


Informative Inventory Report

1990-2021

Hungary

Compiled by:

HUNGARIAN METEOROLOGICAL SERVICE

Unit of National Emissions Inventories

2023

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ES EXECUTIVE SUMMARY

Hungary, as a party of the Convention on Long-range Transboundary Air Pollution (CLRTAP), is required to inventory emissions of air pollutants. The list of pollutants, the reporting years and the calculation methodologies are defined by several Protocols of the Convention.

The main purpose of this Informative Inventory Report is to describe the input data and calculation methodologies on which the emissions estimates are based thus increasing the transparency of the inventory. The full inventory is presented in table format called NFR.

The 2023 submission contains (partly recalculated) time-series for all years between 1990-2021 (2000-2021 in the case of TSP, PM_{10} and $PM_{2.5}$).

Since the 2012 submission, always the latest version of the Guidebook has been used, i.e. the current submission is based on the 2019 EMEP/EEA Guidebook. Large part of the preparation of NFR and IIR has been assigned to the Unit of National Emissions Inventories of the Hungarian Meteorological Service since 2011. Thank to this fact the availability of data and possibility of verification have significantly improved, because in many cases the same data sources are needed for the preparation of air pollutant emission inventory and the greenhouse gas inventory (especially in the case of activity data). As a consequence, UNFCCC reporting of indirect greenhouse gases and CLRTAP reporting became more consistent.

In the following table the total emissions of the main pollutants are summarized. The values are well below the commitments of Hungary in the original Gothenburg Protocol and the National Emission Ceiling Directive (Directive 2001/81/EC) for 2010 and the years after. However, our national emission reduction commitments under the Directive on the Reduction of National Emissions of Certain Atmospheric Pollutants (Directive (EU) 2016/2284), hereafter referred to as the NECD, were met in 2020 and 2021 only for SO2, NOX and NMVOC, but missed for NH3 and PM2.5. Further comparisons are presented below in chapter 1.2 of the IIR.

Table ES.1 Total emissions in Hungary

	1990	**1995**	**2000**	**2005**	**2010**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
NOx (kt)	**246.5**	**191.3**	**188.9**	**179.4**	**148.0**	**128.3**	**120.7**	**121.9**	**121.0**	**115.4**	**107.7**	**109.9**
NMVOC (kt)	**310.6**	**213.3**	**191.0**	**173.6**	**130.3**	**126.3**	**124.4**	**123.8**	**116.9**	**117.6**	**112.3**	**114.3**
SOx (kt)	**829.3**	**613.5**	**427.3**	**42.8**	**30.4**	**23.8**	**23.0**	**27.6**	**22.9**	**17.4**	**16.4**	**14.0**
NH3(kt)	**137.8**	**80.7**	**86.8**	**80.0**	**70.4**	**76.3**	**77.1**	**78.0**	**76.6**	**76.3**	**76.8**	**76.8**
PM2.5(kt)	**NR**	**NR**	**48.3**	**40.4**	**50.1**	**51.0**	**49.5**	**47.2**	**40.9**	**38.3**	**36.9**	**37.8**
PM10(kt)	NR	NR	71.7	71.5	71.5	71.6	69.2	64.9	59.9	57.6	53.5	52.8
TSP(kt)	NR	NR	103.9	131.0	105.6	104.4	99.2	89.9	88.0	86.6	77.6	71.6
CO(kt)	1451.0	981.6	856.7	697.5	551.9	464.4	450.2	439.8	378.4	359.3	341.0	345.3
Pb (t)	817.7	144.9	21.3	14.2	12.1	12.7	12.8	12.7	12.5	13.0	12.6	14.6
Cd (t)	1.9	1.7	1.8	1.4	1.5	1.7	1.6	1.6	1.5	1.4	1.4	1.4
Hg (t)	2.8	2.0	1.7	1.4	0.9	0.9	0.9	1.0	0.9	0.9	0.8	0.8
PCDD/F (g I-Te	113.5	79.3	82.2	63.5	77.6	78.1	77.3	66.4	59.3	64.7	60.6	57.7
PAHs (t)	78.1	29.5	24.7	23.1	29.0	29.8	30.4	29.7	24.3	22.1	21.4	21.5

NR= PMs are to be reported from 2000

1 INTRODUCTION

1.1 National inventory background

CLRTAP- Convention on Long-range Transboundary Air Pollution

Present Informative Inventory Report is required by the Convention on Long-range Transboundary Air Pollution ratified by Hungary in 1980.

Table 1.1 HU ratification dates of CLRTAP and its Protocols

	Signature	Ratification*	
1979 Convention (a)	13. 11. 1979	22. 09. 1980	R
	Base year	Ratification*	
1984 EMEP Protocol (b)	-	08.05.1985	Ap
1985 Sulphur Protocol (c)	*1980*	11. 09. 1986	R
1988 NO_X Protocol (d)	*1987*	12. 11. 1991	Ap
1991 VOC Protocol (e)	*1988*	10. 11. 1995	R
1994 Sulphur Protocol (f)	*1980*	11. 03. 2002	R
1998 Heavy Metals Protocol (g)	*1990*	19. 04. 2005	R
1998 POPs Protocol (h)	*1990*	07. 01. 2004	R
1999 Gothenburg (Multi-effect Protocol) (i)	*1990*	13. 11. 2006	Ap

*Notes: * R = Ratification, Ap = Approval*

(a) **Convention on Long-range Transboundary Air Pollution**, adopted 13.11.**1979 in Geneva**, entry into force 16.3.1983.

(b) Protocol to the 1979 Convention on Long-range Transboundary Air Pollution on Long-term Financing of the Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe (EMEP), adopted 28.9.**1984 in Geneva**, entry into force 28.1.1988.

(c) Protocol to the 1979 Convention on Long-range Transboundary Air Pollution on the Reduction of Sulphur Emissions or their Transboundary Fluxes by at least 30 per cent, adopted 8.7.**1985 in Helsinki**, entry into force 2.9.1987.

(d) Protocol to the 1979 Convention on Long-range Transboundary Air Pollution concerning the Control of Emissions of Nitrogen Oxides or their Transboundary Fluxes, adopted 31.10.**1988 in Sofia**, entry into force 14.2.1991.

(e) Protocol to the 1979 Convention on Long-range Transboundary Air Pollution concerning the Control of Emissions of Volatile Organic Compounds or their Transboundary Fluxes, adopted 18.11.**1991 in Geneva**, entry into force 29.9.1997.

(f) Protocol to the 1979 Convention on Long-range Transboundary Air Pollution on Further Reduction of Sulphur Emissions, adopted 14.6.**1994 in Oslo**, entry into force 5.8.1998.

(g) Protocol to the 1979 Convention on Long-range Transboundary Air Pollution on Heavy Metals, adopted 24.6.**1998 in Aarhus** (Denmark), entry into force 29.12.03

(h) Protocol to the 1979 Convention on Long-range Transboundary Air Pollution on Persistent Organic Pollutants, adopted 24.6.**1998 in Aarhus** (Denmark), entry into force 23.10.03.

(i) Protocol to the 1979 Convention on Long-range Transboundary Air Pollution to Abate Acidification, Eutrophication and Ground-level Ozone, adopted 30.11.**1999 in Gothenburg** (Sweden), entry into force 17.05.05.

Reporting requirements

Reporting is based on Guidelines for Reporting Emission Data under the Convention on Long-range Transboundary Air Pollution (ECE/EB.AIR/97), which include NFR (Nomenclature for Reporting) reporting template and recommended structure of IIR. The latest version of the Annex IV template (as revised in 18.11.2019) is used for reporting of emissions.

The latest reported year is always the year two years before the submission (e.g. in 2022 the latest reported year is 2020).

NFR Table of Hungary is available at:
http://www.ceip.at/ms/ceip_home1/ceip_home/status_reporting/2016_submissions/

The required reporting of time series by pollutants:

YEARLY: MINIMUM **(**and *ADDITIONAL)*

A. National totals:

1. Main pollutants: SO_X, NO_X, NH_3, NMVOC, CO: 1990–x-2
2. Particulate matter: $PM_{2.5}$, PM_{10}, TSP, BC: 2000–x-2
3. Heavy metals: Pb, Cd, Hg / (*As, Cr, Cu, Ni, Se, Zn):* 1990–x-2
4. POPs: 1990–x-2

B. Sector emissions:

1. Main pollutants: SO_x, NO_X, NH_3, NMVOC, CO: 1990–x-2
2. Particulate matter: $PM_{2.5,}$ PM_{10}, TSP, BC: 2000–x-2
3. Heavy metals: Pb, Cd, Hg / (*As, Cr, Cu, Ni, Se, Zn):* 1990–x-2
4. POPs: 1990–x-2
5. Activity data: 1990–x-2

The same reporting format is required by NEC Directive (currently: Directive on the Reduction of National Emissions of Certain Atmospheric Pollutants (Directive (EU) 2016/2284)).

Updated Guidelines (ECE/EB.AIR/125) for Reporting Emission Data under the Convention on Long-range Transboundary Air Pollution and updated EMEP/EEA Guidebook (EMEP/EEA 2019 a follow-up of earlier versions of CORINAIR and EMEP/EEA Guidebooks) as technical guidelines are applied from present submissions.

Update of the Guidelines affected also the Annexes, so the format and content of the Reporting Tables has also changed. HU has used the "NFR14" template and the new NFR codes as required by the ECE/EB.AIR/125.

Definition of pollutants

The list and definition of the substances to report is also slightly changed between the two versions of ***Guidelines for Reporting Emission Data Under the Convention on Long-Range Transboundary Air Pollution (ECE/EB.AIR/97 and 125)*** as it is presented in the following Tables. HU reports all substances for all years where calculation method in the 2019 EMEP/EEA Guidebook is available and data availability permits.

1.2. Table: Substances for which there are existing emission reporting obligations

Annex I of ECE/EB.AIR*/97 (OLD)*	*ECE/EB.AIR/125 – Definitions*
Sulphur oxides (SO_X) means all sulphur compounds, expressed as sulphur dioxide (SO_2). The major part of anthropogenic emissions of sulphur oxides to the atmosphere is in the form of SO_2 and, therefore, emissions of SO_2 and sulphur trioxide (SO_3) should be reported as SO_2 in mass units. Emissions of other sulphur compounds such as sulphate, sulphuric acid (H2SO4) and non-oxygenated compounds of sulphur, e.g. hydrogen sulphide (H_2S), are less important than the emissions of sulphur oxides on a regional scale. However, they are significant for some countries. Therefore, Parties are also recommended to report emissions of all sulphur compounds as SO_2 in mass units.	**Sulphur (SOx)** which means all sulphur compounds expressed as sulphur dioxide (SO2) (including sulphur trioxide (SO3), sulphuric acid (H2SO4), and reduced sulphur compounds, such as hydrogen sulphide (H2S), mercaptans and dimethyl sulphides, etc.);
Nitrogen oxides (NO_x) means nitric oxide and nitrogen dioxide, expressed as nitrogen dioxide (NO_2).	**Nitrogen oxides**, which means nitric oxide and nitrogen dioxide. expressed as nitrogen dioxide (NO_2);
Ammonia (NH_3)	**Ammonia (NH_3)**
Non-methane volatile organic compounds (NMVOCs) means any organic compound, excluding methane, having a vapour pressure of 0.01 kPa or more at 293.15 K, or having a corresponding volatility under the particular conditions of use. For the purpose of these Guidelines, the fraction of creosote which exceeds this value of vapour pressure at 293.15 K should be considered as an NMVOC.	**Non - methane volatile organic compounds (NMVOCs)**, which means, all organic compounds of an anthropogenic nature, other than methane, that are capable of producing photochemical oxidants by reaction with nitrogen oxides in the presence of sunlight;
Heavy metals (i.e. cadmium, lead, mercury) and their compounds.	**Cadmium (Cd)** and its compounds; **Lead (Pb)** and its compounds; **Mercury (Hg)** and its compounds;
Persistent organic pollutants: (polycyclic aromatic hydrocarbons (PAHs), dioxins and furans (PCDD/F) and hexachlorobenzene (HCB).	**Polycyclic aromatic hydrocarbons (PAHs)**; **Dioxins and furans (PCDD/F)**; **PCBs;** **HCB**
	Particulate matter (PM) which is an air pollutant consisting of a mixture of particles suspended in the air. These particles differ in their physical properties (such as size and shape) and chemical composition. Particulate matter refers to: (i) **$PM_{2.5}$** or particles with an aerodynamic diameter equal to or less than 2.5 micrometers (µm); (ii) **PM_{10}** or particles with an aerodynamic diameter equal to or less than 10 (µm);
	Carbon monoxide (CO)

Table 1.3 HU commitments of NEC Directive and Gothenburg Protocol

	Fixed emission level for 1990	HU commitment for 2010 (and until 2020) NEC	Gothenburg Protocol	Hungarian emission in the 2023 inventory submission 2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
SOx(kt)	1010	500	550	30	34	30	29	26	24	23	28	23	17	16	14
NOx (kt)	238	198	198	148	139	132	128	126	128	121	122	121	115	108	110
NH3 (kt)	124	90	90	70	71	70	72	73	76	77	78	77	76	77	77
NMVOC (kt)	205	137	137	130	134	134	131	122	126	124	124	117	118	112	114

The Gothenburg Protocol was amended in 2012 to include national emission reduction commitments to be achieved in 2020 and beyond and introduces emission ceiling for fine particulate matter ($PM_{2.5}$) as well. The new commitments are not absolute (Gg) emission levels anymore, but % reduction commitments relative to emission level of year 2005 within the most up-to-date (continuously recalculated) emission inventory submission. The new commitments of Hungary are presented in the following table together with the actual status of relative reduction.

Table 1.4 Base year emissions and reduction commitment percentages for 2020 defined by the amended Gothenburg Protocol

	Hungarian emission inventory submission 2023		**Gothenburg Protocol commitment**	*present status of compliance*	
	Emission of year 2005	Emissions of year 2021	**% reduction compared to 2005 level**	*% change compared to 2005 level in 2021*	*% distance from 2020 commitment in 2021*
NOx(kt)	**179**	**110**	**-34%**	*-39%*	*5%*
VOC (kt)	**174**	**114**	**-30%**	*-34%*	*4%*
SO2 (kt)	**43**	**14**	**-46%**	*-67%*	*21%*
NH3 (kt)	**80**	**77**	**-10%**	*-4%*	*-6%*
PM2.5 (kt)	**40**	**38**	**-13%**	*-7%*	*-6%*

Note: Red = at present commitment not achieved

1.2 Institutional arrangements

The minister responsible for the environment has overall responsibility for the CLRTAP reporting.

He is responsible for the necessary institutional, legal and procedural arrangements, and for the strategic development of the inventory. Since the Ministry of Environment and Water had been abolished after the elections in spring 2010, its main tasks have been taken over by the Ministry of Rural Development and from 2014 the Ministry of Agriculture. Following the 2022 elections, the Ministry for Technology and Industry took over the environmental issues until December 1, when the new Ministry for Energy Affairs was established with responsibilities for climate policy and environment, among others. Within this ministry, a State Secretariat for Environment Protection and Circular Economy was established with the following tasks: waste management, air quality and noise policies, environmental remediation, industrial emissions, environmental education, eco-labels etc.

The preparation of the inventory has always been a joint effort of several institutions and experts. In the end of 2011, the Ministry of Rural Development has contracted the Hungarian Meteorological Service (OMSZ) for the compilation of the NFR tables and preparation of a substantial part of the IIR (except for road transport, aviation and projections). Transport emissions were estimated by KTI Institute for Transport Sciences Non-profit Ltd.). As a recent development, the Institute of Agricultural Economics Nonprofit Kft. (AKI) became responsible by legislation for the agriculture sector of the inventory.

The Hungarian Meteorological Service is a central office under the control of the minister responsible for environment, i.e., currently the minister for energy affairs. The financial background of operation is determined in the Finances Act. The duties of the Service are specified in a quite recent Governmental Decree from 2021 (353/2021. (VI. 24.)). These duties include also the preparation of emission inventories of greenhouse gases and air pollutants for the fulfillment of reporting obligations arising from international treaties. Actually, a greenhouse gas inventory division was already established in 2006 within the Met. Service for the preparation and development of the GHG inventory. The name of the division was changed to Unit of National Emissions Inventories in 2015 to reflect the fact that this unit is also responsible for the compilation of air pollutant emission reports. This division is responsible for most inventory related tasks, compiles the inventories and other reports with the involvement of external institutions and experts, partly on a contractual basis. Many parts of the inventory (energy, industrial processes, and waste) are prepared by the experts of the Unit of National Emissions Inventories themselves. OMSZ has introduced the quality management system ISO 9001:2000 for the whole range of its activities in 2002 to fulfill its tasks more reliably and for the better satisfaction of its partners.

1.3 Inventory preparation process

The annual inventory cycle is aimed to be carried out in accordance with the principles and procedures set out in the UNECE Emission Reporting Guidelines (ECE/EB.AIR/125). As a general method of preparing the inventory, the procedures described in the 2019 EMEP/EEA Guidebook are applied.

As described above, the Unit of National Emissions Inventories at the Hungarian Meteorological Service contributes largely to the inventory therefore the following synergies can be utilized. There is a well-functioning national system in relation with the UNFCCC reporting with all the necessary institutional, legal and procedural arrangements. The availability of data (and possibility of verification) has significantly expanded thank to the fact that in many cases the same data sources are needed for the preparation of air pollutant emission inventory (especially in the case of activity data) and the GHG Inventory. The government decree No. 278/2014 (replacing 528/2013. and earlier 345/2009.) delegates data provision rights relating data needed for the preparation of the GHG Inventory to the Meteorological Service. It can also be built on the QA/QC activities carried out regularly by the emission team. A high-level archiving system secures the availability of the electronic databases and all the calculations and background information.

Usually, the sectoral experts are responsible for the choice of methods and emission factors. According to the recommendations of the EMEP/EEA 2019, the calculation methods are chosen by taking into account the technologies available in Hungary whenever possible. The calculation of emissions occurs basically by using the formula: AD x EF, where the activity data (AD) can be raw material or product or energy use etc. Part of the available data (e.g. production data) can directly be entered into the formula above; others required previous processing and conversion. For example, energy data are not always available in the required depth and resolution. The default emission factors (EF) are being gradually replaced by country-specific emission factors characteristic of domestic technologies. Efforts are made to use the highest possible Tier method, especially in case of key categories. After preliminary quality control of the basic data, the necessary calculations are carried out by the core team. After other necessary QC steps, NFR table is filled in and the assigned chapters of IIR report are prepared.

The official submission is made then by the Ministry for Energy Affairs.

1.4 Methods and data sources

GENERAL DESCRIPTION OF METHODOLOGIES, EMISSION FACTORS AND ACTIVITY DATA

Different data sources are taken into account during preparation of NFR for activity data and emission factors as well.

The data sources for activity data include: Hungarian Central Statistical Office (HCSO), National Energy Balance, activity data reported by companies for UNFCCC reporting (CRF) purposes and other international statistics (FAOStat, EUROSTAT), and EU ETS database (verified greenhouse gas emissions database held by the National Inspectorate for Environment, Nature).

These data sources became available owing mainly to the present situation that the same HMS unit was contracted for the preparation of CLTRAP and NEC reporting as the preparation of the Greenhouse Gas Inventory. In Hungary HMS is responsible for the coordination and compilation of the GHG Inventory required by UN Framework Convention of Climate Change (UNFCCC). At the very end of 2009, a new government decree on data provision relating to GHG emissions was put into force. This decree (amended in 2014) assures the availability of data needed for the preparation of the GHG Inventory.

Emission factors used are taken from 2019 EMEP/EEA Guidebook and 2006 IPCC Guidelines.

LAIR

In several cases emission data reported directly by individual companies are taken into account during preparation of CLRTAP reporting. This database is available in the ***Hungarian Air Emissions***

Information System (LAIR) as a segment of the National Environmental Information System (OKIR) operated by the Ministry of Agriculture and updated by the Regional Inspectorates for Environment Nature.

The database is partly available for the public at: http://www.okir.hu/en/lair

The emission data of LAIR is reported yearly by companies covered by Government Decree 306/2010. (XII. 23.) and all companies covered by Directive on Integrated Pollution Prevention and Control (2008/1/EC) and 166/2006/EC Regulation on European Pollutant Release and Transfer Register (E-PRTR) (amended by Industrial Emissions Directive).

Technologies (emission sources) and the related emission limit values prescribed for companies covered by Govt. Decree 306/2010 are listed in Ministerial Decree 4/2011 (I.14) VM. This list is mainly taken from Annexes on ELVs of Gothenburg Protocol and other technology specific EU regulations.

The method and frequency of the required measurement are regulated in the Ministerial Decree 6/2011 (I.14.) VM. This decree prescribes the use of accredited laboratory and the implementation of continuous measurement systems for large emitters.

LAIR as part of the Hungarian Environmental Information System has been migrated into a new database in the beginning of 2015. From 2015 all data provisions are to be completed electronically.

The list of pollutants to be reported into the Air Emissions Information System database can be found in Annexes of Government Decree 306/2010 (XII. 23.). It contains mostly the pollutants covered by E-PRTR and IPPC (and several additional). However, there is no reporting threshold for the pollutants, the operators report only those pollutants, which are included in their environmental permit. The environmental permits are of course issued based on the legal instruments mentioned before, but the implementation (e.g. the content of the environmental permits) is not fully consistent across the regional Inspectorates for Environment Nature. This causes some inconsistencies within the country level database.

Emission of pollutants is reported in kg/year, however connecting these emissions to activity data or data on fuel use is a little cumbersome at the moment.

In addition, high precaution is needed to use the data of this system, since the list of pollutants are not the same as the needs of NRF reporting (especially for NMVOC (separate organic compound are reported and not in group), solid particles (no PM10 and PM2.5 fractions are reported but “dust”). This is probably due to the fact that IPPC and E-PRTR (replaced by IED) do not explicitly require the grouping of organic compounds and disaggregation of particulate matter emissions. Both EU regulation (IED; proposal on medium combustion plants, etc.) and updated Gothenburg Protocol Annex X contain emission limit values (ELV) only for TSP/”dust” and not for PM10 and PM2.5. Therefore, when plant specific data is used in the case of particulate matter emissions, the proportion of PM10 and PM2.5 emissions is calculated from TSP based on proportion of T1 or T2 emission factors for TSP/PM10/PM2.5.

In addition, the completeness and quality of data reported by the individual companies have to be compared with other data sources, such as national statistics, EU ETS data, etc. There are several further characteristics of the data from LAIR which requires specific attention or might be regarded as disadvantageous

- It is available only from year 2002. So, whenever LAIR data is used there is a need of change of method, splicing, extrapolation, etc. before 2002, in order to be able to report the entire time series.

- Combustion and process emissions are not always separated in LAIR. (The reporting is disaggregated by point sources, so it depends on the situation and environmental permit whether the combustion emissions and process emissions use the separate stacks or not.) In these cases, it is not possible to divide emissions between sector 1 (Combustion) and sector 2 (industrial processes) in NFR.

The advantage of the use of directly reported emissions is that it includes also the abatement techniques implemented unlike the most default factors. Also, reporting is continuously improving due to the enforcement actions of the regional Inspectorates for Environment, Nature.

Due to the above-mentioned facts, the data from this system is used only in cases when needs of NFR reporting and data available in the system exactly matches (the same pollutant and the complete group of polluters are covered) and/or the completeness and reliability of data is assured. Thus, data is verified with other data sources (sometimes with TIER1 approach of Guidebooks) or there is no other data source available. The use of directly reported emissions is prioritized in the case the above-mentioned criteria are met. It is worth mentioning that LAIR has been used for EPER/E-PRTR reporting purposes as well.

In year 2015 the LAIR database has been completely renewed and restructured. In some cases, also facility data have been updated. In these cases, old and new data have been compared and recalculations have been performed where the changes are justified.

IPPC Permitting

Hungary is a Member State of the EU since 2004. So, it is important to state that air polluting facilities in Hungary are regulated based on EU requirements. For example, 2008/1/EC Directive on Integrated Pollution Prevention and Control replaced now by directive on industrial emissions 2010/75/EU (IED) which describes the use of BAT is implemented and enforced. Compliance is regularly checked by the regional Inspectorates for Environment, Nature.

In order to present the implementation of IPPC Directive in Hungary, please find below some short quotation from *Reports submitted by Member States on the implementation of directive 2008/1/EC, Directive 2000/76/EC, Directive 1999/13/EC and further development of the web platform to publish the information*

*(*http://eea.eionet.europa.eu/Public/irc/eionet-circle/reporting/library?l=/ippc/implementation_2006-2008/main_reports&vm=detailed&sb=Title

"The IPPC (unified environment utilization) permits are issued by the regional environment, nature and water authorities, currently there are 10 of them."

"The content requirements of applications for unified environmental permits of the Gov. Decree include the submission of all information mentioned in Art. 6 of the Directive.

BAT guides were prepared (full translations, Hungarian summaries and national guidelines adapted to Hungarian circumstances)." (Available at www.ippc.hu *)*

"Facilities falling within the scope of the Gov. Decree shall provide data in line with the provisions of the permit. Data shall be provided on the template form published in the official journal of the Ministry of Environment and Water or on electronic data carriers. The operators shall perform their data provision obligation in line with the provisions of the permit. The unified environmental permit contains the measurement and supervision/monitoring requirements that are necessary to follow up the environmental effects of the activity. It specifies the measurement method and frequency, the evaluation process and the method, content and frequency of the mandatory data provision to the

authorities. Unless provided otherwise by the authority, the authorized person shall provide data at least annually. The data provider is liable for providing all the data and for the quality of the provided data, the accounting rules, statistical system and other registers, measurement and monitoring data. The permits for facilities falling within the scope of the decree shall contain provisions in case of extraordinary kinds of operation (e.g. start-up, immediate stop, malfunction, and cessation of the activity). It shall contain measures that are necessary to prevent extraordinary, unexpected contaminations, and it shall contain provisions regarding the method and contents of the notification to be sent to the authorities. In case of facilities that are not subject to the Act on civil protection, the operators shall attach the description of measures applicable to operation safety and measures to be implemented in case of accidents.

The Gov. Decree prescribes that the supervising authorities shall visit the facilities falling within the scope of unified environmental permit at least once a year. During the visits, compliance with the provisions of the permit shall be checked, a record shall be taken, and the adequate measures shall be taken, if necessary."

E-PRTR

The European Pollutant Release and Transfer Register (E-PRTR) contains the reported emission data of industrial facilities including the main air pollutants. List of pollutants to be reported and requirements of reporting are regulated by 166/2006/EC Regulation of the European Union (replaced now by directive on industrial emissions 2010/75/EU (IED), which is of course applicable in Hungary too. Facilities falling under the E-PRTR regulation comply with their air pollutant release reporting requirement by the means of the LAIR system described above. Data of LAIR is then checked (and corrected if needed) by local Inspectorates for Environment, Nature and finally prepared for publication by the Ministry responsible for environment.

Hungary has a local website where E-PRTR data ("easily accessible key environmental data from industrial facilities ") is available: http://www.okir.hu/en/eprtr in addition to the European website: http://prtr.ec.europa.eu/

Unfortunately, in the case of particulate matter, heavy metals, and persistent organic pollutants the coverage, grouping, disaggregation level differs from CLRTAP reporting. In addition, pollutants are to be reported for the E-PRTR only above thresholds determined by the E-PRTR Regulation. In every case it is important to take into consideration that E-PRTR has different objectives than the CLRTAP inventory as it aims to make publicly available the environmental data of big emitters at facility level whilst CLRTAP reporting aims to provide complete, country level information.

1.5 Key categories

Please find below the definitions of the 2019 EMEP/EEA Guidebook related to key category and key category analysis:

"A key category is one that is prioritized within the national inventory system because it is significantly important for one or a number of air pollutants in a country's national inventory of air pollutants in terms of the absolute level, the trend, or the uncertainty in emissions. It is good practice for each country to identify its national key categories in a systematic and objective manner. This can be

achieved by a quantitative analysis of the relationship between the magnitude of emission in any one year (level) and the change in emission year to year (trend) of each category's emissions compared to the total national emissions."

A LEVEL assessment was performed to identify key categories using Approach 1. In Approach 1 the "*key categories are identified using a predetermined cumulative emissions threshold. Key categories are those which, when summed together in descending order of magnitude,* ***cumulatively add up to 80 % of the total level****."*

During a level assessment, the „*contribution of each source category to the total national inventory level"* is assessed in the given year. Equation for level assessment (Approach 1) of the 2019 EMEP/EEA Guidebook is:

Key category level assessment = |source category estimate |/ total contribution

After definition of the level, the source categories are sorted in descending order of magnitude, and the cumulative total is summed up in the following column. The key categories are where the cumulative total reaches 80% threshold.

