubber

Reference [1] provides a good overview of techniques which may be applied. The solvent management plan which is an essential tool to determine the solvent consumptions and emissions, especially fugitive VOCs emissions, and define the abatement strategy if necessary is described in reference [33]. Mainly primary measures are available to comply with limit values as described in the following:

Table 8-21: Table 13, Annex VI, limit values for VOC emissions from conversion of natural or synthetic rubber

Pag.	Limit values	Reduction techniques available	Potential Applicability (%)
61	Table 13: Limit value for conversion of natural or synthetic rubber New and existing installations: conversion of natural or synthetic rubber (solvent consumption > 15 Mg/year): ELVc = 20 mg C/m^3 and ELVF = 25wt-% of the solvent input. Or total ELV = 25 wt-% of solvent input. If techniques are used which allow reuse of recovered solvent, the limit value shall be 150 mg C/m^3. The fugitive limit does not include solvents sold as part of a preparation in a sealed container.	VOC emissions are reduced either by primary or secondary measures but generally, not by a combination of the 2 approaches. Emissions are reduced by switching solvent-based to low or non-solvent based products [1]. The associated monitoring for total VOC emissions and fugitive emissions is to monitor total and fugitive VOC emissions by compiling, at least once every year, a solvent mass balance of the solvent inputs and outputs of the plant, **Erreur ! Source du renvoi introuvable.**.	

8.3.13. Limit values for VOC emissions released from surface cleaning

Reference [1] provides a good overview of techniques which may be applied. The solvent management plan which is an essential tool to determine the solvent consumptions and emissions, especially fugitive VOCs emissions, and define the abatement strategy if necessary is described in reference [33]. The techniques available to comply with limit values are as in the following:

Table 8-22: Table 14, Annex VI, limit values for VOC emissions from surface cleaning

Pag.	Limit values	Reduction techniques available	Potential Applicability (%)
61	Table 14: Limit values for surface cleaning Surface cleaning using substances mentioned in paragraph 3 (z) (i) of Annex VII: - Solvent consumption between 1-5 Mg/year: ELVc = 20 mg expressed as the mass sum of individual compounds/m^3. ELVf = 15 wt-% of solvent input. - Solvent consumption > 5 Mg/year: ELVc = 20 mg expressed as the mass sum of individual compounds/m^3. ELVf = 10 wt-% of solvent input Other surface cleaning: - Solvent consumption between 2-10 Mg/year: ELVc = 75 mg C/m^3. ELVf = 20 wt-% of solvent input. - Solvent consumption > 10 Mg/year: ELVc = 75 mg C/m^3. ELVf = 15 wt-% of solvent input.	In order to reduce VOC emissions from cleaning processes, BAT is to minimise the use of solvent-based cleaning agents and to use a combination of the techniques given below [13]: (a) Protection of spraying areas and equipment: Application areas and equipment (e.g. spray booth walls and robots) susceptible to overspray and drips, etc. are covered with bag covers or disposable foils where foils are not subject to tearing or wear. (b) Solids removal prior to complete cleaning: Solids are removed in a (dry) concentrated form, usually by hand, with or without the aid of small amounts of cleaning solvent. This reduces the amount of material to be removed by solvent and/or water in subsequent cleaning stages, and therefore the amount of solvent and/or water used. (c) Manual cleaning with pre-impregnated wipes: Wipes pre-impregnated with cleaning agents are used for manual cleaning. Cleaning agents may be solvent-based, low-volatility solvents or solvent- free. (d) Use of low-volatility cleaning agents: Application of low-volatility solvents as cleaning agents, for manual or automated cleaning, with high cleaning power. (e) Water-based cleaning: Water-based detergents or water-miscible solvents such as alcohols or glycols are used for cleaning. (f) Enclosed washing machines: Automatic batch cleaning/degreasing of press/machine parts in enclosed washing machines. This can be done using either: (a) organic solvents (with air extraction followed by VOC abatement and/or recovery of the used solvents); or (b) VOC-free solvents; or (c) alkaline cleaners (with external or internal waste water treatment). (g) Purging with solvent recovery: Collection, storage and, if possible, reuse of the solvents used to purge	The selection of cleaning techniques may be restricted by the type of process, the substrate or equipment to be cleaned and the type of contamination.

Pag.	Limit values	Reduction techniques available	Potential Applicability (%)
		the guns/applicators and lines between colour changes.	

