Czech Hydrometeorological Institute

Informative Inventory Report

Czechia

2023

Submission under the UNECE Convention on Long-range Transboundary Air Pollution

Reported inventories 1990–2021

Prague

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Subtitle

Emission inventories from the base year of the protocols to the year 2021

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This report describes methodologies of emission inventory compiling used in Czechia. The report is compiled under the UNECE Convention on Long range Transboundary Air Pollution, as well as the Directive (EU) 2016/2284 on the reduction of national emissions of certain atmospheric pollutants (NEC Directive), in accordance with the EMEP/EEA air pollutant emission inventory guidebook.

The report was completed under corporate design

I. Contents

Executive Summary

Czechia acceded to The Convention on Long-range Transboundary Air Pollution of the United Nations Economic Commission for Europe (UNECE/CLRTAP) and has been a member of the EU since 2004 [1]. These facts make the obligation to report annual emission data. The report includes a description of the determination of the emissions.

Since 2019, a part of the documentation for emission inventory processing is an electronic (e-ANNEX) inclusive EEA Emission Review Tool (EMRT) summary placed on Czech Hydrometeorological Institute (CHMI) websites. See e-ANNEX.

As a part of the UNECE/CLRTAP and under the NEC Directive, Czechia annually presents reported data on air pollutants (AP) [1][2]. The report consists of the following pollutants, see ANNEX I:

- main pollutants: nitrogen oxides (NO_X), non-methane volatile organic compounds (NMVOC), sulphur oxides (SO_X, as SO_2), ammonia (NH_3);
- particular matter: particulate matter (PMs) with diameters approx.10 micrometres PM_{10} and fine particular matter $PM_{2.5}$, which are smaller than 2.5 micrometres, total suspended particulate (TSP), black carbon (BC);
- carbon monoxide (CO);
- priority heavy metals (HMs): Lead (Pb), Cadmium (Cd) and Mercury (Hg);
- additional heavy metals (HMs): Arsenic (As), Chromium (Cr), Copper (Cu), Nickel (Ni), Selenium (Se), Zinc (Zn)
- persistent organic pollutants (POPs): polychlorinated dibenzodioxins/dibenzofurans (PCDD/F), hexachlorobenzene (HCB), polychlorinated biphenyls (PCBs) and polycyclic aromatic hydrocarbons (PAHs). PAHs consist of benzo(a) pyrene, benzo(b) fluoranthene, benzo(k) fluoranthene, and Indeno (1,2,3-cd) pyrene.

Emissions are reported under the EMEP/EEA air pollutant emission inventory guidebook structure. Emission factors (EFs) were used according to EMEP/EEA EIG [3].

Main updates presented in IIR 2023

The Czech IIR 2023 submission presents the results of the emission inventory 1990–2021, including most of the recalculations recommended in EMRT Review 2022. The most significant change was in NFR 1A4bi Residential: Stationary. The outputs of the current ENERGO 2021 survey were used, which enabled the recalculation of emissions to date from 2015 to 2020. The recalculation of historical data back to approximately 2010 will be carried out in the following years. Changes in the composition of the boilers were mainly reflected in the emissions of NMVOC, PM, TSP, CO, PAHs and HCB. At the same time, there was a change in the emission factor used for estimating NH_3 emissions when burning biomass in boilers with an input of up to 5 MW. Increased NMVOC emissions from using disinfectants against COVID-19 (2020 – 2021) were included in the NFR 2D3i. Time series for road transport were recalculated to obtain new background for precision activity data for COPERT. These updates are described in more detail in chapters for relevant NFR categories. An updated projection of emissions until 2050 (WM scenario) was processed. For estimating future emissions from the energy sector (NFR 1A1), the outputs of the TIMES model were used for the first time. For estimating emissions from agricultural activities, the N-flow concept was used.

Significant emission trends in Czechia

The evaluation of emissions for 2021 (see the following Fig.) shows a year-on-year increase in some emissions. Although the number of degree-days in the heating period of 2021 compared to 2020 slightly increased (by about 2%), model calculations of emissions reflected positive replacements of

boilers in households following law measures. Compared to 2020, during which there was a slowdown in industrial production, provision of services, and consumption of fuels in almost all sectors, there was another increase in 2021, which was reflected in the increase in emissions of REZZO 1 and REZZO 2 sources (NO_X, CO, NH_3 by approx. 6% and other pollutants by about 3%).

In 2020, one of the oldest coal-fired power plants (Prunéřov 1) was shut down. The production of generator gas at the Sokolovská uhelná – Vřesová plant was terminated. The increase in fuel consumption by approx. 8% of the REZZO 4 category increased emissions of all pollutants.

Total emissions of NMVOC had the most significant decrease compared to 2020 (4.7%) among the main pollutants. Emissions of NO_X increased by 2%, and emissions of SO_X increased by 2.8%. The total emission decrease is $PM_{2.5}$ by 2.3%, PM_{10} by 1.7%, and TSP by 1.2%. Emissions of CO increased by 0.2%. Emissions of HMs are increased, except lead (Pb) by 8.4% and nickel (Ni) by 2.0%. Emissions of POPs decreased: PCDD/F by 17%, PAHs by 4.6%, HCB by 12.6%, and PCBs by 20.4%.

Share of categories in Czechia in 2021

The sector of residential heating (NFR 1A4bi) still contributes significantly to air pollution, specifically $PM_{2.5}$ emissions 71%, PM_{10} emissions 55%, CO emissions 66.9% and benzo[*a*]pyrene 96.2%. The decisive share of the public sector energy (NFR 1A1a) prevailed in emissions of SO_X 39.4% and Hg 43.3%. The NFR 2G emitted 26.9% of Pb emission.

The public electricity (18.6%), passenger cars (15.0%), road freight transport sector over 3.5 tonnes NFR 1A3biii (9.6%), off-road machinery (8.9%) and Inorganic N fertilisers (8.2%) and created more than 60% of NO_X emissions. The most significant sources of emissions of NMVOC are found in the NFR 1A4bi household heating, with a share of 36.6%. Agriculture (NFR 3D and 3B) is the main source of ammonia emissions, whose share of total emissions is 88.2%. The figures below present trends of the main pollutant emissions from 1990–2021.

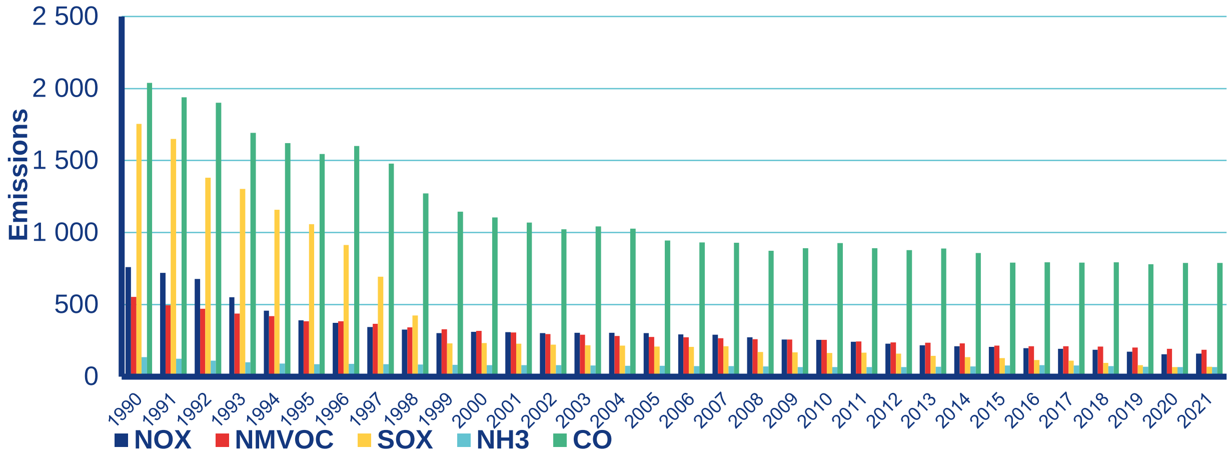

Fig. 0. 1 Total emissions of main pollutants, 1990–2021

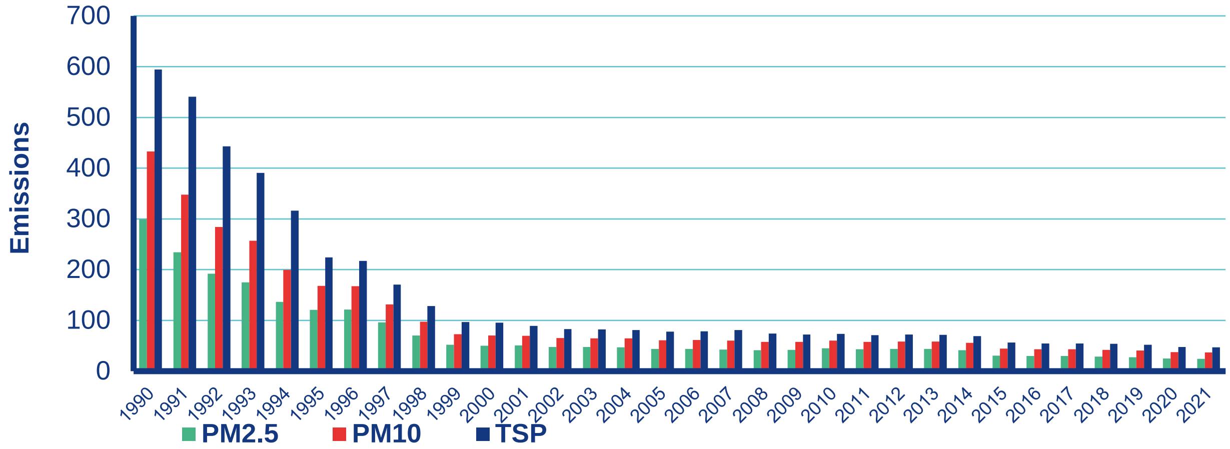

Fig. 0. 2 Emissions of particular matter, 1990–2021

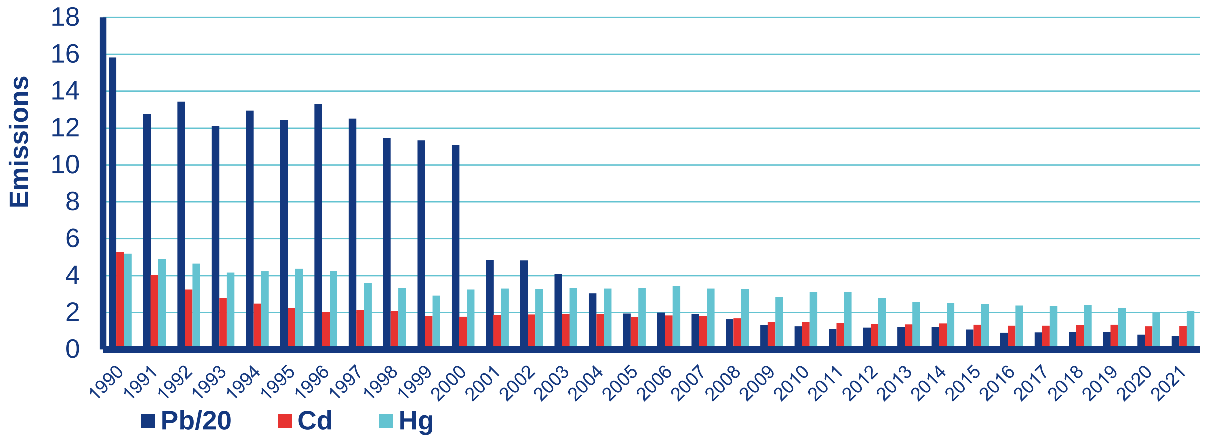

Fig. 0. 3 Emissions of heavy metals, 1990–2021

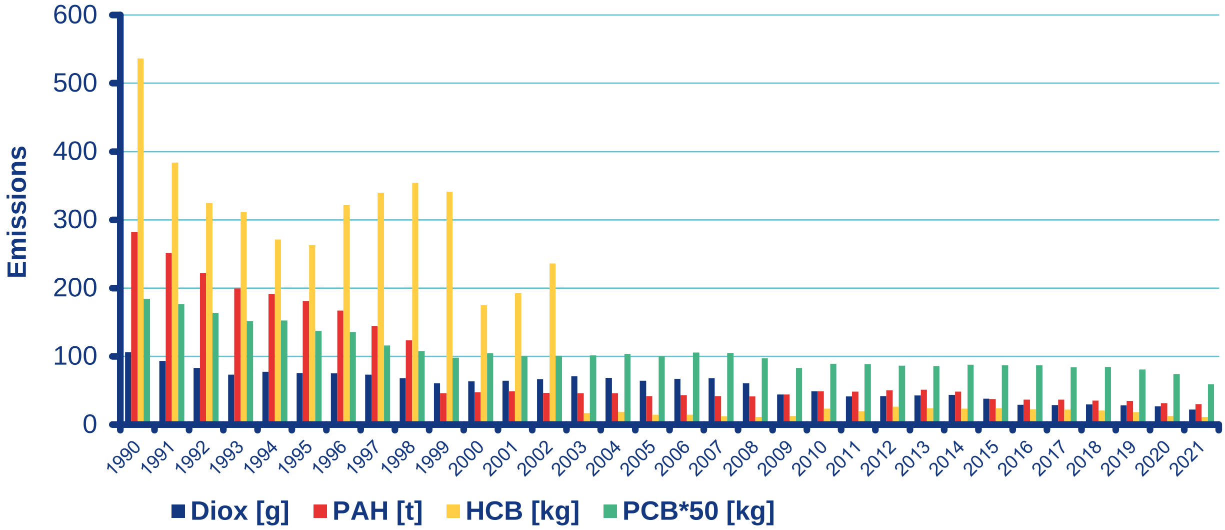

Fig. 0. 4 POPs emissions, 1990–2021

I. Introduction

The date of the last edit of the chapter: 15/03/2023

I.1 National Inventory Background

UNECE/CLRTAP was negotiated in 1979 and is an important instrument for preventing the long-range transfer of air pollution [1]. The Convention has a framework character: the contractual reduction of air pollution is realised through protocols adopted by the Convention. Eight protocols have been adopted yet. Czechia acceded to the Convention on 1st January 1993 and is a party to all eight protocols.

- Protocol on Long-term Financing of the Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe. It was agreed upon in 1984 and came into force on 28th January 1988.
- Protocol on the Reduction of Sulphur Emissions or their Transboundary Fluxes by at least 30%. It was agreed upon in 1985 and came into force on 2nd September 1988.
- Protocol concerning the Control of Nitrogen Oxides or their Transboundary Fluxes. It was agreed in Sofia in 1988 and entered into force on 14th February 1991.
- Protocol concerning the Control of Emissions of Volatile Organic Compounds or their Transboundary Fluxes. It was adopted in 1991 and entered into force on 29th September 1997.
- Protocol on Further Reduction of Sulphur Emissions. It was agreed upon in Aarhus in 1994 and came into force on 5th August, 1998.
- Protocol on Heavy Metals. It was adopted in 1998 and entered into force on 29 December 2003. The protocol framework has been developed for methods of modelling the transfer of heavy metals (cadmium, lead and mercury) over long distances and storing it in the soil, water, sediments of rivers and seas etc.
- Protocol on Persistent Organic Pollutants (POPs). Adopted in 1998, it entered into force on 23rd December 2003.
- Protocol to Abate Acidification, Eutrophication and Ground-level Ozone. It was adopted on 30th November 1999 and entered into force on 17th May 2005.

The current CLRTAP development strategy is focusing, above all, on the increase in ratifications and on the revision of the last three protocols, i.e. the revision of the Protocol on Heavy Metals, Protocol on Persistent Organic Pollutants and Protocol to Abate Acidification, Eutrophication and Ground-level Ozone. An important task is strengthening the implementation of the Protocols and the emission reporting by the Parties, including its control.

According to the Guidelines for Estimating and Reporting Emission Data, each party must report the annual national emission data of pollutants in the NFR source category and submit an informative inventory report on the latest version of the templates to the Convention Secretariat.

I.2 Institutional arrangements

The Czech emission inventory is performed in accordance with the National Law for the Prevention of Air Pollution and Reduction of Air Pollution from 2012. There are Act 201/2012 Coll. on Air Protection Act and Regulation 415 /2012 Coll. on the Permitted Level of Pollution and its ascertainment and on implementing some further provisions of the Act on Air Protection [4].

The information is stored in the Register of Emissions and Stationary Sources (REZZO), maintained by Czech Ministry of the Environment (MoE). This emission database, used for archiving and presenting data on stationary and mobile sources of air pollution, is, pursuant to the valid law (Section 7 of the Air Protection Act), part of the Air quality information system (ISKO) operated by CHMI. Air pollution sources are divided into individually monitored sources, and sources monitored as area sources.

Since 2013, regarding the change in the categorisation of sources pursuant to Annex 2 of the Air Protection Act, REZZO sources have been newly circumscribed (Tab. I.1).

Tab. I.1 The categorisation of pollution sources

Category	Type of source	Origin of emissions	Category
REZZO 1	Stationary plants for the combustion of fuels with a nominal heat input power of 0.3 MW and higher, waste incinerators and other specified sources (technological combustion processes, industrial production etc.)	Reported emission data	Individually monitored sources – reported emissions
REZZO 2	Stationary plants for combustion of fuels with a nominal heat input power of up to 5 MW inclusive, combusting liquid or gas fuels and service stations or facilities for transporting and storing petrol fuel	Calculated emissions from reported activity data (consumption and calorific capacity of fuels, gasoline distribution) and emission factors	Individually monitored sources – emissions calculated from the reported data and emission factor
REZZO 3	Combustion of fuels with a total thermal input lower than 0.3 MW, non-specified technological processes (domestic solvent use, building and agricultural activities)	Calculated emissions from activity data obtained, e.g. from the Census, production and statistical energy surveys and emission factors	Sources monitored collectively
REZZO 4	Road, railway, water and air transport of persons and EMEP/EEA EIG, tyre and brake wear, road abrasion and evaporation from fuel systems of vehicles using petrol, non-road vehicles and machines used in the maintenance of green spaces in parks and forests etc.	Calculated emissions from activity data obtained, e.g. from road traffic census, the register of vehicles etc. and emission factors	Sources monitored collectively

This classification corresponds to the way of emission inventory compilation. Individually monitored sources REZZO 1 and REZZO 2 are mainly represented in categories NFR 1A (except mobile sources and 1A4bi), NFR 1B (except 1B1a and 1B2av), furthermore in most of the categories NFR 2A (except 2A5b), 2B and 2C. Data reported for sector Solvent use are only used for NMVOC emission estimates. The whole inventory for NFR 2D (except 2D3b and 2D3c) is being performed by model calculation. Emissions from waste combustion and cremations (NFR 5C1) are also being monitored individually.

In other sectors, the emissions are calculated using emission factors and activity data. This concerns residential heating (NFR 1A4bi), all categories of mobile sources NFR 1A3 (except gas transport 1A3ei), NFR 1B partly, NFR 2A5b, and agricultural machinery (NFR 3).

I.3 Inventory preparation process

CHMI, under the supervision of the MoE, is designated as the coordinating and managing organisation responsible for the compilation of the national inventory, projection and reporting of its results.

Sectorial experts prepared inventory; see Tab. I.2.

Inventories and projections were prepared with the external help of:

- Transport Research Centre (CDV), Brno and MOTRAN, compile the inventory and projection in NFR 1A3 Energy and Road and non-road Transport.
- Research Institute of Agricultural Technology (VUZT), Prague, compiles the inventory and projection in NFR 3 Agriculture and NFR 1A4cii non-road Agricultural and Forestry mobile sources.
- National Research Institute for the Protection of Materials, Ltd. (SVUOM), Prague, compiles the NFR 2D Solvent Use inventory.
- Charles University Environment Centre, Prague, compiles the projection in NFR 1A1.

Tab. I.2 Institution arrangement

Sector	Author	Institution	E-mail
Energy	Ilona Dvořáková Pavel Machálek Karolína Fizková	CHMI	ilona.dvorakova@chmi.cz pavel.machalek@chmi.cz karolina.fizkova@chmi.cz
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Agriculture	Martin Dědina	VUZT	martin.dedina@vuzt.cz
Waste	Ilona Dvořáková	CHMI	ilona.dvorakova@chmi.cz
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GRIDDED emissions	Pavel Machálek Radek Srněnský	CHMI IDEA-ENVI	pavel.machalek@chmi.cz ras@idea-envi.cz
LPS	Ilona Dvořáková	CHMI	ilona.dvorakova@chmi.cz
Projections	Alfiya Kassymova Barbora Vodičková Jiří Dufek Martin Dědina Lukáš Rečka Saarikivi Risto Juhana	CHMI CHMI CDV VÚZT COŽP UK CHMI	alfiya.kassymova@chmi.cz barbora.vodickova@chmi.cz jiri.dufek@motran.info martin.dedina@vuzt.cz lukas.recka@cuni.cz ristojuhana.saarikivi@chmi.cz
QA/QC	-	-	-
Coordinator	Monika Filipenská	CHMI	Monika.filipenska@chmi.cz

I.4 Methods and data sources

The emission inventory of air pollutants in Czechia is prepared to fulfil reporting requirements. Calculations are based on a combined methodology. In addition to reported primary emission data from operators of sources, other information (fuel consumption, production, etc.) is also used to estimate emissions in certain sectors. A significant part of emissions is estimated based on statistically monitored and reported information and available emission factors.

In 2015 there was the Stage III in-depth review of the Czech emission inventory and IIR. Based on the recommendations, significant improvements were made in reported emissions and the presented report. The improvements are being implemented successively, with full implementation in 2020 reporting.

The 2023 submission presents:

- Submission (1990–2021) of emissions in all categories
- Notation keys for emissions and activity data were thoroughly revised and updated in NFR tables.
- Comment on EMRT findings was adopted in chapter 12, and for details, please refer to e-ANNEX.
- New emissions previously reported as NE were reported; see e-ANNEX
- Next updates are described in more detail in chapters for relevant NFR categories and in e-ANNEX.

I.4.1 Emissions from individually monitored sources - stationary sources

Pursuant to the Air Protection Act, Section 17 (Obligations of an operator of a stationary source), paragraph 3, the operators of stationary sources listed in Annex 2 to this Act are obliged to keep operational records on constant and fluctuating information of the stationary source describing named source and its operation, as well as information on inputs and outputs from the named source, and disclose data each year summarising the operational records by means of the integrated system for notification obligations (ISPOP). Reporting through this system has been mandatory since 2010. The ISPOP data are then submitted to the REZZO 1 and REZZO 2 database. Annex 11 to Regulation 415/2012 Coll. states the requirements for summary operating records.

Operators are obliged to provide emission data on pollutants emitted into the air from the stationary source per reported calendar year for which the operator of the stationary source, according to Section 6(1) of the Act, has the stated obligation to determine emissions. The emission limit values are set in Annexes 2–8 (specific) and 9 (general) to Regulation 415/2012 Coll. Furthermore, specific emission limits and methods, conditions and frequency of ascertaining the pollution levels can be set for any pollutant in an operating permit issued by regional authorities. The manner and frequency of measuring or calculating pollution levels and the scope, manner and conditions for recording, verifying, evaluating and storing results of the ascertainment of pollution are set in Regulation 415/2012 Coll. Part Two (Ascertainment of the Pollution Level and Evaluation of the Fulfilment of Emission Limits). It is preferred if emissions of specific pollutants are reported by the operators of their sources, as this is the Tier 3 approach.

The use of emissions reported by source operators does not, in some cases, correspond to EMEP/EEA EIG [3], namely in categories where operated stationary sources do not reach the set threshold of named sources. Only for natural gas consumption are sufficient data enabling emission calculation from the whole fuel consumption.

Significant year-to-year changes for some very low emissions (usually less than 0.001 kt) may be caused by the methodology of reported data in categories with named sources. These emissions mostly come from annual one-time measurements to prove meeting emission limits when pollutant concentrations may depend on current equipment conditions, fuel burned, material inputs or abatement efficiency.

Emission of the pollutants, for which operators are not required to ascertain pollution levels, is calculated for each source in the emission database based on reported activity data and emission factors (Tier 1 or 2). Emission factors for stationary combustion sources are divided according to the type of fireplace and nominal thermal output. As activity data, fuel consumption expressed in $t.year^{-1}$, $thousand.m^{-3}.year^{-1}$, or the calorific capacity of fuel in $GJ.year^{-1}$ is used. For other sources, emission factors are related to the amount of their product in tons.

To determine emissions of PM_{10} and $PM_{2.5}$, emission factors expressed as a percentage of PMs fraction in total emissions of solid pollutants (TSP) are used. If a source is equipped with abatement technology, the share of particles depends on the separation principle of this technology. In combustion sources without any abatement, the shares of particles are determined according to the fuel type. For other sources, the TSP origin is a crucial factor [5].

Monitored, or based on the activity data, calculated emissions of individually monitored sources are used, namely for the following main categories – NFR 1A1, 1A2, 1A4 (except for 1A4bi), 1B (except for 1B1a and 1B2av), 2A (except for 2A5b), 2B (except for 2B1), 2C, 2H, 2I, 2L and 5 (except for 5A), furthermore for category NFR 1A3ei and also for NFR 2D3c (Asphalt Roofing). Detailed information on some categories is given in e-ANNEX (**REZZO-NFR_code.xlsx**). Two exceptions in emissions of heavy metals and POPs are in some categories taken over as reported and in some other categories calculated, based on activity data or other statistical data about production facilities in some product categories (for details, see chapters III and Executive Summary). This category includes emission of coal sorting and drying mainly in sorting plants producing coal for household consumption, coke plants and wood coal production emissions. Emissions from coal sorting plants are usually based on the one-time measurement of suction devices. Wood coal production emissions are being measured while putting the facility in operation, and for annual reporting, specific production emissions are being used.

Besides the categories mentioned above, the REZZO register also contains solvent emissions using sources (NFR 2D3d to 2D3i). More than 3900 sources (painting and degreasing plants, printing plants etc.) produce more than 7.9 kt of NMVOC emissions. These data are not used directly, but considering a high number of non-monitored facilities and the area character of emissions in the protective and decorative coating, these are used for more precise estimates of total VOC emissions for each NFR 2D category (see chapter IV.4).

The sources in NFR 5A are being monitored similarly. The permits of sources underlying permission mostly include the obligation to ascertain the TSP emissions. These sources are currently not used for emission inventory in NFR 5A according to Tier 1 methodology (see chapter VI).

I.4.1.1 Emission Factors used

As stated above, the emission of the most important point sources is reported in Summary Operational Evidence (SOE). However, part of emissions is being calculated using national emission factors. Namely, NMVOC combustion emissions (boilers, piston engines and other sources) are included. Furthermore, there are being calculated particle emissions of $PM_{2.5}$ and PM_{10} a portion of TSP-reported emissions. There is a similar situation concerning emissions of heavy metals and POPs. For further calculations, emission factors from EMEP/EEA EIG [3] are used (newly, e.g. for some NFR categories 2C). For further information, see the following chapters. Newly, emission factors for NFR 2H2 were supplied. Detailed information on some categories is given in e-ANNEX.

I.4.1.2 Activity Data used

Activity data of individually monitored sources are usually gained from reported data of SOE. This concerns the fuel consumption of various fuels, and their calorific values recalculated to heat content in fuel (NFR 1A1, 1A2 a 1A4). Activity data presented in categories NFR 2A, 2B, 2C, 2H, and partly NFR 2D are being taken over from statistic data. Correctly estimating relevant activity data for sources using organic solvents is very problematic. The completion here is assumed for reporting in the coming years. Activity data for NFR 5 are partly being taken over from reported data (waste combustion) and statistical data. Detailed information on some categories is given in e-ANNEX.

I.4.2 Emissions from collectively monitored sources

The stationary air pollution sources monitored collectively are registered in REZZO 3. They include emissions from local household heating, fugitive TSP emissions from construction and agricultural activity, ammonia emissions from farm animals' breeding, mineral nitrogenous fertiliser application, and VOC emissions from organic solvents.

Besides household heating emissions, other sources are calculated solely using data obtained within the national statistical monitoring. Potential year-to-year changes are usually related to the development of the relevant indicators. By contrast, year-to-year changes in the amount of emissions from local household heating depend primarily on the character of the heating season, expressed by the number of degree-days, and on the changes in the composition of combustion units. The calculation of emissions from local household heating is based mainly on the results of the population and housing census (SLDB). The calculation of activity data for the period 1990–2014 was carried out according to fuel consumption data from Czech Statistical Office (CZSO) and boiler structure from census ENERGO 2015 (CZSO). The calculation of activity data for the period 2015–2021 was carried out according to fuel consumption data from CZSO and the new boiler structure from census ENERGO 2021 (CZSO).

Data of mobile sources registered in REZZO 4 are monitored collectively, too. This category of sources includes emissions from road, railway, water and air transport, and non-road vehicles (machines used in agriculture, forestry and building industry, military vehicles etc.). The database also includes emissions from tyres and brakes, road abrasion and evaporation calculated from data on transport performance. Since 1996 the emission balance from mobile sources has been complied by CDV based on data on the sale of fuels submitted by the Czech Association of Petroleum Industry and Trade (ČAPPO), since 2000 on the data from CZSO, and own emission factors. VÚZT processes sets of emission data on mobile sources in agriculture and forestry. The consistent time series of emissions in the traffic sector from 1990 onwards were reported for the first time on 15th February 2018. For road transport emissions model COPERT V was introduced by CDV in 2018. For non-road transport (NFR 1A4cii), the tractor and non-road machinery fleet composition and related emissions were thoroughly revised in 2018.

Emissions of area monitored sources are being represented in main NFR 1A3 except for categories NFR 1A3ei and 3B. These furthermore include other categories of mobile sources (NFR 1A2gvii, 1A4aii, 1A4bii and 1A4cii), coal mining (NFR 1B1a), distribution of fuel (NFR 1B2av), construction and demolition (NFR 2A5b) and solid waste disposal on land. Some area sources are partially included in NFR 2D Use of solvents.

I.4.2.1 Emission Factors used

Emissions of collectively monitored sources are being calculated using emission factors. In the last period, EMEP/EEA EIG emission factors were implemented to calculate most key sources [6]. In some cases, national emission factors based on emission measurements of large sources (namely in NFR 1A4bi) are preferred. For NMVOC emission estimate in the category of Solvent use, EMEP/EEA EIG emission factors (use in households) and national-specific emission factors, based on long-term reported data about solvent used, applied abatement techniques and reported emission data, are being used [6]. Detailed information on some categories is given in e-ANNEX.

I.4.2.2 Activity Data used

Collectively monitored sources' emissions are calculated using activity data prevailing on publicly accessible web pages of CZSO (metal production and raw materials, agricultural production data, census ENERGO 2015, data from technical inspection of operated cars, waste data ISOH etc.). CZSO officers are preparing some data for emission inventory (fuels sold), or other statistical data are being used (customs statistics for emission estimate in solvent use). More detailed information is provided in the following chapters. Detailed information on some categories is given in e-ANNEX.

I.4.3 The condensable component of PM_{10} and $PM_{2.5}$ (emission factors)

Generally, emissions from individually monitored sources do not contain a condensable component because of Czech legislation. The total suspended particulate matter determination sampling is performed by a heated apparatus to a temperature higher than the dew point of the exhaust gas (usually 70 - 160°C). These are mainly NFR 1A1 and NFR 1A2 sources.

Regarding collectively monitored sources, national emission factors from household heating (NFR 1A4bi) are determined based on sampling performed in the dilution tunnel. The sampling temperature was about 40° C. The EFs were thus determined to contain a high proportion of the condensable component. COPERT emission model calculates emissions from transport. EF is also determined by dilution methods (including dilution tunnels or systems using dilution after sampling); they contain a condensable component.

I.4.4 Inventory preparation timetable

Tab. I.3 Preparation timetable

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Annual Reporting of Operators	■	■	■	Emission database ISKO & Basic data checks																				
Data of Czech Armed Forces	■	■	■	■	■	■																		
Agricultural Data - VÚZT	■	■	■	■	■	■	■																	
Reported Data Checks and Processing - CHMI				■	■	■	■	■	■															
Industrial Processes - Solvents					■	■	■	■	■	■	Data for solvents available in October													
Public Electricity Sector - CZSO					■	■	■	■	■	■	Publication of energetic balance on 15.11. (IEA)													
Agricultural Data - CZSO					■	■	■	■	■	■	■													
Transport Data - CDV					■	■	■	■	■	■	■													
Waste Sector Data						■	■	■	■	■	■	■	Waste data available in January											
Finalization of Emission Inventory											■	■	■											
Submission to CLRTAP														■										
International Review UNECE															International review ■	■	■	■	■	■	■	■	■	■

Collecting individually monitored sources is related to the deadline set by law for reporting of SOE 31st March. By the end of April, the first data in XML format will be available in the central storage ISPOP. During May, the announcements are checked, and in June, correction notifications are sent in case of unfilled or incorrect data. Complete download of the announced data, including additional or correction reports, is being done in September. Additional announcements and corrections are possible for further processing at the beginning of December. The total amount of operating sites may vary, and in the period 2000–2010, it used to oscillate at approx. 22.000, currently 17.000. Some sources or groups of sources are being announced as a sum (for example, a cascade of gas boilers) and emissions or fuel consumptions are being represented by approx. 40.000 records a year.

The processing of this data set in December and January includes mainly the check of the correctness of the NFR and the appropriate composition of emissions. Should unexpected emissions be reported for a certain category, the emissions are being shifted to the appropriate category (for example, NO_X and CO at an operating site for VOC abatement at a source using solvents are being shifted to NFR 1A2 or 1A4). The processing result is the sum of category emissions, including individually monitored sources.

For the processing of emissions of area monitored sources of most categories, routine methodology procedures, collection of timely corresponding activity data or publication by official authorities like CZSO, MIT (fuel data, production facilities data), Ministry of Agriculture (MoA) (livestock and other indicators) and CHMI (number of degree-days) are being used. The collection and processing of these data occur from May–December. Emission calculations for each category take place in January.

The final stage of the data processing at the beginning of February is the emission takeover by sector specialists (transport, agriculture, solvent use) and the filling of the reporting template. The new data analysis is being performed simultaneously compared to the previous year. The IIR texts are being finalised and translated to English in February and at the beginning of March.

I.5 Key categories

The Key category analysis of the Czech Republic inventory is carried out according to the Tier 1 method described in the EMEP/EEA Guidebook. According to these guidelines, the key category is an emission category that significantly influences a country's inventory in terms of the absolute level of emissions. Key categories add up to over 80% of the total emissions, summed together in descending order of magnitude.

National emissions have been disaggregated into the categories reported in the National Format Report; details varied according to different pollutants to reflect specific national circumstances in 2021. The trend analysis has also been applied considering 1990, 2005, and 2020. Results are reported in the following chapter II, The Key trends.

The main source of pollution in 2021 was NFR category 1A4bi (Residential stationary). The NFR category 1A4bi was top in nine emissions (NMVOC, $PM_{2.5}$, TSP, PM_{10}, CO, PAH, HCB, PCDD/PCDF, Cd). The second most frequent NFR category was 1A1a (Public electricity and heat production). 1A1a was top in measurements of three emissions (NO_X, SO_X, Hg) and occurring in others. The rest of the NFR categories only increased values in its most significant pollutants. Almost all emissions decreased since 2020, except NO_X, SO_X, CO and Hg, which interannually slightly increased. In 2021, there was no important event.

I.6 QA/QC and Verification methods

The date of the last edit of the chapter: 15/03/2022

Quality Control (QC) is a system of routine technical activities used to measure and control the quality of the inventory as it is being developed.

Quality Assurance (QA) activities include a planned system of review procedures conducted by personnel not directly involved in the emission inventory preparation.

The process of air pollutant emission inventory is a part of the Air Quality System and Management in Czechia. According to § 7 of the Air Quality Act 201/2012 Coll., based on collected data, MoE performs the emission inventory comprising the total amount of air pollutants that had been emitted into the atmosphere in the previous year and emission projections with estimates for coming years. CHMI had been authorised to monitor the air quality in Czechia. The process of emission inventory is legally bound with activities of other air quality and integrated prevention control bodies (Czech Environmental Inspectorate and regional authorities).

I.6.1 QC procedures

The basic principle of emission inventory processing in Czechia consists of a dual system, including processing reported data of individual facilities (emissions or activity data enabling emissions calculations) and emission calculations based on national statistics. Despite significant differences between these approaches, quality control procedures are similar to a large extent. They are based on thorough methodology preparation of each annual inventory, including processing time schedules, sector splits to individual editors, consideration of new requirements or results performed revisions a fulfilment of quality control (QC) plan. The real control procedures include, e.g. data completeness checks (mainly for individually monitored sources), consistent approach for necessary specialists´ estimates and thorough documentation of all emission inventory input data as well as procedures of final results processing. These results of quality control checks and procedures are being documented.

A new approach that has been applied since 2018 reflecting Stage 3 recommendations and EMRT review includes changes in methodology for sectorial emission inventory where full completeness of individually collected data needs to be secured. Still, activity data precise enough are available to enable the calculation of emissions relevant for the whole sector. These results replace individually reported data initially chosen for emission inventory compilation by calculating national statistics data and emission factors recommended by EMEP/EEA EIG [3]. The key sector with emission inventory solely based on individually reported emission data will, in the following periods, undergo detailed review, and there will be in case of modification of data selection for emission inventory processing.

During data selection necessary for emission inventory processing, up-to-dateness and completeness are checked. National statistics authority data are being verified for up-to-date data. In the same way, the ISPOP system for reporting individual emission data used for emission inventory is regularly being checked.

The procedure of individual data processing includes data import of each reporting into the national emission database EDA, including a LOG entity drawing attention to reporting that, due to some errors, could not have been taken over for further processing in emission inventory. Such reporting needs to be corrected by the source operator, sent again and consequently imported into the national database EDA. The list of imported facilities is compared with the list of reporting by the ISPOP operator. Random checks of data transfer correctness into the EDA database are being performed.

All individually received data are being checked using internal tests for the completeness of reported emissions. Their correctness is being ascertained, especially non-exceeding the upper expected emission threshold. Similarly, the completeness and correctness of reported activity data used for emission calculations of fuels and products are being checked. Check results are being sent to the source operator, and the correctness of corrections is being supervised. In case of need for supervision authority (environmental inspectorate) is being contacted to supervise the correcting procedure of the source operator.

The processing of reported emissions and activity data is being performed by automatic procedures set up in the national EDA database. These procedures are regularly checked and updated. Nevertheless, the classification of national categories does not usually enable unique sector allocation of each reported emission. Therefore the final processing of the emissions sets takes place in MS Excel. Manual correction of automatic allocation to the NFR sector is being documented. In the final set, including more than 50 thousand items for each year, a summary of individually reported or calculated emissions for individual sectors is being performed.

Collectively monitored sources are processed in some sectors (Transport, Agriculture and Residential sector) using advanced tools of MS Excel or simple table calculations with activity data, emission factors and resulting emissions. All tables are being checked for calculation completeness and logical correctness. In case of any errors, the correction occurs before finalising the reporting or in the form of a resubmission.

The conversion of emission data, either reported or calculated, is done directly in the MS Excel application. Via linking of files, errors can be eliminated while filling in files for reporting. However, several errors appeared in previous reporting periods. Errors were caused by incorrect positioning of emission data in specific rows hidden while further processing, or were not checked or wrongly linked to the file with annual summary data and incorrect reporting period. To eliminate these events test version of interlinked files with accessible data for a better check was prepared. This test version was in the following processing locked for adjustment of linking formulas.

In IIR, single tables are created that incorporate summary or concrete values of emission reporting. Considering the large scale of the document, correct value setting could only be performed in some tables and charts.

The reproduction of individual calculations and data transfers is secured by storing primary files with activity data and emission factors and files with intermediate or final calculations. In case of need, a text record of calculations is being performed.

For simultaneous working of sector solvers or air pollutants, documentation concerning sectors solved by the main contributor (CHMI), including partial and final files archived on a shared disc, is regularly backed up and archived after the end of the reporting period. Similar procedures of data storage take place at external solvers.

I.6.2 QA procedures

Due to the insufficient capacity of experts, review procedures on a national level have yet to be established. The emission inventory team uses recommendations and results of international reviews.

I.7 General uncertainty evaluation

The date of the last edit of the chapter: 15/03/2022

In the process of emission inventories in Czechia there are mainly used the data provided by the operators of stationary sources of air pollution, the statistical data of the CZSO (data on fuel consumption, number of vehicles, number of livestock and area of cultivated land), or from the Population and housing census (information on household heating), using emission factors and other sources of data.

From the above overview, it is clear that the emission data from which the inventory has been compiled are of varying quality. Emissions of individual point sources set based on measurements are determined with less uncertainty than the emissions calculated based on statistical data. The uncertainty of emissions from point sources is below 5% (e.g. emissions from large combustion sources), and the uncertainty of emission data based on a model (e.g. emissions from household heating and exhaust emissions from transport) ranges between 25–30%. The uncertainty of emissions set by statistical data and predefined emission factors is estimated according to the methodology of the EMEP/EEA EIG from 50 to 200% (in this way, the emissions from the use of solvents, animal production and non-combustion emissions from transport are estimated) [3].

I.8 General assessment of completeness

I.8.1 Sources Not Estimated (NE)

Notation key: ´**NE**´ (Not Estimated) for existing emissions by sources of compounds that have not been estimated. Where ´NE´ is used in an inventory, the Party should indicate why emissions could not be estimated. For applying the notation key ´NE´, we mostly accept recommendations in EFs tables of EMEP/EEA EIG [3].

The ´NE´ notation key table is available in the appendix e-ANNEX.

I.8.2 Sources Included Elsewhere (IE)

Label: ´**IE**´ (included elsewhere) for emissions by sources of compounds that are estimated but included elsewhere in the inventory instead of in the expected source category.

Tab. I.4 Sources included elsewhere

NFR s	Longname	Reason for IE
1A3aii(i)	Domestic aviation LTO (civil)	1990 – 1995 included in 1A3ai(i)
1A3aii(i)	Domestic aviation LTO (civil)	CO and PAHs 1996 – 1997 included in 1A3ai(i)
1A4aii	Commercial/institutional: Mobile	1990–1997 included in 1A3b
1A4bii	Residential: Household and gardening (mobile)	1990–1997 included in 1A3b
1A4ci	Agriculture/Forestry/Fishing: Stationary	NH_3 1990–2014 included in 1A4ai
1A5a	Other stationary (including military)	1990–2015 included in 1A4ai
1B2c	Venting and flaring (oil, gas, combined oil and gas)	1990–1999 included in 1B2aiv
2A2	Lime production	PMs 1990–1999 included in 1A2f
2A3	Glass production	PMs 1990–1999 included in 1A2f
2A6	Other mineral products	NOx, SOx 1990–1999 included in 1A2f
2B6	Titanium dioxide production	Main, PMs 1990–1999 included in 1A2c
2C1	Iron and steel production	HCB included in 1A2a; Main, PMs 1990–1999 in 1A2a
2C3	Aluminium production	PMs 1990–1999 included in 1A2a
2C4	Magnesium production	PMs 1990–2001 included in 1A2a
2C5	Lead production	PMs 1990–1999 included in 1A2a
2D3c	Asphalt roofing	CO included in 1A2f; all 1990–1999 included in 1A2f
2H1	Pulp and paper industry	1990–1999 included in 1A2d
3B4h	Manure management - Other animals	NH_3 included in 3Da2a
5C1bi – 5C1biv	Waste incineration	included in 1A1a

II. Key trends

The date of the last edit of the chapter: 15/03/2023

The main monitored pollutants in the Czech Republic and European Union are NO_X, NMVOC, SO_X, NH_3, and $PM_{2.5}$. Other pollutants covered in the chapter are TSP, PM_{10}, BC, CO, POPs (PAHs, HCB, PCDD/PCDF) and heavy metals (Pb, Cd, Hg). Emissions are also regulated by law, and their combustion production is monetized.

In the Key trends chapter are mentioned distributions in 2021. Sorted by trend NFR categories, and compared with data measured in the past, especially years 1990, 2005 and 2020.

II.1 Emissions of most observed pollutants (NO_X, NMVOC, SO_X, NH_3, $PM_{2.5}$)

Air pollution is related to the economic and socio-political situation, environmental knowledge, and development of technology. Emissions levels mostly depend on static sources, especially from categories REZZO 1 and 2. REZZO 1 and 2 sources have been major polluters in the past. However, in the 21st century, people invented and started applying several measuring devices, filtering tools and other abatements to diminish the pollution from the combustion gases. The Czech Republic and European Union also strictly control emissions sources. Strict conditions for REZZO 1 and 2 reduce emissions which can be transported by the atmosphere for a long range.

Although REZZO1 and 2 undergo emissions limits, the required air quality still needs to be achieved. Stricter monitoring should be applied to REZZO 3 and 4 for better air quality results.

Nitrogen oxides (NO_X as NO_2)

NO_X emissions have decreased since 1990 because of heavy industry's lower activity and technological evolution. In 1990 emission of NO_X was 760.29 kt, and in 2005, 301.48 kt. In 2021 the emission was 159.49. In total, emissions decreased between 1990 and 2021 by 602.75 kt.

Most emissions come from NFR 1A1a 32.96 kt (20.7%). The category is sensitive to the population's future expansion and energy demands. Therefore, the EU increases renewable energy sources and creates sustainable development.

Another important source of NO_X pollution is NFR 1A3bi. The NFR 1A3bi category is also influenced by population, EU legislation and law. In 2021 NFR 1A3bi produced 24.14 kt (15.1%) of the total NO_X emissions. The reasons why the pollution from passenger cars is so high are two: At first, the passenger cars in the Czech Republic are one of the oldest in the EU. Second, every second citizen owns a car (583 cars per 1000 citizens). The rest of NO_X emissions come from NFR 1A4cii at 13.36 kt (8.4%), 3Da1 12.12 kt (7.9%), 1A4biii 11.95 kt (7.9%) and others.

Volatile organic compounds (NMVOC)

The emission of NMVOC has a decreasing trend over time. In 1990 emission of NMVOC was 554.5 kt. In 2005 the emission was 274.66 kt, and in 2021 was 186.78 kt. The most NMVOC comes from the NFR 1A4bi 56.74 kt in 2021 (30.4% of total NMVOC emissions). NFR 1A4bi sources are small and pointed but numerous. NFR 2D3d is the second most significant source of NMVOC emissions. The category produced 19.59 kt (10.5%) in 2021.

The remaining emissions come from various parts of agriculture (NFR 3) and the Solvent and produce use (NFR 2D).

Sulphur dioxide (SO_X as SO_2)

The total SO_X emission of 1753.81 in 1990 was the second-highest measured emission. And the highest in the database history of SO_X. Due to shut down of old power stations, shift to low SO_X content fuels, applying desulphurization and combustion adaptation in power generation. These steps dramatically changed the situation. The emission of SO_X has a decreasing trend over time. In 2005 emission of SO_X

was 208.47 kt. In 2021, emission was 69.1 kt. In 2021 the most SO_X emission was contributed by the NFR 1A1a. In NFR 1A1a, is indicated 24.13 kt (34.9%). In NFR 1A4bi 16.8 kt (23.4%). Other important sources of SO_X pollution are categories from the industrial segment.

Ammonia (NH_3)

The emission of NH_3 has a decreasing trend over time. In 1990 emission of NH_3 was 135.77 kt. In 2005 emission was 74.44 kt, and in 2021, 66.77 kt. The main contributors of ammonia emissions are from NFR categories 3Da1 19.22kt (28.8%), 3Da2a 13.53 kt (20.3%), 3B1b 9.37 kt (13.1%), 3B1a 8.8 kt (14.0%) and other categories belonging to the agriculture.

Particulate matter ($PM_{2.5}$)

The emissions measured in 1990 were high, 298.98 kt, because of the production of factory combustions. The emission of $PM_{2.5}$ has a decreasing trend over time. In 2005 emission of $PM_{2.5}$ was 43.71 kt. In 2021 emission was 24.39 kt. The future changes in $PM_{2.5}$ emissions depend on the winter season and the expansion of the population due to 14.78 kt (60.6%) coming from NFR 1A4bi.

II.2 Emissions of TSP, PM_{10}, BC, CO

Total suspended particles (TSP)

The TSP emission in 1990 was 594.22 kt due to shut down of old power plants and intensive desulphurization. The total emission was reduced to 77.66 kt in 2005. The TSP still has decreasing trend. In 2021 was measured at only 47.3 kt.

The achievements in TSP abatement belong to the second most significant in Czech emission inventory considering the percentage ratio. Because TSP refers to the entire range of ambient air matter that can be collected, from the sub-micron level up to 100 μm in aerodynamic diameter (d_{ae}). Particles with a diameter larger than 100 μm will not remain suspended in the atmosphere for a significant time. Compared to PM_{10} and $PM_{2.5}$, TSP remains in the air for shorter periods and is generally not carried over long distances. PM 10 and $PM_{2.5}$ are parts of the TSP.

The NFR 1A4bi was the most contributing sector at 16.21 kt (34.3%), and NFR 3Dc was the second at 6.49 kt (13.7%).

Particulate matter (PM_{10})

The emissions measured in 1990 were extremely high, in total 433.08 kt, because of the production of combustions from factories. The emission of PM 10 has a decreasing trend over time. In 2005 emission of PM 10 was 61.06 kt, and in 2021 emission was 36.76 kt.

Nowadays, the production of PM_{10} mainly depends on the heating season. Therefore, most of the emission comes from NFR 1A4bi 15.11 kt (41.1%), second-highest emission comes from NFR 3Dc, 6.49 kt (17.7%).

Black carbon (BC)

The total emissions of BC depend on $PM_{2.5}$ emissions (EMEP/EEA 2016 guide to estimate BC emission factors). The BC has a decreasing trend. In 1990 was measured at 18.74 kt. In 2005 the emission was 6.32 kt, and in 2021 emission was 3.38 kt.

Carbon monoxide (CO)

The CO emissions have a stable decreasing trend with slight fluctuation. The total CO emissions of 2040.19 kt in 1990 were the highest emission, the highest emission in the Czech Republic database history. Through time, the CO emissions come especially from NFR 1A4bi. In 2005 emission of CO was 944.58 kt, and in 2021 emission was 790.2 kt.

Most of the emissions come from NFR 1A4bi, 458.18 kt (58%). Followed by the emission of NFR 1A2a, 91.78 kt (11.6%), and NFR 2C1, 90.1 kt (11.4%).

II.3 Emissions of POPs

Polyaromatic Hydrocarbons (PAHs)

The emission of PAHs has a decreasing trend over time. In 1990 emission of PAHs was 282.01 t, and in 2005 emission was 41.56 t. The decline was due to the reduced coke industry, and heavy industry is slowly disappearing. In 2021 it was 30.01 t and the only source of emission was NFR 1A4bi 27.43 t (91.4%).

Hexachlorobenzene (HCB)

The emission of HCB has a decreasing trend over time. In 1990 emission of HCB was 536.5 kg, and in 2005 emission was 14.65 kg. In 2002 the primary sources of emission NFR 2C3 were limited, and precursors of HCB were prohibited. In 2021 the emission of HCB was 11.09 kg. The most HCB emission was contributed by the NFR 1A4bi, 7.91 kg (71.4%), and NFR 1A1a, 2.66 kg (24%).

Polychlorinated dibenzo-p-dioxins and furans (PCDD/PCDF)

PCDD/F emissions has decreasing trend over time. The emission of PCDD/PCDF in 1990 was 106.01 g I-TEQ, and in 2005 was 64,01 g I-TEQ. The total emission PCDD/PCDF in 2021 was 22.17 g I-TEQ. The remaining amount of PCDD/PCDF emission is covered by NFR 1A4bi, 8.47 g I-TEQ (38.2%) followed by NFR 5E, 4.29 g I-TEQ (19.4%), NFR 2C1, 3.04 g I-TEQ (13.7%), and others.

II.4 Emissions of heavy metals

Lead (Pb)

The emission in 1990 was high, 316.59 t. In the year 2001, emissions dropped due to the end of the use of leaded petrol in transport activities. Since 2001 the Pb pollutant has had a slightly fluctuating trend. In 2005 emission of Pb was 38.96.96 t, and in 2021 emission was 14.68 t.

The biggest producer of Pb emission was NFR 2C1, 3.55 t (24.2%), followed by NFR 2G , 2.33 t (15.9%) and NFR 1A3bvi, 2.31 t (15.8%).Other important sources of Pb emission are NFR 1A4bi, 1A1a and 1A3aii(i).

Cadmium (Cd)

The emission of Cd has a decreasing trend through time. In 1990 emission of Cd was 5.28 t, in 2005 1.75 t, and in 2021 emission was 1.27 t. The main contributors of Cd emission are NFR 1A4bi at 0.61 t (48.4%), 1A1a 0.14 t (10.7%), 2C1 0.13 t (10.1%), and other categories belonging to the Industry.

Mercury (Hg)

The emission trend of Hg is decreasing. In 1990 emission of Hg was 5.2 t. In 2005 emission was 3.33 t, and in 2021 was 2.07 t. From NFR 1A1a comes the majority of emission 0.95 t (46.1%). The following sources of emission are also in connection with combustion from small stationeries. The NFR 1A4bi produced 0.27 t (12.9%) of Hg. And the NFR 1A2a produced 0.2 t (9.7%).

II.5. The overview of emissions

II.5.1. The history of regulated pollutants from 1990 to 2005.

In 1991 Act No. 309/1991 Coll. on Air Protection supplemented by Act No. 389/1991 Coll. on State administration in Air Protection and charges for Air Pollution came into force for the first time in Czechoslovakia (later Czech Republic) history. After Czechoslovakia fell apart in 1993, the Czech Republic took over international commitments CRLTAP (Convention of long-range Transboundary air pollution). As same as another eight international protocols (such as Protocol of Further Reduction of Sulphur Emissions and Protocol on Heavy Metals). Therefore, Czechia implemented the emission limits and fees per ton for SO_2, NO_X, and $PM_{2.5}$, starting to be effective in 1998. This program should prepare the sources for the new operating conditions. The national economy was restructured, the factories were modernised, and many closed or reduced their operation. For example, the iron and steel sector decreased production significantly between 1992–1994. Old boilers were shut down or modernised in the electricity and heat production sector. During 1993–1998, the coal-burning power stations were desulphurised. The combustion sources with lower heat consumption (heating plants/boiler houses) were gradually replaced solid and liquid fossil fuels with natural gas. More pollutants were charged with fees, and the fee rates for emission release rose. As a result, emissions of all pollutants of REZZO 1 and 2 categories decreased. In 2002 law 309/1991 Coll. on Air Protection was replaced by new law Act No. 86/2002 Coll. on Air Protection (and completed by Act No. 86/2002 Coll. Air Quality and Act No. 76/2002 Coll. Integrated Prevention (IPPC) in connection with the best available technique (BAT) and Integrated Pollution Register (IPR). Since 2004 the Czechia has been a part of the European Union, and new international laws came into force: Aarhus Convention on Access to information, European Environmental agency which controls and summaries data on EIONET, European Release and Transfer Register and many more.

II.5.2. Emissions of regulated pollutants from 2005 until the present

Before 2005 Czechia was one of the biggest air polluters in Europe. Since 2005, the air quality conditions have been much better.

New laws and amendments have come into force. In the Czechia the law 86/2002 Coll. on Air Protection was replaced by Act No. 201/2012 Coll. on Air Protection and two years later was amended by Act No. 64/2017 Coll. which changed some parts of low on Air Protection, due to connection with the adoption of the control condition. Act No. 25/2008 Coll. on Integrated Pollution Register, also Integrated Environmental Reporting System (IERS) are one of the most effective and have a long-term effect on improving air quality. In 2016 the Integrated Environmental Reporting System was modified. Moreover, EU E-PRTR also came into effect in 2019.

The emissions of regulated pollutants are on the same value level with a slight deviation. Due to regulations and applied abatements, the pollution level is less sensitive to growth in industry, agriculture, population, and other connected activities. Compared to the previous year, monitored emissions decreased or stayed at the same level, except for SO_X, NO_X, CO and Hg in 2021. The SO_X emissions are higher by 1.87 kt, although a moderate increase from all NFR categories. The NO_X emissions are higher by 3.07 kt mainly because of emissions from NFR 1A1a (Public electricity and heat production). The CO emission increased by 1.46 kt in 2021. The most significant increase is in NFR categories 1A4bi and 1A2a. The rise of Hg levels is moderate, only 0.08 t.

II.5 Summary

NFR 1A4bi (Residential stationary) was the most significant emissions source, contributing enormously to nine emission species (NMVOC, $PM_{2.5}$, TSP, PM_{10}, CO, PAH, HCB, PCDD/PCDF, and Cd) in 2021. The second most significant source was NFR 1A1a (Public electricity and heat production), contributing enormously to three emissions components (NO_X, SO_X, Hg) and occurring in others. Data for every emissions components are in the table down below. The rest of the NFR categories have increased values only in its most significant pollutants (ex., Ammonia was most represented by agriculture).

Only NO_X, SO_X, CO and Hg emissions increased from year to year. The increase of NO_X emissions is because of higher activity of NFR category 1A1a (Public electricity and heat production) during 2021. SO_X, CO and Hg emissions are higher due to a slight increase in several related NFR categories. In 2021, only important event was the reduced mobility of inhabitants. Consequently, heating production and other related categories slightly increased.