Table 1.5 Summary of Approach 1 level key category analysis for 2021

Component	Key categories (Sorted from high to low from left to right)														Total (%)
SOx	1A1a (38.7%)	1A4bi (29.3%)	1A2a (7.8%)	1A2f (5.5%)											81.2
NOx	3Da1 (16.6%)	1A3bi (13.3%)	1A3biii (12.8%)	1A4bi (10.5%)	1A1a (7.9%)	1A3bii (7.2%)	1A4cii (4.9%)	1A4ai (3.7%)	3Da2a (3.5%)						80.3
NH3	3Da1 (31.1%)	3Da2a (13.9%)	3B3 (9.8%)	3B1a (9.7%)	3B1b (9.4%)	3B4gii (5.0%)	1A4bi (4.7%)								83.7
NMVOC	1A4bi (21.1%)	2D3a (8.1%)	3B1b (7.7%)	2D3g (6.8%)	3B1a (6.4%)	1A3bi (5.5%)	2D3d (4.7%)	2H2 (4.4%)	2B10a (4.0%)	1A3bv (3.6%)	3De (3.0%)	2D3h (2.2%)	3B4gii (2.2%)	1A3biv (2.2%)	81.9
CO	1A4bi (65.6%)	1A3bi (15.5%)													81.1
TSP	1A4bi (44.4%)	2A5b (16.9%)	3Dc (8.8%)	3B3 (3.6%)	2A5a (2.9%)	1A3bvi (2.8%)	3B4gi (2.3%)								81.7
PM10	1A4bi (57.4%)	3Dc (11.9%)	2A5b (6.9%)	1A3bvi (3.0%)	5E (1.8%)										81.0
PM2.5	1A4bi (78.2%)	5E (2.6%)													80.8
Pb	1A3bvi (41.4%)	2C1 (22.2%)	1A4bi (12.3%)	1A1a (7.1%)											83.1
Hg	5C1bv (18.5%)	1A1a (18.4%)	1A2f (15.0%)	2K (12.0%)	2C1 (7.3%)	1A4bi (6.9%)	2B10a (4.3%)								82.5
Cd	1A4bi (52.3%)	2C1 (9.0%)	1A1a (7.6%)	2A3 (4.3%)	1A2gviii (4.3%)	1A2d (3.5%)									81.0
DIOX	1A4bi (56.9%)	5E (17.0%)	2C1 (8.8%)												82.6
PAH	1A4bi (91.2%)														91.2
HCB	2C3 (33.6%)	1A1a (21.4%)	1A4bi (16.9%)	1A4ai (13.6%)											85.4

1.6 QA/QC and verification methods

The Hungarian Meteorological Service introduced the quality management system ISO 9001:2000 in 2002. The Unit of National Emissions Inventories has an own, specific ISO procedure, which aims to fulfill the QA/QC requirements of UNFCCC reporting mostly applicable for the CLRTAP reporting as well. Internal ISO audits are conducted every year. The Met. Service passed an in-depth ISO audit in January 2013 during which the activities of the GHG Division were also audited.

ISO procedure regarding the Unit of National Emissions Inventories is used as QA/QC Plan required by the UNFCCC reporting. General elements of this QA/QC Plan are applied in the case of CLRTAP reporting too. In addition, QA/QC Plan has been updated in 2014 in order to extend the provisions regarding CLRTAP reporting too. Please find the English version of the updated QA/QC Plan in Annex 6 of National Inventory Report 2014 MAY submission, available at:

http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/8108.php

In many cases the Hungarian emission data have been compared to data of other EU countries and to the reporting of the EU. It is mentioned in the specific sub-chapters of present IIR, where significant differences have been found.

RepDab Report (available at www.ceip.at) is also generated as an additional QA/QC activity.

Comparison of NFR, LAIR and E-PRTR

Table A2.1 in Annex-2 presents a verification performed using the data sources mentioned in Chapter 1.5, E-PRTR, IPPC and other direct reporting) with NFR (or the relevant sectors of NFR).

It is normal that E-PRTR national totals are always lower than others due to limited scope (reporting is compulsory only above certain amount of emission).

It is also normal that in the case of NOx and CO NFR National Total is much bigger than LAIR and E—PRTR as, transport and residential combustion sectors are significant emitters. Therefore, the SUM of (1A1+ 1A2+ 1A4ai+ 2+ 5C1) NFR sectors is also included in the Table above. In the case of NH3, the SUM of NFR sectors 3B3 (Swine) and 3B4g (Poultry) is also noted in order to facilitate comparison with E-PRTR, where only swine and poultry is regulated.

However, unfortunately, the big difference between the time-series proof that plant specific reporting is very poor in the case of NMVOC and PMs. In the case of SOx, it is possible to observe the strong decline in emission between 2004 and 2005 in all cases.

Verifications with IIASA GAINS model

During the bilateral consultations with IIASA as part of the preparation for the amendment of the NEC Directive held in April-May 2014, national and sectoral totals and key categories have been compared between IIASA GAINS model and HU results.

The recalculated time series by Hungary are much closer to results of IIASA GAINS model.

After the detailed analysis of the remaining differences, further refinements were made from both sides. Several data from IIASA have been implemented for the final time series submitted by Hungary in 2014 May and reasonable suggestions were made to IIASA for correction of some emission factors or activity data.

So, this process might be regarded as a very useful verification exercise.

1.7 General uncertainty evaluation

A general uncertainty evaluation is one of the planned improvements.

Until country specific expert judgments and uncertainty analysis become available, we would like to quote here “some examples on level uncertainty” from various EU Member States in order to emphasize the evident presence of uncertainty in emission estimations:

NOx: 10-74%

SO_2: 4 – 88%

$PM_{2.5}$: 15-349%

NMVOC: 10-85%

(Presented by John van Aardenne (EEA) at the TFEIP 2013 meeting, Istanbul, Turkey http://tfeip-secretariat.org/2013-tfeip-meeting-istanbul/:

European Union emission inventory report 1990–2011 under the UNECE Convention on Long-range Transboundary Air Pollution (LRTAP))

1.8 General assessment of completeness

Sources not estimated (NE)

1.6. Table: Explanation to the Notation key NE

NFR14 code	Substance(s)	Reason for not estimated
2K	POPs	No methodology
All other NE		**Notation of the Guidebook default Tables for the given pollutant(s)**

Sources included elsewhere (IE)

1.7. Table: Explanation to the Notation key IE

NFR14 code	Substance(s)	Included in NFR code
1A2a, 1A2b, 1A2f	All, except NO_x, SO_x, CO	Reported in Sector 2 based on suggestion of the Guidebook
1A3di(ii)	All	1A3dii
1A4aii	All	1A4ai
1A4ciii	All	1A3b
1A5	All	1A4
Sector 2, 3	NO_x, SO_x, CO	Combustion emissions are reported in Sector 1A based on suggestion of the Guidebook.
2 A 5 c; 2 B 10 b; 2 C 7 d	All	Emissions are included in the specific sectors due to the Guidebook.

Categories: other

1.8. Table: Sub-sources accounted for in reporting codes "other"

NFR09 code	Substance(s) reported	Sub-source description
1A2gviii	All	Lots of manufacturing industries, see Ch. 3.4.3.
1 B 1 c		Not occurring
1B2d		Not occurring
2 B 10 a	NO_x, NMVOC, SO_x, NH_3, $PM_{2.5}$, PM_{10}, TSP, CO	Production of sulfuric acid, carbon black, ethylene, propylene, 1,2 diclorethane and vinilcloride balanced, PE (LD and HD), PP, PVC, polistyrene, formaldehyde, urea, ammonium nitrate and other fertilizers
2A6, 2C7c, 2H3, 2L		Not occurring
2 G	NO_x, NMVOC, SO_x, NH_3, $PM_{2.5}$, PM_{10}, TSP, CO, As, Cd, Cr, Cu, Hg, Ni, Pb, Zn, BC, NH3, PCDD/F, PAHs	Consumption of tobacco and use of fireworks
2D3g	NMVOC	Manufacture of shoes, manufacture of pharmaceutical products, polystyrene/ polyurethane foams, paint/glues/asphalt
2D3i	NMVOC	Oil seed processed

2 EXPLANATION OF KEY TRENDS

In the following table the total emissions of the main pollutants are summarized.

Table 2.1 Total emissions in Hungary

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021
NOx (kt)	**246.5**	**191.3**	**188.9**	**179.4**	**148.0**	**128.3**	**120.7**	**121.9**	**121.0**	**115.4**	**107.7**	**109.9**
NMVOC (kt)	**310.6**	**213.3**	**191.0**	**173.6**	**130.3**	**126.3**	**124.4**	**123.8**	**116.9**	**117.6**	**112.3**	**114.3**
SOx (kt)	**829.3**	**613.5**	**427.3**	**42.8**	**30.4**	**23.8**	**23.0**	**27.6**	**22.9**	**17.4**	**16.4**	**14.0**
NH3(kt)	**137.8**	**80.7**	**86.8**	**80.0**	**70.4**	**76.3**	**77.1**	**78.0**	**76.6**	**76.3**	**76.8**	**76.8**
PM2.5(kt)	**NR**	**NR**	**48.3**	**40.4**	**50.1**	**51.0**	**49.5**	**47.2**	**40.9**	**38.3**	**36.9**	**37.8**
PM10(kt)	NR	NR	71.7	71.5	71.5	71.6	69.2	64.9	59.9	57.6	53.5	52.8
TSP(kt)	NR	NR	103.9	131.0	105.6	104.4	99.2	89.9	88.0	86.6	77.6	71.6
CO(kt)	1451.0	981.6	856.7	697.5	551.9	464.4	450.2	439.8	378.4	359.3	341.0	345.3
Pb (t)	817.7	144.9	21.3	14.2	12.1	12.7	12.8	12.7	12.5	13.0	12.6	14.6
Cd (t)	1.9	1.7	1.8	1.4	1.5	1.7	1.6	1.6	1.5	1.4	1.4	1.4
Hg (t)	2.8	2.0	1.7	1.4	0.9	0.9	0.9	1.0	0.9	0.9	0.8	0.8
PCDD/F (g I-Te	113.5	79.3	82.2	63.5	77.6	78.1	77.3	66.4	59.3	64.7	60.6	57.7
PAHs (t)	78.1	29.5	24.7	23.1	29.0	29.8	30.4	29.7	24.3	22.1	21.4	21.5

The following Figures present the distribution of main pollutants by sectors.

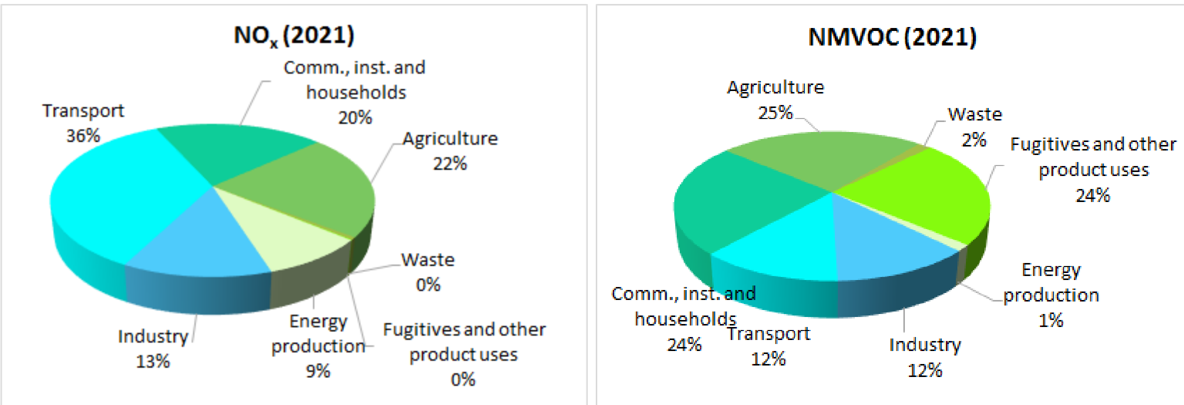


Figure 2.1 NOx and NMVOC emissions by sectors

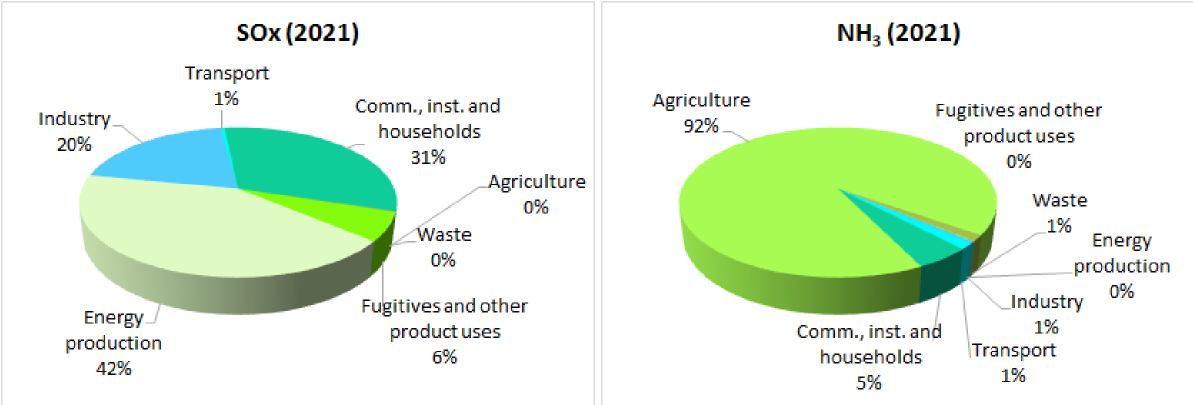


Figure 2.2 SO_x and NH_3 emissions by sectors

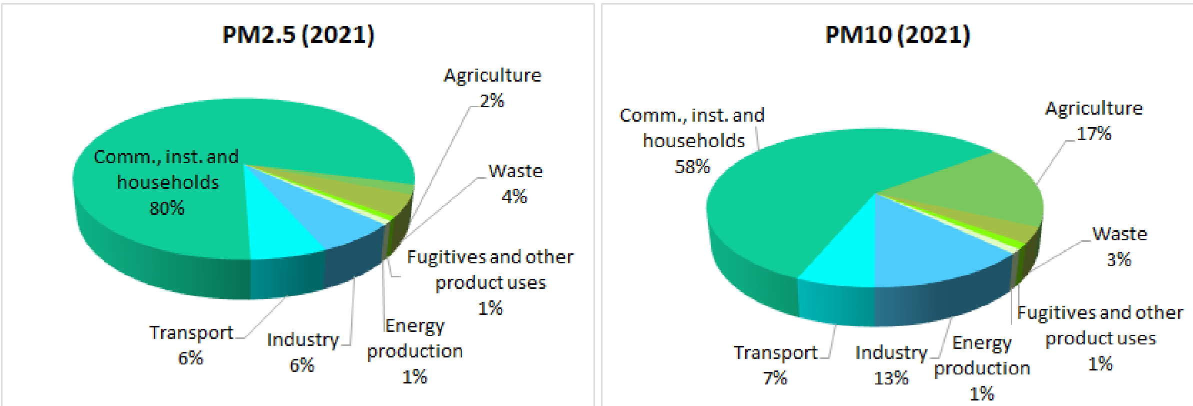


Figure 2.3 $PM_{2.5}$ and PM_{10} emissions by sectors

The significant reduction in emissions between 1987 and 1992 was mainly due to the economic transformation after the regime change. In addition, ongoing changes in fuel-structure, i.e. solid fuel as the most important source in the 80's had been replaced by natural gas, led to further decrease of total emission. The spread of emission abatement technologies introduced either due to environmental regulation or economic drivers results decreasing emissions in general. The global financial and economic crises around 2008-2009 exerted a major impact on the output of the Hungarian economy, consequently on the level of emissions as well.

The substantial reduction in sulphur dioxide emissions is attributable to the decreased use of fossil fuels in general and the decreasing share of coal with higher sulphur content. After 2000, further reductions were observed due to the introduction of SO_2 precipitators in coal-fired power stations. Reduced carbon monoxide emissions compared to 1980 are obviously a consequence of decreased fuel uses and the modification of the car fleet.

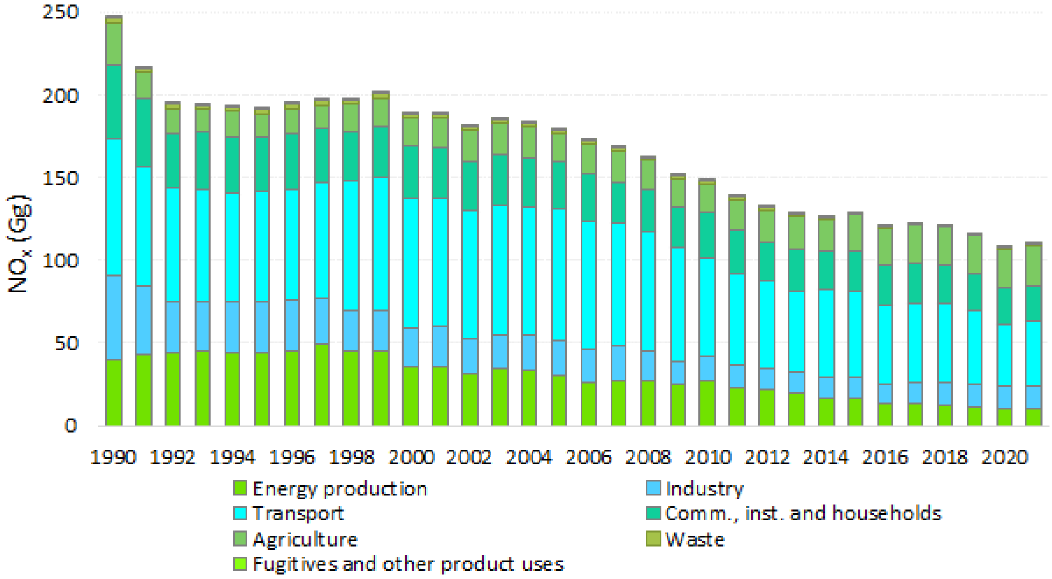


Figure 2.4 Trend of emission of NO_x (kt)

Table 2.2 Trend of emission of NO_x (kt)

NOx	1A1 Energy production	1A2+2 Industry	1A3 Transport	1A4 Comm., inst. and households	3 Agriculture	5 Waste	1B+2D+2I-L Fugitives& product uses	**SZUM**
1990	40.00	50.81	82.93	44.44	25.49	2.51	0.37	246.55
1991	42.59	41.22	72.76	41.15	15.85	2.48	0.35	**216.41**
1992	43.86	30.42	69.56	33.11	14.83	2.48	0.34	**194.61**
1993	44.97	30.30	67.82	34.13	14.09	2.45	0.35	**194.11**
1994	43.67	31.46	65.65	33.76	15.83	2.45	0.32	**193.16**
1995	44.45	30.29	66.62	32.62	14.53	2.46	0.33	**191.30**
1996	44.85	31.31	66.40	34.40	14.69	2.48	0.30	**194.42**
1997	49.33	27.86	69.58	32.49	14.66	2.48	0.31	**196.70**
1998	45.01	24.94	77.68	30.10	16.49	2.47	0.32	**197.01**
1999	45.23	24.30	80.72	30.81	17.07	2.46	0.30	**200.90**
2000	35.85	23.47	78.14	31.59	17.20	2.32	0.30	**188.87**
2001	36.01	23.71	77.77	31.03	17.77	2.23	0.30	**188.83**
2002	31.08	20.91	78.24	29.71	18.93	2.22	0.27	**181.37**
2003	34.10	20.56	78.28	31.34	18.41	2.23	0.26	**185.17**
2004	33.25	21.34	77.17	30.28	18.42	2.14	0.30	**182.90**
2005	29.92	21.70	78.90	29.56	16.83	2.08	0.38	**179.36**
2006	25.67	20.38	77.45	28.48	17.81	2.08	0.16	**172.02**
2007	27.00	20.88	74.10	24.81	18.99	2.10	0.22	**168.10**
2008	26.97	18.25	72.42	24.64	17.87	1.83	0.22	**162.22**
2009	24.80	14.38	68.28	24.72	16.94	1.79	0.18	**151.10**
2010	27.30	14.43	59.98	27.03	17.23	1.84	0.17	**147.99**
2011	22.46	14.63	54.70	26.56	18.05	1.84	0.25	**138.50**
2012	22.04	12.94	52.63	23.59	18.53	1.84	0.15	**131.73**
2013	19.97	12.26	49.00	25.79	19.80	0.91	0.16	**127.90**
2014	16.91	12.60	52.22	23.41	19.93	0.86	0.20	**126.12**
2015	16.65	12.48	51.99	24.62	21.54	0.90	0.16	**128.34**
2016	12.96	12.34	47.03	24.84	22.53	0.83	0.16	**120.69**
2017	13.11	12.90	47.50	24.20	23.26	0.79	0.15	**121.92**
2018	12.33	13.81	47.74	22.93	23.22	0.79	0.17	**121.00**
2019	10.72	14.18	45.10	21.71	22.87	0.71	0.13	**115.42**
2020	10.55	13.84	36.88	21.89	23.92	0.52	0.14	**107.74**
2021	9.85	13.77	39.16	22.02	24.40	0.56	0.12	**109.87**

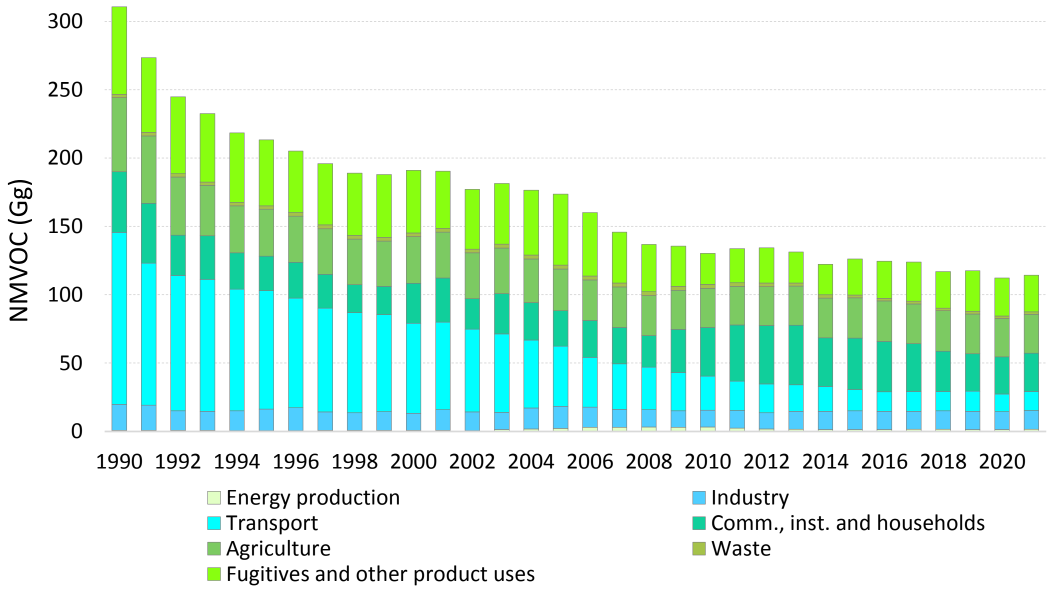


Figure 2.5 Trend of emission of NMVOC (kt)

Table 2.3 Trend of emission of NMVOC (kt)

NMVOC	1A1 Energy production	1A2+2 Industry	1A3 Transport	1A4 Comm., inst. and households	3 Agriculture	5 Waste	1B+2D+2I-L Fugitives & product uses	**SZUM**
1990	0.70	19.16	125.75	44.39	54.15	2.50	63.98	**310.63**
1991	0.75	18.48	103.79	43.75	49.42	2.54	54.66	**273.39**
1992	0.72	14.32	98.97	29.46	42.57	2.55	56.26	**244.87**
1993	0.71	13.95	96.49	31.92	36.82	2.56	50.02	**232.48**
1994	0.67	14.52	88.79	26.58	34.41	2.59	50.76	**218.32**
1995	0.67	15.74	86.64	25.15	34.30	2.63	48.16	**213.28**
1996	0.68	16.75	80.18	26.02	33.77	2.66	45.11	**205.18**
1997	0.75	13.58	75.78	24.85	33.36	2.69	44.84	**195.86**
1998	0.76	13.02	73.05	20.51	33.35	2.72	45.60	**189.01**
1999	0.80	13.79	70.93	20.70	32.98	2.76	45.98	**187.93**
2000	0.73	12.54	65.81	29.36	34.00	2.77	45.79	**191.01**
2001	0.75	15.22	64.02	32.18	33.53	2.76	41.96	**190.42**
2002	0.64	13.59	60.66	22.14	33.58	2.81	43.67	**177.09**
2003	1.41	12.55	57.48	29.42	33.19	2.86	44.57	**181.48**
2004	1.86	15.25	49.66	27.40	31.93	2.85	47.60	**176.55**
2005	2.31	16.11	43.83	26.07	30.46	2.87	51.90	**173.56**
2006	3.05	14.74	36.38	26.96	29.72	2.86	46.42	**160.14**
2007	3.05	13.13	33.36	26.47	29.63	2.98	37.26	**145.88**
2008	3.15	12.77	31.03	23.23	29.28	2.85	34.52	**136.83**
2009	3.00	12.07	28.10	31.54	28.55	2.87	29.39	**135.52**
2010	3.18	12.33	24.99	35.57	28.54	2.88	22.85	**130.34**
2011	2.42	12.79	21.65	40.97	28.24	2.63	25.03	**133.73**
2012	1.77	11.98	20.92	42.91	28.38	2.67	25.77	**134.41**
2013	1.59	13.17	19.31	43.64	28.59	2.36	22.66	**131.31**
2014	1.48	13.30	18.18	35.58	29.02	2.34	22.35	**122.25**
2015	1.43	13.66	15.62	37.58	29.49	2.03	26.45	**126.26**
2016	1.39	13.27	14.44	36.76	29.64	1.93	27.00	**124.43**
2017	1.55	13.25	14.38	35.10	29.05	1.95	28.56	**123.84**
2018	1.56	13.52	14.08	29.47	29.66	1.94	26.65	**116.88**
2019	1.40	13.27	14.68	27.56	29.00	1.94	29.77	**117.62**
2020	1.42	13.13	12.77	27.25	27.98	1.85	27.85	**112.25**
2021	1.57	13.78	13.97	27.91	28.37	1.86	26.81	**114.27**

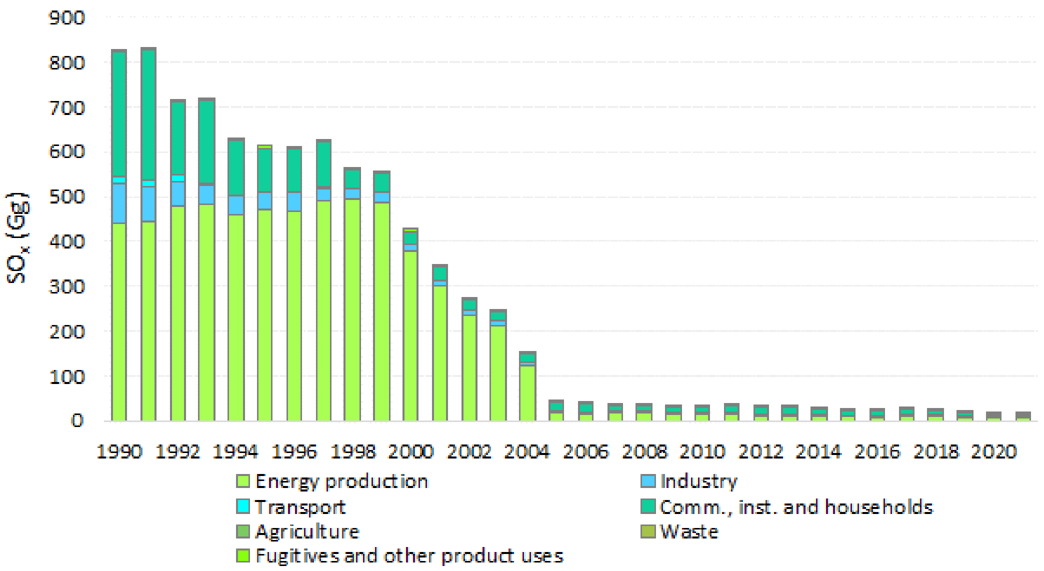


Figure 2.6 Trend of emission of SO_x (kt)

Table 2.4 Trend of emission of SO_x (kt)

SOx	1A1 Energy production	1A2+2 Industry	1A3 Transport	1A4 Comm., inst. and households	3 Agriculture	5 Waste	1B+2D+2I-L Fugitives & product uses	SZUM
1990	441.07	89.06	16.48	277.32	0.00	0.10	5.26	**829.29**
1991	444.33	78.28	14.43	290.04	0.00	0.10	4.94	**832.12**
1992	478.38	56.61	14.25	160.82	0.00	0.10	4.81	**714.97**
1993	482.15	43.61	2.31	186.26	0.00	0.10	4.98	**719.42**
1994	458.96	42.34	2.26	120.99	0.00	0.10	4.54	**629.19**
1995	469.82	39.09	2.29	97.31	0.00	0.10	4.84	**613.45**
1996	466.92	42.69	2.30	95.20	0.00	0.10	4.38	**611.59**
1997	489.14	30.15	2.43	98.82	0.00	0.10	4.53	**625.17**
1998	495.89	21.10	2.29	41.26	0.00	0.10	4.63	**565.27**
1999	488.15	21.71	1.52	41.27	0.00	0.10	4.51	**557.26**
2000	379.48	14.85	1.51	26.98	0.00	0.09	4.39	**427.30**
2001	300.12	12.66	1.74	27.40	0.00	0.09	4.42	**346.42**
2002	233.53	11.45	1.87	21.58	0.00	0.09	3.89	**272.41**
2003	212.56	9.06	1.88	20.89	0.00	0.09	1.63	**246.11**
2004	122.54	7.01	1.97	18.02	0.00	0.09	1.60	**151.23**
2005	16.88	5.77	1.23	17.17	0.00	0.08	1.62	**42.75**
2006	13.62	5.28	0.08	18.35	0.00	0.08	1.54	**38.95**
2007	17.82	5.15	0.08	11.30	0.00	0.08	1.67	**36.11**
2008	16.38	3.90	0.08	14.51	0.00	0.07	0.75	**35.69**
2009	13.81	3.04	0.08	11.79	0.00	0.07	0.86	**29.65**
2010	12.47	3.86	0.07	13.02	0.00	0.08	0.87	**30.37**
2011	15.03	3.71	0.07	14.47	0.00	0.07	0.83	**34.19**
2012	11.36	3.61	0.07	14.56	0.00	0.07	0.73	**30.41**
2013	11.64	2.93	0.06	13.80	0.00	0.04	0.73	**29.19**
2014	10.63	3.21	0.07	11.21	0.00	0.04	0.63	**25.79**
2015	8.91	3.13	0.07	10.99	0.00	0.04	0.64	**23.78**
2016	7.90	2.88	0.08	11.31	0.00	0.04	0.78	**22.99**
2017	11.86	2.80	0.09	11.85	0.00	0.04	0.95	**27.59**
2018	10.77	3.02	0.09	7.93	0.00	0.04	1.07	**22.92**
2019	7.10	3.09	0.10	6.16	0.00	0.03	0.97	**17.45**
2020	7.87	2.73	0.07	4.92	0.00	0.03	0.80	**16.42**
2021	5.87	2.78	0.07	4.40	0.00	0.03	0.86	**14.01**

