Technological pathways in Serbia, Georgia, Kazakhstan, Moldova, Montenegro and Armenia

Draft version

August 2023

Prepared by TFTEI Techno-Scientific Secretariat
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For more information

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List of abbreviations and acronyms

AGP	Amended Gothenburg Protocol
AA	Association Agreement (with the EU)
AAP	Advisory Assistance Programme
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
CFB	Circulating fluidised bed
CHP	Combined Heat and Power
CLP	Classification, labelling and packaging
CLRTAP	Convention on long-range transboundary atmospheric pollution
CLP	Classification, Labelling and Packaging regulation
CMR	Carcinogenic, mutagenic or toxic for reproduction
CN	Combined nomenclature
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
EPIP	Environmental performance improvement programme
E-PRTR	European pollutant release and transfer register

ESP	Electrostatic precipitator
EU	European union
EAEU	Eurasian Economic Union
EPMIB	Environmental Protection and Mining Inspection Body
FBC	Fluidised bed combustion
FCC	Fluid catalytic cracking
FGD	Flue gas desulphurization
GAINS	Greenhouse gas and air pollution interactions and synergies
GDP	Gross domestic product
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
IED	Industrial emission directive
IEP	Integrated environmental permit
IIR	Informative inventory report
IPA	Instrument of Pre-Adhesion of the European Union
IPPC	Integrated pollution prevention and control
IGTIPC	International Green Technologies and Investment Projects Centre
JRC	Joint research centre
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
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
PM	Particulate matter
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
SO2	Sulphur dioxide
SRU	Sulphur recovery unit
STS	Surface treatment using solvents
TA	Technical annexes
TFTEI	Task force on techno-economic issues
TiO2	Titanium dioxide
TPP	Thermal power plants
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 of Strategies and Review
VRU	Vapour recovery unit

Executive Summary

TFTEI has developed 6 Case Studies to explore the possible Technological Pathways toward the Ratification of the Amended Gothenburg Protocol (AGP), in some EECCA and SEE and Balkans countries, as preparatory phase for discussions on barriers occurred during the review period carried out by the AGP, at the 42nd session of the Executive Body (EB) in December 2022 but also as background technical information in support to the discussion on the review of sufficiency and effectiveness of the Gothenburg Protocol, planned in 2023 at the 61st Working Group of Strategies and Review (WGSR) meeting, in September 2023.

Here, the summary conclusions, for Serbia, Georgia, Kazakhstan, Moldova, Montenegro and Armenia are reported.

This report is a draft version of the final report.

Serbia

Air quality and sources of emissions

In the Republic of Serbia, the air quality is classified in three categories, where the category three corresponds to the highest level of pollution. In 2019, in zones and agglomerations where the air quality has been monitored, 43 % of the population was living in category 3 areas, too polluted. When observing only agglomerations and cities with air quality measurements, it can be observed that air quality is deteriorating. 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.

NO_2 concentrations are less significant, and exceedances of limit values were observed in Beograd only, in 2021.

In terms of emissions of $PM_{2.5}$, the critical sector is 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 (Figure 2-8).

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).

Current Legislations and programmes for their alignment with several EU Directives and Regulations

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. A legislative framework is in place and regulations were developed to limit:

- Emissions from new and existing Large Combustion Plants (LCP) which the operating permit was granted after 1 July 1992, similarly to annex III of the Industrial Emission Directive very few differences with limit values of the technical annexes IV, V and X for LCPs),
- Emissions from old LCPs put into operation before the 1 July 1992. included in the 2 old LCPs are included in the National Emission Reduction Plan (NERP) valid for the period from 1 January 2018 to not later than 31 December 2027. The NERP was adopted in 2020. For all plants covered by the NERP, it is envisaged through the Directive Specific Implementation Plan (DSIP) for IED prepared recently to comply with LCP BAT conclusions after this period.

- Medium combustion plants and smaller ones,
- Industrial sources.

As a candidate country to the EU, since 2014, Serbia is working to adopt the "*acquis Communautaire*". Serbia is working to align its own air quality policies and regulations with the EU legislations, in particular, in reference to the following EU Directives of interest for improving air quality and reduce air pollutant emissions (However, for some of them, transitional periods for full alignment will have to be requested and will be subject of negotiation with the EU):

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 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 in a quite advanced situation in the legislation development and its alignment with key EU Directives. The 4th multi-annual National Programme for the Adoption of the *Acquis* (NAAP) (2022-2025) was adopted recently.

The Air Protection Programme in the Republic of Serbia for the period from 2022 to 2030 with action plan was adopted in December 2022. The plan defines the emission sources in which the efforts to reduce pollutant emissions and improve air quality can be prioritized and the actions to be implemented to fulfil its objectives.

The process of transposition of the Industrial Emission Directive (IED) is not yet completely finalised and works for improving alignment are still occurring. The state of progress of the transposition is different from chapter to chapter of the Directive[8]. By end of 2022, 44 IED installations on a total of 219, had received their integrated permit.

Technological Pathways

The implementation of the following techniques is recommended:

<u>SO_x: activities covered by AGP annex IV:</u> 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.

<u>NO_x: activities covered by AGP annex V:</u> 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.

PM: industrial activities covered by AGP annex X: Fabric filters and electrostatic precipitators in industrial processes, with the proper sizing of the equipment.

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. 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), higher rates of replacement of oldest appliances are foreseen. These measures are also linked to an energy policy aiming at reducing the energy demand through better energy efficiency.

In order to have more efficient appliances in place rapidly, the programme also includes activities for Serbia such as to complete the work for full harmonisation of its national legislation with the Eco-design Directive 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 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 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.

In Serbia, old vehicles may represent a high share of road transport emissions. The Air Protection Programme will enforce minimum Euro standards for second-end vehicles: Euro 5/V from first January 2024 and Euro 6/VI from 1 January 2025 (imports of old euro 3/III vehicles were still possible in 2022). This is a crucial step to reduce emissions from road traffic.

For Non-Road Mobile Machineries, according to information collected, limit values for NRMM produced in Serbia are consistent with the standards of tables 4 to 6 of annex VIII of the AGP (but this information has still to be formally confirmed). 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 in the second quarter of 2025.

Georgia

Air quality and sources of emissions

In Georgia, ambient air is monitored through 8 stations and passive tube measurement campaigns. In 2019, the largest $PM_{2.5}$ concentrations were observed in the most industrialised cities of Georgia. Average annual NO_2 concentrations resulted larger than the annual limit value, in Tbilisi and some other cities.

The sector “other combustion stationary sources” which include small domestic combustion, represents 7.25 kt of $PM_{2.5}$ in 2020 or 77 % of total $PM_{2.5}$ emissions in Georgia. In this sector, residential heating itself represents 77% of total $PM_{2.5}$ emissions. Industrial Combustion and Processes had a share of 13%, in 2019 (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).

SO_2: Although a significant decrease in emissions is observed in the past years, the Industrial activities are the main source of SO_x emissions, e.g., iron and steel production.

Current Legislations and programmes for their alignment with several EU Directives and Regulations

As a Party to the CLRTAP, Georgia is 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.

A new Law on Industrial Emissions, similar to the EU IED was adopted in June 2023. Draft by-laws on LCPs, including BAT based integrated permit, and on organic solvents use, are being developed and implemented, likely, up to 2031.

For stationary sources, 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 have been adopted or will be adopted soon:

- The Law on Industrial Emissions has been adopted by the Parliament in June 2023 which transposes the IED directive. Several bylaws will be adopted by the end of 2023. Draft by-laws on LCPs, including BAT based integrated permit, and on organic solvents use, are being developed and implemented, likely, up to 2031.
- The introduction of legal requirements on use of organic solvents in paints to reduce emissions of VOCs based on EU Directive 2004/42/EC is ongoing. The corresponding by-law will be adopted by the end of 2023 and will enter into force from 1 January 2024.

The 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 is ongoing.

The introduction of legal requirements on petrol storage and distribution is currently ongoing.

For mobile sources under the scope of annex VIII of AGP, the situation is as follows:

- For diesel, the sulphur content is limited to 0.001% from the first January 2023, with the Government Decree N238 adopted on 28 June 2023 which imposes not only minimum euro 5b standards for imported vehicles but also characteristics of fuels. The sulphur content of diesel and petrol is aligned with the AGP, tables 13 and 14 of annex VIII from 2023, as well as other characteristics of fuels with only one exception.
- Georgia does not produce road vehicles but imports them. By the Government Decree N238 adopted on 28 June 2023, 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.
- At this stage, limit values for non-road mobile machineries, 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.

Technological Pathway

The implementation of the Law on Industrial Emissions is expected to allow Georgia to be in compliance with limit values of the four AGP Technical Annexes IV, V, VI and X, including LCPs and large industrial plants.

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

<u>NO_x: activities covered by Annex V:</u> 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.

<u>PM: activities covered by Annex X:</u> Fabric filters and electrostatic precipitators, with proper sizing of the equipment.

<u>Domestic heating with solid fuels:</u> The 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.

The reduction of emissions from small domestic appliances is also dependent on energy efficiency of housing. Policies aiming at increasing energy efficiency in housing have co-benefits in terms of air pollution by decreasing the fuel demand and consequently the emissions.

For road transport, the recent adopted Government Decree N238 adopted on 28/06/2023 introducing at minimum Euro 5b emission standards for imported vehicles will enable the reduction of emissions of pollutants.

It could be recommended to continue to develop the legal framework to go further (such as introducing Euro 6c and 6d standards for light duty vehicles based on real driving condition test procedure).

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. The use of new generation vehicles and development of electromobility in traffic can also be envisaged.

Kazakhstan

Air quality and sources of emissions

10 cities in Kazakhstan had high air pollution levels. These are Aktobe, Almaty, Atyrau, Balkhash, Karaganda, Nur-Sultan, Shymkent, Temirtau, Ust-Kamenogorsk, and Zhezkazgan. The air quality monitoring data provided for these cities showed that concentrations of key air pollutants in the ambient air 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.

The main sources of air emissions in Kazakhstan are public power, including electricity and heat production. It is a major source of SO_2 and NOx emissions, with about 66% and 48% respective share in 2020, following by the industrial sectors with 24% and 25% respective share. The most important industrial sectors that emit SO_2 are manufacturing of solid fuels and other energy industries (59%) and stationary combustion in iron and steel industry (28%).

For NOx emissions, the industrial sectors contribution is due to manufacturing of solid fuels and other energy industries (35%), petroleum refining (31%), and stationary combustion in iron and steel industry as well (22%). Transport sector has less important share in NOx emissions (9%). 82% of NOx emissions in transport is due to light duty vehicle emissions.

The main sources of PM_{10} emissions however are industrial processes, accounting for 37% of national totals in 2020, due to emission in construction and demolition sector (70%) and stationary combustion in iron and steel industry (10%).

Important sources of particles, both PM_{10} and $PM_{2.5}$ as well as VOC are fugitive sources, accounting for 28%, 47%, and 33% respectively, of total national emissions in 2020. For PM_{10} and $PM_{2.5}$ emissions, this is due to venting and flaring of oil and gas sector 95% and 99% respectively. For VOC emissions, this is due to two sectors, namely coal mining and handling (46%) and venting and flaring of oil and gas sector (38%).

Residential sector is also important source of air pollutants, namely with 9% of SO_2, 16% of PM_{10}, 27% of $PM_{2.5}$, and 13% of VOC contributions.

Air quality monitoring data and existing emissions source inventories have significant gaps providing a strong rationale for knowledge improvement and actions toward progress in air emission source attribution and emission reduction measures.

Current Legislations and programmes for their alignment with several EU Directives and Regulations

Three strategic documents of the Republic of Kazakhstan have been developed, 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 are dealing with the measures that directly or un-directly could reduce emissions of pollutants (SO_2, NOx, PM, and NMVOC). They are increase of RES share, alignment of the production facilities and transport fuels with the latest technological standards, reduction of SOx and NOx emissions, energy efficiency, etc.

Kazakhstan’s new Environmental Code effective since July 1, 2021, is an important step toward bringing environmental management in line with global best practices. It introduced mandatory integrated environmental permits (IEPs) based on BAT for the most polluting enterprises.

Twelve Best available techniques reference books (BREF) were developed during 2021-2022 in Kazakhstan, and several BREFs are under development. They 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). The largest sources of industrial pollution in Kazakhstan, Category I enterprises, must obtain an IEP based on BAT starting in 2025.

As example, the BREF RK "Combustion of fuels in large plants for energy production" for new installations requires equal or stricter ELVs than ELVs of large combustion plants within the AGP but with several important exceptions. For existing plants, ELVs may be close, equal or less stringent depending on fuels and pollutant considered.

The legal framework for the Sulphur content of gasoil (0.1%) was not clearly identified (an EAEU regulation still to be investigated).

According to information collected, the introduction of legal requirements is not existing for:

- Petrol storage and distribution.
- Use of solvents in industry (Annex VI of AGP).

For solvents in products (AGP annex XI), some rules establishing hygienic and toxicological standards are in place but it was not possible to have details.

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

The sulphur content of diesel and petrol is aligned with the AGP, Annex VIII from 2016, but other characteristics of fuels may be different.

For NRMM, information is missing but it is unlikely that new engines produced in Kazakhstan comply with limit values of the Annex VIII of the AGP.

Technological Pathway

The introduction of mandatory integrated environmental permits (IEPs) based on BAT will allow to reduce emissions from largest emitters, including LCPs and large industrial plants.

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

<u>SO_2: activities covered by Annex IV:</u> 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).

<u>NO_X: activities covered by Annex V:</u> 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.

<u>PM: activities covered by Annex X:</u> Fabric filters and electrostatic precipitators, with proper sizing of the equipment.

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

The Annex X of the AGP, recommends emission limits of PM for small appliances. These limit values could be a good starting point for 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.

The reduction of emissions from small domestic appliances is also dependent on energy efficiency of housing. Policies aiming at increasing energy efficiency in housing have co-benefits in terms of air pollution by decreasing the fuel demand and consequently the emissions.

Passenger cars, light and heavy duty vehicles:

In Kazakhstan, the highest ecological class of vehicles currently implemented is K5 (comparable to Euro 5/V in the EU). However, according to the requirements of the Gothenburg Protocol, the transition to Euro-6 and Euro-VI standards are required. The sulphur content of diesel and petrol is aligned with the AGP, Annex VIII from 2016.

The legal framework could be upgraded to enable 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. 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.

Non-Road Mobile Machineries:

A study could be envisaged to define the state of the art in Kazakhstan for Non-Road Mobile Machineries and assess in what extent recent standards could be introduced.

Moldova

Air quality and sources of emissions

In the Republic of Moldova, currently, the air quality is monitored in a network of 17 outdated stationary stations, installed in the period 1970-1978. They are not recognized at the international level and their results are not shared with the European data system. So, it is difficult to draw the conclusions about air quality within the country.

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

Road transport is the main source of NOx emissions with 48% contribution mainly due to the emissions of heavy-duty vehicles and buses (N2-N3 trucks, and M2-M3 buses).

The industrial sources contribution in emissions of those substances are much less important due to limited number of LCP within the country and the wide use of natural gas as a fuel.

Current Legislations and programmes for their alignment with several EU Directives and Regulations

Since more than ten years, Moldova started to align its policies and regulations with the EU Directives, by 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 part, and the Republic of Moldova, of the other part. It is in force since the first of July 2016.

According to this Association Agreement, Moldova should align its legal framework with the EU legal system in air quality, industrial emissions, road transport and many other sectors. National emission ceilings should also be applied as established in the original 1999 Gothenburg Protocol to Abate Acidification, Eutrophication and Ground-level Ozone. Furthermore, before 2026 the Republic of Moldova shall endeavour to ratify the Gothenburg Protocol, including the amendments adopted in 2012[3].

Until now, the following Directives were transposed for stationary sources:

- Directive 2008/50/EC on Ambient Air Quality and Cleaner Air for Europe and the Directive 2004/107/EC on Arsenic, Cadmium, Mercury, Nickel and PAH in ambient air.
- 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),
- Directive 2016/802 on reduction in the sulphur content in fuels.

The recent Law on industrial emissions adopted 30 of September 2022 partly transposed 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 and defines the rules for periodic and continuous industrial monitoring of emissions.

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

For road transport, Moldova takes some measures to control emissions from the road transport.

Concerning fuel quality, the Directive 98/70/EC on the quality of gasoline and diesel is partially transposed providing environmental specifications for diesel and petrol, so the same sulphur content level as in the Annex VIII, Tables 13 and 14.

According to the EU association agreement, EU directives or regulations introducing Euro 6/VI (basis of tables 1 to 3 of annex VIII of the AGP) implementing rules for type approval of vehicles should have been approximated.

For NRMM, according to the EU association agreement, Regulation (EU) 167/2013 of 5 February 2013 on the approval and market surveillance of agricultural and forestry vehicles (amended nowadays) and several complementing regulations are included. At the moment, these elements are not yet implemented.

Technological Pathway

The implementation of the following techniques is recommended:

<u>SO_x: activities covered by AGP annex IV:</u> 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.

<u>NO_x: activities covered by AGP annex V:</u> 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.

<u>PM: industrial activities covered by AGP annex X:</u> Fabric filters and electrostatic precipitators in industrial processes, with the proper sizing of the equipment.

<u>Domestic heating</u>

A key sector in Moldova emitting PM for which recommended limit values are provided by the AGP is domestic heating with solid fuels such as coal or biomass. The use of the most efficient appliances in term of PM emissions and energy efficiency is essential but technological solutions are not sufficient.

The 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.

The reduction of emissions from small domestic appliances is also dependent on energy efficiency of housing. Policies aiming at increasing energy efficiency in housing have co-benefits in terms of air pollution by decreasing the fuel demand and consequently the emissions.

One of the key measures relating to domestic heating with solid fossil and biomass fuels could be development of the programme for the replacement of existing household heating appliances with new Eco-Design compliant appliances associated to financial incentives. In so-called hot-spots of PM pollution due to household heating, higher rates of replacement of oldest appliances could be foreseen.

In order to have more efficient appliances in place rapidly, the programme could include the activities for Moldova such as aligning its national legislation with the Eco-design Directive 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 and Regulation 2015/1185/EU). The establishment of 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 needs also to be set up.

Passenger cars, light and heavy duty vehicles:

One efficient measure could be to prohibit the imports 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 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.

Montenegro

Air quality and sources of emissions

In terms of air quality, PM_{10} and $PM_{2.5}$ concentrations in all the territory, and SO_2 concentrations in the northern part of the country are the main concerns in Montenegro.

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 important source of SO_2 emissions.

The main source of SO_2 emissions is the energy production sector (98.4%), i.e. the coal-fired Pljevlja Thermal Power Plant generating about one third of electricity in Montenegro, while hydropower plants generate approximately the remaining two thirds. The key contribution to NOx emissions (56%) comes from the road transport, while energy production (TEP Pljevlja) contributes 28%. The key contribution to PM_{10} and $PM_{2.5}$ emissions (85% of contribution for both pollutants) comes from the other stationary combustion, mainly from residential heating (99% for both pollutants). The key contribution to VOC emissions (39%) comes from the other stationary combustion, mainly from residential heating (97%). The road transport had a share of 16%, fugitive emissions 15% (solid fuels, namely coal mining and handling) and solvents, offroad and agriculture livestock have 9% each in total VOC emissions.

Current Legislations and programmes for their alignment with several EU Directives and Regulations

Developed in 2021, the National Air Quality Management Strategy 2021-2029 with important measures to reduce SO_2, NOx, $PM_{2.5}$, VOC was not adopted up to now. The new Strategy 2021-2029 unifies air quality plans for three established air quality zones (Northern, Central and Southern) and includes the Plan of measures for pollution control, which was prepared in accordance with the requirements of the relevant EU regulations and the final benchmark for the negotiation chapter 27, bearing in mind their common purpose and goals related to the improvement of air quality, protection of the environment and human health.

In 2019, Montenegro adopted a new Law on industrial emissions transposing the Directive 2010/75/EU on Industrial Emissions (IED). The Law on industrial emissions regulates the set of measures aimed at prevention and control of emissions deriving from industrial plants located on the territory of and transposes Chapters I and II on the main definitions, i.e. best available techniques definition, integrated permits and inspections of permit conditions respect, Chapter II, however without list of specific industrial activities covered, Chapter III (covering ELV of LCP), 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), Chapter VII including annual reporting provisions for large combustion plants and penal provisions.

By 2019, the Ministry of Economy passed 17 regulations transposing EU regulations for the introduction of eco-design requirements and 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. One part of them, the ones that consider emission limit values PM emissions in solid fuel household heating appliances, namely:

- Rulebook on the technical requirements of eco-design for devices for solid fuel local space heating transposed 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.

- Rulebook on the technical requirements of eco-design for boilers using solid fuels 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.

The sulphur content of gasoil is limited to 0.1% as in annex IV of the AGP.

Regulations on technical conditions for air protection from emissions of volatile organic compounds resulting from the storage, transfer and distribution of petrol transposes Stage I [55]and Stage II, so far the ELVs of AGP (Annex VI) are transposed.

For road transport vehicles, the Republic of Montenegro transposes the latest EU directives or regulations for application to domestic production of new vehicles and new vehicles imported.

Montenegro fully transposed the requirements of AGP Tables 13 and 14 in Regulation on limit values of the content of polluting substances in liquid fuels of petroleum origin.

Technological Pathway

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

SO_2: activities covered by 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).

NO_x: activities covered by 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.

PM: activities covered by Annex X: Fabric filters and electrostatic precipitators, with proper sizing of the equipment.

In terms of domestic appliances and small combustion Montenegro transposed EU provisions and ELVs form small heating appliances such as regulation 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 appliances.

In the scope of the draft programme of air pollution control 2021-2029, a programme for replacement of heating devices and energy measures efficiency 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.

For road transport vehicles, the Republic of Montenegro transposes the latest EU directives or regulations for application to domestic production of vehicles and new vehicles imported.

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.

In the scope of the draft programme of air pollution control 2021-2029, measures for increasing the use of alternative fuels, the use of new generation vehicles and electromobility in the traffic sector are envisaged.

Armenia

Air quality and sources of emissions

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. The national limit value for NO_2 (daily average of 40 µg/m^3) is not exceeded and average daily concentrations range between less than 10 µg/m^3 Alaverdi to around 35 µg/m^3 in Yerevan in 2022.

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. Indeed the consumption of coal and 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 using natural gas.

Current Legislations and programmes for their alignment with several EU Directives and Regulations

As a Party to the CLRTAP, Armenia aims at reducing 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 in line with the provisions of 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. The Agreement entered into force on March 1st, 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).

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 of development:

- 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.

The legal framework for the Sulphur content of gasoil (0.1%) was not clearly identified (an EAEU regulation still to be investigated by TFTEI).

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

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).

For Non-Road Mobile Machineries, the EAEU regulation TR CU 018/2011 based on the UNECE regulation 96-02 corresponds to Stage IIIA limit values of EU regulation 97/68 (requirements of annex VIII for NRMM are based on stage IIIB and IV).

Technological Pathways

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

<u>NO_X: activities covered by Annex V:</u> 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.

<u>PM: activities covered by Annex X:</u> Fabric filters and electrostatic precipitators, with proper sizing of the equipment.

Policies to reduce air pollution and improve air quality should focus in priority on the main sources of PM and especially <u>residential heating with biomass</u> (wood is used and manure in rural area).

The 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.

The reduction of emissions from small domestic appliances is also dependent on energy efficiency of housing. Policies aiming at increasing energy efficiency in housing have co-benefits in terms of air pollution by decreasing the fuel demand and consequently the emissions.

<u>Passenger cars, light and heavy duty vehicles:</u>

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

The legal framework could be upgraded to enable the introduction of the latest Euro 6/Euro VI standards for new vehicles imported and produced in Armenia.

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.

<u>Non-Road Mobile Machineries:</u>

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

General Conclusion on the Six Countries Analysis

As final conclusions, it can be observed that all the six countries examined have been working on programmes to transpose key EU directives in the activities covered by the technical annexes IV, V, VI, X and XI for stationary sources. The EU industrial emissions directive is currently transposed in Serbia, in Georgia, in Moldova, in Montenegro and in Armenia with different states of achievement, Armenia being just starting this transposal on contrary to other countries. Kazakhstan is working on integrated permits and development on country specific BREFs.

The sulphur content of gasoil is consistent with the limit value of table 2 of annex IV in Serbia, Montenegro and Moldova. For Kazakhstan and Armenia, the EAEU regulation needs to be further investigated. The information is expected for Georgia.

The VOC content of products is regulated similarly to annex VI with the transposal of directive 2004/42 in Serbia, in Moldova, in Montenegro, in Georgia. The transposal is in progress in Armenia and even if some rules may exist in Kazakhstan, not sufficient information was obtained to confirm the alignment.

The directive 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 (ELVs considered in table 1 of Annex VI of the AGP) is in different state of transposal in Serbia, Montenegro, Moldova, Georgia. Armenia is being just starting this transposal. There are no such rules in Kazakhstan.

For 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 Annex VI of the AGP) the transposal is only done in Serbia and Montenegro, with different state of progress.

For annex VIII, the situation is different from country to country. For road transport, three groups of countries can be defined: Kazakhstan and Armenia are implementing EAEU regulation and the latest one for new vehicles produced or imported is based on K5 standard equivalent to Euro 5/V; Georgia has adopted a decree on June 2023 limiting the imports of vehicles to vehicles with at minimum an Euro 5b standard; Serbia, Montenegro and Moldova transpose the EU directives or regulations implementing Euro 6/VI as in the Protocol, on time or with some delays (the exact situation still under checking with the Moldova experts).

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

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 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 (first four countries) and in 2023 (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 Technical Secretariat, 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 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 Technical Secretariat (Montenegro and Armenia) with the participation of experts from those countries.

[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

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 [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 and align it 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, 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] 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.

2.2.1. 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.

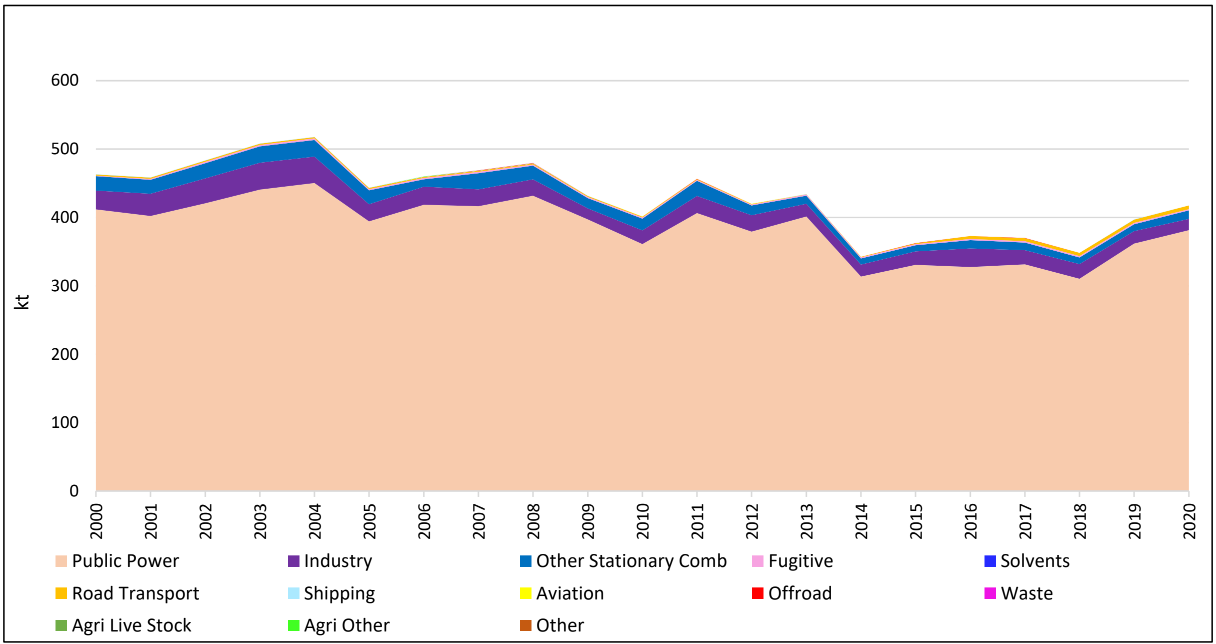

Figure 2-1: Trends in SO_2 emissions from 2000 to 2020 in Serbia

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 emissions but their impact is not yet visible in the emission inventory. The following chapters provide pieces of information on regulations implemented for large combustion installations (LCP) 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).

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.

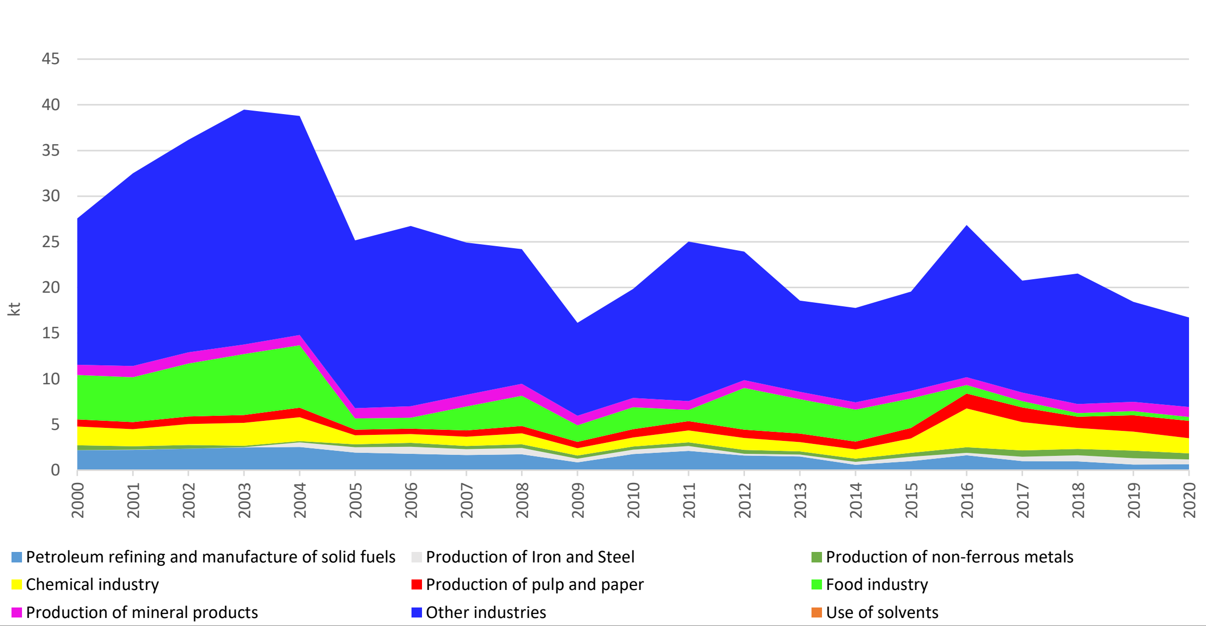

Figure 2-2: SO_2 emissions of manufacturing industry from 2000 to 2020 in Serbia

Road transport

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

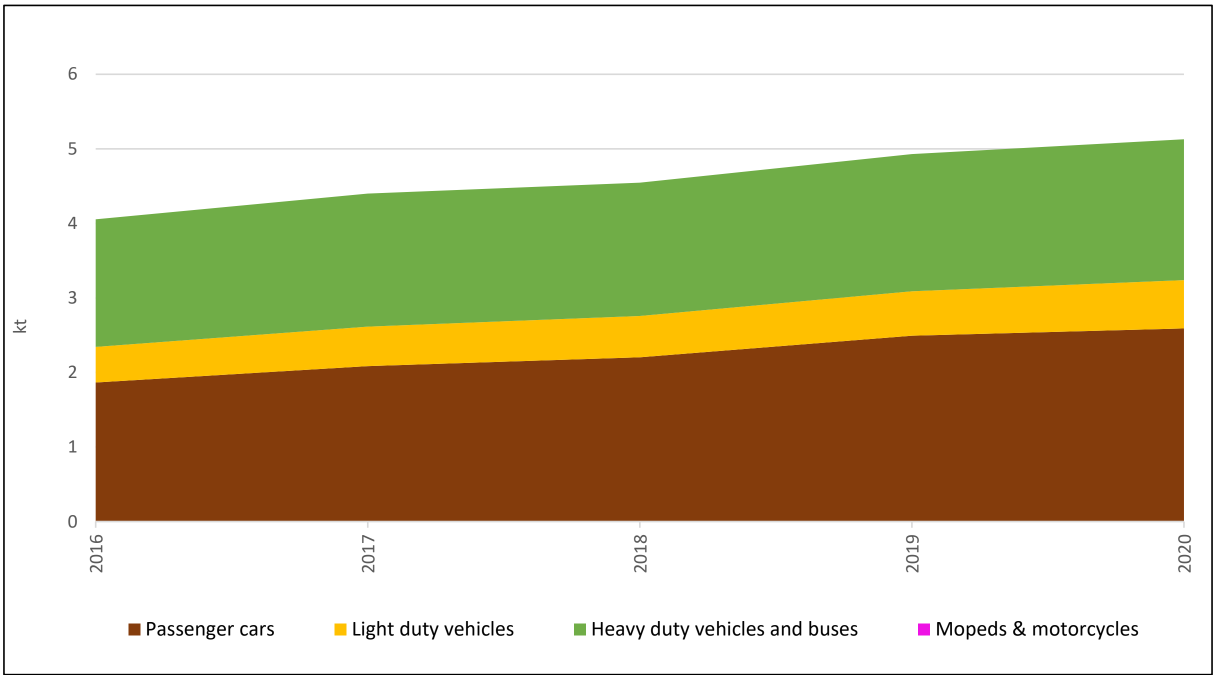

Figure 2-3: SO_2 emissions of road transport from 2016 to 2020 in Serbia

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.

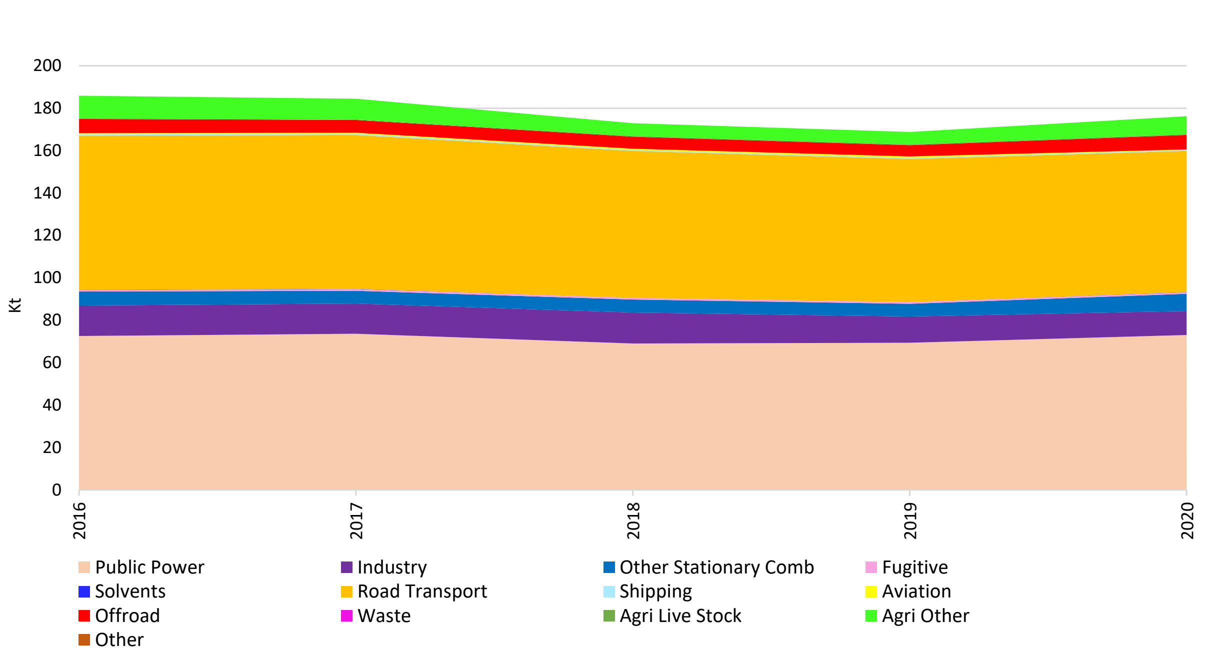

Figure 2-4: Trends in NOx emissions from 2016 to 2020 in Serbia

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.

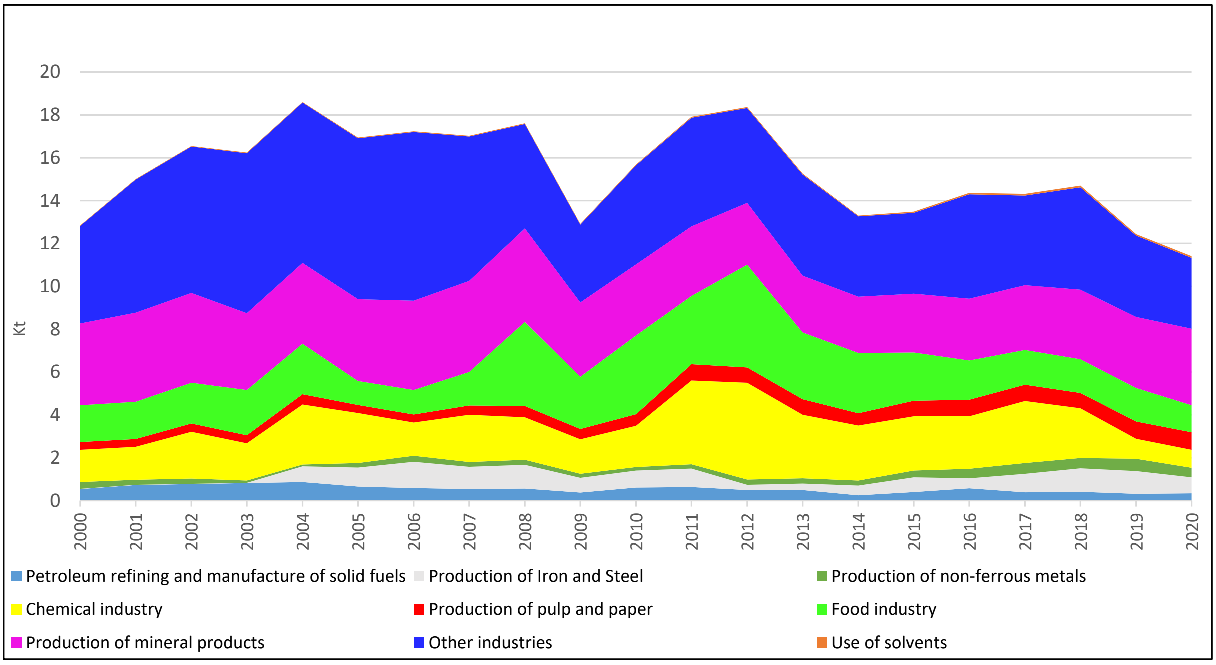

Figure 2-5: NOx emissions of industry from 2000 to 2020 in Serbia

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%).

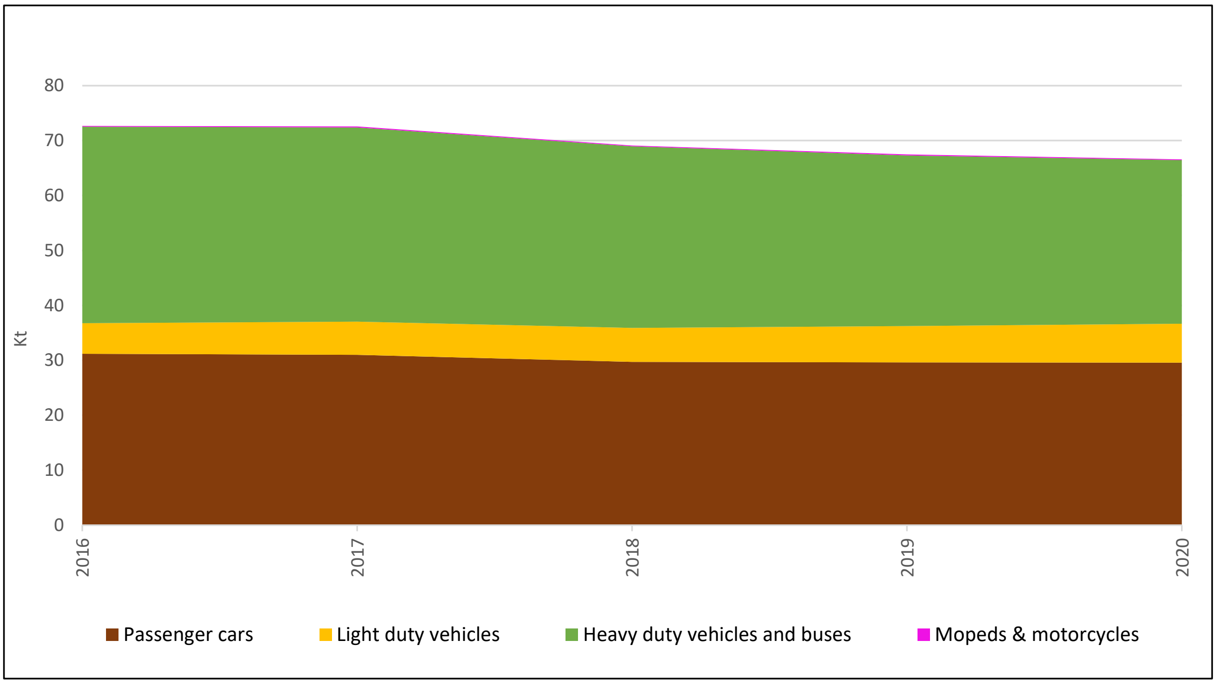

Figure 2-6: NOx emissions of road transport from 2016 to 2020 in Serbia

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 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%).

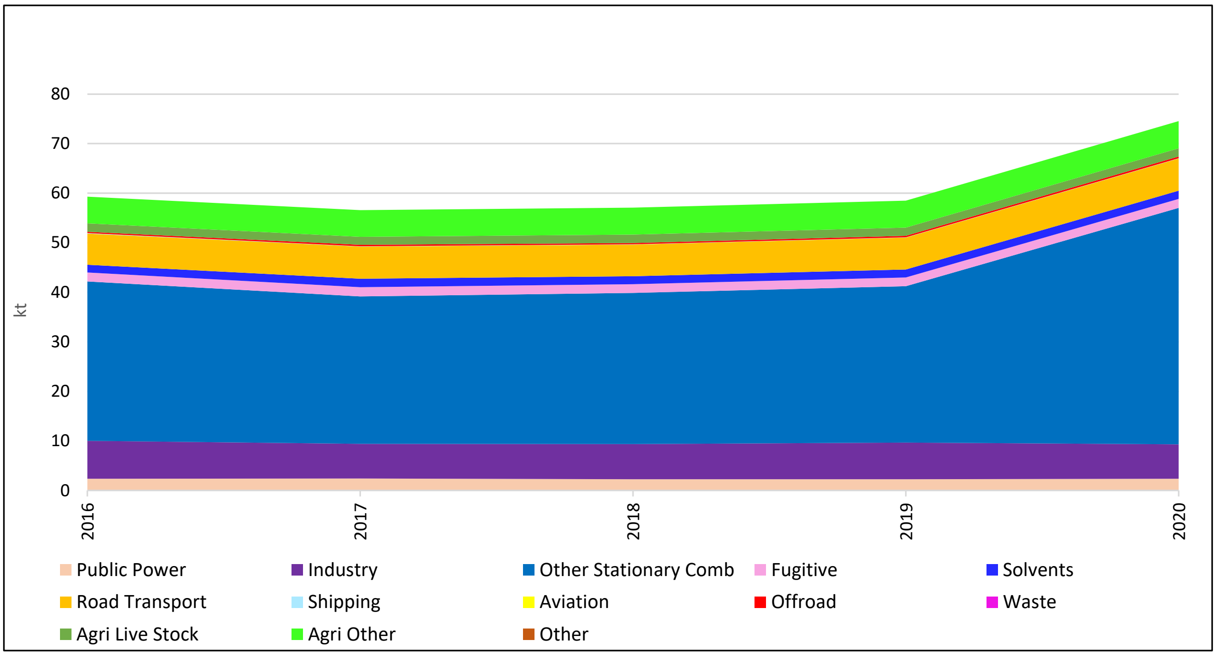

Figure 2-7: Trends in PM_{10} emissions from 2016 to 2020 in Serbia

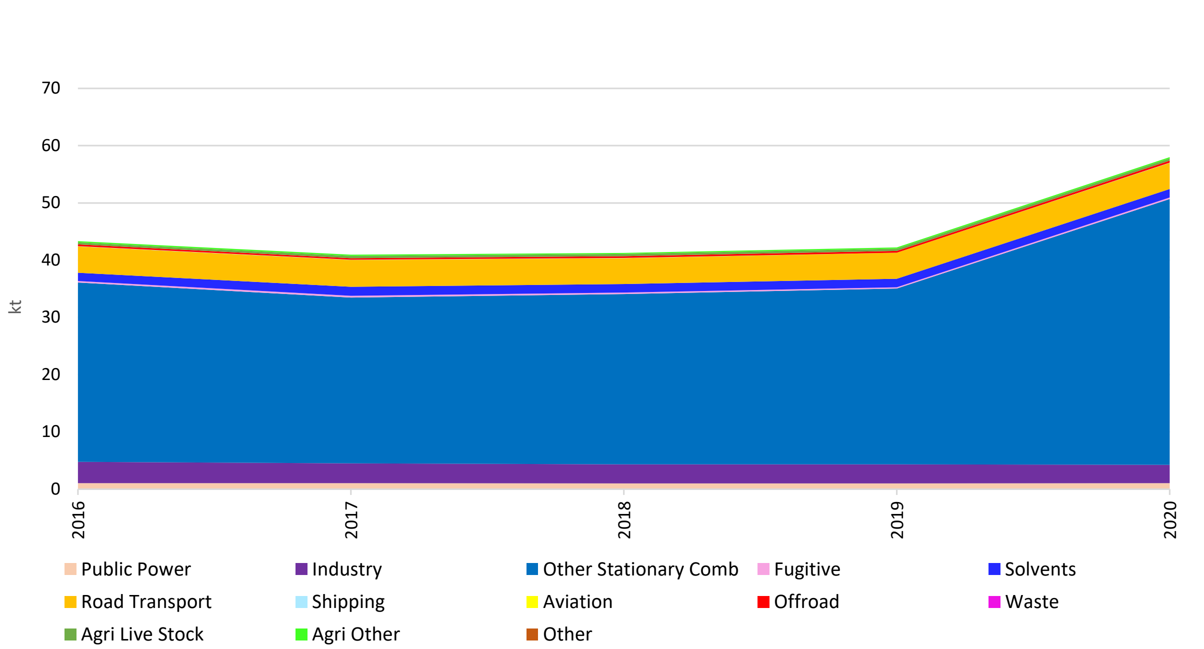

Figure 2-8: Trends in $PM_{2.5}$ emissions from 2016 to 2020 in Serbia

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.

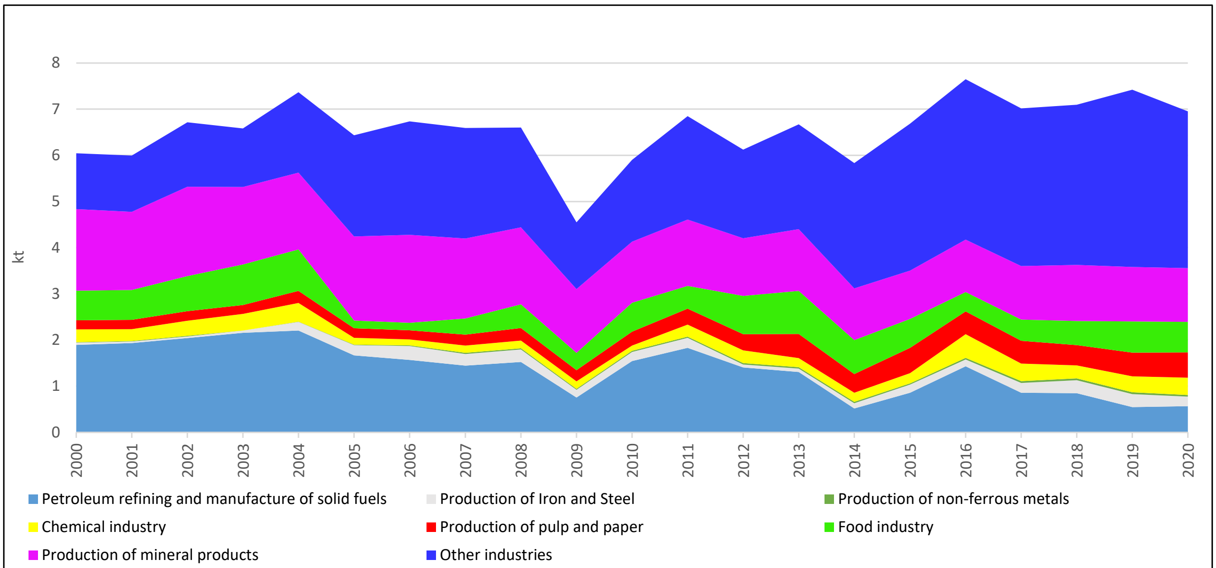

Figure 2-9: PM_{10} emissions of industry from 2000 to 2020 in Serbia

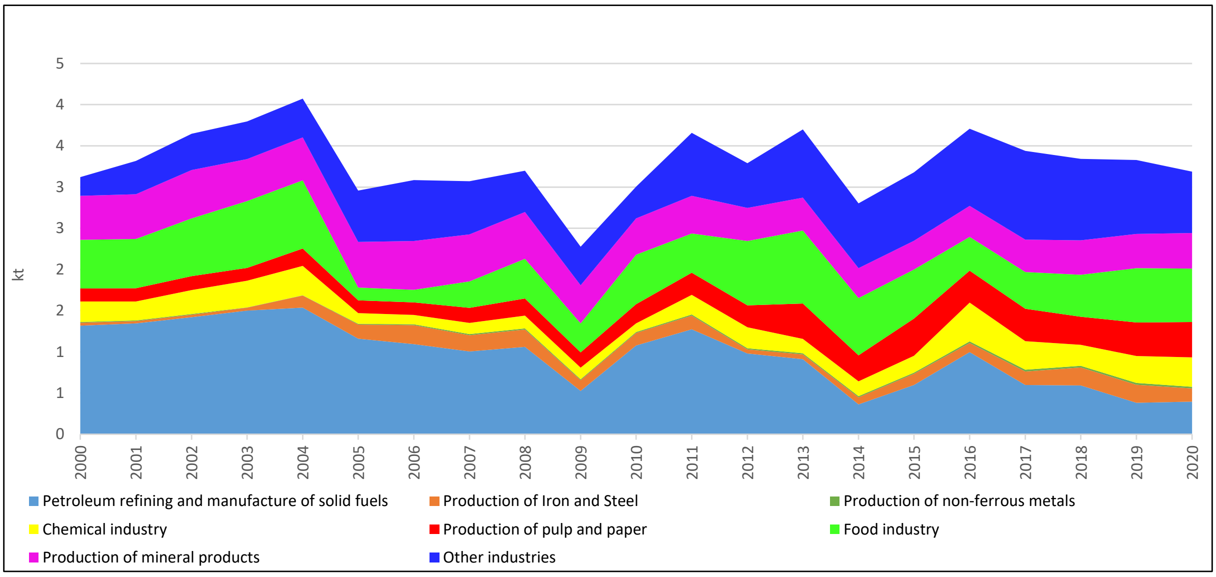

Figure 2-10: $PM_{2.5}$ emissions of industry from 2000 to 2020 in Serbia

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.