Tab. II.1 Key categories of air pollutants in Czech Republic in 2021

Component	Key categories Sorted from high to low												total 2021	2020	2005	1990
NOx	**1A1a**	**1A3bi**	**1A4cii**	**1A3biii**	**3Da1**	**1A4bi**	**1A2f**	**1A3bii**	**1A4ai**	**other**						
%	20.7	15.1	8.4	7.9	7.6	7.5	5.3	4.9	4	18.6						
[kt]	32.96	24.14	13.36	12.64	12.12	11.95	8.45	7.85	6.41	29.61			159.49	156.42	301.48	760.29
NMVOC	**1A4bi**	**2D3d**	**2D3a**	**3Da2a**	**3B1b**	**3B1a**	**2D3g**	**2D3i**	**1A3bv**	**1A3bi**	**1A1a**	**other**				
%	30.4	10.5	6.7	6	5.9	5.3	5.1	3.6	3.1	2.8	2.5	18.1				
[kt]	56.74	19.59	12.6	11.27	11.01	9.86	6.76	5.58	5.73	5.31	4.71	37.62	186.78	193.97	274.66	554.5
SOx	**1A1a**	**1A4bi**	**2B10a**	**1A2a**	**1A2f**	**other**										
%	34.9	23.4	12.3	8.6	4.7	16.1										
[kt]	24.13	16.17	8.51	5.94	3.22	11.12							69.09	67.22	208.46	1753.81
NH3	**3Da1**	**3Da2a**	**3B1b**	**3B1a**	**3B3**	**other**										
%	28.8	20.3	14	13.2	7.1	16.6										
[kt]	19.22	13.53	9.37	8.8	4.73	11.12							66.77	67.13	74.44	135.77
PM2,5	**1A4bi**	**1A4cii**	**1A1a**	**1A3bvi**	**1A3bi**	**2G**	**5C2**	**other**								
%	60.6	4.7	3.9	3.7	3.5	2.9	2.4	18.3								
[kt]	14.78	1.13	0.95	0.9	0.86	0.7	0.59	4.48					24.39	24.96	43.71	298.98
TSP	**1A4bi**	**3Dc**	**1B1a**	**1A3bvi**	**2A5a**	**1A3bvii**	**3B4gi**	**1A1a**	**3B3**	**1A4cii**	**2A5b**	**other**				
%	34.3	13.7	6.3	4.7	3.9	3.7	3.4	3.3	3.3	2.5	2.3	18.6				
[kt]	16.21	6.49	2.99	2.22	1.85	1.75	1.59	1.55	1.54	1.21	1.08	8.82	47.3	47.85	77.66	594.22
PM10	**1A4bi**	**3Dc**	**1A3bvi**	**1B1a**	**1A1a**	**1A4cii**	**2A5a**	**1A3bvii**	**1A3bi**	**other**						
%	44.1	17.7	4.6	3.9	3.5	3.3	2.9	2.4	2.4	15.2						
[kt]	15.11	6.49	1.69	1.41	1.3	1.21	1.06	0.87	0.86	6.76			36.76	34.4	61.06	433.08
CO	**1A4bi**	**1A2a**	**2C1**	**other**												
%	58	11.6	11.4	19												
[kt]	458.17	91.77	90.1	150.15									790.19	788.73	944.58	2040.03
PAH	**1A4bi**	**other**														
%	91.4	8.6														
[t]	27.43	2.58											30.01	31.5	41.56	282.01
HCB	**1A4bi**	**1A1a**	**other**													
%	71.4	24	4.6													
[kg]	7.91	2.66	0.52										11.09	12.68	14.65	536.5
PCDD/F	**1A4bi**	**5E**	**2C1**	**5C2**	**1A3bi**	**other**										
%	38.2	19.4	13.7	6.4	5.7	16.6										
[g I-TEQ]	8.47	4.29	3.04	1.41	1.25	3.71							22.17	26.72	64.01	106.01
Pb	**2C1**	**2G**	**1A3bvi**	**1A4bi**	**1A1a**	**1A3aiii**	**other**									
%	24.2	15.9	15.8	9.8	9.2	7.3	17.8									
[t]	3.55	2.33	2.31	1.44	1.35	1.08	2.62						14.68	16.03	38.96	316.59
Hg	**1A1a**	**1A4bi**	**1A2a**	**5C1bv**	**2C1**	**other**										
%	46.1	12.9	9.7	8.5	4.4	18.3										
[t]	0.95	0.26	0.2	0.17	0.09	0.4							2.07	1.99	3.33	5.2
Cd	**1A4bi**	**1A1a**	**2C1**	**2G**	**2C6**	**other**										
%	48.4	10.7	10.1	8.9	4.8	17.1										
[t]	0.61	0.14	0.13	0.11	0.06	0.22							1.27	1.25	5.28	5.28

III. Energy (NFR 1)

The date of the last edit of the chapter: 15/03/2023

This sector includes all combustion emissions (stationary and mobile). Furthermore, it includes fugitive emissions from the energy sector. The emission data from this sector are based on operator-reported emissions or calculations.

Stationary sources operators listed in Annex 2 of Act 201/2012 Coll. are obliged not to exceed the emission limits set and fulfil other operating permit conditions. For stationary combustion sources, these obligations are obligatory for all combustion sources exceeding the rated thermal input of 0.3 MWt.

Specific emission limit values for stationary combustion plants are stated in Annex 2 to Regulation 415/2012 Coll. They are set for SO_X, NO_X, TSP and CO and depend on rated thermal input and type of fuel used (Tier 3). The PM_{10} and $PM_{2.5}$ emissions are determined based on information on abatement equipment and fuel type. The ammonia emissions are calculated using emission factors (equipment below 5 MW input) and at some sources with $DeNO_X$ technology reported by the source operator. For inventorying of HMs and POPs, please refer below.

Operators of specific sources must also measure some of the other pollutants by law (Annex 4 to Act. 201/2012 Coll.)

Furthermore, limits for the other pollutants are set in operating permits of individual sources. Emissions of obligatorily monitored pollutants unavailable for a concrete source in a certain year are calculated using the emissions reported in the nearest year and activity data (own emission factors). Emissions of pollutants that are not reported are calculated from activity data (total annual amount of energy input in TJ) and emission factor in mg/GJ. The total annual amount of energy input is calculated from fuel consumption and net calorific values; operators also report them in summary operating records. Czech emission factors are predominantly based on either own measurements and partly taken from the EMEP/EEA EIG (Tier 2) [3].

Emissions of road-mobile sources are estimated according to recommendations in the COPERT model; for non-road machinery, we mainly use emission factors of EMEP/EEA EIG and activity data of national statistics [3].

The sectors are the most important sources in key categories for emissions of SO_X (NFR 1A1a – 39.4%, NFR 1A4bi – 21.6%), NO_X (NFR 1A1a – 18.5%, NFR 1A3bi – 14.9%), NMVOC (NFR 1A4bi – 36.6%), CO (NFR 1A4bi –66.9%), TSP (NFR 1A4bi – 48.7%), PM_{10} (NFR 1A4bi – 55.3%), $PM_{2.5}$ (NFR 1A4bi – 71%), Hg (NFR 1A1a – 43.3%), Cd (NFR 1A4bi – 52%), PCDD/F (NFR 1A4bi – 27.9%, 1A2a – 20.9%), PAHs (NFR 1A4bi – 98.1%) and HCB (NFR 1A4bi – 74.9%).

III.1 Large stationary sources (NFR 1A1; 1A2; 1A3$_e$; 1A4)

This chapter covers emissions of the most important group of combustion sources like power generation (public and industrial), heat generation for district heating and technological combustion processes in the industry, like solid fuels transformation or for production and processing of metals, raw materials, chemicals etc.

Information about combustion processes in the sector of services (NFR 1A4ai), agriculture (NFR 1A4ci), military (NFR 1A5i) and household (NFR 1A4bi) are given in chapter III.2.

The criterion for source allocation to NFR 1A1a there is the nominal thermal input and classification NACE. Combustion plants represent NFR 1A1a for producing public electricity and heat with total rated thermal input equal to or greater than 50 MW (according to aggregation rules pursuant to article 29 of the Directive 2010/75/EU on Industrial Emissions – IED), regardless of the type of the used fuel.

These sources are classified according to IED as Large Combustion Plants – LCP. This sector is characterised by a relatively small number of operation units (60 in 2021).

Emissions from facilities for waste incineration with heat recovery are also allocated in this sector according to good practice (EMEP/EEA EIG, see chapter VI.4.1) [3].

NFR 1A1b includes fuel combustion in boilers and process furnaces on the production unit. NFR1A1c covers coal heat treatment (coke ovens, briquetting plants and drying). NFR 1A3e includes only emissions from gas transport.

Distribution of the combustion sources into NFR 1A2a to 1A2gviii is done according to the NACE classification of the source operator. Combustion sources for heat production or power generation are being categorised according to NACE classification in the metal industry (NACE 24), chemical industry (NACE 20 a 21), paper production (NACE 17 and 18) and food production (NACE 10, 11 and 12). Raw material production and processing sites (NACE 07, 08, 09, 23, 41 and 42) are collected in NFR 1A2f and other activities in the processing industry (for instance, 13 – 16, 22, 25 – 33) in NFR 1A2gviii. These are then, in a specific way, divided among NFR categories of sources where processing combustion – processing heating etc., take place. In the e-ANNEX is placed link between the NFR category and classification pursuant to Czech laws (technological sources with the combustion of fuel only significant changes in allocation emissions of NO_X, CO (or other emissions from fuel combustion) were newly made in connection of controls performed by TERT. These emissions were, in most cases, transferred from NFR categories 2A and 2C to 1A2f, 1A2a or 1A2b. This also applies to NO_X and CO emissions from electric furnaces (especially in producing glass, cast iron and non-ferrous metals). NFR 1A2a includes HCB emissions from sintering belts (NFR 2C1 Iron and steel production). Other emissions from sintering belts (also for NO_X, SO_X, TSP, Hg and PCDD/F) are reported by source operators, and other reported emissions are calculated. All emissions are classified in NFR 1A2a in the calculation system because their distribution according to the NFR categories would be technically demanding in the Czech point sources inventory system and could lead to errors. For further detail, please see e-ANNEX.

The development of fuel bases for stationary sources divided into aggregated sectors (GNFR) in 1990–2021 is illustrated below in Fig. III.1 to Fig. III.3.

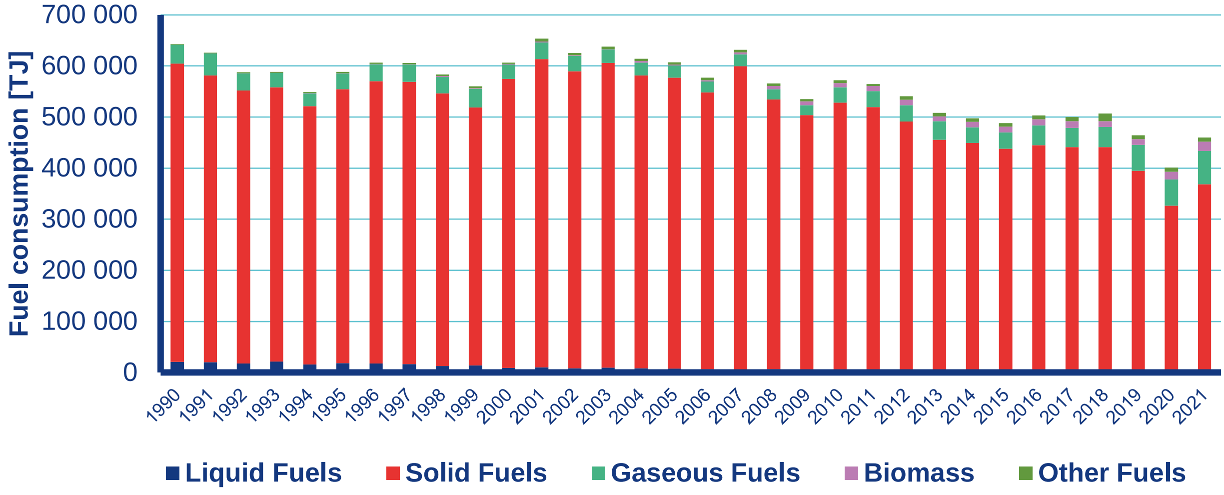


Fig. III.1 Fuel consumption for GNFR sector A_PublicPower, 1990–2021

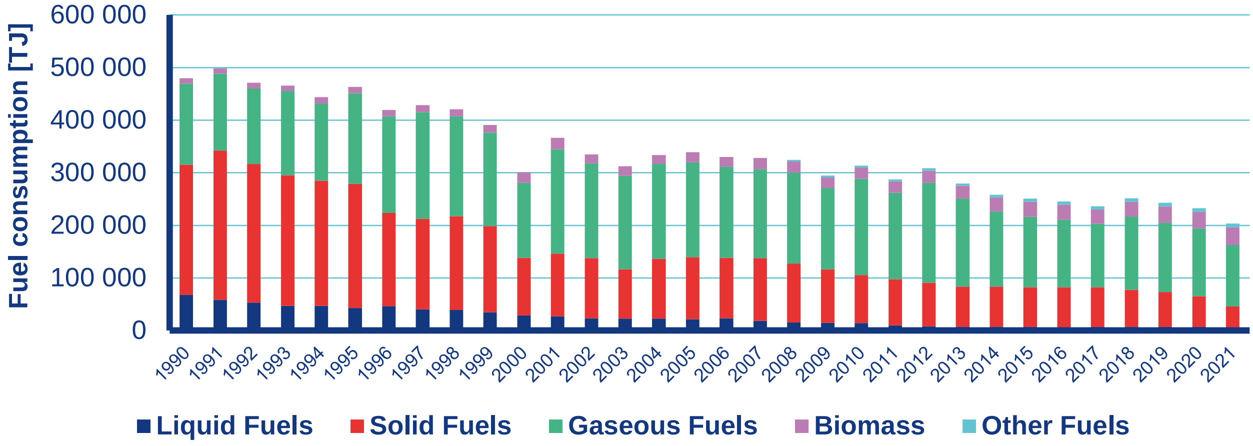


Fig. III.2 Fuel consumption for GNFR sector B_Industry, 1990–2021

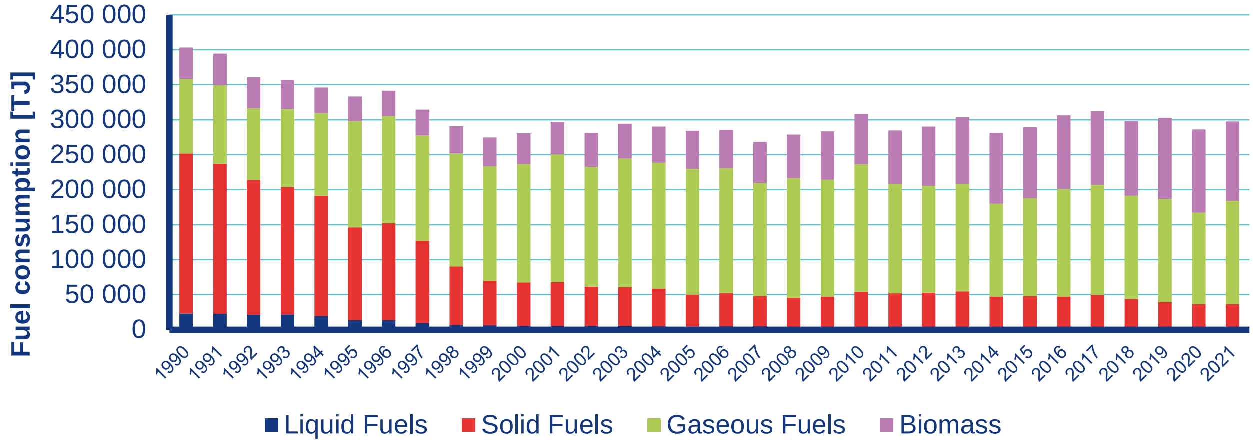


Fig. III.3 Fuel consumption for GNFR sector C_OtherStationaryComb, 1990–2021

Since the 1990s Czech refineries underwent rapid development due to increasing production capacities as well as the need to meet ever more restrictive requirements of environmental legislature. The development of crude oil consumption is presented in the chart below (Fig. III.4).

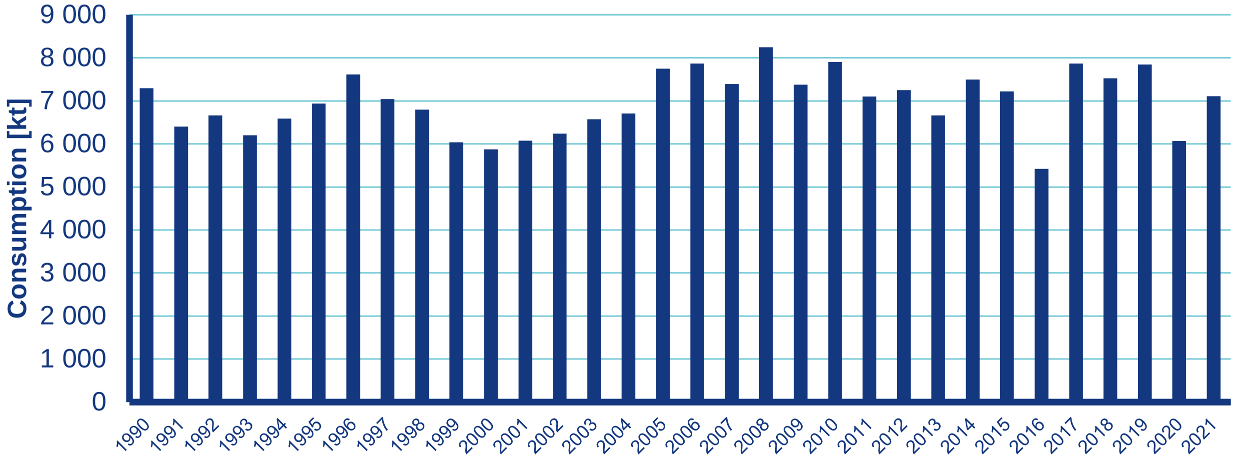


Fig. III.4 Crude oil consumption, 1990–2021

Crude oil refining is essential to the economy of Czechia, not only due to the production volumes reached but also to its broader significance (ensuring energy safety and the close connection with the third most important manufacturing sector: the chemical industry). Operational accidents in both refineries Litvínov and Kralupy caused a strong decrease in 2016. Distribution of emissions from processes operated in refinery Litvínov and follow-up emissions from petrochemical processing of petroleum products was revised and transfers of SO_X, NO_X and NMVOC emissions were made in some years between NFR1A1b, 1A2c, 1B2aiv, 1B2c and 2B10a. For further detail, please, see e-ANNEX.

There is only one technology for coal gasification in Czechia in the former town gas facility Sokolovská uhelná near a lignite mine. Generator gas, after purification, is combusted for power generation. Three coke plants operate in the Ostrava region, producing mainly metallurgy coke.

Sources for district heating with rated thermal input from 0.3 MW and less than 50 MW are included in NFR 1A4ai (Commercial/institutional: Stationary) and 1A4ci (Agriculture/Forestry/Fishing: Stationary).

III.1.1 Emission factors and calculations

The fuel base consists mainly of solid fuels, which are burned primarily in dry-bottom and fluidised bed boilers. Solid fuels are represented mainly by pulverised brown coal (app. 70%) and pulverised hard coal (app. 10%), followed by various types of biomass (wood and other biomass). In addition to solid-fuel boilers in this category, oil-fired and gas-fired boilers, burning mainly natural gas, are represented. Natural gas and fuel oils are also stabilising in solid-fuel boilers.

These plants' specific emission limit values are stated in Annex 2 to Regulation 415/2012 Sb. (see e-ANNEX). Their emission limit values can be set in operating permits of individual sources; in the case of all LCP sources, it is an integrated permit pursuant to Act 76/2002 Coll. on integrated prevention.

Emissions of pollutants that are not reported are calculated from activity data (total annual amount of energy input in TJ) and emission factor in mg/GJ (see e-ANNEX). The methodology is the same for all stationary sources in categories 1A1, 1A2, 1A3ei, 1A4ai and 1A4ci. NH_3 emissions for 1A2 and 1A4ai were newly calculated for all installations under 5 MW thermal input (37 g/GJ for biomass, 0.2 g/GJ for coal). For categories not assuming operation of equipment with rated thermal input below 5 MW, we use notation key NA for ammonia emission. For NFR 1A2a, the TSP and PMs emissions have lowered significantly since 2016 due to the installation of modern bag filters. In the e-ANNEX are placed EFs for calculating HMs, POPs and NH_3 emissions.

The specific calculation is performed for emissions of NFR 1A1c. Based on the TERT recommendation, emissions of PAHs from coke production (heating of coke oven batteries and other combustion sources related to solid fuels transformation) originally reported by operators were newly recalculated. The procedure of calculation recommended in a research report (KONEKO marketing, spol. s r.o., Ing. Neužil) is described in e-ANNEX.

III.1.2 Uncertainties and QA/QC procedures

According to national legislation, emissions for large stationary sources of NFR 1A are determined based on continuous or periodic measurements that comply with European legislation (IED, MPCD and previous directives). The uncertainty of the sum of emissions from those sources is below 5%; see also chapter I.7 General uncertainty evaluation.

QA/QC for NFR 1A1a is the same as in the case of other stationary point sources; see also chapter I.6 QA/QC and Verification methods.

In addition to these general checks, further validation mechanisms take place under international reporting performed annually since the reporting period 2003 pursuant to valid European legislation. It includes information about the annual emissions of SO_X, NO_X and TSP and activity data (heat supplied).

Data are being submitted via the EIONET (European Environment Information and Observation Network) system, which is subjected to further checks. Since 2013, data have been inserted via a web form with an implemented control mechanism, specifically focusing on filling out required items and desired numeric formats.

Before making the completed form accessible to the public, automatic validation checking possible errors preventing from submission is to be activated. Additionally, warning about possible errors that cannot prevent the submission also occurs, but the inserted data are to be checked.

The following checks take place:

- basic data completeness
- unequivocal naming of plants
- consistency of plant ID and name over time
- location check (coordinates)

• E-PRTR ID (in case threshold values are exceeded and the source must report to the EPRTR registry)

- rated thermal input value
- plausibility of fuel input
- share in overall reported emissions
- SO_X (as SO_2), NO_X (as NO_2) and TSP emission outlier test:
- a significant difference in reported and expected SO_X (as SO_2), NO_X (as NO_2) and TSP emissions,

- consistency with emission trends at the national level.

III.1.3 Planned improvements

No improvements are planned, and the chapter is considered to be final.

III.2 Smaller and area stationary sources (NFR 1A4 and 1A5)

Combustion sources for heat production or power generation are being categorized according NACE classification in NFR 1A4ai District heating (NACE 35), NFR 1A4ci Agriculture/Forestry/Fishing (NACE 01–03) and tertiary sector (Commercial/institutional - self-employment, offices, public health, education etc.). In a specific way there are then divided among NFR sectors of sources where processing combustion – processing heating, drying of agricultural products etc. take place. Military combustion sources are allocated in NFR 1A5a. The methodology for NFR 1A4ai and 1A4ci is the same as in the case of NFR 1A1a (see chapter III.1). Natural gas consumption in NFR 1A4ai with thermal input below 0.3 MW is calculated as subtraction of natural gas consumption of all individually and collectively monitored sources from total natural gas consumption in Czechia (data obtained from the CZSO).

Residential sources in NFR 1A4bi belong among collectively monitored sources and they are described in the next part of chapter. NFR 1A4bi includes emissions from local household heating, cooking and water warming. The emission inventory is prepared at Tier 2 approach.

Fuel consumption is being ascertained by CZSO that hands over the data via international questionnaires to EUROSTAT and other institutions. These data represent basic input for emission inventory (Fig. III.5). The consumption of individual coal fuels is being taken over directly from international questionnaire CZECH_COAL in natural units. The caloric values, stated summary in this questionnaire under item “For other uses”, do not correspond to real calorific values of coal fuels distributed to households. The recalculation to energy units was therefore done using caloric values annually ascertained by statistic census among fuel producers in structure of deliveries for power generation, industry and population [7]. This census also discovers other quality characteristics of coal fuels – ash, sulphur and carbon content. From biomass consumption stated in questionnaire CZECH_REN there was according statistic census of MIT segregated consumption of briquettes and pellets [8]. For recalculation of LPG consumption from natural units (questionnaire CZECH_OIL) to energy units the calorific value 45.9 $MJ.kg^{-1}$ was used. Data about consumption of gaseous fuels for emission inventory are taken over directly from energy balance of EUROSTAT.

Data about distribution of total fuel consumption according combustion equipment type (e-ANNEX), structure of combustion equipment in households, share of wet wood combustion and other parameters had been discovered by statistic census ENERGO 2021. The overview of combustion equipment structure in period 1990–2021 was prepared by combination these results with other statistics (SLDB, ENERGO 2021, sales of boilers). The significant change of heating equipment ratio is in Tab. III.1, where the data from ENERGO 2015 and ENERGO 2021 are compared.

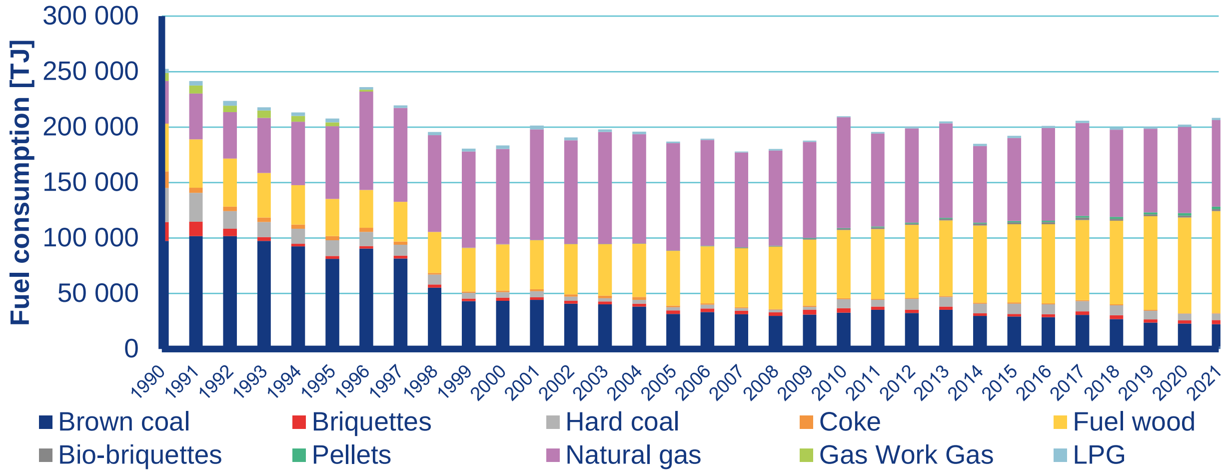


Fig. III.5 Fuel consumption in sector local heating of households, 1990–2021

Tab. III.1 Distribution of solid fuel consumption according type of heating equipment in 2021

Installation type / fuel type	ENERGO	Over-fire boilers	Under-fire boilers	Automatic boilers	Gasification boilers	Stoves/fireplaces
				[%]		
Brown coal	2015	23	31	33	9	5
	2021	6	45	36	9	4
Briquettes	2015	53	22	6	5	14
	2021	35	37	6	12	10
Hard coal	2015	53	15	23	6	5
	2021	23	35	31	8	3
Coke	2015	88	9	1	0	2
	2021	77	8	13	0	2
Wood - dry	2015	31	17	4	19	29
	2021	34	14	4	22	26
Wood - wet	2015	32	14	3	13	38
	2021	30	14	9	8	39
Bio-briquettes	2015	17	9	5	11	59
	2021	24	9	3	11	53
Pellets	2015	0	1	56	0	44
	2021	6	1	40	3	50

III.2.1 Emission factors and calculations

Combustion ammonia emissions for equipment below 5 MW until 2014 is performed solely from total fuel consumption and emissions are reported only in NFR 1A4ai. For data since 2015 ammonia emissions are calculated in individual categories 1A2 and 1A4. Emission factors for solid fuels combustion (NFR 1A4bi) were derived from results of VEC VŠB measurement at nominal heat rating for all monitored pollutants. The values were set for over-fire boilers, under-fire boilers, gasification boilers and automatic boilers. For category stoves, grates and cookers there were used same values of emission factors as for over-fire boilers (similar mode of combustion). Based on the EMRT review, the EFs of Hg for solid fuels were newly taken over from EMEP/EEA EIG and the emissions were recalculated for all years [3].

Emission factors for other fuels were taken over from EMEP/EEA EIG and Methodology Instruction of CME. The overview of emission factors for emission inventory in household heating sector and more information about combustion measurements of VEC VŠB is available in e-ANNEX.

At the same time, there was a change in the emission factor used for estimating NH_3 emissions when burning biomass in boilers with an input of up to 5 MW. The new emission factor was calculated as an average from the emission factors of the European countries which do not use Guidebook emission factor values. The new value of NH_3 emission factor is newly 5.2 $g.GJ^{-1}$.

Significant recalculation was performed for NMVOC emissions from residential heating in y. 2021. The preceding emission factor stated only for emissions of organic compounds expressed as TOC including also CH_4 emissions, was recalculated. For further detail please see e-ANNEX.

Based on the ENERGO 2021 survey results, the proportion of burned dry wood was newly determined, which changed the previous information significantly. The ratio 92% for dried (dry) wood and 8% for non-dried (wet) wood is used for the entire period 1990–2021 and for the emission projection.

From the first measurement results of newly sold boilers, the NMVOC emission factor for newly sold filling boilers was determined. For further details, please see e-ANNEX.

III.2.2 The condensable component of PMs emissions

Detailed description in chapter I.4.3. The table of the condensable component is given in e-ANNEX.

III.2.3 Uncertainties and QA/QC procedures

The chapter will supplied later.

III.2.4 Planned improvements

Currently, an extensive verification of the emission factors of older boilers is conducted. The measurements of newly sold boilers and stoves are in progress at the same time. The results will be processed for reporting in 2025.

The calculation model will also be updated and include more accurate information about the sales of new heating equipment and replacements of energy sources (such as the transition from fuel combustion pumps).

III.3 Transport (NFR 1A3)

The chapters III.3.1, III.3.2, III.3.3, III.3.5 and most of III.3.4 were prepared by CDV. Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery in the chapter III.3.4 was prepared by VUZT. Sorting criteria of means of transport are the type of transport, the fuel used and the emission standard that a particular vehicle must meet (in road transport). Categories of vehicles are not so detailed for non-road transport and mobile sources.

Activity data and main emission factors for all subsectors are displayed in the figures below. National EF is noted as country specific (CS).

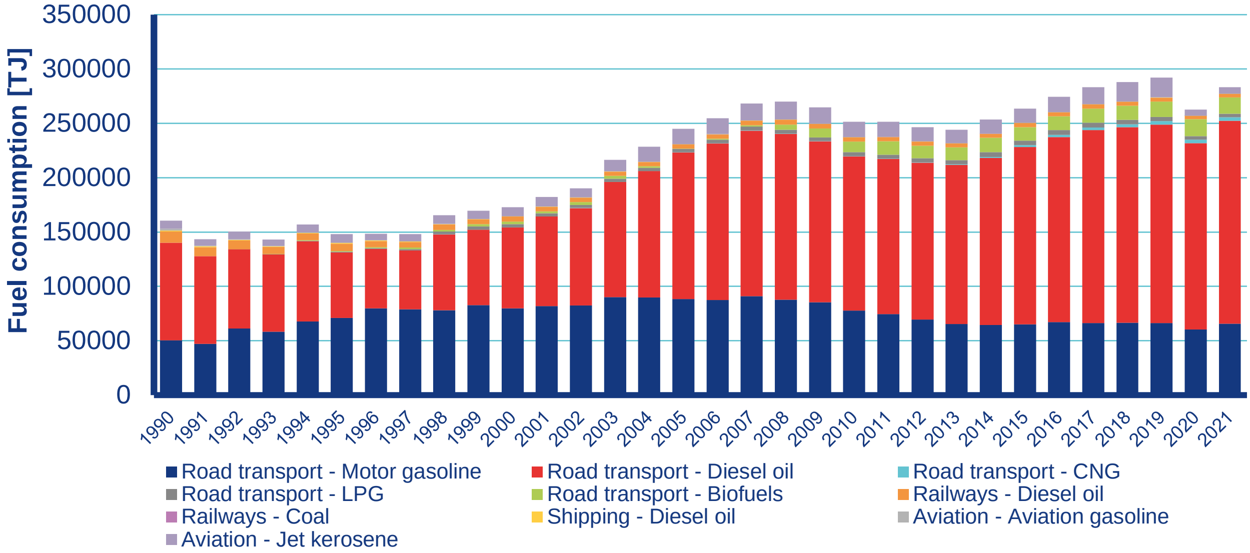


Fig. III.6 Annual fuel consumption by all modes of transport, 1990–2021

The chapter III.3.1 presents the most significant category: emissions from road transport in Czechia. Estimations were made for the following vehicle categories: passenger cars (PCs), light duty vehicles (LDVs), heavy duty vehicles (HDVs), buses and motorcycles (L-category). For calculation purposes, the vehicle categories were broken down by the type of fuel and EURO norms according to COPERT 5 categories.

Since 2005, emissions of NO_X, NMVOC, $PM_{2.5}$ and others from road transport have sharply decreased due to use of catalytic converters and engine improvements (a result of a continual strengthening of emission limits) and a higher quality of fuels. For buses and heavy duty vehicles (over 3.5 t of total permissible vehicle weight), maximum permissible levels of hydrocarbon (HC, incl. NMVOC) emissions were sharply lowered especially because of the introduction of the EURO 3 standard in 2000.

In 2020, there was a significant reduction in transport emissions as a result of COVID-19 pandemic. The drop in emissions was caused by the substantial decrease in activity for all modes of transport, and particularly affected aviation. In 2021, the total fuel consumption in transport sector jumped back to values similar as before pandemic. However, the fuel consumption in aviation and shipping almost did not change in comparison to year 2020. The consumption of aviation gasoline in 2021 was exactly the same as in 2020, the consumption of jet kerosene increased by 12% and the consumption of diesel oil in shipping increased only by 0.4%. In 2021, the consumption in road transport increased for all fuels (by up to 9%) except for biofuels where a slight decrease was noted (by 3%).

III.3.1 Road transport emissions (NFR 1A3b)

In this chapter, an overall view and basic information about subcategories in road transport are given. More detailed information about particular subcategories is given in the respective subchapters. Content and structure of these subchapters are not uniform as every subcategory has its own important information to point out.

The appropriate distribution is necessary to assign a relevant emission factor. NFR 1A3b Road Transport is split into seven subcategories:

- 1A3bi Passenger Cars

- 1A3bii Light Duty Vehicles
- 1A3biii Heavy Duty Vehicles
- 1A3biv Mopeds & Motorcycles
- 1A3bv Gasoline Evaporation (see chapter III.3.2)
- 1A3bvi Automobile tyre and brake wear (see chapter III.3.2)
- 1A3bvii Automobile road abrasion (see chapter III.3.2)

III.3.1.1 Methodology and results

Methodology for the calculation of emissions from road transport is based on COPERT 5.5.1 model on Tier 3 level. The basis of emission calculations in COPERT 5.5.1 are number of vehicles, average annual mileage and average total mileage for COPERT categories. Other important variables are:

- CS meteorological information
- EU average information about driver behaviour (trip length, trip duration, average speed on different roads, etc.)
- Technical parameters of vehicles (technologies for emissions reduction, A/C in vehicles, tank size, number of axles, etc.)
- Fuel quality and composition of fuel
- Calorific value of fuels (from CZSO)

This is only a brief summary. Full description of COPERT 5.5.1 program is to be found in COPERT Documentation. COPERT 5 is based on 2019 EMEP/EEA EIG [3]. Full methodology of application of COPERT 5 in Czechia is described in Pelikán, Brich 2017 and Pelikán, Brich 2018 [9].

Activity data

AD for COPERT program are gained from two large databases - Czech Car Registry (CCR) and Database of Technical Control Stations (TCS). CCR contains information about number of vehicles and technical details of vehicles registered in particular categories in CZ. TCS defines annual traffic performance for a particular car. By combining these two databases it is possible to obtain number of vehicles, average annual mileage and average total mileage for all COPERT categories which are relevant in CZ. Results are in full accuracy four years before the actual reported year. The reason is that new private cars in CZ have to undertake technical control after four years after signing in CCR. To have precise emissions estimates it is necessary to recalculate those four years retrospectively. For the recent submission it was 2017 – 2020. This calculation procedure was developed by Brich in 2014, and the methodology was certified by MoT [10]. COPERT uses these AD to calculate fuel consumption in all categories. Fuel consumption in categories is normalized with the help of total fuel consumption provided by CZSO.

Changes in input COPERT data are described in the chapter VIII.2.1.2, which is focused on the following topics:

- Changes due to update of activity data related to switching to a new version of COPERT program in September 2021 and to a new structure of input data
- Changes due to analyses of Czech Car Registry and Database of Technical Control Stations
- Changes due to updated activity data from CZSO

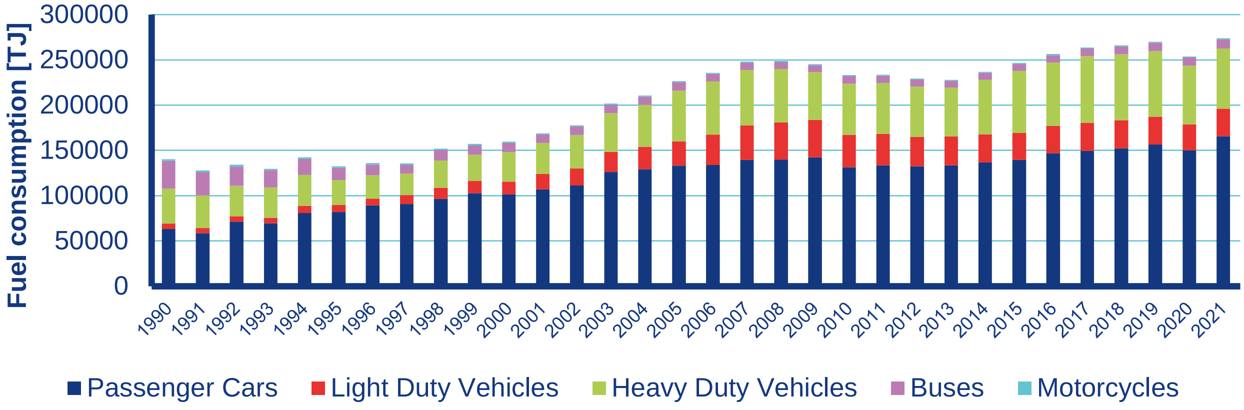


Fig. III.7 Annual fuel consumption by road transport, 1990–2021

Fig. III.7 shows trends in fuel consumption 1990–2021 by particular vehicle categories. General rising trend of fuel consumption by PCs and LDVs is in line with general trend in the whole Europe. There is an obvious influence of the economic crisis between 2008 and 2013 on fossil fuel consumption. From 2014, there is a significant increase of main fossil fuel consumption. In 2016, almost 10 % lower prices of diesel and gasoline influenced increase of fossil fuels consumption with a one-off break in 2020 due to COVID pandemic.

The consumption of gasoline fluctuated around 90 000 TJ from 2003 to 2009, but it started to significantly decline since 2010. It even reached a value 64 650 TJ in 2014. This decline was especially caused by the downward trend in average fuel consumption of modern passenger cars. Since then, gasoline fuel consumption has been fluctuating around 66 000 TJ. The exception is year 2020 influenced by COVID situation, when gasoline consumption was 60 378 TJ.

Fuel consumption of diesel was steadily growing from 2000 until 2008. Steep increase then began after 2013 and was related to economic growth and growing popularity of diesel PCs. The year 2020 was influenced by COVID situation and diesel consumption dropped to 171 416 TJ. In 2021, it jumped to 186 576 TJ which is 2% growth compared to the situation before COVID.

Till 2008, bioethanol was almost not used in Czechia and biodiesel was only used in a small share. Since 2008, the consumption of gasoline has also included the consumption of bioethanol, which was being added to all gasoline in the amount of 2% since January 1. The share of bioethanol as a renewable resource in gasoline reached a value 4.1% in 2010 and the share of fatty acid methyl esters (FAME) as a renewable resource in diesel oil reached a value 6% in 2010. Share of biofuels in fossil fuels was increasing too (6.8% in 2010 and 8.5% in 2015). After 2015, biodiesel consumption started increasing. Lower taxes for blends with high percentage of biodiesel were implemented in 2015, but customers slowly accepted this change. Biodiesel fuel consumption was steadily increasing and it reached more than 12 800 TJ in years 2020 and 2021. Bioethanol shows no specific long-term trend. The highest consumption of bioethanol was before COVID in 2019 (3 078 TJ). It decreased to 2 322 TJ in 2021. The total consumption of biofuels decreased by 3% in 2021.

CNG buses have been used in Czechia from 1994. Use of CNG PCs started after the year 2000. The steep increase of the CNG consumption from 2012 has been caused by subsidies from public resources in order to encourage the use of CNG buses especially. Other subsidies have been determined to CNG LDVs and PCs which have been used by local authorities. CNG consumption continued to increase in 2021 (3 205 TJ). Consumption of LPG was continuously growing until 2016. After 2016, there has been a slight decrease most likely caused by low prices of diesel and gasoline and less subsidies for LPG vehicles in CZ. LPG consumption reached 3 285 TJ in 2021.

Emission factors

Emission factors are based on COPERT 5.5.1 model on Tier 3 level. COPERT methodology is in line with EMEP/EEA EIG [3].Generally, EFs are composed of hot EFs, cold EFs and they are additionally dependent on vehicle category and driving mode (share of urban, rural, highway driving). There are a few types of EFs which are final EFs composed of (dependent on the type of pollutant):

- Hot emission factors – for engine operating at normal temperature, relevant for all pollutants
- Cold emission factors – for cold engine after start, relevant for all pollutants
- Tyre, brake and road abrasion – PM, heavy metals
- Emission factors from lubricant consumption – relevant for SO_X and heavy metals
- Additional influence of A/C – relevant for SO_X and heavy metals
- Mileage degradation – relevant for NO_X, CO and NMVOC

Emissions

Emissions were calculated on the basis of the total consumption in all COPERT vehicle categories which are relevant in CZ. COPERT separately calculates emissions from hot engines, cold engines, emissions originated from A/C and SCR usage (diesel cars) and emissions caused by lubricant consumption during burning processes. A gradually increasing share of road transport in total emissions in Czechia became evident during the ‘90s and this trend continued until 2007. Individual road and freight transport made the greatest contribution.

Downward trends in emissions of NO_X, NMVOC, and CO depend on different EU regulations which came into force and on ongoing technical development (engines, catalysts etc.). SO_X shows the strong dependence on the increasing quality of fuels (sulphur content) bringing a significant downward trend which is slightly influenced by increases in fuel consumption. The share of PM emissions from fuel combustion is decreasing because of technical development. In brake, tyre and road abrasion, technical development is not so progressive and emission production is more dependent on vehicle activity. Pb is strongly dependent on fuel consumption and its content in fuel. General overview of the emission trends, emissions of NO_X, NMVOC, PM and CO for the road transport are presented in the figures below for the entire period 1990–2021.

NO_X emissions were decreasing until 2002 (see Fig. III.8). The increase of emissions after this year was related to economic growth and shift from gasoline to diesel passenger cars and light duty vehicles and increase of traffic performance, especially by heavy duty vehicles. There was a significant increase of traffic performance by passenger cars and light duty vehicles after 2001, however improvement of NO_X reduction technologies stopped increase of NO_X emissions especially in PCs subcategory. From 2005, overall NO_X emissions were decreasing because of a less intense increase of traffic performance in all modes of transport except for diesel passenger cars. In 2016, steep decrease of NO_X emissions was stopped because of economic growth and lower prices of fuels compared to previous years. From 2018, we can see decrease in NO_X emissions caused by decrease of traffic performance by LDVs, HDVs and buses. Generally, the main emitters of NO_X emissions are diesel passenger cars and heavy duty vehicles. In 2021, NO_X emissions slightly increased due to increase of traffic performance after COVID pandemic.

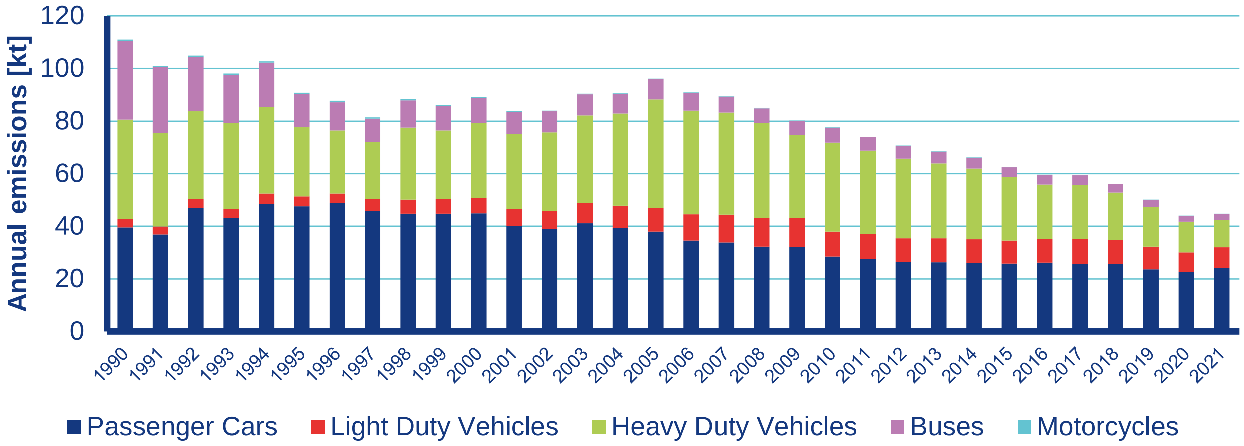


Fig. III.8 Annual emissions of NO_X from road transport, 1990–2021

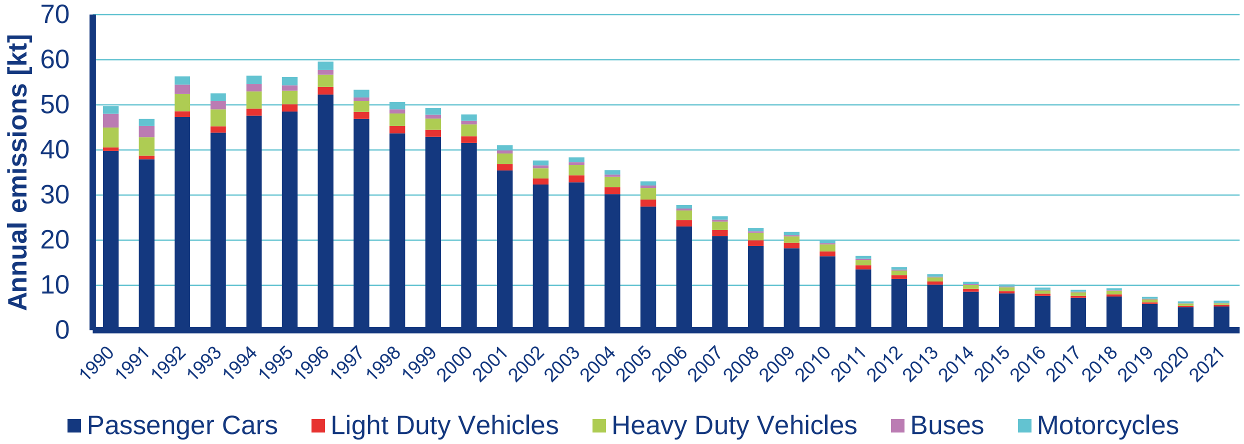


Fig. III.9 Annual emissions of NMVOC from road transport, 1990–2021

Fig. III.9 shows constantly decreasing trend in NMVOC exhaust emissions after 1996 mainly related to decrease of traffic performance of gasoline fuelled cars and enhancement of emission control technologies. Between 2015 and 2017, steep decrease of NMVOC emissions was stopped because of economic growth and lower prices of gasoline compared to previous years. Especially 2-stroke motorcycles have not such advanced emission control technologies which cause a relatively big share of NMVOC production compared to traffic performance. The next reason is that motorcycle fleet in CZ was quite old especially in the ‘90s. The main cause of more significant decrease of NMVOC exhaust emissions after 2018 is a decrease of traffic performance of the largest emitters – petrol fuelled vehicles in general. NMVOC exhaust emissions in 2021 increased by 3% compared to 2020 due to increase of traffic performance after COVID.

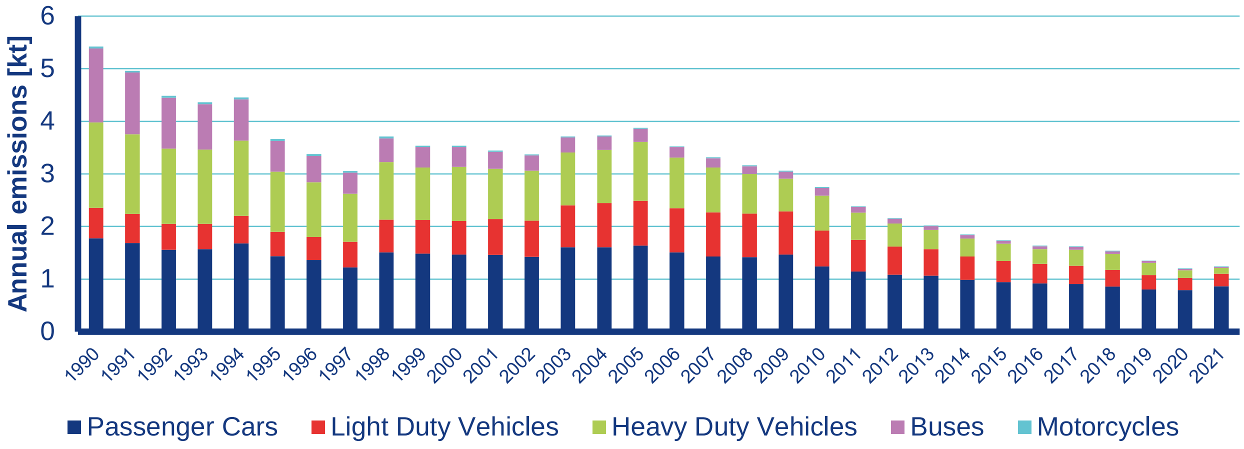


Fig. III.10 Annual emissions of $PM_{2.5}$, PM_{10} and TSP from road transport – exhaust emissions, 1990–2021

Fig. III.10 represents exhaust emissions of particulate matter. In road transport, all PM emissions are considered as $PM_{2.5}$ because of the combustion technology which mostly emits this type of PM. Emission factors contain both filterable and condensable component as the measurement procedure regulated for vehicle exhaust PM mass characterisation requires that samples are taken at a temperature lower than 52°C (at this temperature, PM contains a large fraction of condensable species). PM emissions were decreasing until 1997. Trend in emission production by road transport after this year is unsteady – dependent on changing traffic performance and economic situation. Continual decrease came in 2006, after involving Euro 4 (IV) standard with a significantly lower limit for PM. At present, the main emitters of PM are passenger cars. In ‘90s, passenger cars, light duty vehicles, heavy duty vehicles and buses were approximately on the same level. Due to enhancement of particulate filters technologies and lower pressure of exhaust gases in HDVs, buses and partly in LDVs engines, the share of PMs emissions from these categories has been significantly decreasing especially after 2010. In case of buses, low PM production has been influenced by significant subsidies from public resources to encourage the use of CNG buses after 2012. In 2021, we can see a slight increase in PM exhaust emissions for the most of the categories caused by the increase of traffic performance. The only exception are emissions from HDVs and buses which decreased due to continuing modernization of the vehicle fleet.

Fig. III.11 shows a steady downward trend in CO emissions for all categories since 1997. Trend in emission production before this year is unsteady – dependent on changing traffic performance, economic and political situation. Decreasing emission production is mostly related to the modernization of the car fleet in CZ and removing old passenger cars (Pre-Euro). Another factor is decrease of traffic performance of gasoline cars which are the main emitters of CO. Combustion in 2-stroke engines produces extremely high emissions of CO and motorcycles don’t have such advanced emission control technologies which cause a relatively big share of CO production compared to traffic performance. The next reason is that motorcycle fleet in CZ was quite old especially in ‘90s. 4-stroke motorcycles have much lower emission production and their growing share in motorcycle fleet has improved emission behaviour of motorcycle category in the last years. In 2021, CO emissions slightly increased due to increase of traffic performance after COVID.

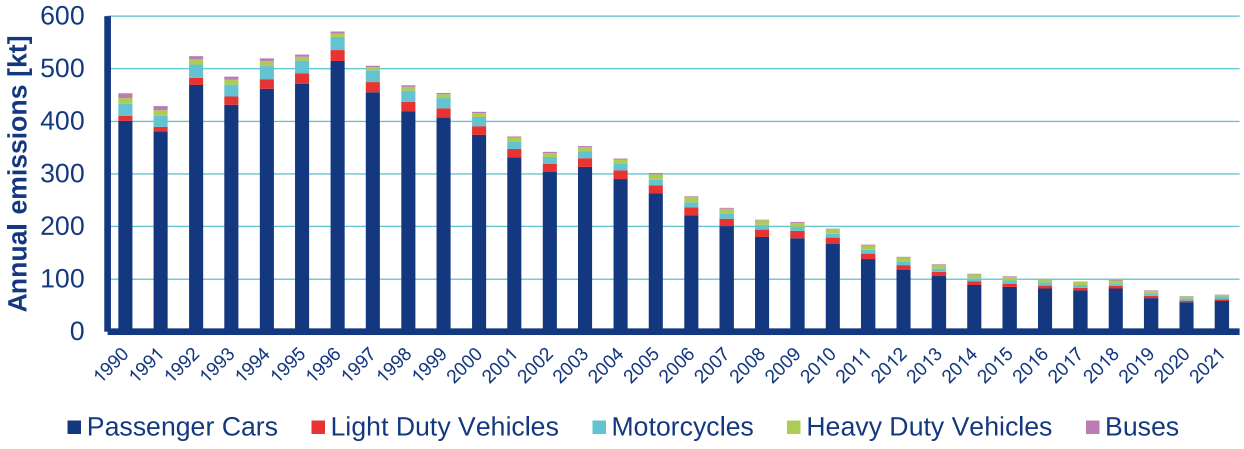


Fig. III.11 Annual emissions of CO from road transport, 1990–2021

III.3.1.2 Passenger cars (1A3bi)

- passenger gasoline cars Pre-Euro
- passenger gasoline cars with Euro 1–6 limits
- passenger diesel cars conventional
- passenger diesel cars with Euro 1–6 limits
- passenger cars using LPG, CNG and biofuels (separately)

Activity data

General rising trend of fuel consumption by PCs is in line with general trend in the whole Europe (see Fig. III.12). In 2007, the economic crisis started in Czechia and influenced overall fuel consumption. The decrease of fuel consumption stopped in 2012. With a renewal of economic growth, it started to increase again. In 2014, the overall fuel consumption reached the same level as it had been usual in years before the crisis. Decrease in gasoline consumption was the most significant. Decrease of gasoline consumption stopped in 2015. The following years it fluctuated around 65 000 TJ with an exception in 2020 when it dropped below 60 000 TJ. Diesel oil consumption wasn't influenced by the economic crisis, nor by COVID situation in 2020 so much. It has been steadily increasing since 1997 and reached around 85 000 TJ in 2019 and 2020. After COVID pandemic, it jumped to almost 96 000 TJ. Fig. III.12 shows growing share of diesel oil compared to gasoline. The reason is growing popularity of diesel cars because of their lower fuel consumption and the lower price of diesel oil (especially in the warm part of the year) compared to gasoline cars.

From 2008, biofuels started to be used on a larger scale in Czechia. Till then, there was almost no bioethanol used and biodiesel was only used in a very small share. The consumption of biofuels by passenger cars has been steadily increasing since 2008. It exceeded a value 8 000 TJ in 2021. CNG started to be used in Czechia from 1994 but a rise in the use of this fuel dates back to 2008. There has been a significant increase of CNG consumption from 2012. Still, the share of CNG on total PCs fuel consumption is very small (0.9% in 2021).

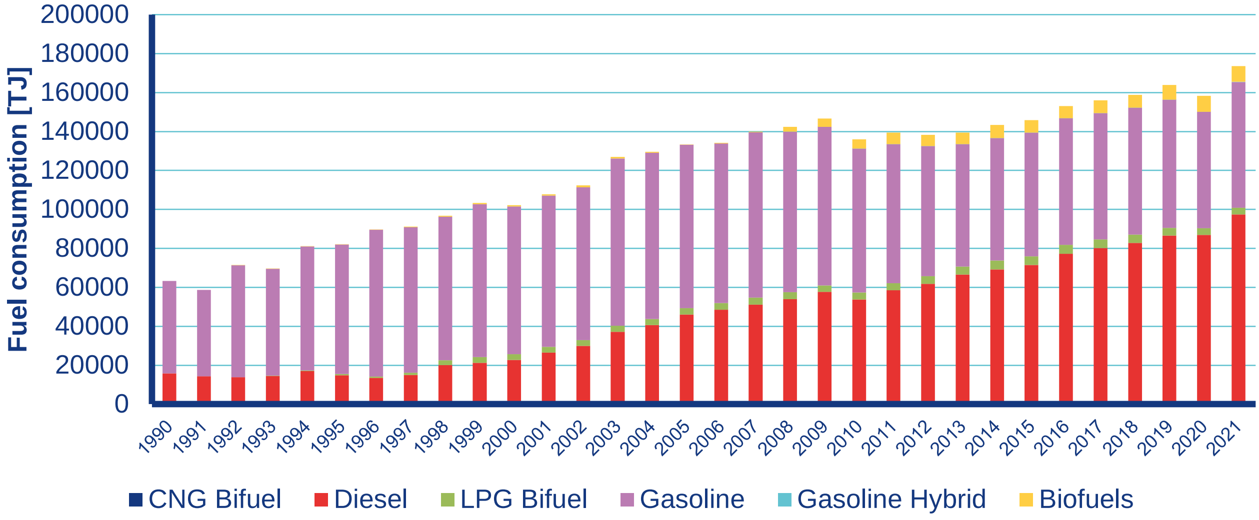


Fig. III.12 Annual fuel consumption by passenger cars, 1990–2021

Emission factors

Implied EFs of selected pollutants, for which PCs subcategory is a key category (CO and NO_X), are presented in this chapter. Emission factors are based on COPERT 5.5.1 model on Tier 3 level. Implied EFs for the most important fuels were extracted from COPERT program (see Fig. III.13 and Fig. III.14).