8.3.14. Limit values for VOC emissions released from extraction of vegetable and animal fat and refining of vegetable oils

Reference [1] provides a good overview of techniques which may be applied. The solvent management plan which is an essential tool to determine the solvent consumptions and emissions, especially fugitive VOCs emissions, and define the abatement strategy if necessary is described in reference [33]. The techniques available to comply with limit values are as in the following:

Table 8-23: Table 15, Annex VI, ELVs for VOC emissions from extraction of vegetable and animal fat and refining of vegetable oil

Pag.	Limit values	Reduction techniques available	Potential Applicability (%)
61/62	Table 15: Limit values for extraction of vegetable and animal fat and refining of vegetable oil New and existing installations (solvent consumption > 10 Mg/year): - Animal fat: ELV = 1.5 kg VOC/Mg product - Castor: ELV = 3 kg VOC/Mg product - Rape seed: ELV = 1 kg VOC/Mg product - Sunflower seed: ELV = 1 kg VOC/Mg product - Soya beans (normal crush): ELV = 0.8 kg VOC/Mg product - Soya beans (white flakes): ELV = 1.2 kg VOC/Mg product - Other seeds and vegetable material: ELV = 3 kg VOC/Mg product - All fractionation processes, excluding degumming: ELV = 1.5 kg VOC/Mg product - Degumming: ELV = 4 kg VOC/Mg product	BAT are as in the following [18][19] - Counter current flow of meal and steam in the desolventiser-toaster - Vaporization from the oil/hexane mixture - Condensation in combination with a mineral oil wet scrubber - Gravitational phase separation in combination with distillation	Almost 100%

According to the BREF Food, Drink, Milk [18], the majority (typically > 90 %) of TVOC emissions to air consist of hexane. Hexane emissions are typically reduced by hexane recovery techniques. biofilters, bio scrubbers and wet scrubbers followed by condensation are typically used with the intention of reducing odour emissions. BATs are the use of all the following techniques: counter current flow of meal and steam in the desolventiser-toaster, evaporation from the oil/ hexane mixture, condensation in combination with a mineral oil wet scrubber, gravitational phase separation in combination with distillation.

8.3.15. Limit values for VOC emissions released from impregnation of wood

Reference [1] provides a good overview of techniques which may be applied. The solvent management plan which is an essential tool to determine the solvent consumptions and emissions, especially fugitive VOCs emissions, and define the abatement strategy if necessary is described in reference [33]. The techniques available to comply with limit values are as in the following:

Table 8-24: Table 16, Annex VI, ELVs for VOC emissions from impregnation of wood techniques available for compliance

Pag.	Limit values	Reduction techniques available	Potential Applicability (%)
62	Table 16: limit values for impregnation of wood Wood impregnation Solvent consumption 25 to 200 Mg/year: ELVc = 100 mg C/m^3 (not applicable to impregnation with creosote). ELVf = 45 wt-% or less of solvent input or 11 kg or less of VOC/ m^3 Wood impregnation (solvent consumption > 200 Mg/year) ELVc = 100 mg C/m^3 (not applicable to impregnation with creosote). ELVf = 35 wt-% or less of solvent input or 9 kg or less of VOC/ m^3	In order to reduce emissions of VOCs to air from wood and wood products preservation using solvent-based treatment chemicals, BAT is to enclose the emitting equipment or processes, extract the off-gases and send them to a treatment system (thermal oxidation, waste gases sent to a combustion plant, adsorption unit, absorption unit, condensation [13]. For creosote: In order to reduce emissions of organic compounds and odour to air from wood and wood products preservation using creosote, BAT is to use low-volatility impregnating oils, i.e. Grade C creosote instead of Grade B.	Almost 100%

According to the STS BREF [13], the main VOC emission source in this sector is from the solvent content of the applied substances. Solvents that remain in the wood after complete drying evaporate over longer periods of time. Fugitive emissions occur during handling, application and drying stages. However, the majority of the emissions occur during the drying process.