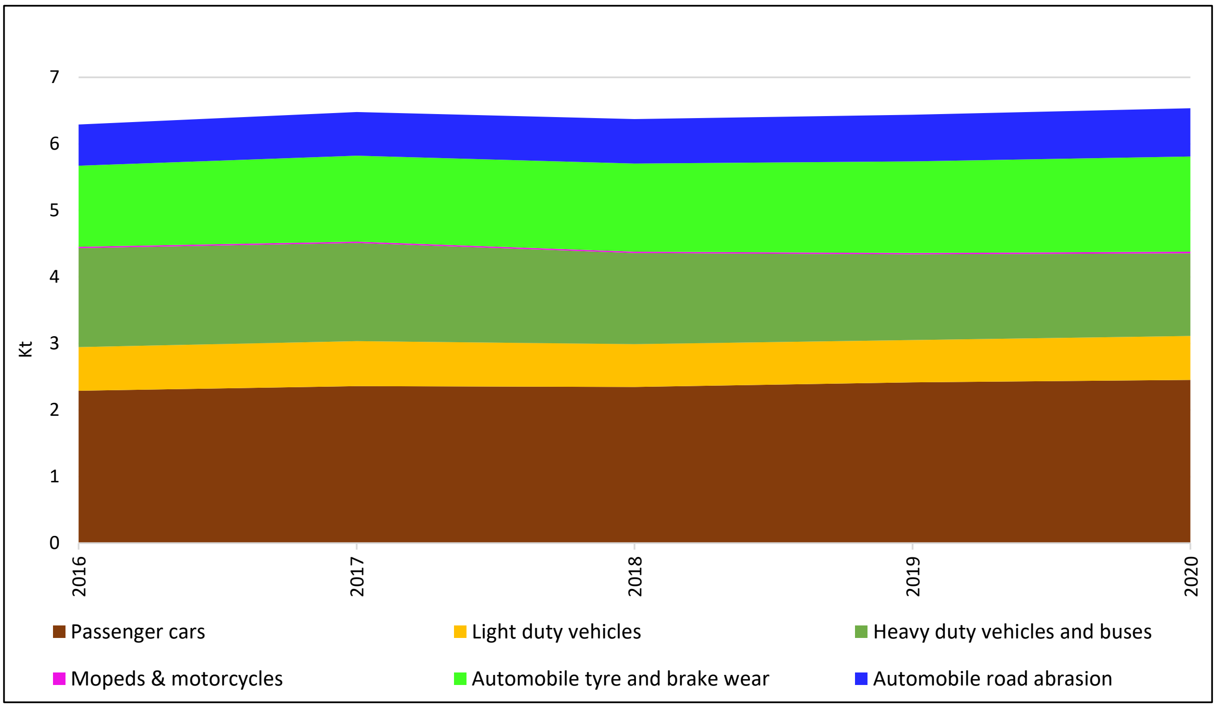

Figure 2-11: PM_{10} emissions of road transport from 2016 to 2020 in Serbia

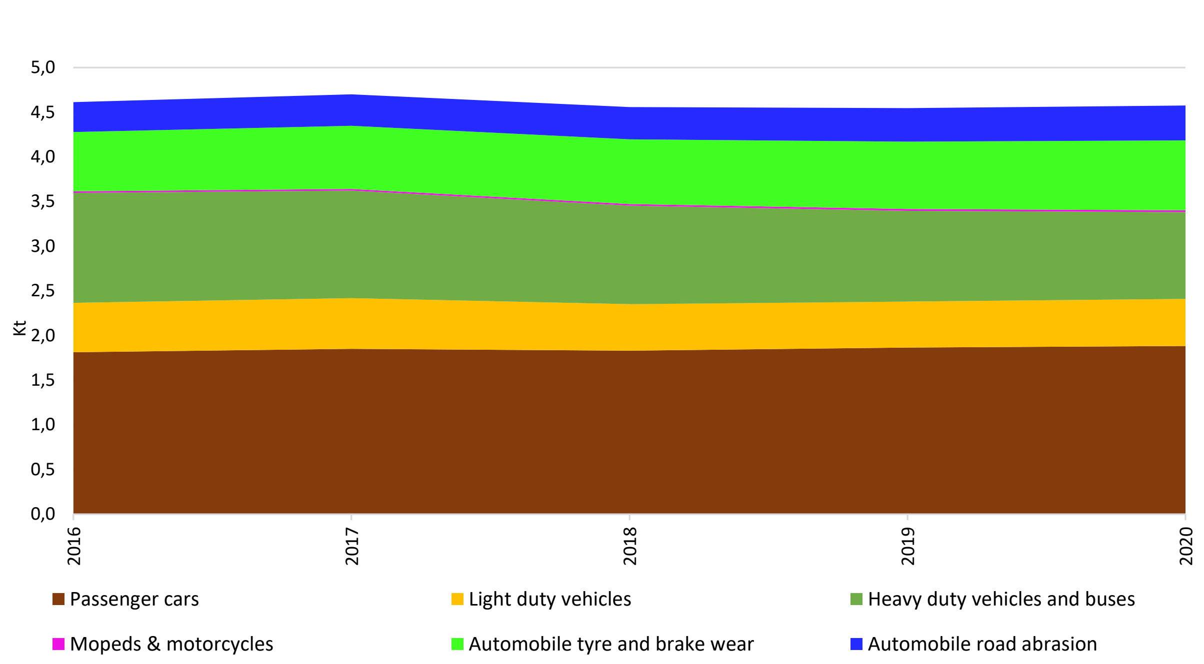

Figure 2-12: $PM_{2.5}$ emissions of road transport from 2016 to 2020 in Serbia

2.2.4. VOC emissions

Total VOC emissions

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%.

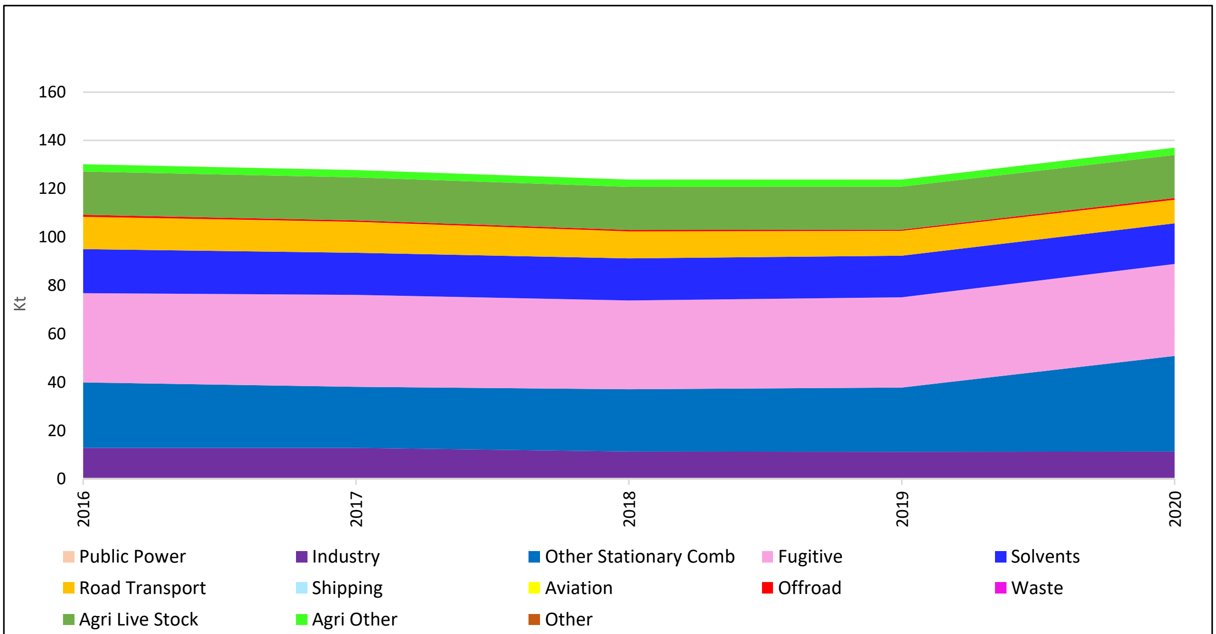

Figure 2-13: Trends in VOC emissions from 2016 to 2020 in Serbia

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%).

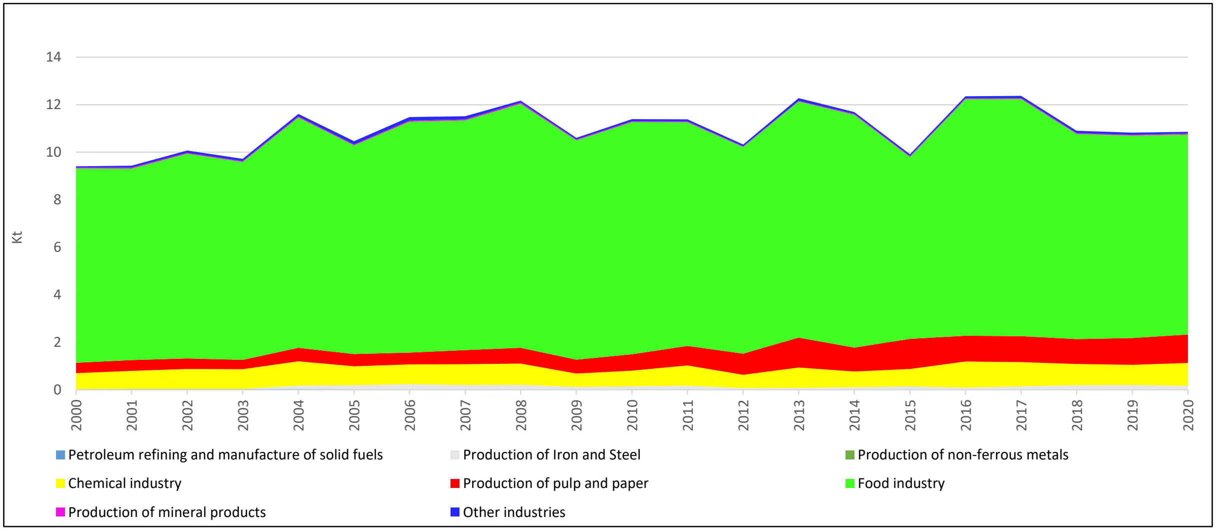

Figure 2-14: VOC emissions of industry (except use of solvents) from 2000 to 2020 in Serbia

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.

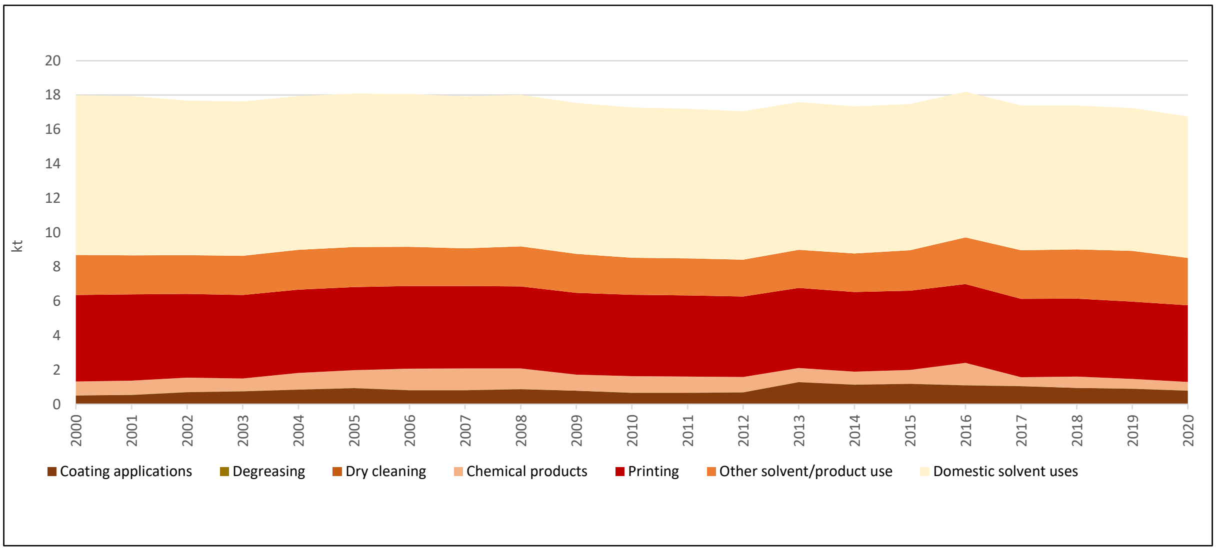

Figure 2-15: VOC emissions from the use of solvents from 2000 to 2020 in Serbia

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%).

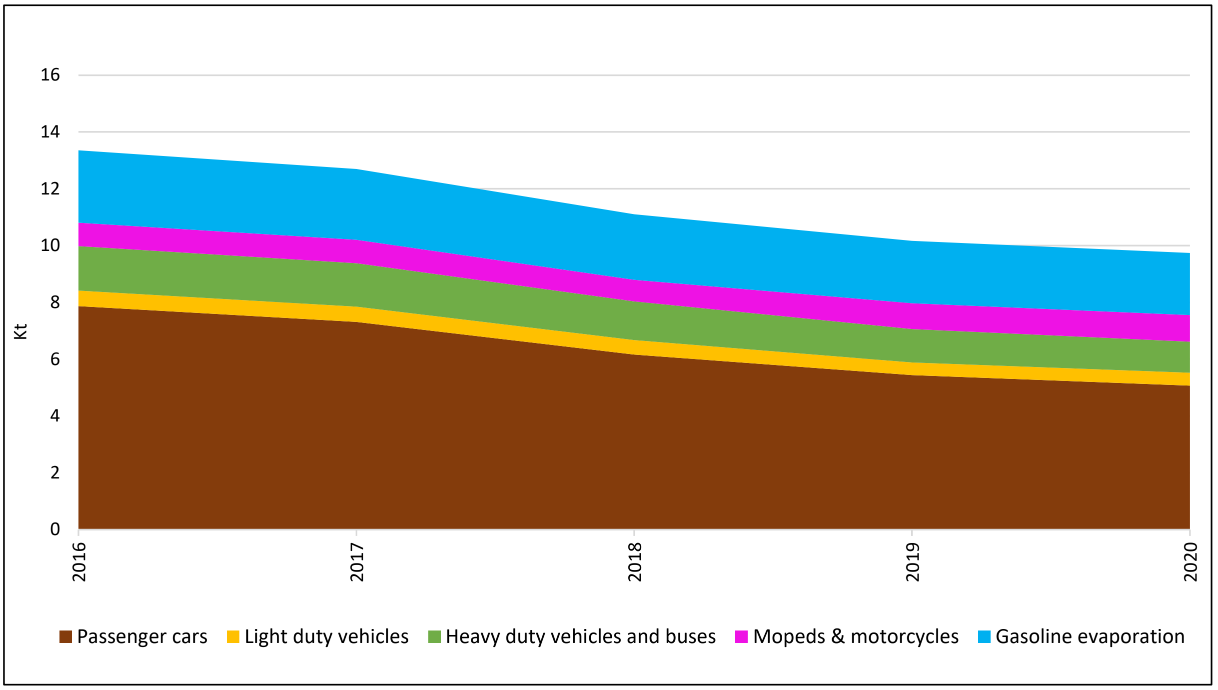

Figure 2-16: VOC emissions of road transport from 2016 to 2020 in Serbia

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).

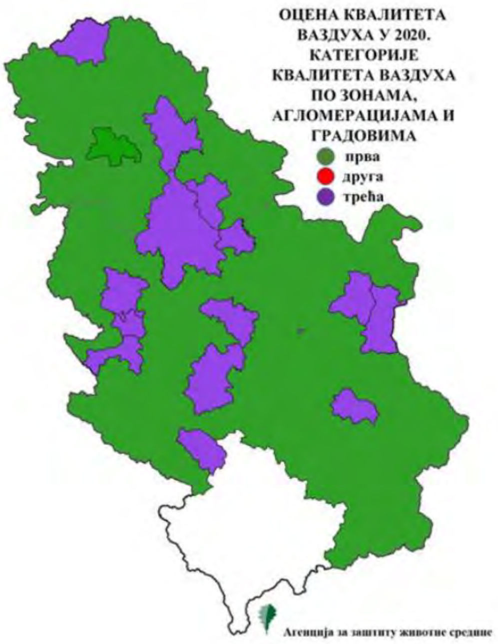

Figure 2-17: Zones of the Republic of Serbia in category 1 (in green) and in category 3 (in purple) [12] in term of air quality

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 PM2.5

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 $PM_{2.5}$:

<u>SO_2</u>

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 at stations Bor Gradski park for 19 days and Bor Institut for 4 days.

<u>NO_2</u>

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).

<u>PM_{10}</u>

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 of Bor [12].
From this analysis, it is obvious that efforts to reduce emissions of pollutants should focus 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 improving 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 finalization of the transposition of the IED in national regulations, several projects were launched and finalized. 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 provisions 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, n° 6/16) [18] and regulation "on limit values of emissions of pollutants in the air from stationary sources (OGRS, n° 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:

- o 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;
- o 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

	Date of entering into force and limit values applied (From regulation n°6/16, [18])
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, 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] 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 provisions 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 out-put mechanism for four 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 LCP industrial installations technically connected to activities of annex I of the IED, compliance have 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 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 has been 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.

<u>Stationary engines (Refer to chapter 2.8.1.1 for details on ELVs and comparison with ELVs from Gothenburg Protocol (annex V for NOx)</u>

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.

<u>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)</u>

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 but the ongoing projects to improve 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 emission limit values of VOC 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 this regulation apply are given in its Annex 2.

It has also to be kept in mind that Annex VI of the AGP [31] introduces stricter 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 limits 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 limit 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), Serbian Environment Protection Agency (SEPA) and 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 finalized 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 provisions 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 machineries 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, this limit value for the Sulphur content of gasoil is already 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 gas-oil 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). The limit value of 0.1% w/w is in place.

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 refueling were derived from limit values of the Directive 1994/63/EC on Stage I petrol vapour recovery [34] and Directive 2009/126/EC on Stage II petrol vapour recovery [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 the two EU directives (refer to chapter 2.4.2.1) and ensure full implementation of the requirements of the two Directives relating to petrol distribution chain from the terminals to service stations and car refueling.

2.4.1.6. Solvents in products

Provisions of this 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 productare fully transposed, except for the provisions which are prescribed only for EU member states (e.g. reporting to the Commission) through:

1. Law on Chemicals ("Official Gazette of Republic of Serbia", No. 36/09, 88/10, 92/11, 93/12 and 25/15);
2. Rulebook on Bans and Restrictions of Production, placing on the Market and Use of Chemicals ("Official Gazette of the Republic of Serbia", No. 90/13, 25/15, 2/16, 44/17 and 36/18).

2.1.2. 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].

2.4.1.7. 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 at supporting 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 provisions 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 provisions 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, provisions 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 provisions 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.

2.4.1.8. 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 provisions 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. A report is to be published in September 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 proposal for updates of Annex VIII so far.

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 have been considered but also limit values implemented by 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 reffer to homologation of road vehicles (produced in Serbia or imported) [48]. Standards are prescribed. There are different requirements for domestically produced and imported vehicles and as an example, the approval provisions (homologation) shall be applied two years after the date of adoption of this Rulebook.

The Rulebook transposes provisions of the EU directives related to passenger cars and light duty vehicles as well as heavy duty vehicles. With regard to 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, in line with the Annex 1 of European Commission regulation (EU) N°459/2012 May 2012 [48]): two years after the date of adoption of this Rulebook. This means that for these vehicles, application of the provisions of Euro 5 and Euro 6 has been postponed for two years. Limit values for new vehicles produced in Serbia, consistent with Euro 6 standards entered in force since 2019. <u>Information to be confirmed later.</u>

- 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 entered in force since 2020. <u>Information to be confirmed later.</u>

Currently, passenger cars, light duty vehicles or heavy-duty vehicles produced in the Republic of Serbia comply with limit values of Annex VIII of the AGP.

At the EU level, regulations prescribing limit values for light duty vehicles have evolved and Euro 6c and 6d standards based on real driving test procedure, are now applicable (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 [51]). <u>The consideration of these recent regulations in the RS regulations has to checked.</u>

2.5.2. Non road mobile machineries

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 reffer to homologation of road vehicles (produced in Serbia or imported) [48].

The AGP Annex VIII limit values (Tables 4 to 6) [31] correspond to Stage IIIB and Stage IV for diesel engines for NRMM, agricultural and forestry tractors.

Limit values for NRMM of the 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 (stage IIIB and IV), were established through different rule books for NRMM produced in Serbia.

According to information collected, limit values for NRMM produced in Serbia are consistent with these standards of tables 4 to 6 but <u>this information has still to be confirmed by experts of RTSA.</u>

These EU standards (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].

Full compliance with EU Regulation 2016/1628 [53], which is an umbrella regulation for the homologation of an entire non road mobile machine, 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.

Regulation 2016/1628 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 in the second quarter of 2025 [8].

2.5.3. Locomotives and rail cars

Limit values for locomotive and railways are provided in the 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 (stage IIIB and IV).

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

Information to be completed.

2.1.1. Inland waterway vessels

Limit values for inland water ways are provided in the Table 9 of Annex VIII of AGP [31]. Limit values for NRMM of the Annex VIII of the AGP (Table 9) are based on limit values 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 (stage IIIB and IV).

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

Information to be completed.

2.1.2. Recreational crafts

Limit values for recreational crafts are provided in the 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.

Information to be completed.

2.5.4. Motorcycles and mopeds (L-category)

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

Information to be completed.

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

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

2.5.5. 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 2.3.2.1, the Republic of Serbia is currently enhancing its legal framework (project from 2019 to 2021 to complete the transposition of this directive [36].

The requirements of Tables 13 and 14 for the Sulphur content of petrol and diesel are implemented in the Republic of Serbia but the exact values of other parameters still need to be validated by experts.

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 the 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 developed, 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 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 implementation of these directives will enable the alignment of the national regulations with limit values present in the technical annexes.

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. It can be assumed that limit values of the Annex VIII are applied for the new vehicles or new non road mobile engines produced in Serbia (in terms of mobile sources, information is still expected to finalise the assessment). 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 will have to follow the conditions of Euro 5/V from 1st January 2024 and Euro 6/VI from 1st January 2025 [7].

Since 2012, date of adoption of the AGP [31], many new EU directives were adopted and these new regulations could be considered to update the Annex VIII according to a TFTEI report to be published in Autumn 2023 [47]. The revision of the AGP has not yet programmed **Erreur ! Source du renvoi introuvable.**.

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:

- 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 last TFTEI report on the review of limit values of the AGP technical annexes 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 fabric 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] will enforce minimum euro standards for second-end vehicles: Euro 5/V from first January 2024 and Euro 6/VI from 1 January 2025 (imports of old euro 3/III vehicles were still possible in 2022). This is a crucial step to reduce emissions from road traffic.

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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
	400 in the case of combustion of pulverized lignite		
100-300	200	200	150
>300	150	150	100
	200 in the case of combustion of pulverized lignite		

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:

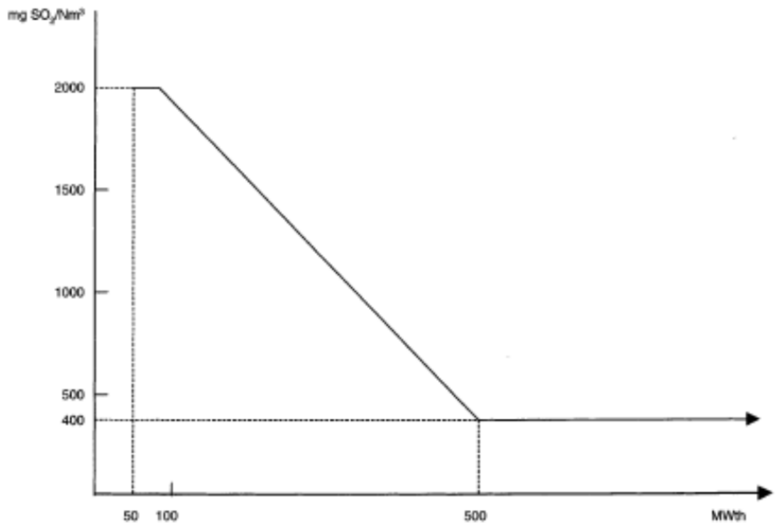
Total thermal input (MWth)	Emission limit value
50-300	20
>300	10 20 for biomass and peat

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

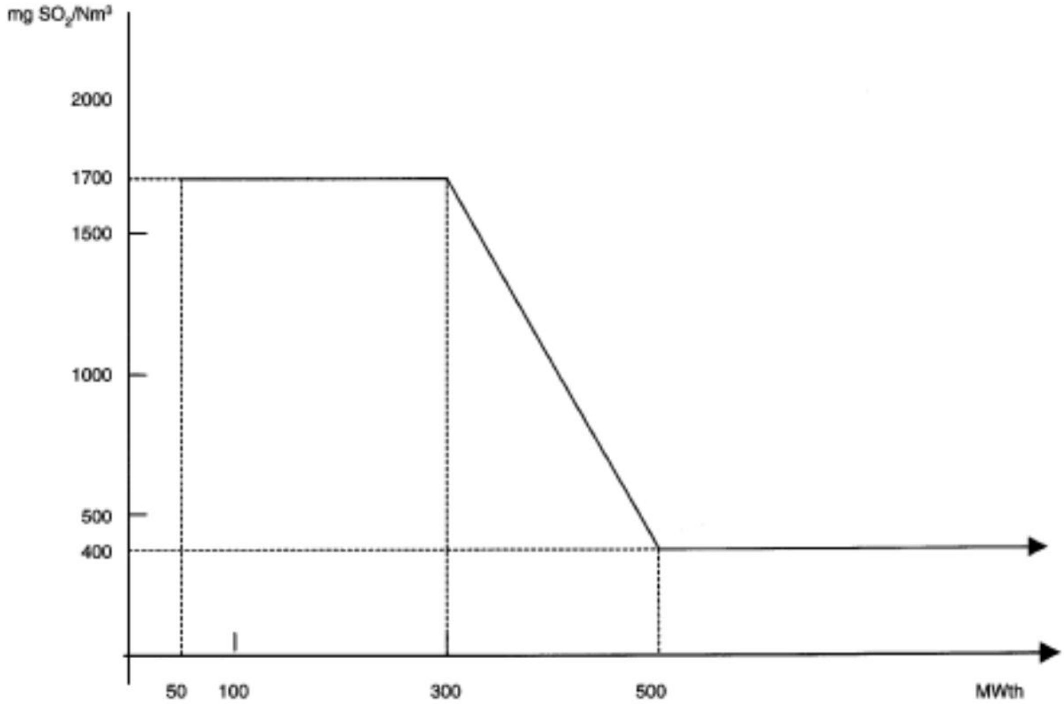
Old plants

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

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 at encouraging 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 requirements of the Protocols and though significant progress were achieved after signing the EU Association Agreement, some additional measures were required to fulfil the requirements 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].

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 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

[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.

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 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].

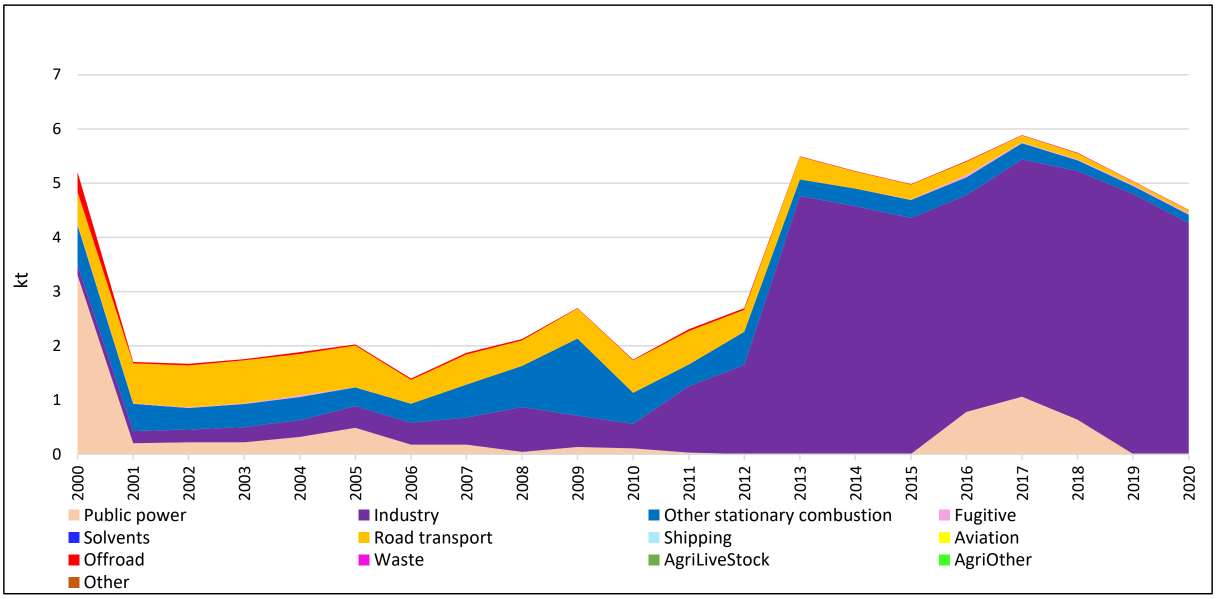


Figure 3-1: Trends in SO_2 emissions from 2000 to 2020 in Georgia

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.

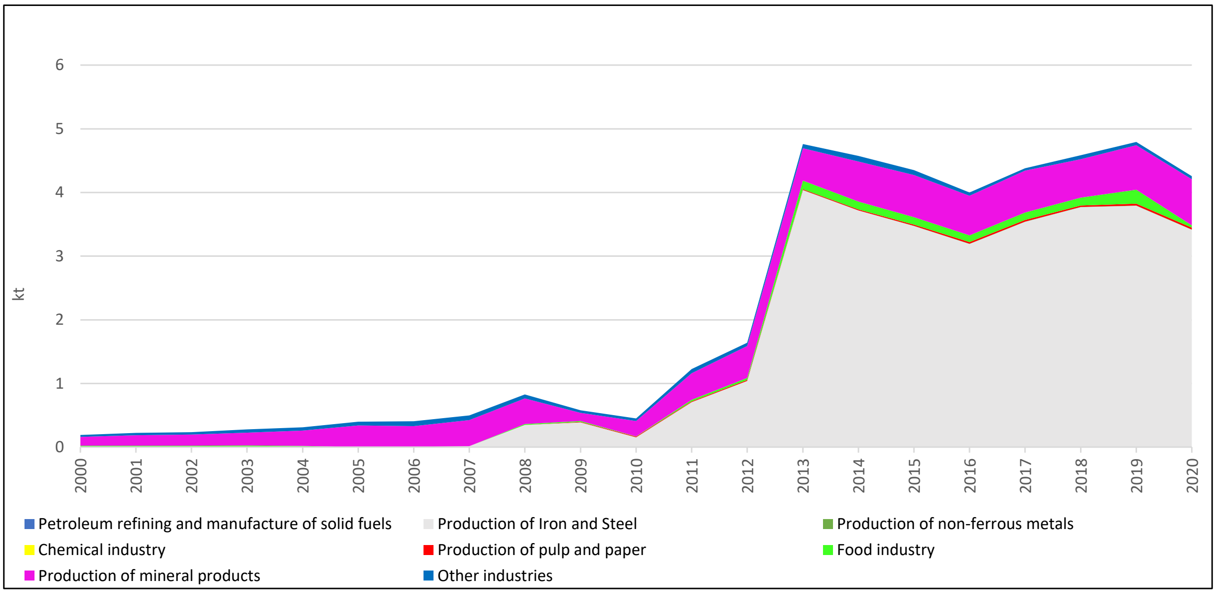


Figure 3-2: SO_2 emissions of manufacturing industry from 2000 to 2020 in Georgia

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.

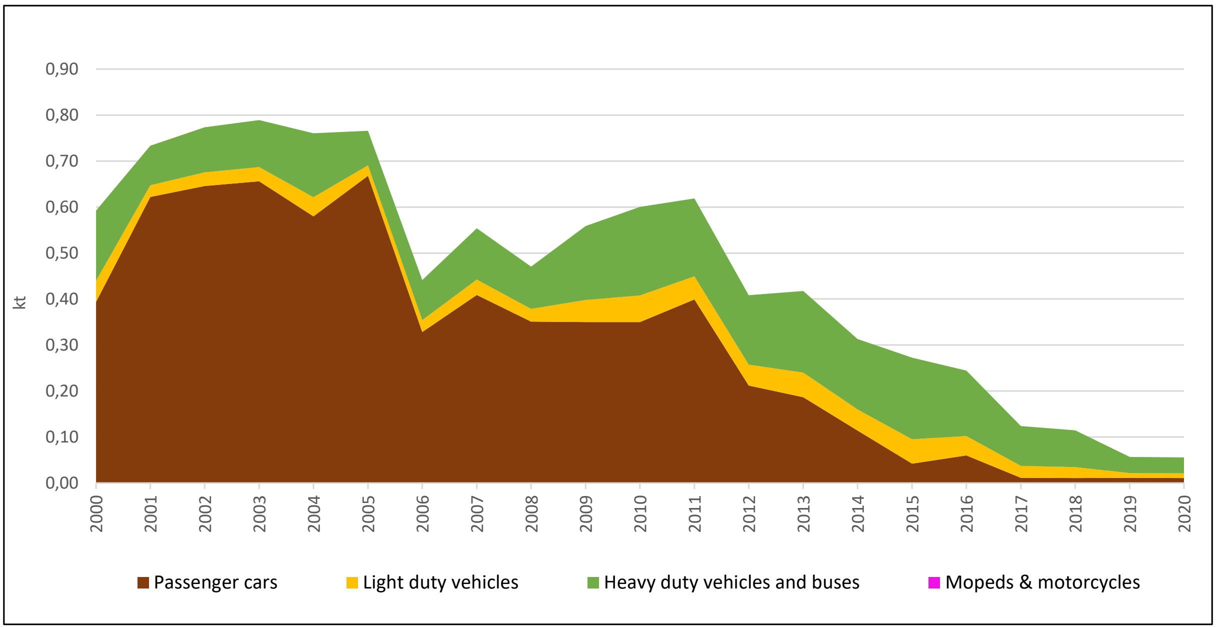


Figure 3-3: SO_2 emissions of road transport from 2000 to 2020 in Georgia

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].

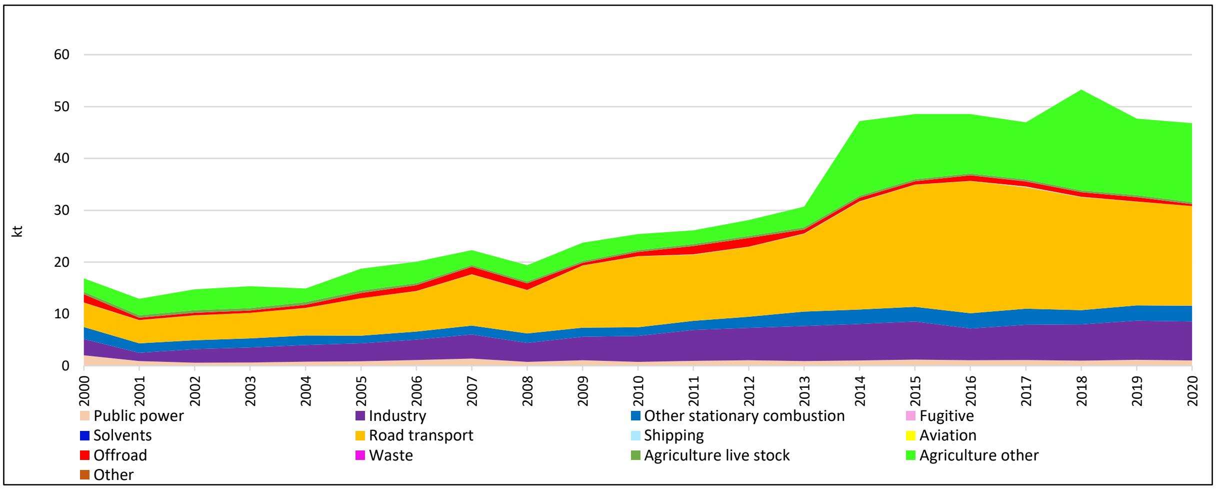


Figure 3-4: Trends in NOx emissions from 2000 to 2020 in Georgia

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.

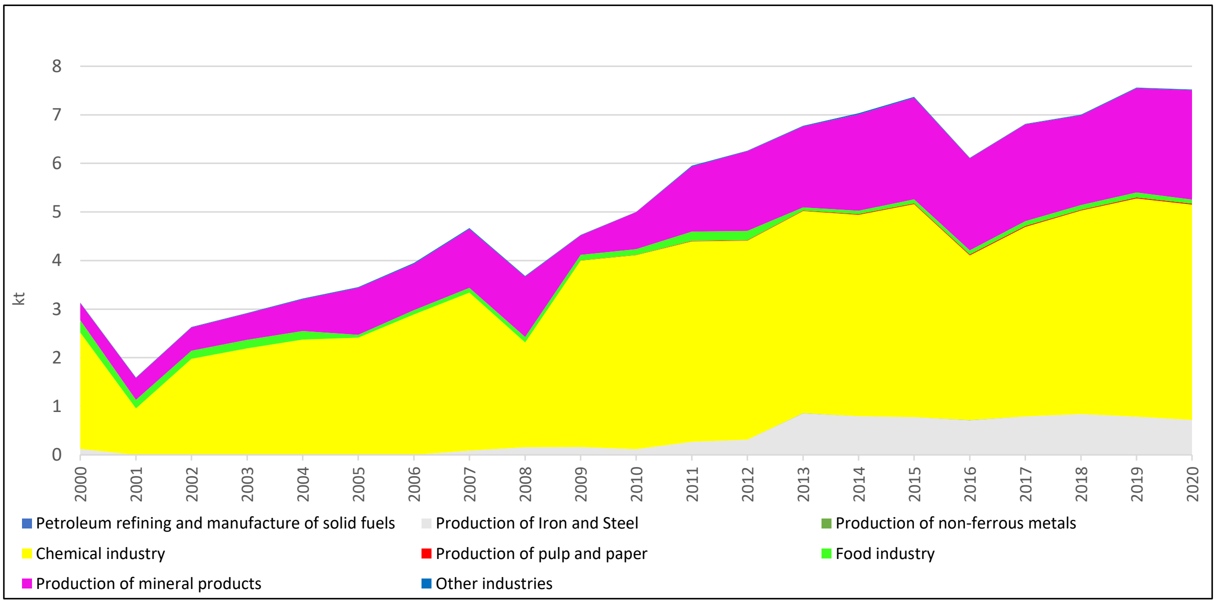


Figure 3-5: NOx emissions of industry from 2000 to 2020 in Georgia

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.

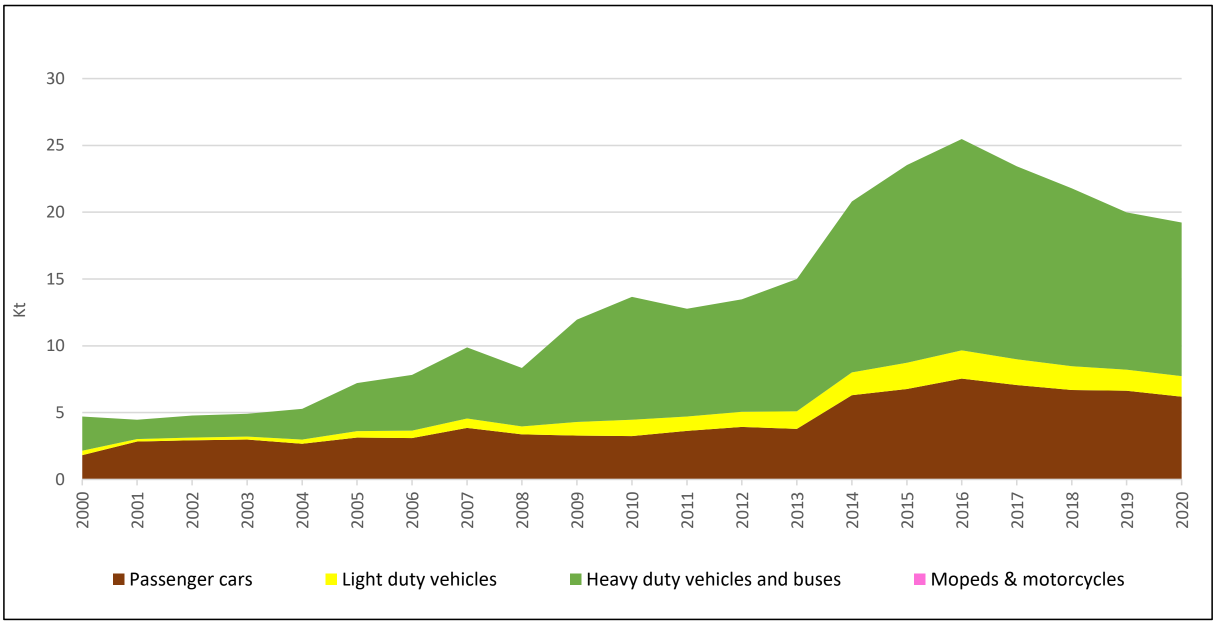


Figure 3-6: NOx emissions of road transport from 2000 to 2020 in Georgia

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.