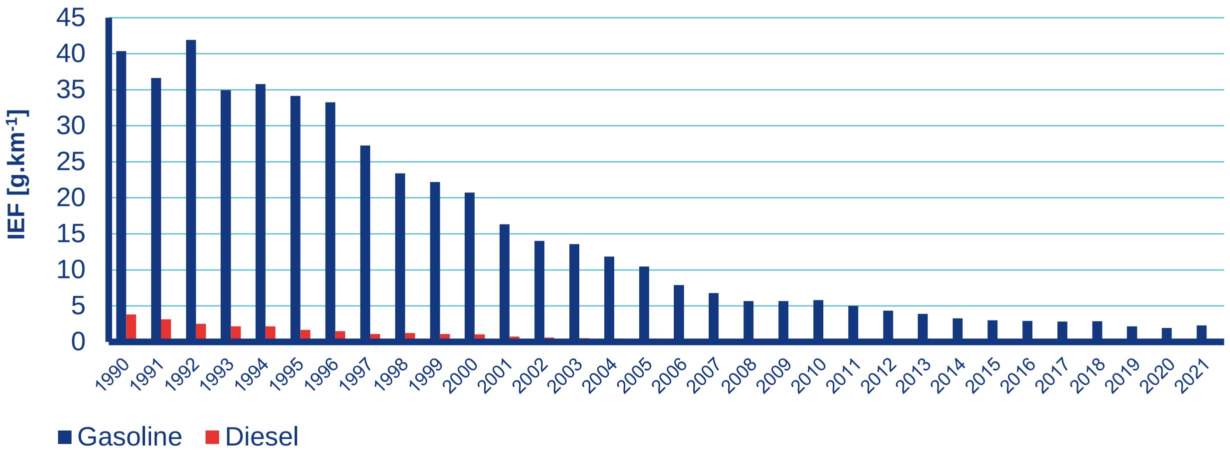


Fig. III.13 CO implied emission factors for passenger cars, 1990–2021

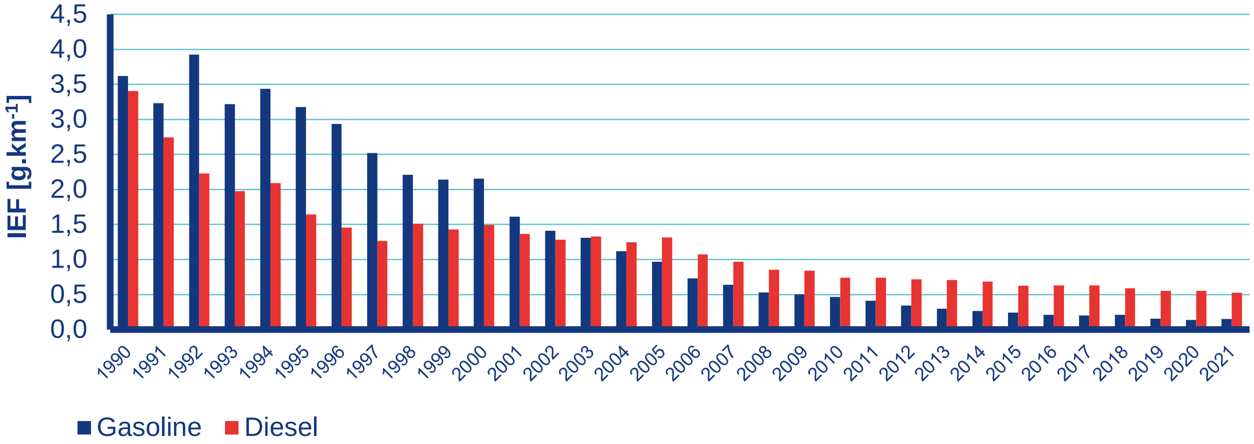


Fig. III.14 NO_X implied emission factors for passenger cars, 1990–2021

Emissions

Emission values of all pollutants are to be found in national inventory files (NFR) available at EMEP Centre on Emission Inventories and Projections website. Brief description of emissions of pollutants in road transport is stated in chapter III.3.1.1 (Emissions).

III.3.1.3 Light Duty Vehicles (1A3bii)

- light duty gasoline vehicles conventional
- light duty gasoline vehicles with EURO 1–6 limits
- light duty diesel vehicles conventional
- light duty diesel vehicles with EURO 1–6 limits

Activity data of LDVs subcategory and overall fuel consumption are briefly described in the chapter III.3.1.1 (Activity Data). The most important fuel is diesel oil which share has been around 90% in the most of the years 1990-2021.

LDVs emissions of all pollutants are to be found in national inventory files (NFR).

NO_X implied EFs, for which LDVs subcategory is a key category, are displayed in the Fig. III.15. Emission factors are based on COPERT 5.5.1 model on Tier 3 level. Implied EFs for the most important fuels were extracted from COPERT program.

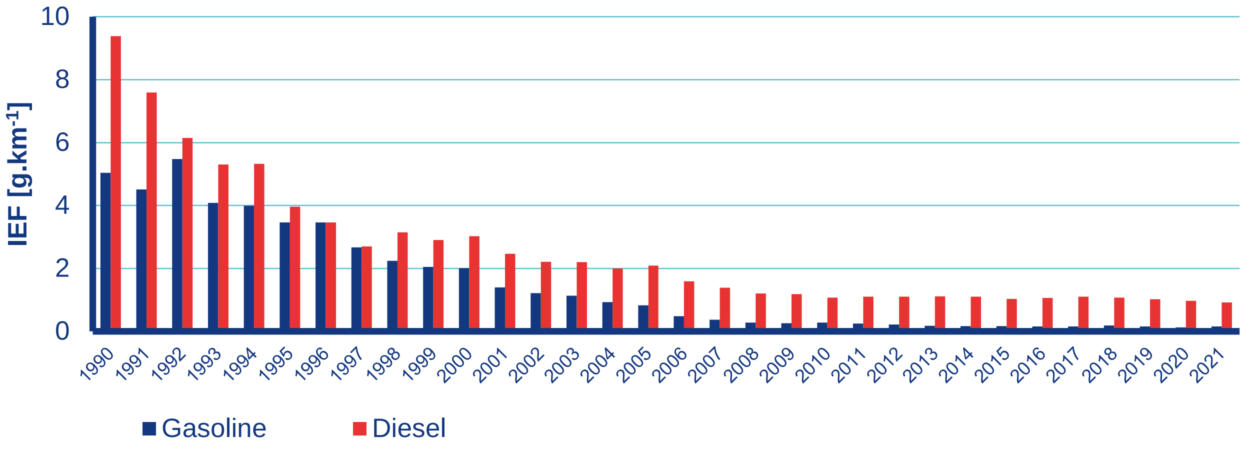


Fig. III.15 NO_X implied emission factors for light duty vehicles, 1990–2021

III.3.1.4 Heavy Duty Vehicles and Buses (1A3biii)

- heavy duty diesel vehicles (including buses), conventional
- heavy duty diesel vehicles (including buses) with EURO I-VI limits, heavy duty vehicles (including buses) using CNG and biofuels (separately)

Activity data of HDVs and buses subcategory and overall fuel consumption are briefly described in the chapter III.3.1.1 (Activity Data). The most important fuel is diesel oil which share is more than 99% in the whole time series 1990–2021.

HDVs emissions of all pollutants are to be found in national inventory files (NFR). Brief description of NO_X, NMVOC and PM emissions from HDVs subcategory is stated in the chapter III.3.1.1 (Emissions).

NO_X implied EFs, for which HDVs and buses subcategory is a key category, are displayed in the Fig. III.16. Emission factors are based on the COPERT 5.5.1 model on Tier 3 level. Implied EFs for the most important fuels were extracted from COPERT program.

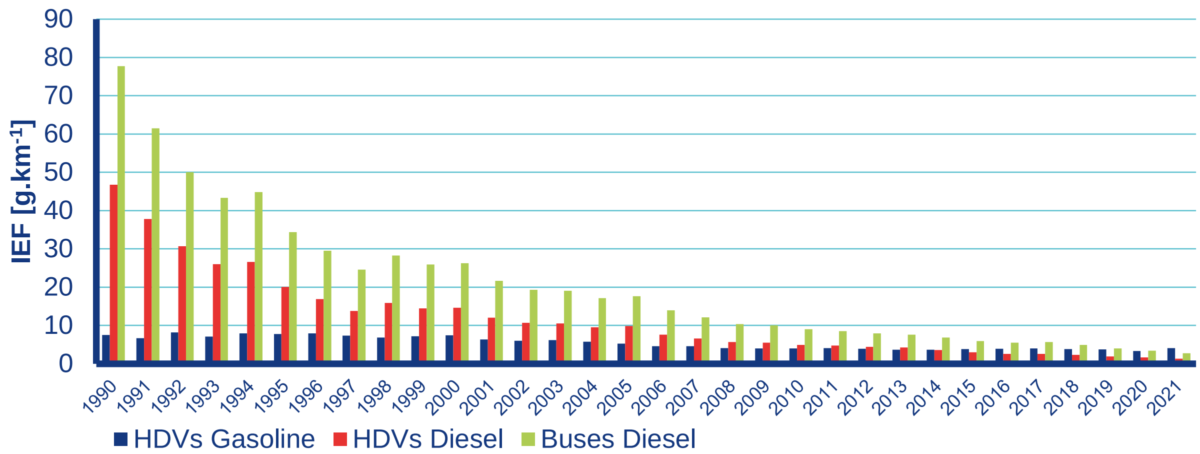


Fig. III.16 NO_X implied emission factors for heavy duty vehicles and buses, 1990–2021

III.3.1.5 Mopeds and Motorcycles (1A3biv)

Activity data of motorcycles subcategory and overall fuel consumption are briefly described in the chapter III.3.1.1. The main fuel used in CZ is gasoline which share is more than 99% in all years. Emission values of all pollutants produced by motorcycles are to be found in national inventory files (NFR). Brief description of NO_X, NMVOC and PM emissions from L-category is stated in the chapter III.3.1.1 (Emissions). Motorcycles are not a key category for any pollutant, therefore no detailed description of implied emission factors was provided in this chapter.

III.3.2 Gasoline evaporation and abrasion (NFR 1A3bv, 1A3bvi and 1A3bvii)

NMVOC emissions in the subcategory 1A3bv from road transport were estimated by the model COPERT 5.5.1 on Tier 3 level. Gasoline evaporation was taken into consideration. To estimate these emissions, statistical data regarding the number of vehicles with or without emission control were taken into account. The Tier 3 method is based on a number of input parameters, which include fuel vapour pressure, vehicle tank size, fuel tank fill level, canister size, diurnal temperature variation and cumulative mileage.

For the calculation of emissions from tyre, brake and road abrasion model COPERT 5.5.1 was used. Tier 2 method was applied as no Tier 3 has been developed yet.

III.3.2.1 **Emission factors and calculations**

All processes which are taken into account in the calculation of evaporation are shown in Fig. III.17. Activity data for relevant subcategories are displayed in Fig. III.18.The main sources of evaporative NMVOC emissions are gasoline passenger cars and motorcycles.

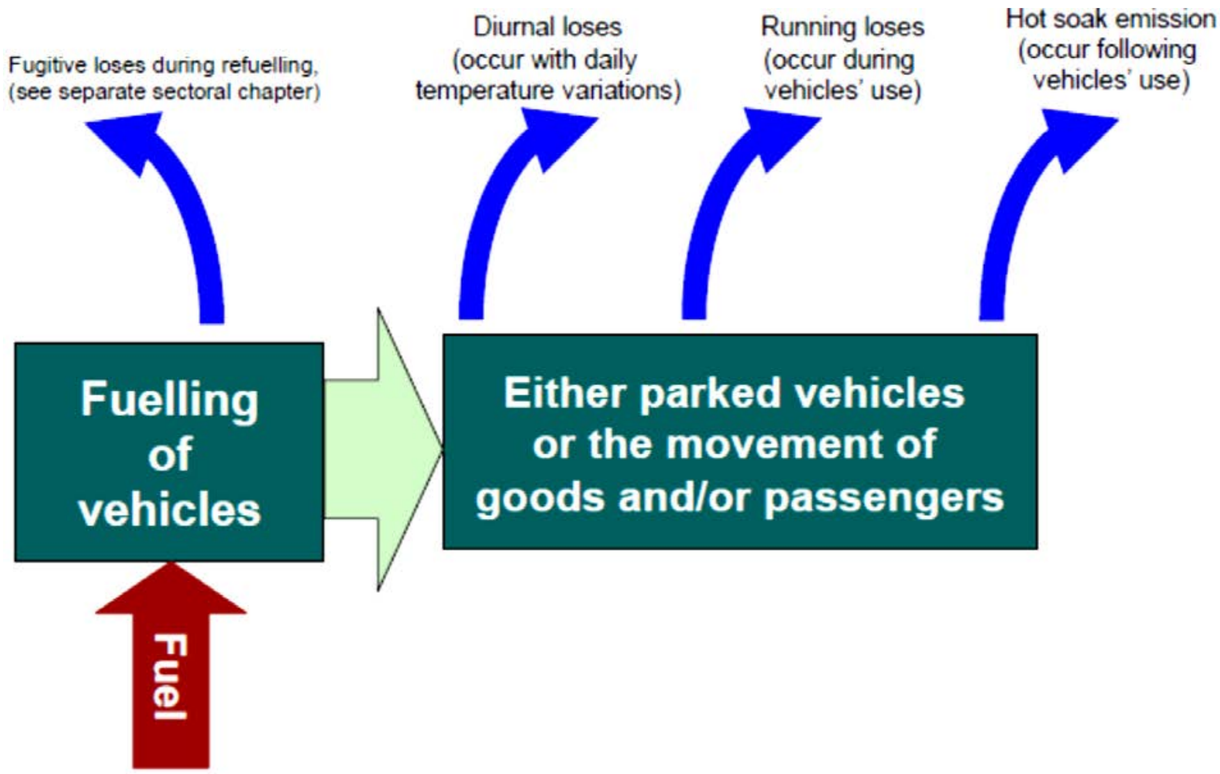


Fig. III.17 Processes resulting in evaporative emissions of NMVOC (source: EMEP/EEA EIG 2019)

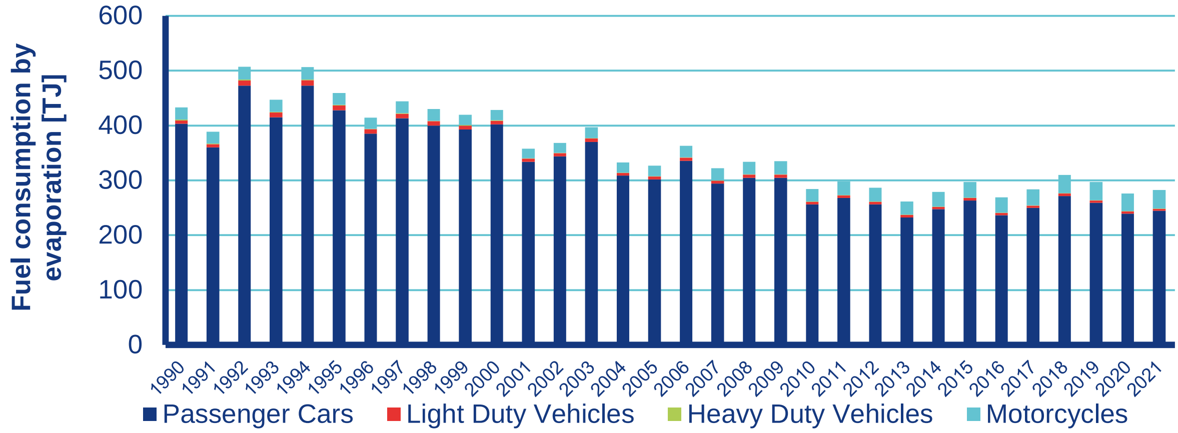


Fig. III.18 Annual fuel consumption by evaporation in relevant subcategories, 1990–2021

Key activity data for abrasion are only traffic performance of car fleet in Czechia (see Fig. III.19). The development of traffic performance after 1990 and its decrease due to the economic crisis in 2008-2013 is clearly seen in the graph below. From 2014, traffic performance started to increase in a steep way again. The increase stopped in 2020 because of COVID situation but in 2021 it even exceeded the numbers from 2019 by 5%.

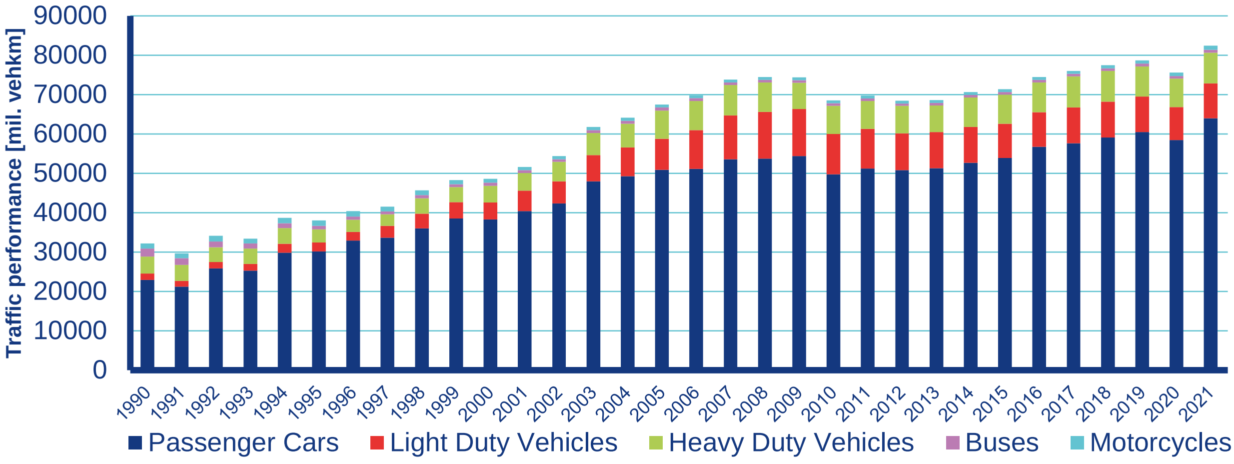


Fig. III.19 Annual traffic performance in relevant subcategories, 1990–2021

Implied EFs of pollutants from tyre, brake and road abrasion (PM_{10} and Pb), are presented in this chapter. Emission factors are based on the COPERT 5.5.1 model on Tier 2 level. Implied EFs for all vehicle categories were extracted from COPERT program (see Fig. III.20 and Fig. III.21).

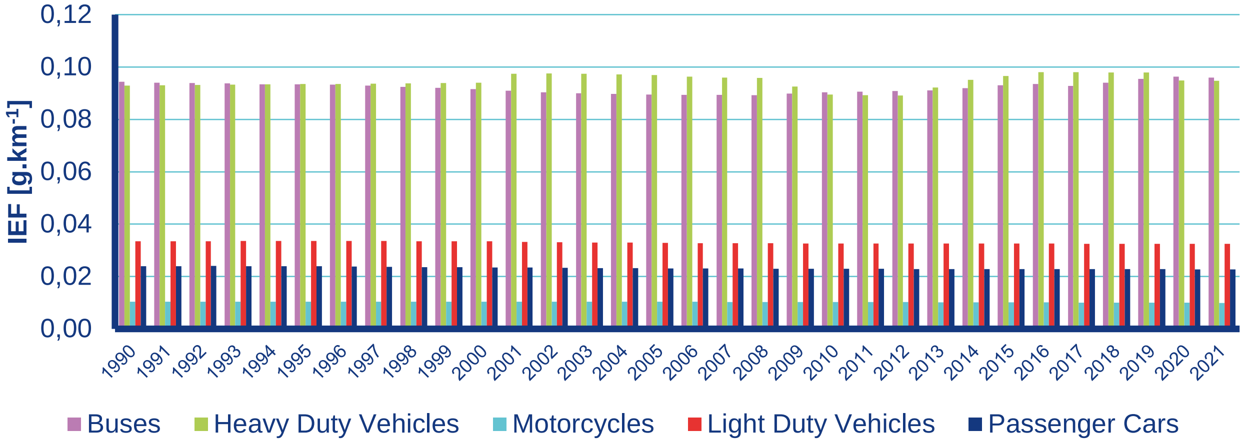


Fig. III.20 PM_{10} implied emission factors from tyre, brake and road abrasion, 1990–2021

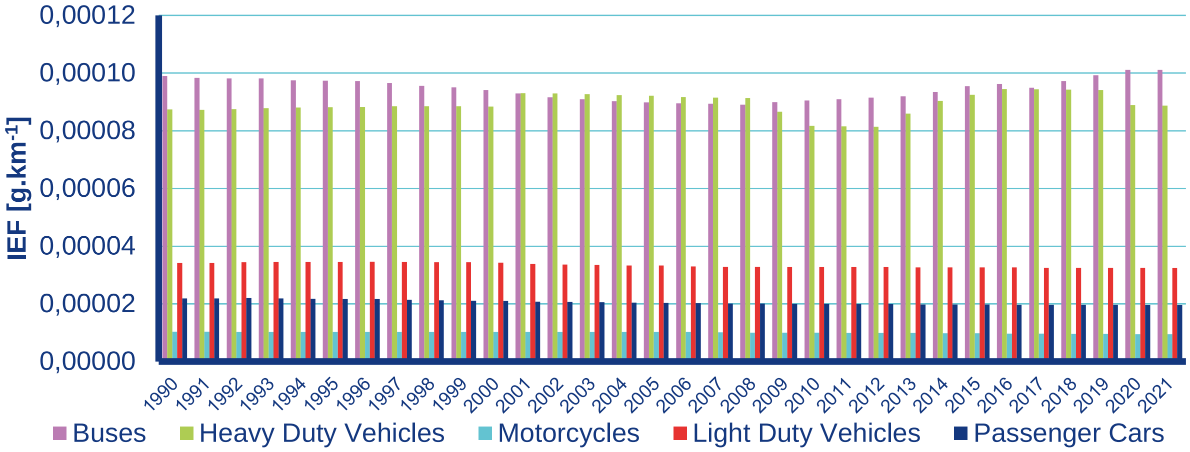


Fig. III.21 Pb implied emission factors from tyre, brake and road abrasion, 1990–2021

Emissions values of all pollutants produced by process of evaporation and by tyre, brake or road abrasion are to be found in national inventory files (NFR).

III.3.2.2 **Planned improvements**

No improvements are planned, the chapter is considered to be final.

III.3.3 Non-road transport (NFR 1A3a, 1A3c, 1A3d)

This chapter contains information about emissions from aviation, railway and inland navigation. Emissions from pipeline transport (NFR 1A3e) are listed in chapter III.1.

Combustion processes in air transport are very different from those in land and water transport. This is caused by its operation in a wider range of atmospheric conditions (namely by substantial changes in atmospheric pressure, air temperature and humidity). These variables are changing vertically with altitude and horizontally with air masses. In NFR 1A3a, emissions of both national (domestic) and international civil aviation are reported with the respect to distinctive flight phases: the LTO (Landing/Take-off: 0–3,000 feet) and the Cruise (above 3,000 feet). Emissions from military aircraft and helicopters used for public and private purposes are also included in this category.

The Czech railway sector is undergoing a long-term modernization process. The aim is to make electricity the main energy source for rail transport. Use of electricity, instead of diesel fuel, to power locomotives has been continually increasing and electricity now provides 86% of all railway traffic volumes.

Inland navigation includes goods transport on navigable parts of rivers (Vltava, Labe) and leisure boats on rivers, channels and reservoirs.

III.3.3.1 **Emission factors and calculations**

Civil aviation

For IFR flights in time series 2005 to present year, bottom-up data from EUROCONTROL were used. These data were updated in time series 2017-2020 by EUROCONTROL. Time series 1990–2004 was estimated by extrapolation of EUROCONTROL fuel consumption with the help of fuel consumption from Czech Oil questionnaire provided by CZSO. Emissions were calculated with EUROCONTROL implied emission factors. LTO/Cruise ratios were calculated from EUROCONTROL. In 2023 submission, the whole time series 1990–2020 was recalculated based on the updated activity data (see chapter VIII.2.

For VFR flights, ratio between LTO a Cruise was obtained from ÚCL as their expert judgement because there is no database for VFR flight characteristics in CZ. These ratios and EFs were applied on fuel consumption obtained from CZSO. Fuel consumption for helicopters was obtained from CZSO too. Ratio between LTO and Cruise from ÚCL. EFs according to Table 3.10 in EMEP/EEA EIG were applied on fuel consumption for VFR flights [3]. Helicopters' fuel consumption has been approximately 1 kt of kerosene from 2007 until present (based on CZSO estimate). EFs according to Table 3.11 in EMEP/EEA EIG were applied on fuel consumption of helicopters. In addition, army air force emissions are included in the aviation subsector. Activity data for military flights are based on CZSO estimate. Fuel consumption of jet kerosene used by military flights has been reported since 2002. EFs according to Table 3.11 in EMEP/EEA EIG were applied on fuel consumption for army air force [3].

In order to ensure comparability of statistics, fuel consumption for aviation was fuel balanced on fuel consumption stated in Czech Oil questionnaire for jet kerosene and aviation gasoline on national level.

Tab. III.2 Ratio of fuel usage between LTO and Cruise flight mode in 2021

Subsector	Flight mode	Ratio
1A3a (IFR, domestic)	LTO	0.27
	CRUISE	0.73
1A3a (IFR, international)	LTO	0.12
	Cruise	0.88
1A3a (VFR, Helicopters)	LTO	0.90
	Cruise	0.10
1A3a (Army flights)	LTO	0.25
	CRUISE	0.75

Activity data were gained from CZSO and EUROCONTROL. Data were divided between LTO and Cruise flight mode according to ratio which is stated in the Tab. III.2. Data for domestic aviation and international aviation were gained from EUROCONTROL (IFR flights) and from CZSO (VFR flights, helicopters and army flights).

Method for VFR flights, helicopters and army air force is on Tier 1 level. Main pollutants for IFR flights based on EUROCONTROL are on Tier 3 level. Other pollutants are still on Tier 1 level, but the emission factors have been actualized according to the newest version of EMEP/EEA EIG [3]. EF method for the most significant pollutants and EFs are stated in Tab. III.3.

Tab. III.3 EF method used and EFs for the most significant pollutants for IFR domestic and international flights in the current year ($g.kg^{-1}$)

Subsector	Method CO	Method NO_X	Method NMVOC	EF CO	EF NO_X	EF NMVOC
Domestic Jet Kerosene LTO	Tier 3	Tier 3	Tier 3	0.00	12.04	4.25
Domestic Jet Kerosene Cruise	Tier 3	Tier 3	Tier 3	0.00	12.41	0.93
Domestic Aviation Gasoline LTO	Tier 3	Tier 3	Tier 3	796.05	8.42	25.73
Domestic Aviation Gasoline Cruise	Tier 3	Tier 3	Tier 3	786.80	12.94	16.91
International Jet Kerosene LTO	Tier 3	Tier 3	Tier 3	8.66	14.96	1.69
International Jet Kerosene Cruise	Tier 3	Tier 3	Tier 3	2.79	13.72	0.38
International Aviation Gasoline LTO	Tier 3	Tier 3	Tier 3	899.24	5.53	23.62
International Aviation Gasoline Cruise	Tier 3	Tier 3	Tier 3	969.14	9.61	16.97

Railways

At present, the energy consumption share of locomotives powered by electricity is 54% in Czechia. Use of electricity, instead of diesel fuel, to power locomotives has been continually increasing and electricity now provides 86% of all railway traffic volumes. Railways' power stations for generation of traction current are allocated to the stationary component of the energy sector (NFR 1A1a) and are not included in the further text. In terms of energy inputs used by trains, diesel fuel is the only energy source that plays a significant role apart from electric power. Coal-fuelled locomotives are used only for recreational purposes and rides and their contribution to emissions is very small.

In general, diesel fuel consumption by railways has a slightly decreasing trend from 2000. The only exception is the period 2005–2008 when it was increasing. After this, the diesel fuel consumption oscillated around 4 000 TJ per year because of the economic crisis and replacement of diesel-powered locomotives by electric ones. In 2021, diesel consumption was 3 112 TJ. CZSO provides data about coal consumption since 2005 (lignite for purposes of historical rides). In the previous submission, coal consumption was estimated also for years 1990-2004. Whereas it is not possible to verify those data, the values were marked as 'NE'. From 2005 to 2017, 1 kt of lignite was burnt every year. Since 2014, bituminous coal has been used as well. Total coal consumption has been decreasing since 2018 (11 TJ in 2021). The reason is no consumption of lignite from 2018. The small fluctuations in fuel consumption mean big proportional difference in emissions from solid fuels because of relative change ± 100% of fuel consumption.

In 2023 submission, new methodology for calculation of railway emissions from diesel oil was introduced which increased detail and accuracy of calculation from Tier 1 to Tier 2 level as per EMEP/EEA EIG [3] for most of the pollutants. Based on the new activity data obtained from Czech Railway Administration (Správa železnic), České dráhy (ČD) and CZSO, national diesel fuel consumption statistics were broken down by locomotive type in order to apply three different sets of emission factors. There are three diesel locomotive categories:

- line-haul locomotives,
- shunting locomotives,
- rail-cars.

Calculation of railway emissions from diesel consists of three main steps:

1) Rail traffic performance calculation – Average traffic performance of line-haul locomotives and rail-cars is calculated based on the data from Správa železnic for profile weeks in 2019. In each category, five the most frequent locomotives and their share on rail traffic performance in brtkm was defined. Final value is weighted traffic performance of these locomotives. Shunting locomotive traffic performance is based on the study Perůtka et al., 2020.
2) Calculation of traction diesel consumption – Specific traction diesel consumption is calculated for each locomotive category. Final traction diesel consumption is a product of activity data and specific traction diesel consumption. Based on this value, share of each locomotive category on the total rail diesel fuel consumption given by CZSO is set.
3) EFs application – Tier 2 or Tier 1 EFs according to EMEP/EEA EIG are applied on final diesel consumption calculated for each category.

Emission factors

Railway transport is not a key category for any pollutant. Emission factors for diesel oil are Tier 2 for the following pollutants: NO_X, NMVOC, NH_3, $PM_{2.5}$, PM_{10}, TSP, BC, CO. EFs for the rest of the pollutants are on Tier 1 level. EFs for coal are on Tier 1 level according to EMEP/EEA EIG which recommends using EFs for 1A2 Combustion in manufacturing industries and construction. Some emission factors (Hg, As, benzo(a)pyrene, benzo(b)fluoranthene) are not stated in a corresponding chapter in EMEP/EEA EIG. According to the recommendation from the guidebook, Tier 1 EFs for HDVs were applied in case of missing EFs. In Tab. III.4, there are presented EFs for the most significant pollutants produced by railways and their calculation methods [3].

Tab. III.4 EF method used and EFs for the most significant pollutants for railways in the current year

Locomotive type	Fuel type	Method CO	Method NO_X	EF CO	EF NO_X
Line-haul	Diesel Oil	Tier 2	Tier 2	18.0 $g.kg^{-1}$	63.0 $g.kg^{-1}$
Shunting	Diesel Oil	Tier 2	Tier 2	10.8 $g.kg^{-1}$	54.4 $g.kg^{-1}$
Rail-cars	Diesel Oil	Tier 2	Tier 2	10.8 $g.kg^{-1}$	39.9 $g.kg^{-1}$
Steam	Coal	Tier 1	Tier 1	931.0 $g.GJ^{-1}$	173.0 $g.GJ^{-1}$

Navigation

Fuel consumption by national navigation is very low. The CZSO only provides data regarding diesel oil consumption within the recreational fleet, which basically represents most of the fuel consumption by national navigation in Czechia. There is no Czech merchant fleet. Activity data (diesel oil consumption in TJ) are to be found in national inventory files (NFR).

Navigation is not a key category for any pollutant. EFs are only applied to diesel oil due to a lack of data. Emission factors for heavy metals and PAHs are not stated in the EMEP/EEA EIG. Tier 1 EFs for HDVs were used for inland navigation. PM_{10} EF is country-specific, $PM_{2.5}$ EF was derived with the help of ratio between $PM_{2.5}$ and PM_{10} EF (90.3%) as stated in EMEP/EEA EIG (Tier 1 – marine diesel oil/marine gas oil) [3]. EFs for the most significant pollutants produced by navigation and their calculation methods are presented in Tab. III.6.

Tab. III.5 EF method used and EFs for the most significant pollutants for inland navigation in the current year ($g.kg^{-1}$)

Fuel type	Method CO	Method NO_X	EF CO	EF NO_X
Diesel Oil	Tier 1	Tier 1	19.7	33.9

III.3.3.2 Planned improvements

In 2025 submission, improvements are planned in the subsector NFR 1A3d. Recalculation of emissions from navigation are going to be performed in the entire time series 1990-2021 based on the new methodology and activity data to be gained.

III.3.4 Other non-road mobile sources & machinery (NFR 1A2gvii, 1A4, 1A5)

This chapter contains information about emissions from operation of machines (e.g., mining and construction machines like excavators, caterpillars and loaders, transport inside industrial areas, gardening), agriculture and forest machines and consumption of gasoline and diesel oil in further sectors (services, integrated rescue system and military).

The biggest contribution to emissions comes from operation of agricultural machinery (1A4cii), mainly represented by tractors. Emissions of CO, NMVOC, NO_X, TSP occurring from agricultural non-road machinery operation were recalculated. Emissions of NH_3, SO_X, BC, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, PAHs were newly calculated. All produced emissions were recalculated in the entire time series 1990-2020. The key step for emission data revision was opening of the non-road vehicles database running together with the road vehicles database by the Czech Ministry of Transport. Data were sorted according to age and engine power into groups of tractors according to relevant efficiency for categorization into Stage I-V.

Estimates of emissions regarding non-road mobile sources were calculated for diesel oil and jet kerosene in NFR 1A4aii. In 1A4cii, diesel oil and gasoline are consumed, in 1A4bii gasoline only. The operation of agricultural machinery (NFR 1A4cii) covers a major part of fuel consumption of small combustion, other subcategories are negligible. AD regarding other fuels potentially used in Czechia are not available.

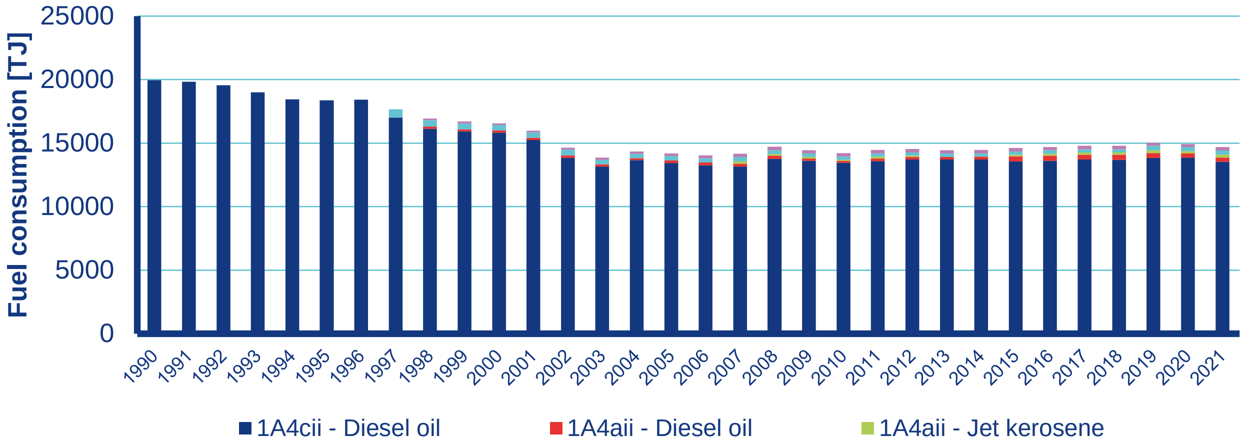


Fig. III.22 Annual fuel consumption by non-road mobile machinery, 1990–2021

III.3.4.1 Emission factors and calculations

Activity data for each category were prepared on the basis of CZSO statistical census. For NFR 1A4cii, total diesel fuel consumption was gained and allocated to each machine category according to year of production and performance related parameters.

Mobile combustion in manufacturing industries and construction

Emission factors for main pollutants are Tier 2 and they are used according to EMEP/EEA EIG [3]. The exceptions are emissions of SO_X and Pb. Those are country-specific and based on a content of pollutants in fuels. Heavy metals and PAHs were calculated on Tier 1 level. Mobile combustion in manufacturing industries and construction is not a key category for any pollutant. Tab. III.6 shows EFs and EF method used. Tier 1 EFs are constant in time, therefore they are not stated in the table. There are only stated CS EFs and Tier 2 EFs which are changing in time.

Tab. III.6 EF method used and EFs for the most significant pollutants for non-road mobile machinery in the construction and other industries in the current year ($g.kg^{-1}$)

Subsector	Fuel type	Method CO	Method NO_X	EF CO	EF NO_X
1A2gvii	Diesel Oil	Tier 2	Tier 2	6.02	1.57

Commercial/Institutional/Residential

Mobile machinery is typified as all machinery equipped with a combustion engine which is not primarily intended for transport on public roads, and which is not attached to a stationary unit. The most important utilization of mobile machinery is:

- 1A4aii Commercial/Institutional: Mobile
- 1A4bii Residential: Household and Gardening: Mobile
- 1A4cii Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery

This chapter does not include agricultural machinery emissions (see Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery in chapter III.3.4.1).

Gasoline-driven lawn mowers used for gardening are included in 1A4bii. Tractors, harvesters, chain saws, gasoline off-road vehicles and other machinery used in agriculture and forestry are in the subcategory 1A4cii. Since agriculture emissions are the most important, more attention is paid to them. Mobile sources reported under NFR 1A4 (non-road mobile) represent versatile equipment and means of transport like diesel non-road machinery (e.g., forklifts).

Emission factors for main pollutants are Tier 2 EMEP/EEA EIG [3]. Exceptions are emissions of SO_X and Pb. Those are country-specific and based on the content of pollutants in fuels. Heavy metals and PAHs are calculated on Tier 1 level. Emission factors of diesel agriculture and forest machines are based on emission measurements done in the past years for each type of vehicle for various performance parameters. Non-road machinery is a key category for NO_X and $PM_{2.5}$. In Tab. III.7, there are presented EFs for these pollutants and also for CO, which is another significant pollutant produced by non-road mobile machinery, and their calculation methods.

Tab. III.7 EF method used and EFs for the most significant pollutants for non-road mobile machinery in the current year ($g.kg^{-1}$)

Subsector	Fuel type	Method CO	Method NO_X	Method NMVOC	EF CO	EF NO_X	EF NMVOC
1A4aii	Diesel Oil	Tier 2	Tier 2	Tier 2	6.02	1.57	0.54
	Jet Kerosene	Tier 2	Tier 2	Tier 2	6.02	1.59	0.53
1A4bii	Gasoline	Tier 2	Tier 2	Tier 2	736.58	3.92	62.37
1A4cii	Gasoline	Tier 2	Tier 2	Tier 2	736.58	3.92	62.37

Military

Basically, all military ground transport fuelled by diesel oil is included in this category. There is no military navigation (1A5biii) in Czechia, so this is not reported.

Activity data used for NFR 1A5b are gained from CZSO. Diesel oil consumption was decreasing from 1999 to 2005. The following years, it was increasing and reached around 390 TJ in 2008. Since then it was quite steady with a drop to 344 TJ in 2013. In 2021, it jumped to 432 TJ.

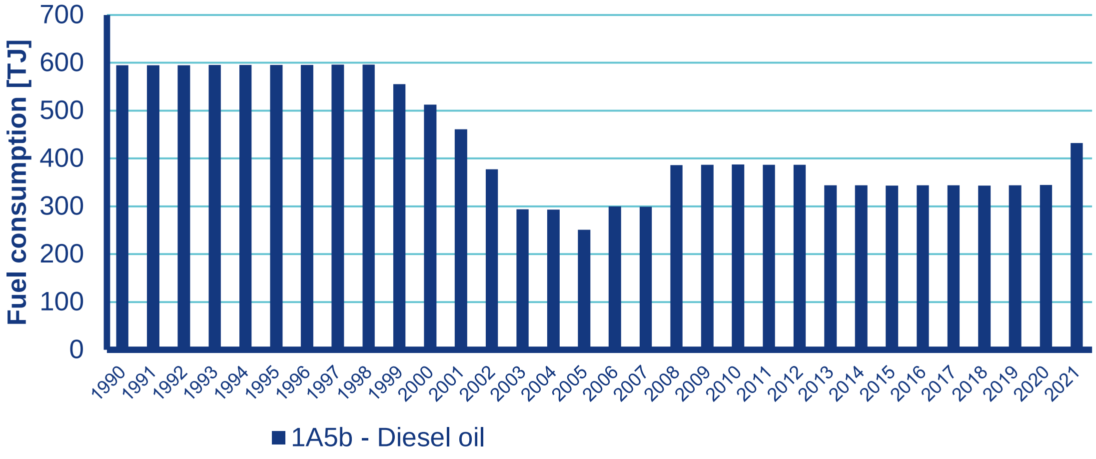


Fig. III.23 Annual fuel consumption by other mobile sources, 1990–2021

Emission factors for main pollutants are Tier 2 and they are used from the EMEP/EEA EIG [3]. Exceptions are emissions of SO_X and Pb. Those are country-specific and based on the content of pollutants in fuels. Heavy metals and PAHs are calculated on Tier 1 level. Other mobile sources are not a key category for any pollutant. EFs for the most significant pollutants produced by other mobile sources and their calculation methods are presented in Tab. III.8.

Tab. III.8 EF method used and EFs for the most significant pollutants for other mobile sources in the current year ($g.kg^{-1}$)

Subsector	Fuel type	Method CO	Method NO_X	EF CO	EF NO_X
1A5b	Diesel Oil	Tier 2	Tier 2	6.02	1.59

Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery

In past, calculated relevant emissions occurring during operation of agricultural machinery (mostly tractors) were relatively high in comparison with other sectors using similar types of diesel engines. It was cause for revision of used emissions factors, activity data and for updating this section (June 2018). Emission data for wood processing tool (wood cutting) are available 1997 onwards.

The key step for activity data revision was opening of the road and non-road vehicles database running by the Czech ministry of transport. Included data have been sorted according to age and engine power into groups of tractors according to relevant efficiency for categorization into Stage I - V.

For calculation of emissions tractors less than 15 years old are taking into consideration. The reason for this approach is an assumption that intensive land farming (estimated share 75% of crop farming in Czechia) require new tractors with higher rated power for aggregation of some field operation into just one. From economical point of view tractors older than 15 years are not used for most significant field operations. It means these tractors do not represent a significant share of agricultural activities and operations. It is a high projection that they are not significant sources of emissions into air. Currently, older tractors with lower rated power are successively being used in stock farming for moving of raw and other materials, at small farms and municipalities. This will reduce the number of machines included in emission calculations to approx. 20 thousand tractors.

In Fig. III.24 the share of tractors produced in 1987–2017 is presented. From the total number of tractors putted into operation in Czechia within last 30 years only 8% is newer than 10 years. From the total number of tractors there is approximately 35% share of tractors putted into operation within last 30 years.

On Fig. III.25 the share of tractors structured according to rated power is shown. Only tractors putted into operation within last 30 years have been taken into account. The most significant categories of agricultural machinery comprise tractors with efficiency 37 - 75 kW and 75 - 130 kW.

Mobile agricultural machinery is a key source of NO_X (as NO_2) and CO. This category of mobile machinery is also an insignificant source of NMVOC and TSP. For national estimation of mentioned emissions produced by agricultural machinery in Czechia the Tier 2 approach is used according to the 1A4 Non road mobile machinery 2016 EMEP/EEA EIG – Update May 2017 (Table 5 of the EMEP/EEA EIG [3]). Diesel oil consumption is taken from CZSO. Emissions originating from non-road agricultural machinery operations are depended on type, age and engine output of tractors/harvesters.

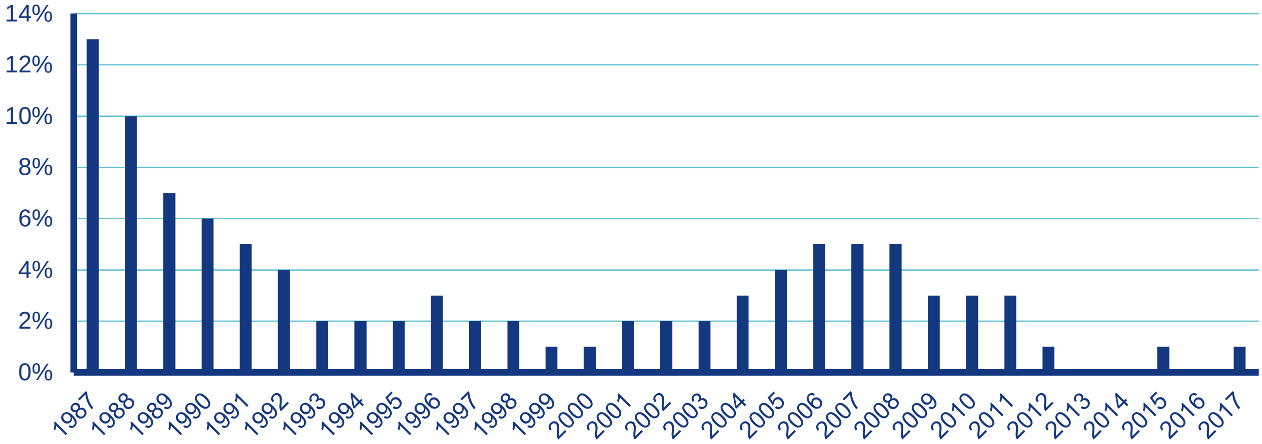


Fig. III.24 Share of tractors by year of production

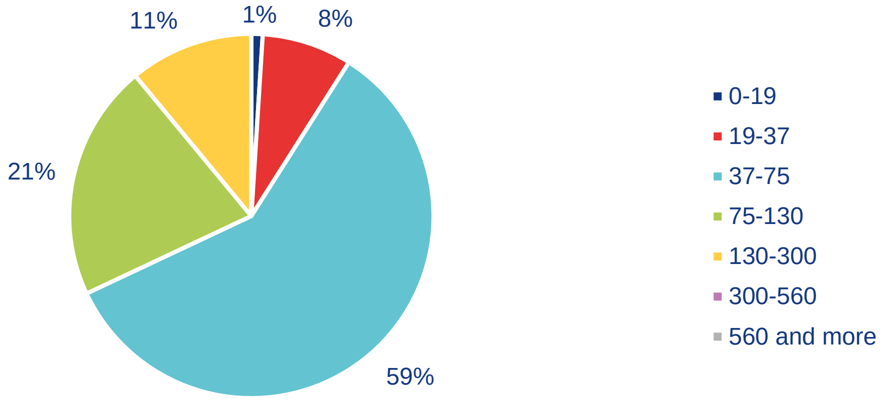


Fig. III.25 Share of tractors [%] according to rated power [kW]

III.3.4.2 Planned improvements

No improvements are planned, the chapter is considered to be final.

III.3.5 Uncertainties for Transport sector

Uncertainties were calculated according to chapter A.5 of EMEP/EEA EIG [3] and evaluated for entire time series (1990–2021) for all reported categories. Uncertainties of national emissions within transport sector for particular pollutants are given in Tab. III.9.

Tab. III.9 Uncertainty data for Transport sector (NFR 1A3) from uncertainty analysis

Gas	Base Year Emissions (2000)	Year Emissions (2021)	Combined Uncertainty as% of Total National Emissions in Year 2021
	[kt]	[kt]	[%]
NO_X	99.31	51.02	25.27
NMVOC	50.48	7.92	40.91
SO_X	3.48	0.28	25.47
NH_3	1.18	0.82	129.16
TSP	6.30	5.40	29.54
BC	2.37	1.18	33.11
CO	433.61	83.45	42.42
HMs	0.21	0.03	134.77
POPs	3.84E-09	3.50E-09	119.30
PAHs	2.42E-04	4.71E-04	124.81

III.4 Fugitive emissions from fuels (NFR 1B)

The source category Solid fuels (1B1) consists of three sub-source categories:

- 1B1a Coal mining
- 1B1b Coal transformation
- 1B1c Other

The source category Oil fuels (1B2) consists of next sub-source categories:

- 1B2a Oil extraction, refining/storage and distribution of oil product
- 1B2b Gas extraction
- 1B2c Venting and flaring
- 1B2d Other fugitive emissions from energy production

The NFR 1B1 deals with fugitive emissions from coal mining, handling, transformation and other sources. In Czechia, there are mined bituminous coal and lignite. Lignite is mined in open-cast mining, and bituminous coal is from underground mining. Since the 1990s, coal mining has significantly lowered, and coal imports have grown. Lignite is mainly mined in North-West Bohemia, and bituminous coal is mined in Silesia (North-East of Czechia), as part of the Silesian basin. An important input for metallurgical production is the coke production located nearby bituminous coal mining in Ostrava and Třinec. The only facility for coal gasification (Sokolovská uhelná) ended its activity in

2020 and switched to standard coal combustion. The trend of lignite and bituminous coal mining is apparent in Fig. III.26.

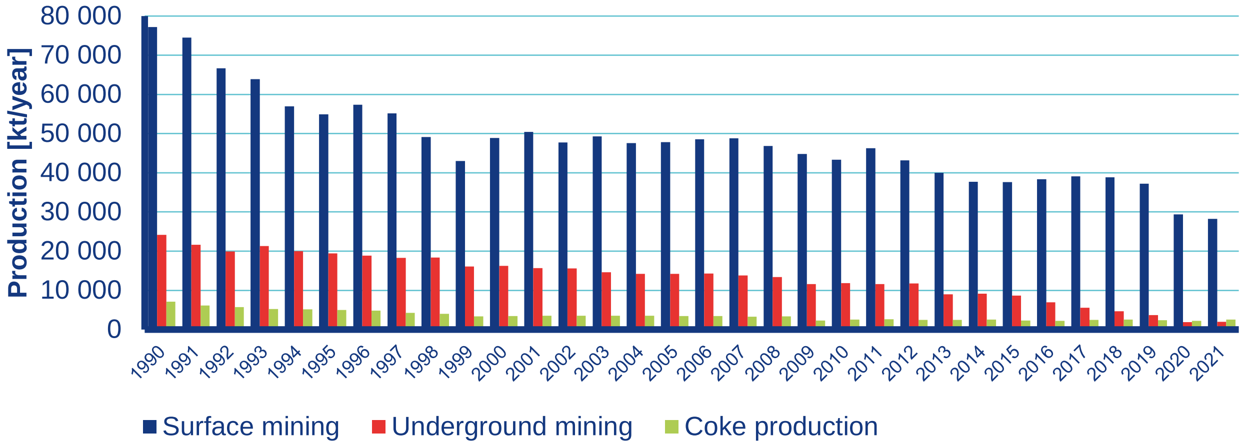


Fig. III.26 Surface and underground mining (COAL) and coke production (kt.year^{-1})

NFR 1B1c includes coal sorting and drying emissions, mainly in sorting plants producing coal for household consumption, coke plants and wood coal production emissions.

Category 1B2 deals with fugitive emissions from Oil extraction, refining/storage and distribution of oil products. There are only limited deposits of oil and gas in Czechia located in Southern Moravia, so the fossil fuels import plays an important role in foreign trade. Oil processing to fuels takes place in two refineries (Litvínov and Kralupy nad Vltavou) with consequent petrochemical facilities.

The distribution network of fuels includes 4000 public petrol stations and approximately 2500 stations not accessible to the general public (mostly for distribution of diesel fuel) or with limited access. Multi-purpose petrol stations prevail, and the number of stations with biofuels and other fuel distribution (mainly CNG) grows.

NMVOC emissions from oil drilling come from oil storage and filling railway transport tanks. Due to low amounts, emissions from accompanying oil gas and carbon gas from bituminous coal are omitted. The most significant emission comes from refinery oil processing. It includes oil as well as oil product storage (NMVOC emissions), catalytic converters regeneration (emission of NO_X and SO_X) and refinery flaring (emission of NO_X and SO_X). Emissions from consequent petrochemical processing of oil products and flaring are allocated in NFR 2B10a.

III.4.1 Emission factors and calculations

This chapter deals with fugitive emissions from coal mining and handling. The EMEP/EEA EIG lists EF for NMVOC and particulates but currently does not address the emission of Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, and BC [3].

In Czechia, there are mined bituminous (underground) and lignite coal. Lignite is mined mainly in open-cast mining and bituminous coal in underground mining. Emission factors for quantifying particulate emissions from lignite mining are taken from EMEP/EEA EIG, Tier 2, Table 3-2 Open cast mining [3].

Emission factors for primal manipulation with mined lignite (import and export) come from EMEP/EEA EIG, Tier 2, Table 3-6 [3]. Emission estimation from bituminous coal mining regards only manipulation with coal and through import and export.

Emission factors for quantifying particulate emissions are taken from EMEP/EEA EIG, Tier 2, Table 3-6 [3]. EFs for NMVOC are adapted to the conditions in the Czech coal mines. EFs depend on geological conditions, the composition and the amount of firedamp. Considering the data available and expert consultation EF for NMVOC was estimated at 0.56 $kg.Mg^{-1}$. Firedamp from underground mining is partly being combusted in cogeneration units.

For NFR 1B1b, solid fuel transformation source operator reported emissions are used (coke production and gasification). Emissions from the coke production process are being ascertained according to a unified methodology of quantifying emissions from coking plants (see e-ANNEX).

Emissions for coal sorting plants NFR 1B1c are usually based on the one-off measurement of suction devices. Wood coal production emissions are being measured while putting the facility in operation, and specific production emissions are being used for annual reporting.

NFR 1B2 presents reported emissions excluding only emissions from oil fuels distribution calculated based on total diesel oil and petrol consumption of CZSO and emission factors. Refinery emissions may fluctuate depending on the product´s demand, sulphur content and the current operating conditions of each facility. Higher emissions in 2016 were caused mainly by shutting down some parts of petrochemical production due to an accident in the ethylene unit in August 2015.

Followed emission factors are used for calculating emissions in NFR 1B2av: For emission from diesel oil was used for the whole time series EF 16.8 $g.t^{-1}$. For petrol distribution in 1990–1992, was used EF 1022 $g.t^{-1}$ (without regeneration). Until 1998, according to law, we assumed successive installation of stage 1 and 2 regeneration, and from 1999 onwards, EF 70 $g.t^{-1}$ was used.

Due to changes in integrated permits in refineries (Claus plants and flares) and petrochemical processes, there were changes in 2014 to the obligation to monitor and report emissions of combustion flares. According to the agreement with the source operator, the emissions of SO_X and NO_X were reported according to E-PRTR regulation. These were used to complete reported emissions (NFR 1B2c and partly 2B10a).

Distribution of emissions from processes operated in refinery Litvínov (mainly tail gas disposal) and follow-up emissions from petrochemical processing of petroleum products was revised, and transfers of SO_X, NO_X and NMVOC emissions were made in some years between NFR categories 1A1b, 1A2c, 1B2aiv, 1B2c and 2B10a. NMVOC emissions for NFR 1B2aiv for 1990 and 1991 were calculated using the implied emission factor from 1992 (app. 3 kt NMVOC). Detailed information on some categories is given in e-ANNEX.

The inventory of fugitive NMVOC emissions in the gas industry includes a balance of gas leakages in the whole chain from extraction to import, storage, compression stations and distribution to end users. The performed inventory is closely linked to GHG (CH_4) inventory in the appropriate sector. National emission factors by IPCC balance and NMVOC emission were calculated as a long-term share of higher hydrocarbons in natural gas at 4.02% (w).

III.4.2 Uncertainties and QA/QC procedures

The chapter will supplied later.

III.4.3 Planned improvements

No improvements are planned, the chapter is considered to be final.

IV. Industrial processes (NFR 2)

The date of the last edit of the chapter: 15/03/2023

For emission estimates from industrial processes in Czechia combined system described in chapter I.4 is used. The emissions from industrial processes listed in Annex 2 to Act No. 201/2012 Coll. are monitored. Emissions from these sources for the whole period are ascertained by source operators themselves, who carry out authorized measurements or in exceptional cases by calculations/computations using emission factors. Unless source emissions listed in Annex 2 are ascertained (NFR 2B1 Ammonia production) or are ascertained only for more important sources (NMVOC emissions in NFR 2H2 Food processing), the inventory performed using EMEP/EEA EIG methodology. Inventorying of emissions from processes not listed in Annex 2 (e.g. 2A5b Construction and demolition) is done according to methodologies contained in EMEP/EEA EIG with exception of solvent use emissions (mainly NFR 2D3a), where EMEP/EEA EIG methodology was used. Emissions in NFR 2D Solvent use are estimated by specific way, where emissions of significant sources are monitored in detail by annual SOE reporting but household emissions and sources not underlying Annex 2 contribute to majority of total emission. Emissions are determined based on a material balance in statistics of production and imports, data from the largest producers and users, etc. A number of industrial processes belong to key categories. Some facilities in sector industrial processes may be part of LPS reporting [3].

Annual emissions closely depend on main industrial indicators of production (steel, clinker, etc.) as well as economic (GDP) that correlate industrial indicators like passenger cars production linked to other production sectors in Czechia. Activity data of the most important production facilities are based on REZZO database in cooperation with CZSO, Lime and Clinker Producers´ Association.

The following chapters describe the method of assigning sources listed in Annex 2 to NFR and other sources monitored collectively. Unless stated differently, emissions of all reported substances were ascertained by source operators themselves (Tier 3 approach).

The sources belong to key categories (NFR) for NMVOC – 2D3d, 2D3a, 2D3i and 2D3g (25.9%), SO_X – 2B10a (12.3%), $PM_{2,5}$ – 2G (2.9%), PM_{10} – 2A5a (2.9%), TSP - 2A5a (3.9%) and 2A5b (2.3%), Pb –2C1 (24.2%) and 2G Fireworks (15.9%), Cd – 2C1 (10.1%), 2G Tobacco (8.9%) and 2C6 (4.8%), Hg – 2C1 (4.4%), As – 2C5 (10.2%) and 2A3 (4.9%), Cr – 2C1 (5.4%), Cu – 2G (6%), Ni – 2C1 (5.9%) and 2G (3.3%), Zn – 2C1 (20.1%) and 2G (3.3%), PCDD/F – 2C1 (13.7%).

The following chapters describe the method of calculation for sub-sectors. In 2021, the methodologies for classifying NO_X, NMVOC, SO_X and CO emissions in processing mineral raw materials and the production and processing of metals were adjusted. Until 2020, emissions of NO_X, NMVOC, SO_X and CO were reported for processes of processing mineral raw materials and production and processing of metals, which are not directly related to melting furnaces (glass vats, smelting in the production of non-ferrous metals), were reported as part of the categories NFR 2A6 and NFR 2C7c. For 2021, these emissions were reported for the first time in NFR 1A2f (emissions from combustion processes related to glass NFR 2A3) and NFR 1A2b (emissions from the combustion processes of processing non-ferrous metals 2C2 to 2C7a). The conversion of emissions from NFR 2C7c and NFR 2A6 in historical reports will only be carried out in the next reporting period. More detailed information is provided in the e-Annex.

IV.1 Mineral products (NFR 2A)

Industrial processing of mineral raw materials represent a broad group of activities that incorporate significant sources of emissions. Fuel combustion emissions by raw materials processing are included in NFR 1A2f, processing emissions are divided among NFR 2A1–2A6. NFR 2A5a Mining of raw materials (coal excluded) belonged in 2021 to key sources of TSP (4.1%) and PM_{10} (2.9%). Activity data of the most important production facilities are based on REZZO database in cooperation with CZSO, SVV and SVC.