8.4. Annex X: limit values for emissions of PM from stationary sources

8.4.1. Limit values for dust emissions released from combustion plants

Table 8-25: Table 1, Annex IV, ELVs for emissions of dust from combustion plants techniques available for compliance

Pag.	Limit values	Reduction techniques available	Potential Applicability (%)
83-84	Table 1: Limit values for dust emissions released from combustion plants		
	Coal, lignite and other solid fuels: Combustion plant with a thermal input capacity between 50 and 100 MW: New plants: 20 mg/m³ at 6 % O_2 Existing plants: 30 mg/m³ at 6 % O_2 Combustion plant with a thermal input capacity between 100 and 300 MW: New plants: 20 mg/m³ at 6 % O_2 Existing plants: 25 mg/m³ at 6 % O_2 Combustion plant with a thermal input capacity exceeding 300 MW: New plants: 10 mg/m³ at 6 % O_2 Existing plants: 20 mg/m³ at 6 % O_2	The means to achieve the associated environmental levels is the application of one or a combination of the following techniques [1] [2][3]: - electrostatic precipitator (ESP), - baghouse filter, - boiler sorbent injection - wet flue-gas, desulphurisation (FGD), - dry or semi-dry FGD system.	Almost 100 %. Some limitations may exist for FGD if: - the plant operates less than 500 hours per year, - it is for retrofitting on existing combustion plant operating less than 1,500 hours per year, - the combustion plant is less than 300 MW_{th}, there may be technical and economic restrictions
	Solid biomass and peat: Combustion plant with a thermal input capacity between 50 and 100 MW: New plants: 20 mg/m³ at 6 % O_2 Existing plants: 30 mg/m³ at 6 % O_2 Combustion plant with a thermal input capacity between 100 and 300 MW: New plants: 20 mg/m³ at 6 % O_2 Existing plants: 20 mg/m³ at 6 % O_2 Combustion plant with a	The means to achieve the associated environmental levels is the application of one or a combination of the following techniques [1] [2][3]: - electrostatic precipitator (ESP), - baghouse filter, - wet flue-gas desulphurisation (FGD), - dry or semi-dry FGD system.	Almost 100 %, except wet-FGD for plants operating less than 500 hours per year. If wet FGD is meant for retrofitting on existing combustion plant operating less than 1,500 hours per year, there may be technical and economic restrictions.

Pag.	Limit values	Reduction techniques available	Potential Applicability (%)
	thermal input capacity exceeding 300 MW: New plants: 20 mg/m^3 at 6 % O_2 Existing plants: 20 mg/m^3 at 6 % O_2		
	Liquid fuels: Combustion plant with a thermal input capacity between 50 and 100 MW: New plants: 20 mg/m^3 at 3 % O_2 Existing plants: Liquid fuels in general: 30 mg/m^3 at 3 % O_2 Combustion plant with a thermal input capacity between 100 and 300 MW: New plants: 20 mg/m^3 at 3 % O_2 Existing plants: Liquid fuels in general: 25 mg/m^3 at 3 % O_2 Combustion plant with a thermal input capacity exceeding 300 MW: New plant: 10 mg/m^3 at 3 % O_2 Existing plants: Liquid fuels in general: 20 mg/m^3 at 3 % O_2 Combustion plant with a thermal input capacity larger than 50 MW: existing plants Distillation and conversion residues from crude oil refining within refineries and chemical installations: 50 mg/m^3 at 3 % O_2	The means to achieve the associated environmental levels is the application of one or a combination of the following techniques [1][2][3]: - electrostatic precipitator (ESP), - baghouse filter, - multicyclones, - wet flue-gas desulphurisation (FGD), - dry or semi-dry FGD system.	Almost 100 %, except wet-FGD for plants operating less than 500 hours per year. Some limitations may exist for wet FGD if: - it is for retrofitting on existing combustion plant operating less than 1,500 hours per year, - the combustion plant is less than 300 MW_{th}, there may be technical and economic restrictions.
	Gaseous fuels: Combustion plant with a thermal input capacity exceeding 50 MW – New and existing plants: Natural gas: 5 mg/m^3 at 3 % O_2	For iron and steel process gases only [1] [2][3]: The means to achieve the associated environmental levels is the application of one or a combination of the following techniques: - fuel choice/management, - electrostatic precipitator (ESP), - baghouse filter, - gas pre-treatment at the iron- and steel-works	For chemical industry process gases: Wet-FGD not applicable for plants operating less than 500 hours per year. Some limitations may exist for wet FGD if: - it is for retrofitting on existing combustion plant operating less than 1,500 hours per year, - the combustion plant is less than 300 MWth, there may be technical and economic restrictions.