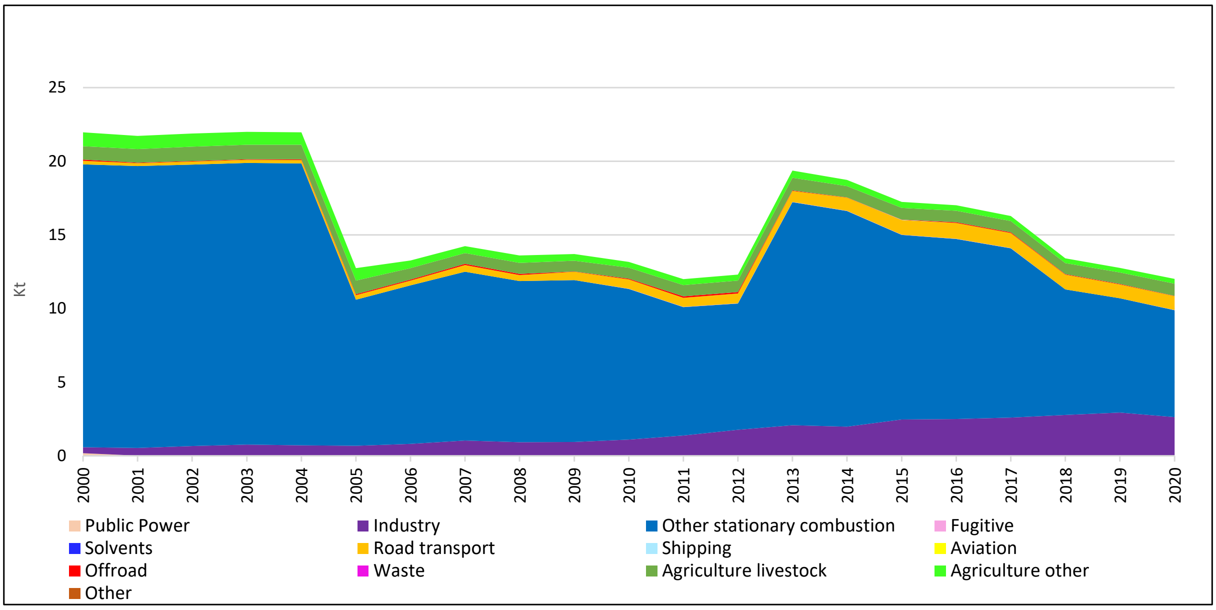


Figure 3-7: Trends in PM_{10} emissions from 2000 to 2020 in Georgia

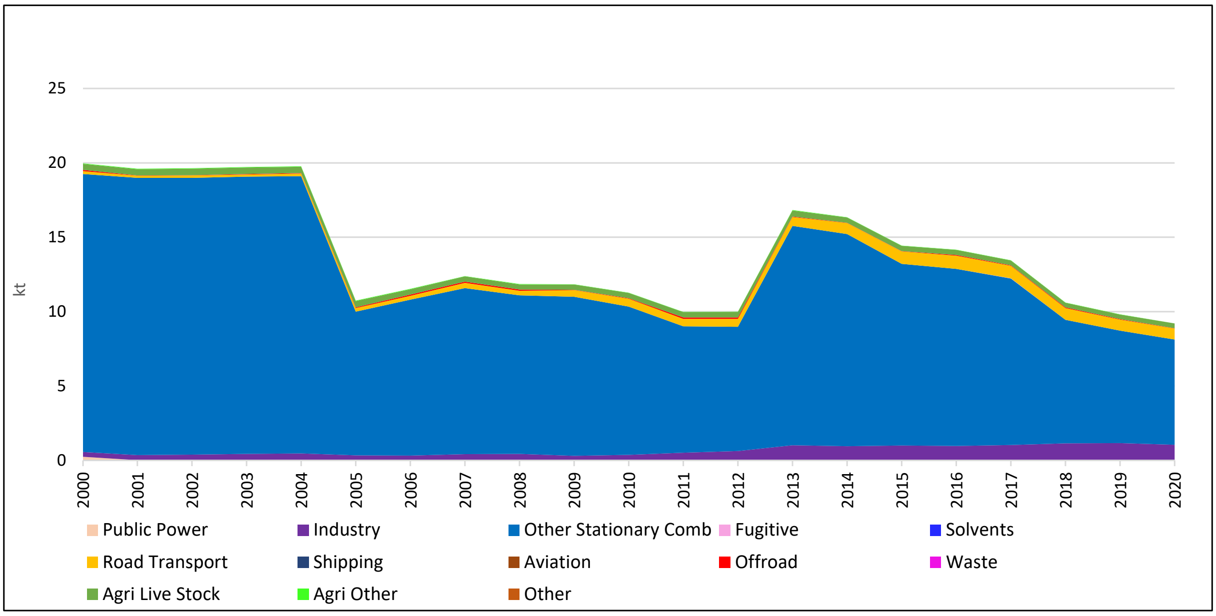


Figure 3-8: Trends in $PM_{2.5}$ emissions from 2000 to 2020 in Georgia

Industrial sources

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

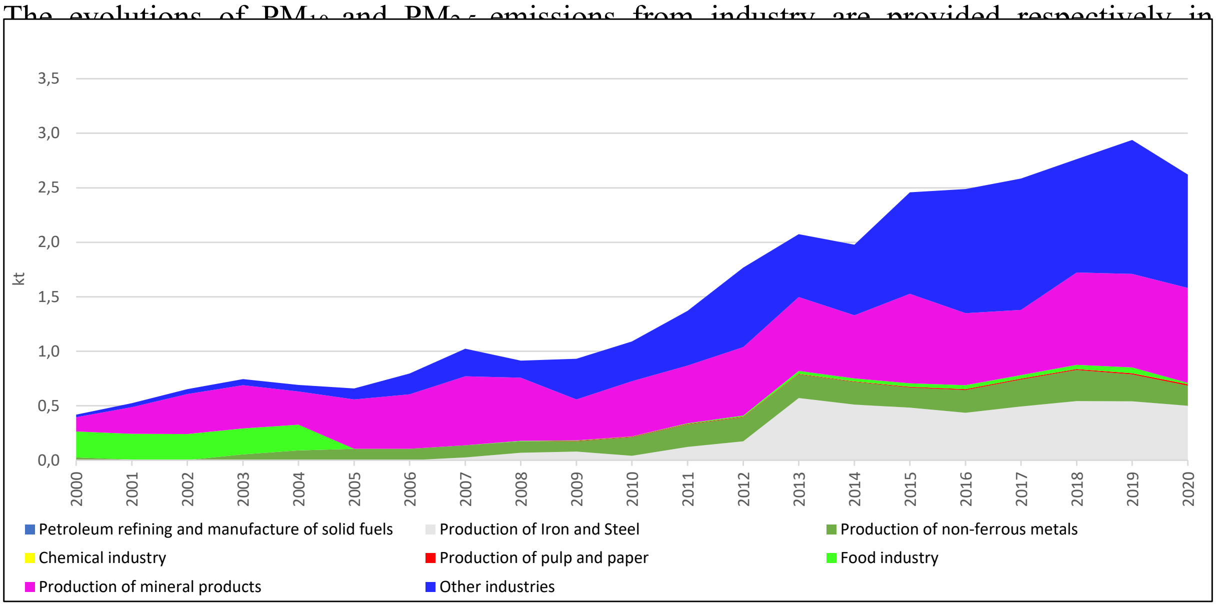


Figure 3-9 and Figure 3-10. In 2020, emissions of PM_{10} and $PM_{2.5}$ are respectively of 2.6 kt and 1.0 kt. For PM_{10}, the largest source of emissions is a group "other industry" (40% of total emissions), followed by production of mineral products (33%) and production of iron and steel (19%). For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

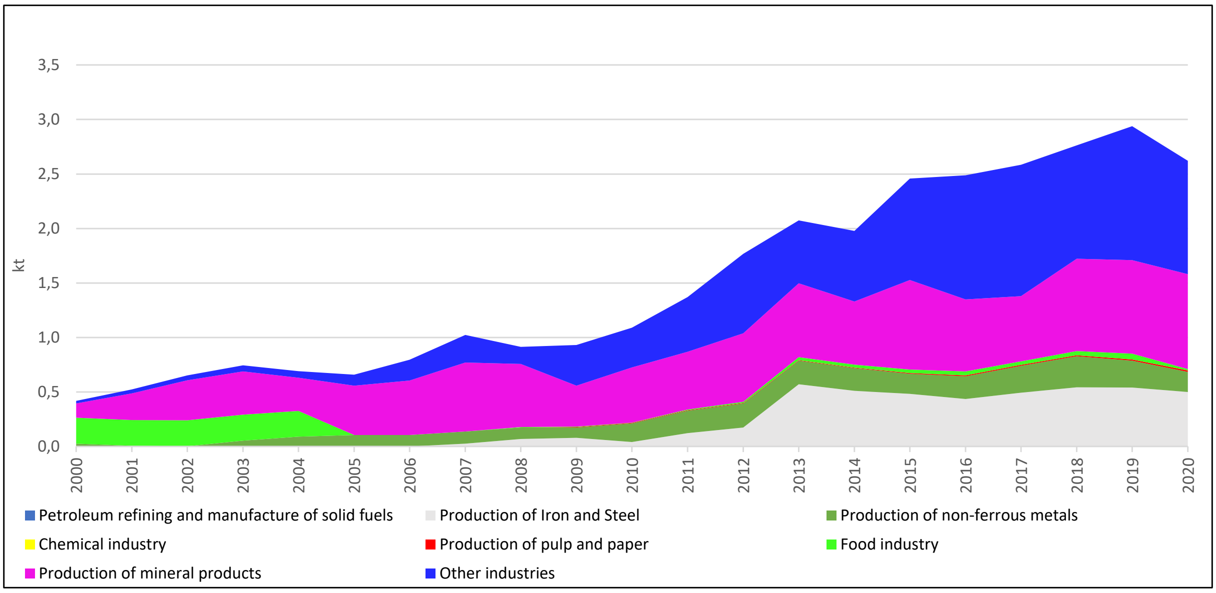


Figure 3-9: PM_{10} emissions of industry from 2000 to 2020 in Georgia

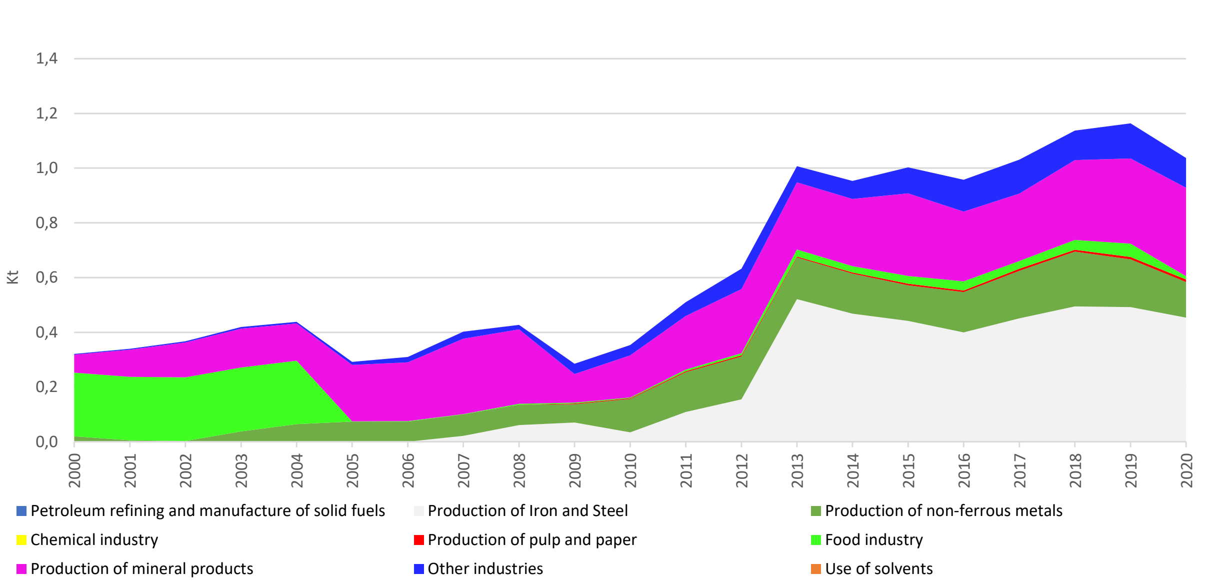


Figure 3-10: $PM_{2.5}$ emissions of industry from 2000 to 2020 in Georgia

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.

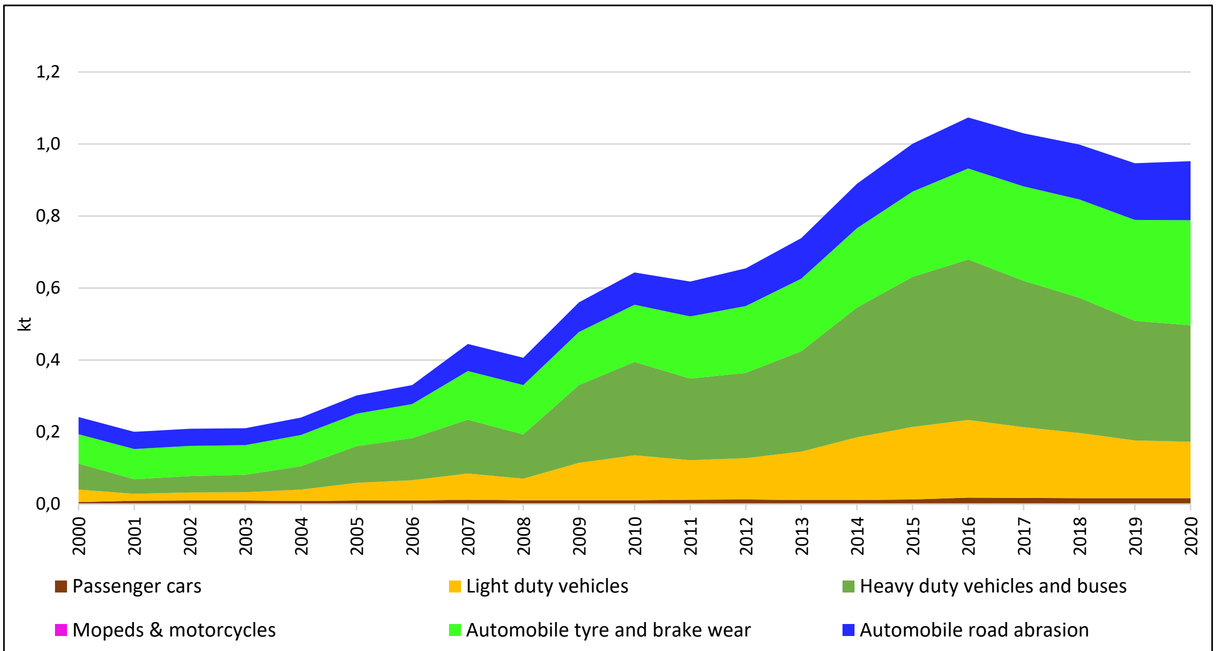


Figure 3-11: PM_{10} emissions of road transport from 2000 to 2020 in Georgia

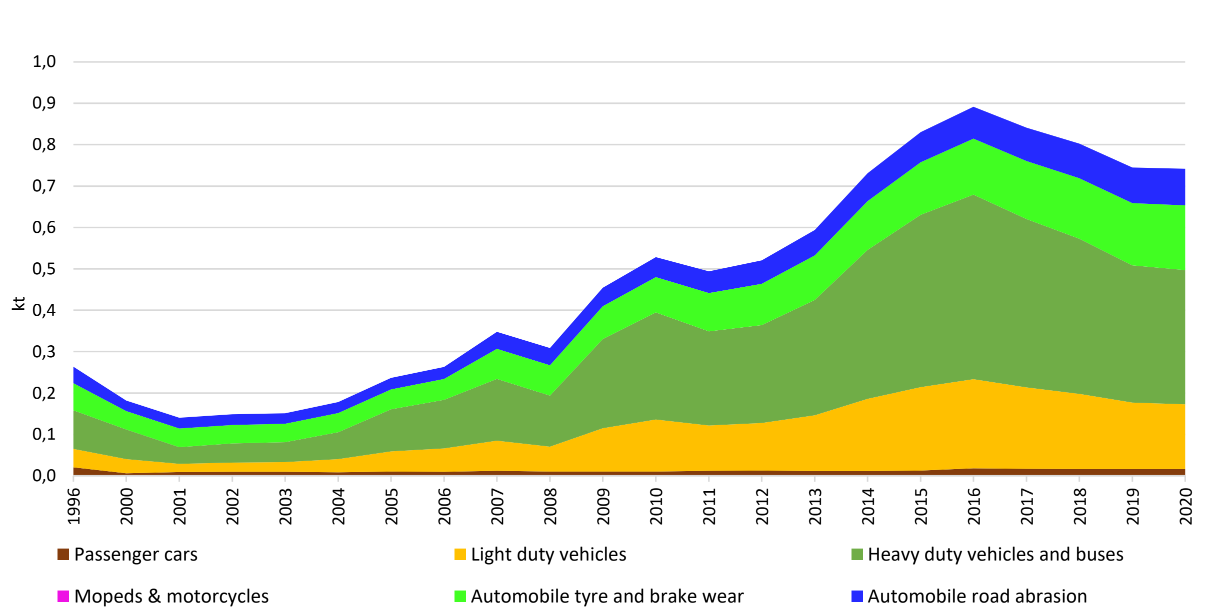


Figure 3-12: $PM_{2.5}$ emissions of road transport from 2000 to 2020 in Georgia

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.

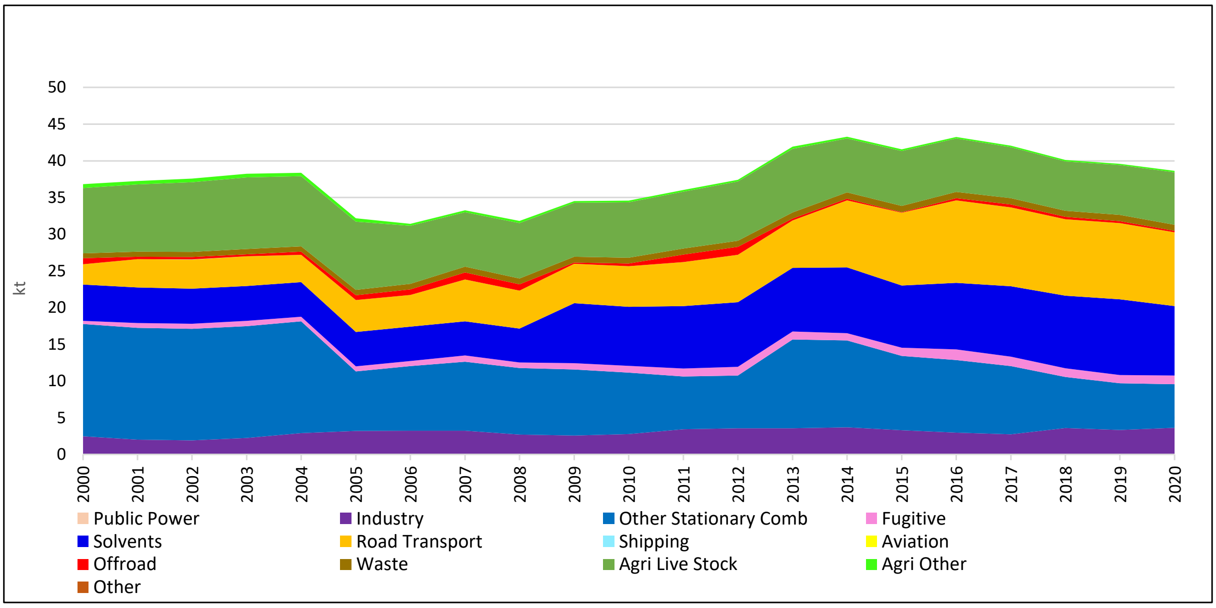


Figure 3-13: Trends in VOC emissions from 2000 to 2020 in Georgia

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 emission from industry (87%).

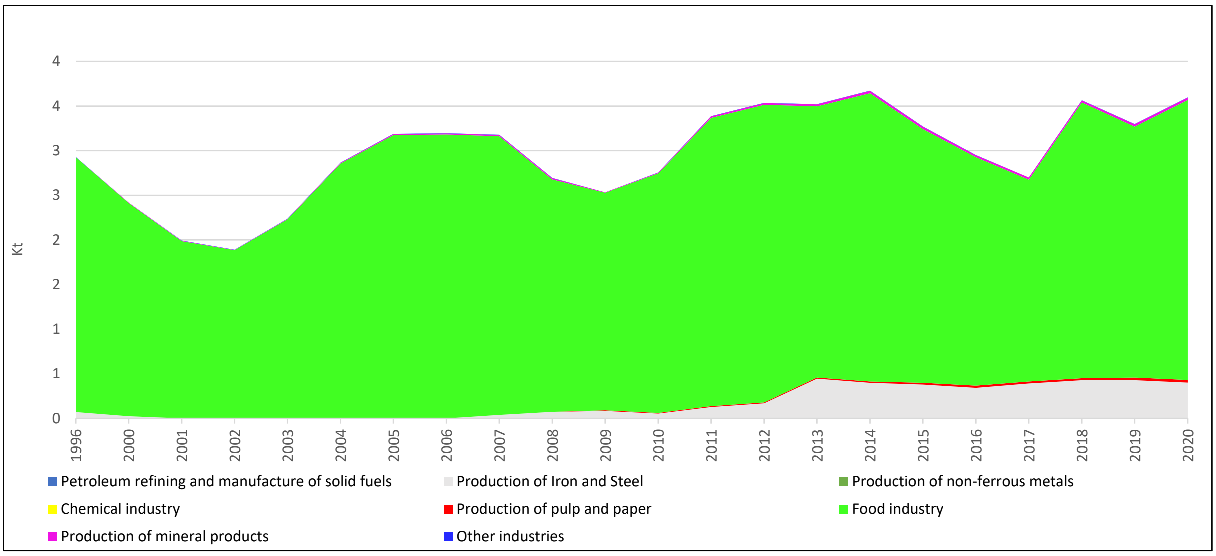


Figure 3-14: VOC emissions from industry (except solvent uses) from 2000 to 2020 in Georgia

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 totally as some sources using solvents are not yet estimated.

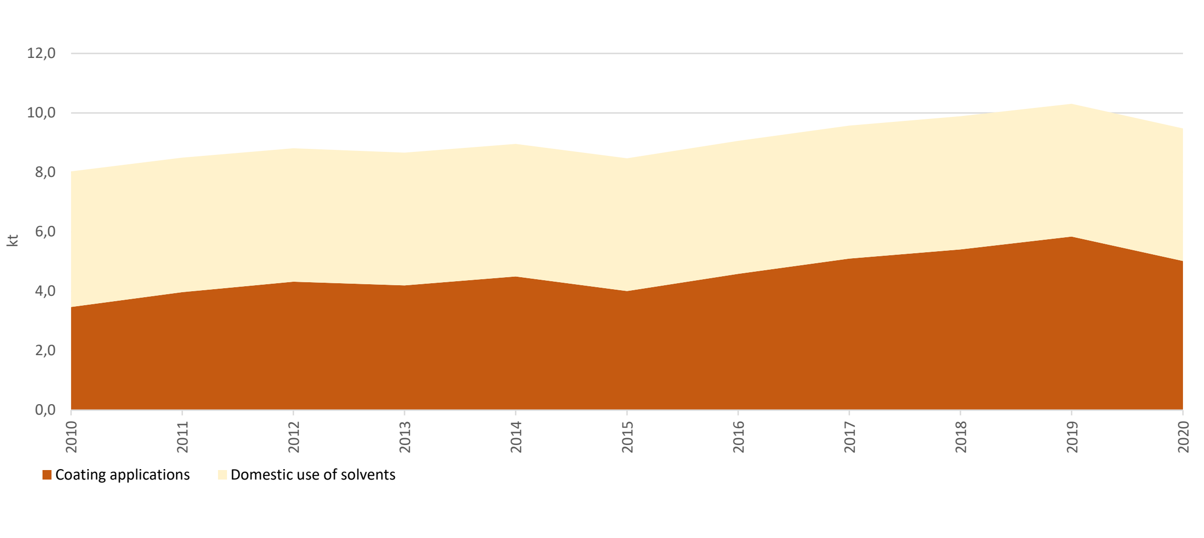


Figure 3-15: VOC emissions from solvent uses from 2010 to 2020 in Georgia

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.

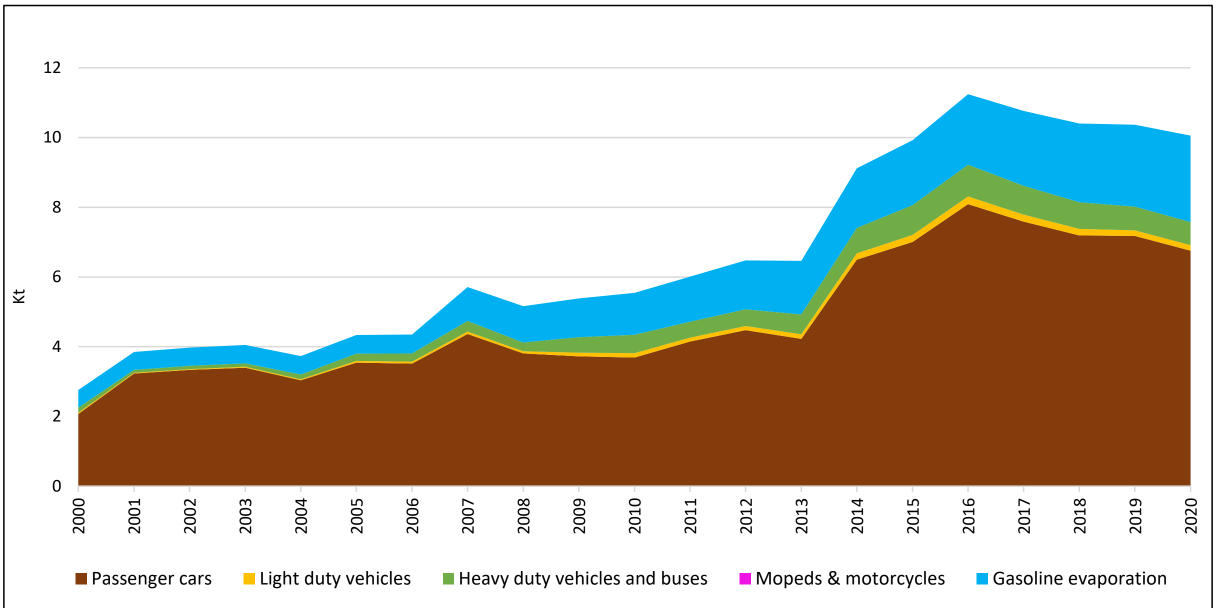


Figure 3-16: VOC emissions of road transport from 2000 to 2020 in Georgia

3.3. Situation in terms of air quality

In Georgia, ambient air monitoring is based on 8 stationary stations 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 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.

The procedure is as in the following [14]:

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 51^{st} 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.

Emissions limit values are a significant part of the environmental decision after approval by 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 [16], [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 continues 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 (pg. 32). 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 waste 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].

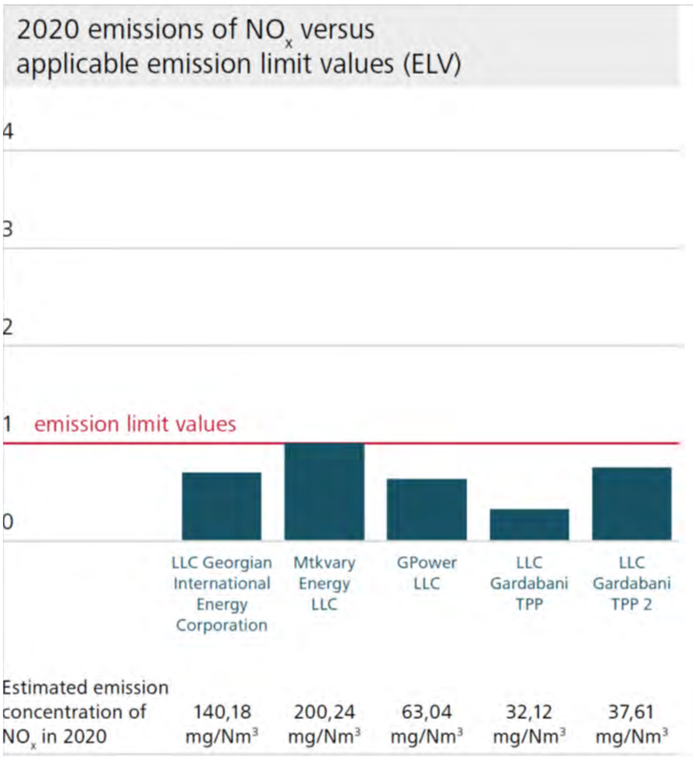


Figure 3-18: Concentrations in waste gases of the five LCPs using natural gas and comparison to limit values of the EU directives [27]

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 has been adopted by the Parliament in June 2023 [14][54]. The different associated by Laws should be adopted by end of 2023 [14].

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.

The draft by-laws to the Law on industrial emissions developed in the scope of the project, will be approved by the Government by the end of 2023, include several special provisions:

- <u>For the large combustion plants:</u> on approval of the technical regulation on combustion plants, the draft by-laws 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 the Directive 2010/75/EU on Industrial Emissions (IED);
- <u>For the installations and activities using organic solvents:</u> on approval of the technical regulation on 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 the Directive 2010/75/EU on Industrial Emissions (IED).

The Integrated permitting system will enter into force gradually from March 1, 2024 to September 1, 2026. Introduction of ELVs for existing waste incineration and co-incineration plants is foreseen to come into force from September, 2026 [14].

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

<u>Storage and distribution of petrol, excluding the loading of seagoing ships (stage I)</u>

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, tables 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 refueling at petrol stations (stage II)

The introduction of legal requirements for car refueling 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. VOC in products

The limit values for VOC concentrations in products 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]**Erreur ! Source du renvoi introuvable.**. Programmes are currently b eing implemented to comply with the requirements of the Directive 2004/42/EC. The Directive is indeed under the scope of the EU Georgia association agreement [8].

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 to reduce emissions of VOCs based on EU Directive 2004/42/EC is ongoing. The corresponding by-law will be adopted by the end of 2023 and will enter into force from 1 January 2024 [14].

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 [36], 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].

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

At this stage, limit values for non-road mobile machineries 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].

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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 instead of 60 kPa as in Annex VIII of the AGP and allowed research octane number starts from 91 instead from 95.

<u>Diesel</u>

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 a difference in PAH concentration which is 11 % m/m in Georgia instead 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 PM2.5 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 have been adopted or will be adopted soon:

- The Law on Industrial Emissions has been adopted by the Parliament in June 2023 [14][54] which transposes the IED directive. Several bylaws will be adopted by the end of 2023.
- For diesel, the sulphur content is limited to 0.001% from the first January 2023, with the Government Decree N238 adopted on 28 June 2023 [36] 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 to reduce emissions of VOCs based on EU Directive 2004/42/EC is ongoing. The corresponding by-law will be adopted by the end of 2023 and will enter into force from 1 January 2024 [14].

The introduction of legal requirements on petrol storage and distribution is currently ongoing.

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 [36], 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 machineries, 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.

For large 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 **Erreur ! Source du renvoi introuvable.Erreur ! Source du renvoi in trouvable.**:

- 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].
The 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 SO2 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 fabric 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**, significant progress has been made recently with the Government Decree N238 adopted on 28 June 2023 [36] establishing EURO 5b as minimum standard for imported

vehicles. 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 (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, 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.

Non-Road Mobile Machineries (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 standards of the newest 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.

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4. Kazakhstan

4.1. Status of ratification of CLRTAP and its Protocols and strategic programmes

Kazakhstan is Party to the Convention on the Long-Range Transboundary Air Pollution (CLRTAP) with its ratification on 11 of January 2001 [1]. It has, however, not signed or ratified any of the Protocols to the Air Convention (EMEP Protocol or pollutant specific Protocols [2]. Notwithstanding, Kazakhstan submits its emission inventories to the Centre on Emission Inventories and Projections (CEIP) [3],[4]. 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 and quality assurance and quality control procedures implemented and the NFR tables. The 2022 submission is available on the CEIP website [13].

The road map for ratification of protocols, the Protocol on Persistent Organic Pollutants (POPs), 1998, the Protocol to Abate Acidification, Eutrophication and Ground-level Ozone, 1999, and the Protocol on Heavy Metals, 1998, was developed with the 31/12/2024 preliminary deadline [5]. The draft National Action Plan has been developed by UNECE to enhance the capacity of the country to join the protocols to CLRTAP and meet the corresponding commitments through the development of the National Action Plan including AGP. It outlines the actions needed to be taken by Kazakhstan to comply with the ELVs of the AGP technical annexes concerning stationary and mobile sources [5]. However, the National Action Plan was not yet approved by the relevant authority of the Republic of Kazakhstan [6].

Several projects were carried out since then, aiming at helping Kazakhstan to establish integrated permitting system based on the best available techniques. As an example, there are two projects supported by German Federal Environment Ministry's Advisory Assistance Programme (AAP) and German Environment Agency (UBA), Germany "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)" [7] realised in 2021-2022 and "Further methodological support for the process to establish Best Available Techniques (BAT) in Kazakhstan" [8] in 2022. Another example is "European Union - Central Asia Water, Environment and Climate Change Cooperation (WECOOP)" project, that aims at enhancing 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)[4].

Furthermore, several strategic documents were adopted by Kazakhstan during the last years, in line with emission reduction.

So far, the strategy 'Kazakhstan 2050: A New Political Course of the Established State' adopted in 2012 [9], sets ambitious goals for sustainable development and Kazakhstan's transition to a low-carbon economy, providing, that by 2050:

[4] https://wecoop.eu

- alternative and renewable energy source (RES) should account for at least 50 % of the 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 according to the latest environmental standards.

In 2013, the Concept for Transition of the Republic of Kazakhstan to Green Economy was adopted [10]. The Concept builds on the 'Kazakhstan 2050' strategy and sets specific sector targets. Here after, 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 TPPs and 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 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' [11] 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 - GDP energy intensity and share of RESs.

Kazakhstan is one of the leaders of the Eurasian Economic Union (EEU) together with Russia and Belarus, existing since 2015. Regulations developed by the EEU are applied in Kazakhstan [12].

This part of report devoted to technological pathway of AGP ratification by Kazakhstan has been developed with kind support of 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 and 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 Center, and also CLRTAP inventory compilers of Republic of Kazakhstan Ekaterina Nikiforova, Eurasian GHG Management LLP, Kalmykov Dmitry, Development Director of Karaganda Regional Ecological Museum (NGO - public association), Aigul Malikova, Director of Karaganda Regional Ecological Museum and Alexander Cherednichenko representative of Zhasyl Damu. They provided more detailed information on the industrial and transport emission sources, air quality and emission regulations via the answers to questionnaires and during several meetings from June 2022 to July 2023 [6].

4.2. Main sources of emissions

The evolution of emissions of air pollutants presented here after, was built on the latest emission data submission for Kazakhstan under the CLRTAP in February 2022 for the period of 1990 to 2020 [13]. 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 and quality assurance and quality control procedures implemented [6].

The main source of information to compile the CLRTAP emission inventory in Kazakhstan is statistics on production of end-products and fuel used by the Bureau of National Statistics of the Republic of Kazakhstan. Since 2019, emissions are estimated based on the methodological document EEA Report No 13/2019 Technical guidance to prepare national emission inventories using Tier 1 and, in some cases, Tier 2 methods [14].

The dynamics of emissions primarily related to differences in methods of emission estimations and experts' judgments used by 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 were not previously considered. For 2019, about ten new categories were introduced and their contribution is significant. For example, concerning particulate matter (PM) emissions, until 2019, the emission reporting of particulates did not include emissions from residential heating and public electricity and heat generation. The reported emissions for 2019 include those important sectors, which explain the increase in particulate emissions levels in 2019. Another reason for emission differences is that no adjustments are made for the previous time series to include the previously omitted sectors.

Concerning transport emission estimation, there are very high uncertainty of the results, as soon as the statistics used for inventory compilation, are not disaggregated according to the characteristics required for emission calculations using even for Tier 1 methodology (e.g. no available data 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). So, it was decided to exclude transport emissions sources analysis from this chapter.

The analysis covers the dynamics of SO_2, NOx, PM_{10}, $PM_{2.5}$, and NMVOC emissions from 2010 to 2020. It should be kept in mind that due to Covid pandemic, activity levels can have been impacted and reduced, so the emissions. So far, the evolution of emissions from 2019 to 2020 may not be indicative of a broader pattern. T

The emissions from NFR tables have been treated by TFTEI to provide figures hereafter. It has to be kept in mind that evolution of emissions may presents rapid growths or changes, due to changes in calculation methods from year to year without recalculation for the timeseries (on contrary to recommended best practices).

4.2.1. SO_2 emissions

Total SO_2 emissions

The evolution of SO_2 emissions from 2010 to 2020 is as presented in Figure 4-1. Between 2010 and 2018 the emission level of SO_2 stays stable. Emissions have tripled in 2019 in comparison with 2018. In 2020, SO_2 emissions reach 1,576 kt.

The major sources of SO_2 emissions are the public power including electricity and heat production (66%), industry (24%), and other stationary combustion (10%). In the latter category, residential heating accounts for 95%. Road transport emission share is negligible and accounts for less than 1%. However, as it was pointed before, road transport emissions have not been accurately estimated yet.

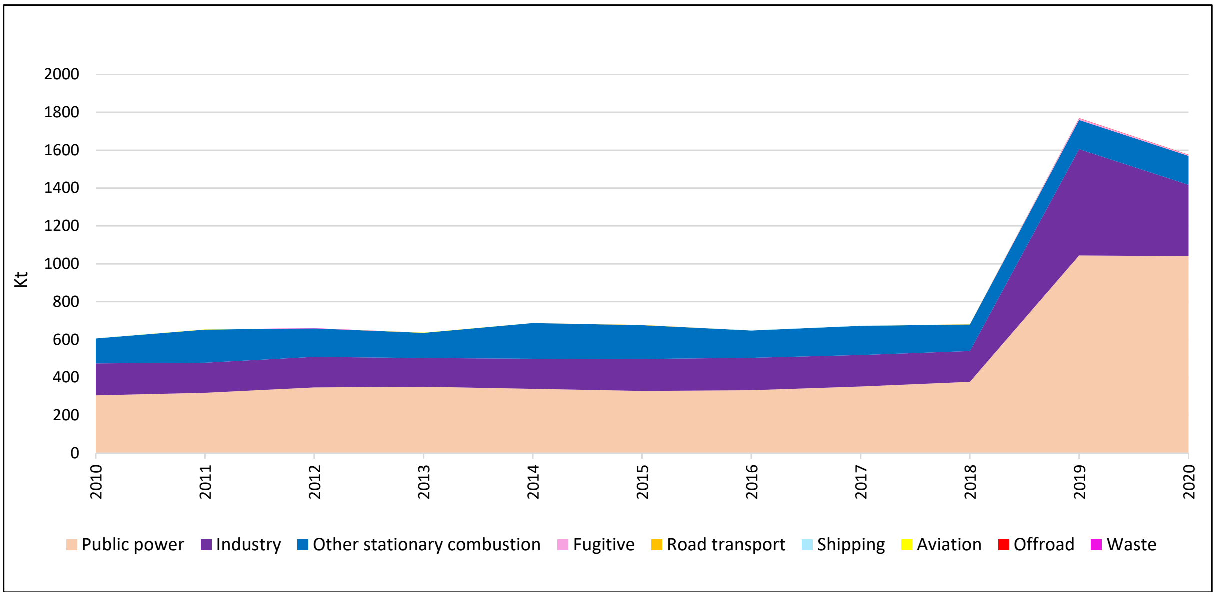

Figure 4-1: Trends in SO_2 emissions from 2010 to 2020 in Kazakhstan

The main source of SO_2 emissions in 2020 is large combustion plants. In the Republic of Kazakhstan, there are 183 operational combustion plants larger than 50 MWh, with a preliminary estimation of about 392 fuel-burning boilers, with a unit capacity of more than 50 MW, among which 104-300 MW units are predominant. About 50% of fuel-boilers are coal-fired, about 48% gas-fired, and 2% oil-fired. In 2019, thermal coal accounted for the bulk (74 %) of the produced coal. More than half of the produced coal (52%) was used for electricity and heat generation. The main energy fuel used in Kazakhstan is the Ekibastuz coal with a sulphur content of about 0,5-0,7% [15].

Industrial sources

Total emissions of SO_2 from industrial sources in Kazakhstan in 2020 are 378 kt. The most important industrial sectors that emit SO_2 are petroleum refining and manufacture of solid fuels (60%) and stationary combustion in iron and steel production (28%). Other sources such as production of mineral products, non-ferrous metals production, and the chemical industry have relatively minor impact on emissions (Figure 4-2).

There are five major oil refineries operating in the Republic of Kazakhstan (Atyrau Refinery LLP, Pavlodar Petrochemical Plant LLP, PetroKazakhstan Oil Products LLP, PetroKazakhstan Oil Products LLP, Joint Venture CASPI BITUM LLP, Condensate LLP, Condensate LLP) and about 30 producers of smaller capacities so-called "mini-refineries" that are registered in the Republic of Kazakhstan. There are also two sulphur recovery units operating at oil refineries [6].

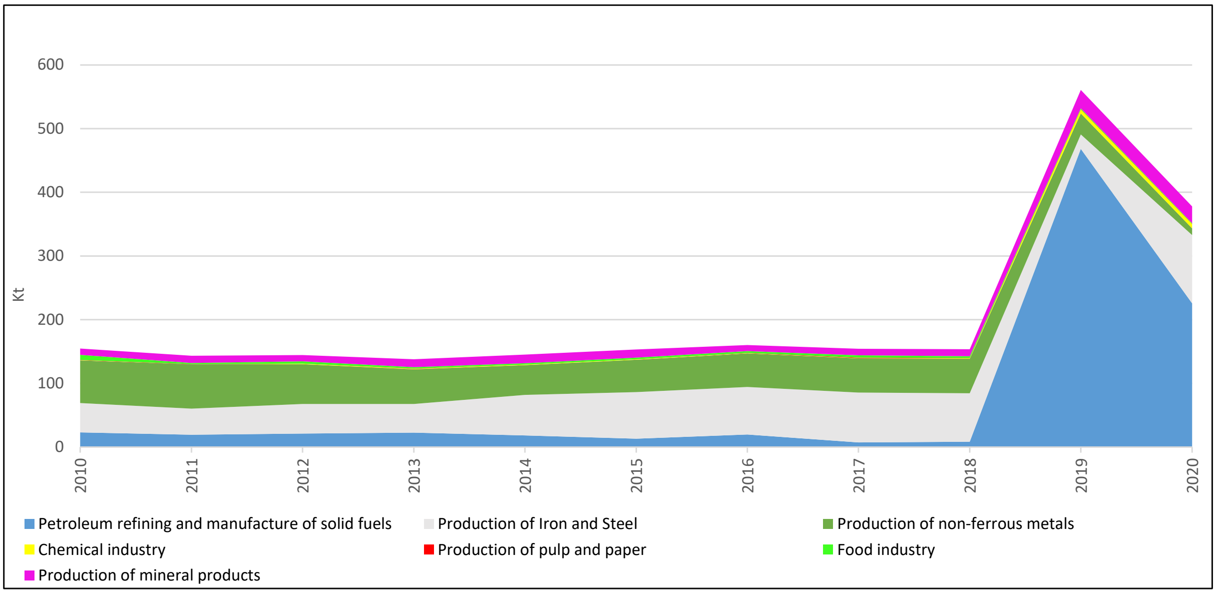

Figure 4-2: SO_2 emissions of industry from 2010 to 2020 in Kazakhstan

4.2.2. NOx emissions

Total NOx emissions

The evolution of NOx emissions from 2010 to 2020 is as follows (Figure 4-3). NOx emissions were growing in the last years, however slightly decreasing from 2019 and accounted for about 646 kt in 2020.

Public power significantly contributes to these emissions. In 2020, the public power sources accounted for 48% of the total emissions, industrial sources for 25%, offroad emissions for 10%, fugitive and other stationary combustion accounted for 9 and 7% respectively. Road transport emission contribution is negligible and accounted for less than 1%.

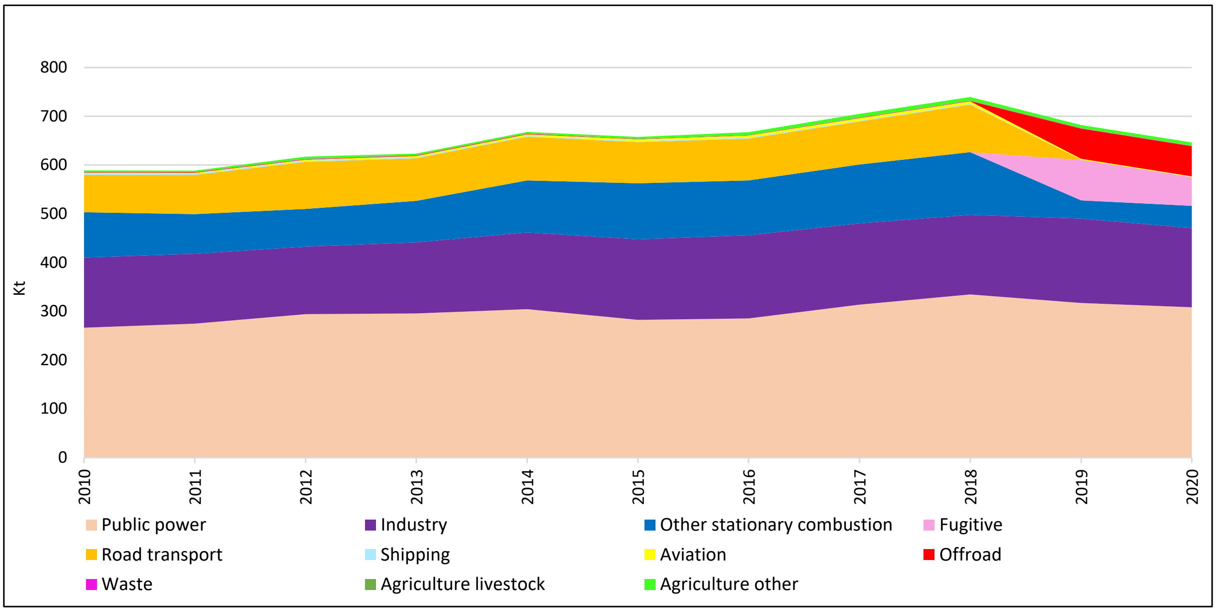

Figure 4-3: Trends in NOx emissions from 2010 to 2020 in Kazakhstan

Industrial sources

Total emissions of NOx from industrial sources in Kazakhstan in 2020 are 162 kt. The main industrial sectors contributing to NOx emissions, are petroleum refining and manufacture of solid fuels representing 66% of total industrial emissions. The manufacturing of solid fuels sector and other energy industries account for 35% of these emissions, while petroleum refining contributes to 31% of the rest. Stationary combustion in iron and steel production is another important NOx emission source with 22% share. The remaining sectors make a lesser contribution (Figure 4-4).

In the Republic of Kazakhstan, sinter production for the needs of the blast furnace shops is carried out on 3 sintering plants with a total sintering area of 1,008 sq.m. (Steel Department of JSC ArcelorMittal-Temirtau). 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.

Weak nitric acid, a semi-finished product used in technological processes as reagents in ammonium nitrate production is manufactured at KazAzot JSC (weak nitric acid shop). Nitric acid production is designed as a combined process [6].

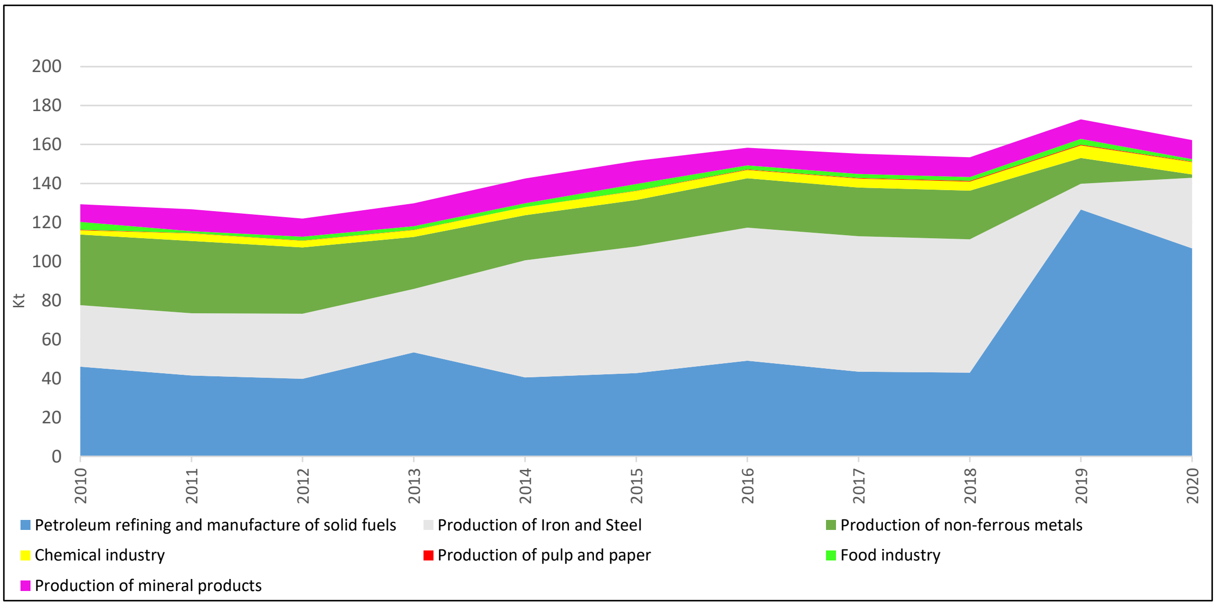

Figure 4-4: NOx emissions of industry from 2010 to 2020 in Kazakhstan

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

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

The evolutions of PM_{10} and $PM_{2.5}$ emissions from 2010 to 2020 are as follows (Figure 4-5 and Figure 4-6). The overall emissions of PM_{10} in 2020 are about 402 kt and $PM_{2.5}$ are about 231 kt.

The main contribution of the PM_{10} emissions in 2020 was made by industrial sources (37%) and fugitive emissions from fuels (28%). 95% of PM_{10} emissions from fugitive sources are due to venting and flaring of oil and gas. Other stationary combustion is the third most contributing sector with 16% of share where residential heating accounts for 98% of the category. Surprisingly, public power share in total PM_{10} emissions is only 3%. Road transport accounts for 5% of total emissions.

The main contribution of the $PM_{2.5}$ emissions in 2020 was fugitive emissions from fuels mainly from venting and flaring of oil, gas, and combined oil and gas (47%) and other stationary combustion (28%). 99% of fugitive emissions of $PM_{2.5}$ are from venting and flaring of oil and gas. Residential heating accounted for 98% in other stationary combustion category. The share of industrial sources other than public power is 16%. Public power contribution in $PM_{2.5}$ emissions is also minor (about 2%). Road transport contribution accounts for 5% in the overall emissions.

The important source of PM emissions in Kazakhstan could be the wide use of Ekibastuz coal, the ash content of which is particularly high (40-45%), and the specific structural properties of the coal have rendered its enrichment uneconomic to date [3]. In 2019, thermal coal accounted for the bulk (74 %) of the produced coal. More than half of the produced coal (52 %) was used for electricity and heat generation, of which 79 % had a high ash content. Around 8 % of the produced coal was used by the general population [16].

District heating plants are operating in several cities in Kazakhstan. However, they are generally old and use coal for generating heat. So far, a key source of population exposure to PM pollution in cities of Kazakhstan is residential heating on solid fuels in individual dwellings [16].

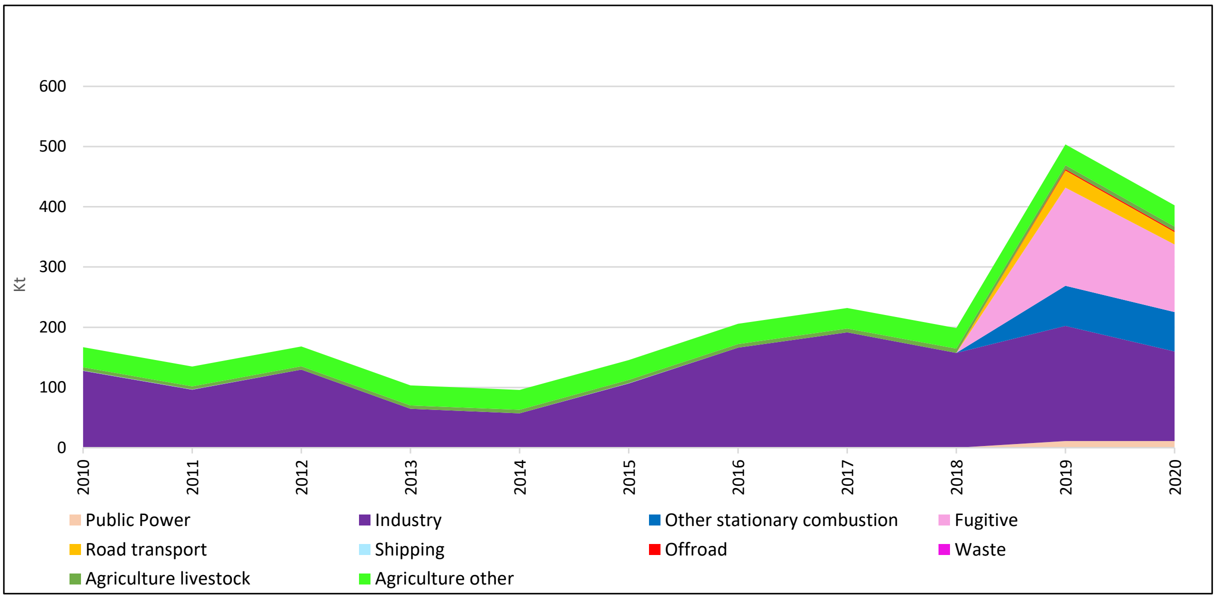

Figure 4-5: Trends in PM_{10} emissions from 2010 to 2020 in Kazakhstan

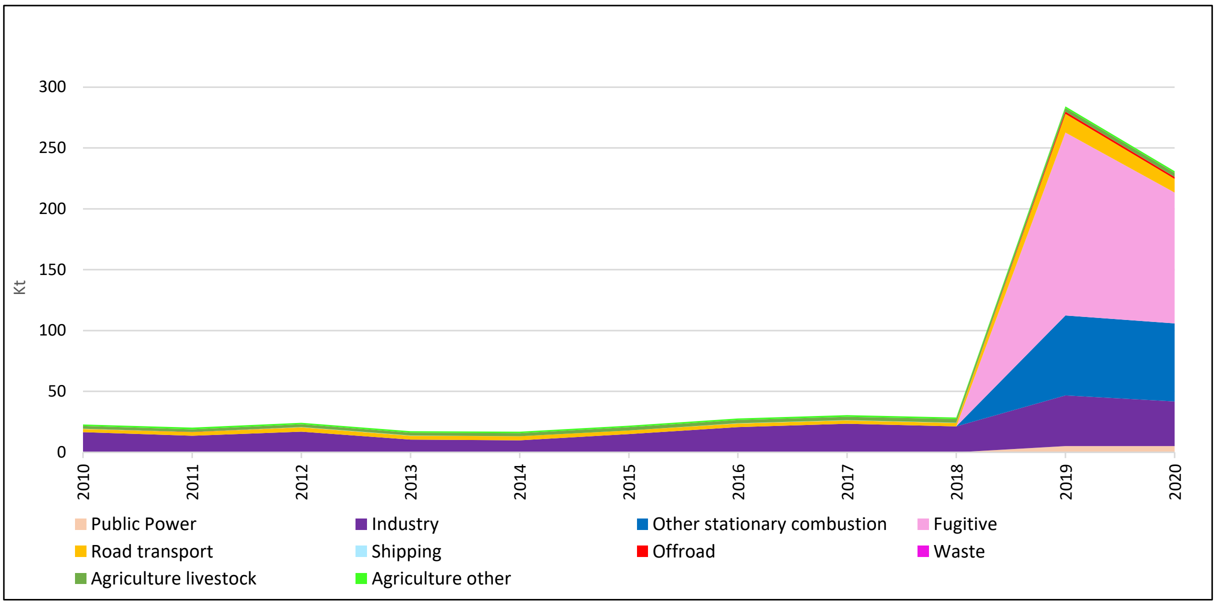

Figure 4-6: Trends in $PM_{2.5}$ emissions from 2010 to 2020 in Kazakhstan

Industrial sources

Total emissions of PM_{10} and $PM_{2.5}$ from industrial sources in Kazakhstan in 2020 are 149 and 37 kt respectively. In 2020, the main industrial sources of PM_{10} emissions were other industries (79%). 89% share of this category is the sector of construction and demolition. The share of stationary combustion in iron and steel industry in total emissions is 10%. The other sectors make only a marginal contribution, significantly lower than the construction and demolition sector (Figure 4-7).