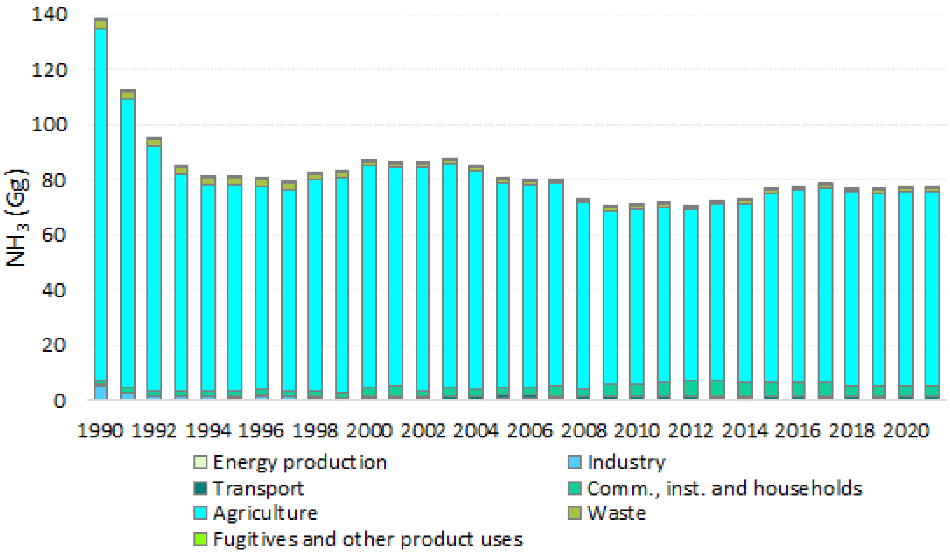


Figure 2.7 Trend of emission of NH_3 (kt)

Table 2.5 Trend of emission of NH_3 (kt)

NH3	1A1 Energy production	1A2+2 Industry	1A3 Transport	1A4 Comm., inst. and households	3 Agriculture	5 Waste	1B+2D+2I-L Fugitives& product uses	SZUM
1990	0.00	5.45	0.05	1.85	127.57	2.73	0.12	**137.77**
1991	0.00	2.49	0.04	1.83	105.03	2.71	0.11	**112.22**
1992	0.00	1.22	0.04	1.84	89.23	2.67	0.12	**95.11**
1993	0.00	1.09	0.08	1.92	78.83	2.66	0.13	**84.71**
1994	0.00	1.30	0.13	1.93	74.63	2.65	0.12	**80.75**
1995	0.00	1.01	0.16	1.95	74.87	2.59	0.09	**80.67**
1996	0.00	1.59	0.19	1.89	74.11	2.53	0.08	**80.40**
1997	0.00	1.30	0.25	1.82	73.02	2.39	0.08	**78.86**
1998	0.00	0.94	0.31	1.84	76.96	2.16	0.09	**82.31**
1999	0.00	0.65	0.38	1.88	77.96	1.96	0.08	**82.91**
2000	0.00	0.75	0.41	3.32	80.57	1.68	0.08	**86.82**
2001	0.00	0.56	0.56	3.79	79.56	1.34	0.09	**85.90**
2002	0.00	0.42	0.70	2.20	81.47	1.28	0.09	**86.17**
2003	0.00	0.31	0.74	3.28	81.58	1.22	0.10	**87.22**
2004	0.00	0.37	0.82	2.97	79.42	1.11	0.06	**84.74**
2005	0.00	0.55	1.25	2.79	74.29	1.06	0.07	**80.02**
2006	0.00	0.59	1.12	3.00	73.78	0.99	0.10	**79.57**
2007	0.00	0.49	1.16	3.21	73.96	0.94	0.10	**79.86**
2008	0.00	0.33	1.16	2.67	67.69	0.90	0.10	**72.86**
2009	0.00	0.35	1.15	3.99	63.32	0.90	0.11	**69.82**
2010	0.00	0.27	1.01	4.56	63.65	0.84	0.08	**70.41**
2011	0.00	0.37	0.98	5.27	63.53	0.87	0.09	**71.11**
2012	0.00	0.35	0.99	5.73	62.19	0.86	0.09	**70.22**
2013	0.00	0.40	0.87	5.89	63.96	0.99	0.07	**72.18**
2014	0.00	0.46	0.94	4.78	65.32	1.00	0.07	**72.57**
2015	0.00	0.30	1.09	5.08	68.74	0.99	0.08	**76.28**
2016	0.00	0.39	1.06	4.95	69.60	1.05	0.07	**77.12**
2017	0.00	0.45	1.04	4.66	70.64	1.10	0.07	**77.95**
2018	0.00	0.23	1.04	3.87	70.34	1.08	0.08	**76.65**
2019	0.02	0.41	1.16	3.61	70.00	1.05	0.09	**76.33**
2020	0.02	0.34	0.98	3.58	70.76	1.06	0.09	**76.83**
2021	0.02	0.33	1.01	3.69	70.71	0.97	0.06	**76.79**

Reporting of TSP and PMs is required only starting from year 2000. The decreasing tendency of emissions between 2000 and 2008 is attributable mainly to the spread of installation of electro-filters (ESP). The increasing tendency after 2008 originates from the sector of households.

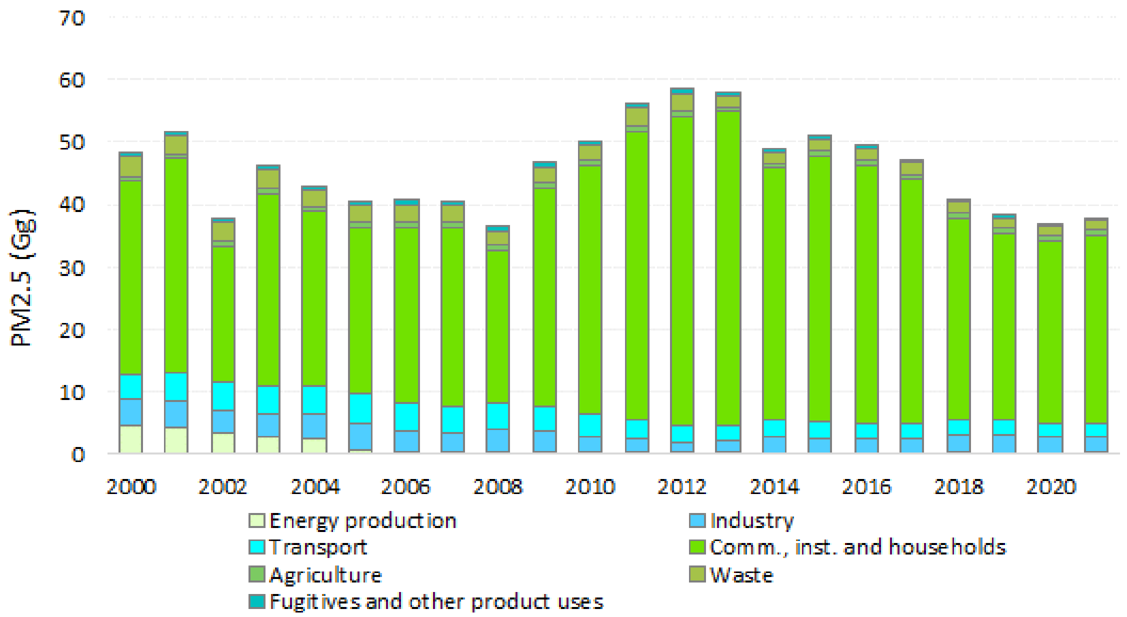


Figure 2.8 Trend of emission of $PM_{2.5}$ (kt)

Table 2.6 Trend of emission of $PM_{2.5}$ (kt)

PM2.5	1A1 Energy production	1A2+2 Industry	1A3 Transport	1A4 Comm., inst. and households	3 Agriculture	5 Waste	1B+2D+2I-L Fugitives& product uses	**SZUM**
2000	4.65	4.18	4.09	30.78	0.80	3.12	0.65	**48.28**
2001	4.39	4.22	4.34	34.40	0.82	2.89	0.69	**51.74**
2002	3.31	3.72	4.52	21.64	0.86	3.05	0.69	**37.78**
2003	2.87	3.55	4.66	30.65	0.87	3.03	0.73	**46.37**
2004	2.57	3.76	4.66	27.86	0.84	2.73	0.51	**42.93**
2005	0.71	4.11	4.89	26.56	0.79	2.81	0.56	**40.43**
2006	0.58	3.25	4.42	28.14	0.77	2.75	0.75	**40.66**
2007	0.57	2.78	4.29	28.68	0.77	2.68	0.75	**40.52**
2008	0.54	3.42	4.21	24.53	0.77	2.35	0.79	**36.60**
2009	0.52	3.12	3.96	35.13	0.76	2.52	0.78	**46.79**
2010	0.44	2.37	3.52	39.89	0.77	2.45	0.64	**50.09**
2011	0.35	2.08	3.07	46.29	0.78	2.87	0.68	**56.09**
2012	0.32	1.56	2.79	49.46	0.76	2.88	0.69	**58.47**
2013	0.32	1.82	2.50	50.19	0.77	1.84	0.57	**57.98**
2014	0.24	2.58	2.64	40.45	0.77	1.72	0.58	**48.97**
2015	0.23	2.34	2.73	42.43	0.77	1.88	0.60	**50.98**
2016	0.19	2.37	2.53	41.26	0.79	1.78	0.58	**49.50**
2017	0.21	2.23	2.56	39.10	0.75	1.86	0.52	**47.23**
2018	0.31	2.79	2.55	32.26	0.78	1.77	0.45	**40.91**
2019	0.26	2.82	2.51	29.80	0.77	1.72	0.41	**38.29**
2020	0.26	2.47	2.13	29.40	0.70	1.57	0.39	**36.91**
2021	0.30	2.45	2.31	30.07	0.72	1.66	0.30	**37.80**

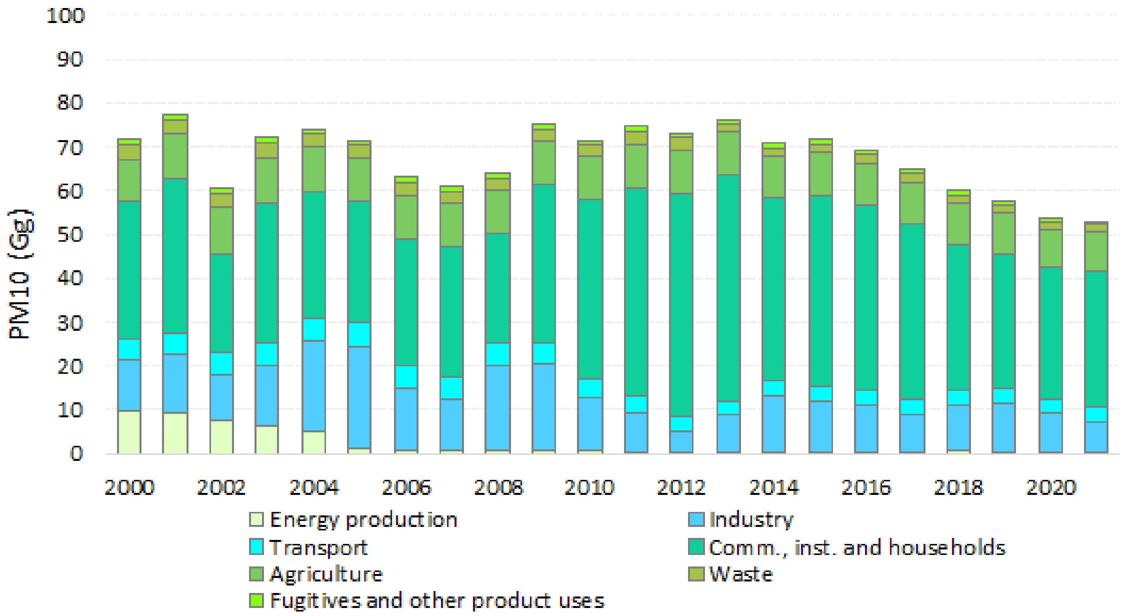


Figure 2.9 Trend of emission of PM_{10} (kt)

Table 2.7 Trend of emission of PM_{10} (kt)

PM10	1A1 Energy production	1A2+2 Industry	1A3 Transport	1A4 Comm., inst. and households	3 Agriculture	5 Waste	1B+2D+2I-L Fugitives & product uses	SZUM
2000	9.87	11.54	4.65	31.59	9.43	3.29	1.31	**71.67**
2001	9.43	13.17	4.94	35.31	10.24	3.05	1.33	**77.46**
2002	7.40	10.69	5.18	22.24	10.54	3.21	1.28	**60.53**
2003	6.22	13.88	5.36	31.47	10.70	3.19	1.34	**72.17**
2004	5.23	20.40	5.41	28.61	10.44	2.89	1.04	**74.02**
2005	1.10	23.36	5.71	27.28	9.98	2.97	1.04	**71.45**
2006	0.84	14.05	5.31	28.90	9.86	2.91	1.28	**63.15**
2007	0.81	11.62	5.23	29.42	9.88	2.83	1.28	**61.06**
2008	0.75	19.19	5.18	25.18	9.85	2.48	1.29	**63.93**
2009	0.71	19.72	4.93	36.03	9.79	2.65	1.23	**75.06**
2010	0.61	11.98	4.38	40.91	9.88	2.59	1.12	**71.47**
2011	0.50	8.84	3.88	47.48	9.78	3.00	1.17	**74.65**
2012	0.47	4.58	3.58	50.72	9.66	3.01	1.17	**73.21**
2013	0.46	8.45	3.23	51.45	9.69	1.92	1.06	**76.26**
2014	0.41	12.93	3.47	41.46	9.71	1.80	1.07	**70.85**
2015	0.39	11.46	3.63	43.49	9.62	1.96	1.09	**71.63**
2016	0.30	10.57	3.43	42.29	9.72	1.86	1.06	**69.22**
2017	0.34	8.61	3.51	40.09	9.47	1.93	0.96	**64.90**
2018	0.53	10.43	3.56	33.07	9.59	1.84	0.90	**59.92**
2019	0.43	10.93	3.58	30.54	9.56	1.78	0.81	**57.64**
2020	0.43	8.91	3.07	30.13	8.67	1.62	0.71	**53.54**
2021	0.51	6.84	3.35	30.81	8.99	1.72	0.59	**52.81**

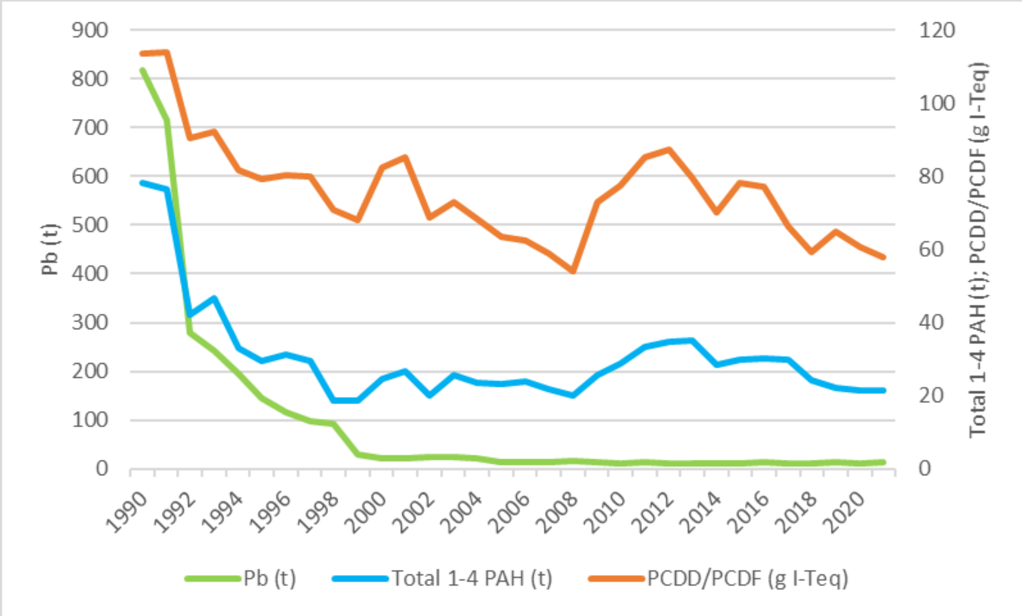


Figure 2.10 Trend of emission of PAHs (t), dioxins (g I-Teq) and Pb (t)

The trend of PAH emissions is mainly influenced by the shutdown of the primary aluminium production in Hungary.

In the case of dioxins, the main driver is probably the improvement of combustion and abatement technologies, especially in the case of waste and hazardous waste combustion. In addition, the organized open-air burning e.g. the stubble-field burning, the reed-burning has been forbidden, and also the open-air burning of the garden wastes is strictly limited recently.

The significant decrease of lead emissions is mainly due to the step-wise reduction of the lead content of the leaded gasoline and the effect of the introduction of the unleaded gasoline after 1990.

3 ENERGY (NFR SECTOR 1)

3.1 Overview of sector

This sector covers emissions from combustion processes and fuel-related fugitive emissions from exploration, transmission, distribution and conversion of primary energy sources.

For a better understanding of the principal drivers behind fossil fuel related emission trends and variations, the main characteristics of the Hungarian Energy System will be described shortly in the following. First of all, not enough, cheap and clean domestic energy resources of good quality are available in Hungary, therefore the energy demand has to be met by import to a great extent. In 2021, primary energy production amounted to 454.3 PJ which was by 26 per cent less than in 1990 and more or less at the same level as in 2005. Most importantly, uneconomical deep coal mines were closed down, but also crude oil and natural gas production decreased. Net import of energy with 620.3 PJ in 2021 was by 5% larger and by 16% smaller than in 1990 and 2005, respectively. Hungary's import dependency is quite significant, over 50%, currently 54.4% (calculated as the ratio of net imports and primary energy consumption). Domestic supply of primary energy was 1,149.7 PJ in 2021, an increase of 5% compared to 2020. Final consumption increased also: from 832.1 PJ in 2020 to 891.7 PJ in 2021. Looking at the main sectors, the highest increase in energy consumption was in transport (10%) due to less restrictions caused by the COVID pandemic than in the previous year. The energy consumption of industry and the tertiary sector increased as well. Also, the residential sector used more energy due to higher heating demand.

(Data source: The Hungarian Energy and Public Utility Regulatory Authority (HEA), and HCSO: http://mekh.hu/download/6/93/31000/7_2_annual_national_energy_balance_2014_2021.xlsx https://www.ksh.hu/stadat_files/ene/en/ene0002.html

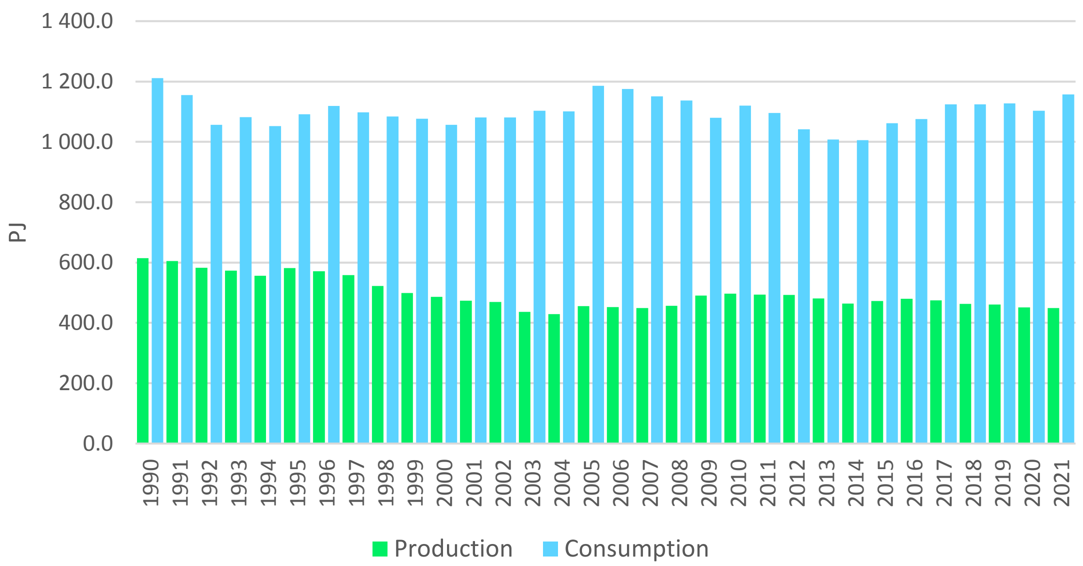


***Figure 3.1** Primary energy balance of Hungary (1990-2021)*

In 2021, final domestic electricity use amounted to 43,387 GWh, 5% more than in the previous year. Electricity consumption increased by 21% since 2014. The market penetration of the nuclear electricity started in 1983 in Hungary when the first 440 MW block of the Nuclear Power Plant in Paks was put into service. In recent years, 44% (2021) to 53% (2014) of the domestic generated electricity was produced by nuclear energy whereas the share of fossil fuels decreased to 40% in 2013 and remained below that level afterwards. According to the official statistics of the Hungarian Energy and Public Utility Regulatory Authority, the share of electricity from renewable sources in gross final consumption of electricity increased from 4.4% is 2005 to 13.7% in 2021. The last few years saw significant increases in solar electricity production (from 1 GWh in 2011 to 3,796 GWh in 2021) and also wind power production increased to 664 GWh in 2021 from 10 GWh in 2005. At the same time, electricity produced from combustible fuels decreased from 21,710 GWh in 2005 to 15,301 GWh in 2021.

The main drivers behind the annual changes in emissions are the following: (1) yearly changes in fuel use, (2) changes in the fuel-mix, (3) changes in the chemical characteristics of fuels (e.g., sulphur content), and (4) changes in applied technologies (e.g. abatement). The first two aspects are visualized in *Fig 3.2*.

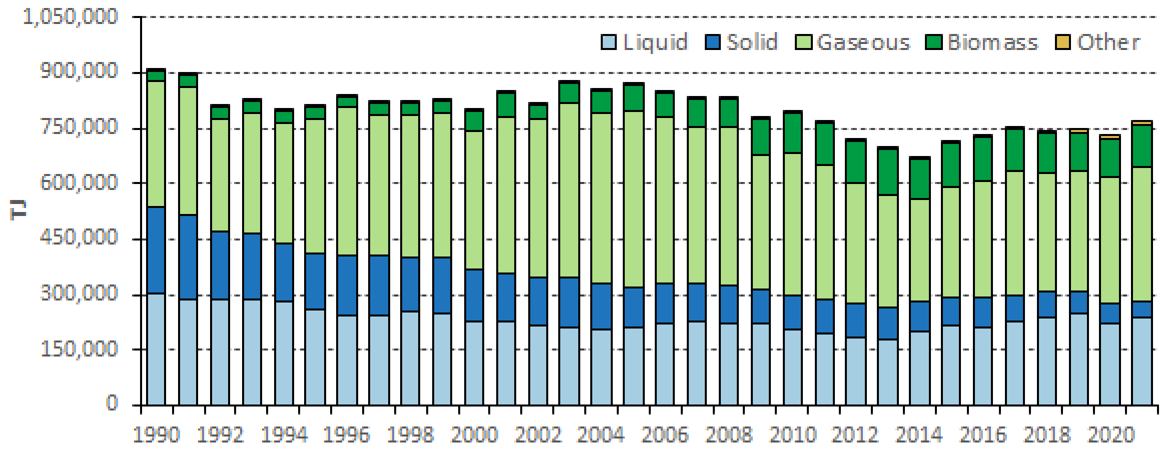


Figure 3.2 *Fuel combustion from 1990 to 2021*

This figure clearly demonstrates the effects the regime change around 1990 when the fuel use suddenly decreased by more than 20 per cent. Also, the global economic crisis made its influence felt with a 6 per cent drop between 2008 and 2009. Combustible energy consumption decreased further between 2010 and 2014 by 16%. However, the decreasing trend stopped and fuel consumption has increased again since 2014 by 14% despite a 2% drop in 2020. Alone in 2021, fuel consumption increased by 5%. Beside these significant changes in overall fuel combustion, the share of the different fuel types, i.e. the fuel-mix, changed throughout these decades. The importance of liquid and solid fuels diminished whereas natural gas became the dominant fossil fuel. Biomass use increased too. Figure 3.3 compares the proportion of combusted fuel types in 1990 and 2021. It is worth mentioning that, within the period investigated, some classical types of fossil fuels have disappeared or their use decreased significantly, e.g. city-gas, heavy fuel oil (by destructive technologies it has been transformed to motor fuels and partly petrol-coke is produced from it). At the same time, the market penetration of new fuel types became significant e.g. petrol-coke, bio-ethanol, LPG and compressed natural-gas (CNG) for cars and buses, biomass for firing in power plants, biogas produced by fermentation of sludge and animal carcasses etc. All these changes were taken into consideration in our emission calculations.

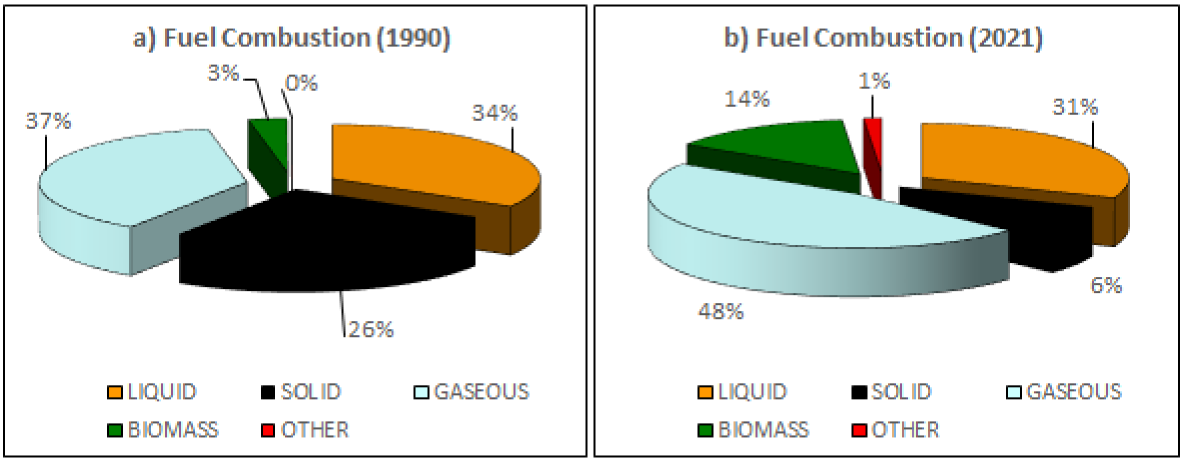


Figure 3.3 *Fuel combustion in 1990 (a) and 2021 (b)*

3.2 General methodological description

The emissions calculations are based on the common method of using emission factors. For 1990-2020, the methodology described in the latest EMEP/EEA Air Pollutant Emission Inventory Guidebook 2019 was used for all sectors, including this one. Whenever default emission factors were applied, these were generally taken from this very guidebook. In many cases country-specific factors seemed more appropriate. Besides, plant specific measurements were taken into account for important sources. These cases and the used country specific or measured values are documented in the relevant category level of the IIR.

Whatever the emission factors might be, the first step is to determine the relevant activity data that is the energy use of fuels per activity. For this submission, the IEA/Eurostat Annual Questionnaires have been used mostly for the entire time series. (Former inventories were partly or fully based on Hungarian Energy Statistical Yearbooks. The publication of the yearbooks ceased; the last one contained statistics for the year 2010. After consultations with the national energy statistics provider, i.e. the Hungarian Energy and Public Utility Regulatory Authority, it was decided to build recent and future inventories on IEA annual questionnaires.)

To increase consistency of the time series, we had to make some minor amendments of the allocation of fuel consumption compared to the IEA annual questionnaires, as follows:

- Based on 2011-2017 data allocations and value-added volumes of industrial production for previous years, some gasoil consumption has been reallocated from road transport to non-road mobile machinery (1A2gvii);
- The time series of gasoil use in navigation has been improved by interpolation where the missing amounts were taken again from road transport;

- Some natural gas use has been reallocated between petroleum refining (1A1b) and autoproducer plants (1A2gviii) to increase consistency with fuel consumption reported by the refinery under the ETS;
- Further natural gas consumption has been reallocated between other energy industries (1A1c) and commercial/institutional (1A4a) to reflect fuel consumption in oil and gas extraction. Data on natural gas production served as basis of extrapolation here;

Fuel use and emissions of autoproducer plants (that generate electricity or heat, wholly or partly for their own use as an activity which supports their primary activity) are accounted for fully in under the relevant economic sector in the period 1998-2021 as required by the guidebook, and to the extent possible also for previous years. (In earlier submissions, almost all autoproduction was allocated to the source category “other stationary combustion 1A2gviii” for all years before 2013 with a few exceptions (e.g. coke oven gas and blast furnace gas were also previously reallocated from autoproducers to iron and steel, and to manufacture of solid fuels).