Pag.	Limit values	Reduction techniques available	Potential Applicability (%)
	Other gases other than steel industry gases: 10 mg/m³ at 3 % O_2 Steel industry gases: 30 mg/m³ at 3 % O_2	For chemical industry process gases [1] [2][3]: The means to achieve the associated environmental levels is the application of one or a combination of the following techniques: - electrostatic precipitator (ESP), - baghouse filter, - wet flue-gas desulphurisation (FGD), - dry or semi-dry FGD system.	For iron and steel process gases only: ESP and baghouse filters are only applicable if a significant amount of auxiliary fuels with a high ash content is burned together with iron steel gases.

8.4.2. Limit values for dust emissions released from mineral oil and gas refineries

In oil refineries, dust emissions particularly occur during fluid catalytic cracking (FCC). FCC is a conversion process for upgrading heavy hydrocarbons, using heat and a catalyst to break larger hydrocarbon molecules into lighter molecules. The EU BREF document [5] reports ESPs in combination with multistage cyclone separators and centrifugal washers with third stage ceramic or metal filters to be the most efficient technique for PM emission abatement:

- Electrostatic precipitators operate such that particles are charged and separated under the influence of an electrical field. Electrostatic precipitators are capable of operating under a wide range of conditions. Abatement efficiency may depend on the number of fields, residence time (size), catalyst properties and upstream particles removal devices. At FCC units, 3-field ESPs and 4-field ESPs are commonly used. ESPs may be used on a dry mode or with ammonia injection to improve the particle collection.
- Common configuration of cyclonic collection devices consists of a single vessel containing many conventional cyclones or improved swirl-tube technology. For FCC, performance mainly depends on the particle concentration and size distribution of the catalyst fines downstream of the regenerator internal cyclones.
- Centrifugal washers combine the cyclone principle and an intensive contact with water e.g. within a venturi washer. This entails separating the dust by intensively mixing the incoming gas with water, usually combined with the removal of the coarse particles through the use of centrifugal force. The removed dust is collected at the bottom of the scrubber. Also, substances such as SO_2, NH_3 and some VOC and heavy metals may be removed.
- Third stage blowback filters are reverse flow (blowback) ceramic or sintered metal filters where, after retention at the surface as a cake, the solids are dislodged by initiating a reverse flow. The dislodged solids are then purged from the filter system.

The techniques available to comply with limit values are as in the following:

Table 8-26: Table 2, Annex X, ELVs for dust emissions from FCC regenerators in mineral oil and gas refineries techniques available for compliance

Pag.	Limit values	Reduction techniques available	Potential Applicability (%)
84	Table 2: Limit values for dust emissions released from mineral oil and gas refineries ELV for dust (mg/m³) from FCC regenerators	The techniques are electrostatic precipitators (ESP), multistage cyclone separators, centrifugal washers (venture washers, wet scrubbing), third stage blowback filter	Almost 100 % for ESPs and multistage cyclone separators, some limitations exist for wet scrubbers

Pag.	Limit values	Reduction techniques available	Potential Applicability (%)
	50 mg/m^3	(ceramic or sintered metal filters) [5]	

8.4.3. Limit values for dust emissions released from cement clinker and lime production

As the BATs for dust emission reduction from cement clinker production are similar to those of lime production and both processes are also included in the same BREF document [7], both processes are jointly discussed here. The BATs for dust emission abatement are classical bag filters or ESPs. Bag filters usually reduce emissions to less than 10 mg/m^3 but state-of-the-art ESPs are also reported to achieve emissions of 10 mg/m^3. As summarized in the following table, the techniques available to comply with limit values of the AGP are:

Table 8-27: Tables 3 and 4, Annex X, ELVs for dust emissions from cement clinker and lime production and techniques available for compliance

Pag.	Reference and Update Index	Description	Potential Applicability (%)
85	Table 3: Limit values for PM emissions released from cement clinker production General (existing and new plants): 20 mg/m^3 at 10 % O_2	The techniques are electrostatic precipitators (ESP), bag filters, hybrid filters [1] [7][8]	100% applicable to all types of kilns
85	Table 4: Limit values for dust emissions released from lime production General (existing and new plants): 20 mg/m^3	The techniques are electrostatic precipitators (ESP), bag filters, hybrid filters [1] [7][8]	100% applicable

8.4.4. Limit values for dust emissions released from iron and steel production

In the different processing steps of iron and steel production, typical abatement techniques for dust reduction including both dry (e.g. ESP or bag filter) and wet dedusting (e.g. wet ESP or scrubber) are applied [10]. The applied technologies depend on the processing step and the associated emissions.