For more details of lime and cement production please refer to information in section individually monitored sources. To determine HMs emissions from glass production until 1995, national emission factors, see Tab. IV.1 based on measurements performed in glassworks in Czechia are used. In the following years, the reported emissions by individual establishments were used to determine emissions. The description is in the chapter individually monitored sources.

Tab. IV.1 Emission factors for determination of emissions from the production of glass

	Pb	Cd	Hg	As	Cr	Cu	Ni	Se
	$g.t^{-1}$ glass							
1990–1995*	9,034	0,191	0,004	0,597	0,567	0,010	0,676	2,14
from 1996**	1,700	0,130	0,003	0,190	0,230	0,007	0,490	0,800

* country specific EFs
** EMEP/EEA EIG [3]

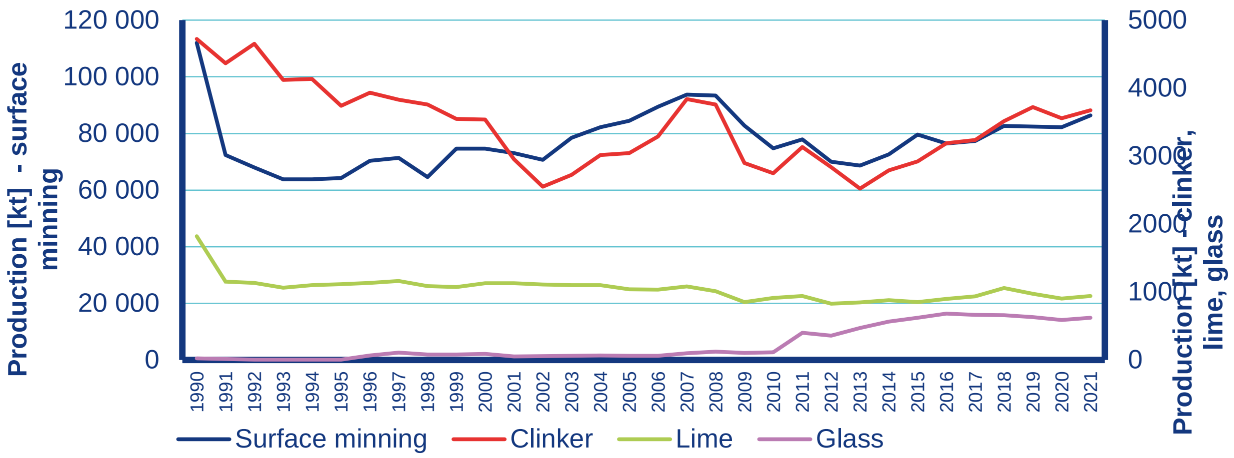


Fig. IV.1 Surface mining (non - fuels) clinker, lime and glass production, 1990–2021

The methodology of emission monitoring is long term constant for all sectors and is based, with exception of NFR 2A5b Construction and demolition, on reported source emissions underlying annual reporting duty. Annual measured emission concentrations show large (sometimes orders of magnitude) differences, leading to irregular emissions reported by operators. A part of operation permit for all rotary clinker kilns there is the possibility of waste co-combustion. Emissions of heavy metals and POPs for waste co-combustion cannot be separated from process emissions and are therefore reported in NFR 1A2a. Should emissions of raw material and product handling be exhausted by managed exhaust they are based than on one-time measurements in prescribed intervals. For raw material mining in NFR 2A5a and recycling lines of construction wastes (allocated in NFR 2A6) emissions are mainly ascertained by calculation using emission factors.

In the period 1990 – 2002 there was a significant decrease in production of construction materials. In the period 2000–2003 six factories producing cement and six factories producing lime operated in

Czechia. Since 2004 their number in both fields had dropped to five. All cement factories produced cement clinker in rotary furnaces using a dry process with preheating. Lime is produced in rotary or shaft furnaces. Currently, there are 6 lime production facilities (exclusive facilities which are part of sugar factories). The production of glass is an energy-intensive high-temperature activity producing emissions caused by oxidation of combustion air and vaporization of compounds contained in raw materials present in molten glass mixtures. In Czechia is at present app. 60 operational glass works that melt glass. The Czech glass and costume jewellery industry uses two energy sources – natural gas and electric energy. Electricity dominates in the field of processing, and natural gas dominates in the field of melting. However, electricity is widely used also for melting, which is a certain speciality of Czechia. Emissions TSP, SO_X, NO_X (as NO_2), CO, VOC a NH_3 from processes involved in melting (incl. electric furnaces) and from combustion during the processing and refinement of glass, being ascertained by one-time or continuous measurement, were assigned to NFR 1A2f. Emissions of PMs, TSP and HMs from the preparation of molten glass mixtures and other processes were comprised under NFR 2A3. Production of ceramic products by means of firing, in particular roofing tiles, bricks, fire-resistant blocks, facing tiles, ceramic wares or porcelain in Annex 2 to No. 201/2012 Coll. were comprised under NFR 1A2f. Emissions from the preparation and mixing of materials were comprised under NFR 2A6. Similarly, emission from non-combustion processes by other processing of minerals incl. glass fibres and other isolants are included in NFR 2A6 Pursuant to recommended procedures, only ascertained emissions TSP, PMs, BC and HMs are allocated in categories 2A2 to 2A5b. Because other pollutants (NO_X, NMVOC, SO_X, NH_3 and CO) are emitted at many sources related to mining, production, processing and treatment of mineral materials, emissions of them are reported in NFR 2A6 or 1A2f if fuel consumption is reported. Their relatively higher amount since about 2014 corresponds to changes in legislation and conditions for emission ascertaining during operation of sources.

Tab. IV.2 Mapping of NFR 2A1-2A6 sources categories to main Annex 2 source categories

NFR code	Classification pursuant Annex 2 to No. 201/2012 Coll.*
2A1	5.1.1. Handling raw materials and products
2A1	5.1.2. Production of cement clinkers in rotary furnaces; 5.1.3 Other technological equipment for cement production
2A2	5.1.4. Lime production in rotary furnaces; 5.1.5. Lime production in shaft furnaces and other furnaces
2A5a	5.11. Quarrying and stone processing, refined stone production, mining, treatment, and processing of gravel (natural and artificial) with a projected output of over 25 m3/day
2A6	5.9. Production of composite glass fibres with the use of organic binders
2A6	5.5. Production of glass, fibre, glass products, enamel, and sintered glass for glazing and glass for jewellery processing

*processes without fuel

The most significant emissions are generated from the mining sector (excluding fuels). Mining in Czechia has a very long tradition ranging over many centuries. The products extracted through the mining industry serve today as inputs for a number of very important industries, for example: power generation, building and construction industry, ceramics, glass industry, chemical industry, food industry and other specific sectors.

Until 1994, emissions from the NFR 2A5a were not ascertained and the raw material extraction estimate was carried out using the construction production index back to 1990. Since 1995 these emissions have been ascertained and mineral resource extraction also comes from toll-priced sources. Until 2002, all mining sites were included among the listed sites. Since 2002, emissions have only mining sites with a capacity exceeding 25 m^3/day, but they account for the largest share. Emissions are calculated by source operators using emission factors related to the amount of raw materials consumed, which corresponds to the Tier 1 level. In 2008, the legislation that brought about the change in the obligatory reported emissions was amended in 2008, however, it was not possible to make sufficiently accurate estimates to allow data synchronization between 2008 and 2009. Since 2016, calculations have been carried out in a more detailed manner, covering individual technological operations, incl. the use of abatement technology (i.e. Tier 2 level). The emission factors are published by MoE in the Bulletin.

NFR 2A5b comprises fugitive emissions TSP, PM_{10} and $PM_{2.5}$ from the construction of residential and non- residential buildings (e.g. hotels, shopping centres, schools, etc.). The emission inventory does not comprise emissions from the construction of transport infrastructure and industrial objects. The statistics do not provide information about demolitions. In Czechia these data are processed by the Czech Statistical Office, which maintains a database of floor areas of residential buildings going back to 1997 and of non-residential buildings since 2005. For this reason, emissions from NFR 2A5b, calculated from statistic data, are reported only since 2005. The trend of cement production was used to estimate emissions in 1990-2004.

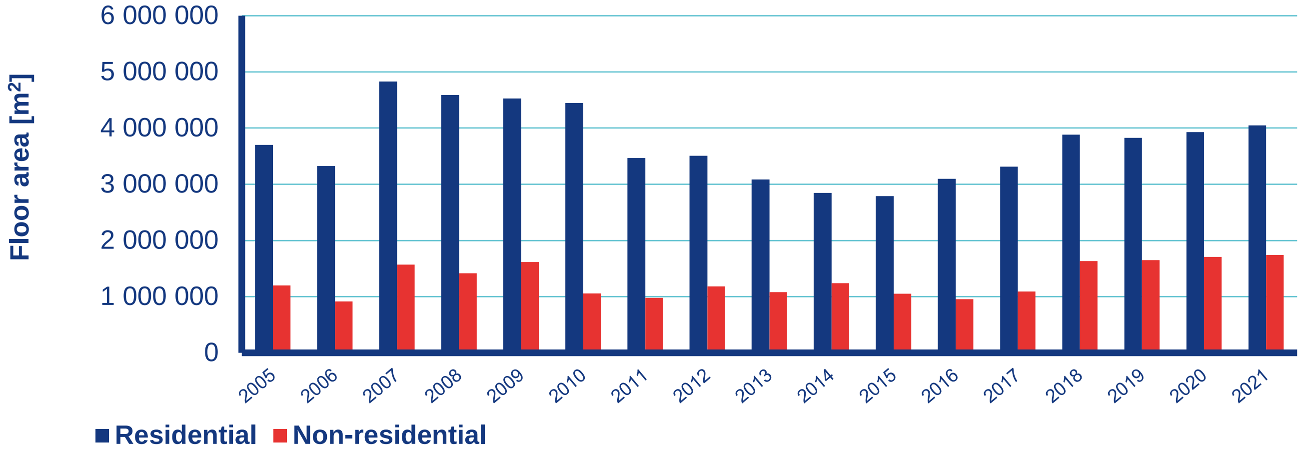


Fig. IV.2 Building floor area, 2005–2021

IV.1.1 Emission factors and calculations

Calculation based on emission factors is used only to estimate emissions in NFR 2A5b. To calculate these emissions, emission factors from the CEPMEIP database were used.

Tab. IV.3 Emission factors for building construction

Poll.	Residential buildings	Non-residential buildings	Unit
TSP	0.21515	0.12268	$kg.m^{-2}$
PM_{10}	0.10757	0.06134	$kg.m^{-2}$
$PM_{2.5}$	0.01075	0.00613	$kg.m^{-2}$

For some categories, source operators use their own calculation and annual emission reporting using emission factors stated in Bulletin of Ministry of Environment. For further detail please see e-ANNEX.

IV.1.2 Uncertainties and QA/QC procedures

The general principles of uncertainty evaluation and QA/QC are described in chapter I.7 and chapter I.6. The detailed information will be supplied later.

IV.1.3 Planned improvements

The methodology for estimating the share of particle emissions from the declared TSP emissions will be updated.

IV.2 Chemical industry (NFR 2B)

The chemical industry represents one of the largest industrial branches in Czechia with production of a wide range of organic and inorganic substances. Chemical industry can be divided into: fundamental chemistry, crude oil processing, pharmaceuticals, rubber industry and plastics processing as well as paper production. Products of chemical industry are mostly inputs for other industrial branches. Emissions of combustion processes in this sector are being reported in NFR 1A2c. Process emissions for named sorts of production include NFR 2B1, 2B2 and 2B6. Titanium dioxide is produced by sulphate process (PRECHEZA, a.s.). Process emissions for production and processing of other inorganic substances, the whole production and processing of organic substances are included in NFR 2B10a, where the largest emissions (mainly SO_X and NMVOC) are reported. There are no production facilities in Czechia in NFR 2B3, 2B5 and 2B7. There is no information about any sources allocation in NFR 2B10b Storage, handling and transport of chemical products and we assume that these activities take place in areas of above mentioned production facilities and are included in reported emissions. Activity data of main productions are based on REZZO database and CZSO data (Fig. IV.3).

NFR 2B do not belong to key categories, except for SO_X (2B10 – 12.3%). The methodology of emission monitoring is long term constant for all sectors and with exception of the NFR 2B1 Ammonia production and 2B2 Nitric acid production, based on reported emissions of sources with annual reporting obligation. Emissions of these sources are being determined on the basis of one-time measurements of the sources operators in prescribed intervals.

An important component of the chemical industry are refineries, which ensure the basic processing of crude oil and the production of petrochemical products. Emissions from the production of sulphur from crude oil (the Claus process) are reported under NFR 1B2aiv. The Claus process is also used in the production of sulphur for tar processing. Emissions from these processes are comprised under NFR 2B10a.

Chlorine production by amalgam electrolysis is a source of Hg emissions. Emissions of other heavy metals take place for example by production of phosphoric acid by thermic method, in production of accumulator fillings or agents for galvanic plating and metallurgy. Emissions of PCDD/F are being monitored in production of dichloromethane and vinyl chloride. Emissions of PAHs occur in production and processing of tar.

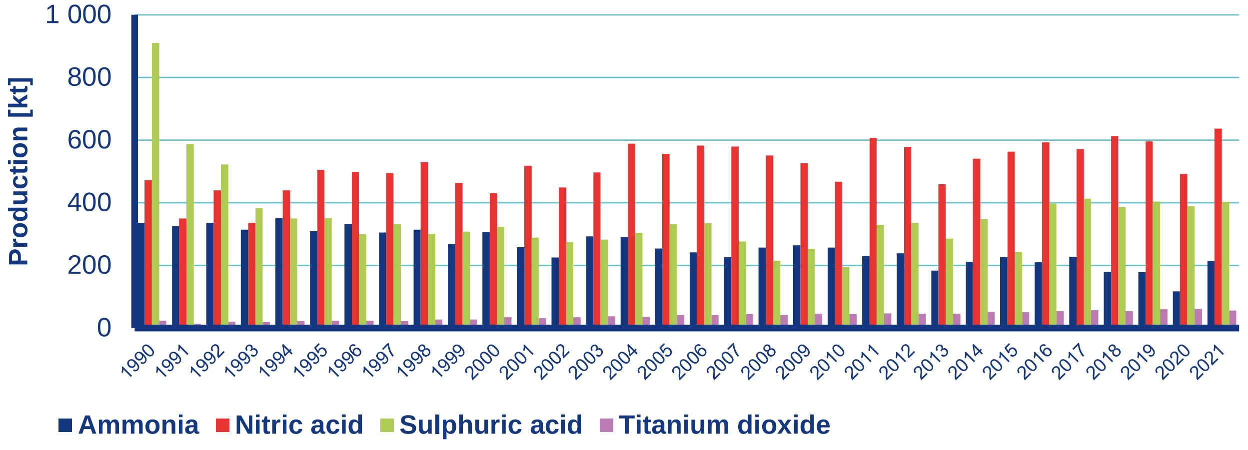


Fig. IV.3 Ammonia, sulphuric acid, nitric acid and titanium dioxide production, 1990–2021

IV.2.1 Emission factors and calculations

Emission factors are used only for calculation of emissions in NFR 2B1 and 2B2. To calculate the emissions, emission factors were taken from the EMEP/EEA EIG [3]. Detailed information on some categories is given in e-ANNEX.

IV.2.2 Uncertainties and QA/QC procedures

The chapter will be supplied later.

IV.2.3 Planned improvements

No improvements are planned, the chapter is considered to be final.

IV.3 Metal production (NFR 2C)

This sector includes primary metal production, metal processing, foundries and surface treatment of metals, plastics and non-metal objects. Metal production, namely iron and steel production belong long-time to most significant emission sources in Czechia. According to the recommended practice, emissions from production technology processes using fuels (production of iron and steel) are reported in NFR 2C1. Other processes namely direct process heating of mean-products and products, air, gas and raw material heaters are allocated in NFR1A2a. There is no information available for sources allocated in NFR 2C7d Storage, handling and transport of metal products and we assume that these activities take place in areas of above mentioned production facilities and are included in reported emissions.

IV.3.1 Iron and steel production (NFR 2C1)

In NFR 2C1 there are identified key categories. The methodology of monitoring emissions of main pollutants for all sectors is long term constant and based, with exception of CO emissions in NFR 2C1 Iron and steel production, on reported emissions of sources underlying annual reporting obligation. Emissions NO_X, SO_X, PMs and CO (sinter plant, pig iron) are being namely assessed by one-time measurement in prescribed intervals. Annually measured emission concentrations show large (sometimes orders of magnitude) differences, leading to irregular emissions reported by operators. For further detail please see e-ANNEX.

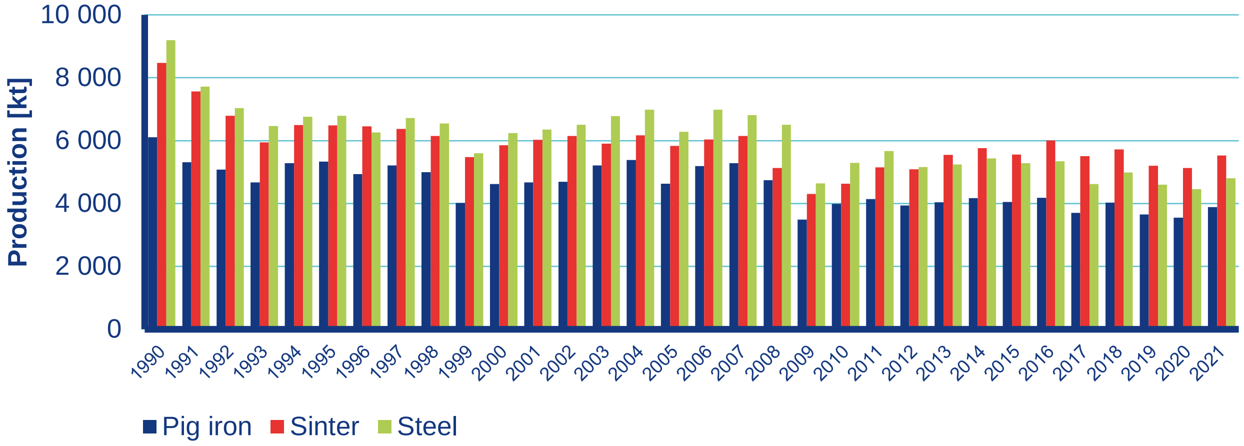


Fig. IV.4 Pig iron, steel and sinter production, 1990–2021

Emissions of CO from open hearth furnace steel plant are since 2014 calculated on basis of steel production and emission factor assessed by source operator as several-year-measurement. NMVOC emissions are calculated using EFs from EMEP/EEA EIG [3]. Emissions of HMs and POPs are calculated on basis of emission factors set from Tab. IV.6 to Tab. IV.9 Activity data were collected on the REZZO database and sectorial statistics HŽ a.s.

HCB emissions from sintering belts are reported as a part of NFR1A2f and therefore uses 'IE' symbol for HCB emissions in NFR 2C1. Emissions from sintering belts (also for NO_X, SO_X, TSP, Hg and PCDD/F) are reported by source operators, other reported emissions are calculated. In the calculation system, all emissions are classified in NFR 1A2a, because their distribution according to the NFR categories would be technically demanding in the Czech point sources inventory system and could lead to errors.

In Czechia there were three works with integrated metals production (VÍTKOVICE, a.s., ArcelorMittal Ostrava, a.s., TŘINECKÉ ŽELEZÁRNY, a.s.), which comprises the production of coke, processing of iron ore, the production of agglomerate, production of pig iron in blast furnaces and production of steel. Due to the fact that the production facility of VÍTKOVICE, a.s. was close to housing estate and high abatement technology costs, the production ended in 1998. Other factories started with the production of steel in electric arc furnaces.

IV.3.1.1 Non-ferrous metal (2C2-7)

In Czechia non-ferrous metals (namely copper, lead, magnesium, aluminium and zinc) are made only by recasting secondary raw materials. The amount of lead and aluminium produced increases every year. Besides these sources, there is a large number of foundries of non-ferrous metals, especially aluminium. An overview of sources and their assignment to NFR is presented in Tab. IV.4. Emission inventory in this sector is being performed on the basis of one-time measurements in prescribed intervals Pursuant to recommended procedures, only ascertained emissions TSP, PMs, BC, HMs and some POPs are allocated in categories NFR 2C2 to 2C7a. Because other pollutants (NO_X, NMVOC, SO_X, NH_3 and CO) are emitted at many sources related to production, processing and treatment of metals, emissions of them are reported in NFR 2C7c or 1A2f if fuel consumption is reported.

Tab. IV.4 Mapping of NFR 2C2-2C7a sources categories to main Annex 2 source categories

NFR code	Classification pursuant Annex 2 to No. 201/2012 Coll.*
Metallurgy of nonferrous metals	
2C7c	4.7. Ore dressing for nonferrous metals
Production or smelting of nonferrous metals, casting alloys, remelting products, refining, and casting production	
2C3–2C7c	4.8.1. Transportation and handling of charge or product
2C3–2C7c	4.8.2. Furnace aggregates for the production of nonferrous metals
2C3–2C7c	4.10. Smelting and casting of nonferrous metals and alloys thereof
2C7c	4.11. Aluminium processing with rolling mill

*processes without fuel

IV.3.1.2 Ferroalloys production (2C2)

Ferroalloys are alloys that contain less than 50% iron and one or more elements. They are used mainly for steel production. In Czechia, only one production plant falls into this category, whose obligation is to report emissions of basic pollutants. Information on HMs and POPs emissions is not available. The EMEP/EEA EIG also does not offer EF for HMs and POPs, so we do not estimate these emissions.

IV.3.1.3 Aluminium production (2C3)

Emissions from aluminium foundries are determined from the reported activity data. HCB emissions are calculated using recommended EF 5. Since 2002 HCB emissions are not expected due to prohibition of HCB precursor (hexachloroethane) to degas the aluminium melt.

IV.3.1.4 Magnesium production (2C4)

The plant engaged in the recycling and production of magnesium in Czechia is only the company Crown Metals CZ s.r.o. (previously Magnesium Elektron CZ s.r.o.). Emissions are determined from the emissions reported by the operator.

IV.3.1.5 Lead production (2C5)

Emissions are determined from the emissions reported by the operators.

IV.3.1.6 Zinc Production (2C6)

Only one company in Czechia is engaged in the secondary processing of zinc. It is Ekozink Praha, s.r.o. It was founded with the aim of ecological processing of zinc waste from hot dip galvanizing. Emissions of the main pollutants are classified in NFR1A2b. The reporting obligation only applies to Zn emissions. Other HMs and POPs emission are calculated from EF in EMEP/EEA EIG [3].

IV.3.1.7 Copper production (2C7a)

Only one company in Czechia is engaged in the secondary processing of zinc. It is Měď Povrly a.s. Emissions from copper production were newly determined only for this operated plant. Emissions from other productions (crucible furnaces), which are part of plants with other non-ferrous metal productions, were transferred to NFR 2C7c. As, Ni, PCDD/F and PCBs emissions were calculated using emission factors from EMEP/EEA EIG [3]. For emissions of the other pollutants, reported data registered in the emission database (REZZO) were used.

IV.3.1.8 Nickel production (2C7b)

At present, nickel is not processed in Czechia.

IV.3.1.9 Other metal production (2C7c)

This category includes emissions from copper and copper alloy plating, galvanic nickel plating, chromium plating, zinc plating and zinc alloy plating, etc. These processes tend to emit heavy metals and other pollutants. The only exception there is the hot zinc coating reported under NFR 2C6. Emission inventory in the sector of surface treatment is based on one-time measurements within prescribed intervals. Activity data are not being reported in statistics. More detail information including selected emission and activity data, emission factors and calculation for NMVOC are presented in the e-ANNEX. Technological processes that precede surface treatment are mechanical pre-cleaning of surfaces and degreasing. Mechanical pre-treatment of surfaces produces emissions of TSP, which are a mixture of abrasives and particles of the underlying material. This group of sources includes finishing and polishing, abrasive blasting and deburring or tumbling. Emissions from these sources were included under NFR 2L (see Tab. IV.5). Some processes of degreasing use solvents, and emissions from them are reported under sector 2D3e.

IV.3.1.10 Storage, handling and transport of metal product (2C7d)

There is no information available for sources allocated in this category and we assume that these activities take place in areas of above mentioned production facilities and are included in reported emissions.

Tab. IV.5 Mapping of NFR 2C7c sources categories to Annex 2 source categories

NFR code	Classification pursuant Annex 2 to No. 201/2012 Coll.
Surface treatment of metals and plastics and other non-metallic objects and processing thereof	
2L**; 2C7c	4.12. Surface treatment of metals and plastics and other non-metallic objects and processing
2C7c	4.13. Metal machining (grinding mills and machining shops) and plastics with a total electrical consumption of over 100 kW
2C7c	4.14. Welding of metallic materials with a total electrical consumption equal to or greater than 1000 kVA
2C7c	4.15. Spraying of protective coatings made of molten metals with a projected output of less than or equal to 1 t of coated steel per hour
2C7c	4.16. Spraying of protective coatings made of molten metals with a projected output of greater 1 t of coated steel per hour
2C7c	4.17. Hot zinc coating

*processes without fuel

**processes without plating bath

IV.3.2 Emission factors and calculations

For emission inventory of heavy metals and POPs during pig iron casting emission factors based on the measurement results had been set.

Tab. IV.6 Casting (blast furnace) – emission factors

Abatement	Pb	Cd	Hg	As	Zn	BaP	BbF	BkF	InP	PAHs	PCDD/F
	[mg·t^{-1}]										[μg I-TEQ.t^{-1}]
Dry ESP	52.00	6.00	48.00	4.50	1729.00	0.09	0.53	0.25	0.11	1.00	0.01
Bag filter	11.10	1.29	0.66	1.50	79.66	0.03	0.18	0.08	0.04	0.33	0.01

Emissions of TSP, SO_X and NO_X in tandem furnaces and oxygen converters are being measured once a year. Fluctuation of SO_X emission is related with use of different amounts of heavy fuel oil in the process of iron production (carbon content balancing). NMVOC emissions are calculated using emission factors for sinter, iron and steel production stated in EMEP/EEA EIG – Tier 2. CO emissions in tandem furnaces are being estimated by emission factor of 7043 g.t^{-1} of produced steel while CO emissions of oxygen convertors are being balance estimated based on operating measurement. For emission inventory Pb, Cd, Hg, As, PCDD/F, PAHs and PCBs are being based on national emission factors (Fig. IV.3 and Fig. IV.4). Emissions of other pollutants reported under UN CLRTAP are being estimated based on emission factors according EMEP/EEA EIG – Tier 2 [3].

Tab. IV.7 Tandem furnaces – emission factors

Pb	Cd	Hg	As	BaP	BbF	BkF	InP	PAHs	PCBs	PCDD/F
[mg.t^{-1}]									[μg.t^{-1}]	[μg I-TEQ.t^{-1}]
854.15	34.39	24.54	5.98	0.03	0.18	0.07	0.04	0.31	30.00	1.43

Tab. IV.8 Oxygen converters – emission factors

Pb	Cd	Hg	As	BaP	BbF	BkF	InP	PAHs	PCBs	PCDD/F
[mg.t^{-1}]									[μg.t^{-1}]	[μg I-TEQ.t^{-1}]
549.75	9.46	7.65	1.94	0.47	5.84	1.98	0.25	8.53	30.00	0.08

Emissions of TSP, NO_X (as NO_2) and CO for electric arc furnaces are being monitored by one-time measurement once a year. National emission factors for PCDD/F had been set 0,144 μg I-TEQ.t^{-1} and for emissions of PCBs 2,2 μg.t^{-1}. Emissions of other pollutants according UN CLRTAP are being based on EMEP/EEA EIG – Tier 2 emission factors [3].

Siemens-Martin furnaces used to be operated in Czechia until 2001. The resulting emissions depend namely on the sort of the input (pig iron or metal scrap), the sort of the fuel used and production intensification by oxygen. One-time measurement of TSP, SO_x, NO_x and CO emissions for this type of furnaces used to take place once a year. For inventory of other pollutants required by UN CLRTAP emission factors according EMEP/EEA EIG – Tier 2. The emission factor for Pb according EMEP/EEA EIG 300 g. t^{-1} of steel was adapted to more real value 30 g. t^{-1}of steel [3].

National emission factors have only been set for emission inventory of heavy metals and POPs for cupola ovens.

Tab. IV.9 Cupola furnaces – emission factors

Pb	Cd	Hg	As	BaP	BbF	BkF	InP	PAHs	PCBs	PCDD/F
[mg.t^{-1}]									µg.t^{-1}	µg I-TEQ.t^{-1}
149.80	5.00	7.00	12.00	0.50	2.67	1.21	0.18	4.55	1023.02	0.48

For copper production the emissions of As, Ni, PCDD/F and PCBs were calculated using emission factors from EMEP/EEA EIG. For emissions of the other pollutants, reported data registered in the emission database (REZZO) were used. For further detail please see e-ANNEX.

IV.3.3 Uncertainties and QA/QC procedures

The chapter will be supplied later.

IV.3.4 Planned improvements

The distribution of emissions from production processes between NFR 1A and NFR 2C will be revised.

IV.4 Solvent use (NFR 2D)

This chapter describes solvents and other product use. Using solvents and products containing solvents leads to emissions of non-methane volatile organic compounds (NMVOC) into the atmosphere (NFR 2D3a, 2D3d-i). Although the EMEP/EEA EIG methodology recommends verifying Hg emissions from fluorescent tubes, there is currently no data to quantify Hg emissions.

Emissions of NMVOC, PM and TSP from the production and use of Hot Mix Asphalt and emulsified asphalt are included in NFR 2D3b according to EMEP/EEA EIG [3]. All types of asphalt production emissions are reported annually by source operators in Summary Operation Records. The asphalt production processes also cover combustion sources. Therefore, emissions from combustion are regarded in NFR 1A2f.

Reported emissions in NFR 2D3c (NMVOC and PMs) especially come only from annual reports in Summary Operation Records. Technological heating emissions from this process are reported in NFR 1A2f.

The investigation of asphalt producers shows that applied technological procedures prevent the PAHs emission from the asphalt blowing. Therefore, the symbol NE was used as in the case of the other emissions (NFR 2D3g).

Except for NMVOC emissions, there is no necessary data for other emissions calculations in NFR 2D3i. Consequently, there is used the notation key NE for another emission.

The solvent and other product use sector belong to one of the largest pollution sources of NMVOC emissions in Czechia, accounting for app. 30% of total NMVOC emissions. The largest share (2021) was for decorative coating application at 35.3%, domestic solvent use 22.7%, other solvent use (including using disinfectants against COVID-19) 17.3% and chemical products 12.2%.

The main activities leading to air pollutant emissions in the Solvent Use sector in Czechia are coatings application in industry and households, degreasing and other applications of solvent-containing products, such as printing and the use of adhesives. Emissions of NMVOC also arise from the manufacturing and use of paints in the pharmaceutical, plastic, leather and textile industries, wood preservation, glass fibre production, use of household and solvent-containing detergents and extraction of fats and oils. The range of monitored categories is shown in the table below.

Tab. IV.10 Activities and emissions reported from the solvent and other product use sector

NFR	Source	Description
Paint application		
2D3d	1. Decorative coating application	Includes emissions from paint application in construction and buildings and domestic use.
	2. Industrial coating application	Includes emissions from paint application in car repairing and manufacturing of automobiles, coil coating, boat building, wood coating and other industrial paint application.
	3. Other coating application	Emissions in this sector include car components production, containers, tins and barrels, aircrafts, coating of plastics etc. This sector includes painting in site (bridges, buildings).
Degreasing and dry cleaning		
2D3e	Degreasing	Includes emissions from degreasing, electronic components manufacturing and other industrial cleaning.
2D3f	Dry cleaning	Includes emissions from dry cleaning.
Chemical products		
2D3g	Chemical products	Includes emissions from polyurethane, polystyrene foam and rubber processing, paints, inks and glues manufacturing, textile finishing, leather tanning and other use of solvents.
Other product use		
2D3b	Road paving with asphalt	Solvents emissions from construction and repairs of roads, pavements and other solid surfaces.
2D3c	Asphalt roofing	NMVOC emissions from production of asphalt roofing materials
2D3h	Printing	Solvents emissions from printing industry.
2D3a*	Domestic solvent use including fungicides	NMVOC emissions from the use of personal care, adhesive and sealant and household cleaning products
2D3i	Other product use	Includes emissions from oil extraction, application of glues and adhesives, preservation of wood, Glass and Mineral Wool production, use of tobacco and other solvent use. The amount of emissions for 2020 and 2021 also includes estimated emissions related to using disinfectants against COVID-19.

* In the next period, the methodology is expected to be improved using the TNO study.

Category Solvents use belongs to the key sources of NMVOC emissions with a share of 26.5%. It covers various technological activities from all the monitored categories. The Solvent application registers the most numerous technological equipment among point-monitored sources (almost 4000 installations, including one or more equipment such as paint boxes, degreasing baths, printing machines, and others.). Unlike the EU Directive, the lower limits for including these resources among the individually monitored sources are significantly lower. These limits often start at 0.6 t of the yearly projected solvent consumption. Thousands of other sources, particularly in the decorative painting and surface maintenance sector, are below the limit, and households also produce a significant part of the emissions by.

Emission inventories for solvents are based on model estimates, as direct and continuous emissions are only measured from limited sources. The model for calculating the total amount of used solvent is used, and emissions are calculated for industrial sectors, households for the stated NFR sectors, and individual pollutants. Solvents emission modelling is based on estimating the amount of used solvents, knowledge of production volume, and solvent-containing products trade. All relevant solvents must be estimated or at least represent more than 90% of the total pollutant emission.

The motor industry, one of the essential industries in Czechia, applies a significant proportion of paints and solvents. Passenger cars are produced in three major car facilities - Škoda Auto, owned by the Volkswagen Group, Toyota Peugeot Citroën Automobile Czech and Hyundai. Trucks are manufactured only by Tatra and Scharzmüller that mainly manufactures trucks accessories. Iveco Czechia and SOR Libchavy are focused on the production of buses. There are also many major suppliers in Czechia for the domestic and foreign automotive industry. Škoda Transportation produces trams, locomotives and train sets.

The printing industry in Czechia is at a high level, comparable to the advanced countries. The most used technique was offset in the past. In 2004, according to the survey, it was about 80% of the polygraph´s output. In the years to come, no such detailed investigation has already been carried out. However, it is possible to assume an increase in the share, especially for digital printing, to 50% and a significant decrease in offset printing below 30%. Like in Europe, digital print and electronic media cause a drop in demand for some types of ink (such as printing labels, books, and printed matters). Paints and coatings protect materials and significantly increase the durability of many objects. Regarding vehicles, coatings serve as corrosion protection. Paint application for industrial goods is decisively affected by the economic situation of individual countries. Architectural paints are the largest application area of paints and coatings. Residential construction has a rising demand for facade and interior wall paints, and it is forecasted that about 58% of all paints and coatings will be utilized in construction. Another important application is the transportation segment. Besides the division by various application areas, the paints and coatings are mainly based on acrylics, vinyl, alkyd, epoxy, polyurethane (PUR), and polyester.

The smallest share of emissions includes producing asphalt roofing materials and road paving with cutback asphalt and asphalt emulsions.

In 2013–2014, an external evaluation was carried out by our external contractor (SVUOM) to assess the estimation of NMVOC emissions from scattered sources, including NMVOC emissions from solvents and other products. Emissions were estimated based on the volume of production or other activity indicators by calculating the amount of emissions using emission factors. In addition to the EMEP/EEA EIG, national emission factors were used for some categories based on data reported by individually monitored sources [3].

IV.4.1 Emission factors and calculations

Emissions are estimated using top-down data (from the National statistical office, the MIT of Czechia, National Associations, and data collected from REZZO) and bottom-up data from inquiries in solvent consumption and expert technical estimations.

Emissions from point sources are gathered from the web-based air emissions data system for point sources (ISPOP). Emissions for diffuse sources are calculated from the data received from Czech Statistical Office using international emission factors and expert opinions. The statistical statement of the Customs Administration of Czechia is a significant source of data and information. For emissions in NFR 2D3a we newly use recommended emission factor of 1.2 kg/capita/year according to EMEP/EEA EIG Tier 1 [3].

Emissions from the application of paints produced by companies which are members of the Association of Paint Manufacturers of Czechia are estimated by an expert, which compiles national statistics on the annual sales of paint products of its members. The paint sales and product statistics are divided into decorative (DIY/architectural) and industrial sectors. For these two sectors, the statistics are further divided into subgroups of several products and surfaces to be painted, such as "waterborne decorative indoor paints" or "solvent-borne decorative indoor paints". For each of these subgroups, the expert estimated the average NMVOC content and average density.

For NMVOC pollutant or product a mass balance is formulated: Consumption equals (production + import) – (export + destruction/disposal).

The National statistical office collects data on the production, import and export amounts of solvents and solvent-containing products. Many data and trends in the production of many branches are gained from publishing Panorama of the Manufacturing Industry of Czechia. MIT elaborates on the publication by cooperating with the Czech Statistical Office and the Confederation of Industry of Czechia. This yearbook aims to provide expert advice on the development and achievements of the manufacturing industry and present the results of industrial companies operating in Czechia. They are also a solid basis for monitoring production and predicting further developments. Import and export figures are available on the National Statistical office, too. Where data on the overall consumption is available from the bottom-up approach, it is used for those years; data for the years in between are interpolated.

Emission factors are based on the values in the EMEP/EEA EIG and adjusted on a country-specific basis according to the assessment of some individual sectors [3]. Emission factors can be defined from surveys of specific industrial activities or aggregated factors from industrial branches or sectors. In some sectors, corresponds emission factor with the VOC Solvents Directive (Czech series of acts, mainly Act. No201/2012 Co. and Regulation No 415/2012 Co.). Furthermore, emission factors may be characteristic of certain products' use patterns.

Capture and destruction (abatement) of solvents lower the pollutant emissions must be, in principle, estimated for each pollutant in all industrial activities and all uses of pollutant-containing products.

Unfortunately, confidentiality creates a lack of activity data in some branches. In these cases, Czechia used expert estimation, often based on earlier data.

More detailed information, including activity data, emission factors and emission estimates for NMVOC inventory by different sub-categories, are presented in the e-ANNEX.

IV.4.2 Uncertainties and QA/QC procedures

The calculations of NMVOC emissions from solvent use were done in several steps. As a first step, the number of solvents used and the solvent emissions were calculated. To determine the number of solvents used in Czechia in the various applications, a bottom-up and a top-down approach were combined. A study (Neuzil et al. 2014; Machalek et al. 2015) described emission estimates based on the bottom-up approach. Emissions of volatile organic compounds from individually monitored sources included in the REZZO 1 database are calculated by a procedure which is directly set out by the Czech law (415/2012 Coll., Annex 5) for the protection of air quality, where it was adopted from the COUNCIL DIRECTIVE 1999/13/EC on the limitation of emissions of volatile organic compounds due to the use of organic solvents in certain activities and installations, Annex III. The calculation entails the ascertainment of emissions usually released in a controlled manner and the calculation of uncontrolled fugitive emissions entering the atmosphere. The resulting total combined uncertainty concerning the estimate of fugitive emissions, using the formula presented above, amounts to 13%. All the calculations tend to give results closer to the lower bound of the given range, and the real uncertainty can be somewhat higher. It, however, follows from the nature and the principle of calculating fugitive emissions of NMVOC that this ascertainment is based on the balance method, which generally provides relatively accurate results. The total uncertainty should not exceed the threshold of 15%, provided that the input data correspond to reality.

The basic approach to emission inventories, the top-down balance method, utilizes results from emissions reported to the REZZO database, especially to ascertain the rate of capture and destruction of VOC contained in the products used. Suppose a product containing VOC is used in an installation without an end technology for reducing output concentrations of VOC or for their complete or partial regeneration. In that case, the total amount of VOC gets released into the atmosphere. The uncertainty associated with ascertaining emissions from these sources is related solely to the accuracy of the activity data and, of course, also with the proportion of VOC contained in them. The uncertainty concerning emissions derived from statistical data and predefined emission factors based on the consumption of VOC in products is estimated, according to the EMEP/EEA EIG methodology, to range from 50 to 200% [3].

IV.4.3 Planned improvements

Emissions of NFR 2D3a will be recalculated under Tier 2 during further following years. Updates in other categories of solvent use (NFR 2D3d-2D3i) are either planned.

IV.5 Other product use (NFR 2G)

NFR 2G in Czechia includes following activities: use of fireworks, use of tobacco and use of shoes. All activity data was obtained from national statistics of Czech Statistical Office.

Use of fireworks during various festive occasions in Czechia was in recent years very popular. Started 2020, their consumption started to decline, mainly due to a ban of fireworks in some public spaces and also due to the covid-19 pandemic (see Fig. IV.5). Almost all fireworks used here are assumed to be imported since the CZ has no known significant producer of fireworks. Activity data were found in External Trade Database in cross-border concept (https://apl.czso.cz/pll/stazo/STAZO.STAZO?jazyk=EN&prvni=N). In the database can be searched based on year and commodity code according to customs nomenclature (http://www.kodyzbozi.cz/). In this case, combined nomenclature KN (8) and commodity code 36041000 (Fireworks) was selected. Data are available from 1999.

Tobacco consumption shows moderate decrease (see Fig. IV.6) mainly caused by complete ban on smoking in public areas (including restaurants, cafes, pubs and bars) and rise of prices of tobacco products. Activity data for tobacco combustion were obtained from Catalogue of Products (main aggregates) – https://www.czso.cz/csu/czso/food-consumption-2021, Table 2, in which is listed yearly cigarette consumption per capita. Emissions were calculated assuming that one cigarette contains 1 g of tobacco (EMEP/EEA EIG [3]).

On the other hand, production of shoes decreased significantly compared to the 1990s, most of shoes is imported at present (see Fig. IV.7). Production of shoes was obtained from Public database – Manufacture of selected Products (main aggregates) – https://vdb.czso.cz/vdbvo2/faces/en/index.jsf?page=statistiky#katalog=30835. Data are available from 1993.

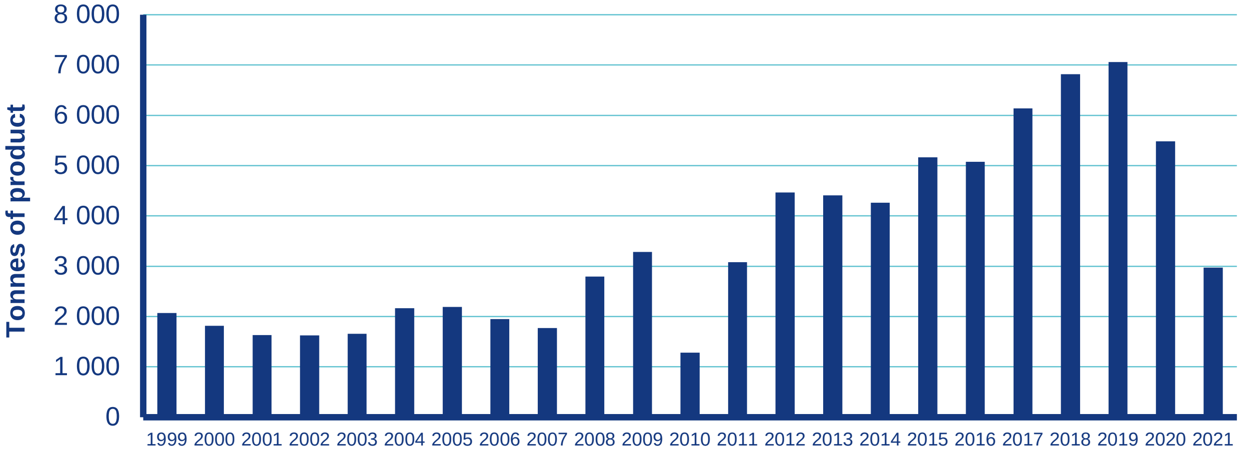


Fig. IV.5 The fireworks import, 1999–2021

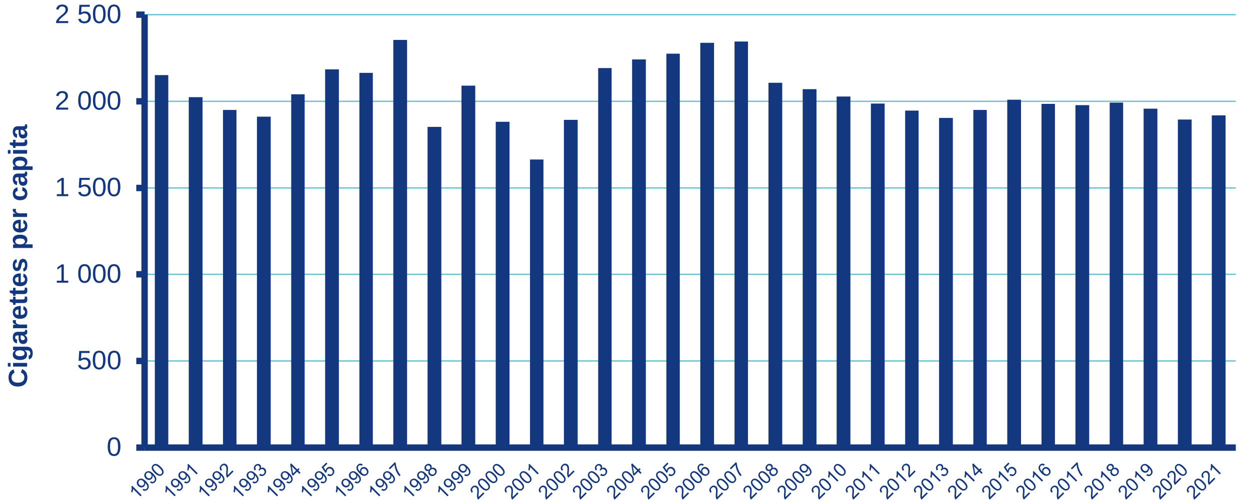


Fig. IV.6 Tobacco smoking, 1990–2021

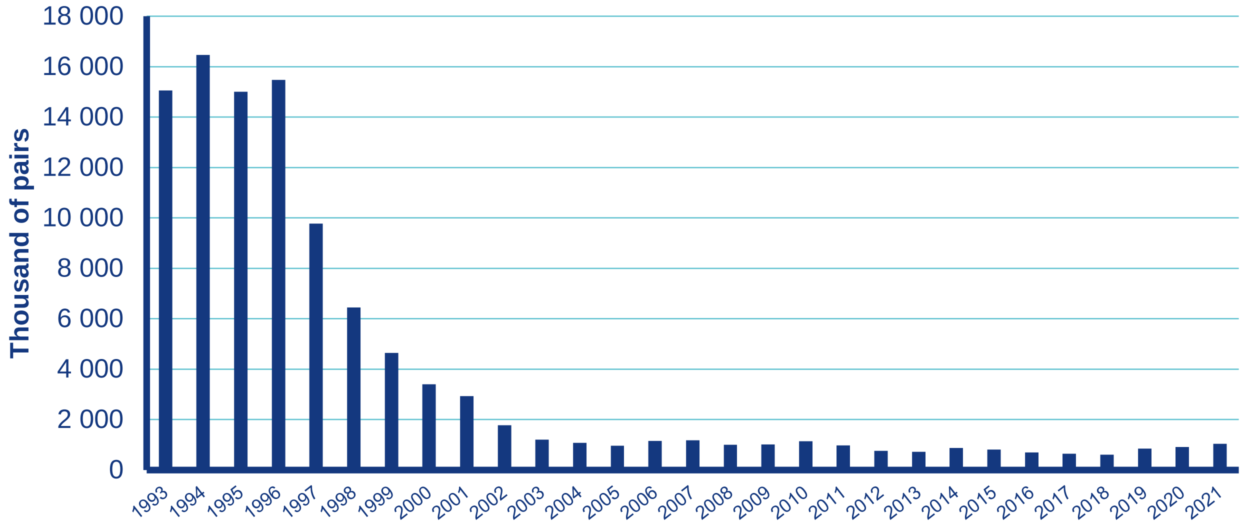


Fig. IV.7 Shoes production, 1993–2021

IV.5.1 Emission factors and calculations

For all groups of processes, emission factors from EMEP/EEA EIG were used [3]. They are listed in tables 3-13 to 3-15. In all cases it is Tier 2 approach.

IV.5.2 Uncertainties and QA/QC procedures

Emissions for NFR 2G are calculated based on official statistics and default emission factors, uncertainty is therefore estimated from 50 up to 200% , see also chapter I.7 General uncertainty evaluation.

QA/QC for NFR 2G is the same as in case of other collectively monitored sources, see also chapter I.6 QA/QC and Verification methods.

IV.5.3 Planned improvements

No improvements are planned, the chapter is considered to be final.

IV.6 Other industry production and wood processing (NFR 2H; 2I)

The consumer industry has a long-standing tradition in Czechia. Textile, shoe or food products have, in the past, been a significant part of the exported goods. However, after 1990 privatization in certain number of enterprises the production was reduced or completely stopped. At present, in beverages branch the major beer production capacity is represented by several large factories, dozens of smaller and almost 400 mini-breweries. In the field of wood processing, the production of pulp is significant, but much of the wood is exported without further processing. Trend of pulp production is shown in Fig. IV.8.

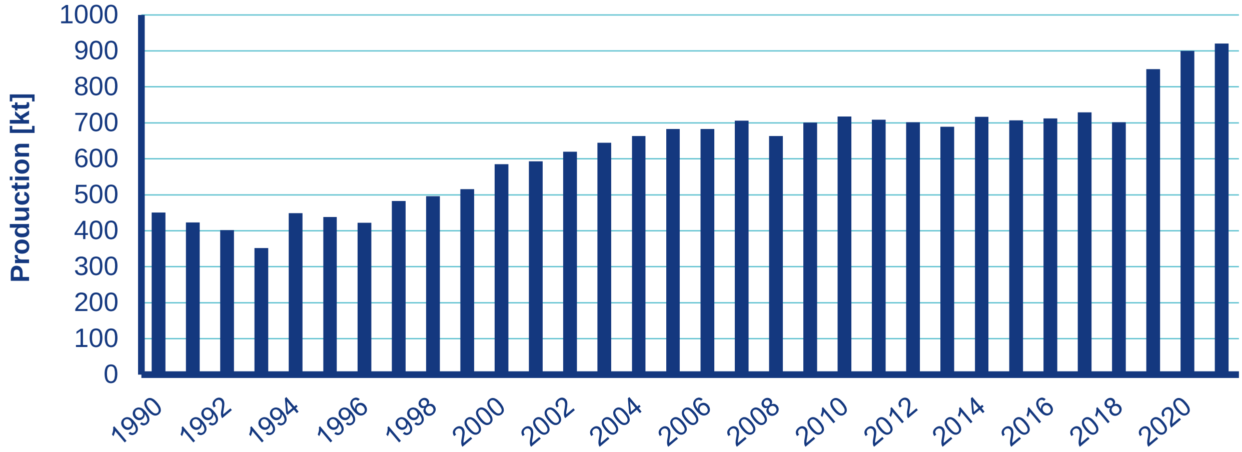


Fig. IV.8 Pulp production, 1990–2021

There are currently two large production plants for pulp production. Sulphate pulp is produced at Mondi Štětí. Sulphite pulp for the paper industry was produced by Biocel Paskov until 2012, and since 2015 there has been a transition from paper pulp production to chemical pulp for the production of viscose fibres. The biggest wood processing plant producing OSB boards and other products is Kronospan Jihlava. There is a long tradition of sugar production, currently producing almost same quantity as before 1990 at seven sugar factories.

The definition of sources according to the national classification usually includes the entire production process not divided into partial processes. In accordance with the recommended practice, emissions from combustion processes are reported in categories 1A2d, 1A2e or 1A2gviii.

IV.6.1 Emission factors and calculations

Newly, emission factors for NFR 2H2 were supplied. Detailed information on some categories is given in e-ANNEX.

IV.6.2 Uncertainties and QA/QC procedures

The chapter will supplied later.

IV.6.3 Planned improvements

No improvements are planned, the chapter is considered to be final.

IV.7 Other (NFR 2J and 2K; 2L)

Czechia is Party of Stockholm Convention and fulfils its obligations. While acceding the Convention there were ascertained data about emissions and use of POPs (NFR 2J and 2K).

The system of emission inventory in Czechia enables allocation of most individually monitored sources into specific NFR categories. Emissions of sources that could not be allocated to other NFR categories are allocated in NFR 2L even there are not in some cases emissions solely attributed to bulk material handling (2L Other production, consumption, storage, transportation or handling of bulk products).

IV.7.1 Emission factors and calculations

For NFR 2J and 2K there is used notation key “NO” (not occurring), e.g. categories or processes within a particular source category that do not occur within a Party.

In NFR 2L there are stated emissions reported in Summary Operational Evidence (SOE) of individually monitored sources. Emission factors therefore are not used in this category.

IV.7.1.1 Production of POPs (2J)

This chapter deals with the production of persistent organic pollutants (POPs) and pesticides. Neither the twelve initial POPs under the Stockholm Convention (Aldrin, Dieldrin, Chlordane, Toxaphene, Mirex, Endrin, Heptachlor, Hexachlorobenzene (HCB), Polychlorinated biphenyls (PCBs), DDT, Polychlorinated dibenzo-p-dioxins (PCDD), Polychlorinated dibenzofurans (PCDF)) nor PAHs are produced in Czechia

IV.7.1.2 Consumption of POPs and heavy metals (2K)

None of the twelve initial POPs under the Stockholm Convention (Aldrin, Dieldrin, Chlordane, Toxaphene, Mirex, Endrin, Heptachlor, Hexachlorobenzene (HCB), Polychlorinated biphenyls (PCBs), DDT, Polychlorinated dibenzo-p-dioxins (PCDD), Polychlorinated dibenzofurans (PCDF)) are consumed/on sale in Czechia.

IV.7.1.3 Other production, consumption, storage, transportation or handling of bulk products (2L)

The emission specification according EMEP/EEA EIG includes emissions from other production, consumption, storage, transport or handling of bulk products. Emission reported in NFR 2L can be allocated as “Other production” and come from Emission database [3]. NFR 2L includes all emissions in processes without fuel combustion that are not allocated in previous categories.

This paragraph includes emissions specified in EMEP/EEA EIG as other production, consumption, storage, transport or handling of bulk products [3].

Emissions reported in NFR 2L belong to sources specified as “Other production” and come from the reported emissions of Summary operation evidence (SOE). NFR 2L includes all emissions from processes without fuel combustion not allocated to any of previous categories, namely: Production or processing of synthetic polymers and composites, surface treatment of metals, plastics and other non-metallic items and other processing and other stationary sources not allocated elsewhere (e.g. hygiene products, feed material production etc.).

The conditions of emission reporting are set by national law for this category. Annex 8 to decree 415/2012 Sb. includes emission limits for some national categories given in overview of emission limits of selected pollutants. For these emissions one-time measurements are performed that are used for calculations of annual emissions based on relevant activity data. The most important emission comes from category Production and processing of other synthetic polymers and production of composites, Surface treatment of metals and plastics and other non-metallic objects and processing and Other sources (e.g. cooling installation).

The emissions related to storage, transport or handling of products are sometimes included in emissions from a certain production. This concerns only metallurgy areas, and in some cases where the operation conditions are set by Integrated permit according IPPC directive. For other facilities, material transport or handling the emissions are not calculated mainly due to unavailable appropriate activity data.

IV.7.2 Uncertainties and QA/QC procedures

The chapter will supplied later.

IV.7.3 Planned improvements

Emissions of sources classified under NFR 2L will be inspected in more detail and, if not covered by EMEP/EEA EIG, will be reclassified [3].

V. Agriculture (NFR 3)

The date of the last edit of the chapter: 15/03/2023

The agricultural sector consists of the following categories:

- 3B Manure management
- 3Da1 Inorganic N fertilizers (includes also urea application);
- 3Da2a Animal manure applied to soils
- 3Da2b Sewage sludge applied to soils
- 3Da2c Other organic fertilisers applied to soils (including compost)
- 3Da3 Urine and dung deposited by grazing animals
- 3Dc Farm-level agricultural operations including storage, handling and transport of agricultural products
- 3De Cultivated crops
- 3F Field burning of agricultural residues

An overview of the main pollutants occurring in agriculture is shown in Tab. V.1.

Tab. V.1 Overview of main pollutants occurring in NFR 3b and 3D

NFR Code	NO_X (as NO_2)	NMVOC	SO_X (as SO_2)	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC
3B	x	x		x	x	x	x	
3Da1	x			x				
3Da2a	x			x				
3Da2b	x			x				
3Da2c	x			x				
3Da3	x			x				
3Dc					x	x	x	
3De		x						

In Czechia, NFR 3F field burning of agricultural residues is not allowed by the law on air protection. It means emissions occurring from this category are not considered in the IIR.

In NFR 3B and 3Da2a, all emissions of monitored pollutants decreased between 1990 and 2021 due to significant animal population , especially in cattle breeding. While milk production per head has increased, animal numbers decreased. In the case of pig production amount of rearing pigs and cows also decreased rapidly in the last decade. In future, a slight increase in pig production in Czechia is expected.

In NFR code 3Da1, ammonia and NO_X emissions have slightly decreased between 1990 and 2021 (approx. 13%). This situation was mainly caused by a significant increase in the consumption of mineral fertilizers between 2014 and 2018.

The agricultural sector is responsible for more than 91% of NH_3 emissions in Czechia. The main sources of ammonia emissions in Czechia represent manure management (category 3B) with a 39% share in total ammonia emissions, followed by inorganic N fertilizers application (category 3Da1) by 34% share and animal manure application to soils (category 3Da2a including 3Da3) by 25% of share. Other non-agricultural sources are a biological treatment of waste – composting (category 5B1), municipal and industrial waste incineration (category 5C1A and 5C1bi), residential: Stationary (category 1A4bi), chemical industry, transport and others. These non-agricultural sources represent approximately 9% share of total ammonia emissions.

Fig. V.1 shows the distribution of sources of NH_3 emission from the agricultural sector for 2021 in Czechia.