In 2020, the main industrial source of $PM_{2.5}$ emissions were stationary combustion sources in production of iron and steel (36%), other industry (32%) with 88% share of the construction and demolition sector, and production of non-ferrous metals (9%). The other sources have a minor contribution (Figure 4-8).

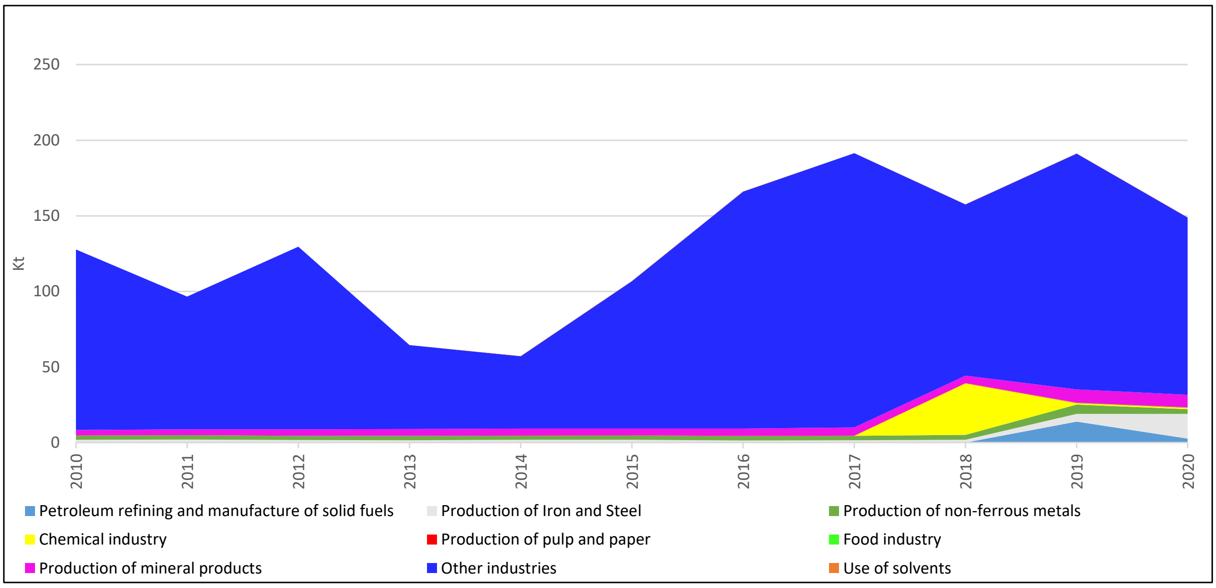

Figure 4-7: PM_{10} emissions of industry from 2010 to 2020 in Kazakhstan

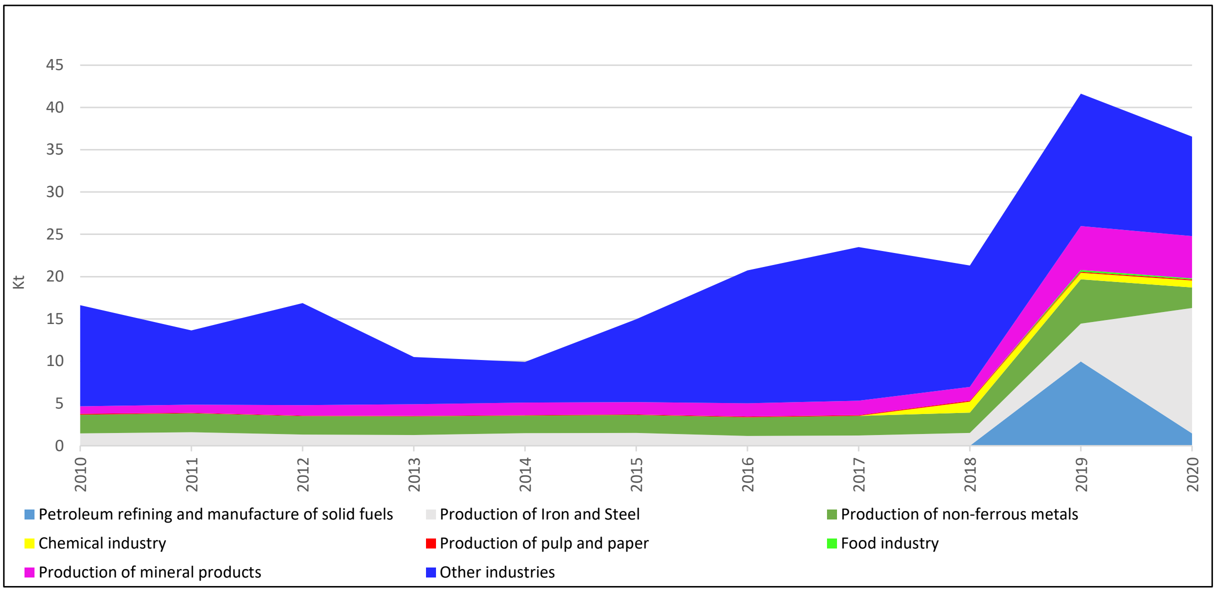

Figure 4-8: $PM_{2.5}$ emissions of industry from 2010 to 2020 in Kazakhstan

Among industrial sources of PM_{10} and $PM_{2.5}$ emissions in Kazakhstan, there are industries of mineral products, such as cement and lime. In Kazakhstan, there are 26 registered producers of quick lime and air hydrate lime (2017) [6].

4.2.4. VOC emissions

Total VOC emissions

The evolution of VOC emissions in Kazakhstan from 2010 to 2020 is as follows (Figure 4-9). The overall emissions of VOC in 2020 are about 587 kt.

Fugitive emissions were the main contributor to VOC emissions in Kazakhstan in 2020 (33%), with important share of solid fuels within the coal mining and handling (46% of the overall fugitive emissions) and venting and flaring of oil, gas, and combined oil and gas (38%). Agricultural emissions accounted for 25% of the overall VOC. Use of solvents and other stationary combustion (with 98% of emissions due to residential heating source) contribute both 13% in total VOC emissions. Industrial sources contribute 9% to the total emissions. Road transport accounts for 1% of total emissions.

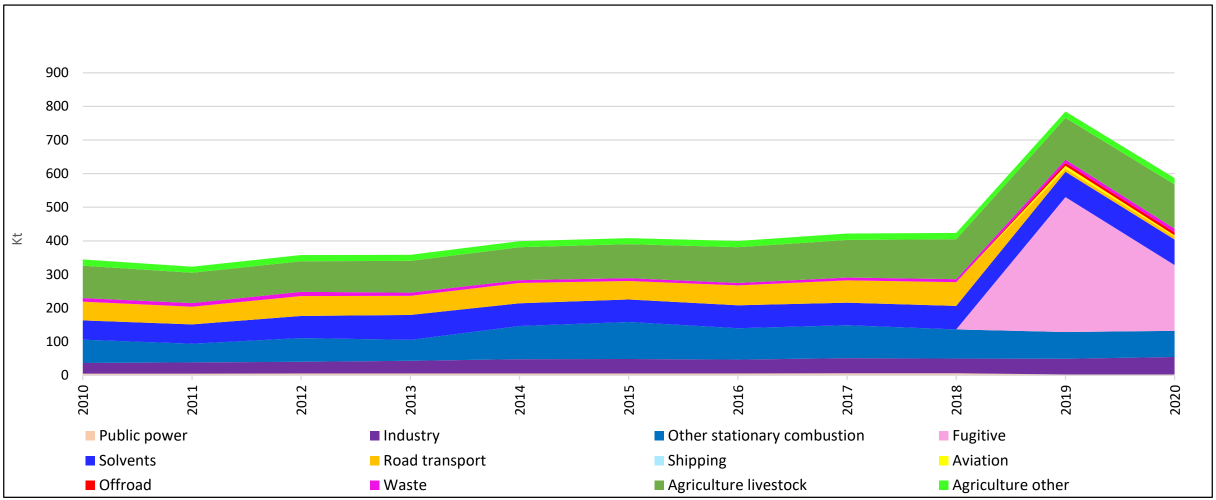

Figure 4-9: Trends in VOC emissions from 2010 to 2020 in Kazakhstan

Industry (except industrial uses of solvents)

The following figure presents the evolution of emissions in industry (use of solvent are presented in the following subchapter) (Figure 4-10). Total VOC emissions from industry are 52 kt in 2020. In 2020, the main industrial source of VOC emissions was chemical industry (38%), stationary combustion in iron and steel production (25%), and food industry (27%).

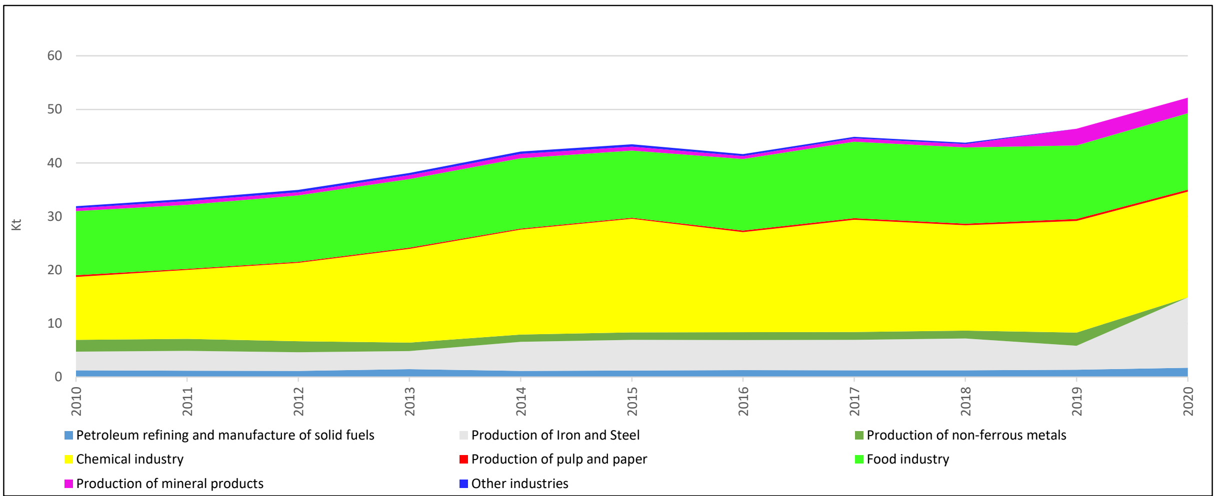

Figure 4-10: VOC emissions of industry (except industrial uses of solvents) from 2010 to 2020 in Kazakhstan

Use of solvents and other products

The following figure presents the evolution of emissions of VOC from the use of solvents and other products (4-11). Total VOC emissions from the uses of solvents are 53,4 kt in 2020.

In industrial use of solvents, coating applications sector accounts for 97% (it has to be noted that some domestic uses of solvent may be present in this category).

The other important source of solvents is their domestic use. It represents 4% share of national total VOC and 30% share of the solvent category of emissions (Figure 4-11).

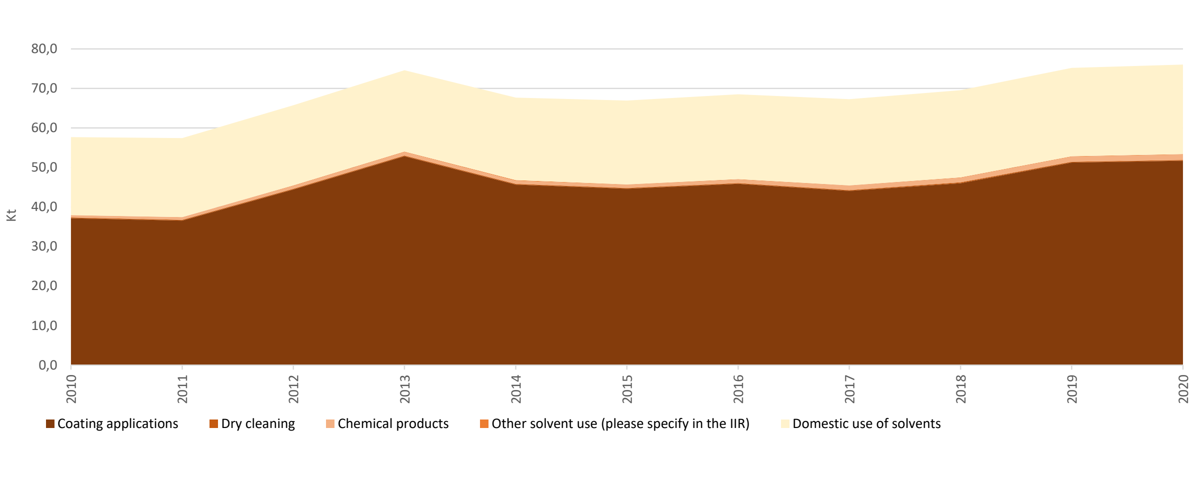

Figure 4-11: VOC emissions from the use of solvents from 2000 to 2020 in Kazakhstan

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. Air pollution causes up to 6,000 premature deaths per year. Moreover, a 2020 study prepared by the World Bank estimates that annually, particulate matter (PM) pollution alone causes 9,360 premature deaths and costs the economy more than $7.1 billion [16].

Most air quality-related diseases and premature deaths in Kazakhstan are linked to the 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 **Erreur ! Source du renvoi introuvable.**. The household s urvey conducted in 2018 [16] 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 [16].

According to information provided up to date, there is no programme in Kazakhstan focusing on the retrofitting of inefficient households' boilers and stoves [6].

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 [16].

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 [16].

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 [10].

Urban air quality in Kazakhstan is assessed using three indexes: the Standard Index (SI), Highest Frequency (HF), and Air Pollution Index (API_5) [16]. 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 [16]. 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 [16].

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 [16].

Ten cities in Kazakhstan have 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 (LVs) 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 LVs [16].

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 ELVs based on BATs in Kazakhstan is in place 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 [5].

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 [19]. It introduced mandatory integrated environmental permits (IEPs) since the first of January 2025 based on BAT for the most polluting enterprises, the ones under the category I. The design of follow-up regulations and technical reference documents for BAT could contribute to reduce air pollution and long-term phase-out of fossil fuels [16].

Pursuant to Kazakhstan’s legislation, every year, permissible limits on total emissions from stationary sources are set. Nearly all point emission sources were subject to compliance with 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 [16] 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 [16].

The 2021 Environmental Code is the primary legislation in Kazakhstan that considers emissions from industrial stationary sources. The previous Code 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 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 [16].

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), there are 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. These are, 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 boiler installations for meeting their own energy needs [16].

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 [18].

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).

Construction and operation of Categories I and II installations without the appropriate environmental permit are prohibited. For Categories III and IV installations an environmental permit is not required for the construction and operation unless they are located within the industrial site of a Category I or II installation and are technologically connected to it.

IEPs are mandatory for Category I enterprises from 2025 onward. In addition, obtaining an IEP is mandatory for newly commissioned enterprises. All other enterprises may obtain an IEP on a voluntary basis. IEPs 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.

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 [19].

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 [16].

In some cases, additional analyses and dispersion modelling are needed to determine the significance of the industry's contribution to air pollution at those locations. Nevertheless, the IEP system and the corresponding sectoral EU Best Available Techniques Reference Documents (BREFs) could be considered for setting stricter emission standards for enterprises in such locations [16].

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 Center (IGTIPC)[5].

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.

Twelve Reference Books are being developed during 2021-2022. They cover the following sectors:

- 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
- Non- Ferrous metals mining and beneficiation (including precious metals) [6].

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" [20].

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

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[5] https://igtipc.org

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 [19].

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 there is a possibility of phased achievement of technological standards and emission standards according to the design solutions it includes a timeframe for achieving the indicators of phased reduction of negative environmental impact. The phased reduction is determined in connection with the completion dates of the relevant sets of activities for reconstruction, re-equipment and modernisation of the installation.

For some of the Category I and for Category II facilities, an environmental protection action plan shall be developed. For the period of implementation of the environmental protection action plan, such a facility shall apply emission standards in accordance with the environmental permit and the conclusion of the state EIA (if any), in force on the date of filing an application for an integrated environmental permit. The action plan shall contain indicators of reducing the negative impact on the environment, which shall be achieved by the operator of the facility during the validity period of the action plan, and a schedule for the phased achievement of such indicators. Upon achieving each corresponding indicator of a step-by-step reduction of the negative impact on the environment, such an indicator becomes a mandatory standard for the operator. The deadline for the implementation of the environmental protection action plan shall correspond to the deadline for issuing an environmental permit and cannot be extended.

Compliance with the emission standards and (or) technological standards established in the integrated environmental permit in accordance with the 2021 Environmental Code becomes mandatory for the operator of a Category I.

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 [21].

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 [22].

According to the latest available information, the BREFs and their Conclusions that are the part of the BREFs are currently under approval by the Ministry of Ecology, Geology and Natural Resources of the Republic of Kazakhstan.

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 [5]. 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 [23] 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 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 [5]. According to new Environmental Code of Kazakhstan, 2021 [19] starting with 2025, emission limit values of integrated permits of new and existing large combustion plants in Kazakhstan should be based on the BAT-AELs 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 [7], developed the draft BREF LCP of Kazakhstan [24] including the Conclusions. However, missing the strategy and programme for the development of the energy industry in the Republic of Kazakhstan for LCP invoke the stakeholder criticism of the emission limit values that are judged not be attainable in the nearest future. So, the draft BREF LCP is currently under consideration of 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 BREFs under development in the Republic of Kazakhstan [24] and the ones of the AGP.

Emission limit values (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 (LCP) within the AGP, with several important exceptions.

Emission limit values of SO_2 and NOx for new large combustion plants in the Draft BREF LCP of Kazakhstan [24] in some cases are close or equal to the AGP Technical Annexes IV and V. However, dust ELVs of the Draft BREF LCP of Kazakhstan, compared with the Annex X of 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 LCP BREF of Kazakhstan 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 LCP BREF of Kazakhstan 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.

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 [19] and the Order of the Minister of Ecology, Geology and Natural Resources of the Republic of Kazakhstan, 2021 № 63 [22]. 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 that are used in households, including permissible dust limits and applies to the manufacture of new boilers in the Republic of Kazakhstan [6].

Concerning the sulphur content of gasoil for domestic heating, the same gasoil as for vehicles is used and is bought at petrol stations. The sulphur content is specified in the interstate standard GOST 32511-2013 [26]. Refer to chapter 4.4.5.

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 [6].

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 [10] 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 **Erreur ! Source d u renvoi introuvable.**.

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 [27] 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 [16].

4.4.3. Industrial installations

The chapter 4.8.2 introduces the tables of comparison of industrial plants emission limit values in draft BREFs under development in the Republic of Kazakhstan [6] and ELVs of the AGP technical annexes.

Comparison with ELVs of the Amended Gothenburg Protocol Annex IV

Concerning sulphur recovery units, ELVs of the Kazakhstan's draft BREF Oil and gas processing [6], 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 ten sulphur recovery units in Kazakhstan and their sulphur recovery rate is equal or more 99%.

There is no titanium dioxide specific regulation, neither production of titanium dioxide in Kazakhstan.

Comparison with ELVs of the Amended Gothenburg Protocol Annex V

Concerning cement and clinker production, the draft BREF RK "Cement and Lime Production" [28] sets NOx emission levels for new process lines as < 400 mg/Nm^3 and for cyclone kilns < 400 mg/Nm^3 that are stricter that the ones of Annex V (Table 3) of AGP and for long rotary kilns in the wet process ELVs are the same (< 800 mg/Nm^3).

Concerning iron ore sinter plants, currently the draft BREF RK on iron and steel production is under development (supposed to be developed in 2023) and it was not possible to compare ELVs of AGP Annex V and ELVs of the draft BREF RK on iron and steel production.

The ELV for nitric acid production at an absorption tower in the draft BREF RK "Production of inorganic chemicals" [6] 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).

Comparison with ELVs of the Amended Gothenburg Protocol Annex X

For mineral oil and gas refineries, in the draft BREF RK "Oil and Gas Refining", 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 [6] that is stricter or equal than ELV in AGP Annex X (Table 2).

For cement and lime production, dust emission limit values of the draft BREF RK "Cement and Lime Production" [28] are the same as of Annex X of the AGP (Tables 3 and 4).

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, as the draft BREF RK on iron and steel production is under development (supposed to be developed in 2023).

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 [6], that is stricter than the ELVs of Annex X of the AGP (Table 7).

Concerning glass production, since 2021, one plant for the production of sheet glass has been in operation in the Republic of Kazakhstan [6]. However up to now, there is no information available on the ELVs to compare with the ones of the Annex X of AGP. 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.

Concerning pulp production and waste incineration, there is no specific regulation, neither the activities in Kazakhstan [6].

4.4.4. Use of solvents in industry

The information concerning the regulation on the use of solvents in industry was not available to analyse.

4.4.5. Sulphur content of gasoil

Concerning sulphur content in gasoil, the Republic of Kazakhstan has a standard used by refineries for oil refining that defines the allowable content of gas oil, including sulphur. The standard transcribes sulphur content of 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].

Comparison with ELVs of the Gothenburg Protocol

According to expert opinion, diesel fuels provided in the refuel stations are also used in domestic heating [6]. Since 2016, diesel provided by the refuel stations (Technical Regulation of the Eurasian Economic Union 013/2011 [29]) and used in domestic heating, corresponds to standards Euro 4 and Euro 5 with the corresponding sulphur content (50 mg/kg and 10 mg/kg or 0.005% w/w and 0.001% w/w) respectively [29].

The AGP annex IV prescribes a limit value for the sulphur content of gasoil used in domestic heating and combustion installation (Annex IV, Table 2). The sulphur content is limited to 0.1% w/w.

According to information provided, the sulphur content of the gasoil used for domestic heating would be lower than the limit of 0.1% of AGP (Annex IV, Table 2) as this gasoil could be similar to a diesel fuel used for vehicles.

4.4.6. VOC contents of products

Law "About chemical product safety" from 21 July 2007 № 302-III [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 [33] 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 [5].

It was not possible to compare the standards of the existing regulation in Kazakhstan and the AGP Annex XI (Tables 1 and 2).

Transposition of the 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 [6], 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 [30]) 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 [31]).

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 [16]. Kazakhstan moved to the new standard Euro-5 for most categories of motor vehicles in 2016 and for the few remaining ones 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) [44]. In addition, Kazakhstan prohibits the import of cars that are below Euro-4 emission standards [6].

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 [16].

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 [16].

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) [34]. 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 [34]. 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 from 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. In tables 4.6 and 4.7, the comparison of standards for different parameters of petrol and diesel has been made [6].

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 [5].

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]. Transition to release into circulation of diesel fuel of the ecological classes K4 and K5 (comparable with Euro-4 and -5) is carried out in the Republic of Kazakhstan no later than the 1st January 2016.

The K4 and K5 ecological classes apply to both gasoline and diesel [6]. 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	2016	50	50
K5	2016	10	10

The characteristics of fuels are detailed in Table 4-6 and Table 4-7 [29] 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: 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:		

Parameter	Unit	K5 fuels
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: 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
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

4.5.2. Non road mobile machineries, mopeds and motorcycles

Specific emission limit values or standards are in place for non-road machinery, which is a significant source of emissions [5]. However, no additional information was available to analyse the situation with non-road mobile machineries, mopeds and motorcycles and associated ELVs.

4.6. Technological pathways

Kazakhstan stepping up efforts to reduce air pollution that imposes high health costs on its citizens. According to Kazakhstan's Concept for Transition to Green Economy [10] and a 2021 study prepared by the World Bank [16], every year, up to 6,000–9,360 people in Kazakhstan are dying prematurely due to poor air quality.

Being a Party to the Convention on the Long-Range Transboundary Air Pollution (CLRTAP), Kazakhstan has, however, not ratified any of the Protocols to the Air Convention. The road map for ratification of protocols, the Protocol on Persistent Organic Pollutants (POPs), 1998, the Protocol to Abate Acidification, Eutrophication and Ground-level Ozone, 1999, and the Protocol on Heavy Metals, 1998, was developed by UNECE with the 31/12/2024 preliminary deadline [5]. The draft National Action Plan has been created to enhance the capacity of the country to join the protocols to CLRTAP and meet the corresponding commitments through a detailed programme with a specific time frame. However, the National Action Plan was not yet approved by the relevant authority of the Republic of Kazakhstan [6].

According to the latest Informational Bulletin 'On the State of the Environment in the Republic of Kazakhstan for 2019'[35], 10 cities in Kazakhstan had high air pollution levels. These are Aktobe, Almaty, Atyrau, Balkhash, Karaganda, Nur-Sultan, Shymkent, Temirtau, Ust-Kamenogorsk, and Zhezkazgan. The air quality monitoring data provided for these cities showed that concentrations of key air pollutants in the ambient air 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 [16].

The main sources of air emissions in Kazakhstan are public power, including electricity and heat production. It is a major source of SO_2 and NOx emissions, with about 66% and 48% respective share in 2020, following by the industrial sectors with 24% and 25% respective share. The most important industrial sectors that emit SO_2 are manufacturing of solid fuels and other energy industries (59%) and stationary combustion in iron and steel industry (28%). For NOx emissions, the industrial sectors contribution is due to manufacturing of solid fuels and other energy industries (35%), petroleum refining (31%), and stationary combustion in iron and steel industry as well (22%). Transport sector has less important share in NOx emissions (9%). 82% of NOx emissions in transport is due to light duty vehicle emissions.

The main sources of PM_{10} emissions however are industrial processes, accounting for 37% of national totals in 2020, due to emission in construction and demolition sector (70%) and stationary combustion in iron and steel industry (10%).

Important sources of particles, both PM_{10} and $PM_{2.5}$ as well as VOC are fugitive sources, accounting for 28%, 47%, and 33% respectively, of total national emissions in 2020. For PM_{10}

and $PM_{2.5}$ emissions, this is due to venting and flaring of oil and gas sector 95% and 99% respectively. For VOC emissions, this is due to two sectors, namely coal mining and handling (46%) and venting and flaring of oil and gas sector (38%).

Residential sector is also important source of air pollutants, namely with 9% of SO_2, 16% of PM_{10}, 27% of $PM_{2.5}$, and 13% of VOC contributions.

Two other sectors that contribute significantly to VOC emissions, are agriculture with 25% and use of solvents with 13%, mainly due to coating application sector (97% of total industrial use of solvents) in 2020.

In some places and cities, the large emission sources may disproportionally contribute to both background pollution throughout the year and peak pollution during winter smog, especially when industrial emissions are trapped by the temperature inversion events that are more common in colder seasons [16].

Industrial sources contribute 9% to VOC total emissions due to chemical industry (38%), stationary combustion in production of iron and steel (25%), and food industry (27%).

Air quality monitoring data and existing emissions source inventories have significant gaps providing a strong rationale for knowledge improvement and actions toward progress in air emission source attribution 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'[9], the Concept for Transition of the Republic of Kazakhstan to Green Economy[10], and 'Strategic Plan for Development until 2025'[11] are dealing with the measures that directly or un-directly could reduce emissions of pollutants (SO_2, NOx, PM, and NMVOC). They are increase of RES share, the alignment of the production facilities and transport fuels with the latest technological standards, reduction of SOx and NOx emissions, energy efficiency, etc.

Air Quality Management programmes in Kazakhstan rely on a mix of direct regulations (such as emission performance standards, best available technique (BAT) requirements, or urban zoning requirements) with economic and fiscal instruments. 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 books for BAT should align immediate measures to save lives from air pollution and long-term phase-out of fossil fuels [6], **Erreur ! Source du r envoi introuvable.**.

Twelve Best available techniques reference books (BREF) are being developed during 2021-2022 in Kazakhstan, and several BREFs are under development [6]. They 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). 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 to comply with limit values introduced by AGP Technical Annexes IV for SO_2, V for NOx, VI for VOC and X for PM.

Large combustion plants

Emission limit values (ELV) of BREF RK "Combustion of fuels in large plants for energy production" for new installations are equal or stricter than ELVs of large combustion plants within the AGP, with several important exceptions. For existing plants, ELVs may be close or equal or less stringent depending on fuels and pollutant considered.

Chapter 4.4.2 provides a summary of differences between the ELVs from the RK BREF on LCPs and ELVs of the AGP Annexes IV, V and X and chapter 4.8.1 details these differences per type of plants and fuels.

For **large combustion plants**, the reduction techniques available for abating SO_2 and NOx emissions are as in the following (chapter 8.1.1 and 8.2.1):

The means to achieve 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

For NOx, the means to achieve the 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)

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 to comply with the limit values prescribed. They may be process specific or generic as presented above for LCPs. For PM, best available techniques to comply with limit values are electrostatic precipitators and fabric filters. Other types of dedusters such as scrubbers are also available but less used. The efficiency of these techniques is optimum when they are correctly dimensioned.

Chapter 4.4.3 provides a summary of differences between the ELVs from the different BREF developed by Kazakhstan and ELVs of the AGP, Annexes IV, V and X and chapter 4.8.2 details these differences per type of activity.

For the **uses of solvents in industry**, chapter 8.3, details the techniques available to comply with limit values of the AGP annex VI. 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.

Concerning regulation of the VOC content of products, only limited information was available to compare of the standards of the existing regulation in Kazakhstan and the AGP Annex XI (Tables 1 and 2).

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

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" [36] 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" [41] 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 [42]. The last TFTEI report on the updates of limit values of the AGP technical annexes also provides information [43].

One of the key measures that could be applied to domestic heating with solid fossil and biomass fuels is the replacement of existing household heating appliances with new improved ones and enhance awareness of user of the appliances.

The "Code of good practice for wood-burning and small combustion installations" was developed and adopted in 2019[36]. This document responds to the needs to inform the general public of the impact of wood burning, on air pollution and human health and how the final users can contribute to the reduction of PM emissions, which have multiple sources. The following main topics were addressed in the document: a) Available best practices for domestic wood heating in order to minimize emissions and increase efficiency, reducing expenditure due to decreased use of wood and storage needs and the use of wood, while reducing the negative impact on the environment and the human health; b)The best heating devices currently available on the market; c) The proper origin and characteristics of wood biomass with a focus on the need to burn dry, clean wood and thus avoiding use of composite, treated and/or contaminated wood.

In term of appliances and combustion, the reduction of PM emissions is 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**Erreur ! Source du renvoi introuvable.**[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 may increase the rate of replacement of 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 oldest appliances could be foreseen.

These measures are also linked to an energy policy aiming at reducing the energy demand through better energy efficiency.

Nevertheless, implementation of energy efficiency measures in practice also requires behavioural incentives through adequate price levels that reflect the full costs of using fuels, including the cost of damages imposed on victims of pollution. When access to finance or affordability impede behavioural response to price signals, additional financial support for targeted homeowners may be needed to maintain energy comfort and invest in energy efficiency [16].

<u>In terms of mobile sources, the following recommendations can be made:</u>

<u>Passenger cars, light and heavy duty vehicles:</u>

In Kazakhstan the highest ecological class of vehicles currently implemented is K5 (comparable to Euro 5/V in the EU). In addition, since 2018 domestically produced fuel is of standard K4 and K5 (comparable to Euro 4 and Euro 5). However, according to the requirements of the Gothenburg Protocol, the transition to Euro-6 and Euro-VI standards are required. Up to now, the regulations are not aligned for enabling implementation of euro 6/VI standards for vehicles produced in Kazakhstan (tables to 3 of Annex VIII of the AGP) or new vehicles imported.

The sulphur content of diesel and petrol is aligned with the AGP, Annex III (10 mg/kg) from 2016.

The legal framework could be upgraded to enable the introduction of the latest Euro 6/EuroVI standards for new vehicles imported and produced in Kazakhstan.

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.

<u>Non Road Mobile Machineries:</u>

Information is also missing but it is unlikely that new engines produced in Kazakhstan comply with limit values of Tables 4 to 9 of the Annex VIII of the AGP. Techniques of engines have evolved, and their emissions can be even lower than limit values prescribed in the Annex VIII.

A study could be envisaged to define the state of the art in Kazakhstan for Non-Road Mobile Machineries and assess if engines produced currently comply with tables 4 to 9 of the Annex VIII of the AGP.

Final conclusions

The implementation of the 2021 Environmental Code and supporting regulations, definition of BAT and introduction of integrating permitting system, would allow the legal framework of Kazakhstan to be consistent with some of the requirements of AGP Technical Annexes IV, V and X, for the LCPs and industrial sources covered, however, only if the BAT-AELs implemented will be the same as in the AGP Technical Annexes or stricter. It was noticed for that some BAT AELs can be less stringent than ELVs of the technical annexes of the AGP for PM emissions from LCPs.

The evolution of the legal framework for LCP and industrial sources of category I could be probably achieved in 2026-2028 according to TFTEI, due to the intense work of definition of BAT and development of BREF. The implementation of BATs for LCPs and industrial processes will enable reductions of SO2, NOx en PM emissions but the reduction of emissions will be effective if measures are enforced.

For annexes VI and XI of the AGP, there was not enough reliable information available to assess the legal framework about the VOC limit values of industrial processes or associated with products.

For annex VIII of the AGP, only Euro 5/V standards for road vehicles (both passenger cars and duty vehicles) are established. For all other vehicles covered by Annex VIII such as Non-Road Mobile Machineries. the legal framework has not yet been developed according to information collected. Studies could be envisaged to better know the state of the performance of engines and assess if engines produced currently comply with limit values of tables 4 to 9 of the Annex VIII of the AGP.

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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 [24]). 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/m³	Existing installation, mg/m³	New installation mg/m³	Existing installation, mg/m³
< 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	NOx	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	NOx	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	SOx	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	SOx	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	Dust	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	Dust	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	Dust	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/m^3	Existing installation, mg/m^3	New installation mg/m^3	Existing installation, mg/m^3
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 LCP for industrial plants

The following tables present ELVs in draft BREFs of Kazakhstan [6]. 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 Kazakhstan and ELVs prescribed by the AGP

ELVs of technical annexes of the AGP		ELVs prescribed by the Kazakhstan regulation
Annex IV: 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 10 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/m^3 Existing lepol and long rotary kilns in which no waste is co-incinerated: 800 mg/m^3	The draft BREF RK “Cement and Lime Production” sets NOx emission levels for new process lines (levels for existing lines to be completed): < 400 mg/Nm^3 for cyclone kilns: < 400 mg/Nm^3 for long rotary kilns in the wet process: < 800 mg/Nm^3
Table 5	Iron ore sinter plants New installation: 400 mg/m^3 Existing installation: 400 mg/m^3	Currently the BREF RK on iron and steel production is under development (supposed to be developed in 2023)
Table 6	Nitric acid production excluding acid concentration units New installation: 160 mg/m^3 Existing installation: 190 mg/m^3	The draft BREF RK “Production of inorganic chemicals” (existing and new installations to be completed): for nitric acid production at an absorption tower of <180 mg/Nm^3 for ammonia production of <230 mg/Nm^3.
Dust		
Table 2	Mineral oil and gas refineries FCC regenerators: 50 mg/m^3	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/Nm^3
Table 3	Cement production Cement installations, kilns, mills and clinker coolers: 20 mg/m^3	The draft BREF RK “Cement and Lime Production” for kiln gases from cement production at < 20 mg/Nm^3 regardless of the production method
Table 4	Lime production Lime kiln firing: 20 mg/m^3	The draft BREF RK “Cement and Lime Production” for kiln gases from lime production at < 20 mg/Nm^3 regardless of the production method
Table 5	Primary iron and steel production Sinter plant: 50 mg/m^3	Currently the BREF RK on iron and steel production is under development (supposed to be developed in 2023) No information on ELV

ELVs of technical annexes of the AGP		ELVs prescribed by the Kazakhstan regulation
	Pelletization plant: 20 mg/m^3 for crushing, grinding 15 mg/m3 for all other process 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	Currently the BREF RKs on iron and steel production is under development (supposed to be developed in 2023) No information on ELV
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 No information on ELV
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 pulp production in Kazakhstan
Table 10	Waste incineration	There is no waste incineration in Kazakhstan

ELVs of technical annexes of the AGP		ELVs prescribed by the Kazakhstan regulation
	Municipal waste incineration plants (> 3 Mg/hour): 10 mg/m³ Hazardous and medical waste incineration (> 1 Mg/hour): 10 mg/m³	

5. Moldova

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 [1]) and has also accessed the Co-operative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe (EMEP) on 26 July 2016. On 1st October of 2002 Moldova ratified the original 1998 Protocol on Heavy Metals and the original 1998 Protocol on Persistent Organic Pollutants (POP) [2]. Moldova signed Gothenburg Protocol 23 of May 2000 [2] but did not ratify it[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) [3]. It is in force since the first of July 2016.

Chapter 16th of the Association Agreement EU – Republic of Moldova [3] is devoted to strengthening cooperation in the field of environment including air quality and industrial pollution. This chapter also states that the Republic of Moldova shall carry out approximation of its legislation to the EU acts and international instruments referred to in Annex XI to this agreement according to the provisions of that Annex (Article 19).

Annex XI of the Association Agreement EU – Republic of Moldova outlines provisions on:

1. air quality:

- Concerning Directive 2008/50/EC [4]:
    - adoption of national legislation and designation of competent authority/authorities (to be implemented to 2020)
    - establishment and classification of zones and agglomerations (to be implemented to 2021)
    - 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)
    - establishment of short-term action plans for zones and agglomerations in which there is a risk that alert thresholds will be exceeded (to be implemented to 2025)
    - establishment of a system to provide information to the public (to be implemented to 2021)
- Concerning Directive 2004/107/EC [5]:

[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.

- adoption of national legislation and designation of competent authority/authorities (to be implemented to 2020)
    - establishment and classification of zones and agglomerations (to be implemented to 2021)
    - 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)
    - 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 [6] 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
    - 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 as amended by Regulation (EC) No 1882/2003 [7]:
    - adoption of national legislation and designation of competent authority/authorities (to be implemented to 2020)
    - identifying all terminals for storing and loading petrol (to be implemented to 2019)
    - 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)
    - requiring all road tanker loading gantries and mobile containers to meet the requirements (to be implemented to 2021)
- Concerning 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 [8]:
    - adoption of national legislation and designation of competent authority/authorities (to be implemented to 2021)
    - setting up maximum VOC content limit values for paints and varnishes (to be implemented to 2026)

- 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 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 (to be implemented to 2020)
  - development of national programmes to meet national ceilings (to be implemented to 2022)
  - 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) [9]:
  - adoption of national legislation and designation of competent authority/authorities (to be implemented to 2020)
  - identification of installations that require a permit (Annex I) (to be implemented to 2019)
  - implementation of BAT taking into account the BAT conclusions of the BREFs (to be implemented to 2026)
  - establishment of an integrated permit system (to be implemented to 2022)
  - establishment and implementation of a compliance monitoring mechanism (to be implemented to 2024)
  - establishment of emission limit values for combustion plants (to be implemented to 2020)
  - preparation of a transitional national plan to reduce total annual emissions from existing plants (optional to setting emission limit values for existing plants) (to be implemented to 2022)

Annex VII of Association Agreement EU – Republic of Moldova [3] 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 [27]:

- 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 [10], currently 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 [11].
- 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 [40], currently 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 [41].

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 [12], 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 [13], and Directive 2000/25/EC of the European Parliament and of the 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 [14], currently 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 [15].

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 [16], currently 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 [17].

- 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 [18].
- 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 [19].

In addition, in 2018, Moldova adopted two important document 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 "Moldova 2030" 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 [20].

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 [21].

The evolution of emissions of the Republic of Moldova was built on the emission data submission for Moldova under the CLRTAP in October 2022 for the period of 2000 to 2020 [22]. More detailed information on the industrial emissions and transport sources but also air quality and air emissions was provided by the experts of the Republic of Moldova via the answers to questionnaires and further discussion with the experts from June to November 2022. Namely, Stela Drucioc, Head of Air and Climate Change Policies Division of the Ministry of Environment, Elena Bicova Institute of Power Engineering of Moldova, and representatives of the Ministry of Environment, Institute of Energy, Institute of Ecology and Geography Elena Mosanu, Tatiana Kirillova, Irina Vasiliev, Iordanov Iordanca-Rodica [23].

5.2. Main sources of emissions

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 EEA Report No 13/2019 Technical guidance to prepare national emission inventories using Tier 1 method. It should be kept in mind that due to Covid pandemic, activity levels can have been impacted and reduced, so the emissions. So far, the evolution of emissions from 2019 to 2020 may not be significative of a general trend.

5.2.1. SO_2 emissions

Total SO_2 emissions

The evolution of SO_2 emissions from 2000 to 2020 is as follows (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 [24].

In 2020, SO_2 emissions reach 4.5 kt. The major sources of SO_2 emissions in 2020 are due to other stationary combustion (62%) mainly residential heating (71% of the category) and stationary combustion in industry (36%). Road transport sector accounts for less than 1%.

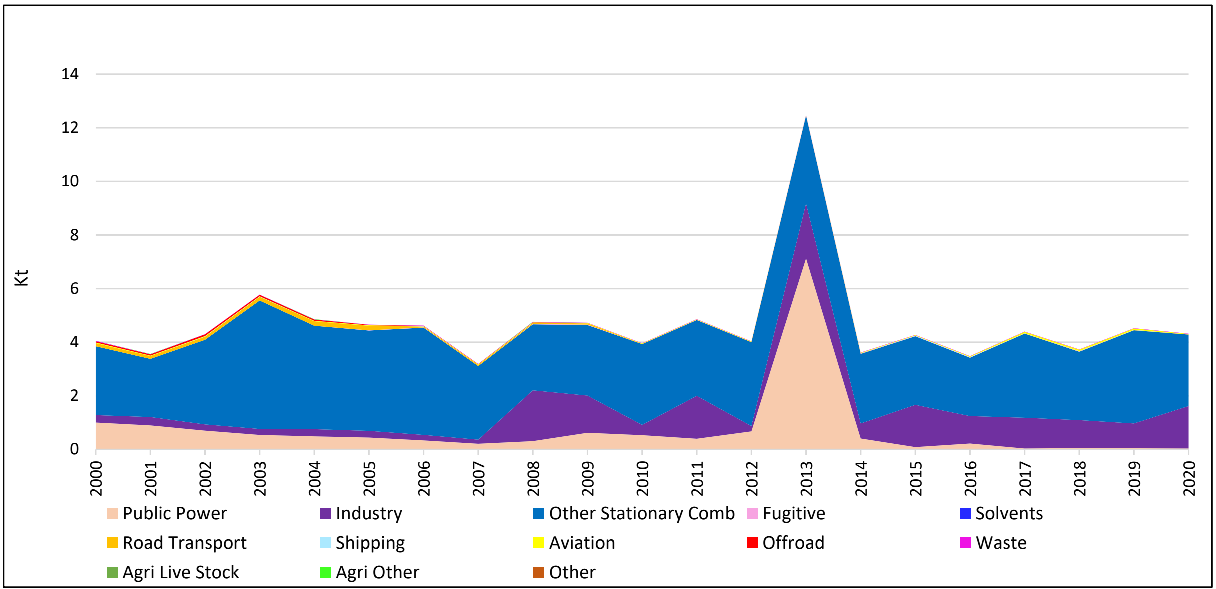

Figure 5-1: Trends in SO2 emissions from 2000 to 2020 in Moldova

Industrial sources

In 2020, the industrial sources of SO_2 emissions are 1,6 kt. The main sources of SO_2 emissions are production of mineral products (95%), due to the stationary combustion sources of non-metallic minerals (100%). The other sources have minor contribution (

).

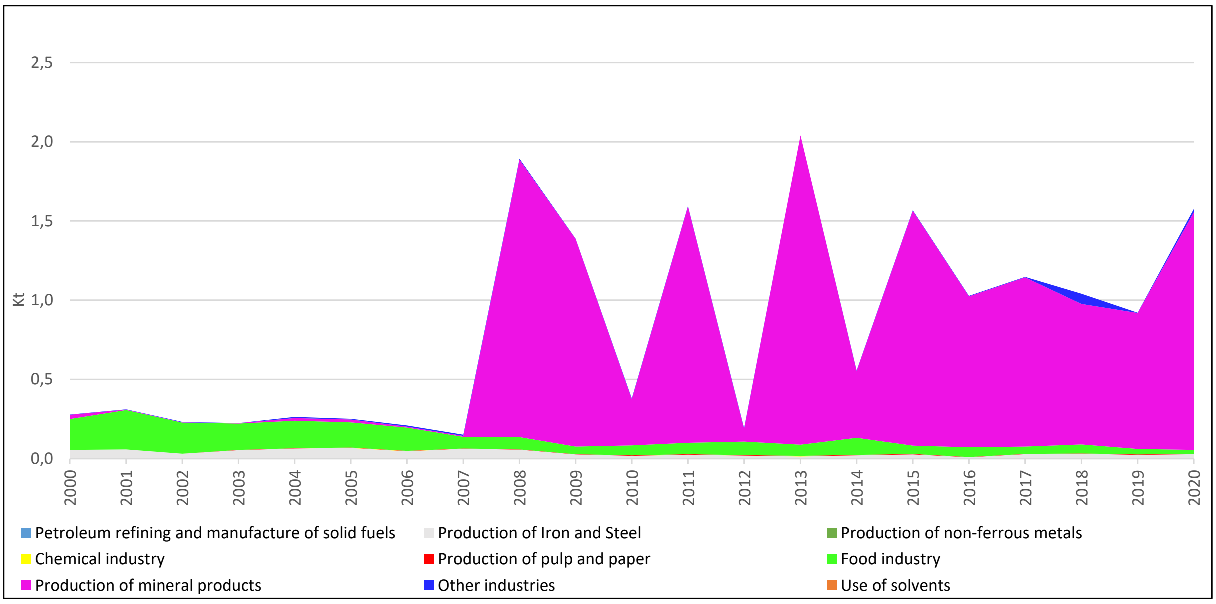

Figure 5-2: Trends in SO_2 emissions of industry from 2000 to 2020 in Moldova

5.2.2. NOx emissions

Total NOx emissions

The evolution of NOx emissions from 2000 to 2020 is as follows (Figure 5-3).

From 2000 onward, NOx emissions in the Republic of Moldova are steadily growing. In 2020, NOx emissions are accounted for about 34.2 kt.

In 2020, road transport accounted for 48% of the total emissions. In the structure of category contributions, there is increasing share of road transport (mainly heavy-duty vehicles and buses (N2-N3 trucks, and M2-M3 buses)) [24]. Public power 17% and agriculture emissions accounted for 10%. Other stationary combustion accounted for 9% due to stationary combustion (83%). Industrial sources accounted only for 4% in the national totals.