The techniques available to comply with limit values are as in the following:

Table 8-28: Table 5, Annex X, ELVs of dust from iron and steel production facilities and techniques available for compliance

Pag.	Limit values	Reduction techniques available	Potential Applicability (%)
85	Table 5: Limit values for dust emissions released from primary iron and steel production Sinter plant: 50 mg/m^3	The techniques are electrostatic precipitators (ESP), bag filters, hybrid filters [1] [10][11]	Almost 100 %
	Pelletization plant: 20 mg/m^3 for crushing and grinding, 15 mg/m^3 for the rest	The techniques are electrostatic precipitators (ESP), bag filters, hybrid filters [1] [10][11]	Almost 100 %
	Blast furnace: Hot stoves (>2.5 t/hour) 10 mg/m^3	Dry dedusting (ESP or Filters) [1] [10][11]	Almost 100 %
	Basic oxygen steelmaking and casting (>2.5 t/hour) 30 mg/m^3	Dry dedusting (ESP or Filters), wet dedusting (wet ESPs or scrubbers) [1] [10][11]	Almost 100 %

Pag.	Limit values	Reduction techniques available	Potential Applicability (%)
	Electric steelmaking and casting (>2.5 t/hour) 15 mg/m^3 for existing, 5 mg/m^3 for new	Direct off-gas extraction and hood system / doghouse system [1] [10][11]	Almost 100 %, adjustment for existing plants could be difficult

8.4.5. Limit values for dust emissions released from iron foundries

The BATs for dust emission abatement are classical bag filters or ESPs or even wet scrubbing systems. Wet scrubbing entails separating the dust by intensively mixing the incoming gas with water, usually combined with the removal of the coarse particles through the use of centrifugal force [10][11]. The removed dust is collected at the bottom of the scrubber. In case of an ESP, higher emission values are reported as compared to a bag filter or a wet scrubbing system.

The techniques available to comply with limit values are as in the following:

Table 8-29: Table 6, Annex X, ELVs of dust from iron foundaries techniques available for compliance

Pag.	Limit values	Reduction techniques available	Potential Applicability (%)
85	Table 6: Limit values for PM emissions released iron foundries Iron foundries (>20 t/day): 20 mg/m^3 For all furnaces (cupola, induction, rotary) and all mouldings (lost, permanent)	The techniques are electrostatic precipitators (ESP), bag filters, or wet scrubbing [1]	Almost 100 %.
	Hot and cold rolling 20 mg/m^3, 50 in case bag filters cannot be applied	The techniques are electrostatic precipitators (ESP) or bag filters [1]	Almost 100 %

8.4.6. Limit values for dust emissions released from non-ferrous metal production

Annex X (Table 7) of the Gothenburg Protocol only provides one overall ELV for overall non-ferrous metals production. Even though the abatement techniques for dust emissions are relatively similar consisting of bag filters, ESPs or wet scrubbers, the processes and processing steps for primary and secondary metal production are different for each metal and so are the abatement techniques and ELVs.

The techniques available to comply with limit values are as in the following:

Table 8-30: Table 7, Annex X, ELVs for dust emissions from non ferrous metals production techniques available for compliance

Pag.	Limit values	Reduction techniques available	Potential Applicability (%)
85	Table 7: Limit values for dust emissions released from non-ferrous metals production and processing ELV for dust (mg/m³): 20 mg/m^3	The techniques are electrostatic precipitators (ESP), bag filters, hybrid filters, partly wet scrubbers for some furnaces, very detailed information from the EU BREF available [1] [12]	Almost 100 %

8.4.7. Limit values for dust emissions released from glass production

Beside primary measures regarding the handling and properties of raw material input, the BATs for dust emission abatement from glass production are classical bag filters or ESPs. The techniques available to comply with limit values are as in the following:

Table 8-31: Table 8, Annex X, ELVs for dust emissions from glass production techniques available for compliance

Pag.	Limit values	Reduction techniques available	Potential Applicability (%)
86	Table 8: Limit values for dust emissions released from glass production ELV for dust (mg/m^3) for new installations: 20 mg/m^3	Beside primary measures (raw material modification) the techniques are electrostatic precipitators (ESP) and bag filters [1] [24][25]	Almost 100 %. Some limitations may exist if the primary measures are not able to reach concentrations below 1000 mg/m^3.
	ELV for dust (mg/m^3) for existing installations: 30 mg/m^3	The techniques are electrostatic precipitators (ESP) and bag filters [1] [24][25]	Almost 100 %

8.4.8. Limit values for dust emissions released from pulp production

The separation of dust during pulp production is carried out in an electrostatic precipitator or multistage cyclone.