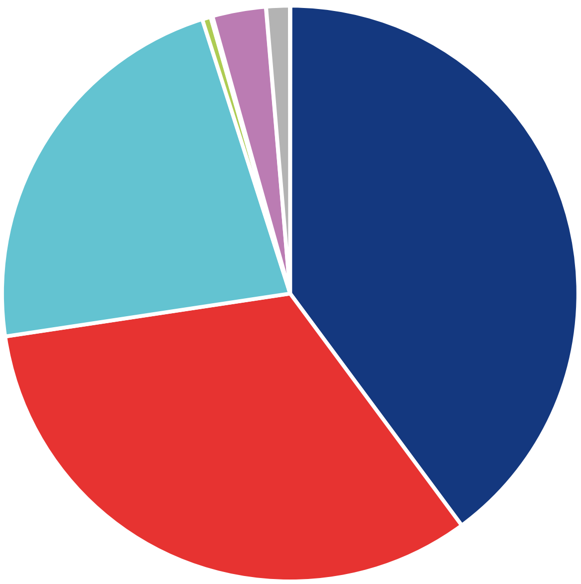


Fig. V.1 NH_3 emissions from the agricultural sector, 2021

Besides, NH_3 agriculture in Czechia contributes to other main pollutants such as NO_X, NMVOC, PMs and TSP. Tab. V.2 shows the agricultural contribution of total national emissions of mentioned pollutants.

Tab. V.2 Agricultural contribution to total emissions of NO_X, NMVOC, NH_3, PMs and TSP (year 2021)

	Emissions					
	NO_X (as NO_2)	NMVOC	NH_3	$PM_{2.5}$	PM_{10}	TSP
National total [kt]	153.77	198.89	68.43	32.36	42.44	51.75
Agriculture [kt]	17.85	37.75	60.36	0.63	5.60	8.30
Agricultural share [%]	11.6	19.0	88.2	1.9	13.2	16.0

The mineral and organic manure application is the most significant agricultural contributor to total NO_X emissions (approximately 11%). The remaining 1% of NO_X is related to emissions from livestock breeding. The agricultural share of NMVOC emissions accounts for 19%, and cattle breeding (categories 3B1a and 3B1b) contributes to the total NMVOC emissions by approximately 15%. PM_{10}

and TSP from category 3Dd Farm-level agricultural operations, including storage, handling and transport of agricultural products, represent the most significant sources of emissions from agriculture.

Extra-large cattle, pigs and poultry farms characterise Czech agriculture. The e-ANNEX **NFR-3B-1** shows the share of animals bred on farms (agricultural holdings) by size group of cattle, pigs and poultry (data from 2016). Tab. V.3 shows the number of dairy cattle farms and the share of dairy cattle by the size of groups [11].

Tab. V.3 Number of dairy cattle farms, share of breed dairy cattle by size groups (ČMSCH, a.s. 2019)

Cattle farms			
Amount of dairy cattle (heads)	**number**	**%**	**% of cattle**
1–10	1 888	56.6	1.1
11–50	419	12.6	2.8
51–200	395	11.8	11.9
201–500	405	12.1	36.7
501–1000	191	5.7	34.5
More than 1000	37	1.2	13.0
Total	3 335	100	100

In Czechia, dairy cattle were bred on 3 335 farms in 2019. However, only 28% of cattle farms (633) have kept approximately 84% of the total dairy cattle amount in Czechia. The following chapters describe the method of calculation for subsectors.

V.1 Livestock breeding - Manure management (NFR 3B), Animal manure applied to soil (NFR 3Da2a), urine and dung deposited by grazing animals (NFR 3Da3)

Within the category manure management, the following subcategories are distinguished:

- 3B1a Dairy cattle
- 3B1b Non-dairy cattle
- 3B2 Sheep
- 3B3 Swine
- 3B4a Buffalo
- 3B4d Goats
- 3B4e Horses
- 3B4f Mules and asses
- 3B4gi Laying hens
- 3B4gii Broilers
- 3B4giii Turkeys
- 3B4giv Other poultry
- 3B4h Other animals

Animals in NFR 3B4a (buffalo) and 3B4f (mules and asses) are not kept as livestock in Czechia. Therefore these subcategories are not estimated.

The number of animals is a key activity data for emissions inventories calculation relating to manure management (NFR 3B), animal manure applied to soil (NFR 3Da2a), urine, and dung deposited by grazing animals (NFR 3Da3). The number of animals was taken from an annual agricultural census from the official statistics (CZSO). The number of animals is considered as an average annual production. Tab. V.4 shows trends of the livestock population in the period 1990-202 1.

Tab. V.4 Livestock population, 1990-2021 (thousands of heads)

	1990	1995	2000	2005	2010	2015	2020	2021
Cattle	3 506	2 030	1 574	1 392	1 349	1 407	1404	1 406
Swine	4 790	3 867	3 688	2 877	1 909	1 560	1 499	1 518
Sheep	430	165	84	140	197	232	204	183
Poultry	31 981	26 688	30 784	25 372	24 838	22 508	24247	23 809
Horses	27	18	24	21	30	33	38	33
Goats	41	45	32	13	22	27	29	25

Trends in the livestock populations in the key categories (cattle, swine) determine emissions trends in the agricultural sector. The cattle population in 2021 corresponded to only 40% of the population in 1990, and the swine population in 2021 corresponded to even less - only 31% of the initial population.

V.1.1 Emission factors and calculations

The Czech team accepted remarks from the international Technical expert review team (TERT) and prepared a new concept calculating NH_3, NO_X and NMVOC emissions from livestock. This concept was based on the following decisions:

- To estimate NH_3, NO_X and NMVOC emissions from animal breeding, the Tier 2 approach according to the 3B Manure management EMEP/EEA EIG has been used since 2020 (submission 2021) [3].
- To calculate ammonia and NO_X emissions according to Tier 2, the Manure management N-flow tool developed by Aether Ltd. 2019 under contract to the EEA was used [12].
- All used activity data for NH_3, NO_X and NMVOC emissions inventories are in accord with the latest data used for greenhouse gas (GHG) inventories (submission 2023) and with the Gross nitrogen balance per hectare of utilised agriculture area for the Czech Republic (Eurostat) as a result of activities focusing on unification of national data used for calculation of all inventories (GHG, NH_3, NO_X, NMVOC and Gross nitrogen balance).

V.1.1.1 Activity data

The number of livestock

Tier 2 uses a mass-flow approach based on the concept of a flow of TAN through the manure management system. According to 3B Manure management EMEP/EEA EIG, the first step is to define the homogeneous livestock subcategories concerning feeding, excretion and age/weight range [3]. The e-ANNEX NFR-3B-2 shows number of animals allocated on relevant subcategories used for inventories calculation. The source of these data is the Czech Statistical Office. This allocation has been used for the all-time series from 1990 to 2021. It includes 43 different livestock categories divided on weight and age. These data are used for defining relevant NFR categories and as input data for the Manure management N-flow tool.

Values of N-excretion (Nex)

The emission of $NH_3$3 and NO_X from manure management is calculated based on nitrogen excreted from livestock. Nex value in all animal categories, except dairy cattle, had been based on the national data for typical animal mass (TAM), Eq. 10.30 IPCC 2006 Gl. and the default excretion rate (Table 10.19, IPCC 2006 Gl. In dairy cattle's case, the excreted nitrogen calculation depends on milk production, which has been increasing in the Czech Republic since 1990. Therefore Nex rate value for the entire time series was taken new from OECD reporting (the documentation provided by the Crop Research Institute team). The country-specific values of Nex were derived from the national legislation Decree No. 377/2013 Coll. on the storage and use of fertilizers. The use of the updated coefficients was supported mainly by the need to synchronize input data used to evaluate the nitrogen flows in agriculture to increase the methodological level of reporting the nitrogen balance, greenhouse gas emissions and pollutants for the Czech Republic in terms of the requirements of international organizations.) Since 2021, these values are also jointly used for calculating GHG emissions and Gross nitrogen Balance (for Eurostat). The e-ANNEX NFR-3B-3 presents all revised Nex used for calculating NH_3 and NO_X inventories.

V.1.1.2 Agricultural Waste Management System (AWMS)

There are four main Manure Management systems defined in Czechia according to Table 10.18 (IPCC 2019) [14].

1. Anaerobic digester

2. Liquid system

3. Solid storage

4. Pasture/Range/Paddock

The use of manure in anaerobic digesters is relevant for cattle, swine and poultry manure. The operation of anaerobic digesters began in 2001. Currently, 397 biogas power stations are operated in the Czech agriculture. The significant accruement of biogas power stations occurred between 2008 and 2013.

The specific structure of Czech animal breeding (mostly in factory farming) allows building anaerobic digesters close to farms to consume daily manure production efficiently without manure storage. The number and capacity of anaerobic digesters have remained at their maximum value since 2014. In the same way, animal waste management systems (AWMS) are used for N_2O, CH_4, NH_3 and NO_X emission estimations. Based on a statistical survey of the amount and types of biomasses used for anaerobic digestion in 2018, the AWMS for cattle, swine and poultry categories have been updated. The overview of used AWMS per individual animal categories is provided in the e-ANNEX **NFR-3B-4**.

Values of feed intake and values of excreted volatile solids

Emissions of NMVOC occur from silage, manure in livestock housing, outside manure stores, field application of manure and from grazing animals. Feeding cattle with silage has been identified as the largest source of NMVOC in agriculture. Values of feed intake in MJ (average gross energy intake) are basic activity data for calculating NMVOC originating from dairy and non-dairy cattle. These data values presented in NIR for GHG inventory are used as a source. These data are available in the e-ANNEX **NFR_3B_5**; likewise, values of excreted volatile solids are used to calculate NMVOC originating from all livestock categories other than cattle. Moreover, the calculation of NMVOC is also dependent on ammonia emissions originating from animal housing, manure storage, manure application and livestock grazing. These ammonia emissions are downloaded from the Manure management N-flow tool for all livestock categories.

V.1.1.3 Ammonia emissions factors

Housing

In 2012 the study on the implementation of Best Available Techniques (BAT) in the installation falling in Czechia under Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control) was carried out. There was found that approx. 44% of rearing pigs on intensive pig farms were housed in the system with a partly slated floor with a reduced slurry channel, 32% in the system with a partly slatted floor with a vacuum system and 22% in the system with a partly slatted floor with scraper [13]. According to the relevant Best Available Reference Document for Intensive Livestock Farming (ILF BREF since 2017 IRPP BREF), all these systems were considered BAT with different potentials for ammonia emissions reduction. However, for calculating ammonia emissions national inventory with the assistance of the Manure management N-flow tool default EF presented in Table 3.9. 3B EMEP/EEA EIG have been used [3]. The reason for this approach has been the need for more detailed information for implementing abatement measures resulting from BATs application into inventories calculated according to Tier 2.

Manure storage

Depending on the housing type, livestock manure is collected solid or slurry. This share is primary input data to the Manure management N-flow. According to Czech law 201/2012 on air protection, all slurry tanks must be covered by a fixed or floating cover or a natural floating cover to reduce ammonia emissions into the air.

Manure application

A significant subsidy program focused on introducing low ammonia application techniques started in 2011 in Czechia. This effort resulted in faster incorporation of manure into the soil. The Czech statistical office confirmed this trends based on data published in April 2018 in the “Farm Structure Survey – 2016” and in September 2021 in the “Integrated farm survey - 2020” [15]. Tab. V.5 presents share of low ammonia application techniques.

Tab. V.5 Manure consumption by application technique (CZSO 2021)

Manure application techniques	Manure applied (tons)	Share (%)
Broadcast		
No incorporation	2 994 173	15.4
Incorporation within 4 hours	2 174 620	11.2
Incorporation between 4 and 24 hours	10 826 971	55.5
Band-spread		
Trailing hose	2 394 88	12.0
Trailing shoe	336 783	1.7
Injection		
Shallow / open-slot	537 289	2.8
Deep / closed-slot	282 397	1.4

Presented values show that 85% of manure was applied by low ammonia emissions techniques defined in the Options for Ammonia Abatement: Guidance from the UNECE Task Force on Reactive Nitrogen [16]. Approximately 15% of manure was applied and incorporated into the soil immediately by injection or within 4 hours, where ammonia abatement effect is on the level of 80 - 90 in case of injection and on the level of 45 - 65% in case of incorporation of manure into the soil within 4 hours. Share of manure incorporation within 24 hours represents 56% of the total amount of applied manure with ammonia abatement effect at 30%, similar to utilization of band spreading with a share of 14%. Based on these facts, possibly 85% of all manure has been applied by technique with abatement effects on ammonia emissions of at least 30%.

Ammonia emissions from manure application are registered under NFR code 3Da2a and from grazing animals under NFR code 3Da3.

Abatement measures, According to the Options for Ammonia Abatement: Guidance from the UNECE Task Force on Reactive Nitrogen, ammonia abatement effects were incorporated into the inventory. Mitigation measures were included directly in the N-flow tool calculation program as an extension of the original program. The extension of the original program was created as a result of the specific contract No 070201/2020/831771/SFRA/ENV.C.3 - Capacity building for Member States regarding the development of national emission inventories led by the Ricardo Energy & Environment, a trading name of Ricardo Nederland BV, under contract to the European Commission dated 28 May 2018. Reducing measures regarding manure storage and its application to the soil was considered for the Czech Republic. Penetration rates of used abatement measures and related comments are available in the e-ANNEX **NFR-3B-6.**

NO_X emission factors

For calculation of NO_X (as NO_2) emissions inventory with the assistance of the Manure management N-flow tool default EF presented in Table 3.10. 3B EMEP/EEA EIG have been used [3].

NMVOC emission factors

Since 2020 emissions of NMVOC have been calculated using the Tier 2 approach. For calculating NMVOC emissions inventory, default EFs presented in Table 3.11 for dairy cattle, and other cattle and Table 3.12 for livestock categories other than cattle of 3B EMEP/EEA EIG have been used [3].

PMs emission factors

The estimation of PMs emissions is based on the Tier 1 approach according to the 3B EMEP/EEA EIG [3]. For calculating $PM_{2.5}$, PM_{10} and TSP emissions inventories, default EFs presented in Table 3.5 of the EMEP/EEA EIG have been used. These emissions include primary particles in the form of dust from housings. The inventory includes PMs emissions from cattle, swine, poultry, horses, sheep and goats. The number of grazing days is taken into account. Each category of animals has been multiplied by default specific emission factor.

Ammonia, NO_X and NMVOC emissions

Trends in ammonia, NO_X and NMVOC emissions originating from manure management are presented in Fig. V.2 and from manure application and animal grazing in Fig. V.3.

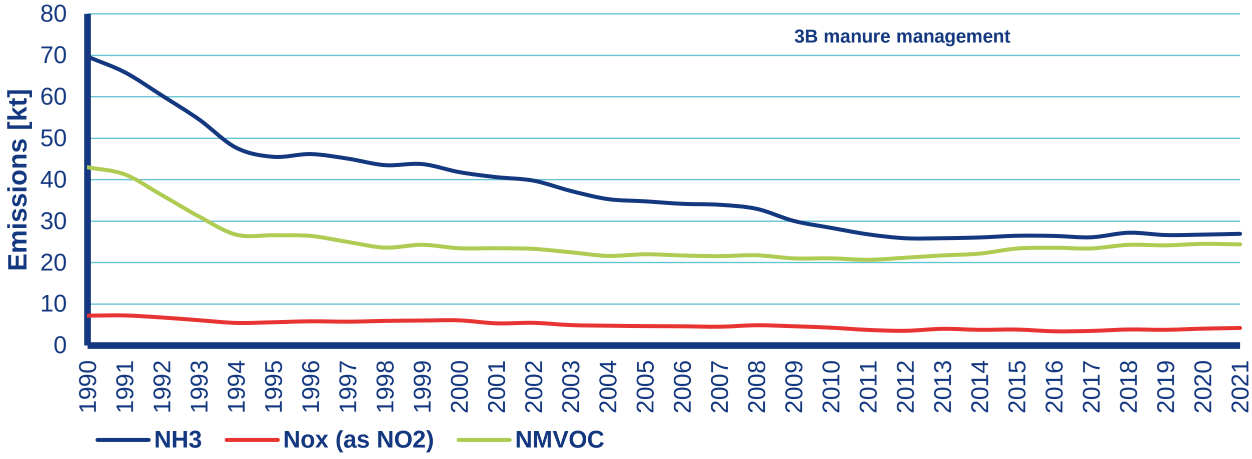


Fig. V.2 NH_3, NO_X and NMVOC emissions originating from manure management, 1990–2021

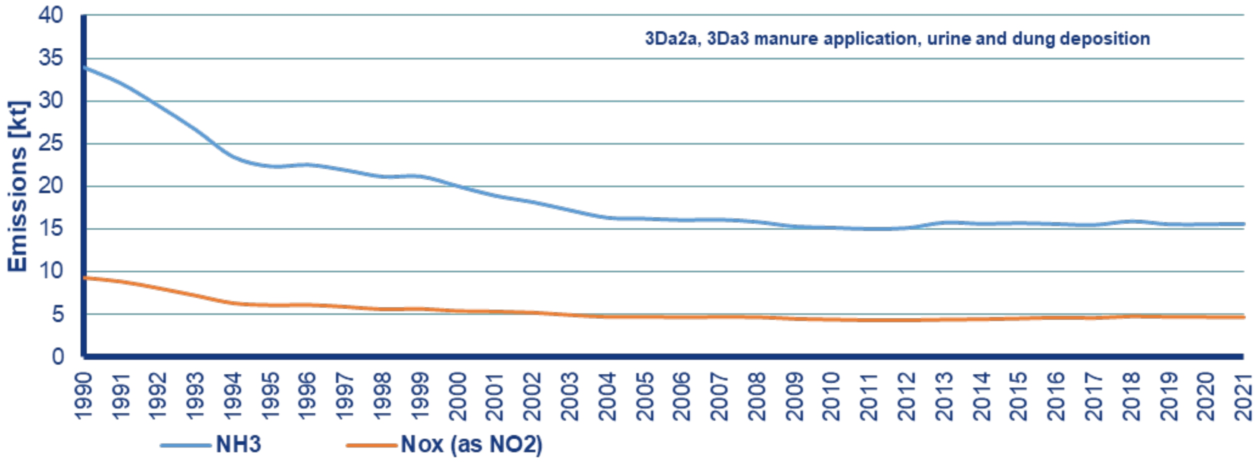


Fig. V.3 NH_3 and NO_X originating from manure application, urine and dung deposited by grazing animals, 1990–2021

V.1.2 Uncertainties and QA/QC procedures

There needs to be more data available to assess the uncertainty of the calculations. The same calculation system has been used for the whole series.

V.1.3 Planned improvements

There are planned following issues:

- Verify harmony of input data used for NH_3, GHG emissions inventories and Gross nitrogen balance inventory with the expert group for greenhouse gases and nitrogen balance calculation.
- Incorporate ammonia abatement techniques following BATs utilization in housing pigs and poultry into inventory calculation.
- Verification of animal feed properties.

V.2 Crop production and agricultural soils - Inorganic N fertilizers (NFR 3Da1)

For the Inorganic N-fertiliser (also includes urea application) sector (NFR 3Da1), emissions of NH_3 and NO_X are estimated. As seen in fig. 5.1 emissions of NH_3 from inorganic fertilisers contribute 26% of the total ammonia emissions from the agricultural sector, and emissions of NO_X contribute 68% of the total NO_X emissions from the agricultural sector in 2021. Trends in inorganic fertilisers' consumption are presented in Tab. V.6. Source of these data is CZSO [17].

Tab. V.6 Consumption of inorganic fertilisers (CZSO)

Agricultural production year	Consumption (tonnes of nutrients)			
	Fertilizers, total	Nitrogenous (N)	Phosphorous (P_2O_5)	Potassium (K_2O)
1994/95	333 456	229 334	61 172	42 950
1999/00	279 238	212 988	39 834	26 416
2004/05	279 918	206 576	43 083	31 097
2006/07	301 864	223 684	47 083	31 097
2007/08	320 042	237 875	49 034	33 133
2008/09	278 198	221 667	35 218	21 313
2009/10	281 484	225 982	35 078	20 424
2010/11	303 927	238 554	39 991	25 382
2011/12	318 225	248 024	43 001	27 199
2012/13	337 764	261 216	47 053	29 495
2013/14	353 989	268 892	50 847	34 250
2014/15	357 668	270 023	52 005	35 641
2015/16	385 739	292 750	54 401	38 589
2016/17	380 659	285 739	56 194	38 725
2017/18	374 995	281 271	54 969	38 755
2018/19	365 071	274 305	52 595	38 171
2019/20	360 414	267 676	55 656	37 083
2012/22	343 049	256 521	51 617	34 911

The highest consumption of inorganic N-fertilisers was in the agricultural production year 2015/2016. Since 2016/2017, consumption of these fertilisers has decreased.

V.2.1 Emission factors and calculations

For national estimation of NH_3 emissions from consumption and application of inorganic N-fertilisers, the Tier 2 approach has been used according to the 3.D Crop production and agricultural soils guidebook [3]. Tier 2 is not available to estimate NO_X, which means the Tier 1 approach has been used.

V.2.1.1 Activity data

The IFASTAT database has been used as a key source of basic activity data regarding the amount of inorganic N-fertilisers consumption. In this context is very important to underline that these data express the amount of fertilizers sold, which are assumed to equal the amounts applied. Since the 2022 submission, storage effects have been approximated by applying a moving average to the sales data (moving cantered three-year average, for the last year a two-year average). It results in the smoothing of extreme values and redistribution of emissions between neighbouring years.

In the e-ANNEX NFR-3D-1 consumption of different inorganic N-fertilisers is presented. According to this database, the total consumption of inorganic N-fertilisers is mentioned in the Tab. V.6 is divided into the consumption of Ammonium nitrate (AN), Ammonium phosphates (AP), Ammonium sulphate (AS), Calcium ammonium nitrate (CAN), NK Mixtures, NPK Mixtures, NP Mixtures, N solutions, Other straight N compounds and Urea. Differences in the methodological approach of data collection cause differences in total consumption data on inorganic N-fertilizers between the IFASTAT database, the EUROSTAT database, the Czech Statistical Office (CZSO) and FAOSTAT. The IFASTAT database expresses the consumption of mineral fertilizers used in the economic year (e.g. 2020/2021), while the data in the FAOSTAT and EUROSTAT databases are in the calendar year (2020).

NH_3 emissions factors

Ammonia emissions from inorganic N-fertilizers are calculated by the default EF in Table 3.2 of the 3D EMEP/EEA EIG for each group mentioned above of inorganic N-fertilizers. [3]. Czechia is classified into a cool climate zone with a soil pH below 7.0.

NO_X emissions factors

NO_X emissions from inorganic N-fertilizers are calculated by default EF in table 3.1 of the 3D EMEP/EEA EIG for all inorganic N-fertilizersd [3].

Ammonia and NO_X emissions

The e-ANNEX **NFR-3D-2** presents a share of different types of inorganic N-fertilisers on total ammonia emissions from inorganic N-fertilisers consumption in 2021 is presented. In 2021 ammonia emissions from Urea and N solutions based mainly on urea reached a proportion of the total ammonia emissions from inorganic N-fertilisers consumption at 23% and 20%, respectively. In the e-ANNEX **NFR-3D-1** are also presented trends in ammonia emissions originating from different types of inorganic N-fertilisers. Ammonia emissions from the consumption of urea and urea-based fertilisers are decreasing. Trends in NH_3 and NO_X emissions originating from inorganic N-fertilisers consumption (in kt) are presented in Fig. V.4.

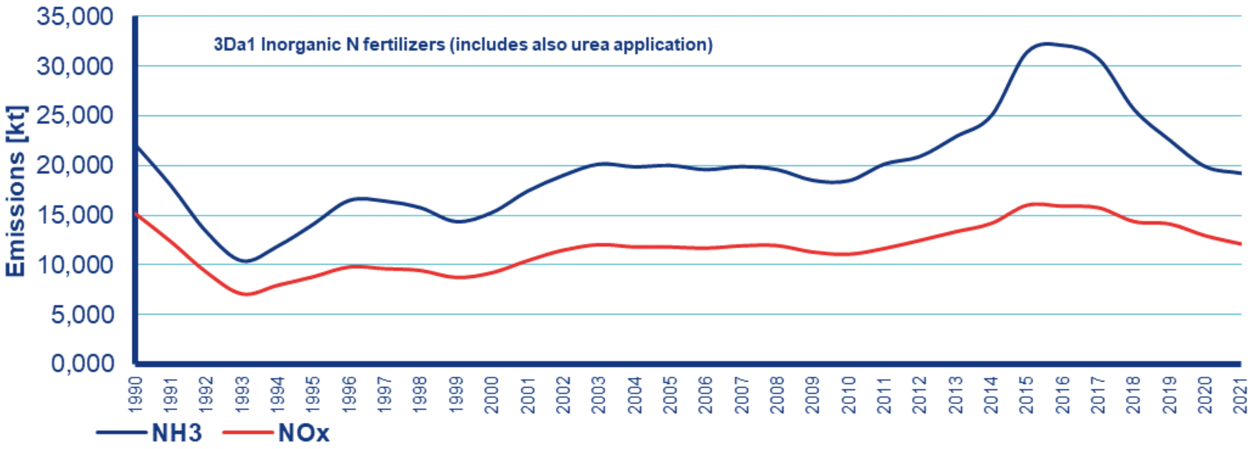


Fig. V.4 NH_3 and NO_X emissions originating from inorganic N-fertilisers consumption, 1990–2021

V.2.2 Uncertainties and QA/QC procedures

There needed to be more data available to assess the uncertainty of the calculations. The same calculation system has been used for the whole series.

V.2.3 Planned improvements

A new law has imposed measures for the low-emission urea application since July 1 2022. According to the Options for Ammonia Mitigation Guidance principles from the UNECE Task Force on Reactive Nitrogen, the measure represents a low ammonia emissions option focused on urea-based fertilisers. The law do not allow surface application of urea-based inorganic N-fertilisers without a rapid incorporation into soil or application of urea-based inorganic N-fertilisers untreated by urease inhibitor. Consequently, ammonia emissions from urea application could decrease by 70%. Then, the specific default EF for urea can be reduced. This measure will be included in the national ammonia emission inventory in 2024.

V.3 Crop production and agricultural soils - Sewage sludge applied to soils (NFR 3Da2b) and Other organic fertilisers applied to soils (including compost) (NFR 3Da2c)

For the sectors, Sewage sludge applied to soils (NFR 3Da2b) and Other organic fertilisers applied to soils (including compost) (NFR 3Da2c) emissions of NH_3 and NO_X are estimated. NH_3 from both sectors contribute less than 1% of the total ammonia emissions from the agricultural sector. Equally, emissions of NO_X contributed less than 1% of the total NO_X emissions from the agricultural sector in 2021.

V.3.1 Emission factors and calculations

The Tier 1 approach has been used for national estimation of NH_3 emissions from Sewage sludge applied to soils (NFR 3Da2b), and Other organic fertilisers applied to soils (including compost) (NFR 3Da2c), according to the 3.D Crop production and agricultural soils [3].

V.3.1.1 Activity data

According to the Tier 1 methodology, emissions of NH_3 and NO_X are calculated as a multiplication of the amount of N applied into the soil and the default emission factor. The source of activity data regarding sludge application and compost production is the Czech Statistical Office. The e-ANNEX NFR-3D-6 shows trends in the utilisation of sewage sludge. The average N-content in sewage sludge is assumed to be 3.66 kg N per kg dry matter [18] and 0.55 N per kg dry matter in composts in Czechia [19]. In Tab. V.7 and in Tab. V.8 from composts applied on soil are presented.

Tab. V.7 Activity data used to estimate NH_3 and NO_X from sewage sludge, 1990–2021

	1990	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021
Amount of sludge applied on soil (tons of DM)	6 841	28 615	34 467	60 639	63 061	62 551	75 451	88 883	90 663	63 064	66 008
N-content (%)	3.66	3.66	3.66	3.66	3.66	3.66	3.66	3.66	3.66	3.66	3.66
N applied on soil (tons of N)	253	1 058	1 275	2 243	2 333	2 314	2 791	3 288	3 354	2 333	2 445

Tab. V.8 Activity data used to estimate NH_3 and NO_X from composts and digestate, 1990–2021

	2005	2010	2015	2016	2017	2018	2019	2020	2021
Amount of applied composts (tons of DM)	47 260	70 333	87 275	124 502	130 013	128 619	143 736	145 599	145 710
N-content (%)	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55
N applied on soil (tons of N)	259	386	480	684	715	707	790	801	801

Ammonia emissions factors

For calculating of ammonia emissions originating from sewage sludge applied to soils and other organic fertilizers applied to soils (including compost and digestate), default EFs presented in the tab. 3.1 of the 3D EMEP/EEA EIG has been used [3].

NO_X emissions factors

Ammonia emissions from sewage sludge applied to soils and other organic fertilizers applied to soils (including compost and digestate) are calculated by default EFs from Tab. 3.1 in the 3D EMEP/EEA EIG [3].

Ammonia and NO_X emissions

Fig. V.5 presents trends in NH_3 and NO_X emissions originating from sewage sludge applied to soils and other organic fertilizers applied to soils (including compost and digestate) in 2005–2021 (in kt).

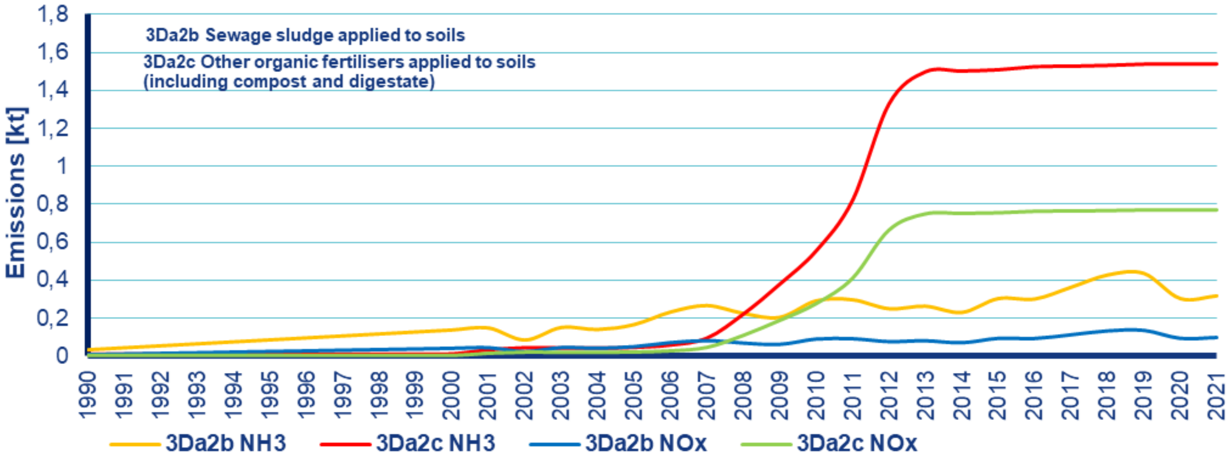


Fig. V.5 NH_3 and NO_X emissions from sewage sludge applied to soils and other organic fertilizers applied to soils (including compost and digestate), 2005–2021

V.3.2 Uncertainties and QA/QC procedures

There needed to be more data available to assess the uncertainty of the calculations. The same calculation system has been used for the whole series.

V.3.3 Planned improvements

No improvements are planned, and the chapter is considered to be final.

V.4 Crop production and agricultural soils – farm-level agricultural operations including storage, handling and transport of agricultural product (NFR 3Dc)

NFR 3Dc comprises fugitive emissions of $PM_{2.5}$ and PM_{10} produced by agriculture during soil cultivation, harvesting of crops and their subsequent cleaning and drying. It can be assumed that emissions produced during field operations are composed mainly of inorganic soil particles, during harvesting mainly of organic plant remains, and in some cases of spores of moulds etc. Emissions depend on the crop, soil type, soil cultivation method, and climatic conditions before and during farming operations. NFR 3Dc contributed 1% and 9% of the total $PM_{2.5}$ and PM_{10} emissions in 2021. Cropped areas of individual crops divided at the Nomenclature of Territorial Units for Statistics (NUTS 3) have been obtained from the annual report of the Czech Statistical Office. The main focus has been on areas of monitored cereals such as wheat, rye, barley and oats, which are grown on approximately 55% of arable land. The area taken up by cereal crops has been subtracted from the total area of arable land, which gives the area of arable land on which root crops, vegetables, oilseeds, fodder plants, etc., are grown.

V.4.1 Emission factors and calculations

V.4.1.1 The Tier 2 approach has been used for the NFR 3.Dc soils to estimate $PM_{2.5}$ and PM_{10} emissions Activity data

According to the Tier 2 methodology, PM_{10} and $PM_{2.5}$ are calculated as the product of cropped areas of individual crops and emission factors of individual field operations emitting dust particles. The source of activity data regarding the sowing area of crops is the Czech Statistical Office. The e-ANNEX NFR-3D3 shows trends in the utilisation of agricultural areas and areas under crops (as of 31st May of the relevant year).

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

Tables 3.5 and 3.7 in 3D EMEP/EEA EIG for the region with wet climatic conditions present default EFs for calculating $PM_{2.5}$ and PM_{10} emissions inventories [3]. For rape default, EF for crop cultivation utilisation of different tillage practices (conventional tillage - mouldboard plough or disc ploughland, conservation tillage - low tillage) has been considered to obtain a more precise calculation of PMs emissions from the agricultural operation. The share of zero tillage (direct seeding) is only 1.5% in Czechia and was omitted in the calculation. Soil cultivation, the area taken up by cereal crops in each region, was divided into thirds. For one-third of cereals farmed using the minimization approach, the emission factor for soil cultivation was factored in twice; for the remaining area, it was factored in four times, as was the case for areas classified as other arable lands. In the case of permanent grasslands, the emission factor for the operation Harvesting was factored in twice. The total emission of PM_{10} or $PM_{2.5}$ for a given region is determined by the sum of individual emissions of PMs for individual operations and crops. The e-ANNEX NFR-3D-4 shows the share of used tillage methods in 2010 and 2016. In Tab. V.9 frequency of farming operations during the year for individual types of crops is presented.

Tab. V.9 Frequency of farming operations during the course of the year for individual types of crops

Crop	Soil cultivation		Harvesting	Cleaning	Drying
	Conventional tillage	Conservation tillage			
Wheat	4	2	1	1	1
Rye	4	2	1	1	1
Barley	4	2	1	1	1
Oat	4	2	1	1	1
Other arable	4	-	-	-	-
Grass	1	-	2	0	0

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

Fig. V.6 shows trends in $PM_{2.5}$ and PM_{10} emissions from farm-level agricultural operations, including storage, handling and transport of agricultural products (in kt).

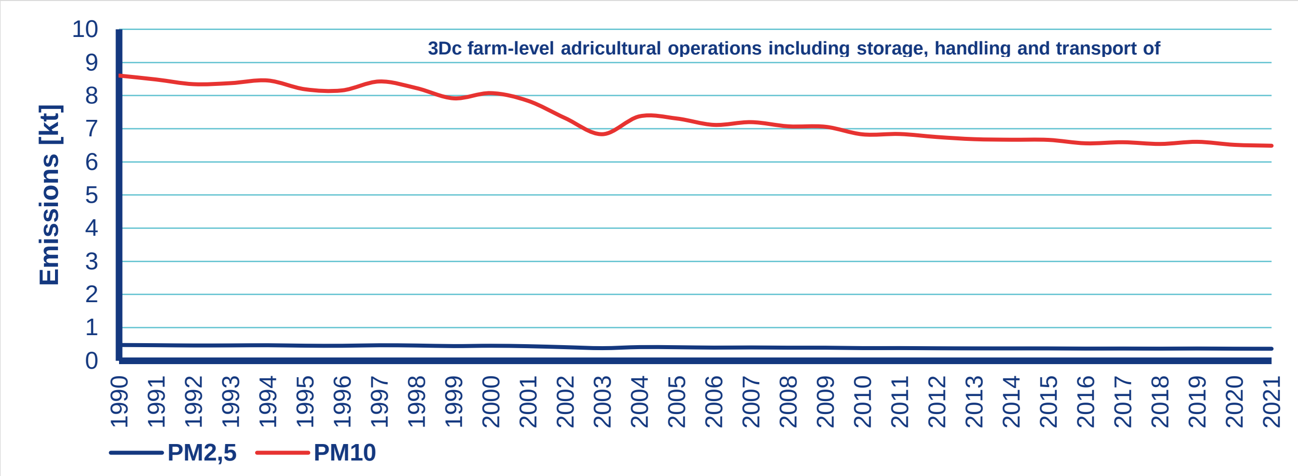


Fig. V.6 PM2.5 and PM10 emissions originating from farm-level agricultural operations including storage, handling and transport of agricultural products, 1990-2021

V.4.2 Uncertainties and QA/QC procedures

There needed to be more data available to assess the uncertainty of the calculations. The same calculation system has been used for the whole series.

V.4.3 Planned improvements

No improvements are planned, the chapter is considered to be final.

V.5 Crop production and agricultural soils – cultivated crops (NFR 3DE)

For NFR 3De cultivated crops, NMVOC emissions are estimated. For NFR 3De cultivated crops, NMVOC emissions are estimated. NFR 3De contributed less than 1% of the total NMVOC emissions production in 2021

V.5.1 Emission factors and calculations

Czechia uses emission factors from 3D EMEP/EEA EIG. The Tier 2 method is used for MNVOC emissions of selected crops (wheat, rye, barley, oats, rape, grain maize, perennial fodder crops – pasture and grass). Tier 1 values from Table 3.3 have been used for the other crops [3].

Activity data

According to the Tier 2 methodology, emissions of NMVOC are calculated as the harvest crop yield multiplication and relevant emission factors. The Czech Statistical Office provides activity data regarding harvested crops and per-hectare crop yields. Trends of yields of harvested crops are in the e-ANNEX NFR-3D-5. All activity data used for calculation in all-time series are in the e-ANNEX **NFR-3D-6**.

NMVOC emissions factors

In Tab. V.10 NMVOC are emissions factors used for calculation of NMVOC from cultivated crops in 2021.

Tab. V.10 Emissions factors for selected cultivated crops

Crop	EEA / EMEP EF	Year fraction emitting
	kg NMVOC / kg DM / hour	
Wheat	2.60×10^{-8}	0.3
Rye	1.41×10^{-7}	0.3
Barley	2.60×10^{-8}	0.3
Oats	2.60×10^{-8}	0.3
Rape	2.02×10^{-7}	0.3
Grain maize – other grain	2.60×10^{-8}	0.3
Perennial fodder crops - pasture	1.03×10^{-8}	0.5
Grass land 15°C	1.03×10^{-8}	0.5

NMVOC emissions

Trend in NMVOC emissions originating from cultivated crops (in kt) is presented in Fig. V.7.

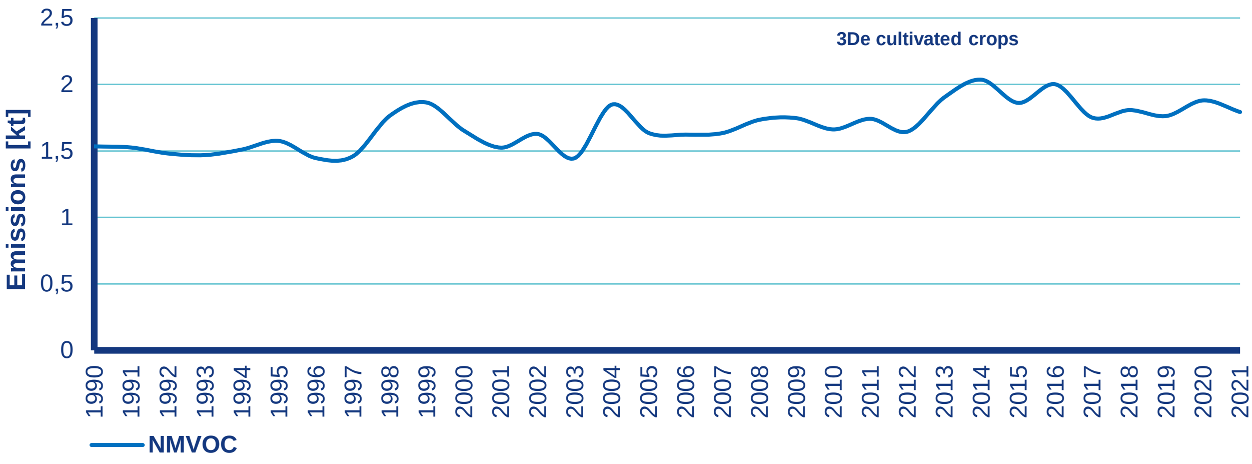


Fig. V.7 NMVOC emissions originating from cultivated crops, 1990–2021

V.5.2 Uncertainties and QA/QC procedures

There need to be more data available to assess the uncertainty of the calculations. The same calculation system has been used for the whole series.

V.5.3 Planned improvements

No improvements are planned, the chapter is considered to be final.

V.6 Other (NFR 3DF, 3F and 3I)

In Czechia NFR 3F field burning of agricultural residues is illegal. Thus emissions occurring from this category are not considered in the IIR.

The CZSO, in cooperation with the Central Institute for Supervising and Testing in Agriculture (UKZUZ), monitor pesticide consumption following Regulation (EC) No 1185/2009 of the European Parliament and the Council of 25 November 2009 concerning statistics on pesticides. The monitoring scale is specified in Annex III of the Regulation. Treatment of straw with NH_3 to increase its value as a feed for ruminant livestock is not common practice in Czechia. Therefore, emissions of NH_3 from the NFR 3I are omitted in the IIR.

V.6.1 Emission factors and calculations

The Tier 1 approach is used to estimate HCB emissions from 3Df use of pesticides according to the 3.D.f-3.I Use of pesticides and limestone 2019 [3].

Activity data

HCB is calculated as the multiplication of used pesticides and relevant emission factors. Source of activity data regarding pesticide use is the Central Institute for Supervising and Testing in Agriculture (UKZUZ), available at the website of UKZUZ [22]: e-ANNEX **NFR-3Df** shows all activity data used for calculation of HCB in all-time series since 1999.

HCB emissions factors

Tab. V.11 shows HCB emissions factors used for calculation of HCB originating from use of pesticides.

Tab. V.11 Emissions factors for selected pesticides

Active Substances	1990	1995	2000	2005	2010	2015
	$mg.kg^{-1}$	$mg.kg^{-1}$	$mg.kg^{-1}$	$mg.kg^{-1}$	$mg.kg^{-1}$	$mg.kg^{-1}$
Altrazine	2.5	1	1	1	not used	not used
Clopyralid	2.5	2.5	2.5	2.5	2.5	2.5
Chlorothalonil	300	300	40	10	40	40
DCPA, Dacthal, Chlorthaldimethyl	1000	1000	40	40	not used	not used
Endosulfan	0.1	0.1	0.1	0.1	not used	not used
Lindane	100	50	50	50	not used	not used
Pentachloronitrobenzene (PCNB), Quintozene	500	500	500	not used	not used	not used
Picloram	50	50	50	50	50	50
Propazine	1	1	1	not used	not used	not used
Simazine	1	1	1	not used	not used	not used
Pentachlorphenol (PCP)	50	50	50	not used	not used	not used

HCB emissions

Fig. V.8 presents trends in HCB emissions from use of pesticides (in kt).

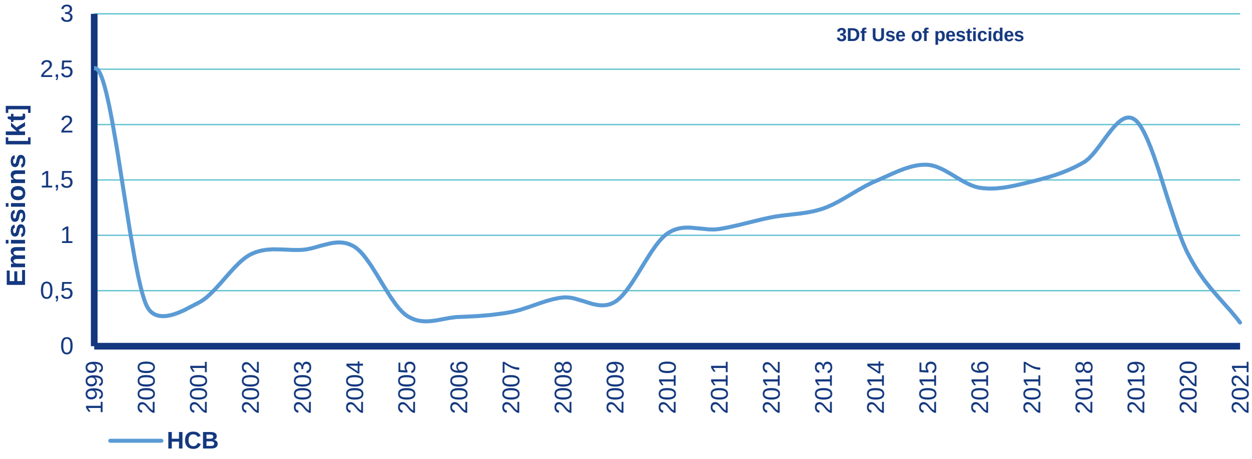


Fig. V.8 HCB emissions originating from used of pesticides, 1999–2021

V.6.2 Uncertainties and QA/QC procedures

There needed to be more data available to assess the uncertainty of the calculations. The same calculation system has been used for the whole series.

V.6.3 Planned improvements

No improvements are planned, the chapter is considered to be final.

VI. Waste (NFR 5)

The date of the last edit of the chapter: 15/03/2023

This sector includes both individually monitored sources (NFR 5B2, 5C1a–5C1bv, 5E – Biodegradation and solidification facilities and Sanitation facilities) and collectively monitored sources (NFR 5A, 5B1, 5D1–5D2, 5E – Car and buildings fires). Links between NFR category and classification pursuant Czech legislation are listed in Tab. VI.1 below.

Tab. VI.1 NFR categories and Czech classification for NFR 5 Waste

NFR code	Longname	Classification pursuant Annex 2 to Act 201/2012 Coll.
5A	Biological treatment of waste - Solid waste disposal on land	2.2. Dumps which accept more than 10 t of waste per day or have a total capacity of over 25 000 t
5B1	Biological treatment of waste - Composting	2.3. Composting facilities and biological waste treatment facilities with a projected capacity equal to or greater than 10 tons per fill or greater than 150 tons of processed waste per year
5B2	Biological treatment of waste - Anaerobic digestion at biogas facilities	3.7. Biogas production
5C1a	Municipal waste incineration	2.1. Thermal waste processing in incinerators
5C1bi	Industrial waste incineration	2.1. Thermal waste processing in incinerators
5C1bii	Hazardous waste incineration	2.1. Thermal waste processing in incinerators
5C1biii	Clinical waste incineration	2.1. Thermal waste processing in incinerators
5C1biv	Sewage sludge incineration	2.1. Thermal waste processing in incinerators
5C1bv	Cremation	7.15. Crematoriums
5C1bvi	Other waste incineration (please specify in the IIR)	Unspecified in Annex 2 to Act 201/2012 Coll.
5C2	Open burning of waste	Unspecified in Annex 2 to Act 201/2012 Coll.
5D1	Domestic wastewater handling	2.7. Wastewater treatment plants with a projected capacity per 10 000+ equivalent residents
5D2	Industrial wastewater handling	2.6. Wastewater treatment plants; facilities intended for the operation of technologies producing wastewater which cannot be assigned to equivalent residents at a quantity greater than 50 m^3/day
5D3	Other wastewater handling	Unspecified in Annex 2 to Act. 201/2012 Coll.
5E	Other waste (please specify in IIR)	2.4. Biodegradation and solidification facilities
		2.5. Sanitation facilities (elimination of oil and chlorinated hydrocarbons from contaminated soil) with a projected oil output of greater than 1 t of volatile organic compounds, inclusive

The sources belong to key categories only for $PM_{2.5}$ – 5C2 (2.4%), Hg – NFR 5C1bv (8.5%) and PCDD/F – NFR 5E Car and building fires (19.4%) and NFR 5C2 (6.4%). Increase of Hg emission from cremations in 2020 and 2021 was caused by high mortality due to the covid-19 pandemic.

According to Report on the Environment of Czechia 2021 (see e-ANNEX), published by Czech Environmental Information Agency (CENIA), at present, the crucial trend in waste management is the effort to move towards a circular economy where material flows are closed in long time cycles and the emphasis is put on waste prevention, reuse of products, recycling and conversion to energy instead of extraction of raw materials and increasing landfills.

Total waste generation, in which the largest share (95.9% in 2021) is held by the generation of non-hazardous waste, rose since 2009 by 23.6% to 39.896.6 kt in 2021. Municipal waste generation also increased in the reporting period by 10.9% to 5.904.4 kt.

Every year since 2009, the generation of packaging waste has risen to 1.328.7 kt in 2020. A declining trend has long been observed in the generation of hazardous waste (in the period 2009–2021 it dropped by 24.3% to a total of 1.636.7 kt).

The total waste treatment is dominated by waste recovery, particularly material, the proportion of which has long been increasing (see Fig. VI.1). Between 2009 and 2021, the share of waste used for material recovery grew from 72.5% to 83.6% and the share of waste used for energy recovery from 2.2% to 3.4%. The share of waste disposed of by landfilling is reducing (from 14.6% to 9.6% in 2021) in favour of material and energy recovery.

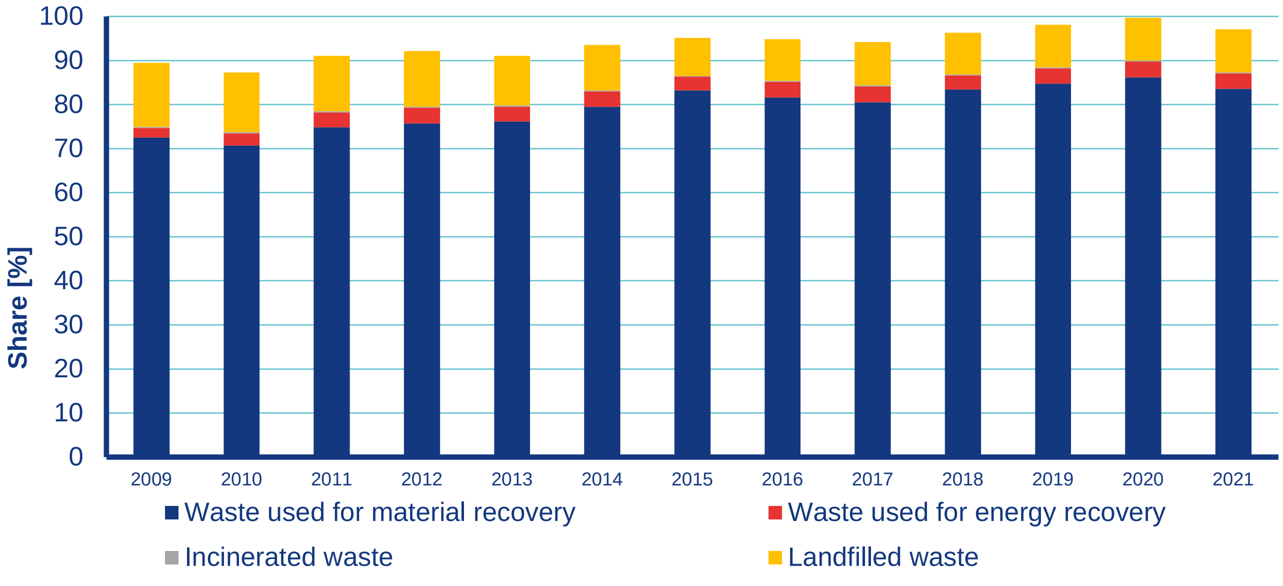


Fig. VI.1 Proportion of selected waste treatment methods in the total waste generation, 2009–2021

The following chapters describe the method of calculation for sub-sectors.

VI.1 Biological treatment of waste – Solid waste disposal on land (NFR 5A)

This category describes emissions from municipal solid waste disposal in landfills. These sources are only a minor source of air pollutant emissions excluding NMVOC.

In the inventory system of Czechia are monitored about facilities for the landfilling of solid municipal waste listed in Annex 2 to Act 201/2012 Coll. (2.2. Dumps which accept more than 10 t of waste per day or have a total capacity of over 25 000 t). Emissions from these facilities are not registered by the REZZO database. Only for some facilities are reported emissions from flaring for emergency combustion of collected landfill gas.

Activity data (amount of landfill waste) were taken from the Waste Management Information System (ISOH). This is a country-wide database information system containing data about the production and management of wastes as well as information about facilities for their treatment and removal. From

2002 until 2006 the ISOH database was operated for MoE by the T. G. Masaryk Water Research Institute (TGM WRI), one of whose parts was the Centre for Waste Management (CeHO). Since 2007 the operator of the ISOH database is the Czech Environmental Information Agency (CENIA)**.** The basic source for aggregated information on waste production and treatment is data on annual reports from originators and authorized persons sent to the ISPOP. This database can be queried by year, area, treatment method and waste catalogue number. The whole republic and all types of waste were chosen in this case.

Fig. VI.2 Comparison of the amount of deposited and incinerated municipal waste, 1990–2021

Fig. VI.2 presents the actualized amounts of deposited and incinerated solid municipal waste in the monitored time frame. Amounts of deposited waste were obtained also from ISOH, but only waste with catalogue number 20 03 01 (municipal waste) was selected. It is apparent that the proportion of landfilled waste is notably high although in the last years it has been decreasing slightly in favour of incineration (see also chapter – NFR 5C1a). Pursuant to State Energy Policy and Decree 352/2014 Coll. (see e-ANNEX), on the Waste Management Plan of Czechia for period 2015–2024, amount of deposited municipal waste will continue to decrease together with increase of fees until it will be completely terminated in 2024. Emissions from deposited waste change depending exclusively on its amount.

VI.1.1 Emission factors and calculations

Czech national legislation does not specify emission limit values or technical conditions of operation for this category. Emission factors for TSP, PM_{10} and $PM_{2.5}$ were taken from the EMEP/EEA EIG (Tier 1 approach) [3]. On the recommendation of the Technical Expert Review Team (TERT) emissions were calculated using default emission factors. Initially, the lower level of EFs were used because of used technology. All large landfills (with capacity restriction pursuant to Annex 1, point 5.4. of Act No. 76/2002 Coll. On the integrated prevention) comply with the emission limitation principles in accordance with integrated permit (compaction, scrubbing, covering with inert material etc.). Moreover, most landfill gas in Czechia gets extracted and burned in co-generation units with energy recovery for different sectors according to NACE classification. It predominantly takes place in NFR 1A4ai and 1A2gviii. There are no estimates available on the emission factors for the other pollutants.

Emissions for historical period 1990–1999 were calculated using activity data estimated based on National Greenhouse Gas Inventory Report of Czechia submitted 2017 (http://portal.chmi.cz/files/portal/docs/uoco/oez/nis/nis_do_cz.html). In this report, only amount of deposited municipal solid waste (MSW) is given. In year 2002 (first year with data available in ISOH), the ratio between among deposited MSW and total waste was stated assuming that in previous years it was similar. Using this factor (0.3) amounts of total deposited waste in 1990–1999 were calculated.

NMVOC emissions for all years were recalculated using methodology recommended by TERT. This methodology was developed to estimate a NMVOC EF for on the basis of CH_4 emissions reported in the framework of the UNFCCC reporting. To do so, CH_4 emission ratio per tonne of disposed waste (based on Czech UNFCCC 2020 reporting) was used, converted it into a volume of CH_4 per tonne of disposed waste (using the molecular volume of CH_4) and then into a volume of biogas per tonne of disposed waste (applying the fraction of CH_4 in biogas F = 50%) and then the fraction of NMVOC in biogas (5.65 g/m^3 of landfill gas), presented in the note at the bottom of table 3-1, chapter 5A of the EMEP/EEA EIG was applied [3].

VI.1.2 Uncertainties and QA/QC procedures

Emissions for NFR 5A are calculated based on official statistics and default emission factors, uncertainty is therefore estimated from 50 up to 200% , see also chapter I.7 General uncertainty evaluation.

QA/QC for NFR 5A is the same as in case of other collectively monitored sources, see also chapter I.6 QA/QC and Verification methods

VI.1.3 Planned improvements

No improvements are planned, the chapter is considered to be final.

VI.2 Biological treatment of waste – Composting and Anaerobic digestion at biogas facilities (NFR 5B)

Composting is a biological method of utilising biowaste which under controlled conditions transforms biowaste into compost through aerobic processes and microbial activity. This process does not produce any emissions of monitored pollutants, only malodorous compounds.

Pursuant to Annex 8 to the Regulation No 415 /2012 Coll., point 1.1. (Composting plants and equipment for biological modification of waste with projected capacity greater or equal to 10 tonnes per one batch or greater than 150 tonnes of the processed waste per year) for these plants is not set any emission limit, only technical conditions of operation:

a) Feeding bunkers have closed construction with the chamber for vehicles, for open halls, and during unloading of collecting vehicles with waste; gases must be exhausted and collected into facilities for cleaning waste gases.
b) Condensed vapours and water produced during the composting process (maturing of composts) may be used for construction of open and not covered composting plants for watering of compost only in cases that they will not increase the dust load of the surrounding environment.
c) Waste gases from maturing of composts in closed halls of composting plants are collected into facilities for cleaning of waste gases.

Activity data (amount of composted waste) were obtained from Waste Management Information System (ISOH). For detailed information about this country-wide database, see chapter VI.1. Activity data are available since 2005. Historical activity data for 1990−2004 were estimated using various information sources – expert article by association CZ Biom ((https://biom.cz/cz/odborne-clanky/kompostovani-biodegradabilnich-odpadu-v-ceske-republice), publication of CENIA (https://www.cenia.cz/publikace/monografie/hospodarstvi-a-zivotni-prostredi-v-ceske-republice-po-roce-1989/), statistical yearbooks of CZSO and CENIA. Calculated NH_3 emissions are below the threshold of significance. Emissions of the other pollutants, reported by operators, were removed.

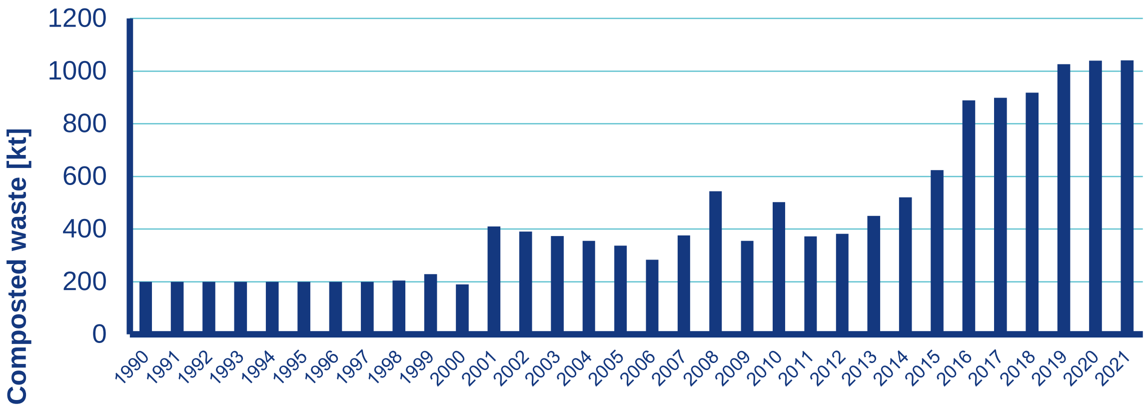


Fig. VI.3 The trend in the waste composting, 1990–2021

As is shown in Fig. VI.3 it is evident, that its amount increases significantly recently due to mainly rising interest in minimization of waste and its ecological utilization. Emissions of NH_3 depend exclusively on activity data, because composition of composted waste is almost constant.