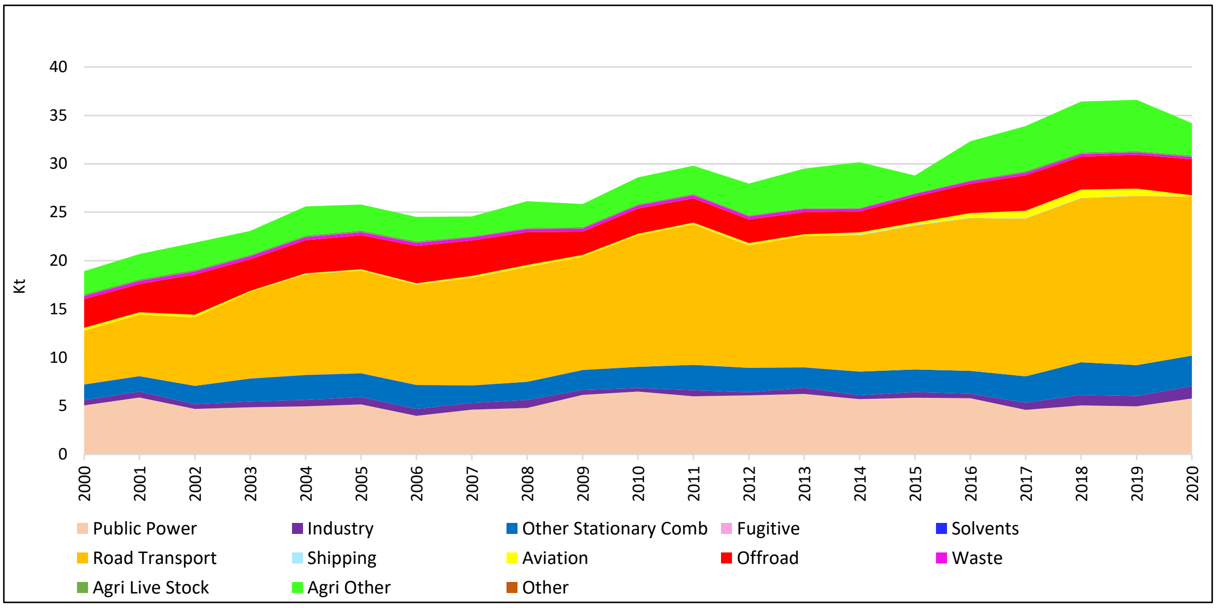

Figure 5-3: Trends in NOx emissions from 2000 to 2020 in Moldova

Industrial sources

The emissions of NOx in Moldova in 2020 is 1.3 kt. Among industrial sources, the major contributor to NOx emissions in 2020 was "other industries" (56%) due to stationary combustion in manufacturing industries and construction (100%). Production of mineral products has the second largest share among industrial sources (33%) due to stationary combustion sources of non-metallic minerals (100%). The other sources have minor contribution (Figure 5-4).

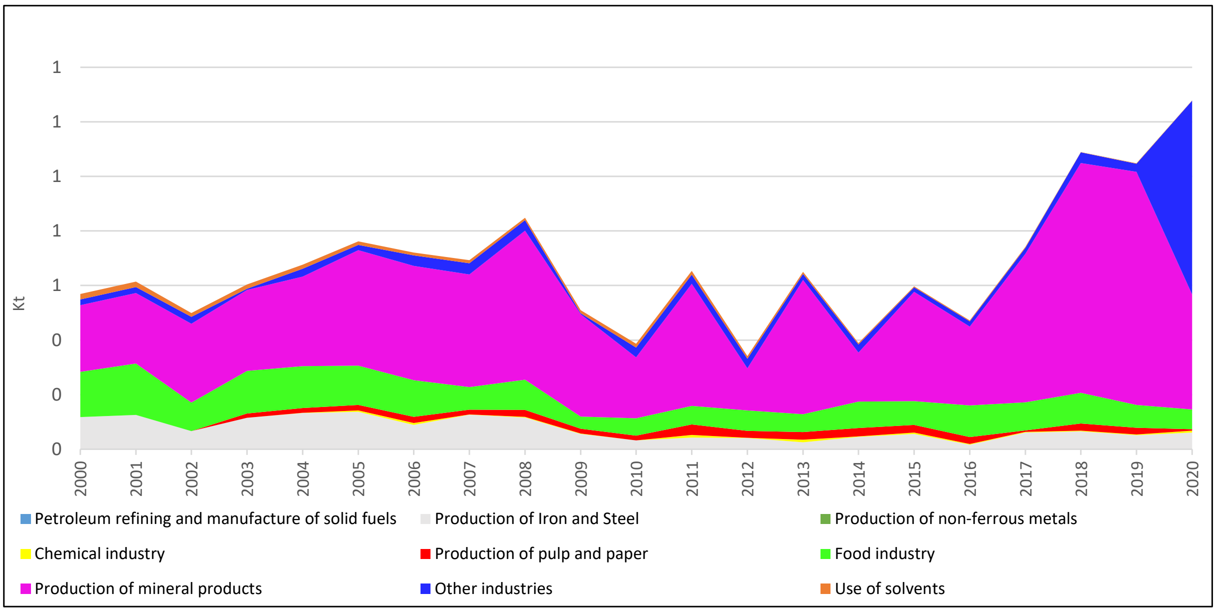

Figure 5-4: NOx emissions of industry from 2000 to 2020 in Moldova

Road transport

The trend of NOx emissions of transport sector coincides with the trend of the total NOx emission trend. In 2020, NOx emissions of the transport sector is about 16.4 kt and comes mainly from heavy duty vehicles and busses (67%), passenger cars (19%), and light duty vehicles (14%) (Figure 5-5).

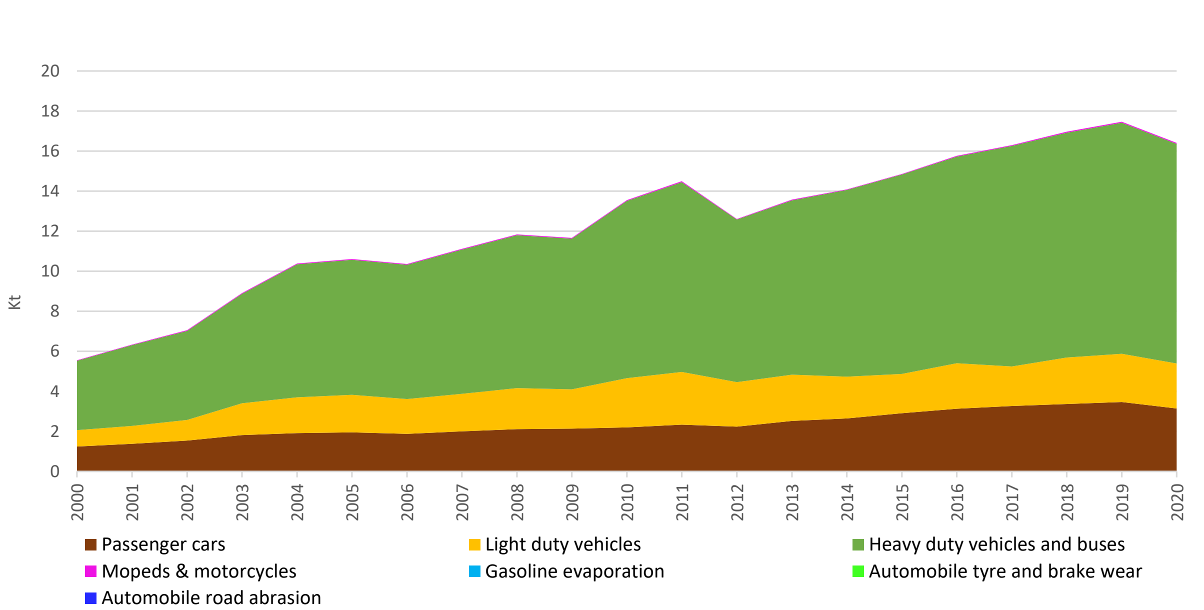

Figure 5-5: NOx emissions of transport from 2000 to 2020 in Moldova

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

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

The evolution of PM_{10} and $PM_{2.5}$ emissions from 2000 to 2020 are as follows Figure 5-6 and Figure 5-7).

Emissions of PM_{10} and $PM_{2.5}$ were stable before 2013, grown from 2013 to 2018, declined in 2019 and grown in 2020. The overall emissions of PM_{10} in 2020 are about 28.4 kt and $PM_{2.5}$ are about 22.5 kt.

The main contribution of the PM_{10} emissions in 2020 was by the "other stationary combustion" (72%) due to residential heating (99% of the category). Industrial processes contribute 14% to the total PM_{10} emissions. Road transport accounts only for 3% in the overall emissions in 2020.

The main contribution of the $PM_{2.5}$ emissions in 2020 was also by the "other stationary combustion" (88%) due residential heating (99% of the category). Industrial processes generate minor emissions (4%). Road transport emissions of $PM_{2.5}$ accounts for 4% of the total emissions.

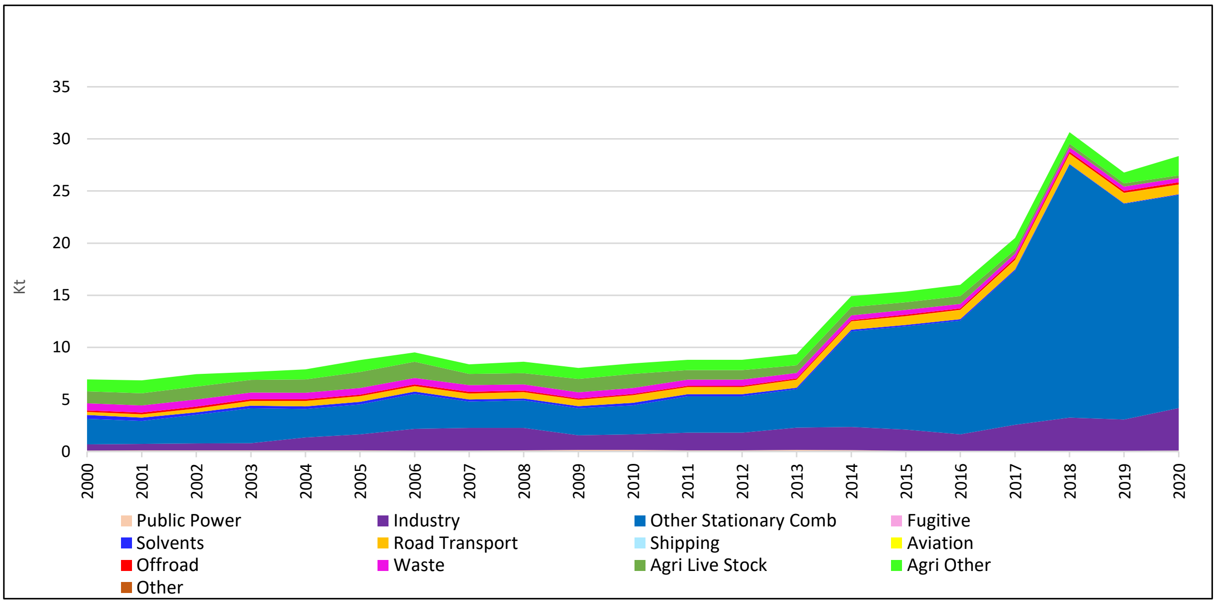

Figure 5-6: Trends in PM_{10} emissions from 2000 to 2020 in Moldova

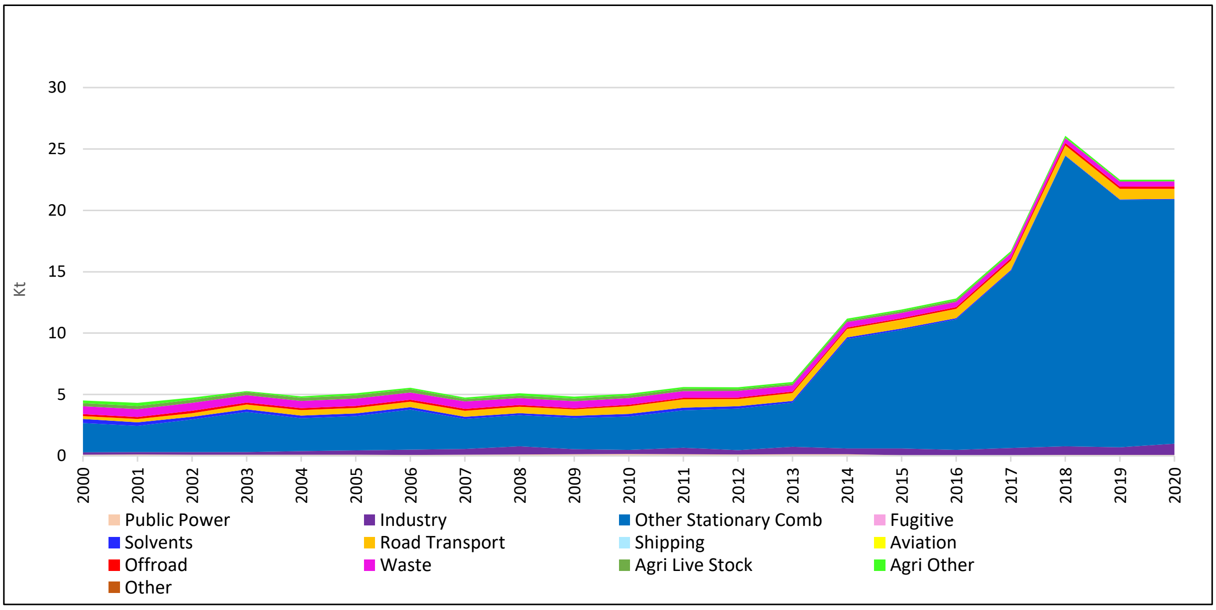

Figure 5-7: Trends in $PM_{2.5}$ emissions from 2000 to 2020 in Moldova

Industrial sources

In 2020, PM_{10} emissions from industrial sources accounted for about 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%), construction and demolition (10%). 13% of the PM_{10} emissions in 2020 was due to production of mineral products (38%) due to cement production and stationary combustion in non-metallic minerals manufacturing industries and construction (36%). The other sectors have minor contribution (**Erreur ! Source du renvoi introuvable.**Figure 5-8).

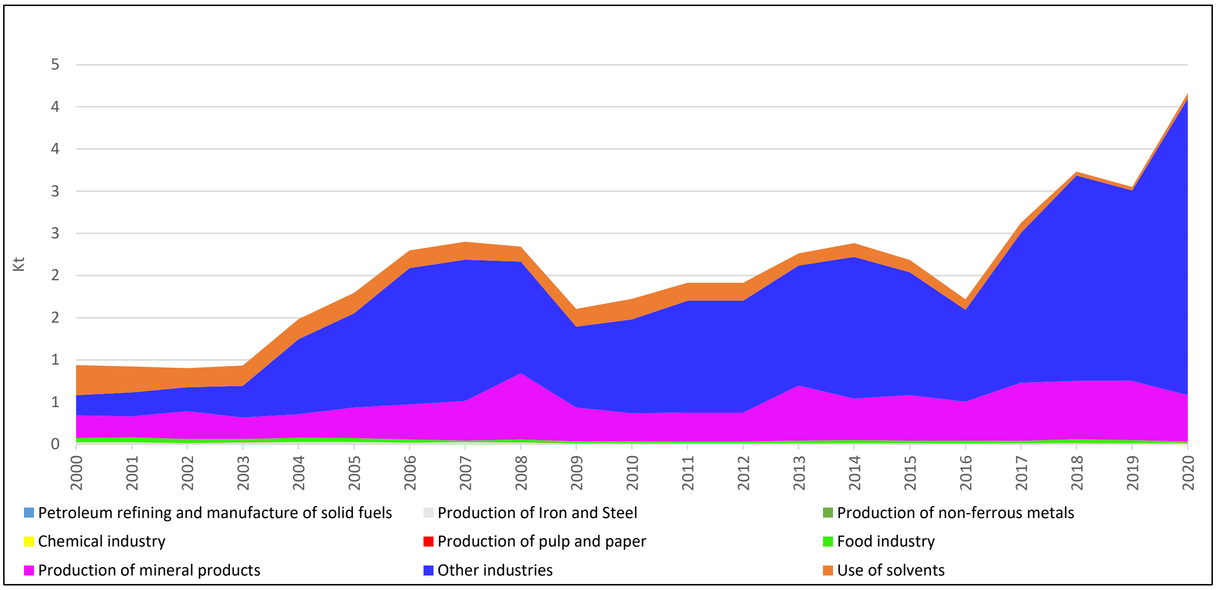

Figure 5-8: PM_{10} emissions of industry from 2020 to 2020 in Moldova

In 2020, $PM_{2.5}$ emissions from industrial sources accounted for about 1kt. The main industrial source of $PM_{2.5}$ emissions were "other industries" (55%) due to road paving with asphalt (65% of the category). The other important source of $PM_{2.5}$ is 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 have minor contribution (Figure 5-9).

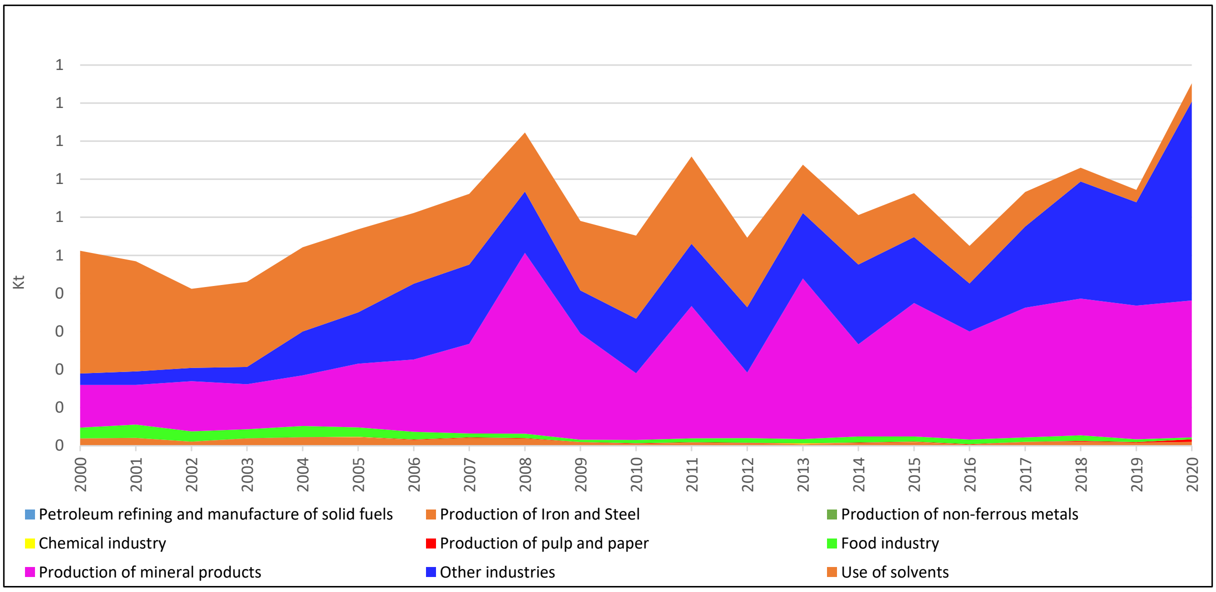

Figure 5-9: $PM_{2.5}$ emissions of industry from 1990 to 2019 in Moldova

Road transport

The trends of PM_{10} and $PM_{2.5}$ emissions of road transport sector are similar. Emissions are progressively increasing for both pollutants from 2000 onward reaching about 1kt of PM_{10} and 0,9kt of $PM_{2.5}$. In 2020, PM_{10} and $PM_{2.5}$ are mainly emitted by heavy duty vehicles and busses

(34% and 40% respectively), by light duty vehicles (18% and 22% respectively), automobile tyre and break wear (19% and 12% respectively) and passenger cars (16% and 18% respectively) (Figure 5-10 and Figure 5-11).

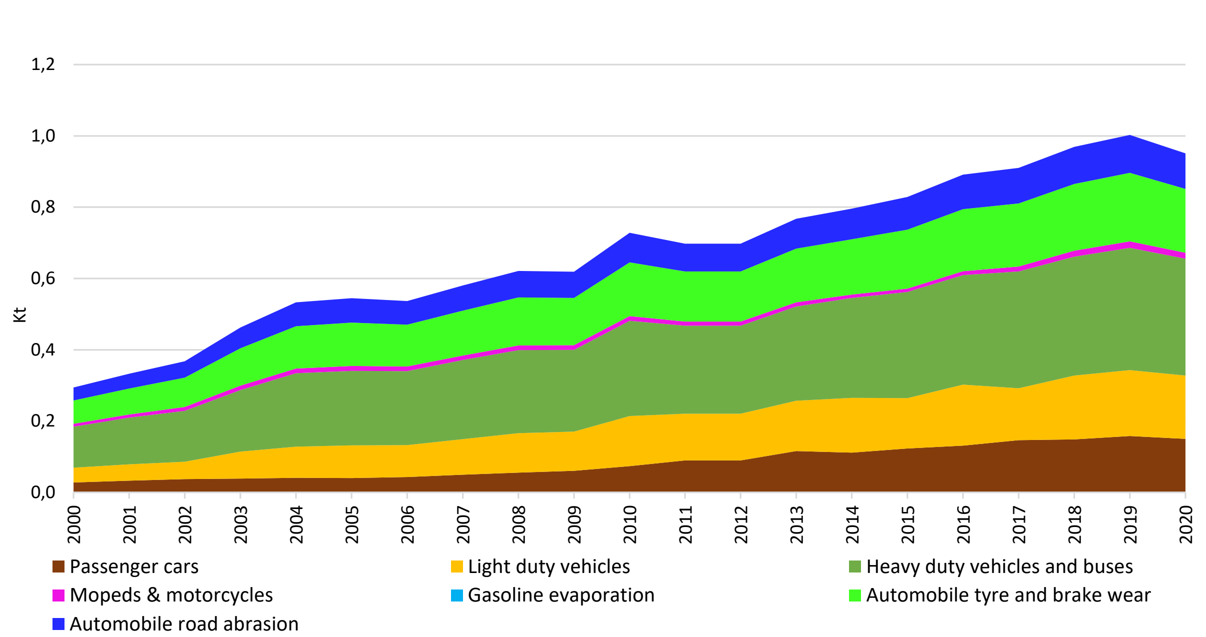

Figure 5-10: PM_{10} emissions of road transport from 2000 to 2020 in Moldova

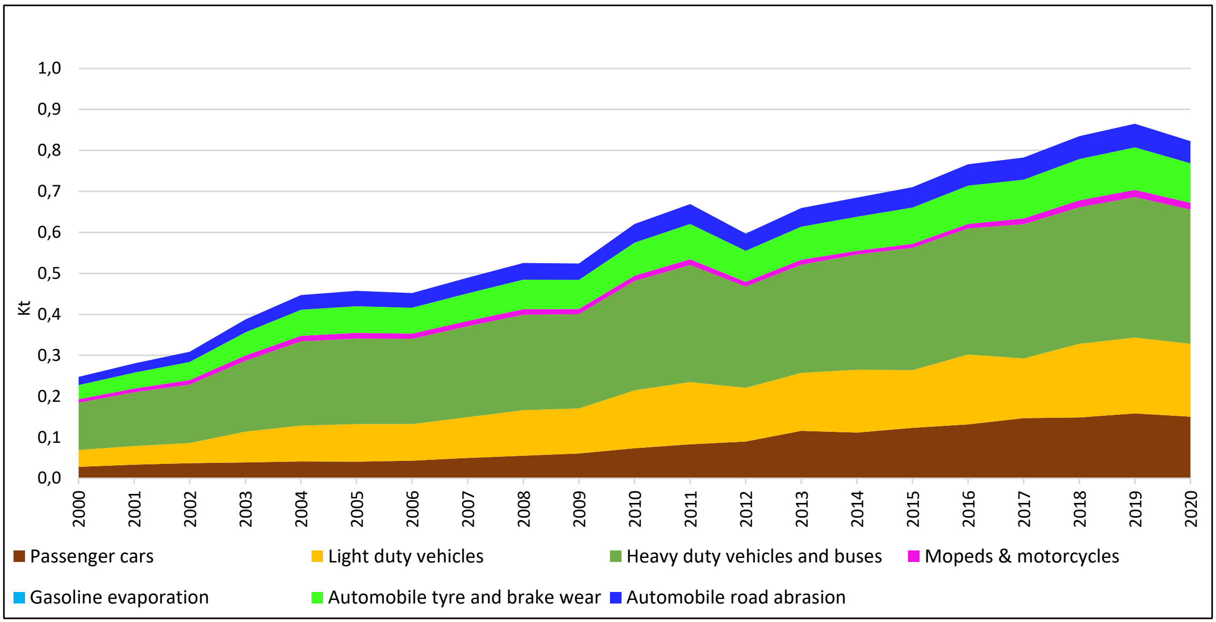

Figure 5-11: $PM_{2.5}$ emissions of road transport from 2000 to 2020 in Moldova

5.2.4. VOC emissions

Total VOC emissions

The evolution of VOC emissions from 2000 to 2020 are as follows (Figure 5-12).

VOC emissions have a tendency to growth by 2005, decrease from 2006 to 2013 and since 2014 onward are growing. In 2020, VOC emissions accounted for about 69.3 kt. The main contributions to the VOC emissions in 2020 were solvent (49%), followed by the “other stationary combustion” (24%) due to residential heating (98% of the category). Industry has minor contribution (7%). Road transport contributes 9% to the total VOC emissions.

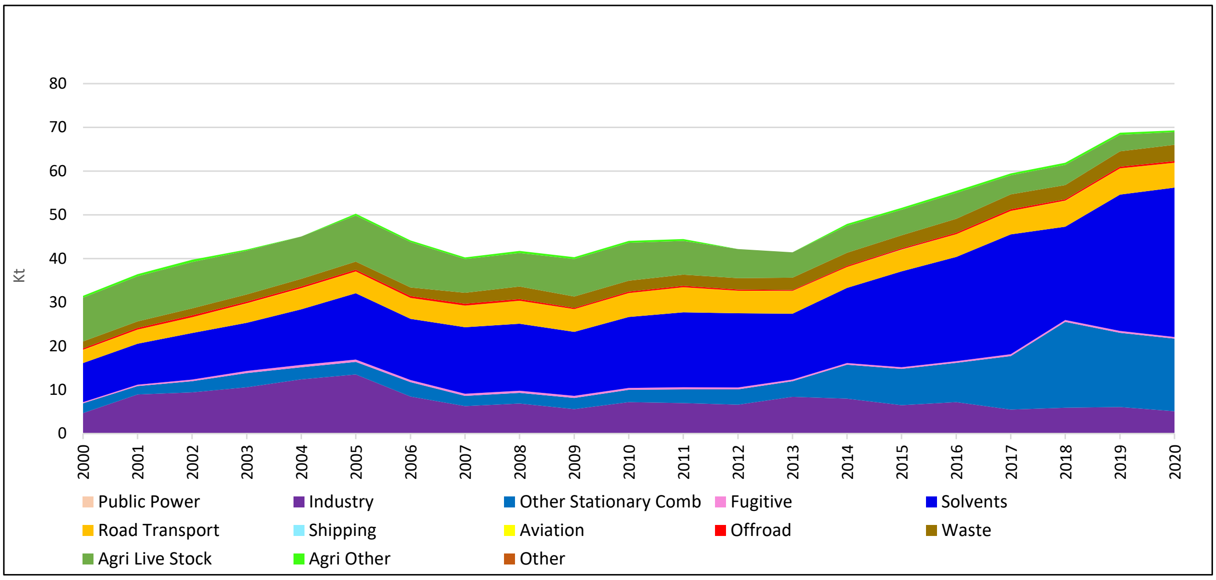

Figure 5-12: Trends in VOC emissions from 2000 to 2020 in Moldova

Industry (except industrial uses of solvents)

Figure 5-13 presents the evolution of VOC emissions in industry (use of solvent are presented in the following subchapter) Total VOC emissions from industry except industrial uses of solvents in 2020 are 4.9kt. In 2020, the main industrial source of VOC emissions was food industry (87%). The other sources have minor contribution.

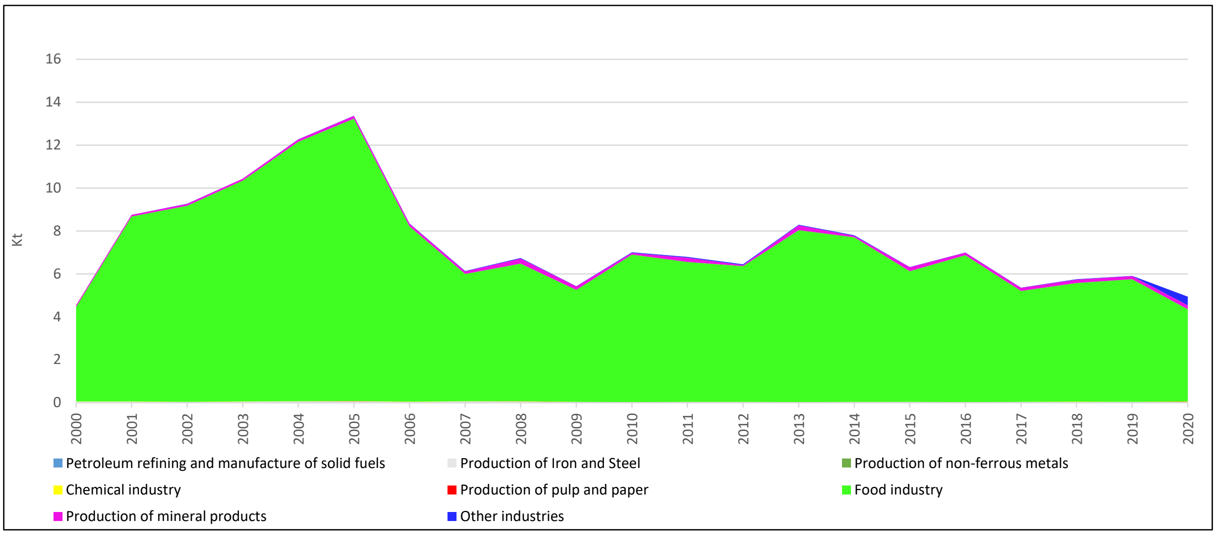

Figure 5-13: VOC emissions of industry (except industrial uses of solvents) from 2000 to 2020 in Moldova

Use of solvents and other products

Figure 5-14 presents the evolution of VOC emissions from the use of solvents and other products. Total VOC emissions from the uses of solvents in 2020 are 30,4 kt.

The "other solvent use" is the most contributing category in 2020 in use of solvents and other products (61%), followed by coating application (25%), and chemical products (13%).

The other important source of solvents is their domestic use. It represents 5% share of national total VOC and 11% share of the solvent category.

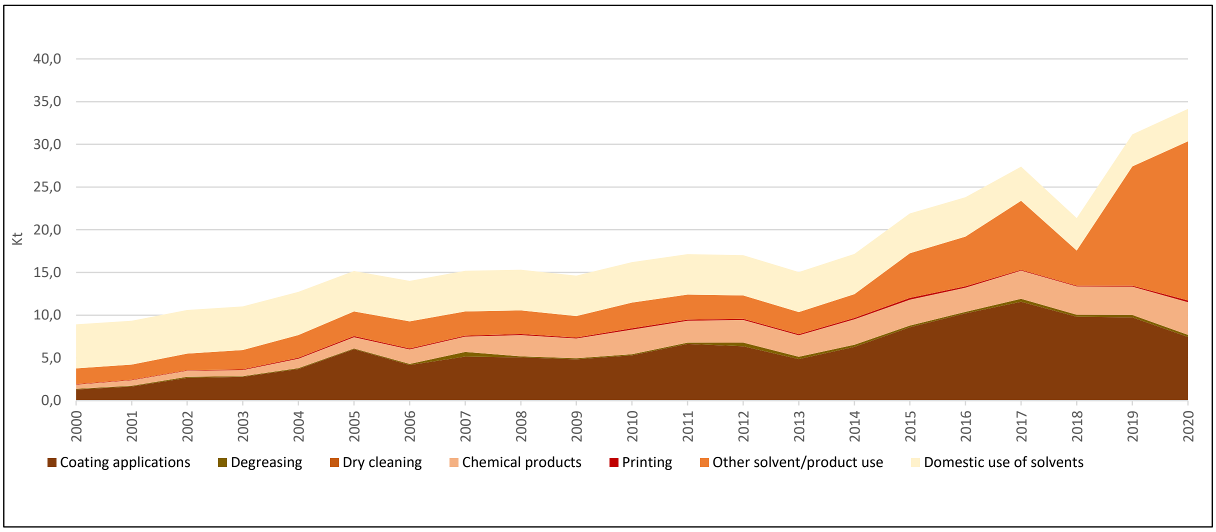

Figure 5-14: VOC emissions from the use of solvents from 2000 to 2020 in Moldova

Road transport

The trend of VOC emissions in road transport sector is similar to PM and in 2020 accounts for 5.7kt. In 2020 the main contribution to VOCs are shared among gasoline evaporation (29%), passenger cars (29%), and mopeds and motorcycles (29%) (Figure 5-15).

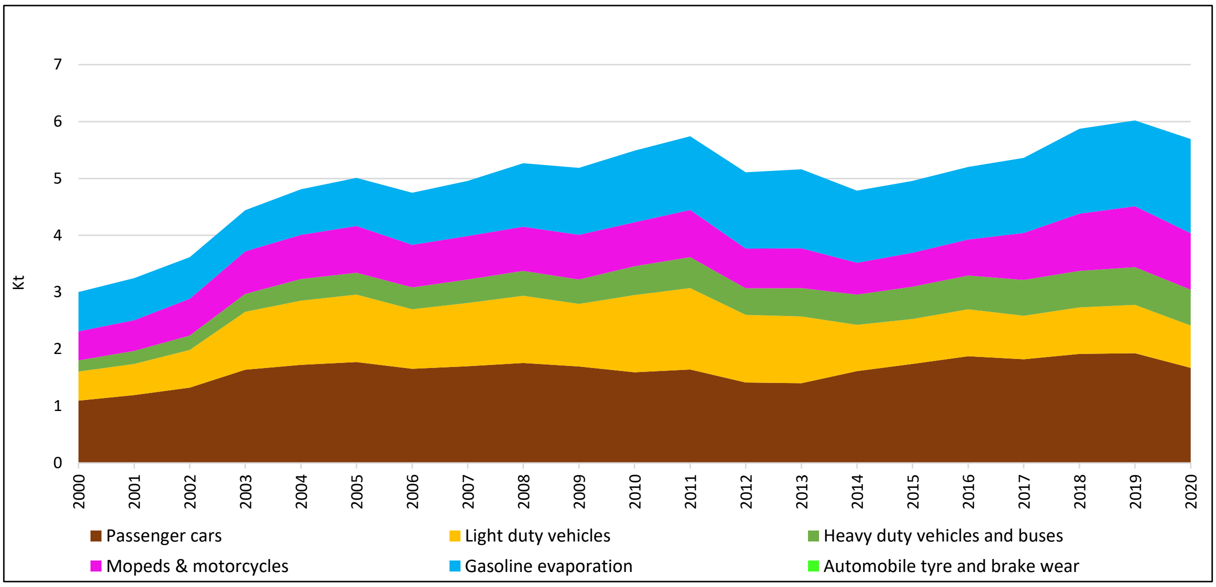

Figure 5-15: VOC emissions of transport from 2000 to 2020 in Moldova

5.3. Situation in terms of air quality

During more than last ten years, the Republic of Moldova undertook the actions to align its policies and regulations with EU regulations and transposed several EU Directives.

For now, the following Directives are transposed:

- Directive 2008/50/EC on ambient air quality and cleaner air for Europe [4].
- Directive 2004/107/EC relating to arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons in ambient air [5].

These two Directives are transposed to the Ambient air quality Law of the Republic of Moldova (LP98/2022 of 14/04/2022) and will come in force from 13/05/2024 [25]. The main objective of the Law is developing Air Quality Monitoring Network and realizing the analyses and assessments based on reliable data regarding air pollutants and share information and indicators of air quality to public in real time.

This Law establishes regulations, assessment and management regimes of ambient air quality, criteria for division of territory of the Republic of Moldova into zones (parts of the national territory delimited for the purpose of air quality monitoring, assessment and management) and agglomerations (the zones with 250,000 or more inhabitants), as well as protection measures to maintain the quality of ambient air according to European Union standards via air quality plans that set out measures to achieve emission limits or other targets.

The Law is also establishing air quality standards considering human health Table 5-1. The table shows that Moldova 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/m³)	**Averaging period**	**Number of permitted exceedances per year**	**Concentration (µg/m³)**	**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.

Currently in the Republic of Moldova, air quality monitoring is performed by means of a network consisting of 17 stationary stations, installed in the period 1970-1978. They operate according to the programme, 3 times/24h and air samples are taken manually for several pollutants (solid suspensions, SO_2, CO, NO_2, NO, soluble sulphates, phenol, and formic aldehyde). 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 the air samples collected at the existing stations do not reflect the real situation of the air quality, as the stations and analytical methods used are obsolete and there is a large margin of error. The results from samples are known one day late. They are not recognized and cannot be shared in the European data system. The 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 can occur in the period between the sampling hours.

As a first step in establishment of the Air Quality Monitoring Network, the first traffic station was installed and put into operation on June 24, 2022. The location of the station is in Chisinau town. The station was donated by the German Government, the Saxony Environment Agency, through the GIZ programme "Capacity Building for Climate Policy Implementation in the Western Balkans, Central and Eastern Europe and Central Asia" [26]. It is an automatic station being equipped with 5 gas analysers to monitor 5 air pollutants: NOx, SO_2, O_3, CO, and PM_{10}.

It is proposed for submission and examination at the meeting of the External Assistance Council, the provision of financial support for the creation of the National Air Quality Monitoring Network, namely, the procurement and installation of 18 atmospheric air quality monitoring stations (traffic, industrial, and background 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 [26], Moldova, draft Strategy for the implementation of monitoring and management of ambient air quality, the location of stations is proposed based on 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

Until now, the following EU Directives, in relation to the air pollutant emissions were 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 [8] which served as basis of Annex XI limit values of the AGP.
- Directive 1994/63/EC [7], Stage I on the control of VOC emissions resulting from the storage of petrol, and its distribution, from terminals to the service stations 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) [6].
- 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) [27].

The Directive 2010/75/EU on Industrial Emissions (IED) [9] is currently under transposition, as well as the Directive 2016/2284 on the reduction of national emissions of certain atmospheric pollutants [28].

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 [29] is available.

The Law on industrial emissions of the Republic of Moldova was adopted 30 of September 2022 [30]. 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 [31].

The Law establishes the approach of public participation in decision making, the criteria to define BAT, the general list of pollutants in air and water, lists the conditions to obtain integrated environmental permits, the conditions to determine emission limits, and emission limits themselves for existing and new installations, but also baseline report before the launching activity. It also defines the rules for periodic and continuous industrial monitoring of emissions.

The Law distinguishes all the activities in three categories, namely the industrial and economic activities with significant environmental risks, low environmental risk and the ones having 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 of 50 MW or more), and important 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 combustion plants with installed thermal capacity equal to or greater than 5 MW and less than 50 MW), metal production and processing, mining, chemical industry, waste treatment wastewater/waste treatment, agriculture and aquaculture, extractive industry, food industry, textile, leather, 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".

It also defines EU 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".

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.

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 precised in the Articles 13 and 15 of the Law.

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 [32], prior to the entry into force of this Law shall:

a) Comply with the emission limits of pollutants (PDV[7]);

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.

In the Annex 1 of the Law on industrial emissions, list of industrial and economic activities with significant environmental risks are established. They are energy industries, metal production and processing, mining industry, chemical industry, waste management, and other activities.

In the Annex 5, the criteria for determining the best available technologies are established. The Annex 6 lists the list of the pollutants to different media, including air. Such pollutants as SO_2, NOx, NMVOCs, dust including fine particulate matter are among them.

The Ministry of Environment, within 24 months from the date of publication of the Law shall approve 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, National Pollutant Release and Transfer Registry to collect information on pollutant releases and transfers was established in the Republic of Moldova [34].

National air pollution control programme will be followed by the Directive (EU) 2016/2284 transposition, that is currently under alignments [23].

5.4.1.1. Combustion installation

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

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[7] 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 [32]

As it was outlined earlier, the Law on industrial emissions [30] regulates industrial installations including LCP and MCP. In addition, BREFs published in Romanian 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. Moldova Environment Agency shall apply the Conclusions of the BAT when setting permit conditions [23].

Emission limit values for LCP (Annex 10) of the Law on industrial emissions [30] correspond to IED Annex V (Parts 1-3).

For plants with a thermal power larger than 50 MW considered in the Gothenburg protocols annexes IV, V and X, the Law on industrial emissions (Annex 10) [30] transposes the annex V of the IED [9] including ELV for large combustion plants. Republic of Moldova recognised BREFs published in Romanian in the Official Journal of the European Union as national BREFs and shall apply the conclusions of the BAT when setting permit conditions [23], ELVs considering in Moldova and applied for LCP are lower or equal of the ones in the Annexes of VI, V, and X of the AGP.

Continuous monitoring of SO_2, NOx, and dust (TSP) is mandatory for large combustion plants with total thermal input of 100 MW or more. In addition, for large combustion plants with a total thermal input of 100 MW or more using gaseous fuel, continuous measurements of CO are also mandatory with some exceptions.

If continuous monitoring is not performed for a large combustion plant, periodic measurements of SO_2, NOx, TSP, and in the case of gas turbines and CO, at least every six months are mandatory. For large combustion plants using coal or lignite, emissions of total mercury are measured at least annually [23].

The Law on industrial emissions [30] establishes also transitional provisions for the large combustion plants referred to installations with a total installed thermal capacity greater than or equal to 50 MW, regardless of the type of fuel used which are in operation on the date of entry into force of the Law, compliance with this Law shall be ensured from 31 December 2028.

According to experts, 97% of LCP use natural gas. 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)[8] and Balti CHPP (24 MW)[9] in addition using gas pistons of 13,2 MW with 4 identical blocks working on natural gas. There is also a small coal and biomass boiler house in Molodovo belonging to Balti CHPP [23].

ELVs for small and medium size combustion installations

Annex X (Table 14) of the AGP [33] introduces recommended limit values for combustion installations from 1 to 50 MWth using solid fuels and liquid fuels, only for PM. The Law on industrial emissions (Annex 8) [30] transposes ELVs for medium size combustion plants of MCP Directive [31]. They are equal to those of Annex X, Table 14 of the AGP. There is no systematised information on the MCPs in the Republic of Moldova [23].

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[8] https://termoelectrica.md/transparenta/indicatori-tehnico-economici/

[9] www.cet-nord.md

Concerning small combustion installation, there is no systematised information nor information on the legislation available for analyses. According to experts, small combustion appliances work mainly on wood and wood consumption is growing in the last 7 years [23].

5.4.1.2. Industrial installations

The Law on industrial emissions [30] regulating industrial activities in the Republic of Moldova is to be enforced from July 2024. Annex 1 of the Law on industrial emissions lists industrial activities covered by the law. They are energy industries, but also production and processing of ferrous and non-ferrous metals, mining industry (production of cement, lime and magnesia, glass production, melting of minerals, production using roasting), chemical industry, waste management, pulp and wood panel production, pretreatment of textile and some others.

Comparison with ELVs of the Gothenburg Protocol

Chapter VI of the Law on industrial emissions is devoted to the special conditions for waste incineration installations. It applies to waste incinerators and co-incinerators that incinerate or co-incinerate solid or liquid wastes. They are the subject to an integrated environmental or environmental, however, there no emission limit values are outlined within the draft law. Article 46 ((3)a)) suggest they are in the list of wastes approved by Government Decision No. 99/2018 however, up to now they are not in the document. However, there is no incineration installations within the Republic of Moldova [23].

Chapter VIII is devoted to the special conditions for installations producing titanium dioxide with emission limit specifications in Annex 13. They correspond to the IED Annex VIII. For sulphate process, ELVs are the same as the AGP (Annex IV, Table 3). However, there is no titanium dioxide production within the Republic of Moldova [23].

Up to now, there is no sulphur recovery units, pulp production or production of nitric acid in the Republic of Moldova [23].

Concerning ELV in the AGP (Annex V and Annex X) of industrial processes, they should be in line with the relevant 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 [23].

There are two major clinker producers in Moldova: "Lafarge Ciment (Moldova)" S.A. from Rezina and Cement Slate Plant from Ribnita (UATSN). In the Republic of Moldova, on the left bank of the Nistru River there is the Rybnitsa Metallurgical Plant (MMK). The plant operates on scrap metal. On the right bank of the Nistru River there are four small enterprises with electric arc furnaces of small capacity (less than 50 t/year). Steel production at these enterprises, compared to the plant in Ribnitsa, is insignificant.

Concerning oil and gas refining enterprises, there is only one small refinery in Comrat city, built to process extracted oil from the Valeni field in the south of the country. It produces 7-17 thousand tons of oil products per year, mainly diesel fuel and fuel oil. Fuel is mostly exported to Romania. In the energy balance, data on oil production and production of products from it exists since 2004, when oil production started.

Concerning ferrous, secondary non-ferrous metals, lime production, there are activities in the Republic of Moldova, however, there is limited information about was available to the analysis.

There are four glass factories in the Republic of Moldova: Î.S. Glass Factory in Chisinau and Î.M. Glass Container Company from Chisinau the operating ones, and Cristal-Flor Glass Factory in Floresti and Glass Factory in Tiraspol (TMR) are currently not operating [23].

5.4.1.3. Uses of solvents in industry

Chapter VII of the Law on industrial emissions [30] is devoted to the special conditions for installations and activities that use organic solvents. The Annex 12 describes technical provisions for installations and activities with the use of organic solvents ELVs of which correspond to IED Annex VII. So, we could conclude that ELV are at least the same as the Annex VI of AGP (Tables 3-15).

Among the activities listed in the Annex VI of AGP, there are only limited information on industries present in Moldova so far. According to experts, in the Republic of Moldova there are more than 100 economic entities specializing in the production of sunflower oil, the largest of which is the S.A. plant ”Sunflower” from the city of Balti. There are also about 13 producers of pharmaceutical products. The other activities covered by the Annex VI of AGP, are present in Moldova, however the details about the activities were not available for analysis. There is no activities concerning coating in the automotive industry and in various industrial sectors, roll coating or processing of natural or synthetic rubber [23].

5.4.1.4. Sulphur content of gasoil

Regulation on reducing the sulphur content of certain liquid fuels [35] transposed 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 (and repealed in 2016) [6]. The Regulation is aimed at reduction of sulphur content in certain types of liquid fuels to reduce SO_2 emissions, occurring as a result of their combustion, reducing the negative consequences of such emissions for 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 in the exclusive economic zone or in pollution control zones. The Regulation is in force since 15 of July 2016 and for some points since the 1 January 2020.

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

The AGP annex IV [33] 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 machineries are considered in annex VIII of the AGP, mobile sources). The sulphur content is limited to 0.1% w/w, so is in the Moldova Regulation on reducing the sulphur content of certain liquid fuels [35] stipulating (point 6) that gas oil, with a sulphur content exceeding 0.1% by mass may not be placed on the market.

5.4.1.5. Storage and distribution of petrol from terminals to service stations

Regulation on the control of emissions of volatile organic compounds resulting from the storage and distribution of petrol from terminals to service stations [36] 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 [7]. The Regulation applies to procedures, installations, vehicles and vessels used for storage, loading/unloading and transportation of gasoline from one terminal to another or from terminal to station by refuelling with petroleum products, in order to limit emissions of volatile organic compounds, resulting from these operations. The Regulation is in force since 31 of January 2021.

There was no information available on the transposal 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 [37].

Comparison with ELVs of the Gothenburg Protocol

Directive 1994/63/EC on Stage I provisions [7] transposed via the mentioned above Regulation [36] were considered in Table 1 of Annex VI of the AGP.

5.4.1.6. VOC content of products

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 [38] 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 [8]. The Regulation was adopted on 16 December 2020. It aims at limiting 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 since 15 of January 2022.

Comparison with ELVs of the Gothenburg Protocol

Directive provisions [8] 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

Up to now, we don't have enough information to judge if emission limits for the most mobile sources, including the passenger cars and light duty vehicles vehicle standards of the Table 1 of the AGP Annex VIII (euro 4, 5, and 6), for heavy duty vehicles of Tables 2 and 3 (euro IV, V, and VI) are implemented in the current regulation. However, according to the Association Agreement EU – Republic of Moldova EU regulation introducing Euro 5 and Euro 6 [16], [17] should have been transposed within 2015-2018.

In 2018, Moldova completed the Fuel Economy Database of newly registered vehicles with the help of the Coalition's Heavy-Duty Vehicles Initiative. This gave the country a baseline for auto fuel consumption and emissions from its incoming 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 [20].

5.5.2. Motorcycles and mopeds

The Association Agreement EU – the Republic of Moldova [3] includes the legislation the Republic of Moldova should be aligned with. The Regulation (EU) 168/2013 on the approval and market surveillance of two- or three-wheel vehicles and quadricycles [11] is among them. This requires the elaboration of 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. At the moment, some provisions regarding approval are included in the Law no. 131/2007 regarding road traffic safety so far [23].

The Tables 11 and 12 of the Annex VIII of the AGP are based on euro 2 and euro 3 limit values which were 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. This directive introduces the Euro 4 and 5 standards for motorcycles. Moldova is thus should adopt the next Euro standards after Euro 2 and 3 considered in the Annex VIII. The TFTEI report is to be published in 2023 [39].

The draft Law on the approval and market supervision of road vehicles and their component parts partially transposed in the provisions of Directive 2007/46/EC establishing a framework for the approval of motor vehicles and their trailers, as well as systems, components and separate technical units intended for those vehicles and Regulation (EU) 168/2013 [11] so far.

5.5.3. Non-Road Mobile machineries

In the Association Agreement EU – Republic of Moldova, 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) [15], amended nowadays is included. This requires the elaboration of the 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 be transposed, the additional regulations for implementing 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 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 [41] is also included in the Association Agreement EU – the Republic of Moldova, however not transposed yet.