The techniques available to comply with limit values are as in the following:

Table 8-32: Table 9, Annex X, ELVs for dust emissions released from pulp production techniques available for compliance

Pag.	Limit values	Reduction techniques available	Potential Applicability (%)
86	Table 9: Limit values for dust emissions released from pulp production Auxiliary boiler ELV for dust (mg/m^3): 40 mg/m^3 when firing liquid fuels (at 3% oxygen content) 30 mg/m^3 when firing solid fuels (at 6% oxygen content)	The techniques are electrostatic precipitators (ESPs) or a combination of a ESP and a wet scrubber [1] [26][27]	Almost 100 %, some limitations for wet scrubbers possible
	Recovery boiler and lime kiln: 50 mg/m^3	The techniques are electrostatic precipitators (ESPs) or wet alkaline scrubbers [1] [26][27]	Almost 100 %, some limitations for wet scrubbers possible

8.4.9. Limit values for dust emissions released from waste incineration

Flue gas treatment of waste incineration is a complex multi-stage process including different filtering and scrubbing processes to remove SO_2, NO_x, HF, HCl and further pollutants. Usually, there is a pre-dedusting stage before other flue-gas treatments. This pre-dedusting may include:

- cyclones and multi-cyclones (generally in combination with other FGC components for the efficient capture of the finer dust fractions);
- electrostatic precipitators (ESPs);
- bag filters (BFs).

Subsequently, flue gas polishing is performed for efficient reduction of PM emissions. This may include the following techniques, depending on local conditions and process specifics:

- bag filters;
- wet ESPs;
- electrodynamic Venturi scrubbers;
- agglo-filtering modules;
- ionising wet scrubbers.

The techniques available to comply with limit values are as in the following:

Table 8-33: Table 10, Annex X, ELVs for dust emissions released from waste incineration plants techniques available for compliance

Pag.	Limit values	Reduction techniques available	Potential Applicability (%)
86	Table 10: Limit values for dust emissions released from waste incineration Municipal waste incineration plants (> 3 Mg/hour): 10 mg/m^3	The techniques are (wet) electrostatic precipitators (ESP), bag filters, or cyclones and multi cyclones for pre-dedusting, and wet scrubbers (mainly for SO_2, HCl and HF) [1] [28]	Almost 100 %
	Hazardous and medical waste incineration (> 1 Mg/hour): 10 mg/m^3 at 11 % oxygen content in the dry base	The techniques are (wet) electrostatic precipitators (ESP), bag filters, or cyclones and multi cyclones for pre-dedusting, and wet scrubbers	Almost 100 %

8.4.10. Limit values for dust emissions released from titanium dioxide production

The techniques available to comply with limit values are as in the following:

Table 8-34: Table 11, Annex X, proposal of potential updates in ELVs for dust emissions released from titanium dioxide production techniques available for compliance

Pag.	Limit values	Reduction techniques available	Potential Applicability (%)
86	Table 11: Limit values for dust emissions released from titanium dioxide production Sulphate process, total PM emissions: 50 mg/m^3	The techniques are high integrity bag filters with appropriate filter cloth [1] [6]	Almost 100 %.
	Chloride process, total emission: 50 mg/m^3	The techniques are high integrity bag filters with appropriate filter cloth [1] [6]	Almost 100 %

8.5. References of chapter 8

[1] TFTEI Techno-Scientific Board. Guidance document on control techniques for emissions of sulphur, NOx, VOC, and particulate matter (including PM_{10}, $PM_{2.5}$ and black carbon) from stationary sources. ECE/EB.AIR/117. 2012. https://unece.org/gothenburg-protocol

[2] BAT conclusions European Commission, Commission Implementing Decision (EU) 2017/1442 of 31 July 2017 establishing best available techniques (BAT) conclusions, under Directive 2010/75/EU of the European Parliament and of the Council, for **large combustion plants**, 2017.