The problem of the network losses in the natural-gas transmission and distribution system should be also mentioned here. These losses are partly not technical ones in the reality, but the result of accounting, e.g., due to issues as measurement accuracy, temperature or pressure conversion or theft. The point is that only about half of the losses reported in statistical publications as distribution losses was taken into consideration as real loss (i.e. that is emitted into the atmosphere as methane), while the remaining half was assumed to be fired. Thus, the natural gas consumption in the residential sector is not the same as reported in the IEA natural gas annual questionnaire because on average 50 per cent of the network losses are added to it.

Gas engines, as their emission characteristics are somewhat different, are treated separately in our calculations. The Hungarian Energy and Public Utility Regulatory Authority collects data like installed capacity, the fuel used (whether it’s biogas or natural gas), fuel consumption, and where they’re operating (e.g. which company or institute). Based on these data, the fuel consumption could be distributed among different user groups or sectors for some years, however, natural gas use in gas engines is taken into account only in the energy industries source category.

The Hungarian Energy Office, the predecessor of the Hungarian Energy and Public Utility Regulatory Authority, provided also data on fuel use and emissions (SO_2, NO_x, CO) from electricity and CHP plants with installed capacity larger than 50 MWe for the period 1995-2010. This made possible to calculate emissions for every power plant separately, thus taken into consideration the specialties of the different power plants. Further official databases including emission measurements were at our disposal. The Hungarian Meteorological Service, as the greenhouse gas inventory compiler institute, has direct access to the EU ETS database with detailed plant by plant fuel use data. The National Environmental Information System is a huge database containing among others emission data from almost all fuel combustion above the threshold of 140 kW_{th}. Emission data reported in line with the LCP Directive were also used, and obviously the publicly available E-PRTR data are worth a look.

Our approach for the current inventory was as simple as follows: if we had reliable measurement data, we used them. Otherwise, emissions were calculated based on country and year specific activity data and default emission factors from the 2019 EMEP/EEA Guidebook were applied with a few exceptions, especially regarding SO_2 emissions from solid fuels, or PCDD/F emissions from waste incineration. All data used and consideration made will be described specifically in the relevant category level of this chapter.

3.3 Energy industries (NFR code 1A1)

This subsector includes facilities generating electricity, district heating stations, oil refineries and coking and briquetting plants.

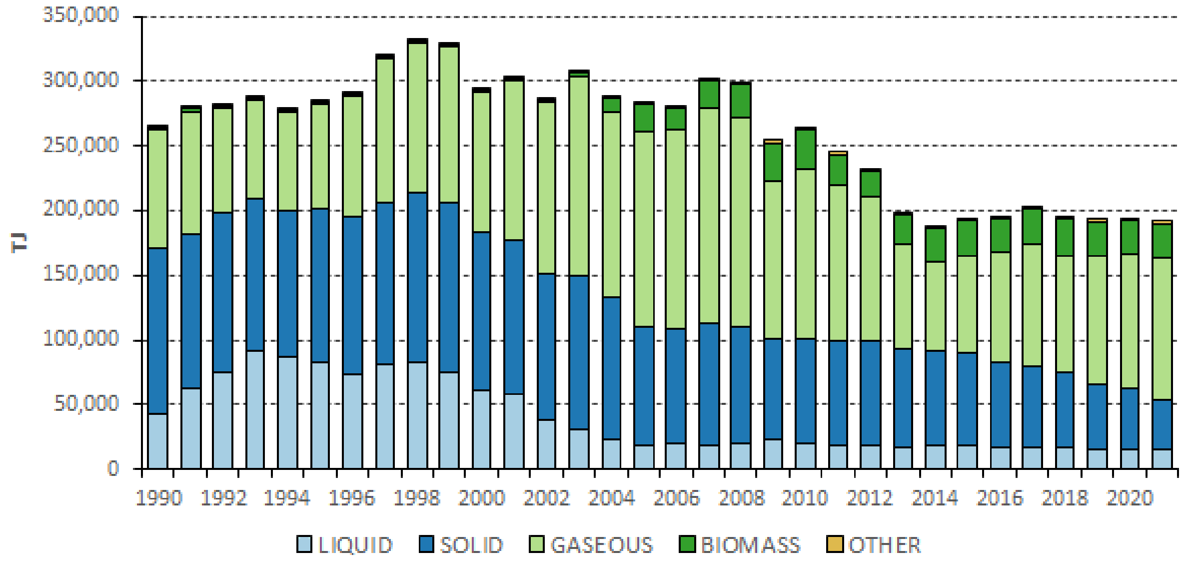


Figure 3.4 *Fuel combustion in energy industries (1990-2021)*

As it can be seen in *Figure 3.4*, total fuel consumption (without nuclear energy) in the energy industries sector shows strong fluctuations. After a significant decrease around the political and economic regime change in 1990, fuel consumption increased quite significantly by 26% until 1998, then decreased by 15% between 1998 and 2005. We experienced a more pronounced drop after 2008 due to the global financial crisis. After 2010, until 2014, fuel consumption has reached record low values every year; combustible fuel use fell altogether by 37% between 2008 and 2015. In 2015, however, the decreasing trend stopped, and we observed a small increase in energy use. Fuel consumption seemed to have stabilized around 194 PJ in recent years. Within the inventory period, the consumption of liquid and solid fuels has decreased significantly. In contrast, the consumption of natural gas has increased until 2007 to a great extent then it shrunk substantially afterwards. Biomass use due to burning co-burning in power plants has become more and more important and exceeded in amount the liquid fuel use in 2005.

Public Electricity and Heat Production was responsible for about 83-85% of fuel use in energy industries. Fuel consumption of oil refining showed a pronounced drop around 2000 but remained more or less at the same level afterwards. In the last two-three years, however, increasing fuel consumption could be observed. Currently, the share of the refinery's fuel consumption is about 14% within energy industries. Less significant is manufacture of solid fuels and other energy industries with a portion of 2-4%.

3.3.1 Public electricity and heat production (NFR code 1a1a)

Reported Emissions: Main Pollutants, Particulate Matter, CO, Priority Heavy Metals, Other Heavy Metals, POPs
Measured Emissions: NO_X, SO_X, TSP, CO, (Pb, Cd, Hg, As, Cr, Cu, Ni, Se, PCDD/F)
Methods: T1, T2, T3
Emission factors: D, PS
Key source: NOx, SOx, Pb, Hg, Cd, HCB

Domestic electricity production showed an overall increasing trend up till 2008; even during the years of the regime change around 1990, whereas import suffered a more severe drop from 28% to 6-7%. In addition to the effects of the financial crisis, an interesting incident occurred in 2009 when domestic production fell back by more than 10% whereas consumption decreased only by 6%. There was a multi-week break in the natural gas supply through Ukraine, thus the electricity generation of our natural gas firing power plants had to be substituted by import electricity and by increased production of the oil-fired power plants. After 2010, until 2014, domestic electricity production decreased every year, and it has dropped quite substantially in 2013 by 13%. In the last seven years (2014-2021), however, domestic production grew again altogether by 23%. The share of import is a highly variable figure: in the previous decade, it changed between 8% (2001) and 18% (2004). After 2010, however, it grew constantly and has reached a share of 31% in 2014 and remained close to 30% afterwards and decreased to 25-27% in the period 2019-2021.

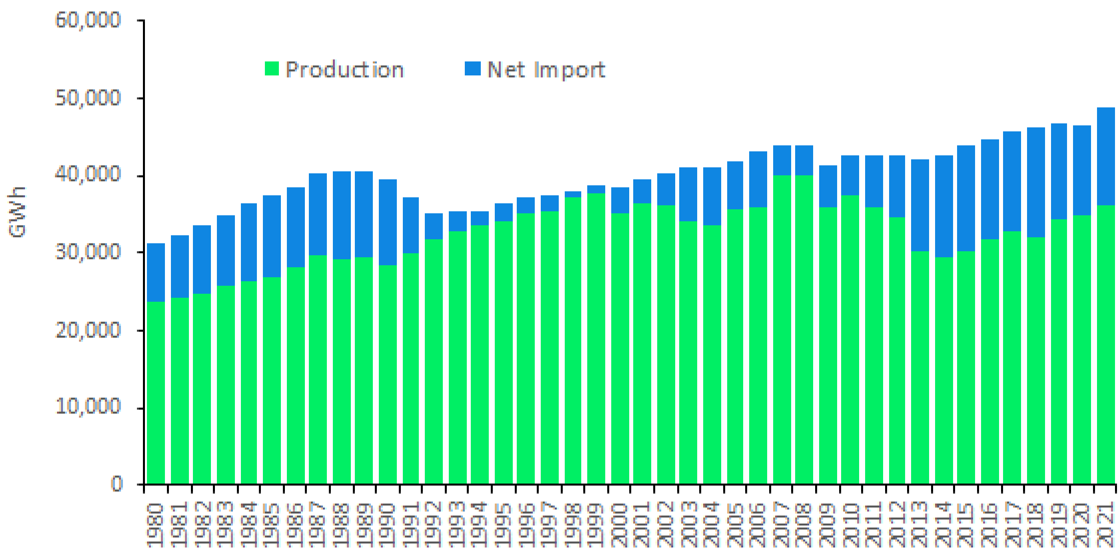


Figure 3.5 *Domestic Electricity Production and Net Import (1980-2021)*

Naturally, as domestic emissions are related to domestic production, the yearly fluctuation of production is one of the decisive factors. Not less important is the way how electricity is produced, e.g., what energy source is used. In Hungary, this sector consumes the deterministic part of our solid fossil fuel production, and around 30% of the domestic primary energy consumption.

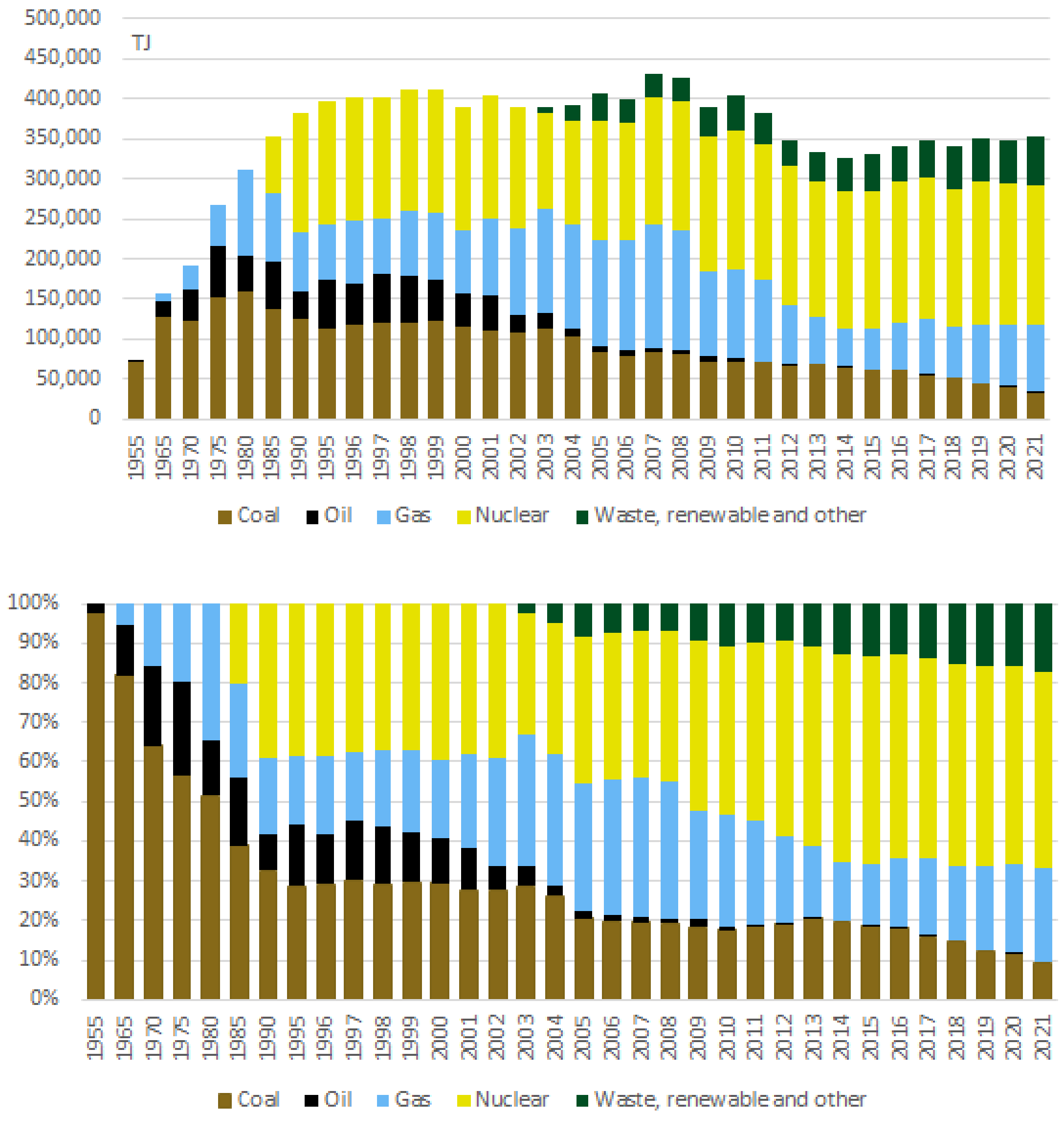


***Figure 3.6a** Energy consumption of power plants (above) and the share of different energy sources in power production (1955-2021)*[1]

Looking at the above figure, the most striking development is the diminishing share of coal combustion in power generation: in 1990 coal still had a share of 33% which then decreased to 21% in 2005, and eventually to 9% in 2021. During this process, new combined cycle gas-turbine units were installed (Újpest, Kelenföld, Százhalombatta, Gönyű, Ajka, Nyíregyháza Power Plants), and aged coal fired units (Inota, Bánhida, AES Borsodi) of low efficiencies were taken out of service or blocks have been converted to the combustion of biomass (Pécs, Kazincbarcika, Ajka Power Plants). An equally important recent development is that the use of all traditional fossil fuels has roughly halved compared to the

[1] Source: MEKH-MAVIR: Data of the Hungarian Electricity System, http://www.mekh.hu/download/1/72/31000/MEKH_statisztikai_kiadvany_villamos_energia_A4_web_V%C3%89GLEGES.pdf

mid-2000s. In contrast, increasing use of renewable sources could be observed by some public power plants. For example, there were significant changes in the installed capacity of Hungarian electricity system in 2019-2021 with increases of almost 560 MW + 560 MW + 405 MW, which are mainly due to the new solar power plants with an installed capacity of more than 50 kW added to the system.

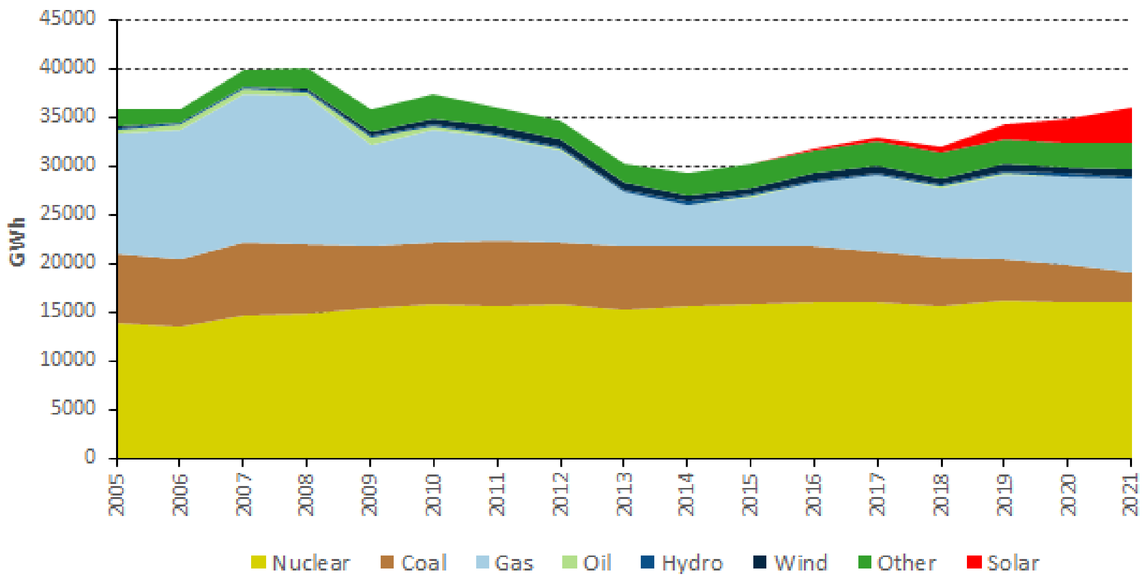
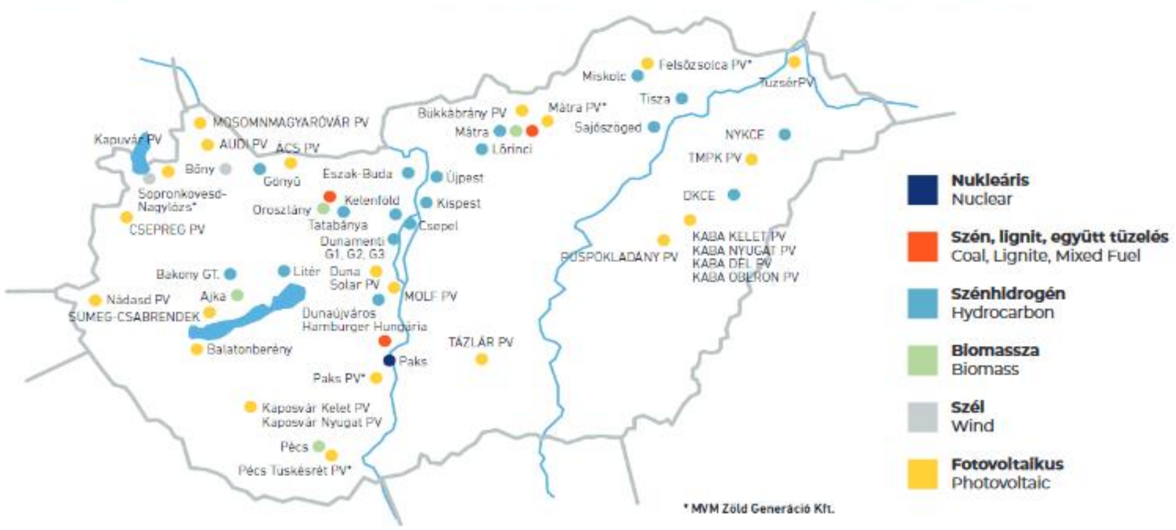


Figure 3.6c *Share of produced electricity by fuel (2005-2021)*

It has to be noted also that the utilisation of domestic power plants is strongly influenced by the fuel costs and the regional wholesale electricity prices changing country by country. For example, the market share of gas-fired power plants depends on the level of basically oil price-indexed gas prices, the CO2 allowance price system, the increase of electricity generation from renewables, etc. Lower level of domestic generation needs to be compensated by import.

POWER PLANTS TAKING PART IN SYSTEM LEVEL COORDINATION ON 31 DECEMBER 2021



Methodological issues

Specific emphasis was given here to large combustion plants on the one hand and to gas engines on the other because for these two groups we could deviate from the general methodology of default emission factors. Usually, fuel consumption and emission data of 17-40 large (or otherwise important) plants were analyzed. These plants were responsible of all coal and biomass use, around 60-90% of all liquid fuel and natural gas use. Based on the LCP Directive and following the Ministerial Decree 10/2003 (that was replaced by the Ministerial Decree 110/2013) on combustion installations with a net rated thermal input exceeding 50 MW, these installations must report measured SO_2, NO_X and dust values, and in most of the cases based on continuous measurements. Reported emission data are summarized in Figure 3.7.

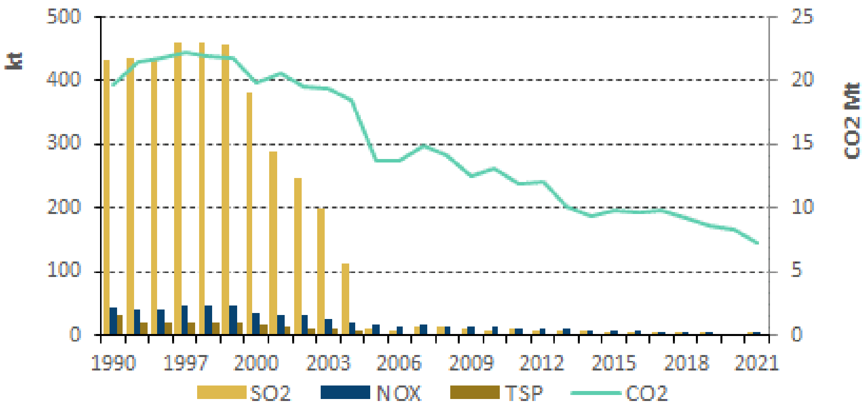


Figure 3.7a *Measured emissions from large electricity plants (1990-2021) Source: Data of the Hungarian Electricity System, 2021*

The most prominent feature in this figure is the substantial drop in SO_2 emissions. In the last decade flu-gas desulphurization plants (FGD) have been installed in two coal (lignite and brown coal) fired power plants of large capacities: in Mátra about in the year 2000 in two steps, and in Oroszlány in 2004, which resulted significant mitigation in the sulphur-dioxide emission. Thus, the SO_2 emissions connected with the operation of the public power plants shrank to a fraction of their earlier value. Similarly, electrostatic precipitators (ESPs) were installed in every solid fossil fuel power plant, and their effects may be observed in the sharp decrease in the pyrogenous TSP emissions.

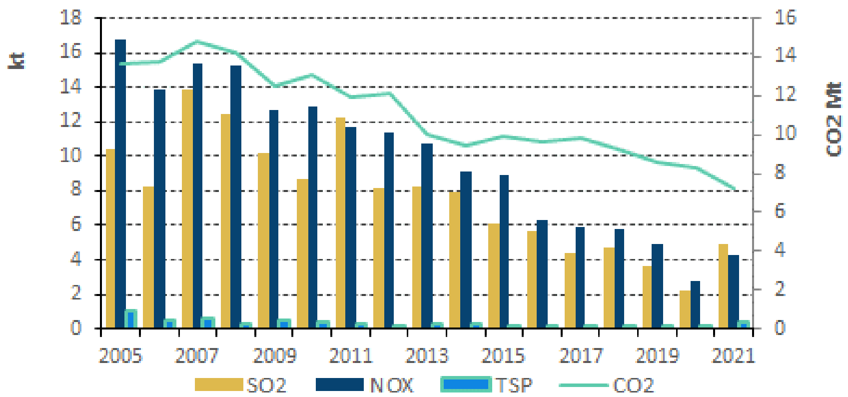


Figure 3.7b *Pollution data of power plants. Source: Data of the Hungarian Electricity System, 2021*

As reported emission values of large combustion plants can be regarded as reliable, these (NO_X, SO_2, TSP) were used in the reporting, whenever available. Besides pollutants in Fig. 3.7, electricity plants larger than 50 MWe also report CO emission to the Energy Office. In case of smaller plants, the common method of emission factors was applied.

As a large part of the reported NO_X, SO_2 and TSP emissions in this source category are based on annual emissions reported by operators on the basis of stack measurements, the issue of continuous measurements needs to be addressed here. When continuously measurements are used to estimate annual emissions, there is a risk that operators have misinterpreted the Industrial Emissions Directive (and the corresponding domestic legislation) and have used validated average values after having subtracted the value of the confidence interval. We have contacted quite almost all operators to ask them about their reporting practice. From the answers received, it seems that the reporting practice is not consistent, some operators use validated average values to calculate annual emissions, some don't, some use half of the confidence interval etc. A few of them just change their practice in 2017. Therefore, we have decided to use all the (updated) specific information received from the plants and in case of no information *to add half of the confidence interval* (i.e. 10% of SO_2, 10% of NO_X, 10% of CO, and 15% of dust) to adjust the emission values reported by plants applying continuous measurement.

Activity data

Energy consumption data were taken from the Hungarian IEA/Eurostat annual questionnaires. In order to see what part of fuel use from the questionnaires allocated to main activity plants is already covered by measured emissions, plant level fuel consumption data was collected from LCPs, basically from the ETS database. As gas engines show somewhat different emission characteristics, separate data on fuel use in gas engines was collected from the Hungarian Energy and Public Utility Regulatory Authority which can be seen on Figure 3.8. Gas engines are considered only in this source category.

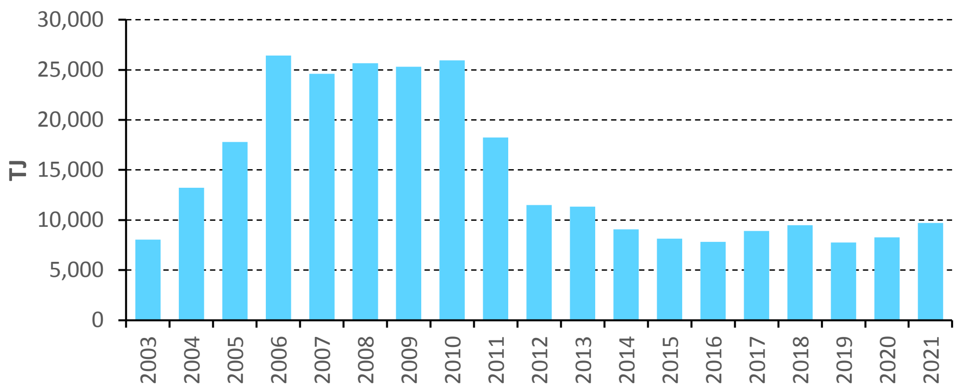


Figure 3.8 *Natural gas use in gas engines (2003-2021)*

As also waste incineration with energy recovery occurs, reported emission data (Pb, Cd, As, Cr, Cu, Ni, Se, and PCDD/F) from the largest municipal waste incinerator (FKF Plant in Budapest) were also taken into account.

Emission factors

First, it should be emphasized that emissions of the important main pollutants from combustions of sensitive fuels (e.g. solid fuels, derived gases) are mainly covered with measurements. The same applies for PCDD/F emissions from waste incineration. Especially, yearly measured NO_x, SO_x, and CO emissions were directly used from solid fuel (coal + biomass) burning power plants as our plant specific information fully covers fuel consumption from the statistics, at least for the period 2005-2021. For previous years, country specific emission factors were derived based on plant specific data. Important country specific emission factors are summarized in the following table.

Table 3.1 Summary of country specific emission factors

Pollutant	Fuel	Emission factor [kg/TJ]	Period
SO_x	domestic coal	3150	1990-1999
SO_x	domestic coal	2620-1120	2000-2004
SO_x	derived gases	70	1990-2012
NO_x	coal	180	1990-1999
NO_x	coal	139	2000-2004
NO_x	derived gases	50	1990-2013
NO_x	natural gas	57-45	2004-2013
CO	coal	175-63	1990-2004
CO	derived gases	3	1990-2013
CO	natural gas	10	2005-2013
TSP	solid fuels	105-4	2000-2013
TSP	derived gases	2	2000-2013

For all other fuel-pollutant combinations, where no measured emissions were used, Tier 1 emission factors from the 2019 EMEP/EEA Guidebook were applied. Some exceptions are highlighted in the following:

- NO_X emission factor for gas engines was taken from Table D4 of the Guidebook. The chosen value (159.4 g/GJ) is a bit higher than the new T2 EF (135 g/GJ) but is in line with the domestic regulation on emission limits from gas engines that is 500 mg/m^3 for NO_X (Ministerial Decree KTM 32/1993). This figure could be verified by emission data of four larger gas engines. Analyzing their fuel use (from EU ETS) and reported emissions, the resulting average emission factor was 152.7 g/GJ. (Recent measurements indicate lower emissions from gas engines which are taken into account for the last few years.) For similar reasons, for CO emissions from gas engines, an EF of 207 g/GJ was chosen (which is lower than the T2 factor of the Guidebook).
- Country specific SOx emission factors for heavy fuel oil were derived based on the share of “high sulphur” and “low sulphur” fuel oils taken from the IEA time series. It was assumed that high sulphur oil has 3% sulphur content, whereas low sulphur oil has 1%.

- For other liquid fuels, domestic legislation was taken into account which maximized the sulphur content of liquid fuels as 0.2% from 2004 and as 0.1% from 2008.

The calculation method of $PM_{2.5}$ and PM_{10} emissions is also worth a mention. In case of measured dust data, $PM_{2.5}$ and PM_{10} emissions were derived from the TSP value using their relative share reflected in T1 default emission factors. For example, for hard coal the default emission factors for $PM_{2.5}$, PM_{10} and TSP are 3.4, 7.7 and 11.4 g/GJ, respectively (see Table 3-2 in the Guidebook). If we knew the TSP emissions from a hard coal firing power plant, then PM_{10} emission was estimated as PM_{10}=7.7/11.4*TSP.

Uncertainties and time-series consistency

As plant specific emission data and measurements have been taken into account to a large extent, and otherwise either default or country specific emission factors are used consistently for the whole time series, there might not be too serious problems with time series consistency.

Source-specific QA/QC and verification

We had more data sources at our disposal for verification purposes, such as the IEA/Eurostat questionnaires for domestic sectoral energy use, plant specific fuel consumption data from different reports, e.g. EU-ETS, LCP, data collected by Energy Office. The same applies for emission data on plant level, where we have data from the National Environmental Information System, from E-PRTR, from LCP reports, and from the Hungarian Energy Office.

Source-specific recalculations

No methodological change has been made but emission reports from more point sources were taken into account.

Source-specific planned improvements

None.