5.5.4. Petrol and diesel quality

Concerning petrol and diesel quality, the Directive 98/70/EC on the quality of gasoline and diesel is partially transposed. Namely, the articles 2,3,4,8 and Annexes 1 and 2 of the Directive, which provide environmental specifications for diesel and petrol. Thus, from February 2019, on the territory of the Republic of Moldova, high-quality fuels, without sulphur and lead, are imported. The implementation of the transposed provisions, namely, ensuring fuel quality control, - upon entering the country and – at the distribution station / at the pump, it is made according to SM EN 14274 standards; SM EN 14275; SM EN 228 and SM EN 590, which is to be implemented. Currently, the customs control regarding the quality of fuels is ensured, through qualitative and quantitative checks, based on Law no. 461/2001 on the petroleum products market [23].

5.6. Technological pathways

Moldova is Party to the Convention on the Long-Range Transboundary Air Pollution (CLRTAP) (Accessed on 5th of January 1995 [1]) and has also accessed the Co-operative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe (EMEP) on 26 July 2016. In addition, 01 October of 2002 Moldova ratified the original 1998 Protocol on Heavy Metals and the original of 1998 Protocol on Persistent Organic Pollutants (POP) on 25 April 2002, and signed Gothenburg Protocol 23 of May 2000 [2].

In the Republic of Moldova, currently, the air quality is monitored a network of 17 outdated stationary stations, installed in the period 1970-1978. They are not recognized at the international level and their results are not shared with the European data system. So, it is difficult to draw the conclusions about air quality within the country.

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

Road transport is the main source of NOx emissions with 48% contribution mainly due to the emissions of heavy-duty vehicles and buses (N2-N3 trucks, and M2-M3 buses).

The industrial sources contribution in emissions of those substances are much less important due to limited number of LCP within the country and the wide use of natural gas as a fuel.

Since more than ten years, Moldova started to align its policies and regulations with the EU Directives, by 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 part, and the Republic of Moldova, of the other part [3]. It is in force since the first of July 2016.

According to this Association Agreement, Moldova should align its legal framework with the EU legal system in air quality, industrial emissions, road transport and many other sectors. National emission ceilings should also be applied as established in the original 1999 Gothenburg Protocol to Abate Acidification, Eutrophication and Ground-level Ozone. Furthermore, before 2026 the Republic of Moldova shall endeavour to ratify the Gothenburg Protocol, including the amendments adopted in 2012[3].

Until now, the following Directives were 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),
- Directive 2016/802 on reduction in the sulphur content in fuels.

Moldova has transposed the Directive 2008/50/EC on Ambient Air Quality and Cleaner Air for Europe and the Directive 2004/107/EC on Arsenic, Cadmium, Mercury, Nickel and PAH in ambient air.

The recent Law on industrial emissions adopted 30 of September 2022 partly transposed 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 and defines the rules for periodic and continuous industrial monitoring of emissions. The Directive 2016/2284 on the reduction of national emissions of certain atmospheric pollutants is currently being transposed.

The Annex I of this chapter introduces the tables of comparison of emission limit values in the in the Republic of Moldova regulation and the ones of the AGP.

Domestic heating

A key sector in Moldova **emitting PM** for which recommended limit values are provided by the AGP is **domestic heating with solid fuels such as coal or biomass**. 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" [42] developed by TFTEI, the report "Prioritizing reductions of particulate matter from sources that are also significant sources of black carbon - analysis and guidance" [43] developed by TFIAM and the report "Review on Black Carbon (BC) and Polycyclic Aromatic Hydrocarbons (PAHs) emission reductions induced by PM emission abatement" [44] 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 [45]. In addition, the last TFTEI report on the updates of limit values of technical annexes also provides information [46].

One of the key measures relating to domestic heating with solid fossil and biomass fuels could be development of the programme for the replacement of existing household heating appliances with new Eco-Design compliant appliances associated to financial incentives. In so-called hot-spots of PM pollution due to household heating, higher rates of replacement of oldest appliances could be foreseen. These measures are also linked to an energy policy aiming at reducing the energy demand through better energy efficiency.

In order to have more efficient appliances in place rapidly, the programme could include the activities for Moldova such as aligning its national legislation with the Eco-design Directive [47] 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 [48] and Regulation 2015/1185/EU [49]). The establishment of 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 needs also to be set up.

For industrial processes emitting SO_2, NOx and / or PM covered by annexes IV, V and X, the Annex– 5.7 of this report (chapters 8.1, 8.2 and 8.4) presenting the best available techniques to comply with the limit values prescribed.

For PM, best available techniques (chapters 8.4.2 to 8.4.10) to comply with limit values are electrostatic precipitators and fabric 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.

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.

Emissions from transport (Annex VIII):

Moldova takes some measures to emission control from the road transport. So, 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 regulations development, after an Association Agreement EU – the Republic of Moldova is previewed including 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 the Regulation (EU) 168/2013.

Concerning fuel quality, the Directive 98/70/EC on the quality of gasoline and diesel is partially transposed providing environmental specifications for diesel and petrol, so the same sulphur content level as in the Annex VIII, Tables 13 and 14.

According to the EU association agreement, EU directives or regulations introducing Euro 6/VI (basis of tables 1 to 3 of annex VIII of the AGP) implementing rules for type approval of vehicles should have been approximated (the exact situation still to be checked with experts).

In addition, the transposition of the latest EU directives or regulations concerning Euro standards for light and heavy-duty vehicles, but also for other types of vehicles. Domestic production and especially for new vehicles imported vehicles could be highly recommended.

One efficient measure could be to prohibit the imports 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 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.

5.7. References of chapter 5 Moldova

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[28] 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

[29] 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

[30] Law on industrial emissions of the Republic of Moldova No. 227, 30 September 2022

[31] 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

[32] On the ambient air protection, Law of the Republic of Moldova, No. LP1422/1997, 17 December 1997

[33] 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

[34] On the National Pollutant Release and Transfer Register, No. 373, 24 April 2018

[35] On the approval of the Regulation on reducing the sulphur content of certain liquid fuels, Government decree No. HG414/2016, 8 April 2016

[36] 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 decree No. HG587/2020, 31 July 2020

[37] 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

[38] 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

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[40] 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

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[48] 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

[49] 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 [30]. 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/m^3	Existing installation, mg/m^3	New installation mg/m^3	Existing installation, mg/m^3
< 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/m^3	Existing installation, mg/m^3	New installation mg/m^3	Existing installation, mg/m^3
		150 (peat) (FBC: 200) 150 (biomass)	200 (biomass)		
< 100	Dust		30	20 (coal, lignite and other solid fuels) 20 (biomass, peat)	30
100 - 300			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/m^3	Existing installation, mg/m^3	New installation mg/m^3	Existing installation, mg/m^3
< 100	NOx	300	450	300	450
100 - 300		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		200	250	200	250
≥ 300		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			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)
		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	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	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

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
		efficiency, determined on the basis of the ISO reference operating mode and expressed as a percentage.)	120 (general for other gases)		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)
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 [30] 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:	ELV should be in line with the EU BREF, as BREFs published in Romanian in the Official

	ELVs of technical annexes of the AGP	ELVs prescribed by Moldova regulation
	400 mg/m^3 Existing installation: 400 mg/m^3	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 [22].
	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 [23]
	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 [23].
	Primary iron and steel production Sinter plant: 50 mg/m^3 Pelletization plant: 20 mg/m^3 for crushing, grinding	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 [22].

	ELVs of technical annexes of the AGP	ELVs prescribed by Moldova regulation
	15 mg/m^3 for all other process Blast furnace: Hot stoves (>2.5 t/hour): 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 [22].
	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 it [23].
	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):	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
	10 mg/m^3 Hazardous and medical waste incineration (> 1 Mg/hour): 10 mg/m^3	BREFs and published in the Official Gazette of the Republic of Moldova. There is limited information available on waste incineration in Moldova [23]

6. Montenegro

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

CLRTAP [1] was taken over by the Montenegro by means of succession it with the date of effect of 23 October 2006 [2] (The former Yugoslavia had signed and ratified the Convention on 13 November 1979 and 18 March 1987 respectively). Montenegro acceded the EMEP Protocol on the 23 October 2006 [3], 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 established a Law on the approval of the protocol on original of 1999 [6], however, emission ceilings were not established within it. Up to now 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 help of Italian Ministry of Environment. For seven years, no national emission inventory was developed, and since 2020 Montenegro is developing and submitting the emission inventories supported by the Environment Agency Austria [8].

This part of the report devoted to technological pathway of AGP ratification in Montenegro has been developed with kind support of Olivera Kujundzic Senior advisor, Directorate for Ecology and Climate Change Ministry of Ecology, Spatial Planning and Urbanism. She has provided detailed information on air quality situation, industrial, road transport and residential heating emission sources and relevant strategic documents and legislation on which our analysis is based. The interviews and document exchange took place from April to August 2023 [8].

6.2. Main sources of emissions

The evolution of air emissions of Montenegro was built by TFTEI using emission data submission under the CLRTAP 15th of March 2021 for the period of 2010 to 2019 [9] and Informative Inventory Report (IIR) submission 2021 [10]. More recent NFR tables and IIR report submitted in 2023 and available on the web platform for CLRTAP submissions [11] were not used, due to noticed inconsistencies in the emission data. The expert of the Ministry of Ecology, Spatial Planning and Urbanism Montenegro insisted that the inventory of emissions should be further improved to reflect more accurate situation in terms of air emissions in Montenegro and to 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 have not been estimated in 2021 NFR tables submission [9].

Total SO_2 emissions

The evolution of SO_2 emissions from the different sources is provided from 2010 to 2019 in the Figure 6-1.

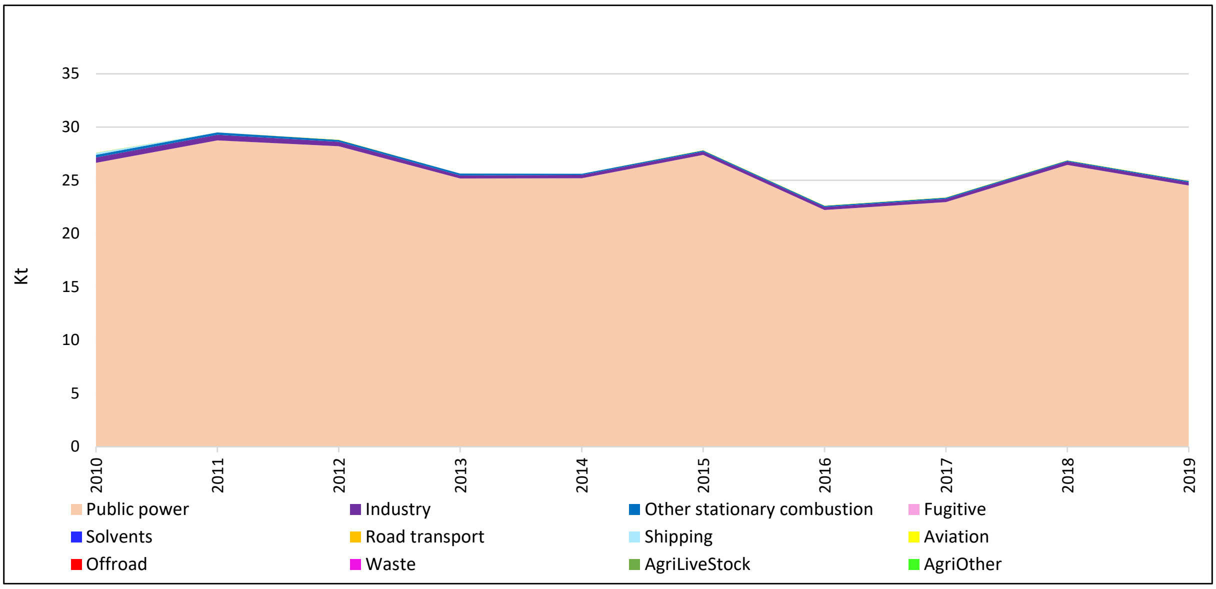

Figure 6-1: Trends in SO_2 emissions from 2010 to 2019 in Montenegro

In 2019, SO_2 emissions in Montenegro reach 24.9 kt. There is an overall tendency of SO_2 emissions of reduction from 2010 to 2019. In 2019, the main source of SO_2 emissions is energy production (98.4%), i.e. the coal-fired Pljevlja Thermal Power Plant [12]. About one third of electricity in Montenegro is generated by this thermal powerplant, while hydropower plants generate approximately the remaining two thirds [10].

Industrial sources

The evolution of SO_2 emissions from the different 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 increased by 97% and 93% from 2013 to 2019 respectively.

Total emissions of SO_2 from industrial sources in Montenegro in 2019 are 0.3 kt. In 2019 the major sources of SO_2 emissions is the Production of non-ferrous metals (60%), other industries via stationary combustion in manufacturing industries and construction (25%), and Food industry (12%).

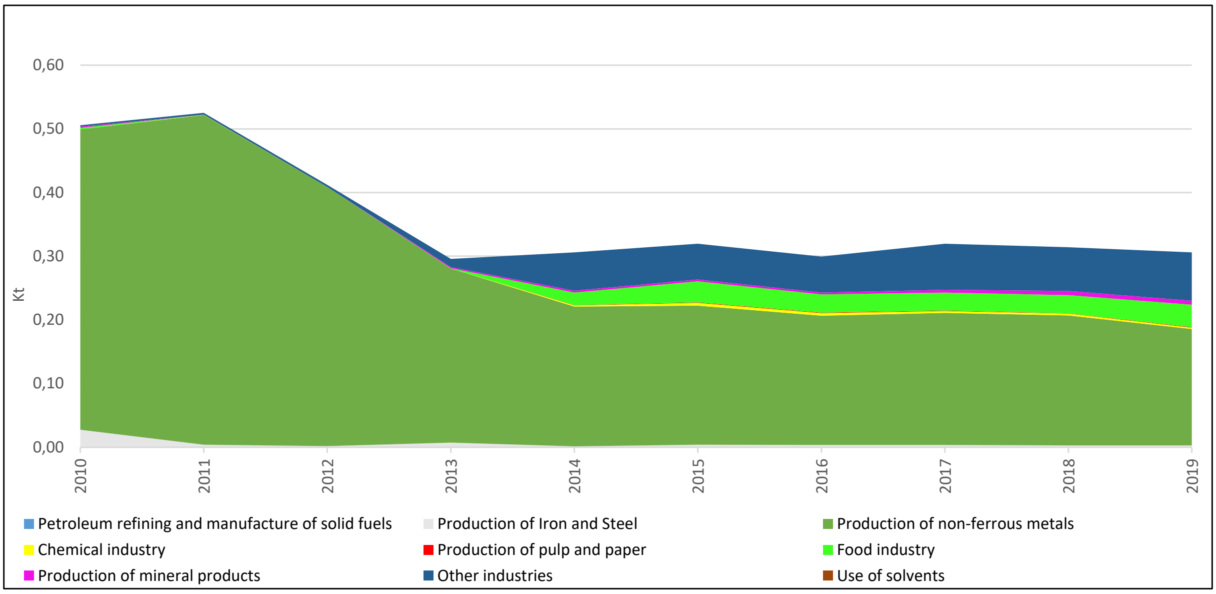

Figure 6-2: SO_2 emissions of manufacturing industry from 2010 to 2019 in Montenegro

6.2.2. NOx emissions

This section presents the evolution of NOx emissions from 2010 to 2019, starting with total NOx emissions. Then, the contribution of industrial sources other than public power is presented. And finally, emissions from road transport vehicles are shown.

Total NOx emissions

The evolution of NOx emissions from the different sources is provided in the Figure 6-3 from 2010 to 2019. In 2019, the total NOx emissions were 12,7 kt.

According to the data from the emissions inventory, in 2019 the key contribution to NOx emissions (56%) comes from the road transport, while energy production (TEP Pljevlja) contributes 28%. The processing industry participates in NOx emissions with 10% contribution due to manufacturing processes, while all other sectors contribute a total of about 6%, including 3% contribution of other stationary mainly due to residential heating.

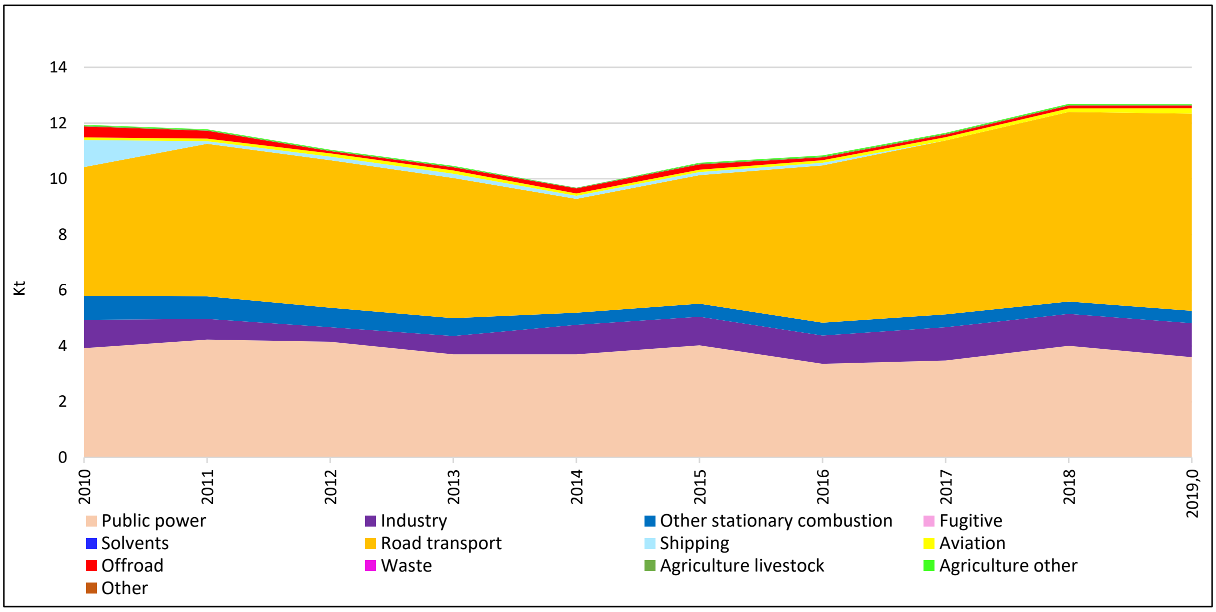

Figure 6-3:Trends in NOx emissions from 2010 to 2019 in Montenegro

Industrial sources

The evolution of NOx emissions from the industrial sources is provided in the Figure 6-4 from 2010 to 2019. In 2019, NOx emissions from industrial source were 1,2 kt.

Other industries category has the highest contribution (69%), and NOx emissions of this category is increasing from 2013 onward due to increase in liquid fuel used [10]. The second important source of NOx is Food industry (18%), Production of mineral products (6%) and Production of non-ferrous metals (4%).

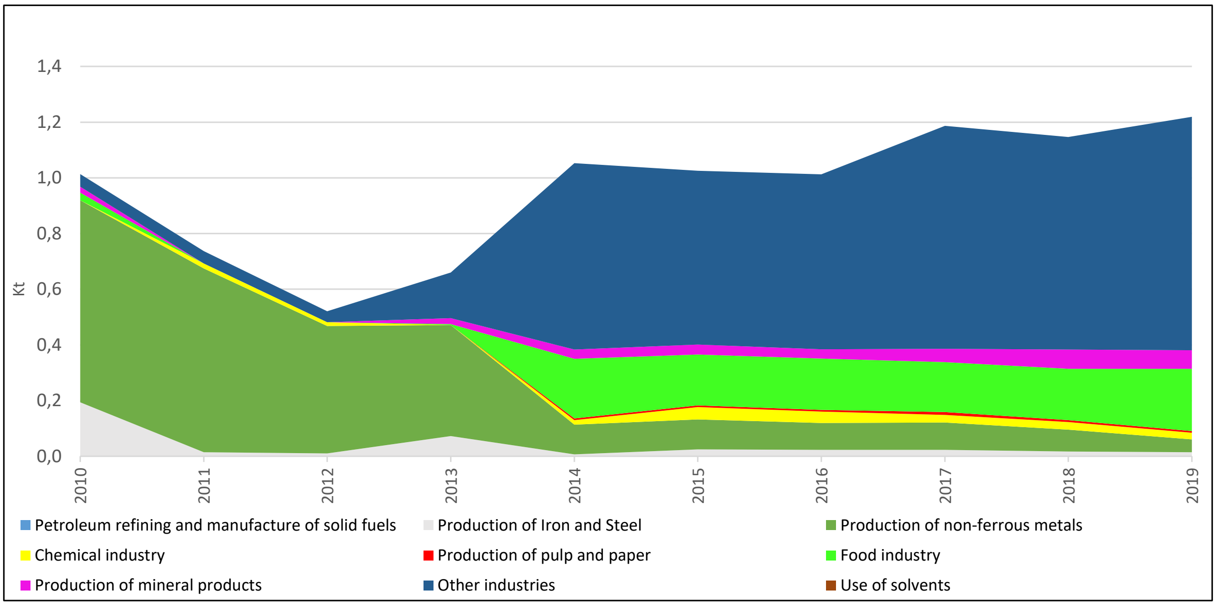

Figure 6-4: NOx emissions of manufacturing industry from 2010 to 2019 in Montenegro

Road transport

The evolution of NOx emissions from road transport is as in the following Figure 6-5, from 2019 to 2020. In 2019, emissions from road traffic were 7 kt and represent 56% of total NOx emissions of Montenegro. 90% share of all NOx emissions are due to heavy-duty vehicles following by passenger cars (10%).

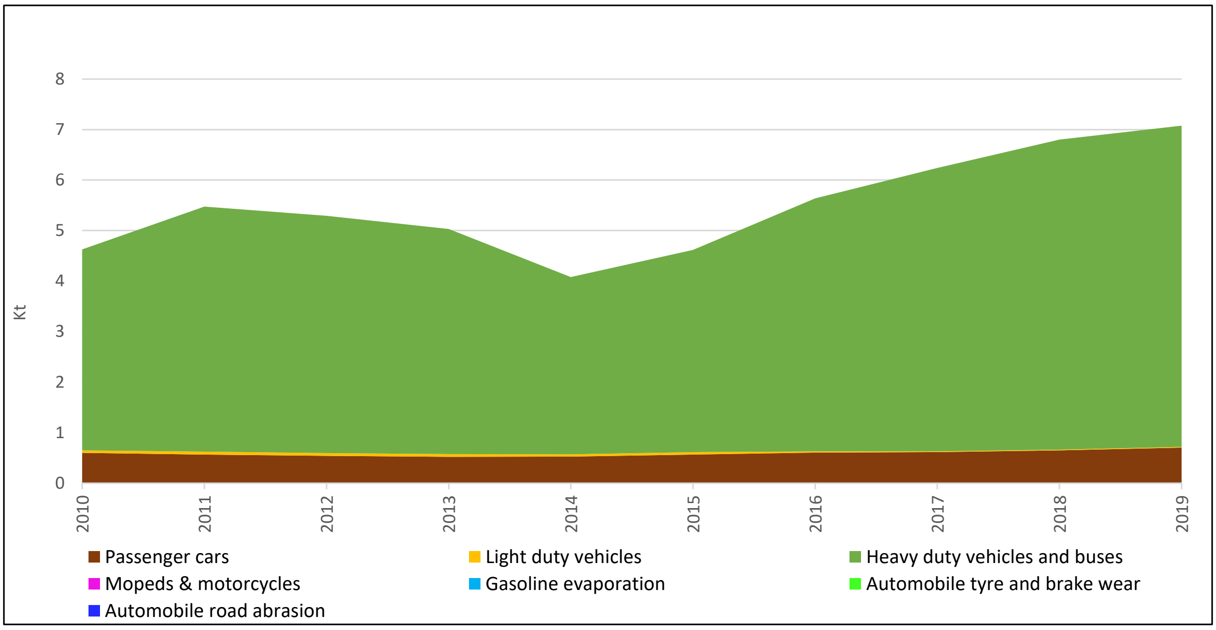

Figure 6-5: NOx emissions of road transport from 2010 to 2019 in Montenegro

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. Then, the contribution of industrial sources other than public power is presented. And finally, emissions from road transport vehicles are shown.

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

The evolution of PM_{10} and $PM_{2.5}$ emissions from the different sources is provided in the Figure 6-6 and Figure 6-7 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 [9], in 2019 the key contribution to PM_{10} and $PM_{2.5}$ emissions (85% of contribution for both pollutants) comes from the other stationary combustion, mainly from residential heating (99% for both pollutants). The road transport had a share of 6% and 10% of PM_{10} and $PM_{2.5}$ total emissions respectively.

Bearing in mind that through air quality monitoring in the period of 2009-2018, increased concentrations of PM, in accordance with Directive 2008/50/EC [13] were recorded. Three air quality plans were drawn up (Pljevlja 2013, Nikšiÿ 2014, Podgorica 2015) with measures to reduce PM emissions. Although data on air quality testify significant reductions in concentrations, it is necessary to update the emissions inventory for reliable quantification of the achieved results [12].

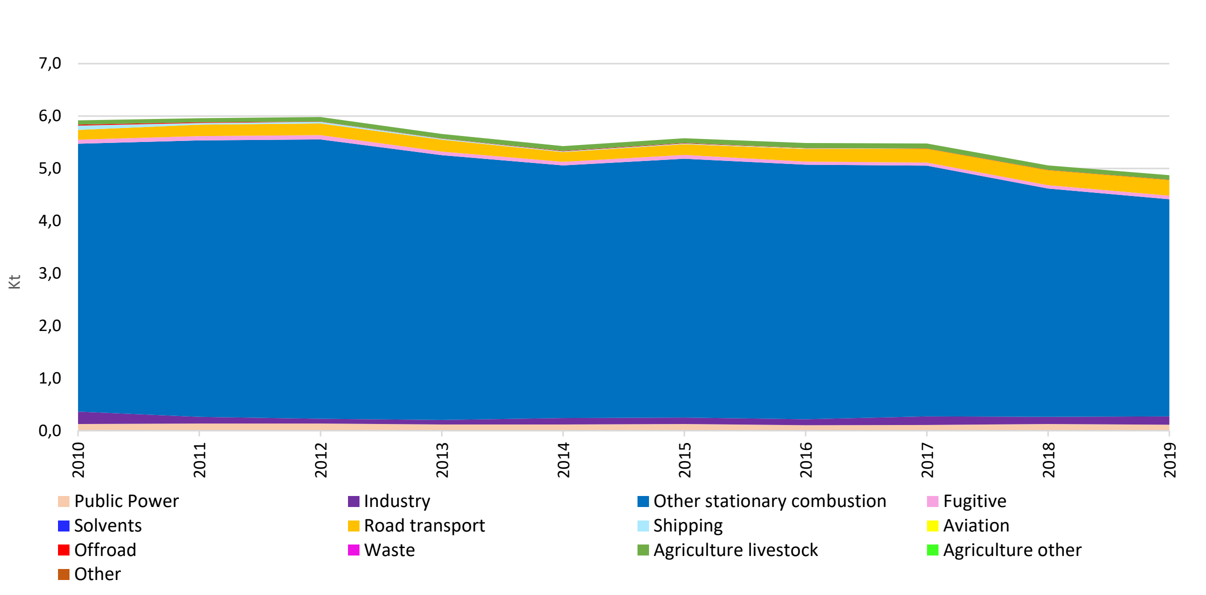

Figure 6-6:Trends in PM_{10} emissions from 2010 to 2019 in Montenegro

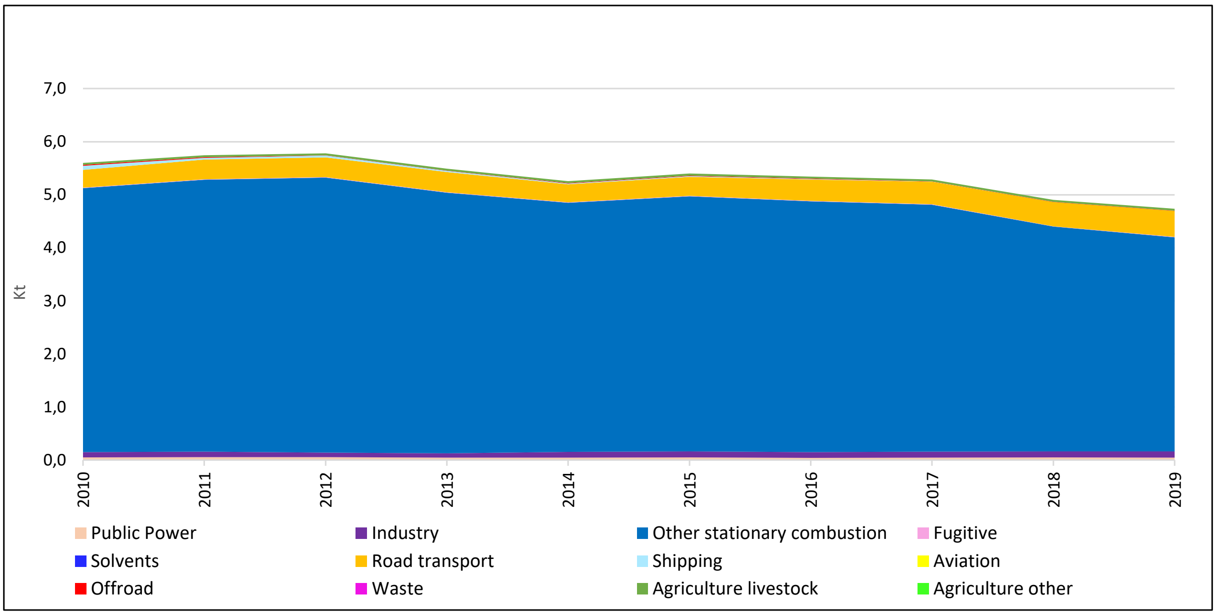

Figure 6-7:Trends in $PM_{2.5}$ emissions from 2010 to 2019 in Montenegro

<u>Industrial sources</u>

The evolution of PM_{10} and $PM_{2.5}$ emissions from the industrial sources is provided in Figure 6-8 and Figure 6-9 respectively, 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, "Other industries" category has the highest contribution (48%), Food industry is the second largest with 33% of share, Production of non-ferrous metals emissions are accounted for 12% emissions of total industrial emissions and Chemical industry with 5% share.

For $PM_{2.5}$ emissions, Food industry has the highest contribution (43%), Other industries category is the second largest with 35% of share, Production of non-ferrous metals emissions are accounted for 13% emissions of total industrial emissions and Chemical industry with 7% share.

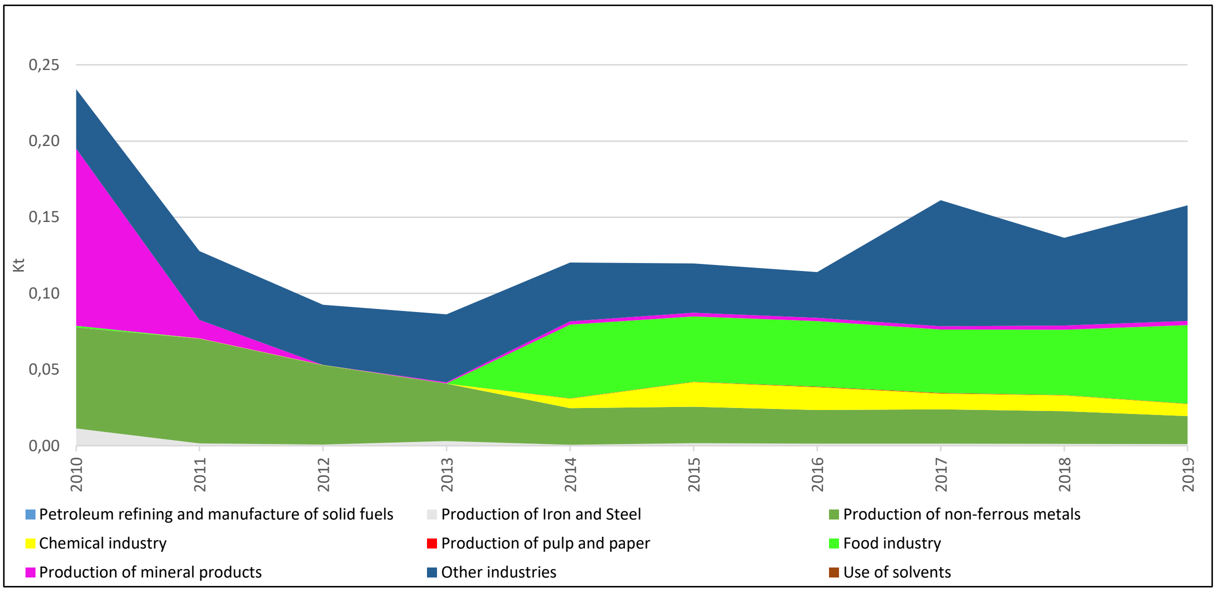

Figure 6-8: PM_{10} emissions of manufacturing industry from 2010 to 2019 in Montenegro

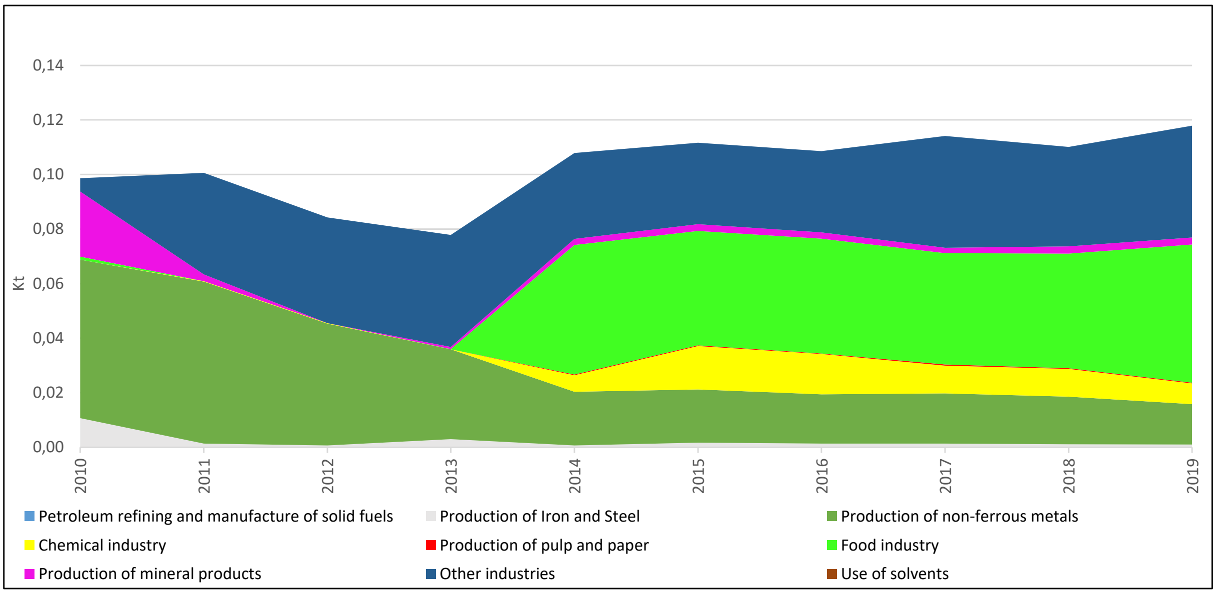

Figure 6-9: $PM_{2.5}$ emissions of manufacturing industry from 2010 to 2019 in Montenegro

Road transport

The evolution of PM_{10} and $PM_{2.5}$ emissions from road transport is provided in **Erreur ! Source du renvoi introuvable.** and Figure 6-11, 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.

57% share of PM_{10} emissions are due to heavy-duty vehicles, following by automobile tyre and brake wear (22%), passenger cars (12%), and automobile road abrasion (9%).

53% share of PM_{10} emissions are due to tyre and brake wear following by heavy-duty vehicles (35%), passenger cars (7%), and automobile road abrasion (4%).

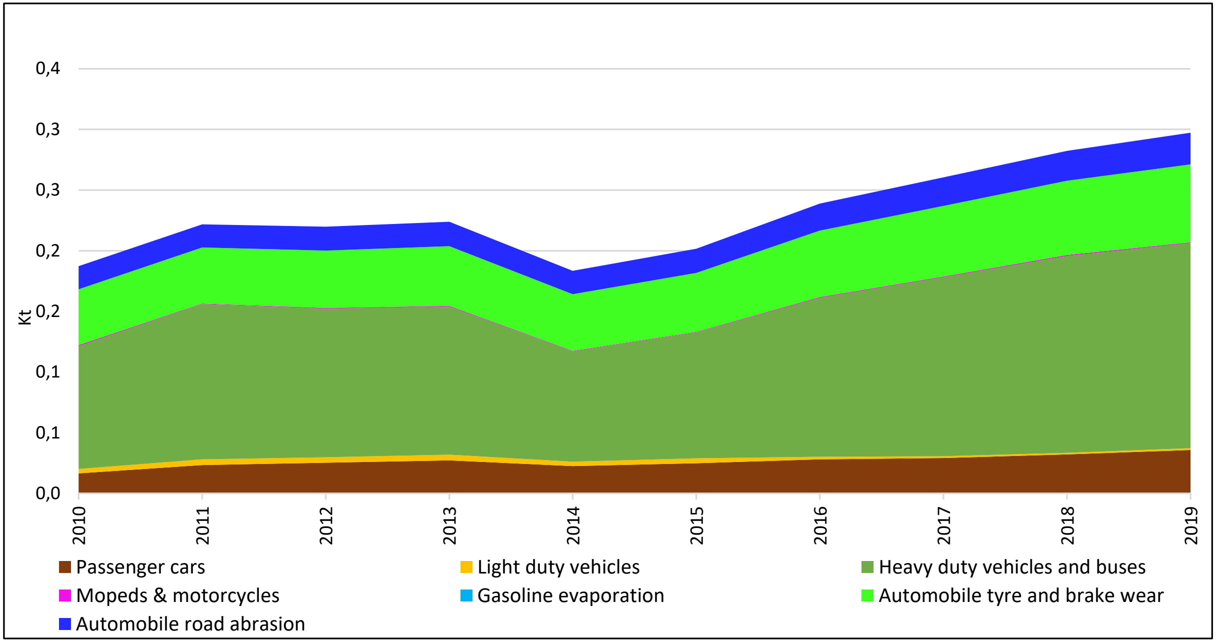

Figure 6-10: PM_{10} emissions of road transport from 2010 to 2019 in Montenegro

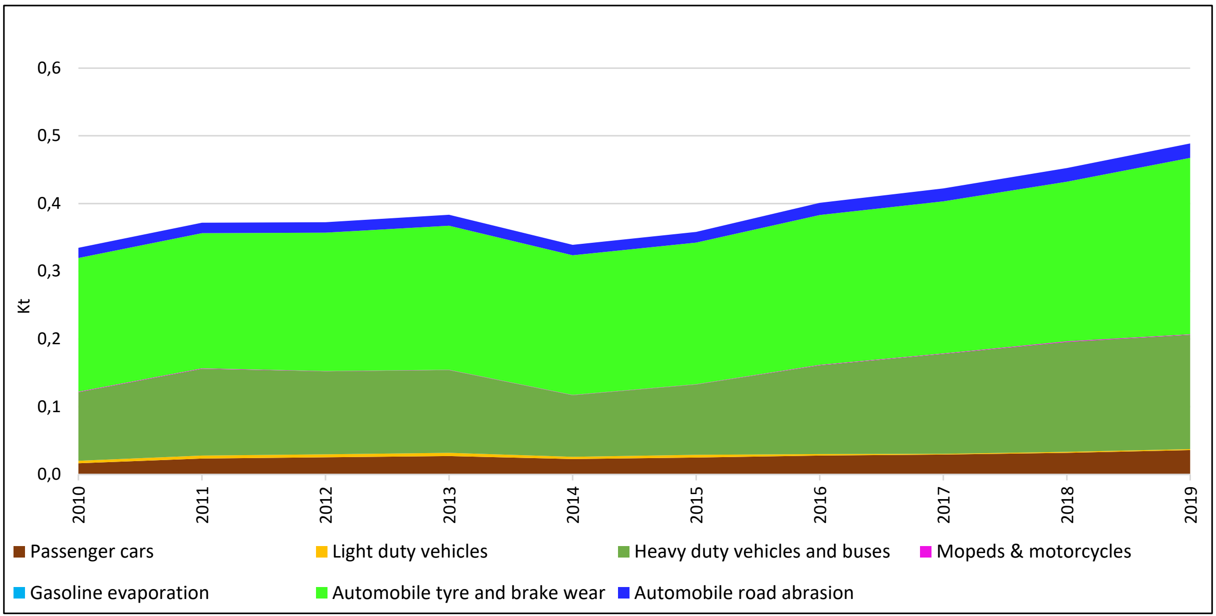

Figure 6-11: $PM_{2.5}$ emissions of road transport from 2010 to 2019 in Montenegro

6.2.4. VOC emissions

This section presents the evolution of VOC emissions from 2010 to 2019, starting with total VOC emissions. Then, the contribution of industrial sources other than public power is presented. And finally, emissions from road transport vehicles are shown.

Total VOC emissions

The evolution of VOC emissions from the different sources is provided in the Figure 6-12 from 2010 to 2019. In 2019, the total VOC emissions were 8,6 kt.

According to the data of the emissions inventory, in 2019 the key contribution to VOC emissions (39%) comes from the other stationary combustion, mainly from residential heating (97%). The road transport had a share of 16%, Fugitive emissions 15% in total VOC emissions. Fugitive emissions entirely presented by emission from solid fuels, namely Coal mining and handling. Solvents, offroad and agriculture livestock have 9% each in total VOC emissions. Manufacturing industry represents only 4% in total VOC emissions.

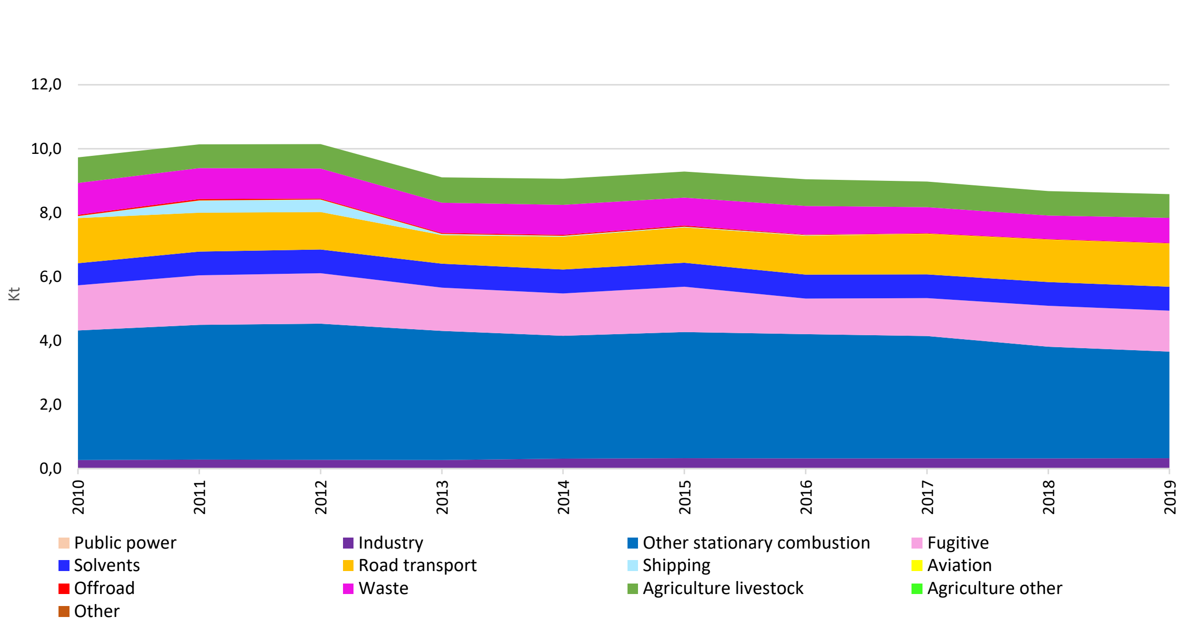

Figure 6-12: Trends in VOC emissions from 2010 to 2019 in Montenegro

The key sources of VOC emissions, individual fireplaces for burning firewood in households could partly be replaced in certain urban areas in the case of the introduction of central fireplaces and district heating systems using modern forms of biomass, with the fact that for most local governments in the northern part of the country, the construction of such systems are quite a demanding investment, both financially and technically.

Another key source of VOC is road traffic, in which, to reduce air pollution, the introduction of electric vehicles is foreseen, the implementation of which is also quite challenging, primarily due to the large financial needs.

Current data show a fairly constant level of these emissions throughout the entire period [12].

<u>Industry (except industrial uses of solvents)</u>

The evolution of VOC emissions from the industrial sources is provided in Figure 6-13, from 2010 to 2019. In 2019, VOC emissions from industrial sources were 0.31 kt.

For VOC emissions, Food industry has the highest contribution (74%), Other industry is the second largest with 18% of share. Chemical industry represents 5% of share.

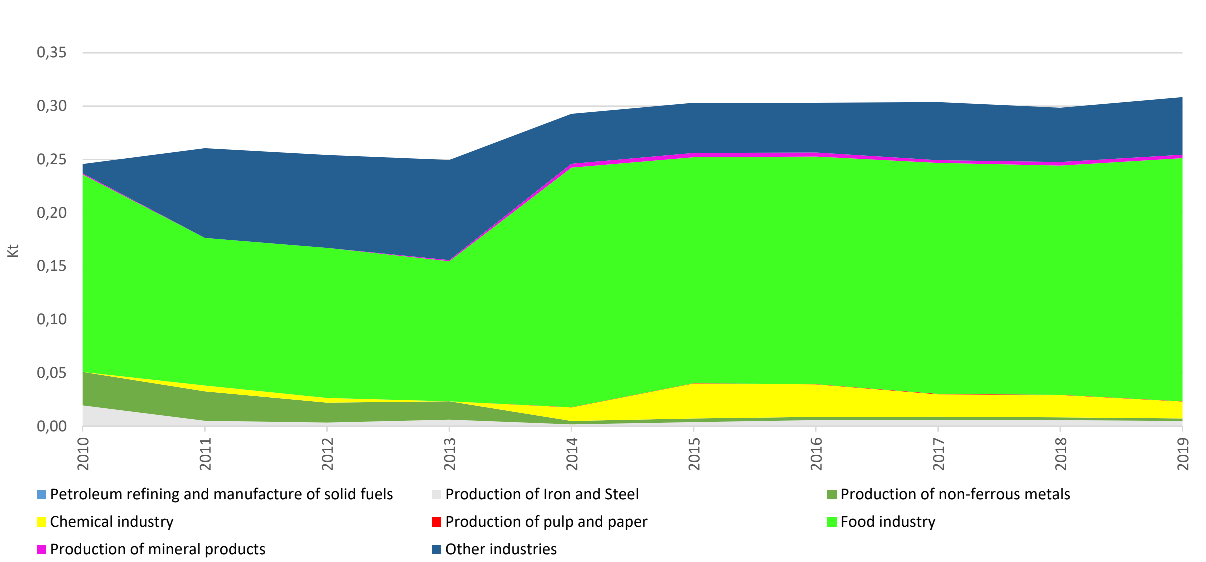

Figure 6-13: VOC emissions of industry (except industrial uses of solvents) from 2010 to 2019 in Montenegro

Use of solvents and other products

The following Figure 6-14 presents the evolution of VOC emissions from the use of solvents and other products. In 2019, total VOC emissions from the uses of solvents was 0,75 kt. Domestic uses of solvents are, the only estimated emitter in Montenegro in 2019.

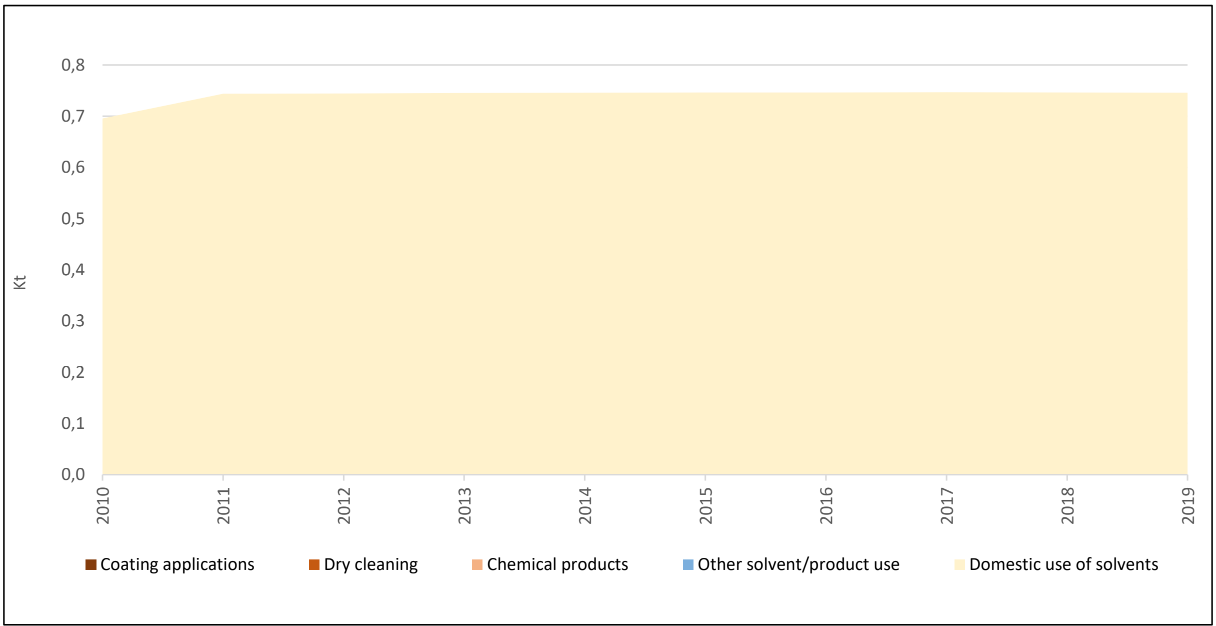

Figure 6-14: VOC emissions from the use of solvents from 2010 to 2019 in Montenegro

Road transport

The evolution of VOC emissions from road transport is as in the Figure 6-15, from 2010 to 2019. In 2019, VOC emissions from road traffic were 1,34 kt.