[3] T. Lecomte, J.F. de la Fuente, F. Neuwahl, M. Canova, A. Pinasseau, I. Jankov, T. Brinkmann, S. Roudier, L. Delgado-Sancho, Best Available Techniques (BAT) Reference Document for **Large Combustion Plants**: Industrial Emissions Directive 2010/75/EU (Integrated Pollution Prevention and Control) 2017.

[4] European Commission, Commission implementing decision (EU) 2014/738 of 9 October 2014 establishing best available techniques (BAT) conclusions, under Directive 2010/75/EU of the European Parliament and of the Council on industrial emissions, for the **refining of mineral oil and gas**, 2014

[5] P. Barthe, M. Chaugny, S. Roudier, L. Delgado-Sancho, Best Available Techniques (BAT) Reference Document for the **Refining of Mineral Oil and Gas**: Industrial Emissions Directive 2010/75/EU (Integrated Pollution Prevention and Control) 2015

[6] Joint Research Centre (JRC), Integrated Pollution Prevention and Control Reference Document on Best Available Techniques for the Manufacture of **Large Volume Inorganic Chemicals - Solids and Others industry**, Brussels, Belgium 2007

[7] F. Schorcht, I. Kourti, B. M. Scalet, S. Roudier, L. Delgado-Sancho, Best Available Techniques (BAT) Reference Document for the Production of **Cement, Lime and Magnesium Oxide**: Industrial Emissions Directive 2010/75/EU (Integrated Pollution Prevention and Control) 2013

[8] European Commission, COMMISSION IMPLEMENTING DECISION of 26 March 2013: Establishing the best available techniques (BAT) conclusions under Directive 2010/75/EU of the European Parliament and of the Council on industrial emissions from **cement production**, Brussels, Belgium 2013

[9] DieselNet, DieselNet Emission Standards: Stationary Engines / Non Road Combustion Engines 2021

[10] R. Remus, Aguad-Monsonet A M., S. Roudier, L. Delgado-Sancho, Best Available Techniques (BAT) Reference Document for **Iron and Steel Production**: Industrial Emissions Directive 2010/75/EU (Integrated Pollution Prevention and Control) 2013

[11] European Commission, COMMISSION IMPLEMENTING DECISION of 28 February 2012 establishing the best available techniques (BAT) conclusions under Directive 2010/75/EU of the European Parliament and of the Council on industrial emissions for **iron and steel production**, Brussels, Belgium 2012

[12] G. Cusano, Gonzalo, F. Farrell, R. Remus, S. Roudier, L. Delgado-Sancho, Best Available Techniques (BAT) Reference Document for the **Non-Ferrous Metals Industries**: Industrial Emissions Directive 2010/75/EU (Integrated Pollution Prevention and Control) 2017

[13] G. Chronopoulos, G.-E. Cakmak, P. Tempany, G. Klein, T. Brinkmann, B. Zerger, S. Roudier, Best Available Techniques (BAT) Reference Document on **Surface Treatment Using Organic Solvents** including Preservation of Wood and Wood Products with Chemicals: Industrial Emissions Directive 2010/75/EU (Integrated Pollution Prevention and Control) 2020.

[14] European Commission, Commission Implementing Decision (EU) 2020/2009 of 22 June 2020 establishing the best available techniques (BAT) conclusions, under Directive 2010/75/EU of the European Parliament and of the Council on industrial emissions, for **surface treatment using organic solvents** including preservation of wood and wood products with chemicals, 2020.

[15] M. Black, M. Canova, S. Rydin, B. M. Scalet, S. Roudier, L. Delgado Sancho, Best Available Techniques (BAT) Reference Document for the **Tanning of Hides and Skins**: Industrial Emissions Directive 2010/75/EU (Integrated Pollution Prevention and Control) 2013.

[16] European Commission, 2013/84/EU: Commission Implementing Decision of 11 February 2013 establishing the best available techniques (BAT) conclusions under Directive 2010/75/EU of the European Parliament and of the Council on industrial emissions for the tanning of hides and skins, 2013.

[17] European Commission, Best Available Techniques (BAT) Reference Document for **Organic fine chemicals**, 2006.

[18] European Commission, Commission implementing decision (EU) 2019/2031 of 12 November 2019 establishing best available techniques (BAT) conclusions for the **food, drink and milk industries**, under Directive 2010/75/EU of the European Parliament and of the Council, 2019.