3.3.2 Petroleum refining (NFR code 1A1B)

Reported Emissions: Main Pollutants (except NH_3), Particulate Matter, CO, Priority Heavy Metals, Other Heavy Metals, POPs
Measured Emissions: NO_X, CO, SO_X, TSP,
(Pb, Cd, Hg, Cr, Cu, Ni, PCDD/F - not available for all years).
Methods: T3, (T1)
Emission factors: D, PS
Key source: -

Methodological issues

In Hungary, practically only one operating refinery remained whose emission reports were used for this submission for the period 2002-2020. For earlier years, the classic methodology with emission factors was applied. Then, total emissions from the refinery were separated into combustion and process related emissions. More details on this sectoral split of emissions can be found in Chapter 3.7.2.2.

Activity data

The data were taken from the joint IEA/Eurostat annual questionnaires. For the calculations, primarily fuel consumption data were used but also refinery intake was taken into account especially for the sectoral split between energy and industry.

Emission factors

For main pollutants, mostly measured data were reported for the period 2002-2019. Also measured Hg emissions were taken into account for some years. For the remaining pollutants and years, T1 emission factors were used from the 2019 EMEP/EEA Guidebook.

Uncertainties and time-series consistency

No category specific information is available.

Source-specific QA/QC and verification

The environmental performance data of the MOL Group can be checked on the internet on the following link:

https://molgroup.info/en/sustainability/reports-and-data

Please not that these data include not only the emissions from the Hungarian refinery but also the emissions of Slovnaft and another refinery located in Italy.

Source-specific recalculations

None.

Source-specific planned improvements

None.

3.3.3 Manufacture of solid fuels and other energy industries (NFR code 1A1C)

Reported Emissions: Main Pollutants (except NH_3), Particulate Matter, CO, Priority Heavy Metals, Other Heavy Metals, POPs
Measured Emissions: NO_X, SO_2, CO, TSP
Methods: T3, T2
Emission factors: D, PS
Key source: -

A unique specialty in Hungary is the coking on contract basis. When the mining of coking coal became uneconomical, it was stopped in the early 90's, which meant that the large coking capacity installed in the country remained unutilized. Thus, coking coal was brought by foreign coke producers into the country, a part of the coke produced was exported, while another part was utilized by the domestic blast furnace for pig iron production (see *Fig. 3.9*). The by-products of the coking, the coke oven gas and of the pig iron production, the blast furnace gas are consumed by the nearby power plant. Of course, the emission connected with the coke production remains in the country and also the coke oven gas is fired here (to produce process heat for coking and to produce electricity in the nearby power plant).

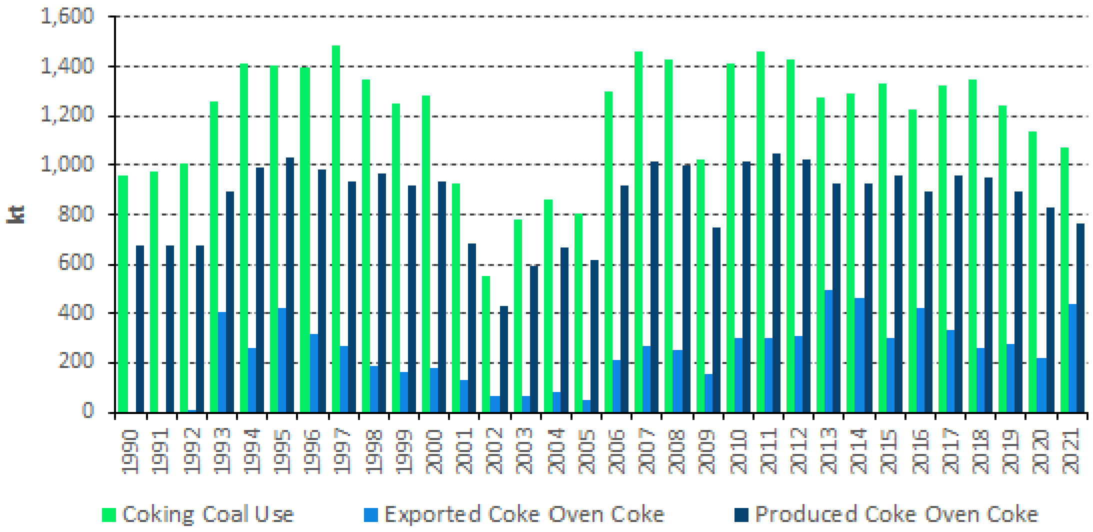


***Figure 3.9** Gas coke distillation in Hungary (1990-2020)*

Methodological issues

There is practically one coking plant in the country (ISD DUNAFERR Coking Plant) whose emission reports were used for this submission. The measured emissions were taken as they were reported (luckily, the coking plant and the nearby blast furnace plant report separately). For the remaining pollutants, Tier 2 approach was applied. For all other energy industries (e.g. coal mines, gas extraction, gasification plants) the general T1 methodology based on fuel consumption was used.

Activity data

For the Tier 2 approach coal use was needed that was taken from the joint IEA/Eurostat annual coal questionnaire (Coking Coal – Transformation Sector - Coke Ovens). In 2010, 1414 kt coking coal was used, and 30% of the produced coke oven coke was exported. We had similar data for 2011 with 1464 kt coking coal use, 1049 kt coke production out of which 303 kt was exported. In 2012, out of 1428 kt coking coal input 1026 kt coke was produced and 309 kt coke was exported. The amount of exported coke increased significantly (by 60%) in 2013, whereas iron production decreased by half. Compared to 2013, neither the production nor the export figures changed significantly in 2014. In 2015, production increased a little, whereas export decreased significantly. Export grew again in 2016 with decreased production level. In 2017 and 2018, production level was around 960 kt but export decreased significantly. In 2019, production decreased to 892 kt. In 2020, both production and export decreased further by 7% and 20%, respectively.

Emission factors

For all non-measured pollutants by the coking plant, default emission factors from Table 5-2 (coke manufacture with by-product recovery) were used.

Uncertainties and time-series consistency

The time series can be regarded as consistent.

Source-specific QA/QC and verification

None.

Source-specific recalculations

No methodological change has taken place.

Source-specific planned improvements

None.

3.4 Manufacturing industries and construction (NFR code 1A2)

This subsector covers emissions from the combustion of fuels in the industrial sector. *Figure 3.10* illustrates the energy consumption of the sector. After 1990, following the economic changes, the quantity of fuels used has significantly decreased. The underlying reasons are the clearly decreased production volumes. In 2009 the global economic crisis caused a remarkable drop of 28% in fuel consumption and also the emissions of the industrial sector. Since 2009, however, fuel consumption increased again by 68%. The fuel mix changed, too. Combustion of coal and oil products is losing its importance among fossil fuels. In contrast, growing biomass and other fuel use can be observed. The figure below clearly demonstrates the dominance of natural gas (60% in 2021).

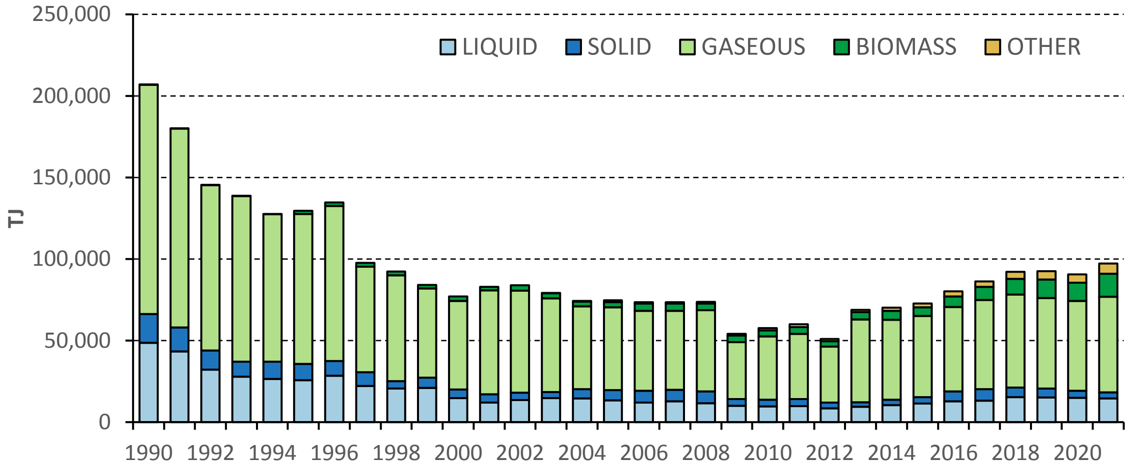


Figure 3.10 *Fuel use in manufacturing industries and consumption (1990-2021)*

Methodological issues

Generally, measured emissions were reported in source categories with larger emitters (e.g. iron and steel, cement production). Otherwise, either Tier 1 approach based on fuel use or Tier 2 approach based on production data was followed. Choice of method, emission factors, and activity data will be described in the following at source category level.

3.4.1 Stationary combustion in manufacturing industries and construction: iron and steel (NFR code 1A2A)

Reported Emissions: NO_X, SO_2, CO
Measured Emissions: NO_X, SO_2, CO
Methods: (T1). T2, T3
Emission factors: D, CS
Key source: SOx

Currently, one large emitter, ISD Dunaferr Group, is operating in the country with a blast furnace plant, steelworks, hot rolling mill, cold rolling mill, profiling works, etc. There are a few other plants as well; however, the sum of their reported emissions is about 1-2% of the total in this source category.

Methodological issues

In this submission, the general recommendation on allocation of emissions at Tier 2 methodology was followed, namely to assign NO_X, SO_2, CO emissions to combustion only. Plant specific (measured) data were reported directly for 2003-2020 which corresponded to a Tier 3 method. To our knowledge, the facility reports cover all relevant processes in the country. For previous years, country specific emission factors were derived using pig iron as activity data. In case of SOx, as the fuel-mix was totally different in the 90's as it is now (i.e. significant amount of high sulphur fuel oil was used in the 90's), emissions were calculated on the basis of fuel use (T1 method) for the period 1990-2000.

Activity data

Pig iron production data from different sources (statistical office, www.worldsteel.org, www.eurofer.org) were used. Fuel consumption data were taken from the IEA annual questionnaires.

Emission factors

The following country specific emission factors were used for the years when no plant-specific data were available (all expressed in kg/kt pig iron):

SOx: 597, NOx: 1500, CO: 51,446.

Uncertainties and time-series consistency

The time series can be regarded as consistent.

Source-specific QA/QC and verification

Different facility reports were taken into account including the National Environmental Information System and E-PRTR. In case of questionable data, the plant was contacted directly by the inventory compiler institute.

Source-specific recalculations

None.

Source-specific planned improvements

The time series of the plant specific measurements will be analyzed.

3.4.2 Stationary combustion in manufacturing industries and construction: non-ferrous metals (NFR code 1A2b)

Reported Emissions: NO_X, SO_2, CO
Measured Emissions: (NO_X, CO)
Methods: T2, (T3)
Emission factors: D
Key source: -

Methodological issues

In this submission, the general recommendation on allocation of emissions at Tier 2 methodology was followed, namely to assign only NO_X, SO_2, CO emissions to combustion. As many plant-specific (measured) data were taken into account as possible for the last three years but for alumina production only up till 2013.

Activity data

Tier 2 approach requires production-based activity data which were received from the Hungarian Central Statistical Office. In 2020, secondary copper and brass (1.826 Gg), secondary zinc (0.028 Gg), secondary aluminum (228 Gg) production were the relevant processes to be taken into account. As regards (secondary) aluminum and alumina production, facility level emission data was taken into account and no production data was used (NO_x and CO only). It should be noted that primary aluminum production was stopped in 2006.

Emission factors

Tier 2 emission factors were taken from Table 3-13, Table 3-17, and Table 3-18 of the 2019 EMEP/EEA Guidebook (Ch. 1.A.2 Manufacturing industries and construction).

Uncertainties and time-series consistency

Although consistency has been improved, the time series can only be regarded as consistent for the period 2003-2019 due to missing activity data.

Source-specific QA/QC and verification

None.

Source-specific recalculations

None.

Source-specific planned improvements

Further improve consistency of the time series.

3.4.3 Stationary combustion in manufacturing industries and construction: chemicals (nfr code 1a2c), pulp, paper and print (nfr code 1a2d), food processing, beverages and tobacco (NFR Code 1A2e), other (NFR Code 1A2GVIII)

Reported Emissions: Main Pollutants (except NH_3), Particulate Matter, CO, Priority Heavy Metals, Other Heavy Metals, POPs
Measured Emissions: None taken into account
Methods: T1
Emission factors: D, CS
Key source: -

Methodological issues

The general Tier 1 approach was followed here, using fuel consumption as activity data with mostly default T1 emission factors.

Activity data

The IEA/Eurostat annual questionnaires were used for the whole time-series (1990-2020). In these subsectors, natural gas is the dominant fuel accounting for 70-80% of total fuel consumption.

In the Other category emissions from the following industrial activities are accounted for: Mining and Quarrying, Manufacture of electrical and optical equipment, Manufacture of transport equipment, Manufacture of textiles and textile products, Manufacture of leather and leather products, Manufacture of wood and wood products, Manufacturing goods not elsewhere classified, Construction. In addition, emissions from some autoproducer plants are included here for the years before 1998.

Emission factors

Mostly default Tier 1 emission factors relevant for small combustion were taken from the 2019 EMEP/EEA Guidebook (Ch: Small combustion, Tables: 3-7 to 3-10) with the following exceptions.

- Country specific SOx emission factors for heavy fuel oil were derived based on the share of “high sulphur” and “low sulphur” fuel oils taken from the IEA time series. It was assumed that high sulphur oil has 3% sulphur content, whereas low sulphur oil has 1%.
- For other liquid fuels, domestic legislation was taken into account which maximized the sulphur content of liquid fuels as 0.2% from 2004 and as 0.1% from 2008.
- Domestic legislation (Regulation of the minister of environment No 23/2001) was taken into account also to derive some country specific emission factors as detailed in *Table 3.2*.
- The SO_2 emission factors for solid fuels were determined from sulphur content of the coal using the equation (EF=Sx20000/CV) from the Guidebook. It was assumed that imported hard coals and brown coals have an average sulphur content of 1% and 1.75%, respectively.

Table 3.2 *Country specific emission factors*

Pollutant	Fuel	Emission factor [kg/TJ]	Period
SO_x	imported coal	167	2002-2020
SO_x	domestic brown coal	1255	2002-2020
SO_x	domestic coal	3800	1990-2001
SO_x	other liquid fuels	93	2004-2007
SO_x	other liquid fuels	47	2008-2020
NO_x	coal	125	2002-2020
NO_x	liquid fuels	136	2002-2020
CO	coal	105	2002-2020
CO	biomass	141	2002-2020
TSP	other liquid fuel	15	2002-2020
TSP	coal	63	2002-2020
TSP	biomass	85	2002-2020

Uncertainties and time-series consistency

The time series are most probably consistent.

Source-specific QA/QC and verification

None.

Source-specific recalculations

No methodological change has taken place. However, the updated IEA/Eurostat time series have been used as activity data (fuel consumption).

Source-specific planned improvements

None.

3.4.4 Non-metallic minerals (NFR code 1A2f)

Reported Emissions: Main Pollutants (except NH_3), CO, Priority Heavy Metals, Other Heavy Metals, POPs
Measured Emissions: NO_X, SO_2, CO, Hg (cement production)
Methods: T3, T2
Emission factors: D, CS
Key source: NOx, SOx, Hg.

Emissions from lime, cement, asphalt, glass, mineral wool, bricks and tiles and fine ceramics production is accounted for here in this source category.

Methodological issues

Generally, Tier 2 approach was followed based on production statistics. For cement production plant-specific data were taken into account. Moreover, measured emission values (SOx, NOx, CO) reported by cement factories were directly used for the period 2008-2013, and 2016-2020. (Measured data were incomplete for the years 2014-2015 at the time of the inventory compilation therefore they were not used.) For previous years, country specific emission factors were derived (Table 3.3). As cement factories combust also industrial waste (among others fossil wastes such as rubber and plastic), facility reports of PCDD/F and Hg were especially important. However, these emission data need to be analyzed further. Except for cement production, only NO_X CO and SO_x emissions were allocated to the energy sector which is in line with the Tier 2 approach.

For cement plants that use validated average values to calculate annual emissions, reported emissions data were amended in some years with the confidence interval as given in the IED (i.e. 20% of SO_2, 20% of NO_X, and 10% of CO).

Activity data

Production data (ceramics, bricks, mineral wool, asphalt, lime) were received from the Hungarian Central Statistical Office. Clinker data were provided by the cement factories.

Emission factors

Tier 2 emission factors were taken from Tables 3-23–3-29 of the 2019 EMEP/EEA Guidebook (Ch. 1.A.2 Manufacturing industries and construction).

There are some exceptions, though. We have analyzed the reported emission data from the five (currently only three) cement plants in the country. Based on plant specific emission data and clinker production statistics, country specific emission factors were derived as summarized in Table 3.3 below.

Table 3.3 *Country specific emission factors in cement production*

Pollutant	Country specific emission factor	Default EFs
NO_x	2500 g/Mg product	**1241 g/Mg product**
CO	2000-1550 g/Mg	**1455 g/Mg product**
Hg	0.06 g/Mg product	**0.041 g/Mg product**
PCDD/F	-	**4.1 ng I-TEQ/Mg clinker**

Uncertainties and time-series consistency

The time series can be regarded as consistent.

Source-specific QA/QC and verification

Statistical and plant specific production data were compared.

Source-specific recalculations

-

Source-specific planned improvements

None.

3.4.5 Mobile combustion in manufacturing industries and construction: (NFR code 1A2GVII)

Reported Emissions: Main Pollutants, Particulate Matter, CO, Priority Heavy Metals, Other Heavy Metals, POPs (except PCDD/F, HCB, PCBs)
Measured Emissions: -
Methods: T2
Emission factors: T2
Key source: -

Methodological issues

Tier 2 method from the 2019 EMEP/EEA Guidebook is implemented. This method classifies the used equipment into the fuel types and layers of engine technology. The engine technology layers are stratified according to the EU emission legislation stages, and three additional layers are added to cover the emissions from engines prior to the first EU legislation stages. The used layers are as follows: <1981; 1981-1990; 1991-Stage I; Stage I; Stage II; Stage IIIA; Stage IIIB; Stage IV; Stage V. The penetration of the new technology is taken into account in the form of split (%) of total fuel consumption per engine age (irrespective of inventory year) as it can be seen for diesel-fueled non-road machinery in Table 3-3 in the Guidebook.

Activity data

All gasoil consumption from the IEA/Eurostat Annual Questionnaire has been regarded as for off-road mobile use. Although we rely mostly on the IEA/EUROSTAT Annual Questionnaires in their original form, the allocation of gasoil does not seem to be consistent for the whole time-series. (For example, gasoil consumption in the industry sector is reported in the AQ as 30 kt and 140 kt for 2010 and 2011, respectively) Therefore, some gasoil consumption had to be reallocated from road transport to industry based on 2011-2015 data allocations and value added volumes for previous years.

Emission factors

Emission factors were taken from Table 3-2 "Tier 2 emission factors for off-road machinery" from the Chapter Non-road mobile sources and machinery of the 2019 Guidebook. The only exception was SOx for which country specific factors were applied corresponding to domestic quality of gasoil (sulphur content currently max. 10 mg/kg).

Uncertainties and time-series consistency

The time series can be regarded as consistent.

Source-specific QA/QC and verification

None.

Source-specific recalculations

-

Source-specific planned improvements

None.

3.5 Transport (NFR sector 1A3)

This sector covers all the emissions from fuels used for transportation purposes and includes also some non-fuel related emissions (e.g. from vehicle tyre and brake wear, or road surface wear).

Looking at the whole period of our time series, a sharp decrease of 60% in transport of goods could be observed during the regime change in the early 90's. The Hungarian transport performance expressed in freight ton-kilometers had not reached the level of 1985 until 2005. Beside these significant changes of volume, also the structure of goods transport altered. Currently, the most important means of freight transport is road transportation with a share of 67%, followed by rail (20%), pipeline (9%) and waterway (3%). In 1990 we saw a completely different picture with railway and waterway being the dominant mode of transport representing 40% and 34%, respectively. Compared to 2020 the share of road transportation was 15% about 25 years ago. In 2020, there was a drop in transport (-10% in freight tonne-kilometres) especially due to a 13% decrease in road transportation, then it increased again by 2021.

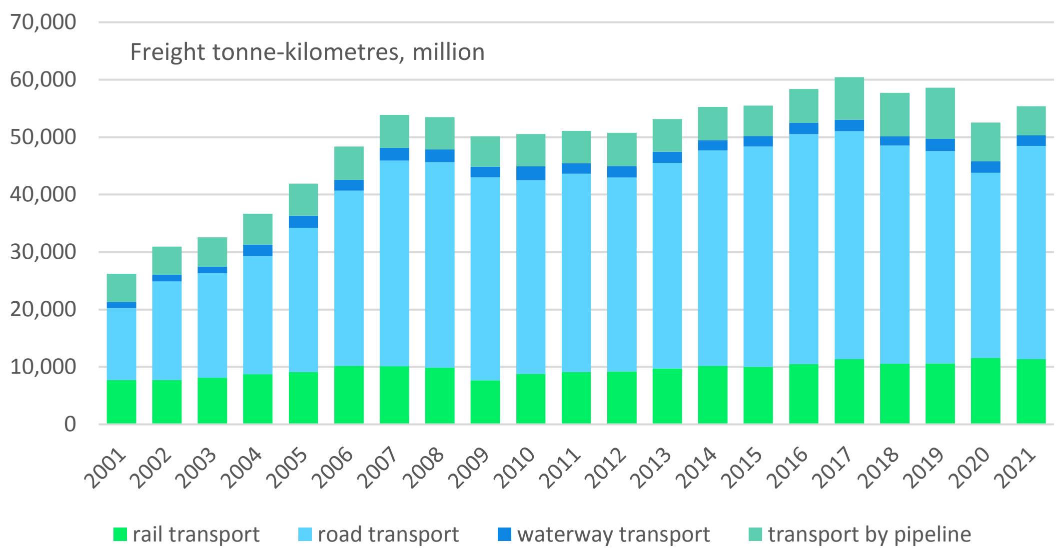


Figure 3.5.1 *Trends in goods transport (2001-2021). Source: HCSO*

Passenger transport also underwent considerable changes. The stock of passenger cars had more than doubled since 1990. Within this increase, the proportion of Eastern European cars characterized by high fuel consumption and obsolete technology decreased; for example, currently more than half of the passenger cars complies with at least the Euro 4 emission standards. At the same time, the average age of the car fleet has increased again in recent years to 15 years in 2021. (The lowest average age of vehicles (10.3 years) was observed in 2006, before the economic crisis.) Figure 3.5.2 summarizes the above-mentioned developments.

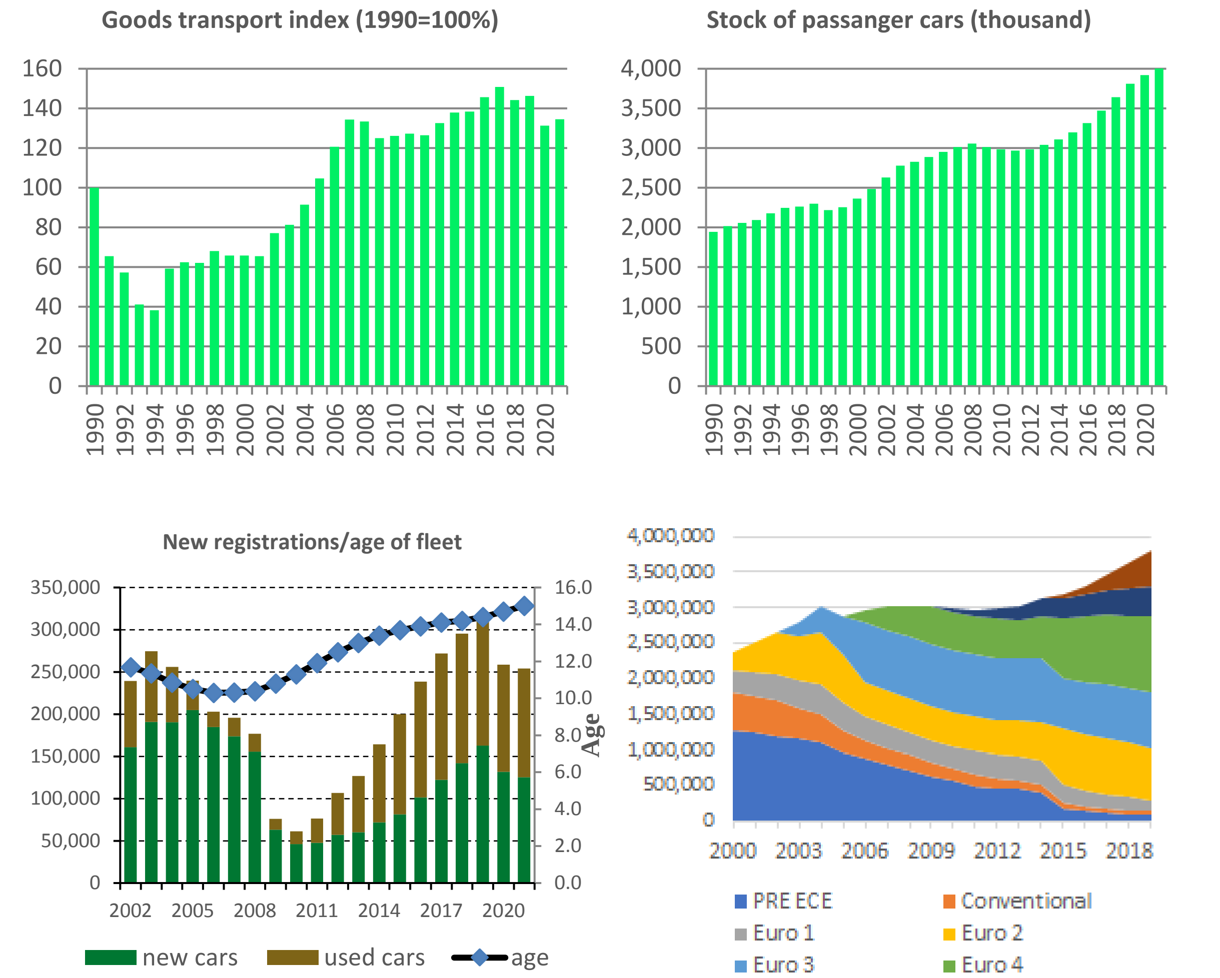


Figure 3.5.2 *General changes in the transport sector*

Electrification of the railways in Hungary eliminated mostly the solid fuel consumption. (Today there are only few lines where steam engines are used during non-scheduled vintage train trips.) Diesel oil consumption of railways decreased as well, by 80% between 1990 and 2021.

Emissions were calculated basically from the national fuel consumption data from the IEA/Eurostat annual questionnaires. The national energy statistics usually does not include the quantities of aviation gasoline used for in-country (or international) aviation, and of the diesel oil used for international (river) navigation. However, aviation gasoline consumption appeared in the latest energy statistics for the years 2016-2021. Fuel consumption data (i.e. both aviation gasoline and jet kerosene) of domestic aviation are also taken from the Eurocontrol database containing data on IFR flights. We can also assume (based on personal communication with the energy statistics provider) that 0.9-1.0 kt aviation gasoline is consumed for domestic flights, mostly for agricultural use. (These emissions are not included in the inventory as VFR flights are not included in the Eurocontrol database.) It is also possible that some minor amount of aviation fuel (for VFR flights) is included elsewhere in the inventories (e.g. under road transport).

According to the information received from the energy statistics provider, natural gas use related to natural gas transport was previously included under distribution losses in the energy statistics. In the inventory, however, a complete time series of emissions from pipeline transport is included separately.

Figures below illustrate the fuel consumption of the sector:

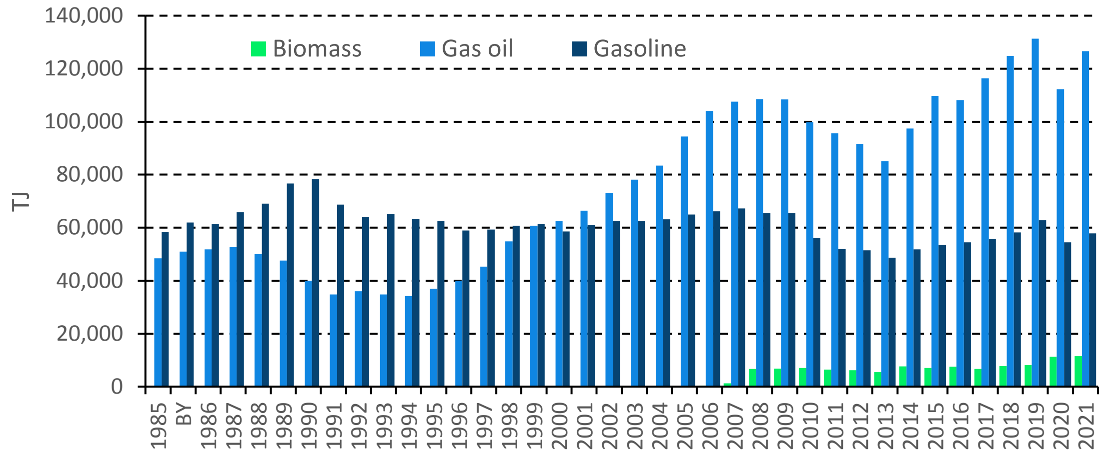


Figure 3.5.3a *Gasoline, diesel and biomass consumption and total energy use in the Transport Sector (1990-2021)*

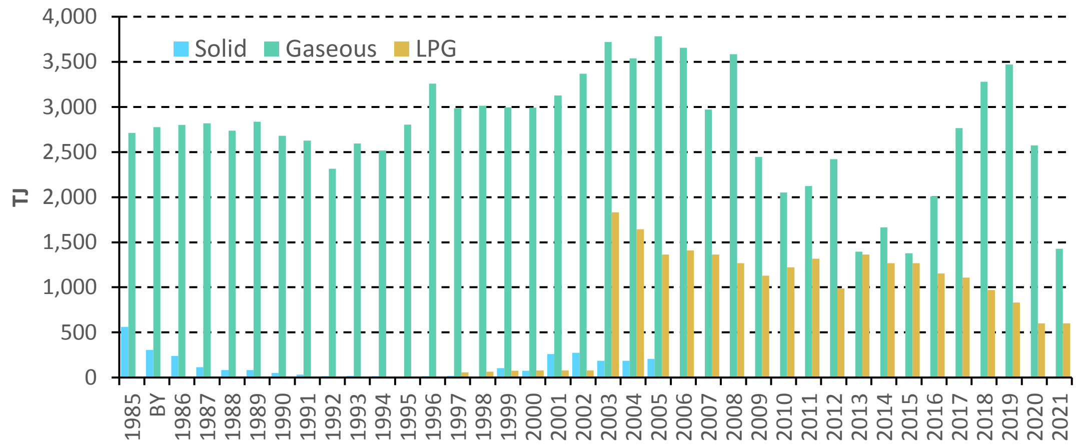


Figure 3.5.3b *LPG, natural gas and solid fuel combustion in the Transport Sector (1990-2021)*

Figure 3.5.3 clearly shows that in contrast to the other described sectors, transport consumption had a rising overall tendency from the mid 90's until 2008. Starting in 2009 the trend of fuel consumption has changed due to the economic crisis. Both fuel consumption and mileage of vehicles (km/year) increased until 2009 and started decreasing afterwards. The increasing fuel prices (up to 2012) could also be one of the reasons of a record low gasoline consumption in the transport sector. It is worth mentioning that the mass of domestically transported goods via road transport decreased by 44% between 2008 and 2012. However, the decreasing trend stopped, fuel consumption started to grow again and national transport of goods increased by 28% since 2012. Then, in 2020, there was a drop of 8% in national transport of goods, and at the same time fuel consumption decreased quite significantly by 12%.