In a biogas station, single-step fermentation (decomposition) transforms organic compounds into biogas. Anaerobic fermentation is a biological process decomposing organic matter which takes place without the presence of air. It naturally occurs in nature, e.g. in bogs, on the bottoms of lakes or in waste dumps. During this process, a mixed culture of microorganisms gradually decomposes organic matter. In 2021, 340 biogas stations in operation were registered in REZZO database.

Czech national legislation does not specify emission limit values or technical conditions of operation for this category. Due to the hermetisation the biogas plant are not expected any releases of air emissions. The small amounts of emissions of NO_X, NMVOC, SO_X, NH_3, $PM_{2.5}$, PM_{10}, TSP and CO reported by operators in this category come from emergency flares burning the excessive biogas. These emissions are included in various sectors according to NACE classification, mostly in 1A4ai.

Data for NFR 5B2 were supplied by VUZT. Activity data were obtained from websites of association CZBA (https://www.czba.cz/en.html). Here is freely accessible map of biogas plants (BP), which contains information about starting date of operation and power (heat and electric). They are divided into agricultural BP (397), BP in landfills (58), industrial BP (21) and BP in water treatment plants (98). Based on these data was found the gradual commissioning of agricultural BP. Tab. VI.2 illustrates year of commissioning, number of BP and cumulative installed electric power for agricultural BP.

Tab. VI.2 Commissioning of agricultural biogas plants

Year of commissioning	Number of agricultural BP	Cumulative installed electric power [MW]
2001	2	1.760
2002	7	5.452
2003	0	5.452
2004	0	5.452

2005	1	6.550
2006	5	10.149
2007	7	15.887
2008	32	39.250
2009	43	76.442
2010	42	11.3057
2011	72	17.5393
2012	127	284.297
2013	59	319.264
2014	0	319.264
2015	0	319.264
2016	0	319.264
2017	0	319.264
2018	0	319.264
2019	0	319.264
2020	0	319.264
2021	0	319.264

It is apparent that the highest increase of BP number was achieved in the period 2008–2013. Since 2013, their number remained constant. This fact is also shown in Fig. VI.4 below.

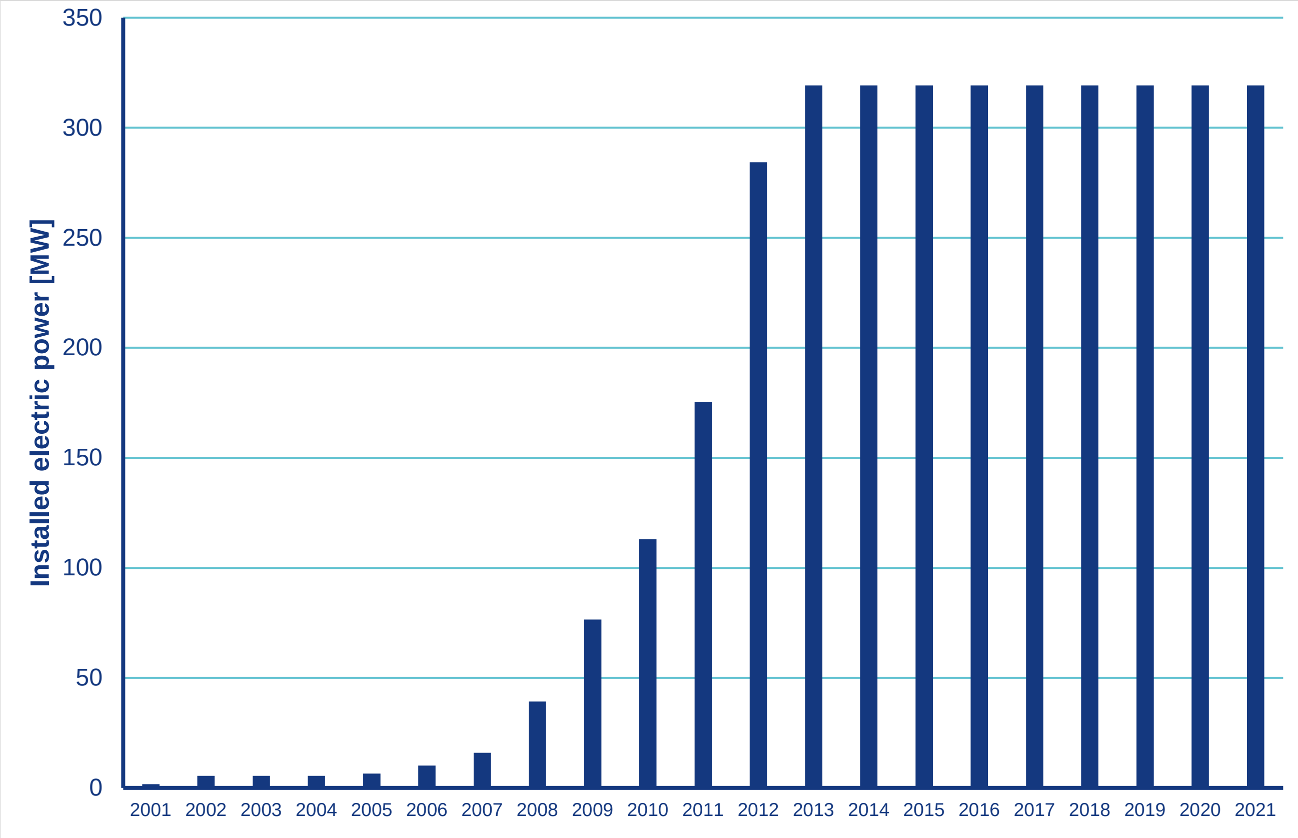


Fig. VI.4 Installed electric power of agriculture biogas plants, 2001–2021

Activity data of non-agricultural biogas plants in Czechia are not available. Considering that the numbers of different types of biogas stations listed in the IIR (p. 89) shows that agricultural ones are predominant, NH_3 emissions from other types can be considered negligible.

VI.2.1 Emission factors and calculations

Emissions of NH_3 for NFR 5B1 Composting were calculated using emission factor from EMEP/EEA EIG (Tier 2) [3].

Emissions of NH_3 for NFR 5B2 Anaerobic digestion at biogas facilities were calculated only for agricultural biogas plants and were calculated using Manure management N-flow tool, used to calculate NH_3 emissions for the NFR 3B Manure management.

VI.2.2 Uncertainties and QA/QC procedures

Emissions of NH_3 for NFR 5B are calculated based on official statistics and default emission factor, uncertainty is therefore estimated from 50 up to 200% , see also chapter I.7 General uncertainty evaluation.

QA/QC for NFR 5B is the same as in case of other collectively monitored sources, see also chapter I.6 QA/QC and Verification methods

VI.2.3 Planned improvements

No improvements are planned, the chapter is considered to be final.

VI.3 Waste incineration (NFR 5C1a–5C1biv)

In these categories there are included all installations for thermal treatment of waste (municipal, industrial, clinical, sewage sludge). The NFR 5C1bii (Hazardous waste incineration) is not considered separately; incineration of hazardous waste is included in NFR categories 5C1bi and 5C1biii. NFR 5C1biv is at present represented by a single facility for incineration of waste sludge, which was out of operation in years 2014–2021, therefore symbol "NA" was used.

Most of facilities use heat generated by waste incineration. For smaller incinerators there are most common heating of own objects (hospitals, factories etc.) and warming of water. The larger facilities supply heat to the public networks, alternatively work on the principle of cogeneration cycle, which provides heat and electricity production.

The database of installations for thermal treatment of waste in Czechia (Register of waste incinerators and co-incinerators) has been maintained since 2002 in accordance with legal requirements. Information from this register is made available to the public on the website of the Czech Hydrometeorological Institute. CHMI makes the following information accessible to the public:

Monthly updated review of waste incineration and co-incineration facilities

(http://portal.chmi.cz/files/portal/docs/uoco/oez/emise/spalovny/index.html)

Information for this review are obtained from periodic report of the Czech Environmental Inspectorate. The following information is monitored: change of operator or source name, technological modifications, changes in the composition of waste, source shutdown or start of operation. These reports also provide information about the performed measurements and compliance with emission limits. Some summary information (especially amount of incinerated waste) are obtained from summary operating records. They are made public in the form of synoptic tables which contain following data: identification data (region, name of operator, name of facility, identification number (IČO), identification number of the operating unit (IČP), address of operator, address of facility) and operating data (putting into operation, capacity in tonnes per year, amount of waste incinerated in last three years in tonnes per year, emission limit values compliance and appropriate comments about operating changes, performed measurements etc.).

Yearly updated geographical navigator

(http://portal.chmi.cz/files/portal/docs/uoco/web_generator/incinerators/index_CZ.html)

The geographic navigator presents overall annual information about facilities for the incineration and co-incineration of waste, which are obtained from summary operating records. These are the following: identification number (IČ), name of the facility, address of the operator, address of the facility, putting into operation, types of waste incinerated, nominal capacity, amount of waste incinerated in tonnes per year, number and brief description of incineration lines, enumeration of equipment for reducing emissions, annual emissions of all pollutants reported.

Evidence of permits for waste incineration and co-incineration

(http://portal.chmi.cz/files/portal/docs/uoco/oez/emise/spalovny/evidence/index.html)

This website is updated based on information of regional authorities, which have been issuing permits since
1. 1. 2003.

The types of permits are the following:

Permits according to § 17 paragraph 1 and 2 of Act 86/2002 Coll. – permits issued until 1. 9. 2012.

Permits according to § 11 paragraph 2 d) of Act 201/2012 Coll. – permits issued after 1. 9. 2012.

Integrated permits according to § 13 paragraph 3 of Act 76/2002 Coll. – for plants meeting certain criteria (primarily capacity constraints) within the categorization according to Annex 1 to Act 76/2002 Coll**.**

Data from Register of waste incinerators are utilized in emission inventory. Co-incineration plants which are in Czechia only cement kilns cannot be included into emission inventory because the largest share of emissions does not come from waste incineration, but from the production of cement clinker. Amount of waste incinerated in in rotary furnaces for production of cement clinkers is included in activity data of NFR1A2f as other fuels.

The emission inventory shows that the share of emissions of all pollutants in the total number is very low. Therefore, thermal treatment of waste has great potential, both economic and environmental.

There are currently four facilities for energetic utilisation of waste in Czechia. Three of them: Pražské služby, a.s. – Factory 14, Facility for energetic utilisation of waste Malešice, SAKO Brno, a.s. – Division 3 ZEVO and TERMIZO a.s. – Incinerator of municipal waste Liberec were operated throughout the whole monitored timeframe 1990–2021. All the facilities reach a high degree of energetic efficiency; efficiency values and the formula used for their calculation are presented in Supplement 12 to Act 185/2001 Coll. On waste (60% or 65% depending on the operation permit issue date). This case concerns the utilisation of wastes in ways listed under code R1 in Supplement No. č. 3 to the same Act. Such facilities should not be referred to as incinerators, but facilities for energetic utilisation of waste.

The trend showing amounts of municipal and other waste incineration in years 1990–2021 is illustrated Fig. VI.5 and Fig. VI.6.

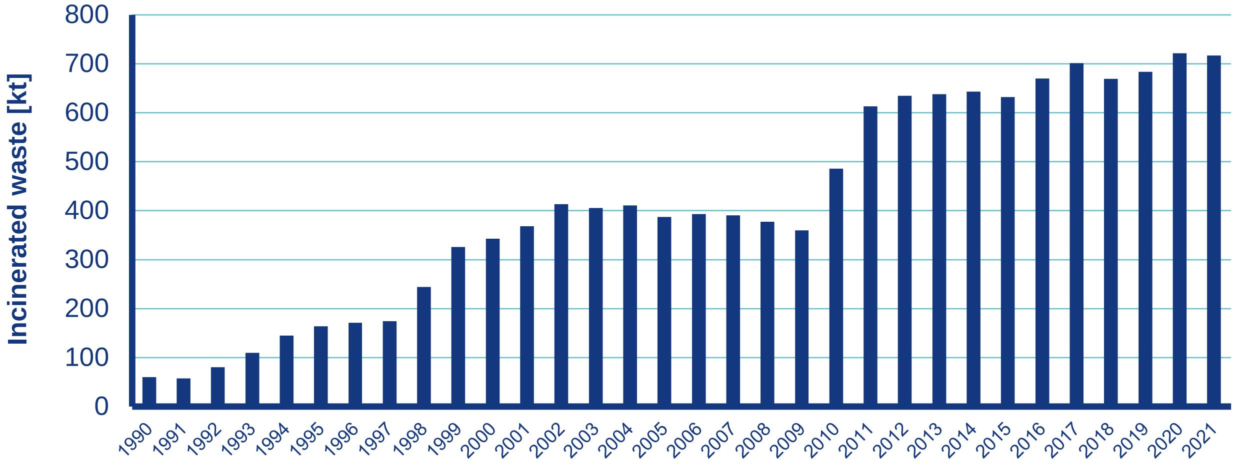


Fig. VI.5 Municipal waste incinerated, 1990–2021

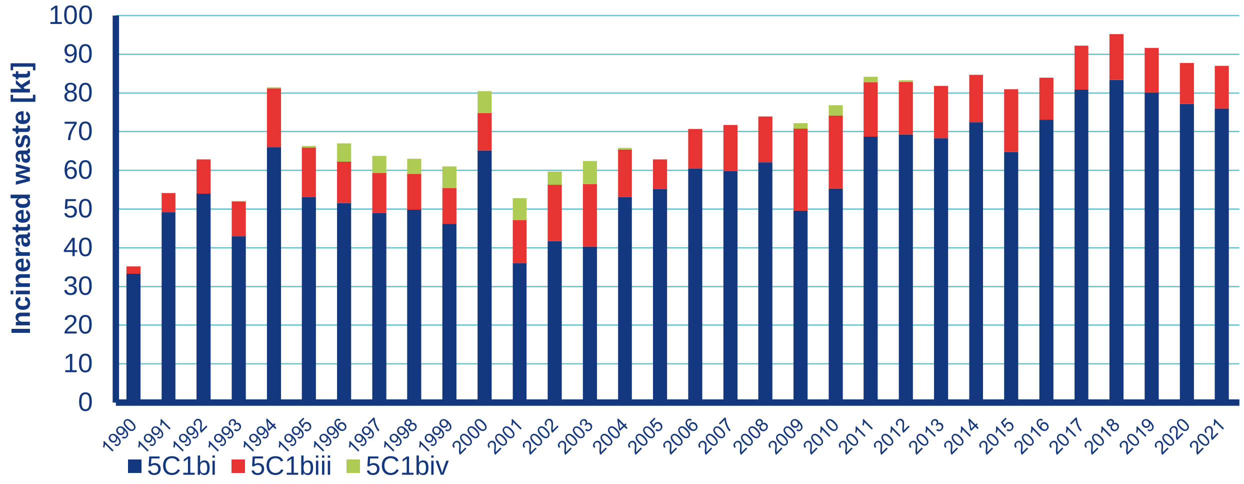


Fig. VI.6 Other waste incinerated, 1990–2021

It is clear from Fig. VI.5 that the amount of incinerated municipal waste has significantly increased in the last years. The reason is increasing preference for incineration to landfilling. From the economic perspective, the use of waste for generating heat is highly beneficial because it leads to savings of fossil fuels. Next there is the ecological perspective. On aspect is the reduction of the volume of waste deposited in landfills. Energetic utilisation of municipal waste reduces its volume by about 90% and its weight by about 70%. But most importantly, emission limits for incinerators are very low compared to emission limits for other facilities for the production of heat or electricity, comparable only to limits imposed for sources burning natural gas. Incineration of waste therefore significantly reduces the amount of pollutants exhausted into the atmosphere. For instance, in the facility SAKO Brno, a. s., an extensive reconstruction took place in the years 2009–2010, which also increased the capacity to incinerate waste. The reconstruction mentioned above explains decrease of waste amount in 2009 when the plant was shut down

Emissions of all pollutants in the period 2002–2021 show high consistency and mainly depend on the amount of waste. In the summer of 2016 new facility was put into operation: Plzeňská teplárenská, a.s. – Facility for energetic utilisation of waste Chotíkov. This is related to the increase in emissions of all pollutants reported, in particular PCDD/F. During testing operation installation of all necessary technologies for reducing emissions gradually took place. After its completion emissions were reduced again, noticeable decrease is apparent in inventorying starting 2018.

In comparison with above mentioned period, 1990–2001 data show significant extremes. This can mainly be explained by the varying amounts of sources and waste composition. Several smaller sources were operated for example in laundries, dry cleaner's and residential heating. Moreover, the obligation to have a permit for waste incineration, which sets emission limits and operating conditions, including requirements for measurement and equipment to reduce emissions entered into force only after the legislation in 2002.

It is apparent from Fig. VI.6 that predominant type in whole reporting period is industrial waste. Amount of all types was very variable, especially in the period 1990–2001. Number of the facilities was also variable, most of them were in 1992–1996. Most of hospitals had their own incinerator as well as more facilities were operated in factories in various branches (food processing, metallurgy, chemical industry etc.). Also the composition of waste varied same as in NFR 5C1. This fact is also reflected in the variable amount of emissions of all pollutants.

In the period 2002–2021, following the adoption of the new legislation, slightly increasing trend in the amount of incinerated waste was stabilized. Relatively large decrease of the number of facilities occurred between the years 2003 and 2005. This was caused by the fact that many of these facilities would not be able to meet demanding emission limits and operational requirements without undergoing extensive reconstruction. Their operation was therefore terminated. On the other hand, numerous facilities underwent modifications leading to a lowering of emissions. In 2017, the capacity of two incinerators of industrial waste was increased, which was reflected in its quantity.

VI.3.1 Emission factors and calculations

Methodology for particular reported categories is the same. Pursuant to Annex 2 to the Air Protection Act, waste incineration plants are ranked among specified stationary sources and they are registered within the REZZO 1 category. The emission inventory preparation in periods 2000–2021 and 1990–1999 was different and is therefore described for each period separately.

I.1.1.1 Methodology for period 2000–2021

For the purpose of emission inventory, the majority of data on pollutants is obtained from the Summary operation records (Tier 3). The respective pollutants are listed in Annex 4 to the Regulation 415/2012 Coll., which sets specific emission limit values pursuant to Annex VI to the Directive 2010/75/EU, on industrial emissions. The following substances are reported in the Summary operation records: NO_X, NMVOC, SO_X, TSP, CO, Pb, Cd, Hg, As, Cr, Cu, Ni and PCDD/F. In addition, NH_3 emissions are reported in the case of its use in the selective non-catalytic reduction of nitrogen oxides, therefore it has an emission limit set in order to reduce its emissions. Emissions of obligatory pollutants, that were for concrete source not available in some year, are calculated using the emissions reported in the nearest year and activity data (specific manufacturing emission). The remaining pollutants which are included in the emission inventory and not reported are calculated using emission factors and activity data, i. e. the amount of waste incinerated in tonnes per year. Czech emission factors for waste incineration are predominantly based on either own measurements (POPs), partly they were taken from the EMEP/EEA EIG, Tier 1 (Zn, Se). PM_{10} and $PM_{2.5}$ emissions are determined based on information about TSP abatement equipment. BC emissions amount to 3.5% of $PM_{2.5}$ in all categories [3].

A summary of used emission factors of heavy metals and POPs not reported for categories 5C1a–5C1biv is presented below.

Tab. VI.3 Emission factors of heavy metals and POPs not reported used for categories 5c1a–5c1biv

NFR	Zn	Se	B(a)P	B(b)F	B(k)F	I(1,2,3-cd)P	HCB	PCBs
[mg.t-1]								
5C1a	24.5	11.7	0.7	3.15	3.15	0.10666	0.15	0.0000156
5C1bi	21000	150	0.6923	3.03845	3.03845	0.10666	0.139	4.150757
5C1biii	21000	150	0.6923	3.03845	3.03845	0.10666	0.04559	1.726015
5C1biv	21000	150	0.6923	3.03845	3.03845	0.10666	0.139	4.150757

I.1.1.2 Methodology for period 1990–1999

Fundamental for the inventorying were also the data of summary operational records (SOE). According to the legislation of that time the emission limits were set until 1998 for the first time (see chapter 2.1). The reporting pollutants therefore were not available in full range.

The initial data were available emissions and activity data (the amount of waste incinerated) in 1990–2001. This period was chosen due to the new legislation valid since 2002 (Act 86/2002 Sb.). For each waste incinerator, emission consistency of each pollutant for full time series was performed and unreal values were calculated using activity data. Based on this data emission factors were calculated for all pollutants of summary operating database. Emission factors gained were grouped by NFR categories. Zero, distant and implausible values were eliminated and from the remaining the average values were calculated. These emission factors were compared to EMEP/EEA EIG and found comparable order of magnitude [3]. Based on these values there were calculated all missing emissions of all reported air pollutants. The remaining pollutants which are included in the emission inventory and not reported (Zn, Se, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, Indeno (1,2,3-cd) pyrene, HCB, PCBs, PM_{10}, $PM_{2.5}$ and BC) are calculated according to the methodology used for the period 2000–2021.

Specific emission factors set for purposes of emission inventory for the categories 5C1a–5C1biv in 1990–1999 are presented below in Tab. VI.4 and Tab. VI.5.

Tab. VI.4 Emission factors of basic pollutants for categories 5C1a–5C1biv, 1990–1999

NFR	TSP	SO_X	NO_X	CO	TOC
	[kg.t-1]				
5C1a	2.413	1.579	2.403	3.572	1.077
5C1bi	3.824	3.736	6.064	5.507	0.949
5C1biii	3.969	4.632	5.760	4.004	1.650
5C1biv	0.396	2.722	4.662	5.772	8.693

Tab. VI.5 Emission factors of reported heavy metals and PCDD/F for categories 5C1a–5C1biv, 1990–1999

NFR	Pb	Cd	Hg	As	Cr	Cu	Ni	PCDD/F
	[mg.t^{-1}]							
5C1a	529	94	104	273	57	178	201	0.001
5C1bi	18 993	639	1 602	3 911	5 284	3 834	1 031	0.030
5C1biii	11 838	3 264	3 520	4 856	1 092	4 967	1 633	0.033
5C1biv	18 993	639	1 602	3 911	5 284	3 834	1 031	0.030

Emissions reported in categories 5C1a–5C1biv include emissions from fuels used (it is possible due to low consumption). As additional fuel natural gas is mostly used, to a lesser extent liquid fuels.

Most of facilities in CR use heat generated by waste incineration. For smaller incinerators there are most common heating of own objects (hospitals, factories etc.) and warming of water. The larger facilities supply heat to the public networks, alternatively work on the principle of cogeneration cycle, which provides heat and electricity production. For this reason, emissions and activity data for all plants in categories 5C1a–5C1biv were allocated under 1A1a (see also chapter III.1). All sources in NFR 5C1a are facilities for energetic utilisation of waste (see also chapter VI.3), symbol "NO" was therefore used in the entire time series. In the case of other categories utilization of heat is not so clear, symbol "IE" was used.

VI.3.2 Uncertainties and QA/QC procedures

According to national legislation, emissions for stationary sources belonging to NFR 5C1a–5C1biv are determined on the basis of continuous or periodic measurements that are in compliance with European legislation (IED and previous directives). The uncertainty of the sum of emissions from those sources is below 5%, see also chapter I.7 General uncertainty evaluation.

QA/QC for categories 5C1a–5C1biv is the same as in case of other stationary point sources, see also chapter I.6 QA/QC and Verification methods.

VI.3.3 Planned improvements

No improvements are planned, the chapter is considered to be final.

VI.4 Cremation (NFR 5C1BV)

This sector mainly covers the atmospheric emissions from the incineration of human bodies, organs and remains in crematorium. Incineration of animal carcasses is also considered here.

Furnaces for incinerating animal remains are usually installed in large animal farming facilities or crematoria for pets. There are currently about 30 facilities in operation in the country.

There are two main types of crematoria: crematoria powered by gas or oil and crematoria powered by electricity. Liquid fuels are used almost nowhere in Czechia. Most cremation furnaces in use are powered by natural gas and have been made by TABO-CS Ltd. The exhausts produced during cremation in the main chamber are drawn through side mixing chambers with inlets of secondary air into final combustion chambers. Secondary and tertiary air facilitates an effective final combustion process which eliminates pollutants in line with requirements for environmental protection.

The contribution of emissions from the incineration of human bodies and carcasses to the total national emissions is thought to be relatively insignificant excepting Hg.

The emissions of all polluting substances depend exclusively on the number of cremations and are comparable throughout the monitored time frame. These are the total emissions including emissions from fuels used that are minor due to low consumption.

Share of cremations has increased rapidly in monitored period, it has stabilized since 2005. Moreover, cremations of pets were started only in 2003. This increasing trend is illustrated also in Fig. VI.7. A sharp increase of cremations in 2020 and 2021 was caused by high mortality due to the covid-19 pandemic.

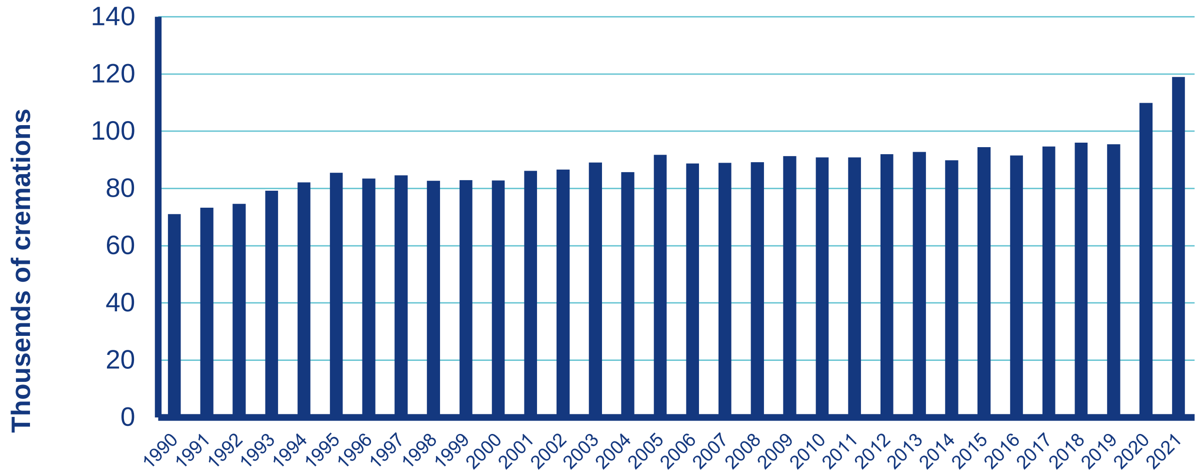


Fig. VI.7 The cremation, 1990–2021

VI.4.1 Emission factors and calculations

Emission limits for cremation are set by Annex 8 to the Regulation 415/2012 Coll., Point 6.13. Crematoria. They are set for TSP, NO_X (as NO_2), CO and NMVOC. The same emission limits are also applicable to facilities incinerating exclusively animal remains including parts of them.

Emissions of these pollutants are reported in the Summary operation records, as well as SO_X, whose emission limits are specified in the permits of individual sources (Tier 3). They are determined by periodic measurements with interval once a three calendar years. Because emissions in category REZZO 2 are available since 1995, for the purpose of additional calculation of earlier years there had been calculated emission factors for the above specified pollutants that had then been calculated additionally on the basis of activity data. An overview of emission factors is being presented in the following Tab. VI.6.

Tab. VI.6 Emission factors for basic pollutants in NFR 5c1v, 1990–1994

Pollutant	Value	Unit
TSP	0.031	kg/body
SO_X	0.022	kg/body
NO_X	0.321	kg/body
CO	0.059	kg/body
NMVOC	0.006	kg/body

The PM_{10} and $PM_{2.5}$ emissions are determined on base of type of technology and fuel used.

Emissions of heavy metals and POPs from the incineration of human bodies are calculated using emission factors and activity data. This concerns the following substances: Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, PCDD/F, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, indeno(1,2,3-cd)pyrene, HCB and PCBs .

National emission factors for heavy metals including Hg were determinated based on study “Emission factors setting and imission contribution of stationary source for the purpose of subsidy application of Operation programme the Environment" (see e-ANNEX), performed by the company Technical services for air protection Prague, a.s. in 2014. This study is focused on setting of emission factors for various technologies, cremation is one of them. Emission factors were stated by combination of research of literary resources and measurements provided on plants in CR. In the case of crematoriums, measurements were provided on eleven representative plants equipped with typical abatement technologies (usually gas combustion in the flame). The proposed emission factors are identical with those stated in the EMEP/EEA EIG [3].

Numbers of cremations in the given year were used as activity data. Shares of cremations in the total number of funerals in the entire reporting period have been obtained from Study of the Institute of Sociology of the Czech Academy of Science (see e-ANNEX), and are presented below. It is apparent that this share has stabilized at about 85% since 2005. The number of deaths was taken from the website of CZSO. Incineration of animal tissues was not included in the balance of heavy metals, which also applies to activity data.

Tab. VI.7 Shares of cremations in the total number of funerals

Year	Share of cremations [%]
1920	0.37
1925	2.09
1930	3.32
1935	4.04
1940	5.01
1945	8.11
1950	11.60
1955	19.63
1960	24.26
1966	45.54
1970	39.00
1975	45.00
1980	64.40
1986	53.54
1990	55.22
1995	72.50
2000	75.94
2005	84.66

2008	84.72

VI.4.2 Uncertainties and QA/QC procedures

According to national legislation, emissions of TSP, NO_X, CO and NMVOC and SO_X for stationary sources belonging to NFR 5C1bv are determined on the basis of periodic measurements. The uncertainty of the sum of emissions from those sources is below 5%. Emissions of other pollutants are calculated based on official statistics and default emission factors, uncertainty is therefore estimated from 50 up to 200% , see also chapter I.7 General uncertainty evaluation.

QA/QC for category 5C1bv is the same as in case of other stationary point sources, see also chapter I.6 QA/QC and Verification methods.

VI.4.3 Planned improvements

No improvements are planned, the chapter is considered to be final.

VI.5 Other waste incineration and Open burning of waste (NFR 5C1BVI and NFR 5C2)

There are no facilities belonging to the NFR 5C1bvi in Czechia. This category includes e .g. small waste oil burners used in motor garages; whose operation was terminated.

NFR 5C2 includes e .g. open burning of crop residues, wood, leaves, straw or plastics. Pursuant to § 16 paragraph 4 of Act 201/2012 Coll. only dry plant matter uncontaminated by chemical substances may be burned in an open fireplace. The municipality may issue a decree to establish the conditions for burning dry plant material in open fireplaces for the purpose of its disposal or place a ban on its burning.

Pursuant to § 19 of Regulation 415/2012 Coll. dry vegetable waste is not classified as waste but as biomass.

Activity data (types of utilised land) were obtained from website of the CSO, Catalogue of Products *(https://www.czso.cz/csu/czso/ceska-republika-od-roku-1989-v-cislech-aktualizovano-9122022)* Table. 02.02 – Lands by species. The trend in types of utilised land in the period 1990–2021 is illustrated below in Fig. VI.8. Here are shown all types of utilised land, for calculation of emissions only selected types were used (see VI.5.1).

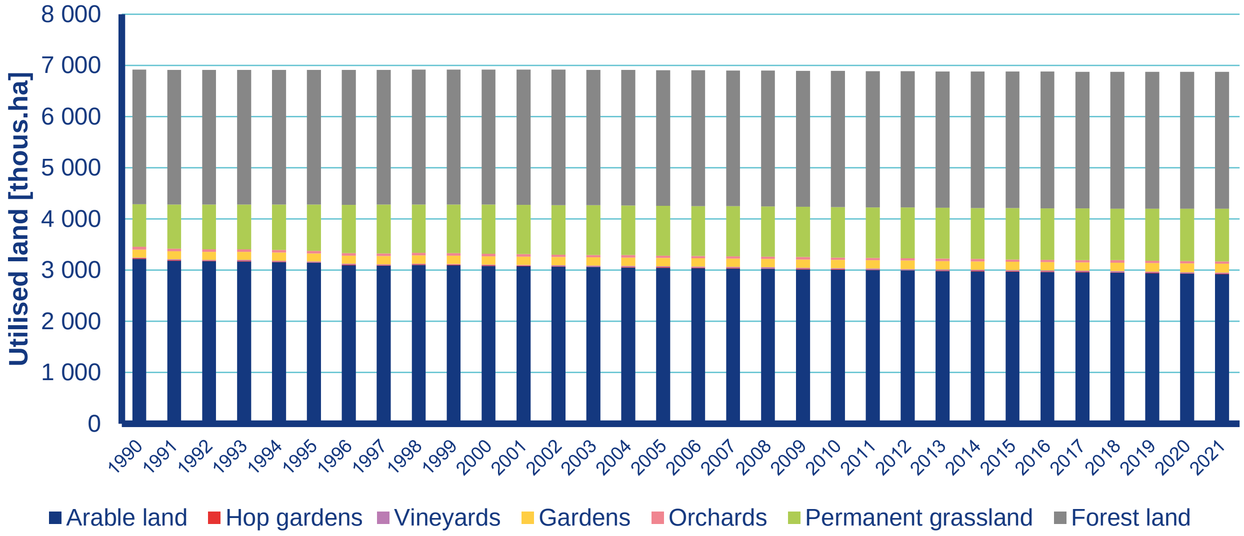


Fig. VI.8 Utilised land, 1990–2021

VI.5.1 Emission factors and calculations

Emissions for 5C2 were calculated pursuant to EMEP/EEA EIG [3], (Tier 1). Areas in forestry, orchard and arable farming were taken into account, assuming that amount of burned waste is 25 kg per hectare. Relevant table containing detailed activity data and calculation is given in e-ANNEX (file NFR-5C2).

VI.5.2 Uncertainties and QA/QC procedures

Emissions for NFR 5C2 are calculated based on official statistics and default emission factor, uncertainty is therefore estimated from 50 up to 200% , see also chapter I.7 General uncertainty evaluation.

QA/QC procedures for NFR 5C2 is the same as in case of other collectively monitored sources, see also chapter I.6 QA/QC and Verification methods.

VI.5.3 Planned improvements

No improvements are planned, the chapter is considered to be final.

VI.6 Wastewater handling (NFR 5D1–5D3)

Waste water treatment is the process of removing contaminants from wastewater, both municipal and industrial. Waste water treatment plants are only an insignificant source of NMVOC. There are divided mainly by the type of the purification process: mechanical, biochemical and chemical. Large plants generally combine more of purification processes. Further cleaning takes place in so-called recipient, i. e. natural watercourse. Discharge of waste waters into recipients is governed by Act 254/2001 Coll. (water Act) and by its implementing regulations.

For waste water treatment plants (both domestic and industrial), only technical condition of operation is set in Annex 8 to the Regulation 415/2012 Coll., points 1.4. and 1.5. This technical condition is the same for both categories and reads as follows:

For the purpose of reducing emissions of polluting materials with disturbing odour, the use of measures for reducing emissions of these matters, e.g. performing exhaustion of waste gases into the facility for reducing emissions, covering of pits and conveyers, closing of objects, and regular removal of sediments of organic nature from equipment for pre-treatment of waste water. Trend in amount of discharged waste water is illustrated below.

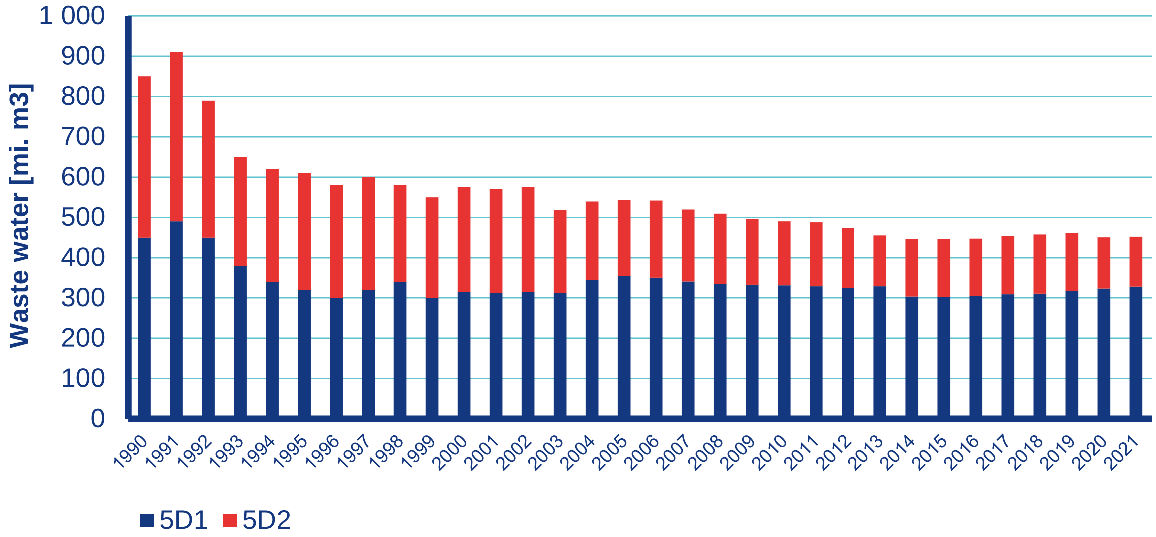


Fig. VI.9 Wastewater handling, 1990–2021

NH_3 emissions from dry toilets use were included in the category 5D1 in the whole time series. Trend in amount of population using dry toilets is shown in figure below.

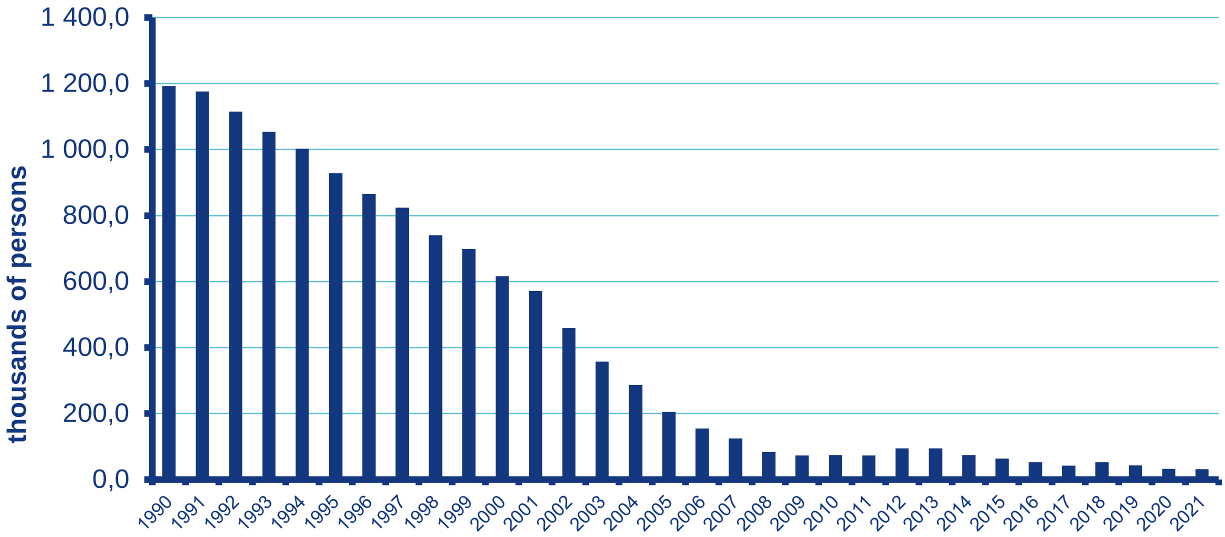


Fig. VI.10 Dry toilettes, 1990–2021

VI.6.1 Emission factors and calculations

In the Summary operation records are reported emissions NO_X, NMVOC, SO_X, NH_3, $PM_{2.5}$, PM_{10}, TSP and CO originating from flares. These emissions were removed from NFR 5D1–5D2 and included in 1A4ai (5D1) and different industrial sectors according to NACE classification (5D2).

Activity data for NMVOC emissions, i.e. amount of waste water discharged into sewerage system, were obtained from public database of CZSO. Data are available in division mentioned above since

2003, only total amount in years 2000–2002 is known. Activity data for historical period 1990–1999 were estimated based on document of CZSO (Waste water discharged into public sewers), see e-ANNEX. Data 2000–2002 were specified using average ratio between subcategories 5D2 and total amount of discharged waste water in 1990–1999.

Activity data for NH_3 emissions (percentage of population using dry toilets) were obtained from CZSO statistics (https://www.czso.cz/csu/stoletistatistiky/splachovaci-zachod-neni-samozrejmosti-ani-v-eu) and related links (EUROSTAT, Population census 2011).

Emission factors for NMVOC and NH_3 were adopted from EMEP/EEA EIG (Tier 1) [3]. Activity data for sector 5D3 are not available.

Relevant table containing detailed activity data and calculation is given in e-ANNEX (file NFR-5D).

VI.6.2 Uncertainties and QA/QC procedures

Emissions of NMVOC for NFR 5D are calculated based on official statistics and default emission factor, uncertainty is therefore estimated from 50 up to 200%, see also chapter I.7 General uncertainty evaluation.

QA/QC for NFR 5D is the same as in case of other collectively monitored sources, see also chapter I.6 QA/QC and Verification methods.

VI.6.3 Planned improvements

No improvements are planned, the chapter is considered to be final.

VI.7 Other waste (NFR 5E)

This sector includes biodegradation and solidification facilities and sanitation facilities. The facilities mentioned above reduce the danger that waste poses to the environment. In addition, car and building fires are included in this category.

Biodegradation is a process of breaking down oil and organic pollution from contaminated wastes. It takes advantage of natural bacterial strains which perform natural decomposition of contaminants. Solidification is a technological process of waste treatment involving their stabilisation by suitable additives which reduce the possibility that dangerous elements and compounds might get eluted from the matrix of the waste.

For biodegradation and solidification facilities, only technical condition of operation is set in Annex 8 to the Regulation No 415 /2012 Coll., point 1.2.: In the case of processing materials which can produce emissions of polluting materials with disturbing odour, technical-organisational measures must be ensured for the reducing these materials, e.g. covering biodegradation areas and collection of waste gases into facilities for the cleaning of waste gases. In open landfills, it is possible to reduce emissions of solid pollutants into the atmosphere, for example, by situating them in leeward positions or by watering and misting.

The sanitation facilities are used to elimination of oil and chlorinated hydrocarbons from contaminated soil. They are mainly used for the clean-up of old ecological burdens**.** Annex 8 to the Regulation No 415 /2012 Coll., point 1.3. sets NMVOC emission limit value for elimination of oil and chlorinated hydrocarbons from contaminated soil) with a projected output of greater than 1 t of volatile organic compounds, inclusive, operated ex situ.

In accordance with EMEP/EEA EIG, accidental fires of car and buildings are included in this category [3]. Emissions of particulates, some heavy metals and PCDD/F are predominantly emitted.

Activity data (number of fires) were obtained from Statistical Yearbooks of Fire Rescue Service of Czechia (FRS CR). They are available since 1991 and are accessible to the public on http://www.hzscr.cz/clanek/statisticke-rocenky-hasicskeho-zachranneho-sboru-cr.aspx. Data since 2004 are available also in English on http://www.hzscr.cz/hasicien/article/statistical-yearbooks.aspx. Activity data for remaining year 1990 were supplemented according to 1991.

Fire numbers of cars, apartment buildings, detached houses and industrial buildings are illustrated below.

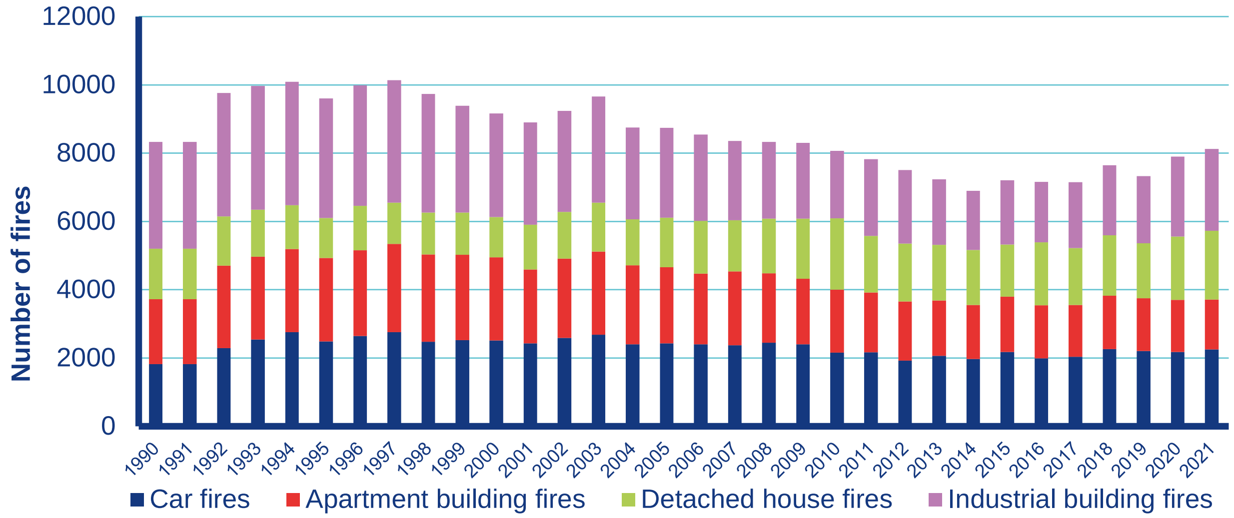


Fig. VI.11 Fires, 1991–2021

Accidental fires of car and buildings are mostly caused by negligence (smoking, incorrect heater operation, manipulation with burning ashes, ignition of food by cooking, incorrect handling, etc.) or technical failures. Atmospheric conditions (drought, direction and speed of wind, etc.) also have a great impact. The decreasing trend indicates mainly the influence of escalating fire prevention.

VI.7.1 Emission factors and calculations

In category biodegradation and solidification facilities and sanitation facilities, only small amount of emissions NO_X (as NO_2), NMVOC, NH_3, $PM_{2.5}$, PM_{10}, TSP a CO is emitted. Emissions of NO_X (as NO_2), NMVOC, NH_3 and TSP are reported in the Summary operation records (Tier 3). The PM_{10} and $PM_{2.5}$ emissions are determined on base of type of technology.

For emission inventorying emission factors from EMEP/EEA EIG, in division into EFs for fires of cars, apartment buildings, detached houses and industrial buildings were used (Tier 2) [3]. Overview of used emission factors is presented below.

Tab. VI.8 Emission factors for car and buildings fires

Pollutant	Unit	Car fire	Apartment building fire	Detached house fire	Industrial building fire
TSP	kg/fire	2.3	43.78	143.82	27.23
PM_{10}	kg/fire	2.3	43.78	143.82	27.23
$PM_{2.5}$	kg/fire	2.3	43.78	143.82	27.23
Pb	g/fire	NE	0.13	0.42	0.08
Cd	g/fire	NE	0.26	0.85	0.16
Hg	g/fire	NE	0.26	0.85	0.16
As	g/fire	NE	0.41	1.35	0.25
Cr	g/fire	NE	0.39	1.29	0.24
Cu	g/fire	NE	0.91	2.99	0.57
PCDD/F	mg/fire	0.048	0.44	1.44	0.27

Relevant table containing detailed activity data and calculation is given in e-ANNEX (file NFR-5E_car and building fires).

VI.7.2 Uncertainties and QA/QC procedures

Emissions for individually monitored sources (biodegradation and solidification facilities and sanitation facilities) are only reported in the Summary operation records and are based on calculations. Uncertainty will be estimated later.

Emissions for car and buildings fires are calculated based on official statistics and default emission factors, uncertainty is therefore estimated from 50 up to 200%, see also chapter I.7 General uncertainty evaluation.

QA/QC for NFR 5E is the same as in case of other sources (divided into individually and collectively monitored), see also chapter I.6 QA/QC and Verification methods.

VI.7.3 Planned improvements

No improvements are planned, the chapter is considered to be final.

VII. Other and natural emissions

The date of the last edit of the chapter: 15/03/2023

There is no active volcano on the territory of Czechia, there are only residues of volcanic activity from various periods of the geological past (about 20 extinct volcanoes), therefore symbol "NO" was used.

In the case of forest fires, CO and NMVOC are emitted predominantly. To a less extent, emissions of NO_X, NH_3, SO_X and particulates are produced.

VII.1 Forest fires (NFR 11B)

Activity data (hectares of burned area) were obtained from Statistical Yearbooks of Fire Rescue Service of Czechia (FRS CR). They are available since 1996 and are accessible to the public on https://www.hzscr.cz/hasicien/article/statistical-yearbooks.aspx . Fig. VII.1 illustrates development of forest areas affected by fire in 1996–2021.

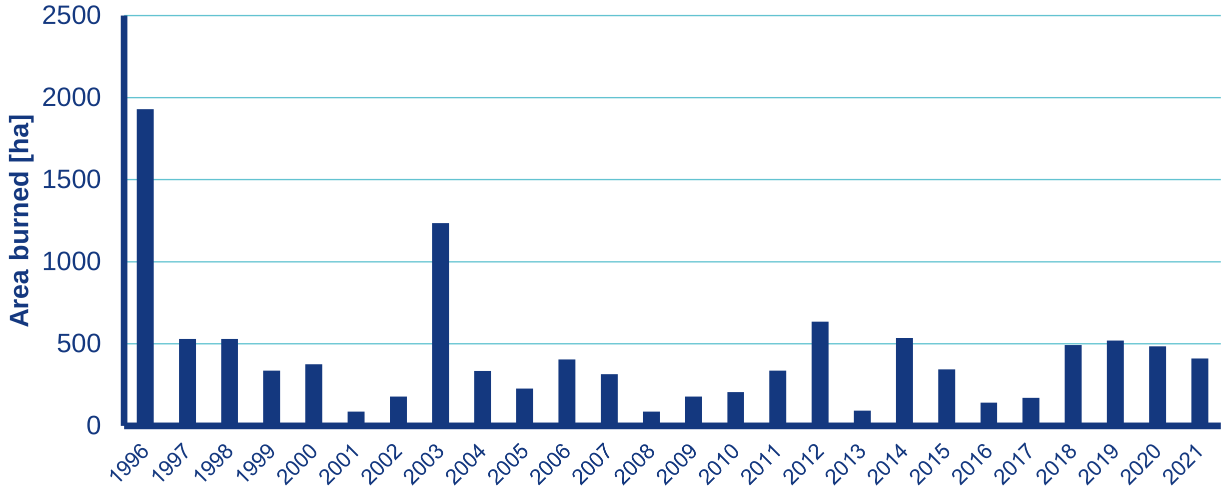


Fig. VII.1 Forest fires, 1996–2021

Size of forest areas affected by fire depends mainly on atmospheric conditions (drought, hot weather, precipitation, direction and speed of wind, etc.). Forest fires can be caused either by natural origin (lightning strikes, self-ignition) or by negligence (smoking, setting fire in the wild).

VII.1.1 Emission factors and calculations

For emission inventorying emission factors from the EMEP/EEA EIG, version 2016, were used (Tier 2) [3]. In the case of Czechia, EFs for temperate forests were chosen.

For the period 1996–2021 emissions of NO_X, CO, NMVOC, SO_X and NH_3 were calculated. For these pollutants, emission factors in kg/ha are stated. Emission factors for particulates including BC are stated in $g.kg^{-1}$ of wood, these data are not available.

VII.1.2 Uncertainties and QA/QC procedures

Emissions for NFR 11B are calculated based on official statistics and default emission factors, uncertainty is therefore estimated from 50 up to 200% , see also chapter I.7 General uncertainty evaluation.

QA/QC for NFR 11B is the same as in case of other collectively monitored sources, see also chapter I.6 QA/QC and Verification methods.

VII.1.3 Planned improvements

No improvements are planned, the chapter is considered to be final.

VIII. Recalculations and improvements

The date of the last edit of the chapter: 15/03/2023

VIII.1 General recalculations in 2023

The full set of data for period 1990–2021 in NFR format 2020 is reported in 2023. Several corrections of reported data were performed including particularly:

- Recalculation (1990–2020) NH3 emissions in NFR 1A4bi
- Recalculation (2015–2020) all emissions in NFR 1A4bi
- Recalculation (1990-2020) of PM and TSP emissions in NFR 1B1a
- Recalculation (2014–2020) in NFR 1B2c according TERT recommended
- New emissions (1990–2020) of PM and TSP in NFR 2D3b using the recommended EF
- Recalculation (1990–2020) NOx, NMVOC and PM emissions in NFR 3
- New estimate (1990–2020) NH3 emissions in NFR 5B1
- Addition (1990–2020) sum of PAHs emissions in NFR 5C2
- New estimate (1990–2020) NH3 emissions from dry toilets
- Several minor corrections – detailed in e-Annex

VIII.2 Recalculations and Improvements in Transport (NFR 1A3)

VIII.2.1 Recalculations

VIII.2.1.1 Railways (NFR 1A3c)

As per planned improvement, new methodology for calculation of railway emissions from diesel was introduced in 2023 submission. The new calculation model is based on a significantly more detailed database and increases detail and accuracy of calculation from Tier 1 to Tier 2 level as per 2019 EMEP/EEA EIG [3].

Calculation of railway emissions from diesel consists of three main steps:

1) Rail traffic performance calculation – Average traffic performance of line-haul locomotives and rail-cars is calculated based on the data from Správa železnic for profile weeks in 2019. In each category, five the most frequent locomotives and their share on rail traffic performance in brtkm was defined. Final value is weighted traffic performance of these locomotives. Shunting locomotive traffic performance is based on the study [27].
2) Calculation of traction diesel consumption – Specific traction diesel consumption is calculated for each locomotive category. Final traction diesel consumption is a product of activity data and specific traction diesel consumption. Based on this value, share of each locomotive category on the total rail diesel fuel consumption given by CZSO is set.
3) EFs application – In compliance with EMEP/EEA EIG [3], the relevant Tier 2 emission factors for diesel oil were applied to the final diesel consumption calculated.

Emissions were recalculated in the whole time series 1990-2020. Data about rail traffic performance were not complete before 2001 and in years 2011–2015. Missing data were calculated with help of regression coefficients determined from the study [28].

VIII.2.1.2 Road transport (NFR 1A3b)

During an internal review, there was identified an error in the activity data related to switching to a new version of COPERT program in September 2021 (update from the version 5.3.26 to the version 5.5.1) and to a new structure of input data. Because of these changes, it was necessary to change activity data calculation programme as well. The error was corrected and the whole time series 1990–2017 recalculated.

Data 2018–2021 are preliminary as it is necessary to make recalculation every year four years retrospectively due to the methodology of obtaining transport performance data. Transport performance is calculated based on the data from national Database of Technical Control Stations. All vehicles are checked by technical controls in four-year cycle due to Czech law (especially new cars, older cars are checked in one or two years). In this submission, the time series 2017–2020 was recalculated due to this methodological issue

Changes due to updated activity data from CZSO:

- CNG fuel consumption change in 2020 (from 63 kt to 64 kt)

VIII.2.1.3 Aviation (NFR 1A3a)

When analysing the latest EUROCONTROL aviation data, inconsistencies in 2021 emissions factors were found out. After a consultation regarding this issue with EUROCONTROL Fuel and Emissions Inventory Team, we received updated data for years 2017–2021. Time series 1990–2016 were estimated by interpolation of updated EUROCONTROL data. Emissions were recalculated with the updated IEFs in the whole time series 1990–2020.

During the last review process, an error in fuel balance in the national emission model was identified. The fuel consumption was balanced based on the sum of domestic and international aviation. In 2023 submission, the error was corrected and now it is balanced according to a respective aviation subsector (domestic or international). Emissions were recalculated in the whole time series 1990-2020.

Recalculations due to error in calculation spreadsheet:

- As values were recalculated in the entire time series 1990-2020 for 1A3ai(i) and 1A3aii(i)

VIII.2.2 Improvements

Update of the activity data due to the update of net calorific values. Net calorific values for all fuels were revised based on the latest IEA questionnaires and not current values were corrected in the whole time series 1990–2021.

New methodology for Railways described in chapter VIII.2.1.1.

VIII.3 Recalculation and improvement in smaller and area stationary sources (NFR 1A4 and 1A5)

The recalculation of data from smaller stationary sources is mainly based on statistics from ENERGO 2021, which providing information about distribution of total fuel consumption according combustion equipment type (e-ANNEX.), structure of combustion equipment in households, share of wet (non-dried) wood combustion and other parameters. The most significant change seems to be the heating equipment ratio (Tab. III.1) and the proportion of 92% for burned dried wood and 8% for the non-dried. This estimation was based on the survey results and applied for the entire period 1990 – 2021.

Recalculation based on new ENERGO 2021 survey had a significant impact on the final amount of emission.

Emission factors for fuels were taken over from EMEP/EEA EIG and Methodology Instruction of CME. The overview of emission factors for emission inventory in household heating sector and more information about combustion measurements of VEC VŠB is available in e-ANNEX.

At the same time, there was a change in the emission factor used for estimating NH_3 emissions when burning biomass in boilers with an input of up to 5 MW. The new emission factor was calculated as an average from the emission factors and new value is 5.2 $g.GJ^{-1}$. This value was used for calculation of emissions during biomass combustion in all types of heating equipment. This recalculation had significant impact on the final emission of NH_3.

Recalculation was performed for NMVOC emissions from residential heating in 2021. For further detail please see e-ANNEX.

Currently, an extensive verification of the emission factors of older boilers is conducted. The measurements of newly sold boilers and stoves are in progress at the same time. The results will be processed for reporting in 2025.

The calculation model will also be updated and include more accurate information about the sales of new heating equipment and replacements of energy sources (such as the transition from fuel combustion to heat pumps).

Results of comparing emissions in 2020 reported last year and this year show us the general decrease of the majority of pollutants. Most of the main pollutants were reduced considerably, decrease of NMVOC was by 19%, particular matter ($PM_{2.5}$ and PM_{10}) by more than 33%.