[19] Commission Implementing Decision (EU) 2019/2031 of 12 November 2019 establishing best available techniques (BAT) conclusions for the **food, drink and milk industries**, under Directive 2010/75/EU of the European Parliament and of the Council

[20] Daginnus, K., Marty, T., Trotta, N. V., Brinkmann, T., Whitfield, A., Roudier, S. European Commission. JRC, Best Available Techniques (BAT) Reference Document for **Common Waste Gas Management and Treatment Systems** in the Chemical Sector, 2023

[21] Directive stage I European Parliament and Council Directive 94/63/EC of 20 December 1994 on the control of volatile organic compound (VOC) emissions resulting from the storage of petrol and its distribution from terminals to service stations. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:31994L0063

[22] Directive 2009/126/EC of the European Parliament and of the Council of 21 October 2009 on Stage II petrol vapour recovery during refuelling of motor vehicles at service stations, 2009

[23] Commission Directive 2014/99/EU of 21 October 2014 amending, for the purposes of its adaptation to technical progress, Directive 2009/126/EC on Stage II petrol vapour recovery during refuelling of motor vehicles at service stations, 2014

[24] B. Scalte, M. GARCIA-MUÑOZ, A. Sissa, S. Roudier, L. Delgado-Sancho, Best Available Techniques (BAT) Reference Document for the **Manufacture of Glass**: Industrial Emissions Directive 2010/75/EU (Integrated Pollution Prevention and Control) 2013

[25] European Commission, COMMISSION IMPLEMENTING DECISION of 28 February 2012: Establishing the best available techniques (BAT) conclusions under Directive 2010/75/EU of the European Parliament and of the Council on industrial emissions for the **manufacture of glass**, Brussels, Belgium 2012

[26] M. Suhr, G. Klein, I. Kourti, Gonzalo, G. Giner-Santonja, S. Roudier, L. Delgado-Sancho, Best Available Techniques (BAT) Reference Document for the **Production of Pulp, Paper and Board**: Industrial Emissions Directive 2010/75/EU (Integrated Pollution Prevention and Control) 2015

[27] European Commission, COMMISSION IMPLEMENTING DECISION of 26 September 2014 establishing the best available techniques (BAT) conclusions, under Directive 2010/75/EU of the European Parliament and of the Council, for the **production of pulp, paper and board**, Brussels, Belgium 2015

[28] F. Neuwahl, G. Cusano, G. Gómez-Benavides, S. Holbrook, S. Roudier, Best Available Techniques (BAT) Reference Document for **Waste incineration**: Industrial Emissions Directive 2010/75/EU (Integrated Pollution Prevention and Control) 2019

[29] TFTEI Techno-Scientific Board. TFTEI background informal technical document for the Review of the Gothenburg Protocol for Industrial Processes Annexes IV, V, VI, X and XI March 2022. Informal document to the 56th WGSR meeting. https://unece.org/sites/default/files/2022-03/TFTEI%20review%20of%20Annexes%20to%20the%20Gothenburg%20Protocol.pdf

[30] Reference Document on Best Available Techniques for the Manufacture of Large Volume Inorganic Chemicals - Ammonia, Acids and Fertilisers August 2007. https://eippcb.jrc.ec.europa.eu/reference/large-volume-inorganic-chemicals-ammonia-acids-and-fertilisers

[31] EnviNOx, *EnviNOx and Best Available Technique* **2021**

[32] European commission, Regulation n°1272/2008 of the European Parliament and of the Council of 16 December 2008 on classification, labelling and packaging of substances and mixtures, amending and repealing Directives 67/548/EEC and 1999/45/EC, and amending Regulation (EC) No 1907/2006, 2008

[33] Guidelines for estimation and measurement of emissions of volatile organic compounds, 2016. http://www.unece.org/fileadmin/DAM/env/documents/2016/AIR/WGSR/Docs_December/E_ECE_EBAIR_WG5_2016

[34] Ceballos DM, Fellows KM, Evans AE, Janulewicz PA, Lee EG and Whittaker SG, *Perchloroethylene and Dry Cleaning: It's Time to Move the Industry to Safer Alternatives*, Front. Public Health 9:638082. doi: 10.3389/fpubh.2021.638082, **2021**.

Indes of tables

Indes of figures