55% share of VOC emissions are due to heavy-duty vehicles following by passenger cars (26%), Gasoline evaporation (15%), and Mopeds & motorcycles (3%).

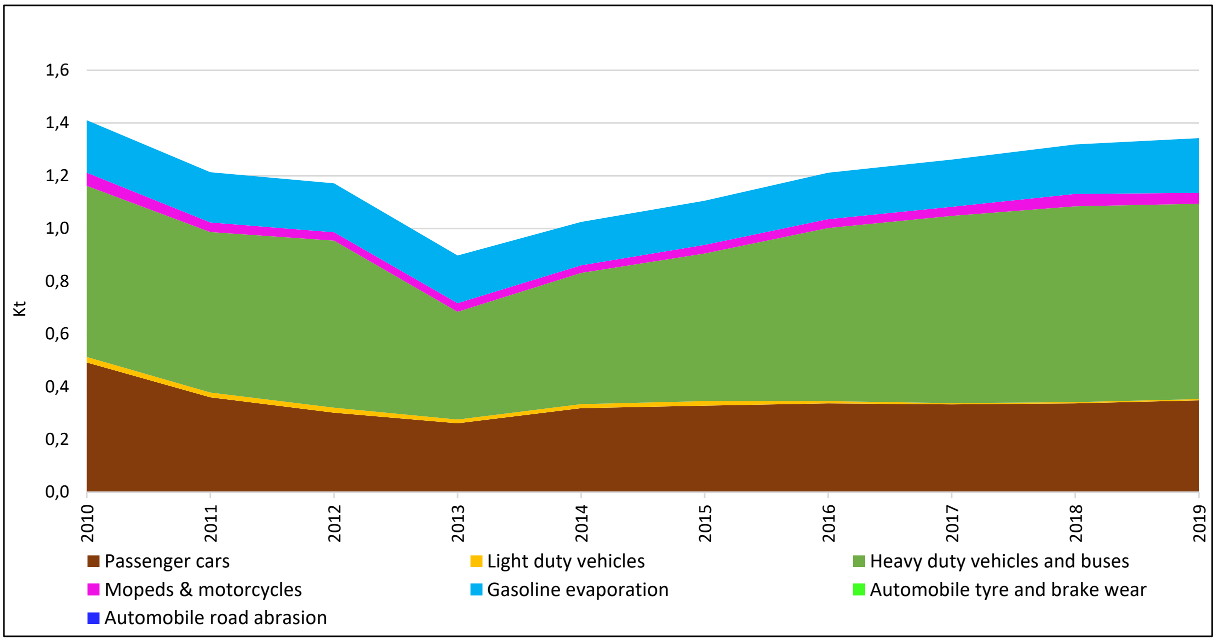

Figure 6-15: VOC emissions of road transport from 2010 to 2019 in Montenegro

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 [12].

The assessment of air quality is carried out in accordance with the Law on Air Protection, 2010 as amended [13] and the next regulations and rulebooks:

1. Regulation on activities that affect or may affect air quality, 2012 [14]
2. Regulation on the establishment of a network of measuring points for air quality monitoring, 2018 [15]
3. Regulation on the determination of types of pollutants, limits values and other air quality standards, 2012 [16]
4. Rulebook on the manner and conditions for monitoring the quality of air, 2016 [17]
5. Rulebook on the content and method of making annual air quality information, 2012 [18]

and in accordance with the relevant European legislation (Directive 2008 /50/EC [19] and Directive 2004/107/EC [20]).

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). The air quality zones are determined basing on preliminary assessment of air quality available data on pollutant concentrations and by modelling of existing data. The boundaries of the air quality zones coincide with the external administrative boundaries of the municipalities that are part of those zones [22].

Table 6-1: Air quality zones in Montenegro [22]

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, Nikšiÿ, Danilovgrad and Cetinje
Southern air quality zone air quality	Bar, Budva, Kotor, Tivat, Ulcinj and Herceg Novi

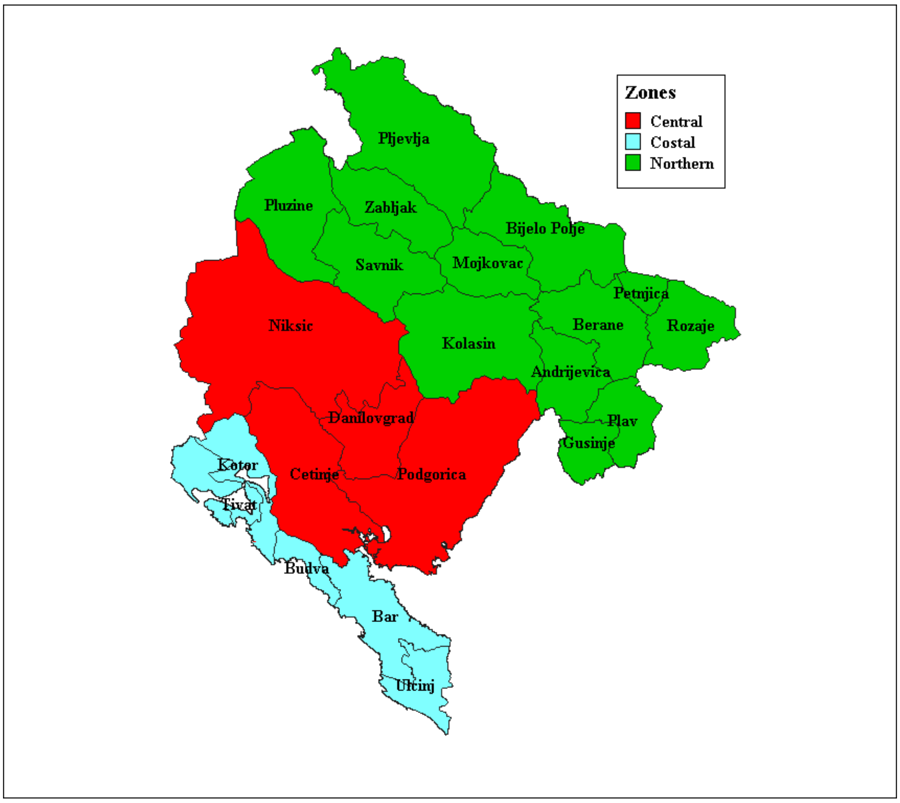

Figure 6-16: Current configuration of Air quality zones [12]

There are 9 continuous monitoring stations and 1 additional EMEP station to measure background concentrations. The data from the monitoring stations are available to the public and other stakeholders on the website of the Environment protection Agency of Montenegro – EPA Montenegro (http://www.epa.org.me/vazduh/) [12].

Air quality monitoring is mandatory in all zones, but not in all municipalities in Montenegro. This European model is applied in order to reduce the costs of air quality monitoring, which requires expensive and sensitive measurement instruments. Therefore, the number of 10 automatic air quality monitoring stations is judged as enough, with the fact that it is necessary to develop mathematical modelling systems in order to complete data based on measurements with indicative data. Regular audits of the positions of the measuring points are also necessary, in order to determine the specifics of certain locations where air quality deviates from what was expected [12].

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 $PM_{2.5}$[10], and also heavy metals (Cd, As, Ni, Pb), PAH (b(a)p), Hg[11] [12].

Since 2019, an EMEP continuous monitoring station in Velimlje was established with continuous measurements of SO_2, NOx, PM_{10}, and $PM_{2.5}$ among others. However, the measurements collected and stored in the PC memory at the station, 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 yet been implemented, that is why the data cannot be published and shared publicly [22]. Moreover, the Institute for Hydrometeorology and Seismology does not have an accreditation for EMEP measurements [8]

Air quality monitoring data shows air quality standard exceedances in the Northern air quality zone during winter months, that is, during the heating season. Despite the 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 indicate significant pollution of the ground layer of the atmosphere for a period of almost 7 months (January-April / October- December). The situation is similar in other parts of the Northern air quality zone, for which the benchmark is the measuring station installed in Bijelo Polje. The worst air quality level was recorded in the period of January-March and the end of October-December, which overlaps with the period when individual and collective fireplaces are most actively used, that is, with the period of the heating season [22].

In 2021 compared to 2020, the air quality in the Central air quality zone was better. However, this improvement was not sufficient, because 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 (at the measuring station Podgorica, Zabjelo roundabout, the number of days with exceedances is 2 times higher than the threshold) [22].

In 2021, measured concentrations of SO_2, PM_{10} and $PM_{2.5}$ in Southern air quality zone were below annual limit values [22].

According to the Law on Air Protection [13], a local government may establish a network for monitoring air quality in its area. Continuing the good practice, during 2021, the Capital City of Podgorica conducted air quality monitoring at 4 locations of the city area with a mobile station (SO_2, NOx, and PM_{10} among others). Analysis of the measurement results determined that the poor air quality was influenced by the occasional presence of increased concentrations of PM_{10} in the air mainly due to households heating. Other monitored pollutants were present in concentrations below the 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 Nikšiÿ, 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, while in the northern zone they range up to 50 µg/m^3, exceeding during 2015, 2016, 2017 and 2019, at the measuring site in Pljevlja [12].

In 2021, SO_2 was measured in five stations two stations in the Northern (Pljevlja and Gradina), two stations in the Central (Podgorica and Nikšić) and one station in the Southern air quality

[10] Data on concentrations of $PM_{2.5}$ are available since 2012.

[11] From 2019 gaseous mercury is also monitored

zone (Kotor). In 2021only in two of five stations both of the Northern air quality zone had SO_2 one-hour threshold violation (350 μg/m^3), but no daily threshold violations (125 μg/m^3)[22].

NO_2

Air quality monitoring of NO_2 is running in 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) [12][12]. In 2021, NO_2 is measured at eight stations, namely Podgorica Zabjelo, Nikšiÿ, Pljevlja, Gradina, Bijelo Polje, Gornje Mrke, Bar and Kotor [12].

In 2021, in all the stations except Podgorica, concentrations were below one-hour and annual thresholds (200 and 40 μg/m^3 respectively) [22].

PM_{10}

The measurement of PM_{10} concentrations in the ambient air has been significantly improved after the expansion and improvement of the state monitoring network. In addition to the measurements that were already established in Podgorica, Bar, Nikšić and Pljevlja, since October 2019, measurements of the PM_{10} concentrations have also been carried out in Kotor and Bijelo Polje. At most measuring points, measurements are performed in parallel with two methods: an automatic method, which allows the results to be available on the website of the Agency for Environmental Protection in real time, and a reference, gravimetric target, 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) during 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 is 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 Nikšiÿ (Central zone) [12].

In 2021, measurements of PM_{10} are 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 are violated only in two out of seven stations (Pljevlja and Bijelo Polje) [22].

$PM_{2.5}$

During 2012, with the acquisition of new equipment for sampling of $PM_{2.5}$, monitoring of this pollutant was established at 4 measuring points in the urban area: Bar, Tivat, Nikšiÿ and Pljevlja. Since October 2019, monitoring of the concentration of $PM_{2.5}$ 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 mostly used for heating the 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 in 2016 and 2018 was slightly above the limit value (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, the 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 of the concentration of $PM_{2.5}$ was exceeded in two air quality zones (Northern and Central), while no exceedances were recorded in the Southern zone. In accordance with Directive 2008/50/EC [19] and the Regulation on determination of types of pollutants, limit values and other air quality standards [16], the limit value of 20 μg/m^3 entered into force on 1 January 2020 [12].

In 2021, measurements of $PM_{2.5}$ are realized at five stationary monitoring stations, namely Pljevlja, Bijelo Polje, Nikšiÿ 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 [22].

It should be bear in mind that the national Montenegro air quality monitoring network was expanded during 2019, whereby numerous measuring points were given new locations and the monitoring of several parameters was introduced at each measuring point, the data for the next decade will represent a new step in air quality monitoring [12].

6.4. Regulations in place to limit emissions of stationary sources and programmes for their evolution

6.4.1. Existing regulations

In 2019, Montenegro adopted a new Law on industrial emissions [23] transposing the Directive 2010/75/EU on Industrial Emissions (IED) [24] into Montenegrin legislation, following by the Implementation Plan for Industrial Emissions Directive [25].

The Law on industrial emissions regulates the set of measures aimed at prevention and control of emissions deriving from industrial plants located on the territory of Montenegro (rules and topics for the integrated prevention and control of industrial environmental pollution).

It transposes Chapters I and II on the main definitions, i.e. best available techniques definition, integrated permits and inspections of permit conditions respect, Chapter II, however without list of specific industrial activities covered, Chapter III (covering large combustion plants together with medium combustion plants and exemptions for LCP), 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), Chapter VII including annual reporting provisions for large combustion plants and penal provisions.

In addition, the Law [23] covers mercury, mercury compounds and mixtures in industrial plants.

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 (see article 4 for detailed contents).

The Law on industrial emissions prescribes that plants can start performing activities only on the basis of an integrated permit (hereafter the permit), issued for a period of up 10 or more years. The permit contains among others, emission limit values of polluting substances, method of monitoring emissions, requirements for regular maintenance and control of measures taken to prevent emissions. The permit establishes conditions based on conclusions on the best available techniques. If the environmental quality standards require stricter conditions than those that can be achieved by applying the best available techniques, the permit shall establish additional measures. Criteria for determining the best available techniques are prescribed by the Ministry. Conclusions on the best available techniques are translated and published by the Ministry on its website [23].

The Law covers large and medium combustion plants and rules to establish emission limit values basing on the total input thermal power. The administrative body prepares an annual inventory of SO_2, NOx, PM emissions and energy consumption for each individual combustion plant [23].

The Law on industrial emissions [23] stipulates the exemptions from complying with the SO_2 ELVs. Combustion plants that use domestic solid fuel, including plants that co-incinerate waste, which, due to the characteristics of that fuel, exceed the prescribed emission limit values for SO_2 can use desulphurization techniques to achieve the prescribed minimum desulphurization rates. The sulphur content in the fuel used in the combustion plant must be regularly controlled.

In areas where air quality standards are exceeded, stricter emission limit values for individual intermediate combustion plants may be applied provided that the application of such emission limit values would effectively contribute to a significant improvement in air quality. These values of emissions are determined by the permit for an individual facility.

The operator of combustion plants with a total nominal input thermal power of 100 MW or more is obliged to provide continuous monitoring of emissions of SO_2, NOx and PM in the outflows gases.

The need for continuous measurement can be excluded with a permit for combustion plants in the next cases:

- for combustion plants whose life span is less than 10,000 working hours.
- SO_2 and PM emissions from combustion plants that use natural gas;
- SO_2 from combustion plants that use liquid fuel with a known sulphur content in cases where there is no desulphurization equipment,
- SO_2 from combustion plants that use biomass if the operator can prove that SO_2 emissions cannot occur under any conditions 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.

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) submits 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 [23] also covers waste incineration and co-incineration, plants using organic solvents, plants producing titanium dioxide, and mercury, mercury compounds and mixtures and establishes ban on traditional gold mining and processing.

Waste incineration and co-incineration facilities covered include waste reception, storage, on-site pre-treatment facilities, waste, fuel and air supply systems, boilers, waste gas treatment facilities, on-site residue and wastewater treatment or storage facilities, chimneys, devices and systems for controlling incineration or co-incineration, recording and monitoring of incineration and co-incineration conditions. According to the Law, waste incineration or co-incineration plants should have a permit to operate. The permit for a waste incineration or co-incineration plant must contain among others limit values of emissions of polluting substances into air.

For plants using organic solvents activities the plants are registered in the register of plants that use organic solvents or products containing volatile organic compounds. For plants in which two or more activities are carried out, each of which exceeds the solvent consumption threshold, the plant operator is obliged to achieve the prescribed emission limit values for substances or mixtures marked with warning signs, for each individual activity, or for other substances or mixtures. Limit values of fugitive and/or total emissions from the plant can be exceeded if they do not endanger human health and the environment. Limit values of emissions of volatile organic compounds and fugitive emissions and/or total emissions and the method of assessing compliance of emissions with limit values are prescribed by the Ministry.

Supervision over the implementation of this law and the regulations adopted on its basis is carried out by the Ministry. Joint inspection supervision over the implementation of this law is performed by the administrative body responsible for inspection supervision, in accordance with this law and the law regulating inspection supervision and fine prescription is possible in some cases noted by the Law.

The Law [23] stipulates transitional provision, stipulating that regulations for the implementation of this law will be adopted within two years from the date of entry into force of this law, so 2025. Until this, regulations adopted on the basis of the Law on Integrated Prevention and Control of Environmental Pollution, 2018 [26] and the Law on Air Protection [13].

Rulebook on the form of integrated permit, 2021 [27] describes the form and Rulebook on content and method of application for an integrated permit, 2020 [28] 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 permit was issued for 2021 and Table 6-3 outlines review of submitted applications for issuing operating permits for existing plants [25].

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

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**
„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 the volume of the bathtub for treatment exceeds 30 m^3	31.07.2014/5	2019 „Aluline“ Mojkovac has ceased to operate so there will be no revision of the permit.	Municipality Mojkovac
„ 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	Agency for Nature and Environment Protection

Operator-plant	Operator's address	Type of activity	Application date	Permit status	Competent authority
				operator plant and the taxpayer to obtain integrated work permit.	
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 October 30, 2018, and afterwards requested an extension of the deadline, which was granted. After the expiry of the request was rejected as incomplete.	ongoing procedure	Agency for Nature and Environment Protection

Rulebook on method and procedure for monitoring of emissions from stationary sources, 2013 [29] prescribes the method of measuring emissions from stationary sources, the measurement procedure, the method of checking the correctness and calibration of the measuring device, the procedure for evaluating the results and the method of submitting data for the environmental protection information system.

Rulebook on emission limit values, technical measures for exemption of application of limit values and monitoring methods, 2020 [30] prescribes the limit values of emissions of polluting substances from the industrial plants, technical measures for exemption from the application of limit values and the method of monitoring. The Rulebook outlines that emission limit values of polluting substances from the industrial plants are determined in accordance with the prescribed list of polluting substances and are established on the basis of the best available techniques and other substances that can be emitted from the plants and have the characteristics of industrial emissions, depending on the nature and transfer potential from one part environment in another.

Limit values of emissions of polluting substances from an industrial plant in the integrated permit, for normal operating conditions facilities, are determined by:

- determining 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
- on the basis of average values for a certain period of time and reference conditions, if they differ from the limit values from sub-paragraph 1 of this paragraph, provided that they do not lead to their being exceeded [30].

Emission limit values can be changed by equivalent parameters or technical measures, which provide the same level of environmental protection. Equivalent parameters may include parameters of other emissions, processes, or conditions with which they may be associated link industrial emissions that are supplemented or replaced by equivalent parameters. Equivalent parameters and technical measures must be based on the best available techniques. Limit values of emissions of polluting substances from industrial plants are monitored by direct control of emissions or equivalent parameters and the reliability of the application of technical measures that are applied when changing indicators of limit values of emissions of polluting substances [30].

Rulebook on criterions for determination of the best available techniques for environment protection and the list of pollutants from industrial installations, 2019 [31] establishes the criteria for determining the best available techniques for environmental protection and a list of polluting substances from industrial plants for integrated permit. Among the polluting substances from industrial facilities to ambient air, there are SO_2 and Sulphur compounds, nitrogen oxides and other nitrogen compounds, volatile organic compounds, dust, TSP.

6.4.1.1. Large combustion plants

Regulation on limit values of emissions from combustion plants and method of calculating emission limit values for plants using multiple types of fuels [32] establishes the emission limit values for combustion plants and the method of calculating limit values for those plants. It applies to large and medium combustion plants. Limit values of pollutant emissions for existing and new large combustion plants are given in Annex 2 of the Regulation.

Comparison of Large Combustion Plants ELVs with ELVs of the Amended Gothenburg Protocol (annex IV, V and X)

For plants with a thermal power larger than 50 MW considered in the Gothenburg protocols annexes IV, V and X, The Law on industrial emissions [23] transposes chapter III and the Regulation [32] the annex V of the IED [24] including ELV for large combustion plants. In addition, Montenegro translated in Montenegrin language Commission Implementing Decisions, concerning large combustion plants (LCP) [33] with ELVs of the for LCP that are lower or equal of the ones in the Annexes of VI, V, and X of the AGP.

The limit values of emissions of polluting substances into the air from existing and new large combustion plants are applied since the end of 2021.

The minimum rates of waste gases desulphurisation from combustion plants are given in Annex 4 of the Regulation 129/21 [32]. **Erreur ! Source du renvoi introuvable.** shows comparison o f the limit values for the rates of desulphurization for LCP of Annex IV AGP and Regulation 129/21 dated 15.12.2021. This table shows, that for existing LCP, desuperization rate is more stringent in the Montenegro Regulation 129/21, and for the new LCP 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 [32]

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 total thermal input of 100 MW or more. In addition, for large combustion plants with a total thermal input of 100 MW or more using gaseous fuel, continuous measurements of CO are also mandatory with some exceptions.

If continuous monitoring is not performed for a large combustion plant, periodic measurements of SO_2, NOx, TSP, and in the case of gas turbines and CO, at least every six months are mandatory. For large combustion plants using coal or lignite, emissions of total mercury are measured at least annually.

Up to now there is only one LCP in Montenegro, the Thermal Power Plant "Pljevlja" with total heat output of 580 MWth. The operating hours of the plant from 2018 to 2023 are 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. TPP Pljevlja will be exempted from compliance with the emission limit values in air referred to in Article 4 (3) of Directive 2001/80/EC, pursuant to, the said the Decision.

The operator plans to implement the project of environmental reconstruction of the plant "Pljevlja", in the period from 2018 to 2022, in accordance with the Programme of measures for adjusting the operation of an existing plant or activity under the conditions and action plan, after which this plant will be operated in accordance with the requirements of the Directive on industrial emissions 2010/75 EU. The plant is not planning to request an additional period to comply with BAT [25].

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 lower than 50 MWth, only for PM. Regulation on limit values of emissions from combustion plants and method of calculating emission limit values for plants using multiple types of fuels [32] transposes ELV for medium size combustion plants of MCP Directive [34], so compliant 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 and 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. One part of them, the ones that consider emission limit values PM emissions in solid fuel household heating appliances, namely:

- Rulebook on the technical requirements of eco-design for devices for solid fuel local space heating [35] transposed 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 [36]
- Rulebook on the technical requirements of eco-design for boilers using solid fuels [37] 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 [38].

Comparison with ELVs of the Gothenburg Protocol

Emission limit values of the PM for small size heating appliances so far, are compliant with the ELVs for small solid fuel combustion installations of the AGP (Annex X, Tables 12-13).

6.4.1.3. Industrial installations

Regulation on emission limit values of air pollutants from stationary sources, 2021 [39] prescribes the limit values of pollutant emissions and other air protection measures applied to emission from point and diffuse stationary sources and activities that cause emissions of pollutants into the air. The list of activities is outlined in the Annex I (To be analysed when the annex will be available).

The Regulation [39] gives the rules on how measurement of emissions should be done. In addition, it gives the general total dust emission limit value as 20 mg/m^3 for mass concentration and for mass flow greater than or equal to 200g/h; and 150 mg/m^3 for mass concentration and for mass flow less than 200g/h, but also general total limit values for the other substances.

If the limit values from stationary sources are exceeded, the Regulation obliges the operator to take 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.

Rulebook on the method of performing monitoring of emissions in water and air from plants that produce titanium dioxide, 2020 [40] prescribes the method of monitoring and limit values of emissions into water and air from plants that produce titanium dioxide transposing the Annex VIII of IED [24] concerning technical provisions relating to installations producing titanium dioxide. However, there is no titanium dioxide production within the Montenegro [8],[9].

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 [41] prescribes the limit values of emissions of polluting substances in waste gas and waste water at waste incineration and co-incineration plants, the method of monitoring, reporting on monitoring results, the method of assessing compliance of emissions with limit values and the operating conditions of waste incineration and co-incineration plants. Annex of the Rulebook [41] transpose Annex VI of IED, concerning technical provisions relating to waste incineration plants and waste co-incineration plants including emission limit values. However, there is no titanium dioxide production within the Montenegro [8],[9].

Montenegro also translated in Montenegrin relevant Commission Implementing Decisions, concerning:

- Cement, lime and magnesium oxide industry [42]
- Iron and steel production [43]
- Non-ferrous metal industries [44]
- Production of cellulose paper and cardboard [45]
- Surface treatment using organic solvents including protection of wood and products from wood with chemicals [46]
- Food industry, the beverage industry and the milk industry [47]

- Waste treatment [48]
- Poultry and pig farming [49]

In Montenegro, there is only one iron or steel. TOSCELIK NIKŠIĆ Steel Ltd, Nikšić Installations for the production of raw iron or steel (primary or secondary melting) including continuous casting, with a capacity exceeding 2,5 t/h. Pursuant to the adjustment plan that the Steel plant handed over, which is currently on the Agency's estimate, the Ironworks will be asked for a transition period during negotiations with the EU. According to the dynamic plan of alignment, Toščelik, Nikšić will achieve complete compliance of measures by the end of 2024 [25].

The only aluminium production plant, Aluminum Plant Podgorica is in bankruptcy - KAP, and carrying out activities of aluminum production, at the location Dajbabe b.b. A dynamic adaptation plan, with an accompanying cost estimate, has not been drafted, that is, submitted with an application for an integrated permit. Since it is certain that this plant will be the subject of negotiation of the transition periods, with 2030th year as a predetermined deadline on the basis of the review of the necessary measures, an initial estimate of the costs for harmonization was made, taking 2019 as the year of the beginning of the adjustment [25].

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 in particular measures related to emission limit values, equivalent parameters, or technical measures based on the best available techniques and to be satisfied for the issuance of licenses for existing plants will be initiated for the following plants in Montenegro with a deadline of 1 January 2030 [25].

Comparison with ELVs of the Gothenburg Protocol

Emission limit values concerning the sectors described above for air emissions are in line with the relevant EU Commission Implementing Decisions. ELVs of the BATs for industrial sources are lower or equal of the ones in the Annexes of VI, V, and X of the AGP.

The other sectors, covered in AGP industrial installation emissions, such as sulphur recovery units, nitric acid production excluding acid concentration units, mineral oil and gas refineries, (FCC regenerators), glass production, pulp production are not relevant for Montenegro, as soon as there are no such activities [8].

6.4.1.4. Use of solvents in industry

Rulebook on the type of activities, emission limit values and methods performing monitoring in plants using organic solvents, 2020 [50] prescribes the types of activities in plants that use organic solvents, the consumption limits of organic solvents, the method of submitting an application for registration in the plant register of plants that use organic solvents or products containing volatile organic compounds, the method of management register, limit values of emissions of volatile organic compounds and fugitive emissions and/or total emissions and the method of assessing the 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 [50] are:

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, fabrics, foil and paper surfaces;

e. the skin

There are two industrial plant using solvents in Montenegro covered by the Rulebook.

"FAB LIVE" Ltd, Podgorica realizing the activity relating to the plasticization of aluminum profiles in powder coat colour which are electrostatically applied to the profile, according to the latest surface treatment technology Al in accordance with the RAL standard, RAL's colour map. The enterprise is fully compliant to IED harmonization plan.

Ltd for processing and coating of metals „ALULINE“ from Bijelo Polje with the main activity of anodizing and lamination of aluminum profiles [25].

Comparison with ELVs of the Gothenburg Protocol

The Rulebook transposes emission limit values of the Annex VII of IED [24] concerning technical provisions relating to installations and activities using organic solvents, so the ELV are the same or lower than in the AGP (Annex VI).

Montenegro also translated the text of BAT on air and water emissions monitoring JRC Reference Report on Monitoring of Emissions to Air and Water from IED Installations [51].

6.4.1.5. Sulphur content of gas oil

Regulation on limit values of the content of polluting substances in liquid fuels of petroleum origin, 2017 [52] prescribes a reduced sulphur content in diesel fuel, fuel oil and marine fuels. This regulation prescribes the types of liquid fuels of petroleum origin, including gasoline, diesel fuels, fuels used in NRMM, vessels, and other gas oils. It prescribes the limit values for polluting substances, the content of metal-based additives and other characteristics of the fuel, which, in terms of environmental protection, should meet the fuels that are placed on the market, fuel use on vessels in ports, territorial waters and exclusive economic zones and sulphur oxide emissions control zones, methods of determining and monitoring fuel characteristics, methods for reducing emissions of pollutants into the air and reporting on compliance with limit values of the content of pollutants.

According 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 the sulphur content does not exceed 0.01g/kg (0.001% w/w). Gas oil can be marketed if the sulphur content does not exceed 10g/kg (0.1% w/w).

Exceptionally, fuel oil whose sulphur content exceeds 1% w/w may be placed on the market only for use:

- in LCP whose emissions of SO_2 are in accordance with the limit values of pollutant emissions into the air, for which an integrated permit is issued, provided that the measurement of pollutant emissions is carried out by a legal entity that has a permit for measuring emissions from stationary sources;
- In plants with combustion chambers whose 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 for which a permit is issued on the permitted emissions of pollutants into the air.

Comparison with ELVs of the Gothenburg Protocol

The AGP annex IV [7] 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 machineries are considered in annex VIII of the AGP, 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 petroleum origin [52].

It additionally tightened the limit values for the content of sulphur in marine fuels in accordance with Directive (EU) 2016/802 on the reduction of content of sulphur in certain liquid fuels [53]. In accordance with 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.

6.4.1.6. Storage and distribution of petrol from terminals to service stations

Regulation on technical conditions for air protection from emissions of volatile organic compounds resulting from the storage, transfer and distribution of petrol [54] prescribes technical environmental protection standards for gasoline storage and transfer devices 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, and the deadlines for achieving them. The Regulation transposes 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 [55] 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 [56].

Comparison with ELVs of the Gothenburg Protocol

The ELV of the Regulation [54] are transposed, so far the ELV of AGP (Annex VI).

6.4.1.7. VOC contents of products

Application of the regulations on VOC emissions from the use of paints and varnishes is going through 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 [60]. The regulation prescribes prohibited or permitted methods of use, production and placing on the market chemicals or certain products that pose an unacceptable risk to human health and the environment.

Up to now, there are two enterprises subject of the integrated permitting are in Montenegro, concerned by the cites above regulation. They are “FAB LIVE" Ltd from Podgorica and Ltd for processing and coating of metals “ALULINE” from Bijelo Polje [25].

Comparison with ELVs of the Gothenburg Protocol

The ELVs of VOC content in coatings (paints and varnishes) are covered by the Regulation [60], Annex 3, phase I (since 01.12.2013) and phase II (since 01.12.2014). The ELV of phase II of AGP (Annex XI, Tables 1 and 2) are completely transposed to the mentioned Regulation.

6.4.2. Additional programmes to align the national regulations with EU directives and reduce emissions of pollutants

Air quality management strategy of Montenegro

Air quality management strategy of Montenegro for the period 2021-2029, hereinafter Strategy 2021-2029, was developed in 2021, following the previous National Air Quality Management Strategy of 2013 implemented by two Action plans (2013-2016 and 2017-2020) [12], however up to now it was not adopted [8].

The new Strategy 2021-2029 unifies air quality plans for three established air quality zones (Northern, Central and Southern) and replaces the plans that were prepared for the Municipality of Pljevlja (2013), the Municipality of Nikšiÿ (2014) and the Capital City of Podgorica (2015). In addition, the new Strategy 2021-2029 includes the Plan of measures for pollution control, which was prepared in accordance with the requirements of the relevant EU regulations and the final benchmark for the negotiation chapter 27, bearing in mind their common purpose and goals related to the improvement of air quality, protection of the environment and human health. The new Strategy 2021-2029 was developed for a period of 9 years with the goals of air pollution reduction set until 2030 [12].

As part of the negotiations between Montenegro and the European Union, the EU's 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) [21]. So, the proposed new Strategy 2021-2029 presents an analysis of economically viable emission control strategies for the period of 2020-2029, which will serve the basis for the final agreement between the EU and Montenegro on its obligations to reduce emissions. These are in addition to regularly annual reporting the emissions, in accordance with the NECD II [21], CLRTAP [1], and the creation of the National Pollution control programme for air. Furthermore, Montenegro is expected to improve the implementation of the acquis of the EU in this area, through regular measures for reduction of air pollution at the national level, and especially in areas where EU limit values for air quality are exceeded, as well as through the creation or updating of air quality plans, in accordance with the Directive 2008/50/EC on ambient air quality and cleaner air for Europe [19].

Through the strategic framework of Montenegro, several activities related to air quality are planned:

- expansion and improvement of the national air quality monitoring network and the ZHMS laboratory for air quality testing in accordance with EU standards;
- improvement of intercity line transportation of passengers in road traffic;
- support for 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;
- improve the control of air, water and land pollution due to emissions from industry and traffic;
- prioritize activities aimed at solving the problem of air pollution, especially pollution with PM from different sources;
- improve data on air conditions in accordance with the needs and effective control of air pollution;

- continuous and comprehensive monitoring of air quality with the determination of cause-and-effect links between pollution and the effectiveness of the actions of competent institutions, especially with regard to the consistent application of regulations;
- increasing the number of measuring points for air quality monitoring; developing an air quality modelling system in order to reduce the costs of real-time data monitoring and increase the coverage of data on the state of air quality;
- implementation of horizontal air protection measures by integrating air quality policy into other sectoral policies [12].

The other strategic documents of Montenegro taking air quality issues into account, mentioned in the Strategy 2021-2029.

The innovative Strategy of Montenegro (2020-2029) is fully aligned with the stated goals [12].

Through the global goals of sustainable development, 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 the air, water and soil by 2030 (sub-goal 3.9) was necessary, as well as reduction of the negative impact of pollutants in cities, paying special attention to air quality and waste management (sub-goal 11.6) is needed [12].

In addition, one of the priorities of National Strategy of Sustainable Development until 2030 (NSOR) 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, application of regulations and economic instruments with which transition to technologies and processes with lower emissions were outlined. In road transport sector, vehicle age and quality were tackled. Public network of air quality monitoring stations was also tackled. However, the update of the strategy is currently under way [8].

The Energy Development Strategy of Montenegro until 2030 is also a key document in this area. Through the process of alignment with the strategic framework, numerous issues were recognized that connect these two documents, both in the area of air protection from pollutants, as well as in the area of greenhouse gas emissions and other issues related to mitigating the negative effects of climate change [12]. Revision of the strategy is also under way, scheduled by the end of 2024 [8].

The Traffic Development Strategy of Montenegro 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 have been recognized to free Montenegro from dependence on fossil fuels and negative environmental impacts through the promotion of alternative types of fuel and electromobility.

National Climate Change Strategy to 2030 is a very important link between climate change policies and air protection policies lies in the provisions of the NECD II [21]. SO_2, NO_x, NH_3, volatile organic compounds (VOC) are also gases that affect climate change. That is why this document contains the goal of reducing emissions of these pollutants at the national level, which indicates the necessity of synergy between these two policies [12]. Revision of the strategy is also under way, scheduled by the end of 2024 [8].

The key strategic goals of the Strategy 2021-2029 are air quality improvement and further improvement of air quality monitoring and management [12]. These strategic goals were supposed to be achieved by the next operational goals:

- for air quality improvement, they are reduction of SO_2 concentrations in the Northern Air Quality Zone, reduction of PM concentrations in the Northern and Central air quality zones, and reduction of pollutant emissions (NOx, SO_2, VOC, NH_3 and $PM_{2.5}$);
- for further improvement of air quality monitoring and management, they are improving the quality of data on air quality and air pollutant emissions and improvement of cooperation between relevant institutions, local government units, the civil sector and enterprises.

Key activities for the implementation of operational goals of the Strategy 2021-2029 were defined as:

- reduction of SO_2 concentrations in the Northern zone of air quality through the ecological reconstruction of the Pljevlja Thermal Power Plant carried out by the Electric Power Company of Montenegro. The deadline for the completion of works on the installation of the waste gas desulphurization system was 2023.
- reduction of PM concentrations in the Northern and Central air quality zones through long-term synergistic action on the parallel implementation of the proposed activities:
    - improvement of household heating through reduced consumption of coal, wet wood for firewood, use of more efficient heating devices, transition to more environmentally friendly fuels, increase in energy efficiency of residential buildings, introduction of central heating systems, etc.;
    - preventive measures related to forest fires and stricter criminal policy related to prohibition of open burning of waste, including agricultural.
- reduction of emissions of pollutants (NOx, SO_2, VOC, NH_3 and $PM_{2.5}$) covered by NECD II [21].
- improving the data quality on air quality and pollutant emissions into the air 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 monitoring of air pollution in accordance with the EMEP programme at the measuring point in Velimlje;
    - development of mathematical air quality modelling methods in order to obtain data completed with indicative data for areas where measurements are not performed.
- improvement of cooperation between relevant institutions, local self-government units, the civil sector and the 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 [12].

Draft programme of air pollution control measures within the Strategy 2021-2029

Draft programme of air pollution control measures (2021-2029) was prepared as a part of the Strategy 2021-2029, in accordance with the requirements of NECD II [21], the Guide for the development of national air pollution control programmes in accordance 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 that it was possible in relation to the available data [23].

Bearing in mind that the national legislation stipulates that the programmes are adopted for a maximum period of three years, and that the specific programme by its nature and the mentioned EU acts covers a longer period of time (2020-2029) as well as the fact that the programme must be developed in accordance with the goals and existing measures and plans for improving air quality, this programme was integrated into the updated Strategy 2021-2029 [12]. However, since the Strategy 2021-2029 was not adopted till now, there is no following up of this draft programme of air pollution control measures [8]. Nevertheless, a progress in the regulation implementation up to now is evident and is in line with the technological pathway of AGP for Montenegro.

Measures to be applied to SO_2 emission reduction for the period 2020-2029 covered by the draft programme of air pollution control measures are as follows:

- Installation the system for desulphurization of waste gases in the Pljevlja Thermal Power Plant

A significant reduction in SO_2 emissions is expected in the energy production sector, after the completion of the ecological reconstruction of the Pljevlja Thermal Power Plant (PTPP), i.e. when the technological process of coal combustion will be improved using secondary measures by implementing which, 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% in 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[12].

The reconstruction of the Pljevlja Thermal Power Plant will ensure compliance with the with the strictest environmental protection parameters stipulated by the latest EU Decision 2017/1442 2017 establishing best available techniques (BAT) conclusions, under Directive 2010/75/EU of the European Parliament and of the Council, for large combustion plants [24]. The operator of PTPP submitted a request to the Secretariat of the Energy Community for the application of the exemption mechanism from the application of 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, in the period 2018-2024, the PTPP can operate for a total of 20,000 hours, which will reduce air emissions by about 50% in 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 [25].

The project documentation, published by EPCG AD Nikšiÿ on July 11, 2019, for the works and equipment for the ecological reconstruction of PTPP, defines the best available technological emission limit values for the existing block, which it will achieve after new and subsequent installations for flue gas treatment, and have limit values for SO_2 130 mg/Nm^3 [12].

- Reduction of sulphur content in liquid fuels of petroleum origin and fuel replacement

Emissions of SO_2 from the sector of production processes and product use have already been reduced, in the period after 2011, when the Regulation on limit values of the content of polluting substances in liquid fuels of petroleum origin which prescribes a reduced sulphur content in diesel fuel, fuel oil and marine fuels was adopted[58].

[12] 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

Implementation of this Regulation resulted in lowering SO_2 emissions from the transport sector, but also the transition to low-sulphur fuels in production processes [12].

Regulation on limit values of the content of polluting substances in liquid fuels of petroleum origin [52] additionally tightened the limit values for the content of sulphur in marine fuels in accordance with Directive (EU) 2016/802 on the reduction of content of sulphur in certain liquid fuels [53]. In accordance with 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% m/m. Although, in accordance with NECD II [21], emissions from international maritime traffic are not taken into account when determining the achieved emission reductions, the initiative to declare the Mediterranean Sea or its parts as emission control areas (ECA) of sulphur oxides (SOx) in accordance with Annex VI of the MARPOL Convention.

- <u>Other measures applied or to be applied to SO_2 emission reduction for the period 2020-2029</u>

Kombinat aluminum Podgorica (KAP), the largest industrial plant in Montenegro, starting in 2019 uses liquefied natural gas for the technological process, instead of fuel oil. In the period 2005-2018, SO_2 and NOx emissions were reduced in KAP even without taking into account the transition to liquefied natural gas but also due to reduction in production and certain improvements implemented in technological processes.

Željezara Nikšiÿ, iron and stee producing factory, also plans to replace its boiler plant, which will use liquefied natural gas as fuel, in order to bring the emissions from this plant in line with the integrated permit.

The Energy development strategy until 2030 envisages construction of the gas pipeline network in the country in 2021, within the framework of 2 regional gas pipelines, which would, after the construction of the distributive gas network, begin the massive use of natural gas. <u>Information of the state of progress of this work should be included later.</u>

The goal of reducing SO_2 emissions in the period 2020-2029 within the Strategy 2021-2029 is ambitious because in the coming period, the environmental reconstruction of the Pljevlja Thermal Power Plant, which represents the most important source of emissions, is planned. In accordance with the Action Plan for the implementation of the Environmental Protection Programme of this company, a system of wet scrubbers will be installed in the PTPP, the performance of which is estimated at 90% efficiency. In the best case, this would achieve a reduction of around 80% of the total current national SO_2 emissions.

However, bearing in mind that emission reductions in accordance with the NECD II [21] 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 in the past period according to the available data from the emission inventory. So, in accordance with Article 5 of the NECD II, the most optimistic estimate of SO_2 emission reduction compared to 2005 is of 50% [12].

Measures to be applied to NOx emission reduction for the period 2020-2029 covered by the draft programme of air pollution control measures are as follows [12].

- <u>Installation the system for denitrification of waste gases in the Pljevlja Thermal Power Plant</u>

As a part of the environmental reconstruction of the Pljevlja Thermal Power Plant, by 2023 it is planned also to install a system for denitrification of waste gases via improvement of the technological process of coal combustion through the application of the selective catalytic reduction technique (SCR), which will reduce emissions from this source by up to 70% representing a reduction of more than 35% in total national 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 new flue gas treatment installations compliance with the limit value for NOx 150 mg/Nm^3 [12].

- Increasing the use of alternative fuels, new generation vehicles and electromobility in traffic

In Podgorica, the increased concentrations of NOx are the result of intensive traffic, and in the coming period, increased concentrations can be expected at the new measuring point that was established to monitor the impact of traffic (Zabjelo roundabout).

In accordance with the study about situational analysis of the 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 a realistic scenario), i.e. around 329,000 passenger vehicles (in the optimistic scenario), while in the same period the expected number of registered cars with electric drive could be about 60,000 in the realistic scenario, or about 96,000 in the optimistic scenario. In 2017, about 198,500 passenger vehicles were registered in Montenegro. For the purposes to assess the effects of the measure, the data of the real scenario of the mentioned study for the period 2020-2029 were used. So, in 2029 the total number of passenger vehicles is expected to increase to 246,695, of which the number of vehicles that are registered for the first time is 26,881. During the observed period, the number of diesel-powered cars is constantly decreasing, then the number of gasoline-powered cars, hybrid cars, and electric cars is increasing, while the number of LPG-powered passenger cars is approximately constant. The proposed measure can contribute to the reduction of NOx emissions by up to 75% from the road transport sector, while VOC emissions will increase by 12%, due to the significantly increased use of motor gasoline compared to diesel fuel.

Implementation of the measure is ongoing. Emissions of NOx 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 standards for emissions when importing used and new cars compared to 2005. Through the Development of low-carbon tourism in Montenegro project, 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 reducing emissions, it is necessary to plan appropriate regulatory and fiscal instruments.

For the transport sector, in which there is a constant trend of energy consumption growth and an increased share of diesel vehicles in the fleet, studies were prepared on the potential of biofuel production and use, the potential of introducing other alternative fuels into the transport sector, the potential of energy efficiency in transport and an action plan for sustainable use of energy in traffic. In addition to the increased use of biofuels, an increase in the level of use of alternative fuels (liquefied petroleum gas-LPG and compressed natural gas-CNG) and electricity in traffic is expected, including the development of infrastructure. Within the project Development of sustainable use of energy, financed from EU support funds (through IPA 2011), activities on the preparation of the Study on potentials for improving energy efficiency in the transport sector were finalized. The prepared Study for the first time analyses the transport sector from the aspect of energy consumption, identifies the potential for improving energy efficiency, recognizes current barriers and proposes measures and activities to overcome them in accordance with practice in developed countries. In addition to this study, two other thematic studies were prepared within the mentioned 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 three studies, an Action Plan for the application of renewable energy sources and energy efficiency measures in the transport sector was drawn up, which identifies key priorities and measures that need to be implemented in the coming period, some of which are directly related to the improvement of energy efficiency. So far, certain activities recognized by the action plan have been implemented, which encourage the development of energy efficiency in the transport sector.

The Rulebook on marking the energy efficiency of vehicle tires and other parameters adopted in 2017 was updated in 2022 [57]. What are the updates? Together with the Regulation on technical requirements for vehicles imported or first placed on the market in Montenegro [58] they prescribe conditions regarding the limit values of exhaust emissions and noise level of the EURO 6 standard for new vehicles, and the EURO 4 standard for second-hand vehicles.

In addition, in the past three-year period, certain initial activities were implemented in terms of supporting projects, the implementation of which can be linked to the increase of energy efficiency in the transport sector. Namely, UNDP and the Ministry of Sustainable Development and Tourism are implementing the innovative project Development of low-carbon tourism in Montenegro which is financed from the funds of the GEF. The project aims at contributing to the reduction of 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 the development of sustainable transport is the development of sustainable urban mobility plans (Sustainable Urban Mobility Plan - SUMP), which aim at improving air quality by reducing the emissions of pollutants and GHG, through the reduction of final energy consumption and greater use of RES in 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 Kotor and Cetinje. The implementation of activities on the development of a SUMP for the capital Podgorica and support to other SUMPs in Montenegro in the development of sustainable urban mobility solutions is planned.

Podgorica already has over 12 km of existing infrastructure, and with the construction of the last of the five projected corridors, it will have about 15 km. Work is underway on two cycling routes with a total length of about 30 kilometres, which are intended for more experienced cyclists.

Combined installation of the system for denitrification of waste gases in the Pljevlja Thermal Power Plant and increasing the 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 key sources (energy production, road traffic) should be reduced by 70-75%. Although the reduction of NOx emissions from energy production is certain, the reduction of NOx emissions from traffic through the renewal and change of the structure of the vehicle fleet is an expensive and long-term process that can hardly be achieved in the next 10 years.

Keeping in mind the fact that the share of new first-time registered of passenger vehicles in the total number of registered passenger vehicles in 2018 was only 1.1% and based on available data, by 2030 NOx emission reductions of up to 15% can be expected [12].

Measures to be applied to $PM_{2.5}$ and VOC emission reduction for the period 2020-2029 covered by the draft programme of air pollution control measures are as follows [12].

Bearing in mind that through air quality monitoring in the period 2009-2018, increased concentrations of PM recorded, and three air quality plans were drawn up (Pljevlja 2013, Nikšiÿ 2014, Podgorica 2015) with measures to reduce emissions of PM. Although data on air quality testify to significant reductions in concentrations, it is necessary to update the emissions inventory for reliable quantification of the achieved results.

To reduce PM emissions, the next measures in industry and energy production were applied before 2021:

- Commissioning of a new electric arc furnace with a built-in system for dedusting gases in the Nikšiÿ Ironworks and disconnection of the old furnace from the production system (2012);
- In the PTPP, an overhaul of the electrostatic filter for controlling the emissions of PM was carried out (2013). The values measured after the overhaul of the filter were within the prescribed limits. Through the environmental reconstruction of the Pljevlja Thermal Power Plant, further optimization of the electrostatic filter is planned in order to comply with the requirements of the new BAT for large combustion plants.
- By changing the fuel (from fuel oil to natural gas) in the anode baking furnace and Bertrams boiler plants in KAP, emissions of PM were reduced by 100% in 2018, according to Strategy 2021-2029 source [12]. Further planned investments in this facility will achieve significant reductions in suspended particle emissions in the Electrolysis facility.

- Replacement of heating devices and energy measures efficiency in individual residential buildings

Applying the measure of replacing inefficient heating stoves with efficient ones and 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 the beginning of 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, which would ultimately result in a reduction of $PM_{2.5}$ emissions at the national level in the amount of 25%.

In addition, by applying this measure, the reduction of VOC emissions would amount to 35%, which in the end, at the national level, amounts to 9%.

Implementation of the measure is ongoing. The Ministry of Economy has been implementing a number of projects such as Energy Wood, Energy Efficient Home and similar for many years.