Significant decrease in emissions was also noticed in the amount of POPs. For example, the emission of benzo(a)pyrene decreased by more than 22%. Other POPs were reduced as well.

The improvement in the calculations had relatively small impact on the emissions of NO_X and metals. The decrease of emission was observed in both cases, but not more than 5% (Cr within more than 14.5% and Ni with 8% were the only exception).

SO_X and PCDD/PCDF were the only exception within the increase of emission. SO_X by more than 13%, for PCDD/PCDF the increase by nearly 11% was observed.

The most noticeable decrease of emission was in case of NH_3 by more than 91%. The reason for this significant reduction is the newly calculated value of emission factor for NH_3.

For further detail please see e-ANNEX.

VIII.4 Recalculations and improvements in fugitive emissions from fuels NFR (1B)

TSP and PM emissions from coal mining were recalculated based on TERT recommendations. Direct emissions from mining are newly calculated only for lignite mining. Emissions from the first handling of mined coal were newly included in the calculation, including transport for direct use in power plants located near the mines, or loading for transport, usually by rail. The amount of exported and imported coal was also included in the calculation. The difference in total reported TSP emissions is a maximum of 0.6 kt.

VIII.5 Recalculations and improvements in Agriculture

VIII.5.1 NH_3, NO_X and NMVOC emissions

Compared with the previous NH_3, NO_X and NMVOC emissions inventory (submission 2022), some changes and updates have been made, see Tab. VIII.1. These changes cause a decrease in the total NH_3 emissions for years 1990-2000 and increase for years 2005-2020. NO_X emission decreased in years 1990-2000 and increased in years 2010-2020. NMVOC emissions increased in years 1995-2016 and decreased in years 2017-2019.

Tab. VIII.1 Comparison of NH_3, NO_X and NMVOC emissions from submissions 2022 and 2023

NH_3 emissions, kt	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020
2022 submission	138.9	86.8	77.4	71.2	61.8	72.7	73.0	72.4	67.6	64.8	61.2
2023 submission	125.7	82.0	77.2	71.2	63.2	76.2	76.8	75.0	71.5	67.5	64.8
Difference,%	-9	-5	0	0	+2	+5	+5	+4	+6	+4	+6
NO_x emissions, kt	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020
2022 submission	27.5	16.5	15.7	17.5	16.3	21.2	21.2	21.0	19.7	19.4	17.9
2023 submission	26.0	15.9	15.5	17.4	16.5	22.1	22.1	21.9	20.8	20.5	19.2
Difference,%	-5	-4	-1	0	+1	+4	+4	+4	+5	+5	+8
NMVOC emissions, kt	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020
2022 submission	70.4	42.5	37.6	38.9	32.4	34.9	35.8	36.5	37.8	37.5	37.7
2023 submission	67.6	42.8	38.0	35.7	33.8	36.5	36.7	36.13	37.6	37.3	38.0
Difference,%	-4	+1	+1	+2	+4	+5	+3	-1	-1	-1	+1

VIII.5.1.1 NH_3 and NO_X emissions

A range of changes has been made for NH_3 and NO_X emissions. Ammonia emissions have decreased in range from 9 to 5% for years 1990 – 2000 and increased in range from 2 to 6% for years 2005 – 2000 compared to submission 2022. NO_X emissions have increased in range from 15 to 26% for years 1990 - 2020 compared to submission 2022. Recalculations for the subcategories are mentioned below.

3B Manure management

Emissions of NH_3 and NO_X from manure management has been recalculated due to unification and harmonisation of input data used for GHG, NH_3, NO_X inventories and the Gross nitrogen balance for the Czech Republic.

Nitrogen excretion rate (Nex)

Nex value in all animal categories, except cattle, had been based on the national data for typical animal mass (TAM), Eq. 10.30 IPCC 2006 Gl. and the default excretion rate (Table 10.19, IPCC 2006 Gl.) until GHG Submission 2021. Nex value for cattle had been calculated in special spreadsheet, common for the calculation of emission factors used for methane emissions from enteric fermentation and manure management. This calculation had been based on population data, annual average excretion rates calculated from gross energy intake (GE), share of protein in feed and in milk. The parameters for estimating the Nex value for cattle had been collected from literature sources and from personal communications with agricultural experts. Value of protein content in milk had been relevant to literature references (Poustka 2007, Ingr 2003 and Turek 2000) and protein content in feed (in dry matter) of 16.5% had been relevant to available references too (Zeman, the Czech feeding standards

12-21%, Central Institute for Supervising and Testing in Agriculture 18%, Karabcová, personal communication 16-18%). Nex rate had been estimated for each cattle category and reported for dairy, non-dairy (weighted average) and as a summarized total for cattle.

The above-mentioned procedure was revised for Submission 2021 (data 2019), when the country-specific value of Nex was derived newly from the national legislation (Decree No. 377/2013 Coll.). Therefore, the reason was the effort to unify the inputs, from 2019, to all relevant reportings (GHG reporting, UN-ECE - NH_3, NO_X reporting, OECD, EUROSTAT). A certain transitional period was needed to apply the new coefficients in the Czech Republic when the year 2019 became a turning point for interdepartmental teams of experts. The use of the updated coefficients was supported mainly by the need to synchronize input data used to evaluate the nitrogen flows in the agriculture to increase the methodological level of reporting the nitrogen balance, greenhouse gas emissions and pollutants for the Czech Republic in terms of the requirements of international organizations.

Decree No. 377/2013 Coll., on the storage and use of fertilizers states the average values of annual nitrogen production, calculated per unit of livestock (1 Livestock Unit = 500 kg live weight of animals). These values were used as coefficients to derive Nex rate. The reported coefficients were obtained based on study of the Ministry of Agriculture of the Czech Republic (research project No. QH82283 “Study on interaction between water, soil and environment from the point of view of manure management in sustainable agriculture”, 2008-2012). The aim of this study was to analyse manure production in various systems of animal housing used in the Czech Republic. The research was based on a detailed survey of the annual manure production per one livestock unit (LU), considering the technological systems of animal housing, the production of various types of manure and species and categories of animals. The results of the survey were used for in force legislation amendment from 1998 and further published in the proceedings of an international conference in 2011 (Klír 2011).

In case of dairy cattle, the Nex rate value for the entire time series was taken newly from OECD reporting (the documentation provided by Crop research Institute in Prague), because the calculation of the amount of excreted nitrogen is dependent on milk production, which is increasing in the Czech Republic from 1990. This equation was used for the calculation of nitrogen excretion rate from milk production (CRI 2001):

$$Nex \quad rate = 46.787 * (\ln(annual \quad milk\ yield) - 308.49)$$

(Data source: Jana Beranova – NIR 2023)

Animal waste management systems (AWMS)

The first country-specific AWMS system distribution had been based on the expert study of Mudřík and Hons (2004) and was updated several times by the expert opinions during the reporting period. The last update of this system based on Kvapilík (Institute of Animal Science, personal communication) was carried out in 2011.

The recent update of AWMS for cattle, swine and poultry categories was based on Klír (2019) and Nesňal et al. (2018) concerned on 2016-2021 data series. The amount of manure in liquid and solid forms consumed in anaerobic digesters was derived from the statistical survey. AWMS were upgraded based on Klír et al. (2011) for goats, horses, and sheep as well. This upgrade concerned 2014-2021 data series.

For 2023 GHG NIR submission, the animal waste management system (AWMS) data were updated and adjusted with respect to the likely development of manure management handling, to remove jump changes in individual handling shares. The current form of AWMS respects the gradual onset of anaerobic digestion in full compliance with UN-ECE reporting and OECD/EUROSTAT reporting. It is an important step to complete harmonization of ammonia and NO_X reporting and nitrous oxide reporting. The overview of the country-specific distribution of AWMS is shown in e-annex 3B-4.

There are four main manure management systems defined in the Table 10.18 (IPCC 2006 Gl., IPCC 2019 Gl.).

1. Anaerobic digesters
2. Liquid storage
3. Solid storage
4. Pasture/Range/Paddock

The use of manure in anaerobic digesters is relevant for cattle, swine and poultry manure. The operation of anaerobic digesters begun in 2001 when 2 biogas station started to work. The specific structure of Czech animal breeding (mostly in factory farming) made it possible to build anaerobic digesters close to farms to consume daily manure production very efficiently without the need to store the manure. Consumption of manure in anaerobic digesters in the Czech Republic is limited, because the sources of biological input (manure, green biomass etc.) are also limited. The number and capacity of anaerobic digesters remained at their maximum number from 2013.The animal waste management system (AWMS) has been updated every year based on a long-term statistical survey of agricultural farms in the Czech Republic. This investigation, ongoing from 2005, evaluated crop production and livestock production of the farms. From the point of view of AWMS, data on livestock housing systems are processed every year. These data show the percentage of individual housing and grazing systems for individual categories of animals. A further complementary basis for the uniform calculation of the AWMS was the statistical study of IAEI (Institute of Agricultural Economics and Information), which surveyed farms for manure transferred annually to biogas stations. Based on these data, nitrogen production in livestock manure (Nex rate) was divided according to the percentage of individual housing systems for each livestock category. At once, the amount of nitrogen in manure transferred to biogas stations was separated. The result was the determination of the percentage of individual methods of manure management in agriculture.

Manure management storage and usage are subjected to national Decree No. 377/2013 Coll. This regulation is based on EU regulation No. 91/676/EHS from 1991. The manure storage capacity corresponds to the estimated production for 6 months. This does not apply to the storage of solid manure on agricultural land prior to use. Solid manure may be stored on agricultural land at suitable places in a field for a maximum period of 24 months. The company/owner can store the manure for fertilizer again on the same agricultural land four years after soil cultivation of the agricultural land. Liquid manure is to be stored in leak-proof tanks or scrub areas in stables. Reservoirs and tanks or areas in the stables must match the capacity of at least four months estimated production of liquid manure or share at a minimum of three months estimated production of liquid manure and dung, depending on the climatic conditions of the region. The decree No. 377/2013 Coll. includes five annexes with data for calculating the production of manure in a situation where records of the manure management system evidence on individual farm level are not available (e.g. typical animal mass of livestock, nitrogen content in excrements, dry mass of excrements etc.). A farmer can calculate the production and control the use of manure according to the number of heads of livestock.

(Data source: Jana Beranova – NIR 2023)

Tab. VIII.2 shows the effects of recalculations on NH_3 and NO_X between submission 2022 and 2023 based on changes in Nex rate updating in dairy cattle and non - dairy cattle categories and based on revision of AWMS in all-time series.

Tab. VIII.2 Comparison of NH_3 and NO_X emissions from manure management of the submissions 2022 and 2023

NH_3 emissions, kt	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020
2022 submission	78.7	48.7	42.0	34.5	27.6	24.9	24.8	24.5	24.5	24.2	23.8
2023 submission	69.7	45.5	41.8	34.8	28.4	26.5	26.4	26.1	27.2	26.6	26.8
Difference,%	-12	-7	0	+1	+2	+6	+7	+7	+11	+10	+12
NOx emissions, kt	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020
2022 submission	1.96	1.16	0.97	0.83	0.73	0.70	0.69	0.70	0.69	0.70	0.70
2023 submission	1.53	0.97	0.89	0.8	0.72	0.72	0.71	0.7	0.74	0.73	0.75
Difference,%	-12	-14	-9	-4	-2	+2	+2	+1	+7	+5	+7

Emissions of NH_3 decreased by 0-12% in years 1990-2000 and increased by 1-12% in years 2005-2020. Emissions of NO_X decreased by 2-14% in years 1990-2010 and increased by 1-7% in years 2015-2020 compared to submission 2022.

3Da1 Inorganic N-fertilisers

Compared to the 2022 submission of ammonia emissions originating from the application of mineral fertilizers, only NH_3 and NO_X emissions for the years 2018-2020 were refined based on the IFAST data update. Tab. VIII.3 shows the effects of recalculations on NH_3 and NO_X between submission 2022 and 2023.

Tab. VIII.3 Comparison of NH_3 and NO_X emissions from mineral N fertilisers of the submissions 2022 and 2023

NH_3 emissions, kt	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020
2022 submission	22.1	14.1	15.3	20.0	18.5	31.4	32.1	30.7	26.0	23.6	20.8
2023 submission	22.1	14.1	15.3	20.0	18.5	31.4	32.1	30.7	25.6	22.5	19.9
Difference,%	0	0	0	0	0	0	0	0	-1	-4	-4
NOx emissions, kt	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020
2022 submission	15.2	8.8	9.2	11.8	11.1	16.0	15.9	15.8	14.4	14.1	12.6
2023 submission	15.2	8.8	9.2	11.8	11.1	16.0	15.9	15.8	14.4	14.1	12.9
Difference,%	0	0	0	0	0	0	0	0	0	0	+2

3Da2a Animal manure applied to soils

A recalculation of NH_3 and NO_X emissions from animal manure applied to soil has been made for all years 1990-2020 due to implementation of low-emission manure spreading techniques for the application of manure and slurry into inventory. Tab. VIII.4 shows the effects of recalculations on NH_3 and NO_X between submission 2022 and 2023.

Tab. VIII.4 Comparison of NH3 and NOX emissions from animal manure applied to soils of the submissions 2022 and 2023

NH_3 emissions, kt	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020
2022 submission	35.6	21.6	18.1	14.6	12.9	13.2	13.0	13.9	13.8	13.5	13.9
2023 submission	31.7	20.4	18.2	14.5	13.1	13.8	13.6	13.5	13.8	13.4	13.4
Difference,%	-11	-6	+1	+1	+1	+4	+5	-4	0	-1	+1
NOx emissions, kt	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020

2022 submission	9.3	5.6	4.8	4.1	3.6	3.6	3.7	3.6	3.7	3.6	3.6
2023 submission	8.4	5.3	4.7	4.1	3.6	3.8	3.8	3.7	3.9	3.9	3.9
Difference,%	-9	-6	-1	0	+1	+4	+5	+5	+7	+7	+7

NH_3 emissions decreased by 6-11% in years 1990-1995 and increased by 1-5% in years 2000 – 2016. NO_X emissions decreased by 1-19% in years 1990-2000 and increased by 1-7% in years 2010-2020 compared to submission 2022.

3Da2b Sewage sludge applied to soils

No recalculations

3Da2c Other organic fertilisers applied to soils

In the submission of data from 2023, ammonia and NO_X emissions from the application of digestate, respectively its plant share, were included in the inventory for the first time. The share of digestate originating from manure has already been included in the inventory in category 3Da2a. Furthermore, activity data regarding the application of composts in the years 1990-2004 was added. Tab. VIII.5 shows the effects of recalculations on NH_3 and NO_X between submission 2022 and 2023.

Tab. VIII.5 Effects of recalculations on NH_3 and NO_X between submission 2022 and 2023.

NH_3 emissions, kt	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020
2022 submission	0	0	0	0.02	0.03	0.04	0.05	0.06	0.06	0.06	0.06
2023 submission	0.01	0.01	0.01	0.05	0.6	1.51	1.52	1.53	1.53	1.54	1.54
NOx emissions, kt	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020
2022 submission	0	0	0	0.010	0.015	0.019	0.027	0.028	0.029	0.032	0.032
2023 submission	0.006	0.006	0.006	0.024	0.278	0.754	0.762	0.764	0.766	0.769	0.770

3Da3 Urine and dung deposited by grazing animal

Changes in calculation of NFR 3B and 3Da2a have effects also on calculation of NFR 3Da3. Tab. VIII.6 shows the effects of recalculations on NH_3 and NO_X between submission 2022 and 2023.

Tab. VIII.6 Comparison of NH_3 emissions from animal manure applied to soils of the submissions 2022 and 2023

NH_3 emissions, kt	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020
2022 submission	2.6	2.2	1.9	1.8	2.2	2.0	2.0	2.1	2.1	2.1	2.1
2023 submission	2.2	2.0	1.7	1.7	2.1	1.9	1.9	2.0	2.1	2.1	2.1
Difference,%	-12	-12	-11	-6	-5	-5	-2	-4	0	0	0
NOx emissions, kt	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020
2022 submission	1.01	0.87	0.73	0.70	0.83	0.76	0.76	0.78	0.78	0.80	0.78
2023 submission	0.85	0.74	0.63	0.61	0.76	0.71	0.74	0.75	0.79	0.80	0.77
Difference,%	-16	-15	-13	-11	-9	-7	-2	-4	+1	0	0

NH_3 emissions decreased by 2-12% in years 1990-2017 and NO_X emissions decreased by 2-16% in years 1990-2017 compared to submission 2022.

VIII.5.1.2 NMVOC emissions

3B Manure management

Since submission 2022, emissions of NMVOC from land application (category 3Da2a) and grazing (category 3Da3) were reported together under category 3B. This procedure was incorrect, therefore the calculated NMVOC emissions were divided into the correct categories. Moreover, emissions of MNVOC from manure management has been recalculated as an inference of changes in ammonia emissions. Ammonia emissions are part of NMVOC calculation. Tab. VIII.7 shows the effects of recalculations on NMVOC between submission 2022 and 2023.

Tab. VIII.7 Comparison of NMVOC emissions from manure management of the submissions 2022 and 2023

NMVOC emissions, kt	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020
2022 submission	68.9	41.0	36.1	33.4	30.9	33.3	34.1	34.9	36.2	35.9	36.1
2023 submission	43.0	26.6	23.5	22.0	21.0	23.4	23.6	23.4	24.3	24.2	24.5
Difference,%	-38	-35	-35	-34	-32	-29	-31	-33	-33	-33	-32

3Da2a Animal manure applied to soil

Tab. VIII.8 shows the effects of recalculations on NMVOC between submission 2022 and 2023.

Tab. VIII.8 Comparison of NMVOC emissions from manure application of the submissions 2022 and 2023

NMVOC emissions, kt	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020
2022 submission	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2023 submission	23.1	14.5	12.9	12.0	11.1	11.2	11.1	10.9	11.4	11.3	11.5
Difference,%											

3Da3 Urine and dung deposited by grazing animals

Tab. VIII.9 shows the effects of recalculations on NMVOC between submission 2022 and 2023

Tab. VIII.9 Comparison of NMVOC emissions from urine and dung deposited by grazing animals of the submissions 2022 and 2023

NMVOC emissions, kt	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020
2022 submission	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2023 submission	0.05	0.04	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.05	0.04
Difference,%											

3De Cultivated crops

Emissions of MNVOC from cultivated crops were underestimated in 2022 submissions. Part of the agricultural land on which agricultural crops were grown were not included in the emission inventory. This agricultural land was supplemented in 2023 submission. Tab. VIII.10 shows the effects of recalculations on NMVOC between submission 2022 and 2023.

Tab. VIII.10 Comparison of NMVOC emissions from cultivated crops of the submissions 2022 and 2023

NMVOC emissions, kt	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020
2022 submission	1.42	1.46	1.52	1.46	1.47	1.61	1.70	1.53	1.58	1.54	1.62
2023 submission	1.53	1.57	1.65	1.63	1.66	1.86	2.00	1.75	1.81	1.76	1.88
Difference,%	+8	+7	+9	+12	+13	+15	+17	+15	+15	+15	+16

The NMVOC emissions increased by 7-17% in years 1990-2020 compared to submission 2022.

IX. Projections

The date of the last edit of the chapter: 15/03/2023

The year 2020 was used as the Base year for the emission projections processed in 2023. However, for most categories, the same methodologies were used for the projection announced in 2021.The new laws and the current political and economic situation seriously changed the dates predicted for 2025, 2030, 2040 and 2050. Obligations that apply from 2020 are included in projections.

The projection report provides updated emissions of NO_X, SO_X, NMVOC, NH_3 and $PM_{2.5}$. In sectors of Energy (NFR 1A1 and 1A2), Transport (NFR 1A3), Combustion sources (NFR 1A4) and Other combustion sources (NFR 1A5). Following Fugitive emissions from fuels (NFR 1B), Agriculture (NFR 3) and Waste (NFR 5). Projections were based on principles and calculations described in EMEP/EEA air pollutant emission inventory guidebook, 2019 (EMEP/EEA EIG) [3]. The projections are usually modelled by two scenarios WM (with existing measures) and WAM (with additional measures). However, projections in 2025, 2030, 2040 and 2050 are processed just in the WM scenario because the Czech Republic should fill the Emission Ceilings each year. The WAM scenario is not required. The projections were compiled in the appropriate Annex IV used in past years. The new format will only be applied from 2025.

The Czech Republic must fulfil NEC Directive 2016/2284/EU commitment to the Reduction of emissions of air pollutants. This directive on national emission ceilings sets stricter national limits from 2020 to 2029 and from 2030 onwards. The national emission limits set for each pollutant from 2020 to 2029 are identical to the limits to which Member States have already committed themselves under the revised Gothenburg Protocol (2012 revision of the Gothenburg Protocol [24]). The commitments are available in tables A and B, Annex II [2]. The total commitments of the Czech Republic are shown in Tab. IX.1.

The conditions defined in NEC Directive 2016/2284/EU Article 4 to limit annual anthropogenic emissions were used to compile national emissions ceilings. Ceilings of primary pollutants were compiled without NO_X and NMVOC emissions in NFR 3B and 3D, as described in paragraph; 3.d. Emissions of nitrogen oxides and non-methane volatile organic compounds from activities falling under the 2014 Nomenclature for Reporting (NFR) as provided by the LRTAP Convention categories 3B (manure management) and 3D (agricultural soils) [2].

Tab. IX.1 Commitments under NEC Directive 2016/2284/EU

		NO_X (as NO_2)	NMVOC	SO_X (as SO_2)	NH_3	$PM_{2.5}$
Reduction from 2005 level [%]		[%]				
	2020 to 2029	35	18	45	7	17
	from 2030	64	50	66	22	60
Reduction from 2005 level [kt]		[kt]				
	2020 to 2029	99.4	43.1	93.8	5.2	7.4
	from 2030	181.8	119.65	137.7	16.4	26.3
Ceilings		[kt]				
	2005	284.1	239.3	208,5	74,4	43,8
	2020	184.7	196.2	114.7	69.2	36.4
	2030	102.3	119.7	70.9	58.1	17.5

IX.1 Methodology

Emission categories were divided into five groups. The emissions from each category were calculated separately. Different organisations participated in the report preparation. Each described sector was prepared separately and used methods available in the following chapters. Final emissions projections were taken from organisation authors and compiled into the Annex IV template. The forming of total emissions, according to the WM projection, is shown in Tab. IX.2

Tab. IX.2 Sectors and participants of Czech projections

Sector	Organisation prepared projection	Organisation provided input data
Energy	CUEC, CHMI	CHMI, MIT, CZSO, MZP
Residential	CHMI	CHMI, MIT, CZSO
Industry	CHMI	CHMI, MIT, CZSO
Transport	Motran s.r.o.	CDV, MoT, MIT, CZSO
Agriculture	VUZT	MoA, CZSO
Waste	CHMI	CHMI, MZP, CZSO

IX.2 Ceilings

Ceilings 2020

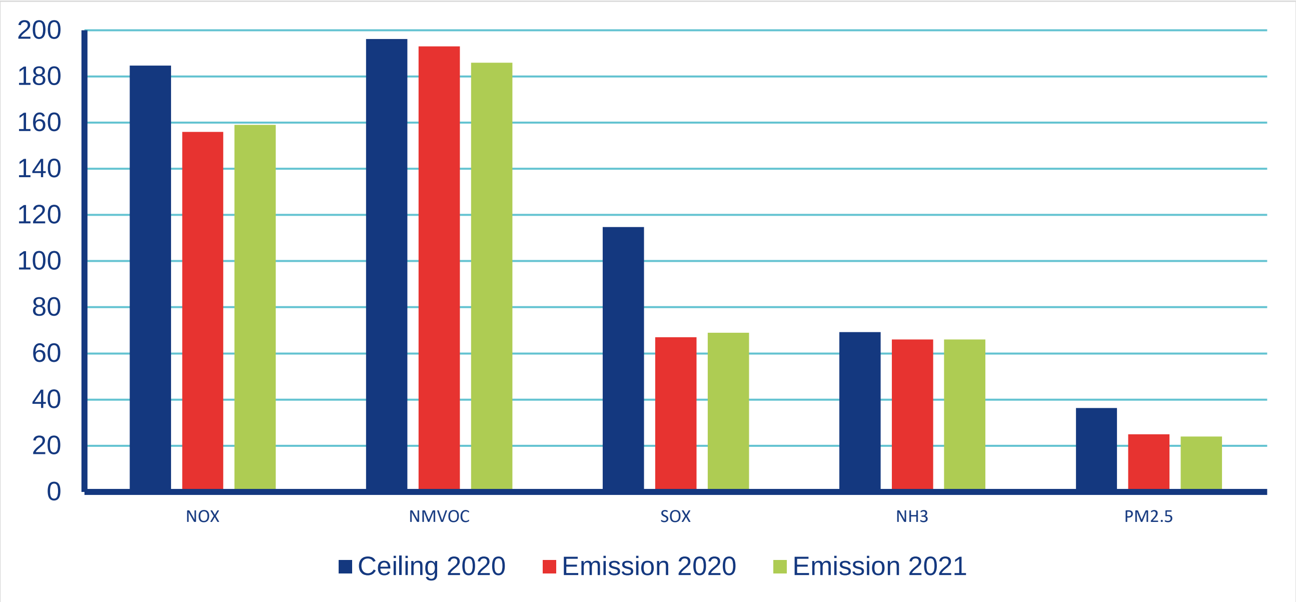


Fig. IX.1 Czech commitments 2020

In 2020 and 2021, emission ceiling limits were achieved for all Emissions pollutants.

Ceilings 2030

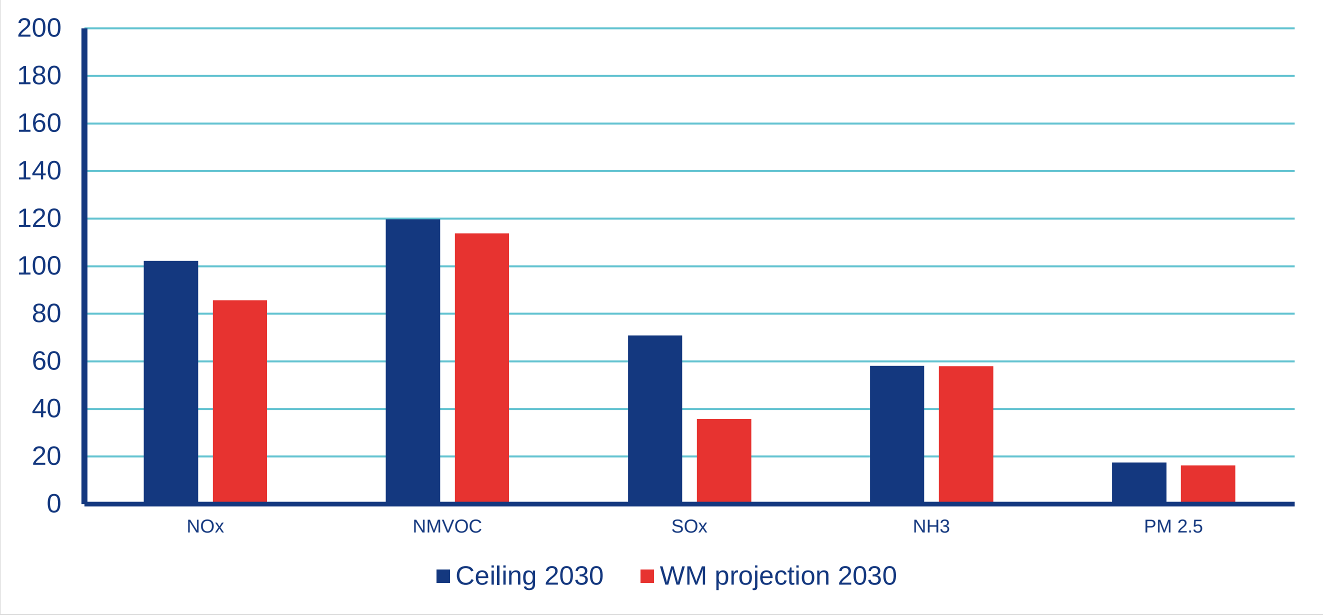


Fig. IX.2 Czech commitments 2030

In 2030 will achieve the emission ceiling limits for all Emissions pollutants by the scenario WM.

Ceilings 2050

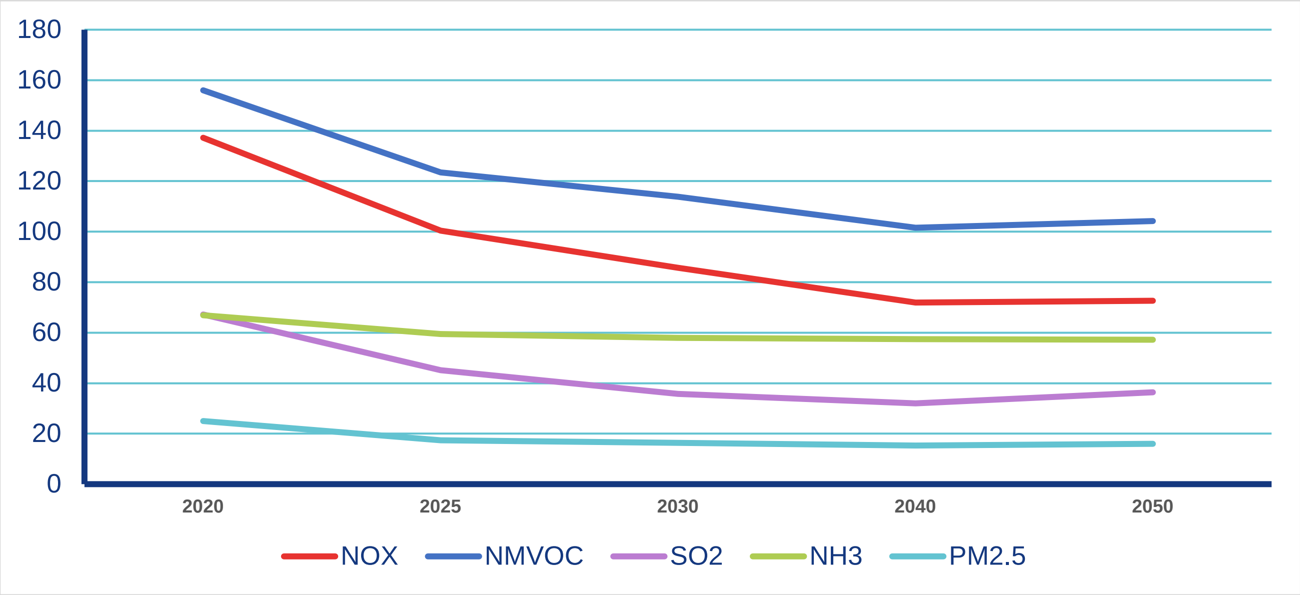


Fig. IX.3 Czech Emissions by WM Scenario

In 2050 will achieve the emission ceiling limits for all Emissions pollutants by the scenario WM. Because the projected values of emissions slightly decrease or stagnate. However, additional policies and precautions will need to be implemented.

IX.2.1 Redistribution of Emissions in 2030

The WM scenario shows the distribution of emissions in NFR categories recorded in 2020, and data in 2030 by WM projection. The data are from Annex IV.

NO_X (as NO_2)

The NFR 1A4 distribution will expand from 22% to 31%. The expanse will be because of a population increase and minimal legal interventions on small combustion sources are planned. The increase will be in NFR 1A2 from 13% to 18%, and NFR 3 will increase by 9%, from 12% to 19% in 2030.

The considerable decrease will be in NFR 1A1 from 20% to 7% and NFR 1A3 from 30% to 20% in 2030. The residue NFR categories will have a similar distribution. The total emission of NO_X (as NO_2) will decrease from 137.2 kt in 2020 to 85.7 kt in 2030.

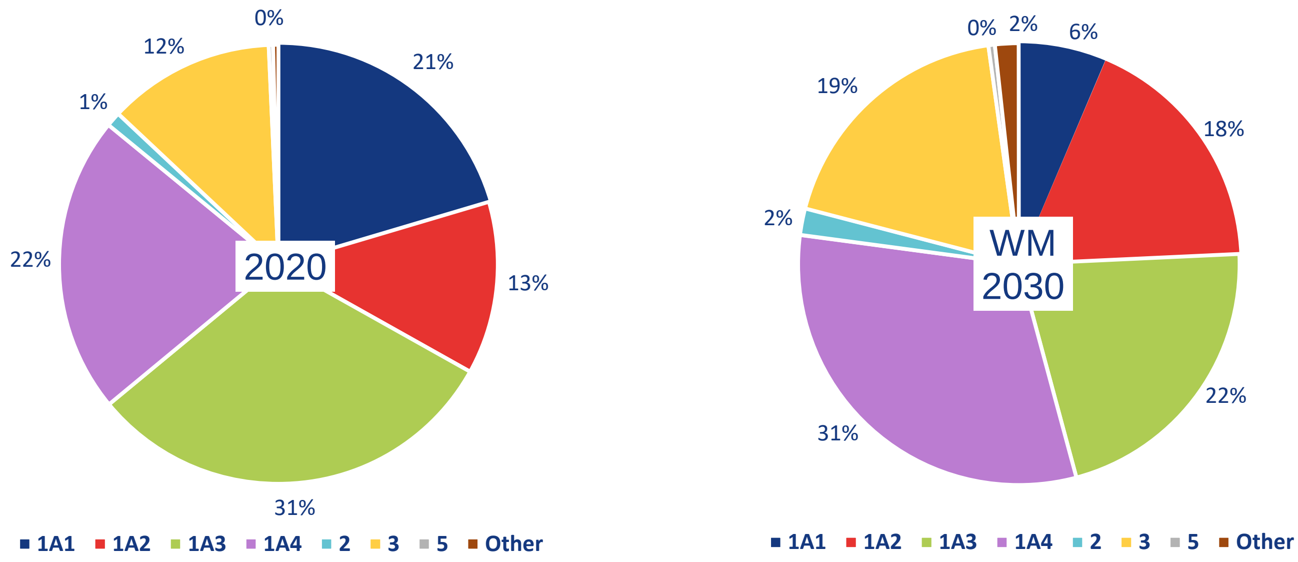


Fig. IX.4 NOX redistribution

NMVOC

The distribution of NMVOC will change and increase in NFR 1A4 from 26% to 33%. The NFR 2 and 3 will expand by 6%. NFR 2 will expand from 34% to 40%, and NFR 3 from 19% to 25% in 2030.

The decrease will be in NFR 1A3 from 7% to 3% in 2030. The residue NFR categories will have a similar distribution. The total emission of NMVOC will decrease from 156 kt in 2020, to 113.8 kt in 2030.

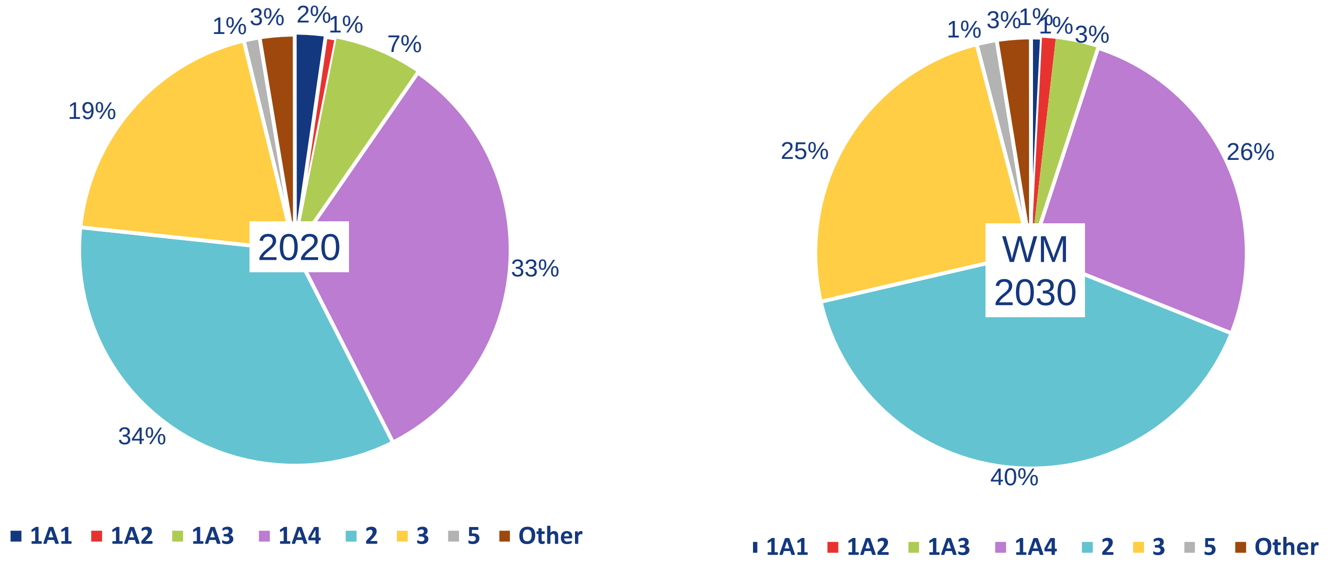


Fig. IX.5 NMVOC redistribution

SO_X (as SO_2)

The NFR 1A4 distribution will expand from 21% to 38% in 2030. The category Other will increase from 4% to 7%, and NFR 1A1 from 6% to 11% in 2030.

The significant decrease will be in NFR 1A3 by 27%, from 42% to 15% in 2030.

The residue NFR categories will have a similar distribution.

The total emission of SO_X (as SO_2) will decrease from 67.2 kt in 2020 to 35.8 kt in 2030.

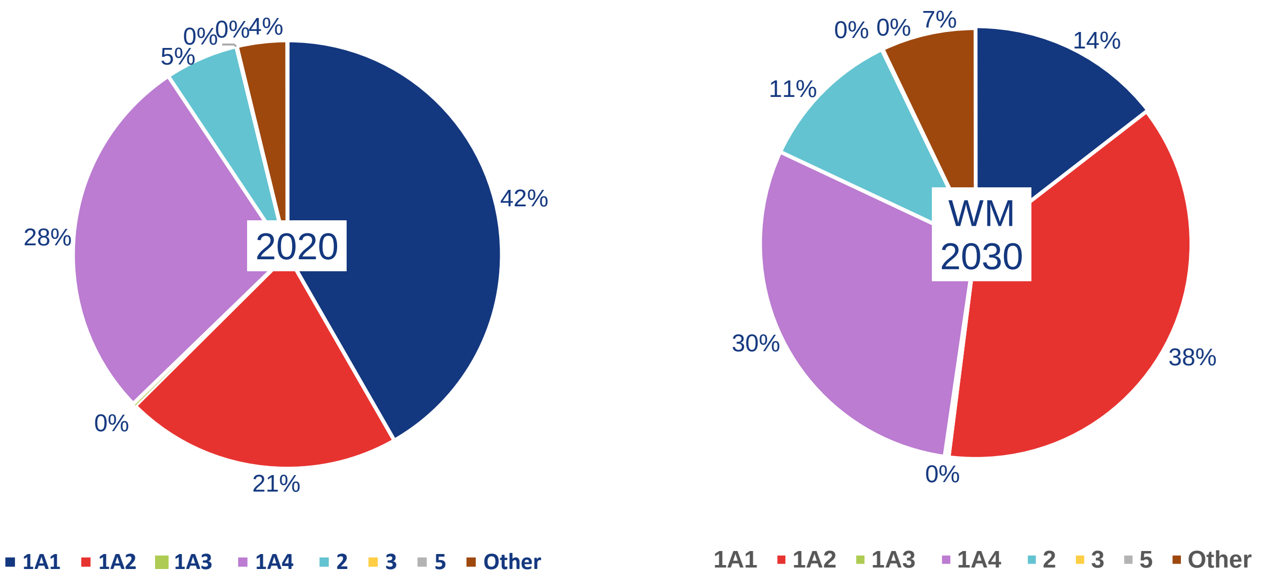
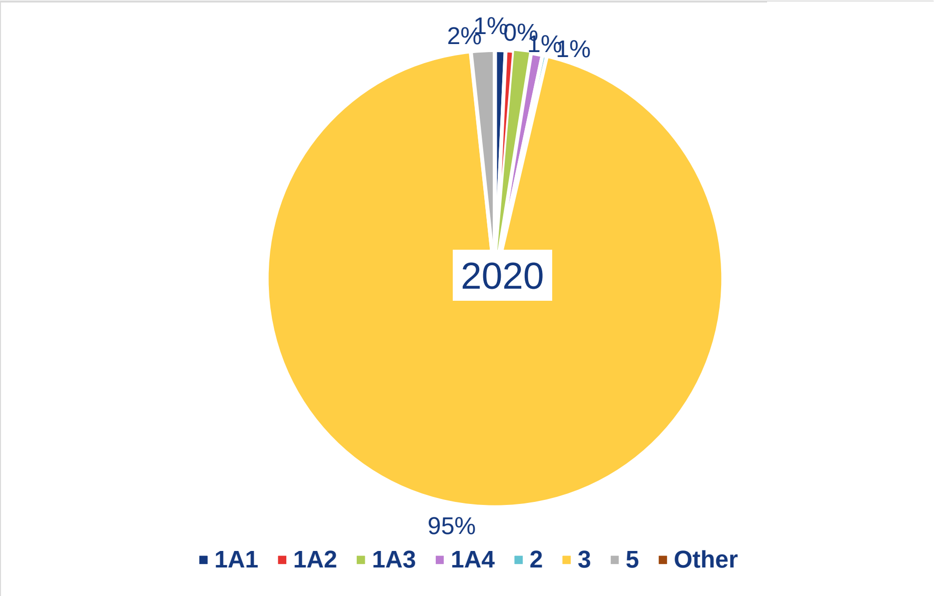


Fig. IX.6 SO_X (SO_2) redistribution

NH_3

The NFR 3 distribution will expand from 88% to 91% in 2030. The rest of NFR categories will have a similar distribution, because almost all emissions will be produced in agriculture.

The total emission of NH_3 will decrease from 66.9 kt in 2020 to 58 kt in 2030.



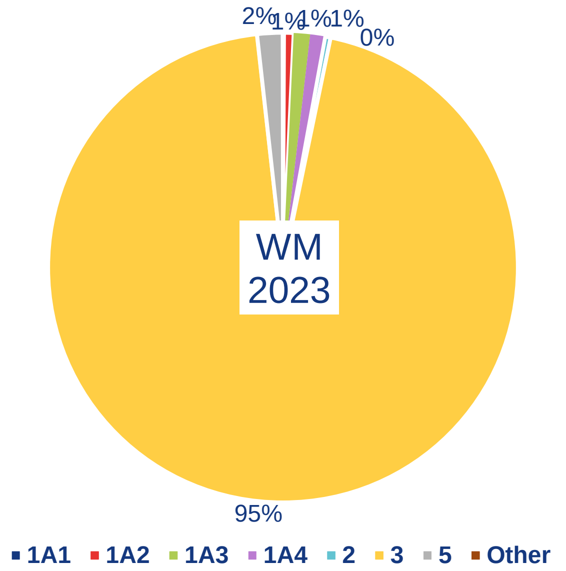


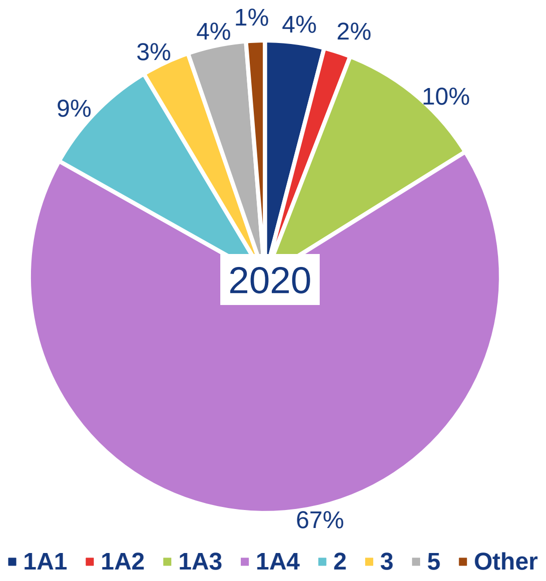
Fig. IX.7 NH_3 redistribution

$PM_{2.5}$

The NFR 2 distribution will expand from 8% to 14% in 2030.

The significant decrease will be in NFR 1A4 by 7%, from 67% to 60%. The rest of NFR categories will have a similar distribution in 2030.

The total emission of $PM_{2.5}$ will decrease from 25 kt in 2020 to 16.3 kt in 2030.



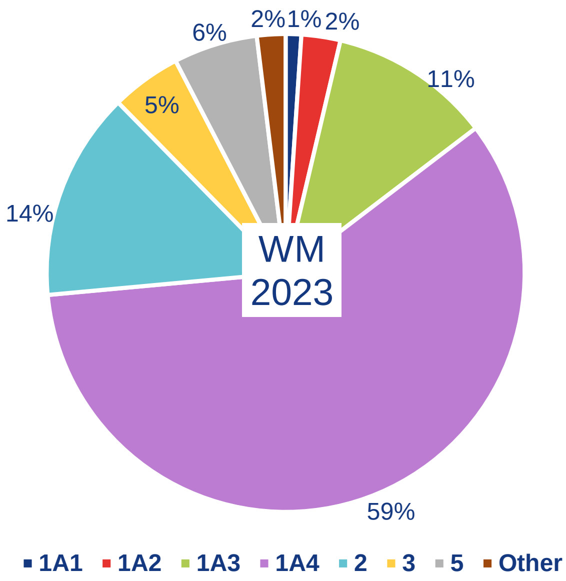


Fig. IX.8 $PM_{2.5}$ redistribution

IX.2.2 Black Carbon

The Czech Republic needs to dispose of more BC emissions data to evaluate further projections in any categories. Especially a need for more information about trends of IEF in 2025 - 2050. Therefore, emissions of BC were not estimated.

IX.2.3 Future improvements

In future IIR the projection of Energy NFR 1A2 and 1A4 will be prepared in the TIMES programme. Categories would gradually process by the TIMES in the following year's reported projection.

IX.3 Energy (NFR 1A1 and 1A2)

IX.3.1.1 Input data

Input data were provided under the Act No. 201/2012 Coll. Air Protection, combustion sources divided to 3 main groups [4].

- Combustion sources with a total rated thermal input exceeding 50 MW. Which fall under the Industrial Emissions Directive (LCP- Large Combustion Plants under the Industrial Emissions Directive)
- Other combustion sources underlying Annex 2 of the Act No. 201/2012 Coll. Air Protection.
- Combustion sources not underlying Annex 2 to the Act on Households and other sources (natural gas combustion only)

The primary background material consisted of such data

- The REZZO 1 and 2 databases (Register of emissions and sources of air pollution) containing the reported data of sources by operators covered by Annex 2
- Household fuel consumption data contained in IEA (International Energy Agency questionnaires)
- Data on natural gas consumption is calculated as the difference between the total consumption of natural gas and the partial consumption of listed sources and households

The detailed description is explained in IIR Chapter III (Large combustion plants) [23].

Projection of 1A1 are based on the TIMES-CZ model, described more in detail in IX.3.1.2.1.

Projections of 1A2 were based on the energy balance forecast the Department of Strategy and International Cooperation in Energy of MIT (Ministry of Industry and Trade) provided.

IX.3.1.2 Methodology

IX.3.1.2.1. NFR 1A1

The projections preparation in the 1. Energy sector in the current submission reflects a transition to complete preparation of projection in the 1. Energy sector by TIMES-CZ model[38][37].

TIMES-CZ is a technology rich, bottom-up, cost-optimizing integrated assessment model built within the generic and flexible TIMES (The Integrated MARKAL-EFOM System) model generator's General Algebraic Modelling System (GAMS) code. TIMES has been developed and maintained within the Energy Technology System Analyses Program (ETSAP) by the International Energy Agency (IEA) [33]. TIMES searches for an optimal solution for an overall energy mix that will satisfy exogenously given energy service demand with the least total discounted costs in a given timeframe with a perfect foresight principle [34].

TIMES-CZ is based on the Czech region of the Pan-European TIMES PanEu model developed by the Institute of Energy Economics and Rational Energy Use at the University of Stuttgart [29] but it is regionalized into 14 regions of Czechia, its base year is updated to 2019 and the model structure is modified by individual data of EU ETS facilities. (the year 2019 was selected as the base year of the model to avoid bias by the pandemic year 2020.) The modelling horizon spans from 2019 to 2050, split into two 2 and six 5 year-time steps. A year is divided into 12 time-slices, 4-seasonal and 3-day levels (day, peak and night). GHG emissions (CO_2, CH_4, N_2O) and other pollutants (SO_2, NO_X, NMVOC, PM) are included in the model.

Assumption of WM scenario:

Final energy service demand is based on National Energy Climate Plan (NECP) [35]. Nuclear power development is an exogenous assumption according to NECP: Temelín nuclear power plant remains in operation for the whole period (2020 – 2050), the operation of the current 4 units of the Dukovany nuclear power plant will be decommissioned gradually in the period 2040 – 2042. New nuclear units will be introduced after 2036 with temporary overlap with the Dukovany nuclear power plant.

The electricity export balance is assumed according to NECP (Tab. 2-9). The maximum renewable energy source (RES) potential for electricity generation corresponds to the Progressive Scenario of the Resource Adequacy Assessment of the Electrical Grid of the Czech Republic until 2040 (MAF CZ) [30].

Assumptions of fuel prices are taken from Recommended parameters for reporting on GHG projections in 2023 [31].

Stock of residential boilers and appliances is based on ENERGO 2015 (the most recent one was published too late to be included in the model).

The heating plant and the ICGT plant Sokolovská uhelná - Vřesová are included in category 1.A.1.c only until 2020. Then coal gasification ends and both sources move to 1.A.1.a category and the ICGT source consumes natural gas instead of gas. All new electricity generating (or CHP) sources are reclassified from sector 1A4a to sector 1A1a.

The reflection of current energy crisis and war is limited to the updated price assumptions based on Recommended parameters for reporting on GHG projections in 2023 [31]. No restriction on natural gas use is assumed. The model has time-steps in 2020 and then 2025. As a result, the model does not reflect the current extremely high prices of energies and the current induced boost in energy efficiency is not reflected in the current submission.

Tab. IX.3 Assumed net electricity export (TWh)

	2019	2020	2025	2030	2035	2040	2045	2050
TWh	17.68073	10.15286	7.753474	6.359068	4.767547	1.233029	1.137333	0.3608

Emission allowance prices are taken from the WEM scenario from Recommended parameters for reporting on GHG projections in 2023 [31].

The electricity consumption in road transport is in line with the medium scenario of the National Clean Mobility Action Plan [36].

Tab. IX.4 Applied EUA prices

	2020	2025	2030	2035	2040	2045	2050
EUR_{2020}	24	80	80	82	85	130	160

Scenario results – activity data

The results of modelling reflect the given assumptions. As a result of decreasing electricity net export and high price of EUA, the input of hard coal and lignite for heat and power generation decreases sharply. Renewable energy sources and natural gas are the main substitutes for hard coal and lignite in heat and power generation. Consumption of lignite decreases slower in sector 1.A.2 (autoproducers) than in sector 1.A.1.a.

In 1.A.1.a Public electricity and heat production, the total energy input decreases until 2030 as a result of lower electricity export, as depicted in Tab. 2-11. Then the total energy input increases again up to 704 PJ in 2050. The most significant changes occur in lignite, hard coal, natural gas, solar and wind. Lignite and hard coal continue in decrease up to zero in 2050 – lignite approximately by 110 PJ within 5 years in the first two periods until 2030. (Decrease between 2019 and 2020 was 59 PJ.) The decrease in hard coal and lignite is substituted partly by increase in use of natural gas (up to 139 PJ in 2050) and renewable energy sources (mainly solar and wind).

The decrease in consumption of and lignite in 1.A.1.a Public electricity and heat production is faster than in autoproducers. In order to provide a complete overview of the heat and power generation, Tab. 2-12 depicts total fuel input for heat and power generation including the autoproducers.

Tab. IX.5 Fuel input for heat and power generation in 1.A.1.a – WM scenario

PJ	2020	2025	2030	2035	2040	2045	2050
Hard coal	33.3	18.8	7.1	2.1	1.9	0.2	0
Lignite	299	190.6	81.3	23.9	17.5	6	0
Natural gas	62.6	30.4	51.4	68.9	68.7	82.7	139.1
Other gases	5.4	8	3.7	2.7	0.3	0.3	0.3
Biogas	2.5	1.3	0.2	0.1	0.3	6.8	7
Biomass	19.9	19	17	16	14	14	16
Liquid fossil	0.2	0.2	0.1	0.1	0.1	0	0.1
Nuclear	312.7	323.9	324.1	373	422.7	409.1	409.4
Hydro	7.7	7.9	7.9	8.1	8	7.9	8.2
Solar	17.7	23.8	32.4	34.5	41.1	51.8	56.8
Wind	2.1	5.1	10.1	14.7	17.1	19.6	22
Waste	4.2	15.7	15.8	15.4	15	22.3	22.3
Total	**767.3**	**644.7**	**551.1**	**559.5**	**606.7**	**620.7**	**681.2**

IX.3.1.2.2 NFR 1A2

Projections of the Energy sector were calculated in MS Excel. Input data were collected in Excel, where all combustion plants with a total rated thermal input exceeding 50 MW were divided under the NFR 1A1 or 1A2. The current fuel mix of each plant, current consumption, efficiency and other parameters were added to the Excel. The amount of emission emitted from 1 GJ of heat was calculated. Each plant had a different amount because of different fuel mix, efficiency, fuel supply and other parameters.

The number of emissions emitted from 1 GJ [t/GJ] was multiplied by the activity data rate given in forecasts provided by MIT. These forecasts consist future fuel mix of each plant, domestic supply, final consumption in different sectors, energy supply, and other parameters.

Emissions were calculated by the equation down below in the table

Tab. IX.6 Emission equation

$$E = EF \cdot AR \qquad 1.1$$

E	calculated emissions	[kt]
EF	amount of emissions emitted from 1 GJ	[kt.GJ^{-1}]
AR	data given in forecast	[GJ]

The calculation scheme also responds to changes that occur till 2030. There are significant changes in the fuel base of individual sources, reconstruction and replacement of boilers and related changes in the total rated thermal input, termination of the source operation, and putting new sources into operation.

The use of coal in the energy sector will be minor due to the end of mining. Moreover, more energy from usable sources will be used.

Emissions with a total thermal input of less than 50MW were calculated according to forecasts of further production (ex., in Industry) given by MIT (Ministry of Industry and Trade). Data obtained from CZSO (Czech Statistical Office), as further consumption, GDP, population, and other parameters were used.

Calculated emissions were summarised and added to template Annex IV.

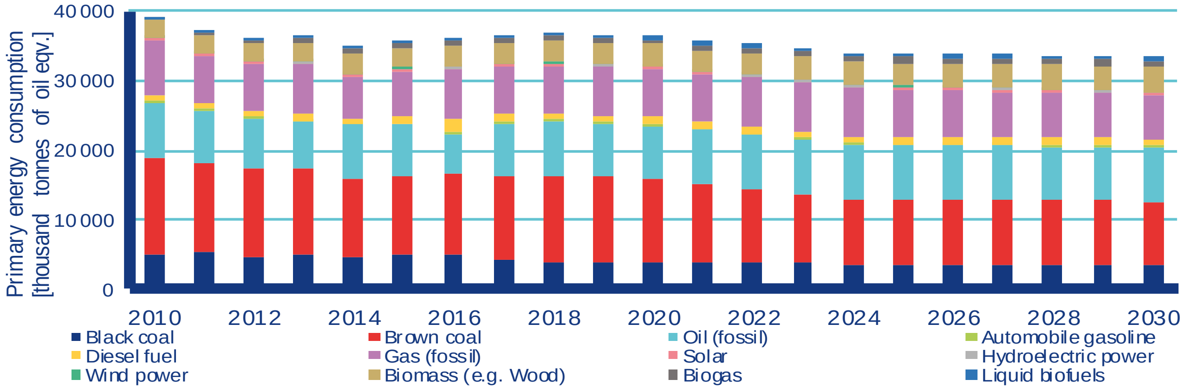


Fig. IX.9 Primary energy consumption. 2010-2030

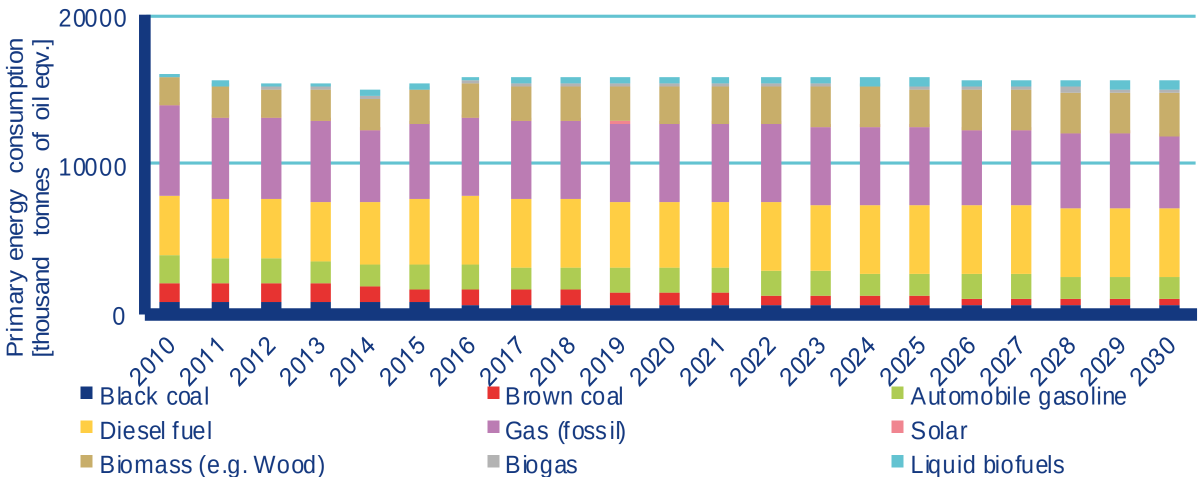


Fig. IX.10 Final energy consumption, 2010-2030

IX.4 Transport (NFR 1A3)

The basic approach was to obtain the time series of activity data (vehicle fleet, fuel consumptions. annual numbers of new and scrapped vehicles. transport volumes and performances, etc.), and then to analyse possible future development in the field of transport demand, vehicle fleet, modal split and the development and introduction of new vehicle technologies, more responsible to the protection of air quality and environment.

From the analysis of input data, the future time series of emission productions were calculated. In addition, the analysis of efficiency of individual policies and measures was made. The possible emission reduction was the output of this analysis. These reductions were subtracted from total future emission mass, depending on the type of scenarios: with existing measures (WM) and with additional measures (WaM). The WAM scenario is not required.