In the second half of 2005 the Hungarian oil and gas company's refinery, MOL Danube Refinery, started to process bioethanol from vegetable raw material with high sugar content, also biodiesel have been used for blending. These bio components appear also in *Fig. 3.12.*

LPG has been used since 1992. It should be noted that due to the current commercial practices, in-container (household, institutional) uses are difficult to separate from traffic uses (i.e., distribution at petrol stations). This may be the reason for the sharp increase in 2003, which does not fully reflect the actual changes but is the result of a change in the approaches used for the preparation of the statistics. Accordingly, liquid fuel uses by the general public (currently including LPG only) show a significant drop in the same period.

3.5.1 Road transport (NFR code 1A3b)

Reported Emissions: Main Pollutants, Particulate Matter, CO, Priority Heavy Metals, Other Heavy Metals, POPs
Measured Emissions: None taken into account
Methods: COPERT-5
Emission factors: COPERT-5
Key source: NO_x, NMVOC, CO, Pb

Methodological issues

For the emission calculations, the COPERT-5 (**Co**mputer **P**rogramme to Calculate **E**mission from **R**oad **T**ransport) model, specifically version 5.6.1 was used for the whole time series. The transition to the COPERT program family was a necessary step in the area of national road transport emission calculations, since most countries use this program which ensures international comparability. By using the latest version of the model, also consistency of the time series is ensured.

Activity data

The COPERT model requires quite detailed background information. To produce input data for the model for the whole time series, basically three data sources were used:

1./ The compiler institute received the COPERT outputs run by KTI Institute for Transport Sciences (KTI) for the years 2006, 2007, 2009, 2011, and the period 2012-2021. The structure of the input data was produced in a way which fully complies with that described in the software requirement.

Generally, the input data required by the COPERT model are as follows:

- vehicle fleet [n]
- mean activity [km/year], lifetime cumulative activity [km]
- traffic situations: vehicle share [%], average speed [km/h], trip characteristic
- national annual energy consumption [tons/year]
- country-specific environmental information:

- national monthly averages of daily minimum and maximum temperatures [°C]
- monthly average relative humidity [%]
- Reid vapor pressure [kPa]
- determination of country-specific sulfur content of petrol and diesel fuels [ppm wt]
- determination of bioethanol ETBE (Ethyl tert-butyl ether) content (biodiesel FAME (Fatty acid methyl ester) content is provided in the model because it is known from EU data)

As the input data were not obtained from the same source and were not always suitable for direct use, therefore the data were needed to be processed prior. The largest bulk of the work was processing the vehicle stock data, since this data ensures the basis for emission calculations performed by COPERT5. Therefore, it was crucial to perform an utmost precise work regarding the vehicle stock data, which was obtained from the Ministry of the Interior (BM). At the request of the KTI, vehicle data tables required to perform the task were extracted from the BM database. The vehicle stock classifications and emission categorizations were prepared using the following table:

Category	Fuel	Engine capacity [cm³] / Gross weight [t]
Passenger Cars	Gasoline	2-stroke (≤1000 cm³)
		≤800 cm³
		801 – 1400 cm³
		1401 – 2000 cm³
		≥2001 cm³
	Petrol Hybrid	≤800 cm³
		801 – 1400 cm³
		1401 – 2000 cm³
		≥2001 cm³
	Petrol PHEV	801 – 1400 cm³
		1401 – 2000 cm³
		≥2001 cm³
	Diesel	≤800 cm³
		801 – 1400 cm³
		1401 – 2000 cm³

		≥2001 cm³
	Diesel PHEV	≥2001 cm³
	LPG Bifuel	≤800 cm³
		801 – 1400 cm³
		1401 – 2000 cm³
		≥2001 cm³
	CNG Bifuel	≤800 cm³
		801 – 1400 cm³
		1401 – 2000 cm³
		≥2001 cm³
Light Commercial Vehicles	Gasoline	N1-I ≤1305 t
		N1-II 1306 – 1760 t
		N1-III 1761 – 3500 t
	Diesel	N1-I ≤1305 t
		N1-II 1306 – 1760 t
		N1-III 1761 – 3500 t
Heavy Duty Trucks	Gasoline	> 3,5 t
	Diesel	Rigid <=7,5 t
		Rigid 7,5 - 12 t
		Rigid 12 - 14 t
		Rigid 14 - 20 t
		Rigid 20 - 26 t
		Rigid 26 - 28 t
		Rigid 28 - 32 t

		Rigid >32 t
		Articulated 14 - 20 t
		Articulated 20 - 28 t
		Articulated 28 - 34 t
		Articulated 34 - 40 t
		Articulated 40 - 50 t
		Articulated 50 - 60 t
Buses	Diesel	Urban Midi <= 15 t
		Urban Standard 15 - 18 t
		Urban Articulated> 18 t
		Coaches Standard <= 18 t
		Coaches Articulated > 18 t
	Diesel Hybrid	Urban
	CNG	Urban
L-Category	Petrol	Mopeds 2-stroke <50 cm³
		Mopeds 4-stroke <50 cm³
		Motorcycles 2-stroke >50 cm³
		Motorcycles 4-stroke <250 cm³
		Motorcycles 4-stroke >750 cm³
		Motorcycles 4-stroke 250 - 750 cm³

Table 1: Vehicle categorization required by the COPERT5 model

In the case of traffic situations, the percentage of vehicle share and average speed values within the driving conditions (urban, rural, motorway) for each vehicle category were used based on the results of previous research carried out by the KTI.

Specifying the average speed is less important in the case of rural and highway traffic as the function takes similar values between 45-105 km/h. However, determining the average speed for urban transport is more important, because of a difference of 1 km/h in the first third of the function results in a larger difference in emissions. Naturally, the functions vary from one pollutant to another, but the influence of speed is similar in each case.

Among the trip characteristics, it is important to mention the average travel time and duration. According to available statistics, European average of 12.5 km were determined by experts. The distribution of the distances traveled varies from country to country, but typically a large proportion (80%) travel only short distance (less than 15 km). It plays a significant role in the emissions of the cold start phase. The average travel distance of 12 km average travel time of 25 minutes was used.

Detailed and accurate calculations of mean activity could not have been made in previous years. Previously, data were obtained from queries extracted from the RKF (Regular Environmental Review) database provided by the Ministry of the Environment, and subsequently corrected based on the annual fuel consumption. However, in COPERT5, it is possible to provide fuel balanced mean activity, which the program automatically counts and takes into account when calculating the emissions. From 2018, there was a development research in the KTI regarding the mean activity and the project outcomes were used from 2019. From now on, the mean activity data will be more precise and the query system calculates the mileage records of the Vehicle Inspection Database for each vehicle category.

The source of the annual fuel consumption data was the national energy statistics provided by the Hungarian Energy and Public Utility Regulatory Authority (MEKH). The data published by the MEKH will also be transmitted to EUROSTAT. Energy conversions were executed following the values given in the EMEP/EEA air pollutant emission inventory guidebook 2019.

Fuel	**Density [kg/m3]**	**Calorific values [MJ/kg]**
Gasoline	750	43.774
Diesel	840	42.695
LPG	520	46.564
CNG	175	48
Biodiesel	890	37.3
Bioethanol	794	28.8

Table 2: Default density and calorific values of primary fuels determined using the EMEP/EEA air pollutant emission inventory guidebook 2019

The country-specific environmental data was obtained partly from the Hungarian Meteorological Service (OMSZ) (average monthly maximum and minimum temperatures), partly from Hungarian fuel standards (Reid vapor pressure - RVP).

2./ For all the years in the period 2000-2017 for which no domestic data were provided by the Institute for Transport Sciences, data purchased from Emisia SA, developer of the COPERT model, were used as inputs. As claimed by the data provider, *"the vehicle fleet and activity data provided by EMISIA SA for the compilation of national emission inventories with use of the COPERT model reflect our best knowledge of national situation in each country until 2013. These data have been updated using the* *road transport dataset and methodology of the TRACCS research project. More specifically, TRACCS dataset of the period 2005-2010 has been combined with the previous FLEETS research project dataset (2000-2005) and with latest official statistics available (2011-2013) to produce aligned and up to date time series for the period 2000-2013 (no projection included). The quality, completeness, and consistency of these two projects datasets, which have been extensively reviewed and cross-checked, ensure that the compiled countries data are also of good quality."*

In case of larger discrepancies between the Emisia database and domestic data, preference was always given to data from domestic sources. Again, whenever necessary, the mileage data were slightly modified to reflect better the domestic statistics on fuel sold.

3./ The compiler institute produced input data for the remaining years (i.e. 1985-1999). Quantification of the stock of each road vehicle type was based on Statistical yearbooks of Hungary and annual reports of Ministry of Economy and Transport about the Hungarian vehicle fleet. Also, personal communications with experts took place. Compared to recent years where about 200 vehicle categories were taken into account, the input database for the earlier part of the time series is less detailed containing 35 vehicle categories, and it probably has a higher uncertainty. Nowadays we have the most precise vehicle categorizations reaching almost 400 vehicle categories required by the COPERT5 model, though the increased number of categorizations are not only the result of the detailed vehicle registration database provided by the BM, but the development of the traffic industry as well, because we have more alternative fueled vehicles and higher Euro standards.

Emission factors

The emission factors used were mainly the default factors from the COPERT5 model with a few exceptions. One of these exceptions is lead. It should be noted that unleaded gasoline was sold only after 1989. Since lead is poison for catalytic converters, it was assumed that real catalyst vehicle has been used after this time.

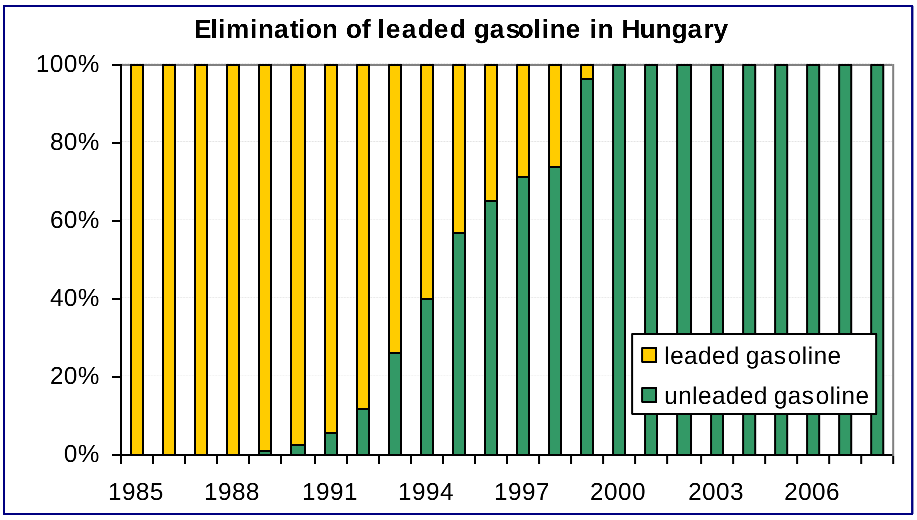


Figure 3.5.4 *Elimination of leaded gasoline in Hungary*

(Source: Hungarian Petroleum Association (MÁSZ), Annual Reports 1996-2008)

Based on information from the refinery, we applied the following values.

Table 3.4 *Country specific emission factors in road transport*

	1990-91	1992-99	2000-2005	2005-
Lead content of leaded gasoline (g/l)	0.34-0.33	0.13-0.04	NA	NA
Sulphur content of gasoline (%wt)	0.2	0.05	0.015	0.001
Sulphur content of diesel (%wt)	0.5	0.05	0.035	0.001

Uncertainties and time-series consistency

As in other countries there is a problem the calculation with transit transport. During the calculation, we were taken into account the emission of transit as a part of emission of Hungarian road transport, but it could be an uncertainty because of the fuel consumption. It is a tendency, that transit transport does not use Hungarian fuel. The size of the country gives possibility to go through it in one day, the maximum length of Hungary can be driven without fuel tanking in the area of the country. The trucks tank typically in abroad.

Using similar versions of the COPERT model has improved the time series consistency of this category.

Source-specific QA/QC and verification

None.

Source-specific recalculations

For this submission, we have used updated fuel consumption data. More importantly, a new version of the COPERT model (5.6.1) was used for the entire time series.

Source-specific planned improvements

-

3.5.2 Air transport (NFR code: 1A3a)

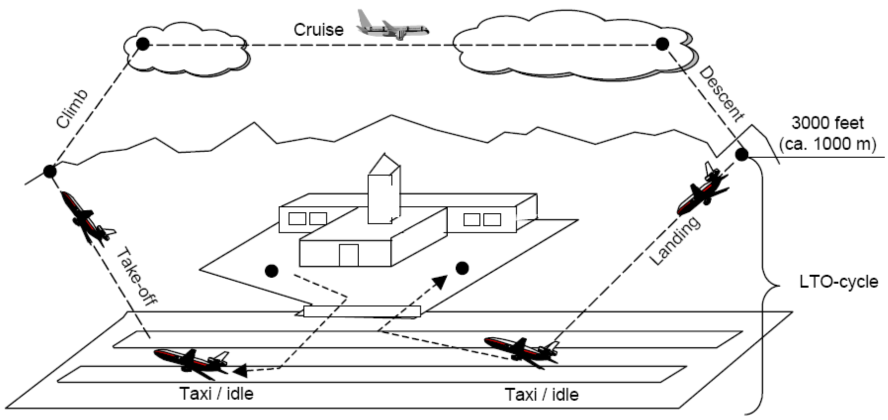
Reported Emissions: Main Pollutants (except NH_3), CO, Particulate Matter
Measured Emissions: None taken into account
Methods: LTO
Emission factors: ICAO, FOI database
Key source: -

Methodological issues

The EEA's Guide to calculating emissions from air transport recommends three different methods. The first and second calculation method *(Tier 1 and Tier 2)* is a top down method, that is, it takes as a basis the total quantity of fuel used in a given year, while the third method *(Tier 3)* is a *bottom-up* method.

For the CO_2 and SO_2 components as well as heavy metals the first method is entirely suitable, since from the fuel quantity and with a good approximation these components can be directly calculated, and they are independent from the different technological engine related solutions. PM_{10} and $PM_{2,5}$ are those pollutants that are most dependent on the type of aircraft and load, therefore, for the approximate calculation of these the first method cannot be recommended. With the help of the third calculation method the fuel consumption can be controlled. The calculations are greatly influenced by the availability of data.

Calculation of air transport emissions is carried out in accordance with international practice, on the basis of the emission factors of the so-called LTO-cycles (landings / take-offs). Based on the figure, it becomes clear that the LTO-cycle contains only land and near-land operations, since approaching the airport for landing and leaving the airport - the take-off - are assessed under ~ 1000 m (3000 ft) altitude. The considered operational phases of an aircraft are, therefore, landing (from about 1,100 m), roll-out, onset to a parking position, getting out from the parking position, approaching the runway and take-off (up to 1,100 m). Depending on the aircraft type, according to the EPA/AP-42 requirements the time taken for the LTO-cycle varies from 26 to 33 minutes.



Structure of the LTO-cycle

Each year, the European Organisation for the Safety of Air Navigation (EUROCONTROL), supporting the European Environment Agency (EEA) and Member States of the European Union (EU), under contract with DG CLIMATE ACTION, calculates:

- the mass of fuel burnt annually and
- the masses of certain gaseous and particulate emissions produced annually

by civil aviation flights starting from and/or finishing at airports in the member states of the EU.

For this submission, emissions are reported based on a methodology developed by EUROCONTROL. The calculation used in the "EUROCONTROL Method" is a mix of a Tier 3A and Tier 3b calculation. For the LTO cycle, a Tier 3a calculation is performed; average fuel consumption and emission data are assumed for (aircraft type, type of engine) combinations. For the CCD phase, a Tier 3B calculation is performed in which the amounts of fuel burnt and pollutants emitted are calculated on a flight segment by flight segment basis.

Activity data

Basically, two databases have been used. First, the IEA/EUROSTAT Annual Oil Questionnaire, especially the time series of jet kerosene consumption, has been taken into account. However, for the period 2005-2020, we have relied on the activity data and emission database of EUROCONTROL. As regards LTO phases, activity data have directly been taken from EUROCONTROL. Activity data for calculations of emissions of CCD phases reported as memo items are based also both on EUROCONTROL data and IEA data, however they might differ up to 29%.

Emission factors

As EUROCONTROL made both activity data (fuel burnt) and the resulting emissions available, emission factors built into the "EUROCONTROL Method" were used implicitly for the period 2005-2020. As for preceding years, (implied) emission factors were derived from emissions taken from EUROCONTROL and jet kerosene use as reported to the IEA. These constant emission factors were applied for the period 1990-2004.

Uncertainties and time-series consistency

The time series can be regarded as consistent.

Source-specific QA/QC and verification

None.

Source-specific recalculations

The latest data from Eurocontrol was used.

Source-specific planned improvements

It is not planned to change the methodology.

3.5.3 Railway transport (NFR code 1A3C)

Reported Emissions: CO, CH, NO_x, SO_2, Particulate Matters, Heavy Metals, POPs
Measured Emissions: None taken into account
Methods: default (according to the Tier 2 calculation method proposed by the EMEP-EEA Guidebook 2019)
Emission factors: Tier 2
Key source: -

Methodological issues

During the previous years the Tier 1 method was applied based on the data published by the Hungarian State Railways (MÁV), Győr-Sopron-Ebenfurt Railway (GySEV) and GySEV-Cargo. The amount of exhaust gas emission components was calculated by the total amount of fuel used by the national rail transport and the previously determined specific emission values. For the years of 2015 and 2016 emissions were calculated from the amount of diesel fuel consumed in the rail traction taken from energy statistics and from the coal consumption of nostalgia trains published by the GySEV and MÁV.

As the NOx emissions from rail have become a key category in recent years, it was necessary to apply a new calculation method (Tier 2 method) that required more detailed data for the year 2017 in comparison to the previously applied simplified method (Tier 1 method).

Activity data

Railway transport emissions are affected by many factors; these will be discussed in the following subsections. Since the currently used method of calculation is based on the fuel consumption of the rail traction, the factors described below, therefore, do not have a direct influence on the calculation.

Table 3.5.3.1 shows the total length of lines and vehicle stock of rail transport for the years 2000, 2005, 2010 and 2015-2019. It can be defined that the length of all the operated railway lines has decreased in recent years, although not significantly. The number of locomotives during the same period also decreased to a minimum. As of 2010, unlike in previous years, the statistical yearbook no longer contains data on the proportion of rail traction (electrical - diesel).

Table 3.5.3.1

Track and vehicle stock of public railways, traction

	2000	2005	2010	2015	2016	2017	2018	2019	2020
The length of the operated railway lines (km)	7,668	7,685	7,352	7,197	7,811	7,682	7,732	7,743	7,787
From which:									
two or multiple tracks	1,293	1,292	1,335	1,205	1,250	1,219	1,219	1,221	1,219
electrified	2,718	2,791	2,929	2,963	3,018	3,066	3,069	3,111	3,111

Track length of operated lines	12 739	12 735	9 178	9 358	11 424	11 531	11 336	11 345	11,393
Stock, numbers of each									
Locomotives	1 107	1 040	1 077	1 153	1 170	1 167	1 133	1 194	1,154
Railcars	339	369	431	515	498	500	493	512	492
Coaches	2 988	3 060	2 788	2 526	2 186	2 147	2 112	2 111	2056
Freight cars	20 778	16 027	11 357	8 916	9 070	9 043	8 750	8 679	8640
The proportion of the traction, [%]									
electrical	81,1	N/A	N/A	N/A	N/A	N/A	N.A.	N.A.	N.A.
diesel	18,9	N/A	N/A	N/A	N/A	N/A	N.A.	N.A.	N.A.

Table 3.5.3.2 shows the change of rail passenger performance. The quantity of all the number of people transported declined by about 12% over a decade, which is true for rail, although it shows an increasing tendency since 2010. Regarding the freight performance, it can be stated that although the weight of goods transported has fallen back to the year of 2001, the performance of transport was not much lower than in previous years. It can be stated that the railroad performance dropped approximately to a half. The proportion of freight performance and weight are relatively constant, and variations in the performance can be caused by changes in transport distances.

Table 3.5.3.2

Interurban passenger transport (2001–2021)				
Year	Number of passengers carried [million people]	Of which train [million people]	Passenger-kilometer [million]	Of which train [million]
2001	755,9	161,7	25 546	10 005
2002	755,9	164,6	26 102	10 531
2003	743,7	159,9	26 418	10 286
2004	737,3	162,7	27 217	10 544
2005	720,1	156,4	26 736	9 880
2006	721,7	156,8	27 733	9 584
2007	682,3	149,8	26 885	8 752
2008	691,1	144,9	25 989	8 293
2009	650,8	142,8	24 881	8 073
2010	652,8	140,5	25 059	7 692
2011	665,9	145,7	25 979	7 806
2012	669,3	147,8	23 285	7 806
2013	671,0	148,5	23 701	7 842
2014	671,9	146,1	25 056	7 738
2015	656,9	144,4	25 623	7 609
2016	648,6	146,6	26 933	7 653
2017	642,9	146,9	28 528	7 666
2018	634,9	148,0	30 148	7 770
2019	625,0	146,9	31157	7752
2020	452.9	100.7	16179	4854
2021	440,9	103,8	16 655	5 435

Domestic freight transport (2001–2021)				
Year	**Weight of freight transported [thousand tons]**	**Of which rail [thousand tons]**	**Freight-ton-kilometer [million]**	**Of which rail [million]**
2001	152 552	17 824	9 766	1 967
2002	237 732	16 560	13 413	1 788
2003	230 961	14 592	13 224	1 593
2004	228 019	15 217	13 692	1 725
2005	238 233	13 440	14 031	1 645
2006	253 388	12 078	14 928	1 491
2007	237 823	10 834	15 629	1 289
2008	251 666	11 198	15 495	1 374
2009	222 568	12 362	14 448	1 268
2010	190 635	11 398	13 667	1 341
2011	176 031	10 763	12 848	1 162
2012	156 503	11 556	12 411	1 423
2013	155 775	12 325	12 504	1 596
2014	184 218	15 020	13 559	2 049
2015	186 575	14 409	13 868	1 784
2016	184 450	13 558	15 216	1 578
2017	177 701	15 191	16 106	1 998
2018	201 265	15 730	17 231	2 020
2019	200 423	14 574	17 755	1 763
2020	184 378	11 071	16 500	1 366
2021	211 446	10 192	18 470	1 278

Calculating emission of railway transport

In the course of our calculations, our focus essentially was on determining the emissions of the rail traction and, in particular, of the mobile sources (diesel locomotives).

In the railway sector, the sources of air pollution can be grouped as follows:

a) transport by railway or public road
- traction
- heating in trains
- dispersing, evaporation
- public road transportation

It is a typical feature that pollution occurs from mobile sources, non-stationary, along the tracks.

b) service-related activities
- car cleaning
- loading
- storage of materials (cargo and fuel as well)
- construction, track maintenance
- vehicle repairs, component manufacturing
- heat supply

c) other activities
- municipal heat supply
- wastewater treatment, waste management
- wreck

As previously mentioned, in the course of calculating emissions only exhaust emissions of diesel locomotives on track were taken into account.

Railway traction vehicles

In terms of emissions from traction vehicles, only those were taken into account which are driven by heat engines. In the case of electrical traction vehicles, that is to say the power plant emissions were not taken into account. Traction with an internal combustion engine is the most polluting traction type. The emissions from coal-fired traction are very low because of its low share. The coal used for this purpose is primarily connected to the nostalgia trains, but a part of it is used for heating as well. The distribution of nostalgia trains is not uniform in space and time: takes place mainly during the summer season and on touristically more popular lines. The amount of sulfur dioxide and solid pollutants emitted locally is significant compared to other traction types, while the other components are negligible. From the amount of diesel consumption used for traction, the emissions of pollutants were calculated based on the specific emission values of the relevant instructions and measurements. It should be noted that the emission of diesel locomotives, apart from fuel quality, is highly dependent on the type, condition and operating conditions of the engine. Petrol-powered vehicles are primarily used by the construction specialist. In fact, a conventional car engine is running in the railway work machine. During the calculation of the air pollution, these machines were also ignored. The reason for this is, firstly, that its emissions are negligible (magnitudes) lower than those of diesel traction. It can be also stated that this source of emission includes diesel locomotives at stations or railway stations, or shunting locomotives for a short distance.

Road vehicles

The railway has a significant road fleet. On the one hand, it is used to complement the basic service activity to ensure its own operation. This corresponds in the case of the composition of the vehicle fleet with the domestic vehicles (both diesel and petrol are included). At the same time, we also took into consideration vehicles with registration plate when calculating the emissions from road transport, so we did not calculate the emissions of the vehicle fleet of railroad separately.

The additional air pollutant effect of carriage of rail transport

The passing train causes dust dispersion/suspension. When braking, the brake block - in the case of modern vehicles the frictional brake pad and some of the iron powder formed by the wear of each the brake disc, tire and rails adheres to the train, while the rest, which are heavier than air, settles within the limit of expropriation. Replacing iron brake blocks with plastic-based material and using disc brakes reduces this pollution.

The air pollution impact of freight transport is more significant. The loading and unloading of bulk goods are usually carried out on siding tracks or on a designated loading track.

Some of the airborne contaminants are dust, and the other part is the liquid, possibly leaving the gas. Considering that the emissions of the above-mentioned origin cannot be reliably calculated, we have also omitted to define it. The recommended specific emission values were grouped into 3 categories divided by EMEP-EEA Guidebook instead of previous country-specific emission factors. Some of the airborne pollutants are dust, and the other part are those materials, which leave from carried goods made up of liquid or possibly gas. Considering that the above-mentioned emissions cannot be reliably calculated, we have also omitted to define it.

The quantities of fuel used for traction were provided by MÁV and GYSEV corporations. Due to the transition to the new calculation methodology, we have recalculated emissions since 2010.

Emission factors

The recommended specific emission values were used in 3 categories grouped by the EMEP-EEA Guidebook instead of the previous country-specific emission factors.

Emission factor values for harmful components [g / ton of fuel]				
Fuel	**Diesel**			**Carbon**
Locomotive type	**line-haul locomotives**	**shunting locomotives**	**railcars**	
NOx	**63**	**54,4**	**39,9**	**2 194**
CO	**18**	**10,8**	**10,8**	**27 367**
NMVOC	**4,8**	**4,6**	**4,7**	
NH_3	**0,01**	**0,01**	**0,01**	
TSP	**1,8**	**3,1**	**1,5**	**10 970**
PM_{10}	**1,2**	**2,1**	**1,1**	
$PM_{2,5}$	**1,1**	**2**	**1**	
N_2O	**0,024**	**0,024**	**0,024**	
CO_2	**3140**	**3190**	**3140**	**380 000**
CH_4	**0,182**	**0,176**	**0,179**	
SO_2*	**0,2**	**0,2**	**0,2**	**45 497**
For diesel, Tier2 guide values (except for SO2, where only Tier1 is present),* *In the case of coal fuel, the former Institute for Transport Sciences Non Profit Ltd. (KTI) emission factors were used in the calculation*				

Uncertainties and time-series consistency

The time series is most probably consistent.

Source-specific QA/QC and verification

None.

Source-specific recalculations

None

Source-specific planned improvements

None.

3.5.4 National navigation (NFR code 1A3DII)

Reported Emissions: CO, CH, NO_x, SO_2, Particulate Matters, Heavy Metals, HCB, PCB, DIOX
Measured Emissions: None taken into account
Methods: default
Emission factors: T1
Key source: -

Methodological issues

The calculations are based on energy statistical data and default emission factors. Currently, it is not possible to distinguish between domestic and international navigation therefore all emissions are included under national.