Here are more details on the projects applied so far:

- Energy Wood - interest-free loans for installation of heating systems on modern forms of biomass. Within this programme, citizens had the opportunity 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 a heating system, i.e. stoves and boilers, on modern forms of biomass. In the previous period, 3 phases of the Energy Wood programme were implemented. Over 1,000 households participated in the programme.
- Energy Efficient Home - interest-free loans for the installation of modern forms of biomass heating systems and the performance of works to improve the energy characteristics of the building envelope. In 2018, the Ministry of Economy provided funds in the amount of €120,000 for the implementation of the Energy Efficient Home programme, the implementation of which began in October 2018. This programme is a continuation of the Energy Wood programme, which was expanded with other EE measures. The goal 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 of achieving 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). Within the first phase of this project, €33,339 was spent and EE measures were implemented in 93 households. For the

implementation of this project in 2019, budget funds in the amount of €100,000 were provided, which are intended for the implementation and subsidization of 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 EU support, certain funds have been earmarked to support the household sector for the implementation of 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, it is necessary for the EBRD bank to establish cooperation with commercial banks in Montenegro (one or more), which would be obliged to establish dedicated credit lines for energy efficiency. If citizens implement energy efficiency measures using funds from these credit lines, they acquire the right to subsidies, from designated EU funds, in the amount of 15-30% of the investment amount.

- Subsidized procurement of briquettes and pellets in Pljevlja - with budget 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 2015-2019 heating seasons. On average, 500-1,000 households participated in the project each season.
- In the previous period, several units of local self-governments continued the implementation of the subsidy programme for the installation of solar systems in new buildings, through the reduction of communal fees (fees for equipping communal land) in the amount of 50-200 € per square meter of installed solar panel and depending on local self-government units. The activities of individual local self-government units were also noted, such as, for example, municipality of Tivat to establish a support programme for citizens (interest-free loans), in cooperation with commercial banks, to implement energy efficiency measures in households on the territory of the municipality.
- Eco-design of products

By 2019, the Ministry of Economy passed 17 regulations transposing EU regulations for the introduction of eco-design requirements and 6 regulations transposing EU regulations for marking the energy efficiency of products that affect energy consumption. For most product application began on January 1, 2019, except for light bulbs, for which application began in 2018. In this context, regulations governing requirements for space heating devices are of particular importance.

- Construction the system for district heating in Pljevlja

Pljevlja is a municipality in the north of Montenegro with 27,531 inhabitants, i.e. 4.42% of the population of Montenegro. During the winter months, especially under unfavourable weather conditions (days without wind and precipitation, stable air pressure, temperature inversions), high concentrations of PM and a large number of days with exceeding limit values are recorded in Pljevlja. In this municipality, there is a higher consumption of coal for household heating (due to the presence of the Pljevlja Coal Mine, do you know the % of S in the coal?) as well as the impact of the Pljevlja Thermal Power Plant. The average annual concentrations of PM_{10} and $PM_{2.5}$ in Pljevlja during 2021 were above the prescribed limit value. In addition, one-hour limit concentrations SO_2 were also above the prescribed limit value [22].

As part of the environmental reconstruction project of the Pljevlja Thermal Power Plant, a central source of heat energy with a capacity of 87 MWth will be provided, with a main heat pipe. For the implementation of the construction of the district heating infrastructure in Pljevlja, certain funds have already been allocated from the capital budget, which were used to create project documentation for the construction of a mini-heating plant that would be used as a backup source of thermal energy. The municipality of Pljevlja however, gave up on the implementation of 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 connection with the hot water pipe to the source in the thermal power plant, as well as the connection of households to the network.

During 2016-2017, within the project Development of sustainable energy use, which was financed with the support of IPA 2011, the Ministry of Economy of Montenegro is prepared a study for the assessment of the potential for the application of high-efficiency cogeneration and the introduction of district heating/cooling systems, and based on the study, prepared a draft of the Action Plan for development and use district heating and/or cooling and highly efficient cogeneration. Finalization of the Action Plan and its adoption was planned for 2019. Are there news?

Heating and cooling technologies used in the study include: micro biomass cogeneration, efficient biomass boilers, biomass stoves, efficient heat pumps and solar water heating. The conclusion of the study is 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 the final consumption for the heating needs of the residential and service sectors, from district heating and cogeneration. It is estimated that this potential will increase to about 100 GWh by 2027, which accounts for about 3% of the total heating consumption in the residential and service sectors by 2027. It can be expected that most of this potential could be gradually met in the next 10 years. As indicated in the study, a feasibility study will have to be done at the level of installations, in order to determine the specifics for each of the municipalities from climate zone 3, as provided for in the Energy Development Strategy Action Plan (2016-2020).

The introduction of a biomass district heating system (wood chips, pellets and briquettes) for space heating in several northern municipalities has been processed by the results of a feasibility study to identify the potential of biomass and assess the possibility of implementing district heating for 10 municipalities in the north of Montenegro.

Out of 10 observed municipalities, projects for the implementation of biomass-based district heating system development in 4 municipalities were selected as sustainable and special studies were prepared for them in Kolašin, Nikšiÿ, Bijelo Polje and Rožaje.

Although the effects of this measure will not have a significant impact on of total emissions at the national level, the measure is extremely important when it comes to local air quality, which in the northern air quality zone is burdened with increased concentrations of PM due to long and harsh winters and the predominant households heating using solid fuels (coal or firewood). 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. due to the extinguishing of 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 foreseen works on the construction of the base, peak and reserve heating source of the city, as well as exchange substations within the PTPP with a capacity of up to 50MW, which will significantly speed up the implementation of this project. EPCG undertook to finance the construction of the heat pipe from the gate of the Pljevlja Thermal Power Plant to the final location in Pljevlja. Certain funds have already been allocated from the capital budget for the construction of the infrastructure for district heating in Pljevlja. In the coming period, it is necessary to plan the construction of the district heating network and the infrastructure for connecting households to the network [12].

- Energy efficiency measures in public sector (heating)

The Government of Montenegro, on the basis of a loan from the International Bank for Reconstruction and Development (IBRD) in the amount of 6.5 mil. € implemented the project Energy efficiency in Montenegro in the period 2009-2014. Energy efficiency measures were implemented in health and educational facilities, many of which use heating oil or solid fuel boilers for heating. For example, in two city schools in Pljevlja, the energy sources for heating were replaced and pellet boilers were installed instead of coal-fired boilers (total power of about 1.2 MW). The achieved results influenced the Government of Montenegro to make a decision on taking a new loan of 5 million € for the continuation of project implementation. The project was continued in the period 2014-2017 in health facilities throughout Montenegro. In July 2018, a new Loan Agreement of 6 million € was signed with IBRD. The subject of this phase of the project is the continuation of the application of energy efficiency measures in healthcare facilities and the creation of a sustainable system of financing energy efficiency projects in the public sector. A sustainable financing system will enable works on the application of energy efficiency measures in other buildings to be financed from the savings realized in adapted buildings. The project will last until December 31, 2023. Are there any news?

The Energy Efficiency Programme in Public Buildings was also implemented in two phases, in cooperation with the German Development Bank KfW, in the period from January 2012 to December 2015. The implementation of the Programme was financed from loans and financial contributions from KfW Bank, in the amount of 13.44 million €. As part of the first phase of the Programme, works were carried out on the application of energy efficiency measures and improvement of working conditions in 20 primary and secondary schools and one student dormitory. The second phase of the programme is implemented based on a loan of 20 million € and donations of 2,743 million €. The second phase began with implementation in January 2015 with a completion date of the end of 2020. The aim of the project was to improve the energy characteristics and conditions for living and working in administrative facilities in the field of education, work and social welfare and public administration.

In 2018, the implementation of the Beautiful Cetinje project was completed, which was implemented by the UNDP office in cooperation with the Capital of Cetinje and the Ministry of Culture, worth about 7 million USD, whose goal was the economic revitalization of the Capital City through the urban reconstruction of cultural heritage, with the application of energy efficiency measures, providing professional training, supporting small businesses and encouraging green ideas and innovations in overall urban development. Within the implemented project activities, the key component of the project was support for low-carbon development through the revitalization of public spaces and the preservation and improvement of buildings of cultural and historical heritage by applying energy efficiency measures, with the aim of making buildings and infrastructure more environmentally friendly and energy efficient. As a continuation of this cooperation, in 2018, the implementation of the project "Improving the cultural heritage management system" was started, which, among other things, aims at strengthening the cultural heritage management system through the reconstruction of selected cultural heritage objects. As part of the project, ten energy inspections of buildings in public use were carried out and energy efficiency studies were done for buildings whose reconstruction is planned in the coming period. Are there any news?

Within the framework of EU support, through IPA 2019, about 2.4 million € are planned for the establishment of a financial support scheme for the improvement of energy efficiency in facilities under the jurisdiction of local units [12].

- Use of renewable energy sources

The increased use of RES in the domestic electricity production market during the last years, where significant investment funds have been invested and are still being invested in new renewable sources, also contributes to the reduction of emissions air pollutants. The largest project started is the Briska Gora solar power plant with an installed capacity of 250 MW, the construction of which will be carried out in phases (I phase 50 MW, and II phase 200 MW). Wind power plants Krnovo (72 MW) and Možura (46 MW) are already in operation, while VE Gvozd (55 MW) and SE Velje Brdo (50 MW) are in the phase of preliminary analysis, and VE Brajiÿi with a total installed capacity of 100 MW is in the phase tender announcements. In addition, in recent years, existing hydroelectric plants and small hydroelectric plants have been revitalized, 11 new small hydroelectric plants have been built, and in the coming period, the construction of one large and several small hydroelectric plants is planned. Are there any last year updates?

The increase in the use of RES to produce electricity and heat in new and existing residential buildings, commercial and public sector represents a step forward in the achievement of goals regarding the participation of renewable energy sources in the total final consumption. In February 2018, the Secretariat of the Energy Community of Southeast Europe published the Guidelines for integration into the network of buyers-producers (prosumers). Action plan of energy efficiency of Montenegro for the period 2019-2021, the measure Development of decentralized energy production by prosumers was defined, the aim of which is to popularize the concept of decentralized energy production.

The Ministry of Economy of Montenegro, in cooperation with the UNDP office, during the period of 2018-2019. started the implementation of certain activities aimed at analysing the current legal framework and procedures relevant to the implementation of the buyer-producer concept and the preparation of appropriate guidelines and recommendations. In addition, UNDP has started activities on the preparation of technical documentation for the construction of photovoltaic power plants on several public buildings: the roof of the Business Center building in Cetinje, the roof of the Technopolis building in Nikšiÿ, the Parking service Podgorica and the Martiniÿi farm [12].

- 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 [59], whereby the burning of harvest residues and agricultural waste is not explicitly stated. Also, this measure is recommended through the Code of Good Agricultural Practices (MPRR, 2013), which states that plant residues**Erreur ! Source du r envoi introuvable.** from the harvest (straw and stubble) should not be burned in the field, except in cases where it is very difficult to introduce the waste into the soil by plowing or when necessary to control weeds, diseases and pests. Bearing in mind that agricultural activities are carried out on small areas (arable crops were harvested on about 2.2 thousand hectares in 2017), the share of crop residue burning has a very small share in total emissions. This measure implies adequate information and a promotional campaign aimed at getting familiar with the regulations and motivating to apply them. These activities require certain investments to implement them in an adequate manner and result in the desired effects. Implementation of the measure is ongoing.

Although due attention should be also paid to the prevention of forest fires, this could be considered a preventive measure rather than an emission reduction measure, so it is obvious that the sector where the greatest results can be achieved is the domestic heating sector. Unfortunately, the transition to more energy-efficient homes, more energy-efficient heating systems and more environmentally friendly fuels represents a large financial burden for households and will therefore require a longer period of time, as well as the continuation and expansion of currently available subsidy programmes.

Taking into account the economic analysis that was 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 will allow.

Special measures to reduce the emissions of VOC are reflected in:

- Application of the regulations on VOC emissions from the use of paints and varnishes is going through 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 [60]. The regulation prescribes prohibited or permitted methods of use, production and placing on the market chemicals or certain products that pose an unacceptable risk to human health and the environment.
- Application of the Regulation on technical conditions for air protection from emissions of volatile organic compounds resulting from the storage, transfer and distribution of petrol, 2019 [54]. The rulebook prescribes technical environmental protection standards for gasoline storage and transfer devices 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, and the deadlines for achieving them.

Taking into account the economic analysis that was 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 is implementing these measures to the extent that financial resources available. The proposed set of measures will be included in the updated Air Quality Management Strategy (expected in 2023) [8].

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

Up to now, there is no production of passenger cars, light and heavy-duty vehicles, motorcycles, non-road mobile machineries in Montenegro [8].

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, their parts, devices and equipment (hereinafter referred to as: vehicles) that are imported, that is, put on the market for the first time in Montenegro, the detailed content of the requirements and technical documentation, method of conducting vehicle homologation, content and appearance of vehicle homologation certificate for vehicle type, i.e. homologation certificate for individual vehicle, method of issuance, content and method of keeping records on vehicle homologation, as well as conditions in terms of personnel, equipment and space for a legal entity that performs homologation tasks.

The regulation determines among other, safety and technical requirements and conditions for vehicles that are imported, i.e. put on the market for the first time in Montenegro (new and second-hand), that should 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 the protection of the environment and human health, including air emissions that applied to new and old vehicles according to UNECE regulations.

So far, new vehicles imported into Montenegro should comply with the minimum standard EURO 6 and EURO VI (both factory production) and meet relevant requirements in relation to the limit values of exhaust emissions.

Second-hand vehicles that are imported into Montenegro should be the minimum of EURO 4 and EURO IV standard (factory production) and meet relevant requirements in relation to the limit values of exhaust emissions.

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, is in force in MNE [63] .

In addition, Regulation on marking the energy efficiency of vehicle tires and other parameters [62] prescribes the requirements for marking the energy efficiency of vehicle tires and other parameters.

Comparison with ELVs of the Gothenburg Protocol

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 [7] 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 [71]. As presented in chapter **Erreur ! Source du renvoi introuvable.** Montenegro fully transposed the requirements of AGP Tables 13 and 14 in Regulation on limit values of the content of polluting substances in liquid fuels of petroleum origin, 2017 [52].

6.6. Technological pathways

Montenegro ratified CLRTAP [1] in 2006 by means of the Law on CLRTAP Ratification [2]. CLRTAP was taken over by the Montenegro by means of succession it with the date of effect of 23 of October 2006 and the Protocol of EMEP, has joined Protocols on Heavy Metals 30 December 2011, and Aarhus Protocol on Persistent Organic Pollutants 9 February 2012.

In 2011 Montenegro established a Law on the approval of the protocol on GP 1999 [6], however, emission ceilings were not establishing within it. Up to now Montenegro has not signed nor ratified amended Gothenburg protocol, 2012 [7].

Air pollutant emission inventories in Montenegro were developed and submitted in 2010-2013 with the help of Italian Ministry of Environment. For seven years, no national emission inventory was developed, and since 2020 Montenegro is developing and submitting the emission inventories supported by the Environment Agency Austria [8].

In terms of air quality, the main concerns in Montenegro are PM_{10} and $PM_{2.5}$ concentrations in all the territory, and SO_2 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 important source of SO_2 emissions.

The main source of SO_2 emissions is energy production (98.4%), i.e. the coal-fired Pljevlja Thermal Power Plant generating about one third of electricity in Montenegro, while hydropower plants generate approximately the remaining two thirds. The key contribution to NOx emissions (56%) comes from the road transport, while energy production (TEP Pljevlja) contributes 28%. The key contribution to PM_{10} and $PM_{2.5}$ emissions (85% of contribution for both pollutants) comes from the other stationary combustion, mainly from residential heating (99% for both pollutants). The key contribution to VOC emissions (39%) comes from the other stationary combustion, mainly from residential heating (97%). The road transport had a share of 16%, fugitive emissions 15% (solid fuels, namely coal mining and handling) and solvents, offroad and agriculture livestock have 9% each in total VOC emissions.

Developed in 2021 of the National Air Quality Management Strategy 2021-2029 [12] with important measures to reduce SO_2, NOx, $PM_{2.5}$, VOC is coherent with AGP technical annexes transposed in the relevant regulation, however, was not adopted up to now. The new Strategy 2021-2029 unifies air quality plans for three established air quality zones (Northern, Central and Southern) and includes the Plan of measures for pollution control, which was prepared in accordance with the requirements of the relevant EU regulations and the final benchmark for the negotiation chapter 27, bearing in mind their common purpose and goals related to the improvement of air quality, protection of the environment and human health.

In 2019, Montenegro adopted a new Law on industrial emissions [23] transposing the Directive 2010/75/EU on Industrial Emissions (IED) [24]into Montenegrin legislation, following by the Implementation Plan for Industrial Emissions Directive [25].

The Law on industrial emissions regulates the set of measures aimed at prevention and control of emissions deriving from industrial plants located on the territory of and transposes Chapters I and II on the main definitions, i.e. best available techniques definition, integrated permits and inspections of permit conditions respect, Chapter II, however without list of specific industrial activities covered, Chapter III (covering ELV of LCP), 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), Chapter VII including annual reporting provisions for large combustion plants and penal provisions.

Regulation on limit values of emissions from combustion plants and method of calculating emission limit values for plants using multiple types of fuels [32] the annex V of the IED [24] and ELV of MCP [34]. In addition, Montenegro translated in Montenegrin language Commission Implementing Decisions, concerning large combustion plants (LCP) [33] with ELVs of the for LCP that are lower or equal of the ones in the Annexes of VI, V, and X of the AGP. The ELV for MCP are compliant with the ones of AGP Annex X (Table 14).

Up to now 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 for abating SO_2 and NOx emissions are as in the following (chapters 8.1.1 and 8.2.1):

The means to achieve SO_2 ELVs is the application of one or a combination of the following techniques [72], [73] according to the size of combustion installations, combined with the selection of low sulphur fuels:

- 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 [72], [73] 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)

Montenegro also transposed EU provisions and ELVs form small heating appliances such as solid fuel boilers [38] and local space heating [36].

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" [74] developed by TFTEI, the report "Prioritizing reductions of particulate matter from sources that are also significant sources of black carbon - analysis and guidance" [75] developed by TFIAM and the report "Review on Black Carbon (BC) and Polycyclic Aromatic Hydrocarbons (PAHs) emission reductions induced by PM emission abatement" [76] 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 [77]. In addition, the last TFTEI report on the updates of limit values of technical annexes also provides information [78].

The sulphur content in gas oil in Montenegro 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 petroleum origin [52].

It additionally tightened the limit values for the content of sulphur in marine fuels in accordance with Directive (EU) 2016/802 on the reduction of content of sulphur in certain liquid fuels [53]. In accordance with 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 of **industrial activities** are covered by the Regulation on emission limit values of air pollutants from stationary sources [39] and translated in Montenegrin language eight BREFs, namely Cement, lime and magnesium oxide industry[42], Iron and steel production [43], Non-ferrous metal industries [44], Production of cellulose paper and cardboard [45], Surface treatment using organic solvents including protection of wood and products from wood with chemicals [46], Food industry, the beverage industry and the milk industry [47], Waste treatment [48], and Poultry and pig farming [49]. In addition, Rulebook on the type of activities, emission limit values and methods performing monitoring in plants using organic solvents, 2020 [50].

Emission limit values concerning the sectors described above for air emissions are in line with the relevant EU Commission Implementing Decisions. ELVs of the BATs for industrial sources are lower or equal of the ones in the Annexes of VI, V, and X of the AGP.

The other sectors are not covered in AGP industrial installation emissions, such as sulphur recovery units, nitric acid production excluding acid concentration units, mineral oil and gas refineries, (FCC regenerators), glass production, pulp production are not relevant for Montenegro, as soon as there are no such activities.

In Montenegro, there is only one iron or steel. TOSCELIK NIKŠIĆ Steel Ltd, Nikšić Installations for the production of raw iron or steel (primary or secondary melting), The only aluminium production plant, Aluminum Plant Podgorica is in bankruptcy - KAP, and carrying out activities of aluminum production, and two industrial plant using solvents: "FAB LIVE" Ltd, Podgorica realizing the activity relating to the plasticization of aluminum profiles in powder coat colour and Ltd for processing and coating of metals „ALULINE“ from Bijelo Polje with the main activity of anodizing and lamination of aluminum profiles [25].

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) presents the best available techniques to comply with the limit values prescribed.

For PM, best available techniques (sub chapters 8.4.2 to 8.4.10 of this report) to comply with limit values are electrostatic precipitators and fabric 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.

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.

Regulation on technical conditions for air protection from emissions of volatile organic compounds resulting from the storage, transfer and distribution of petrol [54] transposes Stage I [55] and Stage II [56], so far the ELV of AGP (Annex VI).

In addition, during several decades, Montenegro develops different additional measures to reduce emissions from households heating, road transport as well as reduce LCP and industrial emissions (district heating, incentives etc.) to improve air quality within the country [12].

For **road transport vehicles**, the Republic of Montenegro transposes the latest EU directives or regulations for application to domestic production of vehicles and new vehicles imported.

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 [7] 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 [71]. As presented in chapter 6.1.1.14, Montenegro fully transposed the requirements of AGP Tables 13 and 14 in Regulation on limit values of the content of polluting substances in liquid fuels of petroleum origin, 2017 [52].

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.

By the implementation of the provisions in key EU Directives in its legislative framework, ELV transcribed in Montenegro legal framework could be consistent with the requirements of the four AGP technical annexes IV, V, VI, X, VIII and XI, tentatively around 2025-28.

6.7. References of chapter 6 Montenegro

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7. Armenia

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 from 2015. In some areas, regulations developed by the EEU apply in Armenia (especially for mobile sources and quality of fuels) [45].

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 [8].

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]):

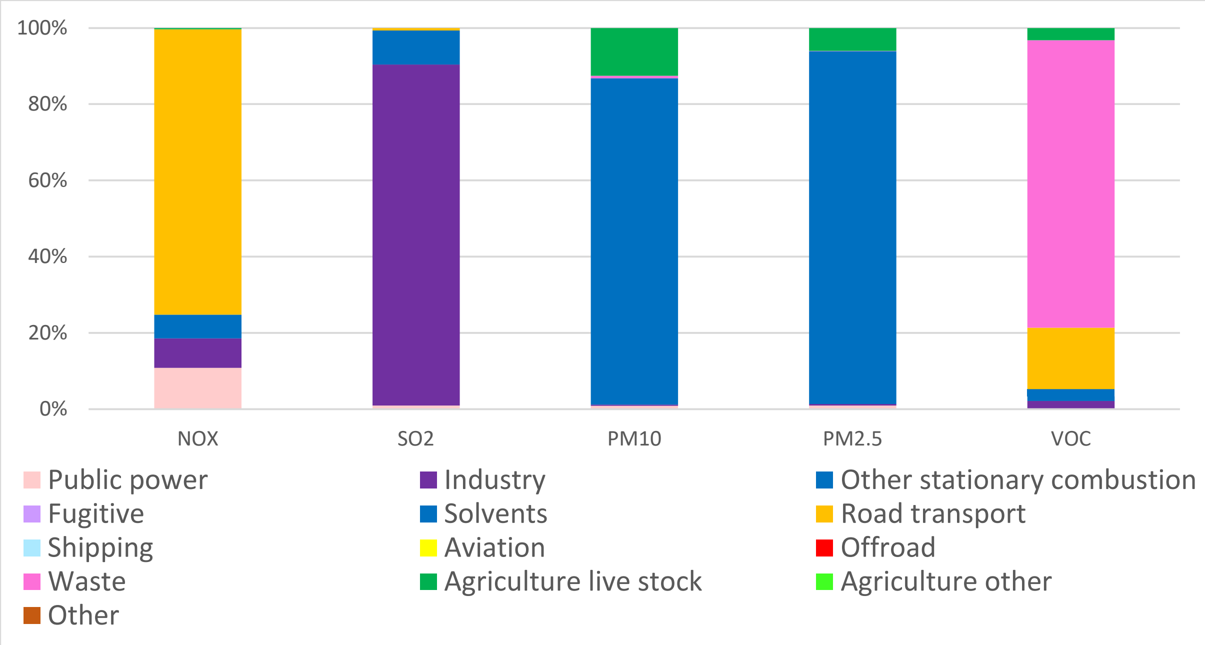

Figure 7-1: Share of emissions of SO_2, NOx, PM_{10}, $PM_{2.5}$ and VOC in Armenia in 2021 [11]

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 law share 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]:

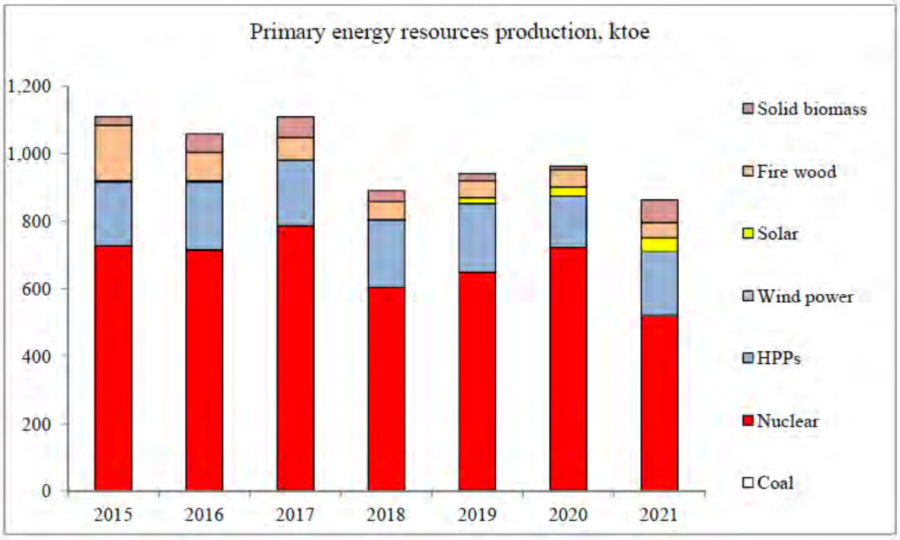

Figure 7-2: Evolution of the primary energy ressources production [12]

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]:

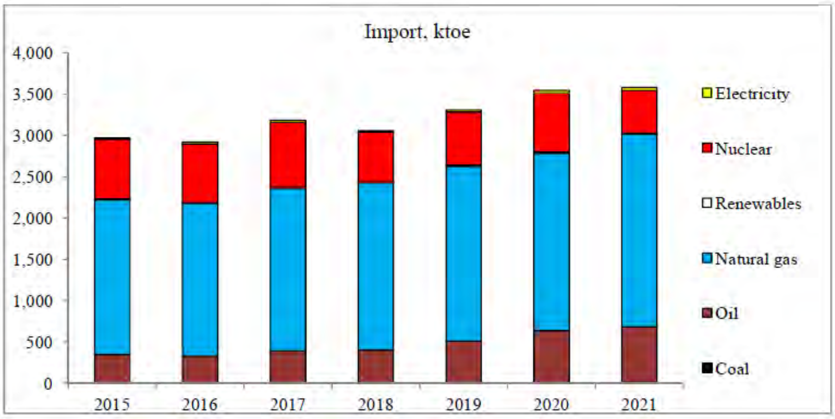

Figure 7-3: Evolution of imported energy resources [12]

Transport is the main sector for consumption of oil products as presented in the following figure [13].

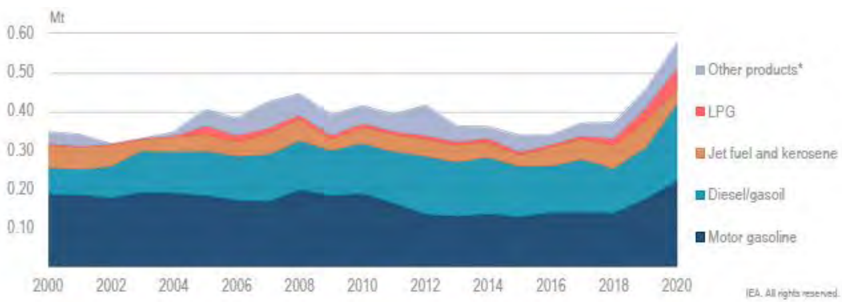

Figure 7-4: Uses of oil products in Armenia [13]

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 mln. kWh of electricity.
- “Hrazdan TPP” OJSC, 410 MW, is a condensing power unit, owned by “Gazprom Armenia” CJSC, produced 1576.9 mln. kWh 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 mln. kWh 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].

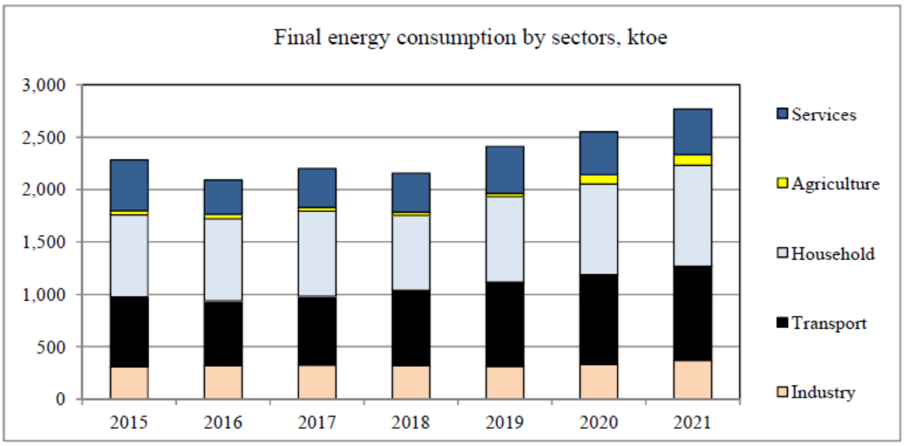

Figure 7-5: final energy consumption per sector, ktoe [12]

In industry, the main fuel used is natural gas. Oil is also used but in a very small proportion.

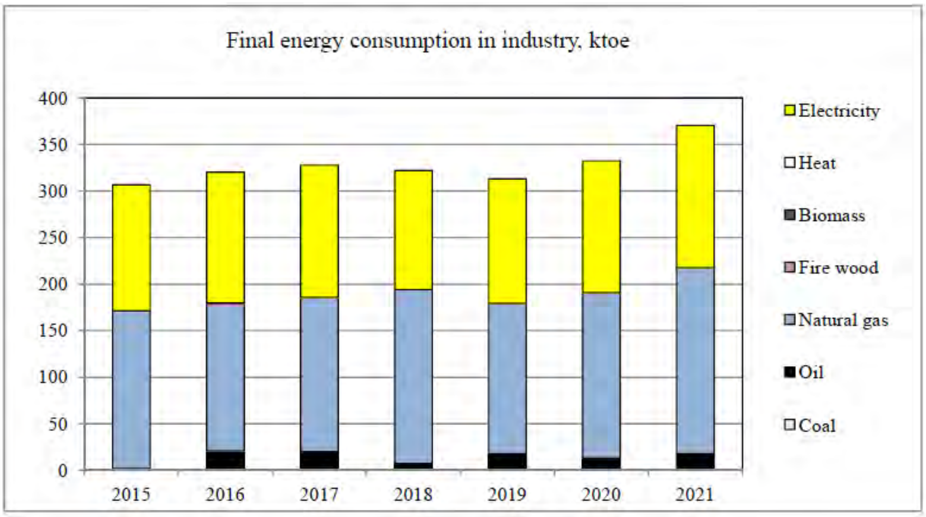

Figure 7-6: Final energy consumption in industry, ktoe [12]

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].

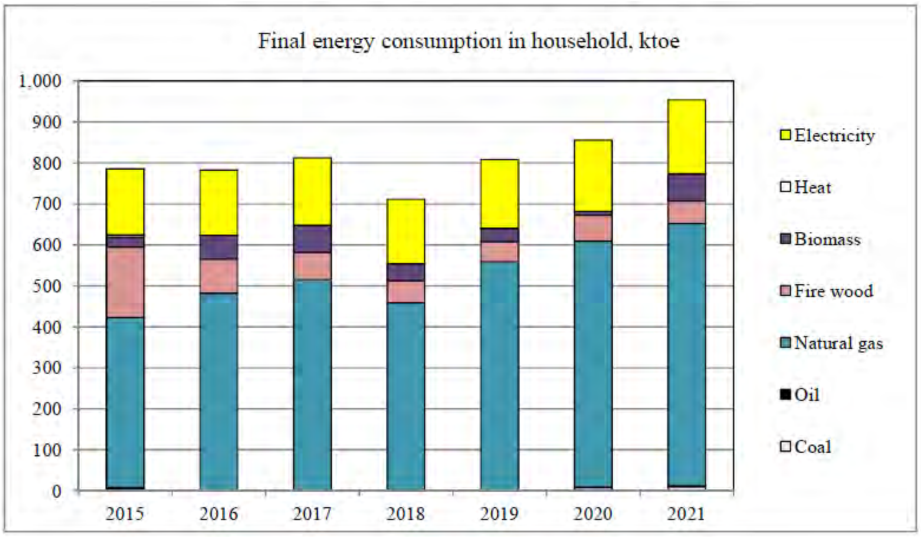

Figure 7-7: Final energy consumption in household, ktoe [12]

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 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].

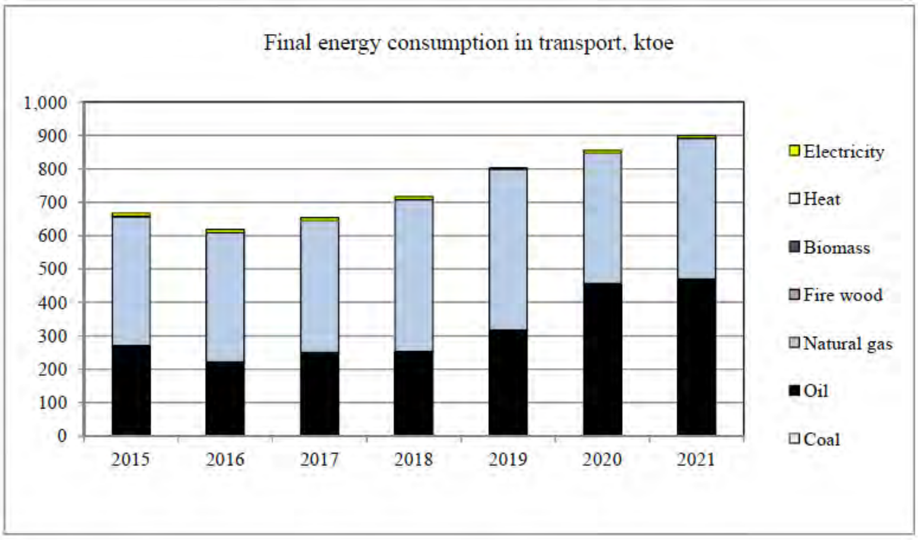

Figure 7-8: Final energy consumption in transport, ktoe [12]

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 follows [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 (The monitoring of emissions is not yet in practices, operators carry out atmospheric air quality monitoring in the territories of the plant and adjacent aeras),
- 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 detail data of the type of vehicles, split per furl, 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 Center (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 Center", "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),
- Sulfur dioxide (SO_2),
- Nitrogen oxides (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)	Sulfur dioxide (SO_2)
Sulfur dioxide (SO_2)	Nitrogen oxide (NO_2)
Nitrogen oxide (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 follows:

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/m^3 Max. Daily: 0.5 mg/m^3
NO_2	24 hour mean: 0.04 mg/m^3 Max. Daily: 0.085 mg/m^3
NO	24 hour mean: 0.06 mg/m^3 Max. Daily: 0.4 mg/m^3
CO	24 hour mean: 3 mg/m^3 Max. Daily: 5 mg/m^3
Dust	24 hour mean: 0.15 mg/m^3 Max. Daily: 0.5 mg/m^3
O_3	24 hour mean: 0.03 mg/m^3 Max. Daily: 0.16 mg/m^3

7.3.2. Concentrations of pollutants observed

The concentrations of pollutants measured in 2021 and 2022 are as follows [8]:

Nitrogen dioxide

The following figure present NO_2 annual average concentrations monitored in 10 cities of Armenia [8].

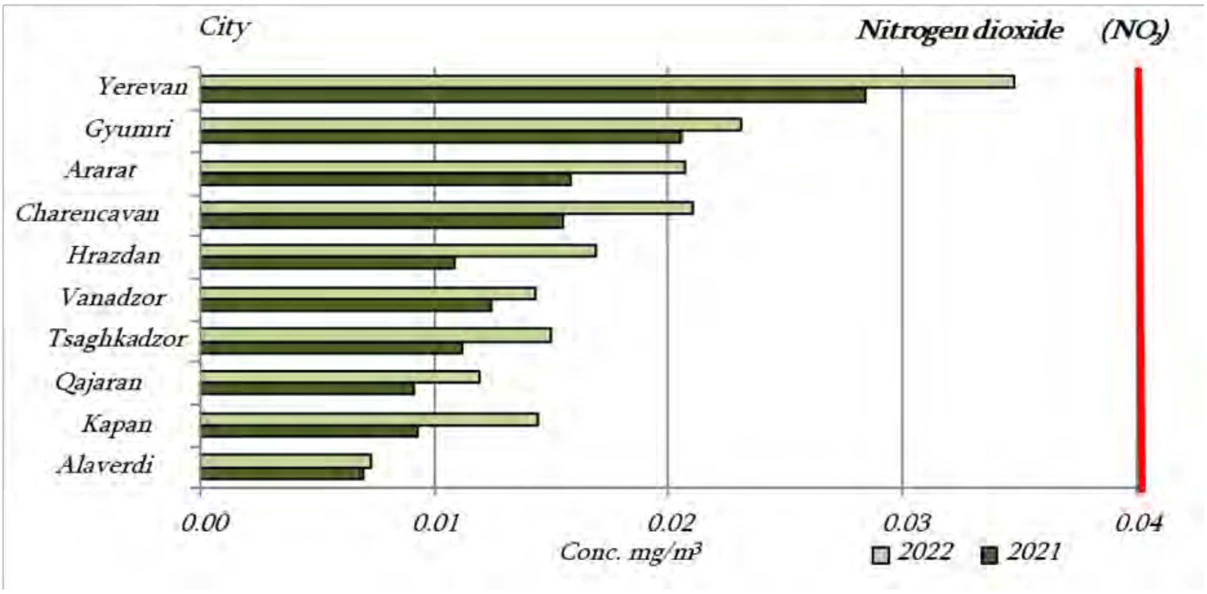

Figure 7-9: Concentrtaions of NO_2 in 10 cities of Armenia in 2021 and 2022 [8]

On average, the annual NO_2 concentraions are below the maximum permissible concentrations expressed as daily average of 40 µg/m^3.

Sulfur dioxide

The following figure presents SO_2 average annual concentrations monitored in 10 cities of Armenia [8].

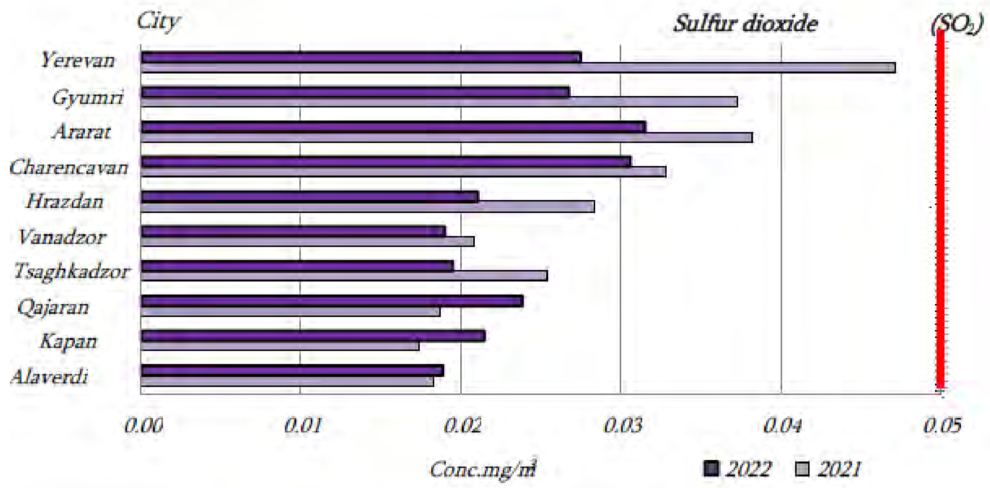

Figure 7-10: Concentrations of SO_2 in 10 cities of Armenia in 2021 and 2022 [8]

Dust

The following figure present 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.

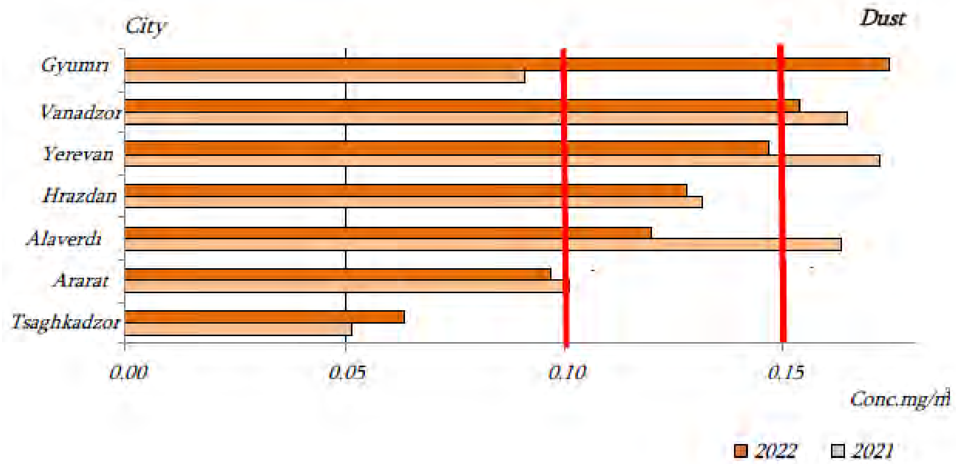

Figure 7-11: Concentrations of dust in 7 cities of Armenia in 2021 and 2022 [8]

In Yerevan, the concentrations of dust in 2021 and 2022 are as follows:

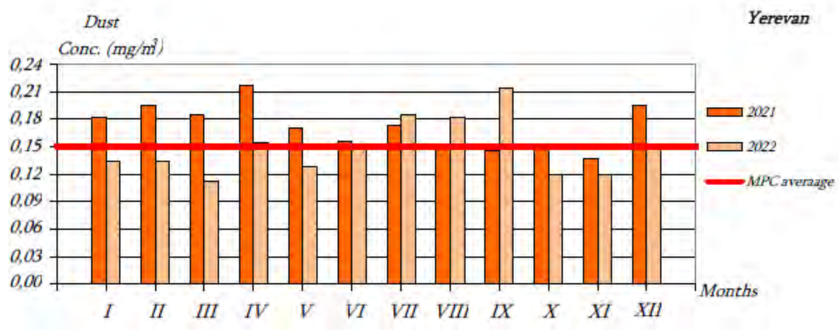

Figure 7-12: Concentrations of dust in Yerevan as monthly average in 2021 and 2022 [8]

The following table presents the evaluation 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

<u>Ongoing works to improve the air quality monitoring network</u>

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 follows [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.

<u>The road map is as follows according to the CEPA:</u>

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 the 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 concentration (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 of pollutant, 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]. In other words, the amount of pollutant emissions, expressed in mg/m^3, is always lower than the maximum allowable concentration (For emissions of polluting substances, calculation of dispersion is performed, and it is determined what concentrations occur as a result of dispersion in the ground level, at the edge of the territory of the emitting organization, at the edge of the boundary of the sanitary protection zone, and in the nearest residential areas. If these concentrations do not exceed the maximum permissible concentrations [27], then the permissible limit emission norms are considered acceptable and are emission limit quantities (emission permits). If the ground level concentrations of pollutants formed as a result of emissions at the edge of the territory of the emitting organization, at the edge of the border of the sanitary protection zone and in the nearest residential areas, exceed the corresponding MPC, then a program of measures to reduce emissions of air pollutants is developed, the implementation of which will ensure the achievement of MPC).

The following table presents emissions of SO_2, NOx and PM of some 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) (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]),
- 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)

Limit values for large combustion plants which are implemented by the technical annex IV (Table1: Limit values for SO_2 emissions from combustion plants), the technical annex V (Table1: 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 are listed in the 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].

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).

There is not yet legal regulation focussing on the reduction of emissions of PM emissions from domestic appliances.

According to its national Determined contribution, Armenia should reduce its GHG emissions by 40% 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 energy efficiency, renewable energy, and energy security actions;
- 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].

For the time being it is difficult to determine if possibly the recommended limit values of table 12, recommended limit values 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, recommended limit values for dust emissions released from boilers and process heaters with a rated thermal input of 100 kWth–1 MWth of annex X related to PM emissions of the AGP [33] for 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 the 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 sulfur 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.

<u>Further checks of the regulation are needed to better understand is gasoil considered in the AGP is covered.</u> It is probable that this gasoil used for mobile machine, is also used for domestic heating.

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 petroleum 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. Article 4 of the directive 1999/32, maximum sulphur content in gas oil cannot be used if their sulphur content exceeds 0,10 % by mass is at least considered by the CEPA).

7.4.5. Storage of petrol from terminals to service stations

Petroleum products only represent around 50% of the energy consumption in transport in Armenia. 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 gasoline 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 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

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

In green values equal to value in table 13, annex VIII of the AGP

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 and 6/VI, 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 machineries (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 requirements 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).

Information related to this type of vehicle is to be completed.

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 $\mu g/m^3$ in some cities or 150 $\mu g/m^3$ in other cities) in several cities (figure 7.11). The national limit value for NO_2 (daily average of 40 $\mu g/m^3$) is not exceeded and average daily concentrations range from less than 10 $\mu g/m^3$ Alaverdi to around 35 $\mu g/m^3$ 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 Machineries, 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] (requirements 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 large 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 fabric 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 Machineries (NRMM), the introduction of stricter standards could be foreseen for new engines introduced on the market.

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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.

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) <u>Combustion turbines with a thermal input capacity exceeding 50 MW – New</u>: Natural gas: 50 mg/m^3 at 15 % O_2 Other gases: 50 mg/m^3 at 15 % O_2 [Update Index 2] <u>Combustion turbines with a thermal input capacity exceeding 50 MW – Existing</u>: 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)	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, - water/steam addition, - dry low-NO_x burners (DLN) - low-load design concept, - low-NO_x burners (LNB), - selective catalytic reduction (SCR).	Advanced control system application is limited for old combustion plants. DLN application is limited in the presence of water/steam addition systems. 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**Erreur ! Source du renvoi introuvable.**. The DeNOx u nit 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 <u>Footwear manufacture (solvent consumption > 5 Mg/year)</u> 25 g VOC / pair of shoes <u>Other adhesive coating (solvent consumption 5 Mg/year–15 Mg/year)</u> 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 <u>Other adhesive coating (solvent consumption 15 Mg/year–200 Mg/year)</u> 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 <u>Other adhesive coating (solvent consumption > 200 Mg/year)</u> 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/ <u>Manufacture of cars</u> (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/ <u>Manufacture of truck cabins</u> (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/ <u>Wood coating</u>
	
	Solvent consumption 15 to 25 Mg/year: ELVc = 100 mg C/m^3 (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/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 1 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 = 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/ <u>Coating of metal and plastics</u>
	Solvent consumption 5 Mg/year–15 Mg/year: ELVc = 100 mg C/m^3 (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/ <u>Other coating, including textile, fabric film and paper (excluding web screen printing for textiles, see printing)</u>
	
	Solvent consumption 5 Mg/year–15 Mg/year: ELVc = 100 mg C/m^3 (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/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 1.0 kg or less of VOC/kg of solid input (yearly)
	
	4/ <u>Coating of plastic workpieces</u>
	
	Solvent consumption 15 to 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 0.375 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/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 0.35 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/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 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/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 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 petroleum-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 , **Erreur ! Source du renvoi introuvable.**. 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	

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/ <u>Packaging rotogravure and flexography</u> 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	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].	

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 i ntrouvable.**.	

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 fabric 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]**Erreur ! Source du renvoi introuvable.** - 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/m^3 at 6 % O_2 Existing plants: 30 mg/m^3 at 6 % O_2 Combustion plant with a thermal input capacity between 100 and 300 MW: New plants: 20 mg/m^3 at 6 % O_2 Existing plants: 25 mg/m^3 at 6 % O_2 Combustion plant with a thermal input capacity exceeding 300 MW: New plants: 10 mg/m^3 at 6 % O_2 Existing plants: 20 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]: - 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/m^3 at 6 % O_2 Existing plants: 30 mg/m^3 at 6 % O_2 Combustion plant with a thermal input capacity between 100 and 300 MW: New plants: 20 mg/m^3 at 6 % O_2 Existing plants: 20 mg/m^3 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/m^3 at 3 % O_2 Steel industry gases: 30 mg/m^3 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 fabric bag filters or ESPs. Fabric 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), fabric 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), fabric 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), fabric 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), fabric 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/m³ for existing, 5 mg/m³ 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/m³ For all furnaces (cupola, induction, rotary) and all mouldings (lost, permanent)	The techniques are electrostatic precipitators (ESP), fabric filters, or wet scrubbing [1] [10][11]	Almost 100 %.
	Hot and cold rolling 20 mg/m³, 50 in case bag filters cannot be applied	The techniques are electrostatic precipitators (ESP) or fabric filters [1] [10][11]	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/m³	The techniques are electrostatic precipitators (ESP), fabric 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 fabric 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 fabric 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), fabric 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), fabric bag filters, or cyclones and multi cyclones for pre-dedusting, and wet scrubbers**Erreur ! Source du renvoi introuvable.**	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 fabric bag filters with appropriate filter cloth [1] [6]	Almost 100 %.
	Chloride process, total emission: 50 mg/m^3	The techniques are high integrity fabric bag filters with appropriate filter cloth [1] **Erreur ! Source du renvoi introuvable.**	Almost 100 %

8.5. References of chapter 8

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