The approach for emission reduction calculations was updated. This update is related to the reduction of greenhouse gas emission. In 2019, new Regulation (EU) 2019/631 of the European Parliament and of the Council f 17 April 2019 setting CO_2 emission performance standards for new passenger cars and for new light commercial vehicles was adopted. By this Regulation, the CO_2 emissions from new cars should decrease on 15% in 2025 and 37.5% in 2030 compared to 2021 year. The CO_2 emissions from new vans should decrease on 15% in 2025 and 31% in 2030 compared to 2021 year.

These standards are defined for new car fleet of every car manufacturers (with some exceptions). It will influence emissions of "traditional" pollutants like NO_X, CO, NMVOC and others as well. Future vehicle fleet and kilometres composition was modelled in order to meet these standards. Resulted vehicle composition contains more zero emission vehicles that in the WM scenario. The percentage of zero emission vehicles in the fleet is set to get weighted average to values of above mentioned percent.

Further emission reduction was calculated by impact of other measures. For example, new vehicles with purer emission standards, and demand – influencing measures (investment to railway and combined transport infrastructure. road toll. and others) influence harmful emission production as well.

IX.4.1.1 Road and non-road transport (1A3a-d)

Emission projections from Transport sector were made by expert from MOTRAN Research. s.r.o. The results of the projection were elaborated in the R-project. The Department of Strategy and International Cooperation in Energy (MIT) provided activity data including expected changes in the share of consumption of individual transport fuels.

The emission projection comes from the official Czech transport forecast defined in t analytical parts of Transport policy of the Czech Republic for the period 2021 – 2027 with a view to 2050. For analytical parts of Transport Policy the national Czech transport model was used. It comes from the prediction of demography and economy as well as export and import of freight. Forecasts of energy consumption split to individual fuels, done by MIT. It is another important input for the model of emissions projections in transport.

Transport and energy forecasts are a base for the calculation of more detailed activity data for emissions projection. These data are further disaggregated to more detailed vehicle categories by fuel used and Euro Standards emission limits. Emission projections model has now 112 transport categories, which differ each other in transport mode, fuel used and emission limits, which a vehicle must meet (by a year of manufacture).

Up to now, emissions datasets from road transport were processed in a model COPERT. Detailed inputs for COPERT model were obtained from the data outputs of the Technical Inspection Stations (STK) linked to the Vehicle Register data. CDV Brno (Transport Research Centre, Brno) provided the evaluation of the dynamic trends.

The underlying data for emission projections were time series including fleet composition, mileage and derived fuel consumption, annual number of new and discarded vehicles, total volumes and transport performance. Analysis was based on the possible future development in demand for transport includes vehicle allocation and modal split, development and operation of new environment friendly vehicles.

Activity data and emission factors have been in structure according to COPERT 5 model. Results from model COPERT recently contain 432 categories of road vehicles, which are different by type of transport, fuel, engine volume for passenger transport, vehicle weight for freight and EURO emission standards. These data were aggregated in emissions projection model to less detailed vehicle categories.

By multiplying these activity data emission factors related to the distance travelled, emission projection were calculated. Analysis of the effectiveness of individual current or future policies and measures was carried out to the projections too.

Tab. IX.7 COPERT appropriative NFR names

COPERT names	NFR Code	Long name
Aircrafts_freight	1A3a.c.d.e	Off-road transport
Aircrafts_passenger	1A3a.c.d.e	Off-road transport
Boats_freight	1A3a.c.d.e	Off-road transport
Boats_passenger	1A3a.c.d.e	Off-road transport
Buses	1A3biii	R.T.. Heavy duty vehicles
Heavy_Duty_Trucks	1A3biii	R.T.. Heavy duty vehicles
L_Category	1A3biv	R.T.. Mopeds & Motorcycles
Light_Commercial_Vehicles	1A3bii	R.T.. Light duty vehicles
Passenger_Cars	1A3bi	R.T.. Passenger cars
Trains__freight	1A3a.c.d.e	Off-road transport
Trains_passenger	1A3a.c.d.e	Off-road transport

Tab. IX.8 COPERT results (from 2025 these are results of emission projection model

Transport mode	**Vehicles**					
Year	**2019**	**2020**	**2025**	**2030**	**2040**	**2050**
Buses	15823	13092	16782	17957	19116	19448
Heavy_Duty_Trucks	139855	125061	155949	182885	206228	230760
L_Category	1147200	899572	1270866	1295240	1338054	1350957
Light_Commercial_Vehicles	578176	543646	584370	685344	772818	864758
- gasoline	84515	81157	63133	50999	30661	23610
- diesel	493661	452934	478372	521137	380460	321100
- other	0	9555	42865	113208	361697	520048
Passenger_Cars	5889714	5530582	6455317	6579119	6796591	6862131
- gasoline	3466557	3132046	3860000	3546287	2528876	1952305
- diesel	2285218	2212567	2271129	2115264	1517303	1183314
- other	137939	185969	324188	917568	2750412	3726512
Total	7770768	7111953	8483284	8760545	9132807	9328054

Tab. IX.9 COPERT results (from 2025 these are results of emission projection model

Transport mode	th.vkm					
Year	**2019**	**2020**	**2025**	**2030**	**2040**	**2050**
Buses	715444	732475	663227	709558	755461	768590
Heavy_Duty_Trucks	8231218	8398826	6781009	7952242	8967116	10033896
L_Category	390344	392597	824403	840212	867986	876356
Light_Commercial_Vehicles	9966415	10169405	8117030	9519612	10734631	12011688
- gasoline	670163	666670	375735	401831	306136	261721
- diesel	9296252	9319284	7213113	7714089	5877003	5024348
- other	0	183451	528182	1403692	4551492	6725619
Passenger_Cars	70745064	71153450	62049083	63239025	65329445	65959415
- gasoline	25723438	25560954	26528556	25143572	18801179	15030158
- diesel	42641366	42140130	32316867	30629691	22903441	18309614
- other	2380260	3452366	3203660	7465762	23624825	32619643
Total	90048485	90846753	78434752	82260649	86654639	89649945

Tab. IX.10 COPERT results (from 2025 these are results of emission projection model

Transport mode	NO_X[kt]					
Year	**2019**	**2020**	**2025**	**2030**	**2040**	**2050**
Buses	2.75	2.62	1.27	1.08	0.83	0.77
Heavy_Duty_Trucks	10.04	10.04	7.57	5.63	3.48	2.52
L_Category	0.06	0.05	0.07	0.04	0.02	0.03
Light_Commercial_Vehicles	10.08	8.98	5.89	4.45	2.66	1.75
- gasoline	0.12	0.09	0.02	0.02	0.01	0.01
- diesel	9.96	8.89	5.84	4.39	2.59	1.67
- other	0.00	0.00	0.03	0.05	0.05	0.06
Passenger_Cars	29.05	25.63	13.66	9.7	4.77	2.83
- gasoline	4.11	3.38	1.87	1.37	0.89	0.7
- diesel	24.74	22.06	11.62	8.11	3.64	1.86
- other	0.20	0.19	0.16	0.22	0.24	0.27
Total	51.98	47.33	28.46	20.9	11.76	7.9

Tab. IX.11 COPERT results (from 2025 these are results of emission projection model

Transport mode	NMVOC[kt]					
Year	**2019**	**2020**	**2025**	**2030**	**2040**	**2050**
Buses	0.09	0.09	0.04	0.04	0.04	0.04
Heavy_Duty_Trucks	0.39	0.29	0.2	0.17	0.17	0.18
L_Category	0.89	0.30	0.49	0.36	0.31	0.3
Light_Commercial_Vehicles	0.55	0.46	0.19	0.15	0.09	0.08
- gasoline	0.21	0.19	0.06	0.05	0.04	0.03
- diesel	0.34	0.27	0.12	0.06	0.02	0.01
- other	0.00	0.00	0.01	0.03	0.04	0.05
Passenger_Cars	11.15	9.43	5.83	4.48	2.96	2.33
- gasoline	10.28	8.69	5.44	4.19	2.76	2.15
- diesel	0.57	0.45	0.23	0.13	0.04	0.03
- other	0.30	0.30	0.16	0.16	0.15	0.16
Total	13.07	10.57	6.75	5.2	3.57	2.93

IX.5 Other combustion sources (1A4)

This sector is characterized as a non-Large Combustion Plants (non-LCP). These are stationary combustion sources with a total rated thermal input of 0.2 to 50 MW.

Projections assume that if a device already meets specific emission limits in 2018, adjusted to the 2025 decree, in future it will still operate the same way, i.e. with the same total rated thermal input and the same fuels and emissions as in 2018.

However, if specific limits covered to the device by 2025 are not fulfilled, reported emissions from 2018 were reduced proportionally using the concentrations, reported by operators and the specific emission limits in accordance with law, valid for the target years of emission projections.

IX.5.1 Residential

IX.5.1.1 Input Data

Projections of emissions in Residential are based on State energy concept and The National Energy and Climate Plan of the Czech Republic [25][26]. The Department of Strategy and International Co-operation, MIP provided forecasts of fuel consumption. Emissions inventory in households, trends of combustion plants were provided by MOI and trends of emission factors were provided by CHMI. More detailed Chapter III.2 Czech IIR [23].

IX.5.1.2 Methodology

The total mix of boilers was calculated. Mix was based on:

- The prohibition on sales of 1st and 2nd class boilers from 1st January 2014;
- The prohibition on sales of 3rd class boilers from 1st January 2018 (part of the burning boilers may meet Class 3 parameters. so they will run also after 2024);

- The prohibition of operation of 1st and 2nd class boilers after the year 2022 (projections are based on the ideal state of fulfillment of the legislative requirement to prohibit the operation of 1st and 2nd class boilers after 2024 was considered);

If source operator replaced an older solid-fuel combustion plant, by a modern solid fuel system, the same fuel type should be used. Also in a case of biomass combustion. The old Energy sources which use the coal, must be gradually replace by a biomass fuels. Especially in a case of gas boiler installations. Because shut down of the coal mines is planned. Many of old boilers will be sell or eliminate through next years, mainly in an areas where the gas pipeline is missing. A fuel consumption forecast indicates that the consumption of brown coal will be reduced and partially replaced by natural gas and renewable sources, primarily by biomass. However, the consumption of the black coal will not be significantly changed.

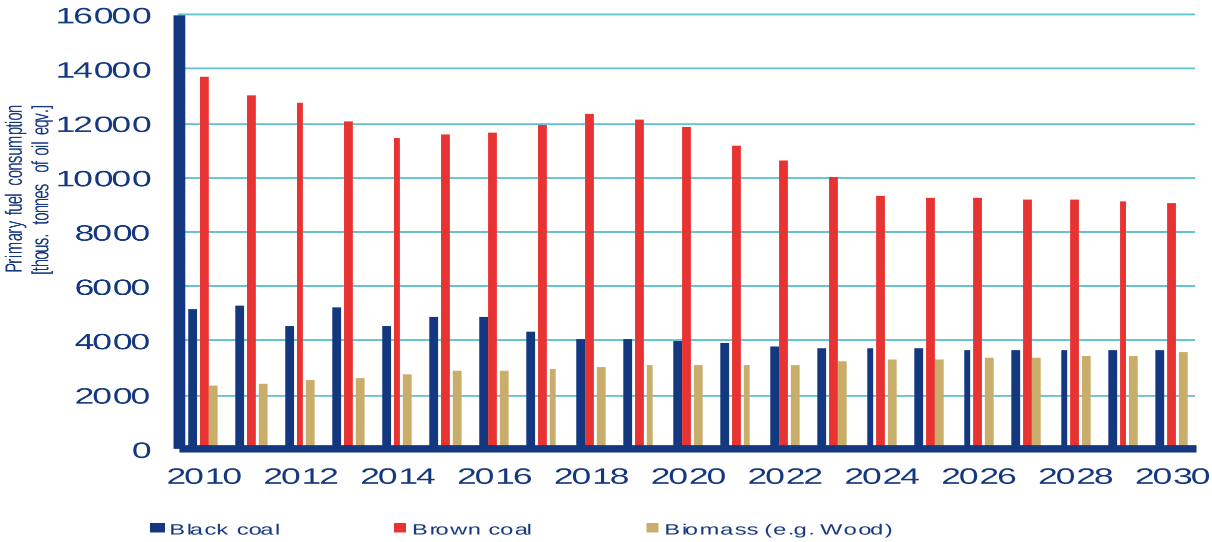


Fig. IX.11 Fuel consumption. 2010-2030

Another group of sources are sources with a power 300 kW and lower, burning natural gas. These are, in general, boiler rooms in public buildings and the business sector. Operators of these sources are under no obligation to report emissions. Therefore, emissions of this category are calculated from the total gas consumption available in the EIA questionnaires. This consumption is multiplied by the emission factor, which is taken from the EMEP/EEA EIG [3].

IX.6 Other (NFR 1A5)

Emissions from the operation of military vehicles and aircraft are included in the NFR 1A5. The Emissions are low. A fuel consumption trend was used as activity data, which have been taken from CZSO and reported by Ministry of Defence and Armed Forces. A trend of this consumption is manifested as, for example, emergency aid during floods. Therefore is difficult to project the development in the future. For Projections the data registered in 2020 were used.

IX.7 Fugitive emissions from fuels (NFR 1B)

Projection of Fugitive emissions were calculated as individual amount of emissions from appropriate activity data and emission factors. It was chosen such activity data, where the prognosis of their development is available at least until 2030. The emission factors were taken from EMEP/EEA EIG or were calculated [3].

Input data for NFR 1B1a, 1B1b, 1B1c and 1B2b were provided by Department of Strategy and International Co-operation in Energy, MIT. Input data were contained a forecast about future fuel consumption and physicochemical properties of fuels. Input data for sectors NFR 1B2ai, 1B2aiv and 1B2av were provided by Czech Association of Petroleum Industry and Trade. Input data were contained data about current consumption. These data were analyzed by linear regression in MS Excel, where calculated emission factors were multiplied by population growth factor. For sector 1B2c emission´s calculation was based on historical data. After analyzing the historical data trend, the future trend was established by multiplying with population growth factor.

IX.8 Industrial Processes and Product Use (NFR 2)

Projections of Industry, especially for category 2D, were calculated with a big margin of uncertainties, because of diversity of organic compounds, their using and absence appropriate measures. Several researches were made in a specific type of emission sources recently. However, there still exist a margin of inaccuracy.

IX.8.1.1 Input data

Projections of Industry were calculated under forecast of further industrial production. Forecasts were provided by MIP. Emissions of base year were taken from Czech emissions inventory, more detailed in Chapter IV Czech IIR [23].

Calculations were made in MS Excel. Projections concerned activities with a major contribution to emissions. Other emissions and activities with a minor contribution were derived on the basis of general economic based growth factors in manufacturing industry. General economic based growth factors, as a recent population estimation and gross domestic product were provided by CZSO. Emission factors were used according EMEP/EEA EIG [3].

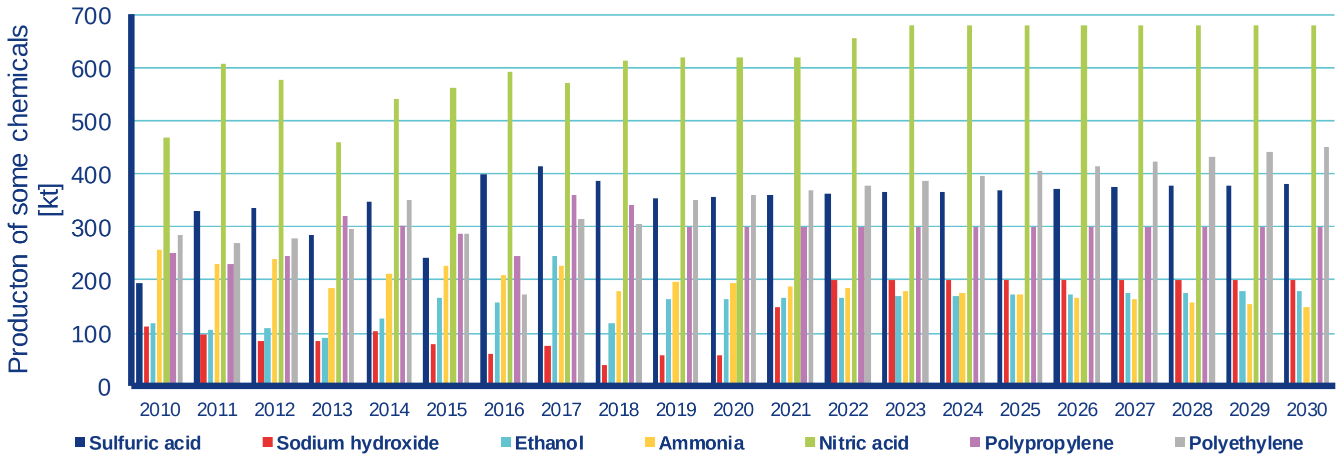


Fig. IX.12 Production of chemicals, 2010-2030

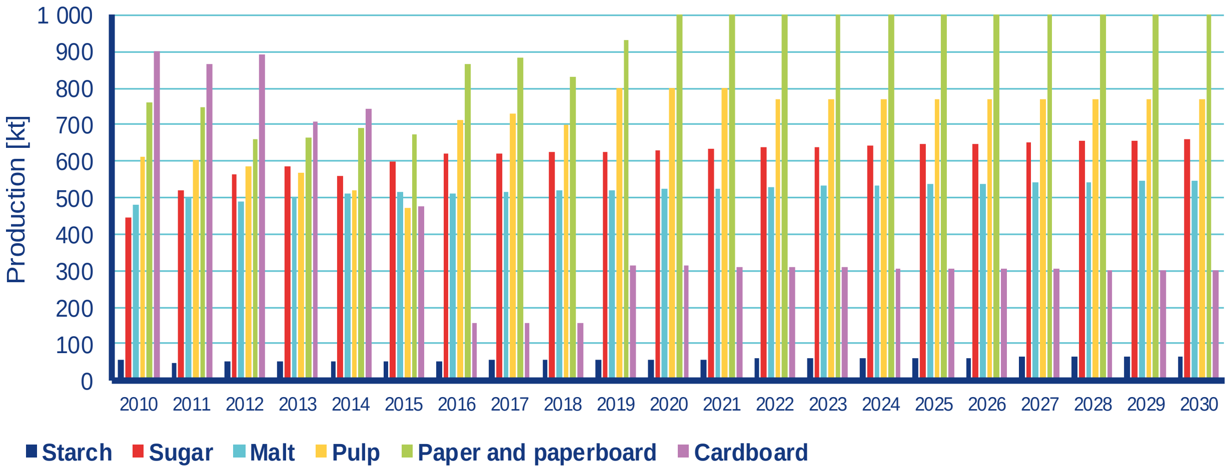


Fig. IX.13 Production of food and paper, 2010-2030

IX.9 Agriculture (NFR 3)

IX.9.1 Agriculture

The projection on emissions of air pollutants originating from agriculture is regularly updated in line with new knowledge as a consequence of new emission sources, changes in emission factors or changes in the agricultural production conditions, e.g. changes regarding the legislation and regulation. Past TERT recommendations prompted changes in the methodological procedure for calculating pollutant emissions.

Many of these changes have led to revisions and recalculations of historical emissions inventories in the past few years (especially from 2020). These changes were reflected in the deviations in the values compared to the projections published in previous reports. Some changes can also lead to a revision in the historical emission inventory; therefore, some deviations are apparent compared to the projection scenarios published in previous reports.

The current projection of pollutant emissions from agriculture is based on the most recent values in the 2023 data submission. It fully reflects recalculations in the historic emissions reported in this report.

IX.9.2 Manure management (NFR 3B), Animal manure applied to soil (NFR 3Da2a), urine and dung deposited by grazing animals (NFR 3Da3)

The number of animals is a key activity data for emissions inventories calculation relating to manure management (NFR 3B), animal manure applied to soil (NFR 3Da2a), urine, and dung deposited by grazing animals (NFR 3Da3). The historical number of livestock from 2005 to 2021 was taken from an annual agricultural census from the official statistics (CZSO). The e-ANNEX NFR-3B-2 shows a number of animals allocated on relevant subcategories used for inventories calculation for the all-time series. No other category of livestock is monitored and recorded. The future estimated number of animals is based on the updated values of the number of livestock resulting from the official Strategy of the Ministry of Agriculture until 2030, approved by the government of the Czech Republic. The number of animals is considered as an average annual production. Tab. IX.12 shows the trends of the livestock population in the period 2005-2040.

Tab. IX.12 Livestock population, 2005-2040 (thousands of heads)

	2005	2010	2015	2021	2025	2030	2035	2040
Cattle	1 392	1 349	1 407	1 406	1 406	1 410	1 451	1 459
Swine	2 877	1 909	1 560	1 518	1 500	1 500	1 500	1 500
Sheep	140	197	232	183	240	165	165	165
Poultry	25 372	24 838	22 508	23 809	25 325	26 601	26 601	26 601
Horses	21	30	33	33	35	35	35	35
Goats	13	22	27	25	35	25	25	25

An increase in the number of cattle by 4 % is expected in 2040 compared to 2021 due to an increase in non-dairy cattle. A slight decrease in the number of dairy cows is expected due to the expected steady increase in milk production per head, but no increase in its consumption or export is expected. Considering the pig breeding market situation, the aim is to maintain at least the current number of pigs. Therefore, no significant change is expected. A slight increase is also expected in the number of the poultry of 10% in 2040 compared to 2020, especially in the number of reared laying hens to increase food self-sufficiency in egg production. Numbers of other livestock categories (sheep, horses and goats) have a negligible effect on future emission predictions.

NH_3 reducing technology

According to Options for Ammonia Abatement: Guidance from the UNECE Task Force on Reactive Nitrogen implementation of NH_3 reducing technology in manure storage and application is already used in inventory and is also used in the projection. The technologies included in the inventory and this projection is the tight lid, plastic sheeting and natural crust in case of slurry storage and band spreading - trailing hose, shoe, slurry injection, incorporation immediately by ploughing, incorporation after 4 hours and incorporation within 24 hours in case of application of slurry and manure. Current penetration rates of used abatement measures are available in the e-ANNEX **NFR-3B-6.** These penetration rates were not changed for the emission prediction calculation.

Emission factors and calculations

To calculate the prediction of ammonia and NO_x emissions, the same Tier 2 calculation methodology based on the mass-flow of TAN through the manure management system was used to calculate the emission balance. The Manure management N-flow tool was used. Default EF is presented in Table 3.9. 3B EMEP/EEA EIG reduced by mitigating measures have been used. Emissions of NMVOC have been calculated using the Tier 2 approach. For calculating NMVOC emissions prediction, default EFs presented in Table 3.11 for dairy cattle, and other cattle and Table 3.12 for livestock categories other than cattle of 3B EMEP/EEA EIG have been used. The estimation of PMs emissions is based on the Tier 1 approach according to the 3B EMEP/EEA EIG. For calculating $PM_{2.5}$, PM_{10} and TSP emissions predictions, default EFs presented in Table 3.5 of the EMEP/EEA EIG have been used [3].

Ammonia, NO_X and NMVOC

Trends of prediction in ammonia, NO_X and NMVOC emissions originating from manure management are presented in Fig. IX.14 and from manure application and animal grazing in Fig. IX.15.

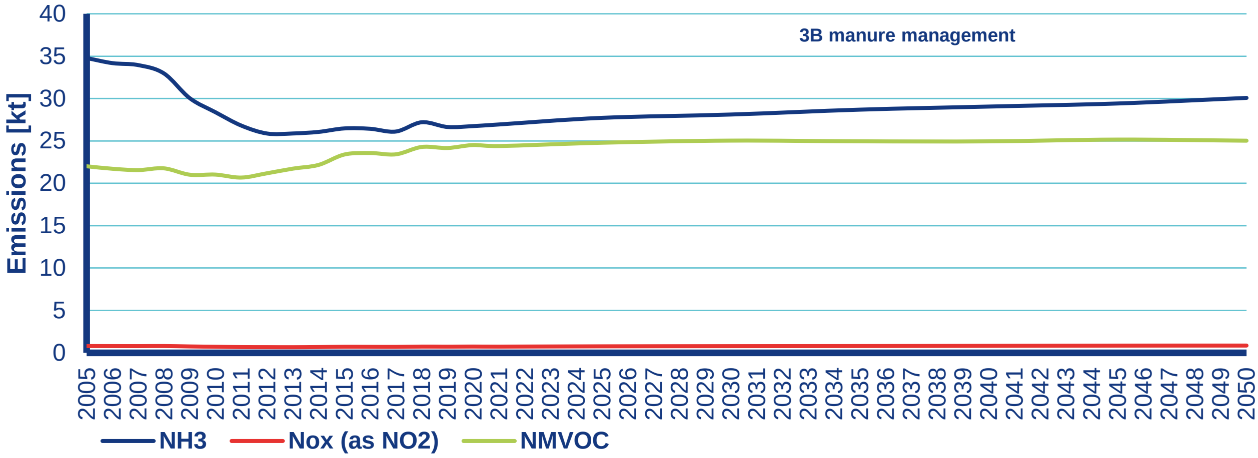


Fig. IX.14 NH_3, NO_X and NMVOC emissions originating from manure management, 2005-2040

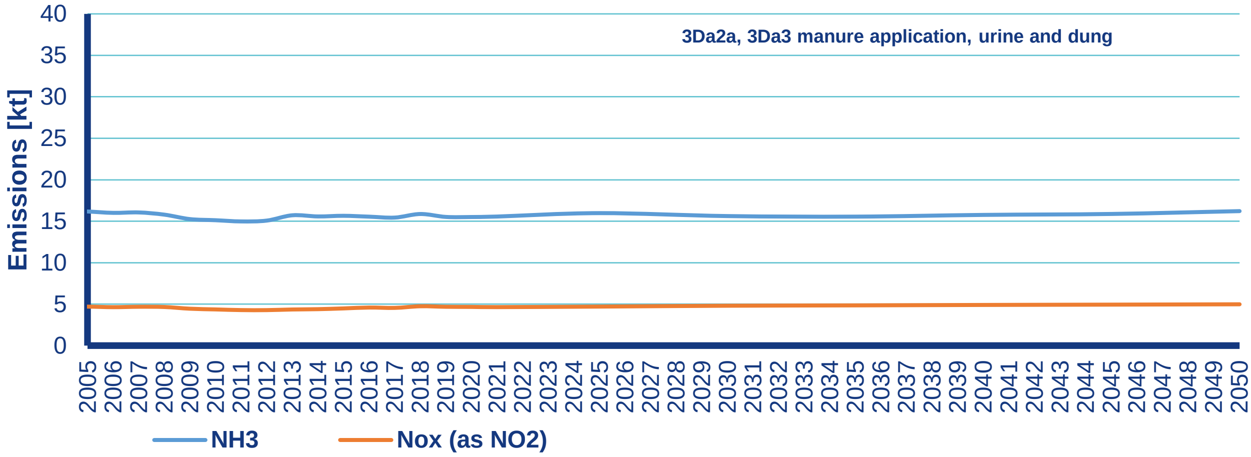


Fig. IX.15 NH_3 and NO_X originating from manure application, urine and dung deposited by grazing animals, 2005-2040

The total ammonia emissions related to livestock farming are expected to decrease by approximately 14% by 2030 compared to 2005. A slight increase of approx. 2% in 2030 compared to 2005 is expected for total NOx emissions related to livestock farming. An increase of approx. 6% can also be expected for total NMVOC emissions in 2030 compared to 2005.

IX.9.3 Crop production and agricultural soils - inorganic N fertilisers application (NFR 3Da1), sewage sludge applied to soils (NFR 3Da2b) and other organic fertilisers applied to soils (including compost) (NFR 3Da2c)

Consumption of nitrogen mineral fertilisers is one of the key sources of ammonia and NO_X emissions from agriculture (NFR 3Da1). The increase in their consumption was associated with a significant decrease in the number of farm animals and the production of farmyard manure. The highest consumption of nitrogen mineral fertilisers, especially urea, was recorded in the production year 2015-2016 and had been decreasing since then. The consumption of sludge and compost used for fertilising agricultural land is not very significant and does not belong to the key sources of emissions. The historical consumption of N inorganic fertilisers from 2005 to 2021 was taken from the IFASTAT database. The future consumption of N inorganic fertilisers is based on a study prepared by the Institute of Agricultural Economics and Information (IAEI), the expert centre for the agricultural economy, food, agricultural advice and information established by the Czech Ministry of Agriculture. Within the framework of the elaborated study, the effects of the current energy crisis, the prices of inorganic fertilisers and the international obligations resulting from, for example, the "Farm to Fork" agreement are considered in future consumption of N inorganic fertilisers. Tab. IX.13 shows the trends of N inorganic fertiliser consumption in 2005-2040.

Tab. IX.13 N inorganic fertilisers consumption, 2005-2040 (kt of N)

	2005	2010	2015	2021	2025	2030	2035	2040
Ammonium nitrate (AN)	10.0	10.0	5.5	3.2	2.3	2.0	1.8	1.6
Ammonium phosphates (AP)	4.0	5.0	4.5	3.4	5.6	4.9	4.3	3.8
Ammonium sulphate (AS)	19.0	17.0	9.1	1.1	6.0	5.2	4.6	4.0
Calcium ammonium nitrate (CAN)	108.0	90.0	98.5	108.9	97.0	84.3	73.8	65.4
NK Mixtures	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NPK Mixtures	11.5	4.0	14.8	11.2	9.3	8.1	7.07	6.3
NP Mixtures	3.0	7.0	4.0	2.6	0.4	0.3	0.3	0.3
N solutions	84.0	87.0	150.1	57.0	61.8	53.7	47.0	41.6
Other straight N compounds	2.5	15.0	31.6	38.3	41.3	35.9	31.4	27.9
Total	289.0	295.0	444.4	309.5	272.7	237.1	207.5	183.8

For the year 2040, compared to 2021, the consumption of nitrogenous inorganic fertilisers is expected to decrease by approx. 40%, among other things, due to the fulfilment of obligations arising from the European Green Deal (reduction of mineral consumption by 20%), the introduction of so-called regenerative and carbon agriculture, or a reduction in the consumption of inorganic fertilisers to reduce the carbon footprint of cultivated crops.

NH_3 reducing technology

In 2021, an amendment to Decree No. 377/2013 on the storage and use of fertilisers came into force in the Czech Republic, which imposes an obligation to immediately incorporate urea into the soil or use urea with urease inhibitors only. According to Options for Ammonia Abatement: Guidance from the UNECE Task Force on Reactive Nitrogen, the measure represents a low ammonia emissions option focused on urea-based fertilisers. This ammonia abatement measure could decrease ammonia emissions from urea application by 70%. This measure has been incorporated into prediction since 2025. Penetration rates of used abatement measures are available in the e-ANNEX **NFR-3D-7.** These penetration rates have not been used for the emission inventory calculation yet.

Emission factors and calculations

For national estimation of NH_3 emissions from consumption and application of inorganic N-fertilisers, the Tier 2 approach has been used according to the 3.D Crop production and agricultural soils guidebook has been used [3]. For the estimation of NO_X, Tier 2 is not available, too, for the estimate of NO_X, which means the Tier 1 approach has been used. The same methods were used to calculate the prediction of ammonia and NO_X emissions. Default EF is presented in Table 3.2. 3D EMEP/EEA EIG for each inorganic N-fertiliser group has been used. For urea, from 2025, measures leading to the reduction of ammonia emissions were taken into account, thereby reducing the recommended emission factor.

Ammonia and NO_X

Trends of prediction in ammonia and NO_X emissions originating from inorganic N-fertilisers application are presented in Fig. IX.16.

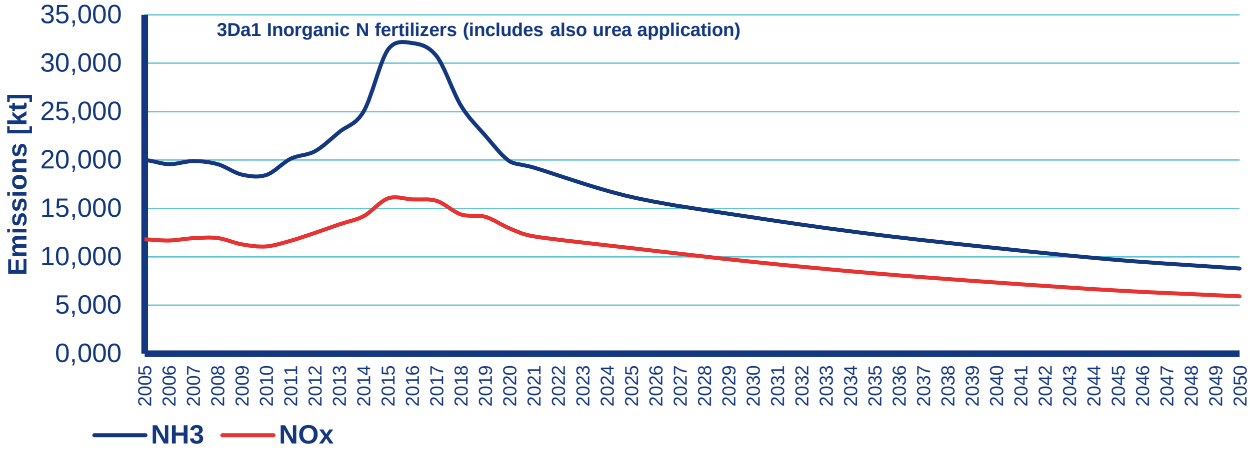


Fig. IX.16 NH_3 and NO_X emissions originating from inorganic N-fertilisers application, 2005-2040

Total ammonia emissions related to inorganic N-fertilisers application are expected to decrease by approximately 46% by 2030 compared to 2005. This reduction should be achieved as a result of gradually reducing the consumption of mineral fertilisers and putting reduction measures for urea-based fertilisers into practice. A similar emission reduction of 38% in 2030 compared to 2005 is also expected for NO_X emissions.

No significant change in the total emissions of ammonia and NO_X from the application of sewage sludge (NFR 3Da2b) and other organic fertilisers (compost and digestate NFR 3Da2c) is expected in the future compared to the current state, which would affect the predictions of these emissions.

IX.9.4 Crop production and agricultural soils – farm-level agricultural operations, including storage, handling and transport of agricultural product (NFR 3Dc)

The area of cultivated crops is a key activity data for emissions inventories calculation relating to manure management (NFR 3Dc). The historical data regarding cultivated crop area from 2005 to 2021 was taken from an annual agricultural census from the official statistics (CZSO). The e-ANNEX NFR-3D-3 shows utilised agricultural areas and areas under crops. The future estimated area of cultivated crops is based on the official Strategy of the Ministry of Agriculture until 2030, approved by the government of the Czech Republic. Tab. IX.14 shows selected crops' cultivated area trends in 2005-2040.

Tab. IX.14 Cultivated area of selected crops, 2005-2040 (thousands ha)

	2005	2010	2015	2021	2025	2030	2035	2040
Wheat	820	834	830	785	853	821	834	669
Rye	47	30	22	25	27	26	27	21

Barley	522	389	366	327	355	342	347	278
Oat	52	52	42	58	63	60	61	49

Emission factors and calculations

The Tier 2 approach has been used for the NFR 3.Dc soils to predict $PM_{2.5}$ and PM_{10} emissions. Tables 3.5 and 3.7 in 3D EMEP/EEA EIG for the region with wet climatic conditions present default EFs for calculating $PM_{2.5}$ and PM_{10} emissions predictions.

PM

The emission of PM from field operations is calculated by the area of cultivated crops multiplied by the number of operations and emission factor for each crop type and type of operation. Operations are divided into soil cultivation, harvesting, cleaning and drying. The expected trend in changes in the soil cultivation method was considered in the calculations of PM emissions projections. This trend should lead to higher use of no-till technologies than current tillage methods. Tab. IX.15 shows the trends of the share of the tillage method.

Tab. IX.15 Trends of share of tillage method, 2020-2040 (%)

Share of tillage method in the year	conventional (deep ploughing or disc ploughing)	minimalisations (shallow ploughing)	no tillage (direct seeding)
	%	%	%
2020	67	32	1
2030	58	32	10
2040	33	32	35

Trends of prediction in PM emissions originating from farm-level agricultural operations, including storage, handling and transport of agricultural products, are presented in Fig. IX.17.

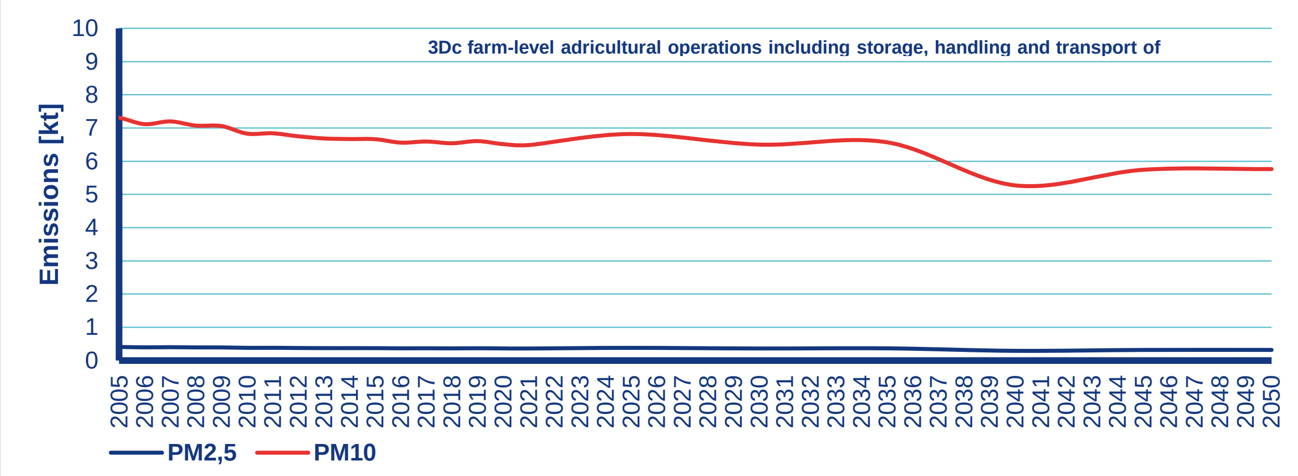


Fig. IX.17 PM emissions originating from farm-level agricultural operations including storage, handling and transport of agricultural product, 2005-2040

The expected change in the tillage method could decrease PM10 emissions by approx. 11% in 2030 compared to 2005. A similar reduction can be expected for PM 2.5 emissions.

IX.10 Waste (NFR 5)

The waste sector (IPCC guidelines sector No. 5) in the Czech Republic is separated into four distinctive categories. The dominant category is NFR 5A, emissions from solid waste disposal sites. The NFR 5A is a limited source range of emissions (NMVOC, and PM2.5).

The second source category is an NFR 5B. This source category consists mainly of composting and up to a small degree of anaerobic digestion of waste. Composting produces a small amount of NH_3. In NFR 5B2 Anaerobic digestion at biogas facilities, NH_3 emissions are estimated.

The third category is NFR 5C. NFR 5C belongs to is accounted for in the Energy sector. Waste incineration produces usable energy. In NFR 5C, only hazardous and industrial waste incineration is accounted for. This category comprises a wide ray of pollutants such as NO_X, NMVOC, SO_X, PM2.5 and BC.

The last category is NFR 5D. The category includes public and private wastewater treatment plants and industrial counterparts and is the source of NH_3 and NMVOC.

Main activity data about future activities comes from the WMP (Waste Management Plan) of the Czech Republic. Key assumptions in WMP are: “The developed forecasts of municipal waste (MW) production imply that municipal waste production between 2013 and 2024 will decline slightly. It can be seen that based on these assumptions, due to the diversion of materially recoverable components of municipal material waste (MMW), in the years 2013-2024, a decrease in landfilling occurs, compensated by a significant increase in material recovery of MW, by the development of composting and anaerobic digestion, and last but not least, by energy recovery“.

These assumptions have yet to materialise fully. Landfill municipal solid waste has slightly increased. Waste treatment options of material recovery, energy recovery, and composting options exceeded their assumptions. However, this positive development was overshadowed by the steady increase in total generated municipal solid waste. Waste projections keep the WMP assumption that, over time, the municipal landfill waste will decrease according to due waste management policies.

NFR 5 have the highest share of total emissions. Emissions are from open waste burning. We assume a reduction of the share of open waste burning and a slight increase in emissions from crematoria for 2025, 2030, 2040, and 2050. We expect the ratio of cremation and burial to the ground will change.

The primary methodological approach to emissions estimation in all categories is an equation multiplying the emission factor by activity data. Any change in methodology is noted explicitly in the specific category. The main source of emission factors is EMEP/EEA EIG [3]. The same spreadsheet with the GHG emissions was used to estimate classical emissions from NFR 5. The values of projected waste emissions for 2025, 2030, 2040 and 2050 are based on extrapolation from emission trends.

In NFR 5C, the previous emission factor is applied, which change NO_X and NMVOC. It is in connection with emission factors from EMEP/EEA EIG. Emission factors for SO_X and NH_3 were assumed from EMEP/EEA EIG 2016.

In NFR 5D, the latest estimations are based on extrapolation from emission trends. An increase in population is observed, while the emissions from NFR 5D have been decreasing.

IX.11 National air pollution control programmes

Under Article 6 of NEC Directive 2016/2284, Member States shall draw up, adopt and implement their respective national air pollution control programmes.

Czech NAPCP submitted in the Czech national emission reduction programme [26]. The last NAPCP was published in 2019.

A summary of measures that can contribute to reducing emissions and improving air quality is given in Tab. IX.16.

The measures under the reduction programme are marked as a priority, supportive, and cross-cutting. The priority measures form the basis of the scenario WaM and help reduce emissions of main pollutants, ensuring that the reduction targets are met. They have been quantified for additional emission reduction potential, and their contribution to reducing emissions and improving quality is either directly quantifiable or unquestionably significant. All other measures will also lead to a reduction in emissions and a reduction in the air pollution load. However, their effect cannot be quantified in most cases for objective reasons, so they are identified as supportive and cross-cutting measures.

The measures are marked with a unique code that follows the reporting obligation requirements. The code consists of two letters and a number. The first letter indicates the sector concerned. The second letter indicates the type of measure, and the number indicates the order of measures in the group.

Groups of measures (sectors) listed in the Catalogue:

A	Reducing the impact of road transport on air pollution levels
B	Reducing the impact of stationary sources on the level of air pollution
C	Reducing the impact of agricultural production on the level of air pollution
D	Reducing the impact of stationary sources operated in households on the level of air pollution
E	Reducing the impact of other sources on air pollution levels.

Types of measures listed in the Catalogue:

A	Economic
B	Technical / technical-organizational
C	Educational / information
D	Other (e.g. administrative)

Tab. IX.16 The list of priority measures

Code	Name of measure
BB12	Additional reduction of emissions by 2030 from the public energy and heat production sector
DA1	Replacement of heat sources in households
DB11	Improving the quality of wood used in stationary sources with a rated heat input up to 300 kW
AB26	Additional emission reductions by 2030 from the transport sector
CB8	Obligations for storage and application of fertilizers
CA2	Grazing supporting

The implementation of priority measures will reduce the amount of pollutant emissions to / below the level of national commitment.

X. Reporting of gridded emissions and LPS

The date of the last edit of the chapter: 15/03/2022

According to the UNECE Convention on Long-Range Transboundary Air Pollution as well as under the NEC Directive parties are obligated to report gridded emissions and large point sources (LPS). Being in line with the revised 2014 CLRTAP Reporting Guidelines (ECE/EB.AIR.125) both datasets shall be reported every four years from 2017 onwards for the year x-2.

Last submission (data for reporting year 2019) was provided 30. 4. 2021. In accordance with the requirements the more detailed description of basic information on the methodology used for LPS & gridded data in Czechia was prepared and submitted. Next submission will be carried out in 2025 (data for reporting year 2023).

X.1 Emission gridding in GNFR structure for EMEP grid

Remark: Gridded data comply summary data reported in 2017.

The preparation of gridded emissions for the year 2019 required extension of expert team for the sphere of GIS applications (IDEA ENVI, Ltd.). The data have been adjusted to the new "EMEP grid" referring to a 0.1° × 0.1° latitude-longitude projection. Emissions of individually monitored sources are being taken over into EMEP grid using coordinates of individual chimneys (approx. 50 thousand items) and emissions of collectively monitored sources are being splitted using area criterions among national totals reported in IIR. The mandatory reporting of gridded emissions includes the following pollutants: SO_X, NO_X, NH_3, NMVOC, CO, PM_{10}, $PM_{2.5}$, Pb, Cd, Hg, PCDD/F, PAHs, HCB and PCBs. The following chapter describes the GIS based method and the proxy data, which was used for the allocation of national emissions to the EMEP Grid.

Czechia coverage site "new EMEP grid" is shown in Fig. X.1. Presentation of selected emission data in GRID structure is a part of e-ANNEX.

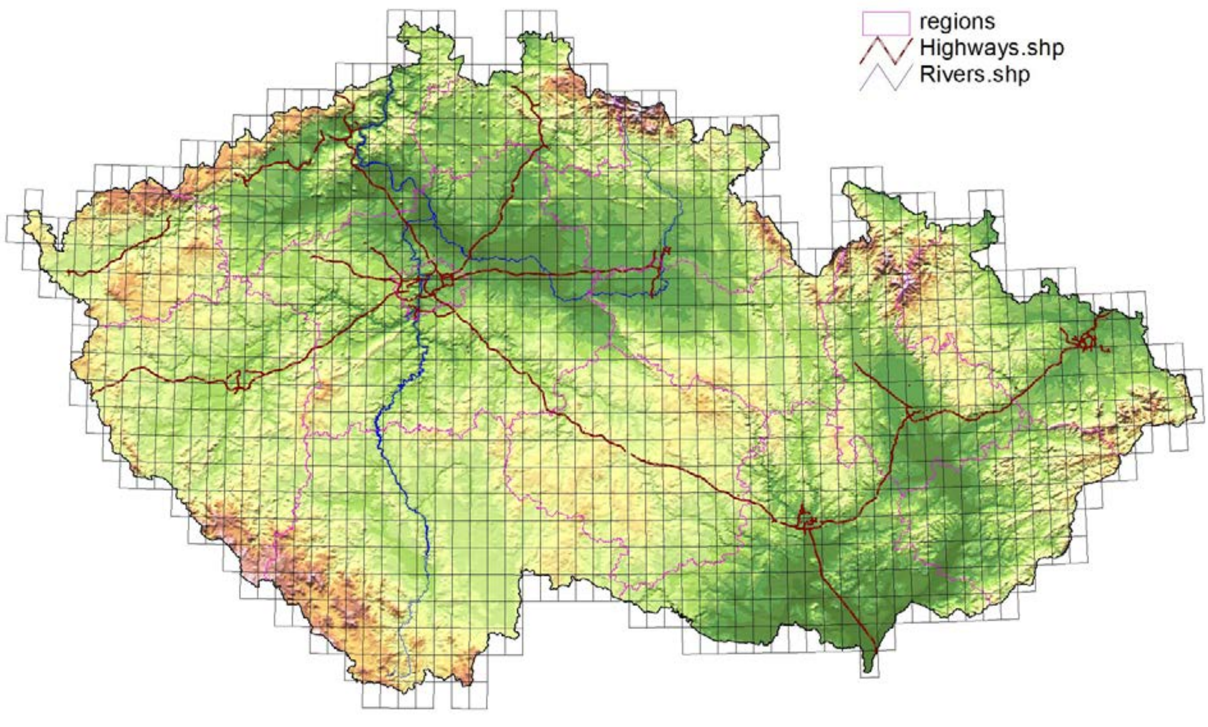


Fig. X.1 EMEP Grid Czechia – allocation of regions, highways network and rivers

X.1.1 Individually monitored sources – power generation, industry, waste combustion etc.

Each significant individually monitored source in emission database REZZO is identified besides by defined chimney coordinates. Less important sources are located by address site in RUIAN registry. Integral part of application for reporting preparation there also is the unique location of each source coordinates in EMEP grid. The processing of individually monitored sources therefore takes place in two steps:

- GNFR code allocation for each individually monitored source using previous NFR code allocation used for emission reporting.
- Summary emission of each GNFR at the level of each EMEP grid element, namely 0.1° x 0.1° grid cell.

X.1.2 Collectively monitored sources

For each source group the gridding take place into EMEP grid by using GIS. For some groups of sources, for example road transport, further information like 5-year transport census is being used for EMEP gridding. For emission distribution by use of solvents at smaller facilities (printing houses, car repair shops etc.) a specific model using number of inhabitants in town and villages is being applied. Emission allocation to each EMEP grid element takes place at most of categories at the lowest NFR level and consequently sum at GNFR level either using other categories of collectively monitored sources or sum of individually monitored sources is being done.

X.1.3 Location using number of inhabitants and household heating model

The criterion of number of inhabitants in town and villages was used for emission distribution in 2D category – organic solvent use, paints and adhesives use in households by assessment of location size and its allocation considering number of communal service facilities for categories of non-industrial use of organic solvents, paints, adhesives and other VOC containing substances. Furthermore this criterion is being used for emission distribution for construction works (NFR 2A5b) and a part of non-road transport (NFR 1A2gvii, 1A4aii, 1A4bii a 1A5b).

For significant category of household heating 1A4bi that is part of GNFR C-Other Stationary Combustion, national emission calculation model for household heating (see Fig. X.1) is being applied. Emissions of each community or part of larger city are being allocated to central point of the built-up area of the community or part of it (in number of 6392) being attributed to individual part of EMEP grid.

X.1.4 Location using GIS layers

Emissions of following categories are being allocated by specific GIS layers:

- Road transport emission using road network layer (accumulated routes of approx. 70% of road vehicles and uncounted routes); passenger, load and bus transport are being assessed separately
- Emissions of other means of transport (railways, water routes)
- Emissions of agricultural and forest machinery (NFR 1A4cii)
- Emissions of manure application (NFR 3Da1) and agricultural works (NFR 3Dc)
- Emissions of waste from solid waste disposal on land (NFR 5A)

Emissions of following categories are being distributed by specific location methodology:

- Air transport emissions (LTO cycle) according public airport location
- Coal mining emissions (brown coal and hard coal) by assuming average emission for each part of EMEP grid in coal mining locations

- Emissions of livestock farming using case study
- Emissions of minerals mining using Mineral information system (SurIS) (NFR 2A5a)

X.2 LPS data

X.2.1 Source characteristic

Large Point Sources (LPS) are defined as facilities whose emissions within one operation unit exceed at least one of the threshold values for the 14 pollutants identified in Table 1 of the EMEP Reporting Guidelines (SO_X, NO_X, CO, NMVOC, NH_3, $PM_{2.5}$, PM_{10}, Pb, Cd, Hg, PAHs, PCDD/F, HCB, PCBs). Large Combustion sources with rated thermal input greater than 300 MW are also included.

X.2.2 Methodology for LPS

LPS are ranked among specified stationary sources and they are registered within the REZZO 1 category. The majority of data on pollutants is obtained from the Summary operation records, remaining emissions are calculated using national emission factors (see chapters for appropriate NFR sectors). NH_3 emissions for GNFR K (AGRICULTURE – LIVESTOCK) are not registered by the REZZO database, they were obtained from Integrated Pollution Register of the Environment (IPR). It is an electronic structured database about environmental pollution from the industrial and agricultural facilities accessible to the public in https://www.irz.cz/.

Individual sources of operation unit are aggregated according to GNFR sector and stack height classes listed in Table 2 of the EMEP Reporting Guidelines.

In comparison with previous years, in 2021 reporting (data 2019), emissions registered in REZZO are strictly compared with those in IPR. If some difference was ascertained, total emissions from IPR were used. Source coordinates (latitude and longitude) and LPS names are also taken over from IPR. LPS emissions are used directly in the emission inventory.

X.2.3 LPS in Czechia

For 2019, Czechia reported emissions from 512 IPR facilities divided into 614 LPS. The largest share is livestock production (39%), followed by industry (31%).

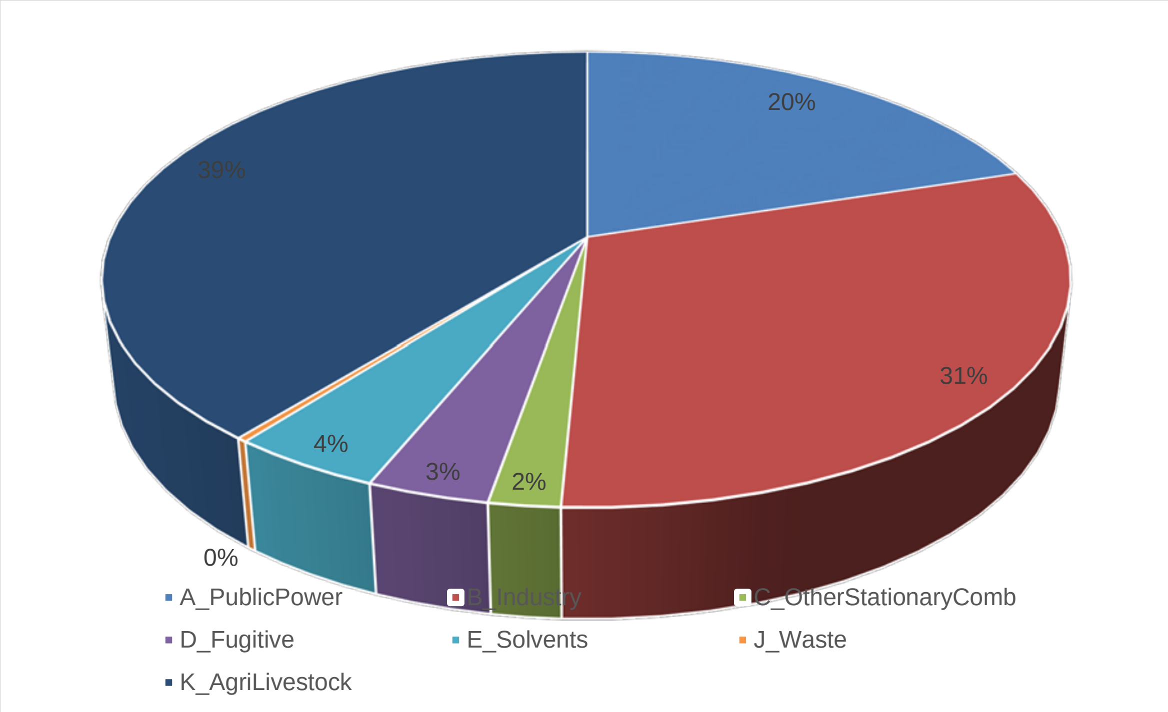


Fig. X.2 Share of GNFRs in the total LPS number in 2019

The shares of national emissions covered by LPS emission in sorting from the highest are listed below in Tab. X.1

Tab. X.1 Shares of LPS emissions in national totals

Pollutant	**Share [%]**
Hg	60.02
SO_X (as SO_2)	35.26
Pb	16.22
NO_X (as NO_2)	15.88
PCDD/F	10.80
Cd	9.95
CO	8.55
NH_3	5.47
PCBs	3.38
PM_{10}	1.84
$PM_{2.5}$	1.63

NMVOC	1.04

It is apparent that the highest shares in national totals have Hg and SO_X emissions which originate predominantly from public electricity and heat production, as do emissions of Pb, NO_X, PCDD/F, Cd, PCBs, PM_{10} and $PM_{2.5}$. The main source of CO emission are industrial processes, in the case NH_3 emission is it livestock production, NMVOC emissions come mainly from solvent use. There were no PAHs and HCB emissions for LPS sources in 2019.

XI. Adjustments

The date of the last edit of the chapter: 15/03/2023

Application of emissions adjustments or request for emissions adjustments were not planned in Czechia in 2023.

XII. EMRT 2017–2022

In the reporting year 2022, 26 observations for Czechia were sent by the Technical expert review team (TERT). Most of given recommendations were accepted. Most of the findings were solved, and appropriate comments were added to individual chapters. The complete overview of observations with assessments and recommendations of TERT and reactions of Czechia is presented in the file **Recommendations** (see e-ANNEX)

List of Figures

List of Tables

Abbreviations

AAP	Annual Average Population
A/C	Air-conditioning
AD	Activity Data
BP	Biogas Plant
CCR	Czech Car Registry
CDV	Transport Research Centre
CeHO	Centre for Waste Management
CEI	Czech Environmental Inspectorate
CENIA	Czech Environmental Information Agency
CHMI	Czech Hydrometeorological Institute
CNG	Compressed Natural Gas
COPERT	COmputer Programme to calculate Emissions from Road Transport
CS	Country Specific
CZ	Czech Republic
CZ Biom	Czech Biomass Association
CZBA	Czech Biogas Association
CZSO	Czech Statistical Office
ČD	České dráhy
EFs	Emission Factors
EIA	Environmental Impact Assessment
EMEP/EEA EIG	EMEP/EEA air pollutant emission inventory guidebook 2019
EMRT	EEA Emission Review Tool
FAME	Fatty Acid Methyl Esters
FRS CR	Fire Rescue Service of the Czech Republic
GDP	Gross domestic product
HDV	Heavy Duty Vehicle
IEA	International Energy Agency
IFR	Instrument Flight Rules
IPR	Integrated Pollution Register of the Environment
ISOH	Waste Management Information System
ISPOP	Integrated System for Fulfilment of Reporting Duties
LCP	Large Combustion Plants
LDV	Light Duty Vehicle
LPG	Liquefied Petroleum Gas
LPS	Large Point Sources
LTO	Landing/Take-off
MIT	MIT
MoA	Ministry of Agriculture
MoE	Ministry of the Environment
MoT	Ministry of Transport
MSW	Municipal Solid Waste
NACE	Statistical Classification of Economic Activities
NR	Not Reported
PaMs	Politics and Measures
PC	Passenger Car
REZZO	Register of Emissions and Stationary Sources of air pollution
SCR	Selective Catalytic Reduction
SOE	Summary Operation Evidence

STK	Technical Control Station/Technical Inspection Station
SVUOM	National Research Institute for the Protection of Materials
SWDS	Solid Waste Disposal Sites
TCS	Database of Technical Control Stations
TERT	Technical Expert Review Team
TGM WRI	T. G. Masaryk Water Research Institute
ÚCL	Civil Aviation Authority of the Czech Republic
UKZUZ	Central Institute for Supervising and Testing in Agriculture
VFR	Visual Flight Rules
VUZT	Research Institute of Agricultural Technology
WaM	Scenario with Additional Measurements
WM	Scenario with Measurements
WMP	Waste Management Plan

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