Activity data and emission factors

Fuel consumption data were taken from the IEA annual questionnaires. Our data source of emission factors was the 2019 EMEP/EEA Guidebook.

Uncertainties and time-series consistency

The time series can be regarded as consistent.

Source-specific QA/QC and verification

None.

Source-specific recalculations

-

Source-specific planned improvements

It is not planned to change the methodology.

3.5.5 Pipeline transport (NFR code 1A3ei)

Reported Emissions: Main Pollutants (except NH_3), Particulate Matters, CO, Heavy Metals, POP (except HCB, PCB)
Measured Emissions: None taken into account
Methods: T1
Emission factors: D, CS
Key source: -

Methodological issues

The calculations are based on (amended) energy statistical data and partly default, partly country specific emission factors.

Activity data

The IEA Annual Gas Questionnaire contains fuel consumption data only for the years 2010-2019. Therefore, backward extrapolation was carried out using total natural gas consumption as proxy information.

Emission factors

The same emission factors were applied as for small industrial combustion (see Ch. 3.4.3).

Uncertainties and time-series consistency

The time series is most probably consistent.

Source-specific QA/QC and verification

None.

Source-specific recalculations

-

Source-specific planned improvements

It is planned to switch to T2/T3 method in the next submission.

3.6 Other sector (NFR sector 1.A.4)

Reported emissions: Main Pollutants, Particulate Matter, CO, Heavy Metals, POPs
Measured Emissions: None
Methods: Tier 1/Tier 2 methodology
Emission factors: Default Tier 1/Tier 2 (Residential: coal, biomass), CS (SO_2)
Key source: NO_x, NMVOC, SO_x, NH_3, $PM_{2.5}$, PM_{10}, TSP, BC, CO, Pb, Cd, Hg, PCDD/F, PAH, HCB

This sector covers combustion in public institutions, by the population and in the Agriculture/Forestry/Fisheries Sector. Mostly, the general Tier 1 approach, i.e., a fuel-based methodology with default emission factors, was applied. Consequently, fuel consumption (amount and structure) determines level and trend of emissions to a large extent. Exceptions from this rule are biomass and coal fired stoves and boilers in the residential sectors for which T2 emission factors were used. Also, T2 method is applied for off-road machinery used in agriculture.

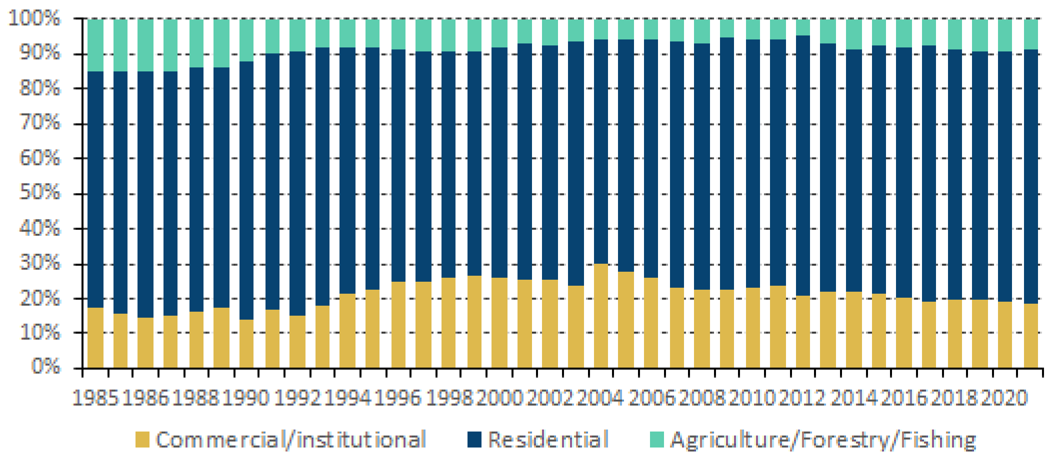


Figure 3.6.1 *Fuel combustion in the subsectors of the Other Sector (1990-2021)*

Figure 3.6.1 demonstrates the share of the three subsectors within the sector. By far, the most important is the residential sector representing around two third of all fuel use therefore in the following we will concentrate more on households. Please note that the calculation method was more or less the same, only the above-mentioned methodological distinction was applied between residential and commercial/institutional or agriculture/forestry/fishing source categories. Off-road mobile emissions in agriculture are reported separately.

Generally, in contrast with the significant reduction of coal and oil consumption, natural gas consumption has increased significantly. The population switched from coal to natural gas combustion. Household heating oil was completely replaced by LPG. During the period 1990-2021, the length of natural gas pipe-network increased from 22,549 km to 85,059 km. The number of households supplied with natural gas increased from 1.6 million in 1990 (42%) to 3.4 million in 2010 (77%) but decreased a little to 3.3 million (73%) since 2010. Residential consumption represented 36% of domestic supply of natural gas in 2021. Piped gas is available in 91% of all settlements in Hungary, and this figure has not changed much since 2005 (but it was only 15% in 1990). 72% of households use natural gas for heating purpose as well. Although individual residential heating became more and more widespread, still 654 thousand dwellings (15% of all dwellings) are supplied with district heating and 604 thousand with hot water. Most of this heat (over 80%) is generated from natural gas use; however, the resulting emission was not accounted for here but under the Energy industries subsector.

The dominance of natural gas and the historical shift from liquid and solid fuels is clearly demonstrated by Figure 3.6.2 below. Steadily rising tariffs and the economic crisis were the main reasons of growing biomass use in this sector as well.

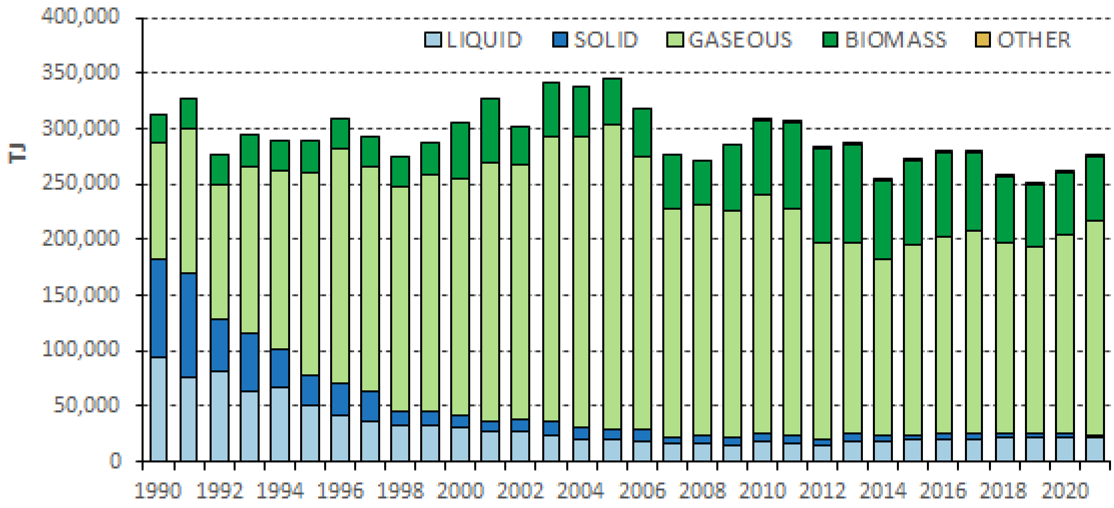


Figure 3.6.2 *Share of different combusted fuel types in the Other Sector (1990-2021)*

Natural gas consumption can be influenced by several factors. One of these factors might be the weather and the resulting heating demand. Heating degree day (HDD) is a quantitative index that reflects demand for energy to heat houses and businesses. This index is derived from daily temperature observations. The inside temperature is 18°C and base temperature (the outside temperature above which a building needs no heating) is 15°C in our calculation (following the standard European methodology). Figure 3.6.3 illustrates the relationship between residential fuel consumption and HDD. The figure demonstrates that increased fuel use can often be explained by increased HDD values and vice versa.

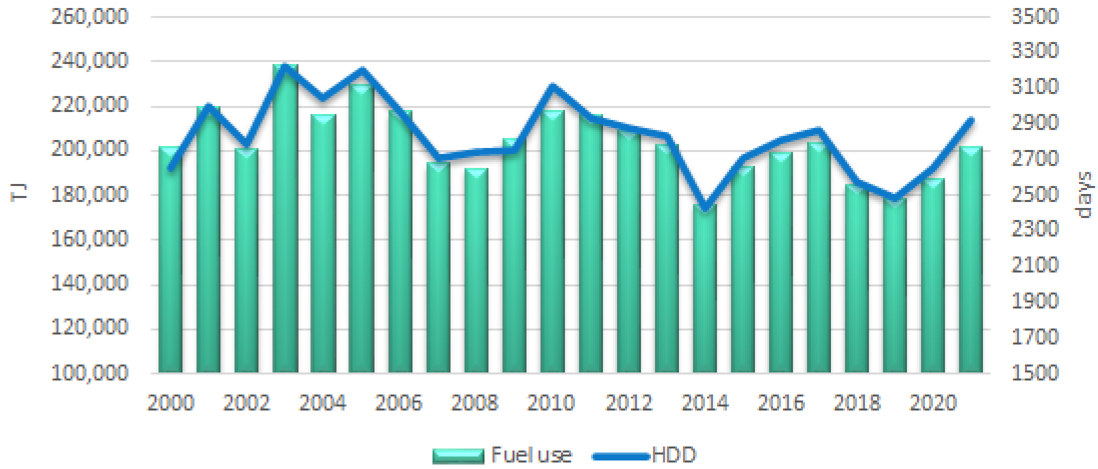


Figure 3.6.3 *Comparison of residential fuel consumption and HDD between 1995 and 2021*

Another factor is definitely the price. The (nominal) price of pipelined gas increased from 325 to 1360 Ft/10 m3 between 2000 and 2012. This price increase might have led to increased biomass use as a substitute fuel in the residential sector. However, the above-mentioned trends have changed in recent years. Gas prices have dropped by 26% since 2012 (but are still more than double as high as in 2005), and consumption started growing again.

So, it seems that the price elasticity of demand of natural gas and other fuels. We know that the price of natural gas was significantly higher in the period 2008-2013 than that of biomass, and in this very period natural gas consumption decreased and biomass consumption increased. After 2014, however, the trend changed due to decreased natural gas prices (the price advantage of biomass disappeared), so gas consumption started increasing again while biomass consumption decreased. This is demonstrated in Figure 3.6.4 below.

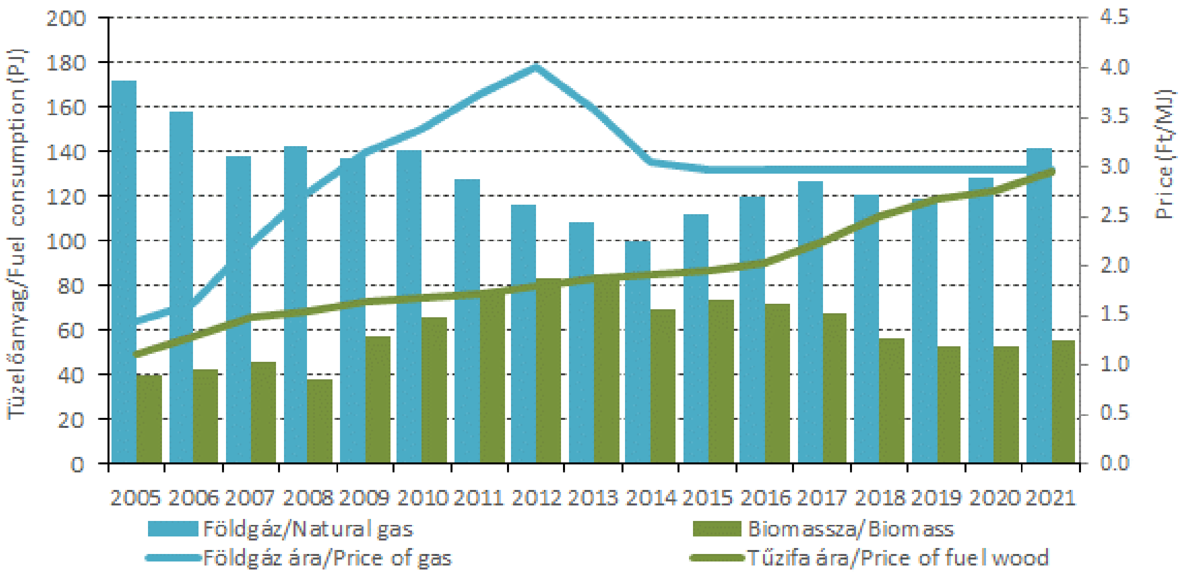


Figure 3.6.4 *Price elasticity of natural gas and fuelwood (2005-2021)*

The monthly natural gas consumption of an average household decreased from 125 m^3 in 2003 to 70 m^3 in 2014, and then increased to 99 m^3 in 2021. In this significant decreasing trend - beside the higher energy prices – most probably also the more energy-conscious approach of the population plays a role and is definitely greatly affected by the weather. In addition, larger decrease in biomass use indicates some fuel switch from fuelwood to natural gas in the residential sector.

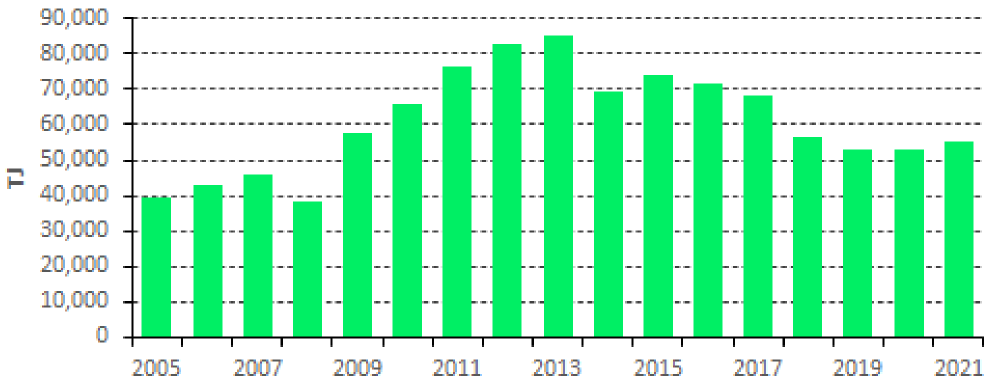


Figure 3.16 *Use of biomass (wood, wood wastes) use in the residential sector (2005-2021)*

Activity data

The joint IEA/Eurostat annual questionnaires served as activity data consistently for the whole time-series (1990-2019). It has to be repeated that about half of the losses in natural gas distribution reported in energy statistics is assumed to be fired and accounted for here in this sector.

The Tier 2 method applied for coal and wood fired stoves and boilers in the residential sector required more information on the used technologies. Based on the latest comprehensive population census conducted by the Hungarian Central Statistical Office in 2011 it was assumed that 35% of coal was used in conventional stoves and 65% in conventional boilers. As regards biomass consumption, 50% was allocated to conventional stoves and the remaining half to conventional boilers.

In order to report separate emissions for the source category “Agriculture/Forestry/Fishing: Off-road vehicles and other machinery”, diesel oil consumption had to be split between stationary and mobile combustion. The Energy Statistical Yearbooks published around 1990 contained separate data for gasoil used in tractors and harvesters. Based on this information, a bit more than 60% could be allocated to mobile consumption in the early period of the time series. Considering the generally diminishing role of liquid fuels in stationary combustion, it is assumed that after 2001 all gasoil allocated to agriculture in the energy statistics has been used for mobile off-road machinery.

Emission factors

Generally, default Tier 1 emission factors were used as published in the Small combustion chapter of EMEP/EEA Guidebook, however with one minor and two major exceptions. Domestic legislation regarding maximum sulphur content of liquid fuels was taken into account similarly as described above for other source categories. As regards SO_2 emission factors for solid fuels, our calculations were based on sulphur content and calorific value of the different coals, as follows:

$EF (SO_2) = [S] x 20,000 / CVNet$

where:

$EF (SO_2)$ is the SO_2 emission factor (g/GJ)

[S] is sulphur content of the fuel (% w/w)

CVNet is fuel CV (GJ/tonne, net basis)

Sulphur content of the domestically produced coals was received from the Hungarian Office for Mining and Geology (MBFH). Recently, domestic lignite and brown had a sulphur content of 1 to 3.3 per cent. In the 90’s, coals with even higher sulphur content were mined; domestic coal had an average sulphur content of 2.9%. The resulting implied emission factor for domestic brown coal changed from 4000 kg/TJ in the 90’s to 3300-3800 in recent years. For domestic coal, 20% retention is ash was assumed. The sulphur content of imported coals, based on data from distributors, varied between 0.5 and 3 per cent, therefore 1.75% sulphur content was assumed for sub-bituminous coal, and 1% for better quality hard coal. Calorific values were taken from the IEA annual coal questionnaire. In the case of imported coal, 10% retention in ash was assumed. The resulting IEF varied between 1200-2500 kg/TJ.

In case of biomass and coal fired stoves and boilers, for all other pollutants default T2 emission factors were applied representing conventional technologies.

As regards biomass burning, it is assumed that still traditional technologies dominate, e.g., 31% of total biomass is consumed in traditional stoves, and 50% in boilers. Effective stoves represent 12%, whereas modern advanced appliances have a share of 5%.

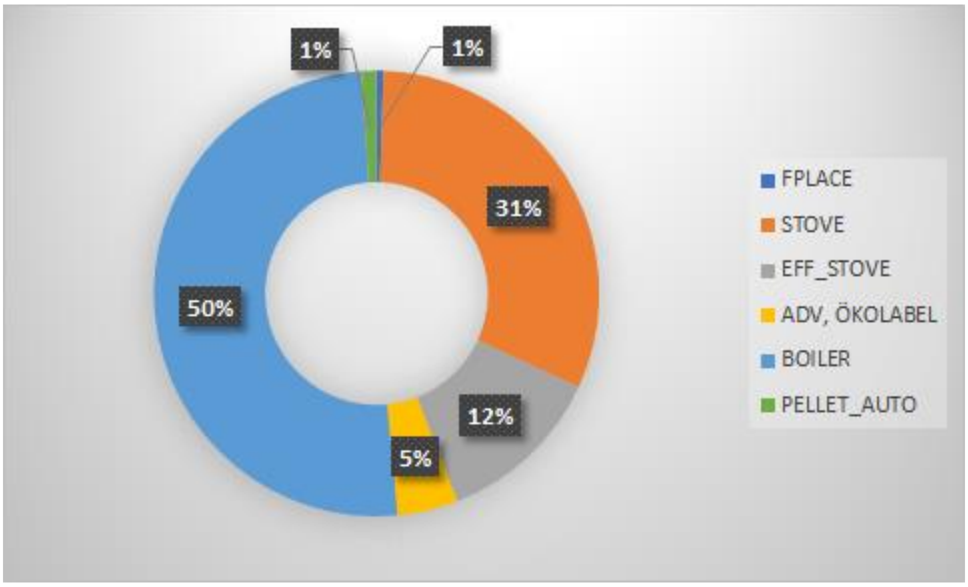


Figure 3.17 *Different biomass burning technologies in the residential sector (2021)*

Further methodological description

The methodology for off-road vehicles and other machinery used in agriculture and forestry is presented here. Tier 2 method from the 2016 EMEP/EEA Guidebook was implemented. This method classifies the used equipment into the fuel types and layers of engine technology. The engine technology layers are stratified according to the EU emission legislation stages, and three additional layers are added to cover the emissions from engines prior to the first EU legislation stages. The used layers are as follows: <1981; 1981-1990; 1991-Stage I; Stage I; Stage II; Stage IIIA; Stage IIIB; Stage IV; Stage V. The penetration of the new technology is taken into account in the form of split (%) of total fuel consumption per engine age (irrespective of inventory year) as it can be seen for diesel-fueled non-road machinery in Table 3-3 in the Guidebook. As domestic information on stock of agricultural machinery indicates a somewhat slower penetration of new technology (as in Denmark), original data in Table 3-3 have been modified as follows:

Table 3.6.1 *Used values for the split (%) of total fuel consumption per engine age (irrespective of inventory year) for diesel-fueled non-road machinery in Agriculture*

Engine age	USED	ORIGINAL in Table 3-3
0	4	8
1	4	7.6
2	4	7.2
3	4	6.79
4	6	6.39
5	6	5.99
6	6	5.59
7	6	5.18
8	6	4.78
9	6	4.38
10	6	3.98
11	4	3.57
12	3	3.17
13	3	2.77
14	3	2.37
15	3	1.97
16	3	1.9
17	3	1.83
18	3	1.76
19	3	1.69
20	3	1.62
21	2	1.55
22	1	1.48
23	1	1.41
24	1	1.34
25	1	1.28

Engine age	USED	ORIGINAL in Table 3-3
26	1	1.21
27	1	1.14
28	1	1.07
29	2	1

Emissions from household machinery in the category are reported in the category 1A4bii separately. Based on the latest survey of the Statistical Office, 56% of the households have garden or backyard on their own. There are 3.9 million households in Hungary; 56% of which is 2.2 million. It was assumed that for every garden 5 liters gasoline are used in a year. This would translate to 10.95 million liters or 8.2 kt gasoline. As part of the households use electronic devices, 6 kt of gasoline use was assumed for the whole time series. As the resulting emissions are not significant, for the calculations T1 methodology was used with default emission factors (i.e. the average factors for 2 stroke and 4 stroke engines).

Uncertainties and time-series consistency

The time series are most probably consistent.

Source-specific QA/QC and verification

None.

Source-specific recalculations

Activity data have been updated in line with the latest IEA/Eurostat Annual Questionnaires. In this submission we also assumed that 50% of the official (=as reported in the IEA/Eurostat Annual Questionnaire) distribution losses are actually combusted – party illegally which led to some increase in fuel consumption (1% on average) and consequently emissions especially in the early part of the time series (1985-2005).

Source-specific planned improvements

It is planned to switch to T2 methodology in the source category *1A4a Commercial/Institutional: Stationary*.

3.7 Fugitive emissions from fuels (NFR sector 1.B)

This sector includes emissions from non-combustion activities during fuel production, processing, transformation, transmission and storage and also venting and flaring operations during these processes. Combustion emissions connected to these processes are to be reported in sector 1.A. Therefore, mainly NMVOC emissions are reported in sector 1.B as suggested by the 2019 EMEP/EEA Guidebook. NO_X, CO and SO_x are to be reported only in source categories where process emissions occur, i.e. in 1.B.2.a.iv Refinery, in 1.B.1.b 'Fugitive emissions from solid fuels: solid fuel transformation and in1.B.2.c Venting and flaring. In the case of heavy metals and PAHs, coking is the significant emission source. The pollutants reported in the different subsectors are summarized in the following table together with the method used.

2.8. Table: Summary of pollutants and emissions estimation methods used within sector 1.B

	NO_x (as NO_2)	**NMVOC**	**SO_x (as SO_2)**	**NH_3**	**PMs**	**CO**	**HMs**	**POPs**
1B1a Fugitive emission from solid fuels: Coal mining and handling	NA	T3	NA	NA	T1	NA	NA	NA
1B1b Fugitive emission from solid fuels: Solid fuel transformation	T1	T1	T1	T1	T1	T1	T1	T1 – only PAHs
1B1c Other fugitive emissions from solid fuels	NA	NA	NA	NA	NA	NA	NA	NA
1B2ai Exploration, production, transport	NA	T2	NA	NA	NA	NA	NA	NA
1B2aiv Refining / storage	T3	T1	T3	T1	T1	T3	T1	T1 PCDD/F
1B2av Distribution of oil products	NA	T1, T2	NA	NA	NA	NA	NA	NE
1B2b Natural gas	NA	T2	NA	NA	NA	NA	NA	NE
1B2c Venting and flaring	T1/T2	T1	T1	NA	T1/T2	T1/T2	T1/T2	T2 – only PAHs

Default emission factors and activity data from statistics are used in every subsector, since direct measurement of fugitive emissions is not possible in general and we have no information on country specific calculations. An exception is coal mining, where country specific method is used based on research projects and another exception is 1.B.2.a.iv Refinery, where process emissions from oil refinery are reported based on plant specific data. The most important source of activity data is IEA Energy statistics of Hungary in the case of sector 1.B. The source categories of sector 1.B are very similar to the source categories of sector 1.B defined in UNFCCC reporting on greenhouse gases. While in UNFCCC reporting on greenhouse gases Natural Gas is the most important source as the main source of methane emissions, in this present LRTAP reporting Oil is of higher concern as the main source of NMVOC. In subcategory *1.B.2.d Other fugitive emissions from energy production* no emissions are reported for most part of the time series. However thermal water extraction is present is Hungary and CH_4 emissions from extraction of thermal water is reported in UNFCCC reporting, the 2019 EMEP/EEA Guidebook suggests to report only NH_3 emissions solely where electricity is produced directly by geothermal energy in this subsector. In Hungary the general use is heat only production and electricity or CHP production from geothermal energy started only in 2017, according to HCSO and IEA Energy Statistics. The associated (quite negligible) NH3, Hg and As emissions were included in the 2020 submission for the first time.

Trend

The aggregated trend of emissions in this sector is interesting only for NMVOC since all the other pollutants are to be reported only in one or two subsectors as it is detailed above. The trend is decreasing which is mainly caused by the decline and eventual disappearance of underground mining activities in Hungary, which is in direct correlation with NMVOC emissions from this subcategory. The emissions are also slightly decreasing in *1.B.2.a – Oil operations* which is the most significant subcategory. This can be explained by the slow fall of oil refined and total gasoline sold in Hungary. The latter is caused probably by the growing fuel prices.

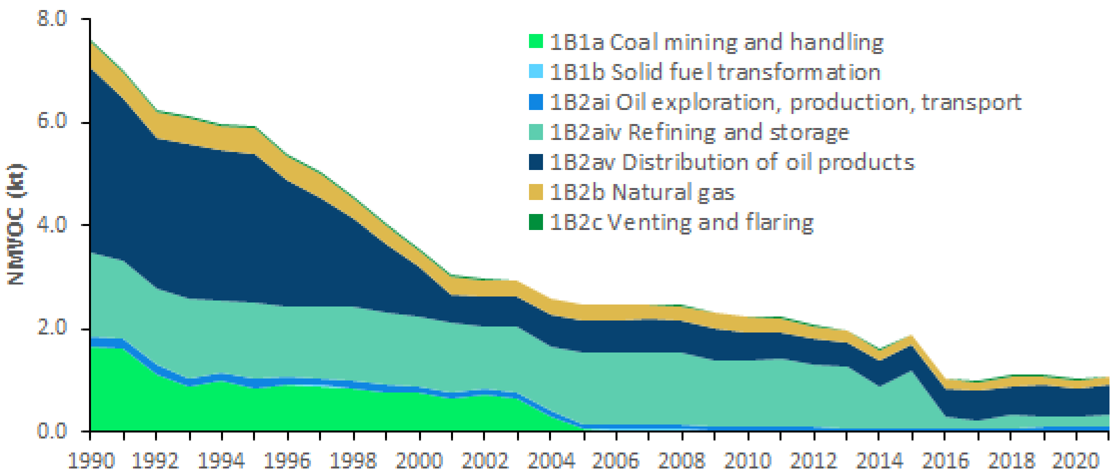


Figure 3.7.1 *Aggregated NMVOC emissions from sector 1.B*

It is worth mentioning that it is especially complicated to define realistic time series and trends of emissions in this sector, since the spread of environmentally sound technologies and improvement of abatement efficiencies has been a continuous process on diffuse or plenty of point sources. The time series presented in this chapter are mainly calculated using the default factors presented in the latest edition of the Guidebook, which usually reflects the state of the technology by the time of the preparation of the Guidebook.

Consequently, on one hand the later in time the more realistic the estimation of emissions is, on the other hand the trends of emissions reflect the change of activity rather than the change caused by application of abatement and control options. However, the application of default factors is necessary in order to fulfill the completeness and consistency criteria of inventory preparation until better data becomes available.

In the case of subsectors Refinery and Distribution of Oil products, a trend is already included in the emission factors. For details, please see the relevant chapters.

3.7.1 Fugitive emissions from solid fuels (NFR sector 1.B.1)

Non-combustion emissions arising during coal mining and transformation into coke are reported in this sector.

3.7.1.1 Fugitive emissions from coal mining and handling (NFR sector 1.B.1.a)

Reported Emissions: NMVOC, TSP, PM_{10}, $PM_{2.5}$
Measured Emissions: NMVOC
Methods: T1, T3
Emission factors: T1, T3

First of all, it is important to state that indigenous production of coal is not significant anymore in Hungary. The production used to be larger but a fast decline started after the change of regime especially in the case of underground mining. It is possible to see the trend of indigenous production of coal mined underground and total production of coal in *Table 3.7.3.* The 2019 EMEP/EEA Guidebook suggests reporting NMVOC and PM_{10} emissions in this sector. Emissions are reported using country specific methods. The country specific method is taken from UNFCCC reporting of CH_4 emissions originating from coal mining. NMVOC and CH_4 are both the components of in-situ gas originating from coal mines. In-situ gas content (quantity and composition) was measured in the one single underground coal working until 2017 in Hungary. The results are published in USGS, 2002. (Please see the Reference list). Methane is reported based on the results of these measurements in UNFCCC reporting. In this present LRTAP reporting NMVOC emissions are reported by proportioning the methane emissions. It is worth mentioning that the same method is used by determination of the emission factor of the 2009, 2013, 2016 and 2019 EMEP/EEA Guidebooks: "The NMVOC factor is based on an assessment of the emission factors for methane from an earlier version of the Guidebook, in combination with a species profile (Williams, 1993). This profile suggests an average NMVOC content between 0 and 12 % in the firedamp."

Surface (open-cast) mining is located in two area of the country, for the largest area no in-situ gas content is assumed, since the lignite exploited there is very young in coalification. (Net calorific value of the lignite mined there is under 10 MJ/m^3 and presented in sector 1.A.) As no methane emissions are reported from surface mining in UNFCCC reporting, no NMVOC emissions are assumed either. At the end of 2014 an old surface mine was re-opened with relatively high (20.75 m^3 CH_4/t coal) in-situ methane content, but the amount of mined coal was almost negligible. However, as CH_4 emission was reported in the UNFCCC regime, NMVOC emissions was also included here.

As far as our knowledge, Hungarian mines are not drained and there are no mine-burning or burning coal waste piles. From the older coal waste piles, the combustible part has been extracted for decades. Methane emission from abandoned mines is now calculated for the UNFCCC greenhouse gas inventory according to 2006 IPCC Guidelines, but not covered by this inventory.

To sum up, it is important to be aware that the decreasing and relatively low emissions (and implied emission factors) of NMVOC originating from coal mining presented in the figure below are due to the low in-situ gas content and NMVOC content of in-situ gases of coals of Hungary and the decreasing percentage of underground mining activity.

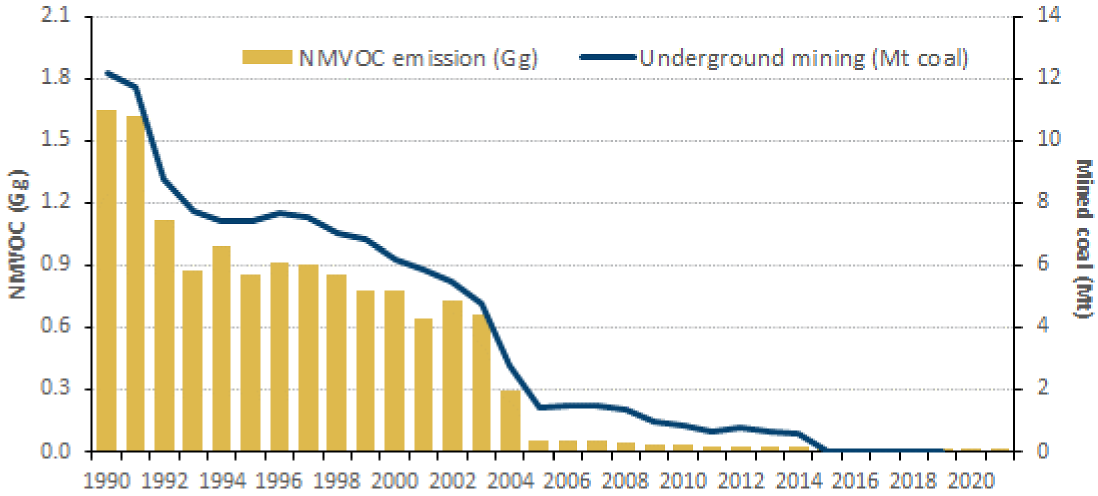


Figure 3.7.1.1 *Trend of NMVOC emissions in sector 1.B.1.a and production data of underground coal mining in Hungary*

Emission factors for particulate matter

TPS, PM_{10} and $PM_{2.5}$ emissions are reported using emission factors of 2019 EMEP/EEA Guidebook.

Emission factor for NMVOC

Methane emissions originating from coal mining are calculated in UNFCCC reporting where emission factors are based on individual measurement data. Between 2006 and 2014 the only one operating underground mine had been Márkushegy with 0.93 m^3/t coal mined in-situ methane content. The methane content of the in-situ gas (firedamp) is 95% based on the research conducted by the Hungarian Geological Service (Somos 1991, please see the Reference List for other references also), so NMVOC content of the gas is less than 5%. This is in line with the 2019 EMEP/EEA Guidebook 1.B.1.a chapter 3.2.2, where it is stated that an average NMVOC content of the firedamp is between 0 and 12 %. The methane emission from coal mining reported in NIR is the 95% of the in-situ gas (firedamp), so NMVOC emissions are calculated as the 0,05/0,95=0,05263 part of the methane emissions. In 2014 an old surface mine (in Mecsek region, where gassy mines of Hungary are located) was re-opened with relatively high (20.75 m^3 CH_4/t coal) in-situ methane content, but the amount of mined coal was almost negligible in the first year, however emission was reported in UNFCCC reporting, so NMVOC emissions also presented here. In the last two years production of this mine was very low, but underground production was also marginal, so this mine represented significant proportion in emissions, therefore the implied emission factor changed significantly. Since 2015 only one minor underground mine was working after the closure of the mine of the last bituminous/sub-bituminous coal fired power plant, and in 2018 underground mining ceased eventually.

Please note that the implied emission factor calculated based on NMVOC emission and AD reported in NFR Table might be misleading, since the latter is the TOTAL indigenous production and not the amount mined underground. However, in the case of PMs and TSP, the whole amount (TOTAL indigenous production) is to be taken into account.

Activity data

Detailed data on coal mining is available from both IEA (IEA_COAL_Total indigenous production) - energy statistics and the Hungarian Mining Authority (MBFH). Data is compared and they are corresponding. Underground mining of coal decreased significantly since 1980. Nowadays the open-cast mining of a coal has become more important. One single underground mine was operating until 2017, and open cast mining is also limited almost to one area of the country and it is combusted mainly in one single power plant. At the end of 2014 an old surface mine was re-opened to produce coal for resident population. However, this coal production is very limited (falls below the threshold of reported amount in the IEA publication) according to the information of Mining and Geological Survey of Hungary (former Hungarian Office for Mining and Geology) there is some CH4 and NMVOC emissions because of relatively high in-situ methane content.

Please note that the Activity data reported in NFR Table is the data of Total indigenous production of coal including underground and surface (open-cast) mining. PMs and TSP emission factors have this data as the unit of measure of the emission factor, but NMVOC emissions are correlated to activity data of underground mining.

It is worth mentioning that total coal production in 2014 increased only by 0.3 Mt compared to 2013, so because of rounding Table 3.7.2 has same values in case of total production, PM and TSP emissions for 2013 and 2014.

Table 3.2 *Activity data and emissions in sector 1.B.1.a*

	Underground mining		**Total production (underground + surface mining)**			
Year	***Coal (Mt)***	**1.B.1.a NMVOC (Gg)**	***Coal (Mt)***	**1.B.1.a $PM_{2.5}$ (Gg)**	**1.B.1.a PM_{10} (Gg)**	**1.B.1.a TSP (Gg)**
1990	12.19	1.78	17.66	0.09	0.74	1.57
1991	11.73	1.72	17.06	0.09	0.72	1.52
1992	8.76	1.21	15.75	0.08	0.66	1.40
1993	7.72	0.98	14.61	0.07	0.61	1.30
1994	7.38	1.03	14.11	0.07	0.59	1.26
1995	7.44	0.90	14.59	0.07	0.61	1.30
1996	7.65	0.93	15.19	0.08	0.64	1.35
1997	7.51	0.91	15.59	0.08	0.65	1.39
1998	7.04	0.86	14.65	0.07	0.62	1.30
1999	6.85	0.78	14.55	0.07	0.61	1.29

	Underground mining		Total production (underground + surface mining)			
Year	***Coal (Mt)***	**1.B.1.a NMVOC (Gg)**	***Coal (Mt)***	**1.B.1.a $PM_{2.5}$ (Gg)**	**1.B.1.a PM_{10} (Gg)**	**1.B.1.a TSP (Gg)**
2000	6.16	0.78	14.03	0.07	0.59	1.25
2001	5.87	0.64	13.91	0.07	0.58	1.24
2002	5.45	0.73	13.03	0.07	0.55	1.16
2003	4.74	0.66	13.30	0.07	0.56	1.18
2004	2.77	0.29	11.24	0.06	0.47	1.00
2005	1.42	0.05	9.57	0.05	0.40	0.85
2006	1.49	0.05	9.95	0.05	0.42	0.89
2007	1.47	0.05	9.82	0.05	0.41	0.87
2008	1.36	0.05	9.40	0.05	0.39	0.84
2009	0.96	0.03	8.99	0.04	0.38	0.80
2010	0.81	0.03	9.11	0.05	0.38	0.81
2011	0.67	0.02	0.00	0.05	0.40	0.85
2012	0.76	0.03	9.30	0.05	0.39	0.83
2013	0.62	0.02	9.55	0.05	0.40	0.85
2014	0.60	0.02	9.55	0.05	0.40	0.85
2015	0.02	0.005	9.26	0.05	0.39	0.82
2016	0.01	0.001	9.23	0.05	0.39	0.82
2017	<0.01	0.001	7.97	0.04	0.35	0.71
2018	NO	0.002	7.90	0.04	0.33	0.70
2019	NO	0.005	6.85	0.03	0.28	0.61
2020	NO	0.001	6.13	0.03	0.26	0.55
2021	NO	0.0002	4.99	0.03	0.21	0.44

Recalculations, QA/QC activities and planned improvements

There was no recalculation in this category. NMVOC emission from abandoned underground coal mines will be calculated after the revision of methane emission for the UNFCCC as the NMVOC calculation is based on methane emission.

3.7.1.2 Fugitive emission from solid fuels: solid fuel transformation (NFR sector 1.B.1.b)

Last update: 15.03.2023
Reported Emissions: NOx, SOx, NMVOC, CO, NH3, PM10, PM2.5, TSP, HMs (Pb, Cd, Hg, As, Ni), PCDD/F, PAHs
Measured Emissions: none
Methods: T1
Emission factors: T1
Key source: Trend PCDD/F

It is important to take into account the definition of the 2019 EMEP/EEA Guidebook in order to avoid double counting and separate the combustion emissions: *"This source category discusses emissions from coke ovens (only fugitive emissions including emissions from charging, door and lid leaks, off-take leaks, quenching, pushing. Emissions from combustion stacks and preheater are included in chapter 1.A.1.c 'Manufacture of solid fuels and other energy industries'. Coke production in general can be divided into coal handling and storage, coke oven charging, coal coking, extinction of coke and coke oven-gas purification. Combustion in coke oven furnaces is treated in chapter 1.A.1.c; the fugitive emissions from door leakage and extinction are covered by this chapter. Leakage and extinction lead to emissions of all major pollutants including heavy metals and POPs."* (2019 EMEP/EEA Guidebook). For fugitive emissions, the default Tier 1 approach is used. NMVOC, NH3, PMs, TSP, several HMs (Pb, Cd, Hg, As, Ni), PCDD/F and PAHs are reported here. In contrast to previous submissions, also NOx, SOx and CO emissions have been included.

Emission factor

Tier 1 default emission factors of the 2019 EMEP/EEA Guidebook are used for all emission calculation reported in 1B1b sector. However, the company producing coke in Hungary is reporting to LAIR, but not all the substances, where default EF is provided in the 2019 EMEP/EEA Guidebook (e.g. no reporting of PCDD/F, PCB, HCB, etc.). It might be the case that there is no emission at all from certain pollutants, but in the absence of detailed information, we prefer to use the default factors. In this way the results are probably a very conservative overestimation of several substances.

Activity data

Production of coke is available from IEA Energy statistics.

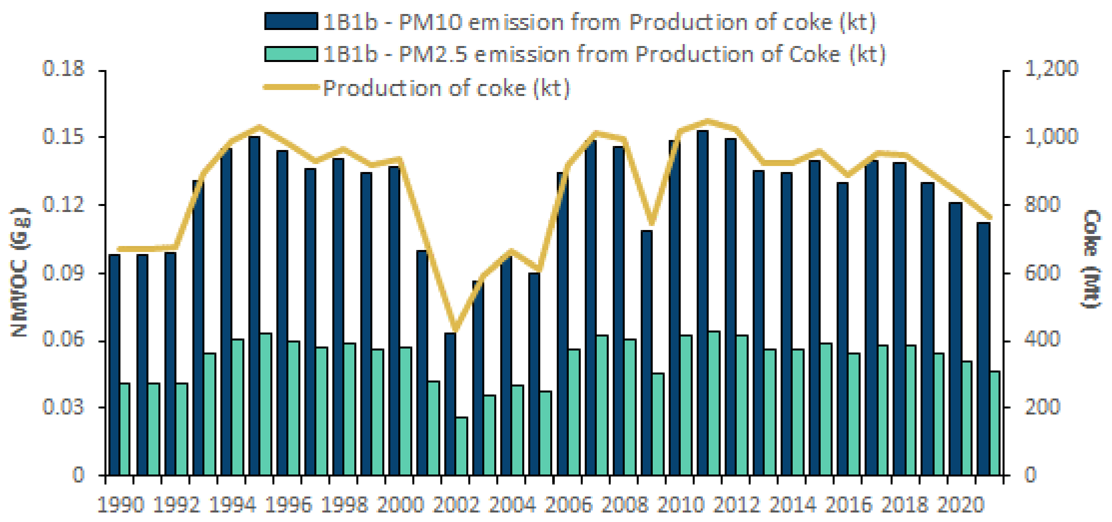


***Figure 3.3** Activity data and PM_{10} emission in 1.B.1.b sector*

Recalculations, QA/QC activities and planned improvements

None.

3.7.2 Fugitive emissions from oil and gas operations (NFR sector 1.B.2)

In this sector fugitive emission arising during exploration, production, transport, transmission, distribution, storage and processing of Natural Gas and Oil are reported including emissions from venting and flaring operations of these processes. NMVOC is the most important pollutant, but in the case of subcategory Venting and flaring also NOX, SOx and CO is reported within this sector (and not in sector 1) as it is suggested by the 2016 EMEP/EEA Guidebook.

In Hungary all the operations mentioned above are present but the processes related to indigenous production of natural gas and oil are not significant due to the relatively low volumes exploited.

In the case of natural gas, the fugitive emissions of methane are of higher concern, which is reported under UNFCCC reporting, NMVOC emissions are less important.

Also, in this sector default emission factors and activity data from statistics are used. 1.B.2.a.iv Refinery and 1.B.2.a v. Distribution of Oil products subsectors are the two exceptions. In the former case plant specific data and extrapolation is used. In the case of subsector Distribution of Oil products, the emission factor is time-dependent since the date and effect of change of technology was quite easy to define. For details, please see the relevant chapters.

The most important time series of activity data and NMVOC emissions by subsector are presented in the following tables.

***Table 3.3** Activity data and NMVOC emissions in 1.B.2.a Oil operations subsector*

Year	*Crude oil indigenous prod. (kt)*	**1B2a i-iii NMVOC (Gg)**	*Refinery intake (kt)*	**1.B.2.a iv – NMVOC (Gg)**	*Total gasoline sold (kt)*	**1.B.2.a v – NMVOC (Gg)**
1990	*1915*	**0.192**	*8147*	**1.629**	*1790*	*3.580*
1991	*1841*	**0.184**	*7655*	**1.531**	*1567*	*3.134*
1992	*1769*	**0.177**	*7458*	**1.492**	*1463*	*2.926*
1993	*1654*	**0.165**	*7717*	**1.543**	*1488*	*2.976*
1994	*1575*	**0.158**	*7043*	**1.409**	*1445*	*2.890*
1995	*1668*	**0.167**	*7506*	**1.501**	*1427*	*2.854*
1996	*1477*	**0.148**	*6787*	**1.357**	*1345*	**2.473**
1997	*1360*	**0.136**	*7022*	**1.404**	*1353*	**2.092**
1998	*1260*	**0.126**	*7171*	**1.434**	*1386*	**1.711**
1999	*1243*	**0.124**	*6982*	**1.396**	*1402*	**1.330**
2000	*1136*	**0.114**	*6801*	**1.360**	*1336*	**0.950**
2001	*1065*	**0.107**	*6842*	**1.368**	*1391*	**0.569**
2002	*1050*	**0.105**	*6035*	**1.207**	*1409*	**0.576**
2003	*1134*	**0.113**	*6382*	**1.276**	*1427*	**0.583**
2004	*1077*	**0.108**	*6371*	**1.274**	*1442*	**0.590**
2005	*948*	**0.095**	*7032*	**1.406**	*1486*	**0.608**
2006	*886*	**0.089**	*6915*	**1.383**	*1527*	**0.624**
2007	*839*	**0.084**	*7087*	**1.417**	*1575*	**0.644**
2008	*811*	**0.081**	*6967*	**1.393**	*1565*	**0.640**
2009	*791*	**0.079**	*6324*	**1.265**	*1565*	**0.640**
2010	*734*	**0.073**	*6389*	**1.278**	*1372*	**0.561**
2011	*659*	**0.066**	*6594*	**1.319**	*1271*	**0.520**
2012	*649*	**0.065**	*6114*	**1.223**	*1256*	**0.513**
2013	*599*	**0.060**	*5968*	**1.194**	*1160*	**0.474**
2014	*584*	**0.058**	*6507*	**0.799**	*1278*	**0.522**
2015	*623*	**0.062**	*6477*	**1.117**	*1288*	**0.527**
2016	*712*	**0.071**	*6637*	**0.235**	*1312*	**0.536**
2017	*714*	**0.071**	*6525*	**0.162**	*1344*	**0.549**
2018	*808*	**0.081**	*7039*	**0.236**	*1409*	**0.576**
2019	*930*	**0.093**	*6805*	**0.195**	*1506*	**0.616**
2020	*841*	**0.084**	*6714*	**0.195**	*1377*	**0.563**
2021	*881*	**0.088**	*6723*	**0.235**	*1458*	**0.596**

Notes regarding 1.B.2.a.v Distribution of oil products subsector:

Numbers in italics = Emissions calculated using Tier1 EF (Stage I control)

Numbers in green= linear interpolation

Numbers in bold= Emissions calculated using Tier 2 country specific EF (Stage II control)

Table 3.4: *Activity data and NMVOC emissions in 1.B.2.b Natural Gas operations subsector and 1.B.2.c Venting and flaring subsector*

Year	*Natural Gas indigenous prod. (Mm3)*	1.B.2.b.i-iii NMVOC (Gg)	1B2c i-ii NMVOC (Gg)	1B2c iii NMVOC (Gg)
1990	*4874*	**0.487**	0.0231	0.019
1991	*4976*	**0.498**	0.0236	0.018
1992	*4753*	**0.475**	0.0225	0.017
1993	*5042*	**0.504**	0.0239	0.018
1994	*4851*	**0.485**	0.0230	0.016
1995	*4886*	**0.489**	0.0231	0.017
1996	*4668*	**0.467**	0.0221	0.016
1997	*4369*	**0.437**	0.0207	0.016
1998	*3877*	**0.388**	0.0184	0.016
1999	*3401*	**0.340**	0.0161	0.016
2000	*3194*	**0.319**	0.0151	0.016
2001	*3231*	**0.323**	0.0153	0.016
2002	*3106*	**0.311**	0.0153	0.014
2003	*2945*	**0.295**	0.0046	0.015
2004	*3051*	**0.305**	0.0031	0.015
2005	*3028*	**0.303**	0.0031	0.016
2006	*3095*	**0.310**	0.0046	0.016
2007	*2615*	**0.262**	0.0031	0.016
2008	*2643*	**0.264**	0.0092	0.016
2009	*2968*	**0.297**	0.0031	0.015
2010	*2900*	**0.290**	0.0030	0.015
2011	*2766*	**0.277**	0.0031	0.015
2012	*2234*	**0.223**	0.0023	0.014
2013	*1960*	**0.196**	0.0030	0.014
2014	*1858*	**0.186**	0.0044	0.015
2015	*1772**	**0.177***	0.0028	0.015
2016	*1841*	**0.184**	0.0027	0.015
2017	*1821*	**0.182**	0.0036	0.015
2018	*1905*	**0.191**	0.0025	0.016
2019	*1716*	**0.172**	0.0023	0.016
2020	*1708*	**0,171**	0.0047	0.015
2021	*1526*	**0.153**	0.0017	0.015

*Revised IEA activity data

3.7.3 Exploration, production, transport of oil (NFR sector 1.B.2.a I-III)

Last update: 03.2023

Reported Emissions: NMVOC

Measured Emissions: none

Methods: T2

Emission factors: T2

NMVOC emissions arising during exploration, production and transport of oil are reported using Tier 2 method from 2019 EMEP/EEA Guidebook

Oil production is not significant in Hungary and the whole production is on-shore of course, so Tier 2 method can be applied. Due to the declaration of the producer company, the exploration and production is performed with high standard equipment.

Emission factor

The emission factors used are Tier 2 default emission factors from the 2019 EMEP/EEA Guidebook for production (i.e. 0.1 kg/Mg oil).

Activity data

Production of crude oil is available from IEA Energy statistics.

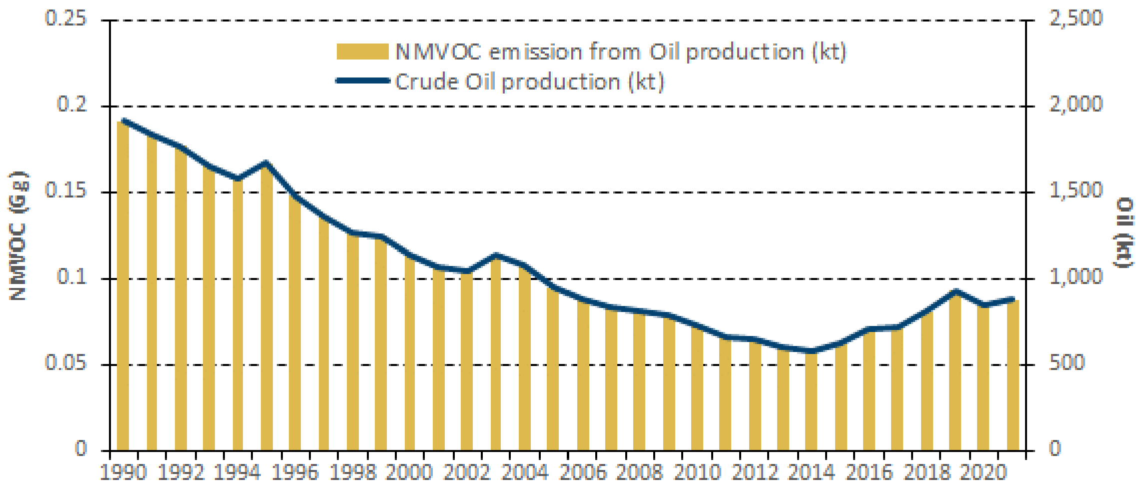


Figure 3.4 *Activity data and NMVOC emissions in 1.B.2.a i-iii subsectors*

Recalculations, QA/QC activities and planned improvements

None.

3.7.3.1 Refining / storage (NFR sector 1B2a IV)

Last update: 03.2022

Reported Emissions: NMVOC, SO_2, NO_x, NH_3, TSP, PMs, CO, HMs, PCDD/F

Measured Emissions: SO_2, NO_x, CO, TSP

Methods: T1, T3

Emission factors: T1, T3

Only emission of NMVOC, SO_2, NO_x, TSP, PMs, CO, HMs and PCDD/F arising from processes are reported in this category. All combustion emissions are reported in category *1.A.1.b.* and refinery venting and flaring emissions are reported in subcategory *1.B.2.c*.

Emission factor

NH3, HMs and PCDD/F are reported using Tier 1 emission factors from the 2019 EMEP/EEA Guidebook.

Plant specific data on SOx, NOx, TSP, and CO of oil refinery is available in LAIR database (see description in chapter 1.5). Thanks to the fact that in LAIR database emissions are reported by technology, it is possible to separate combustion and process emissions in this case. Therefore, process emissions (catalytic cracking and sulphur recovery (Claus-plants)) can be allocated to 1.B.2.a.iv and all other emissions and technologies are reported in 1.A.1.b.

The sectoral splits between 1.A.1.b and 1.B.2.a.iv in case of SOx and NOx are presented together on the following Figure.

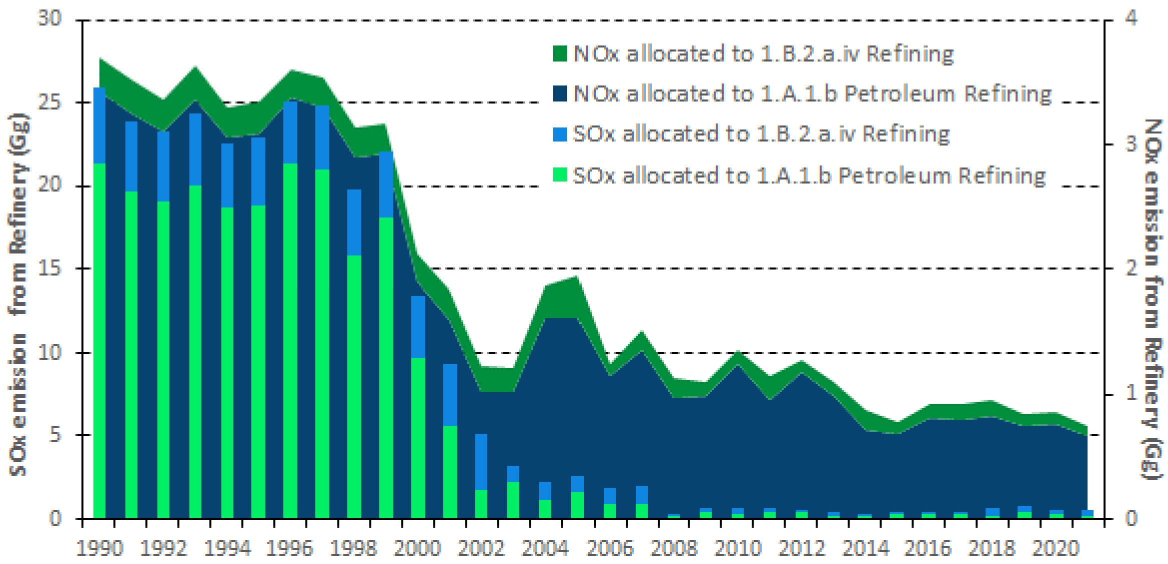


Figure 3.5 *Allocation of SO_x and NO_x emissions from Petroleum Refining between 1.A.1.b and 1.B.2.a.iv subsectors*

Reporting to LAIR database is compulsory only from 2002. So, for the years before 2002 extrapolation is applied using implied emission factor (Gg PROCESS emission/ kt Refinery intake) of year 2002. The application of IEF of year 2002 for extrapolation is better than the application of an average as the trend of IEF of the years after 2002 is decreasing.

Extrapolated process emission time series of SO2, NOx, TSP, PMs and CO are of course also subtracted from the time series of 1.A.1.b for the years before 2002 in order to apply the allocation between 1.A.1.b and 1.B.2.a.iv consistently.

Activity data

Data on refinery intake is available from IEA Energy statistics which is also used for extrapolation for the years before 2002 and for the calculation of IEF.

Recalculations, QA/QC activities and planned improvements

-

3.7.3.2 Distribution of oil products (NFR sector 1.B.2.a V)

Last update: 03.2019

Reported Emissions: NMVOC

Measured Emissions: none

Methods: CS

Emission factors: T1, T2

NMVOC emissions are reported using country-specific method that combines Tier 1 and Tier 2 method included in 2016 EMEP/EEA Guidebook in order to reflect more the trend of emissions. However, only emissions originating from petrol stations are reported due to absence of other data since it is regarded anyway less significant than the emissions originating from service stations. Marine terminals are not relevant for Hungary.

"Considerable reduction of hydrocarbon emissions from gasoline distribution network is achieved. These emission controls have been mandated under the terms of Directive 94/63/EC (EU. 1994) "Stage I controls refer to a variety of techniques reducing NMVOC emissions at marketing terminals (Stage IA) and when gasoline is delivered to service stations (Stage IB)." "Stage II applies to vapour balancing systems between automobile fuel tanks during refueling and the service station tank supplying the gasoline." (2019 EMEP/EEA Guidebook)

Control options to be used by distribution of oil are regulated by 94/63/EC (Stage I) and 2009/126/EC (Stage II) directives. In Hungary the Stage II control option was mandatory from 2001 due to 9/1995 (VIII.31.) KTM Ministerial Decree. It is now withdrawn and both directives are fully implemented in Hungary by 118/2011 (XII.15.) VM Ministerial Decree.

It is very obvious in this subsector that the Tier 2 emission factor is not realistic for the whole time series. It is very probable that before the entry into force of the above-mentioned legislation the most service stations had only limited control in place. Tier 1 emission factor of the 2016 EMEP/EEA Guidebook takes into account Stage I control level and the Tier 2 emission factor is calculated taking into account Stage I and II control levels. 9/1995. (VIII.31.) KTM Ministerial Decree prescribed the compulsory implementation of Stage II control option within 6 years for service stations with gasoline throughputs higher than 100 m3/year in Hungary.

So, in the time series Tier 1 emission factor was used before 1995 and calculated Tier 2 emission factor was used after 2001. Between 1995 (the entry into force of 9/1995 (VIII.31. KTM Ministerial decree prescribing Stage II) and 2001 (6 years after the entry into force as the deadline for implementation) a linear interpolation was made.

Emission factor

Tier 2 emission factor is calculated taking into account Stage I and II control. The abatement efficiencies related to this control options provided in the 2016 EMEP/EEA Guidebook are taken into account. Two country specific properties are needed: the average mean temperature of Hungary is taken from the public website of the HMS and the maximal RVP is determined by Government decree 30/2011.

Please find below the calculation of the country specific Tier 2 emission factor incorporating abatement efficiencies as it is suggested in the 2016 EMEP/EEA Guidebook:

$TVP = RVP \times 10^{AT+B}$

Calculation of TVP in Hungary

2.9. Table 3.5 Calculation of TVP in Hungary

A=	0.000007047× RVP + 0.0132
B=	0.0002311× RVP − 0.5236
T is the temperature (in °C). Average temperature of Hungary:	10
RVP is the Reid Vapour Pressure (in kPa). Maximal RVP determined by Government decree 30/2011.	60
A	0.01362282
B	-0.509734
A*T+B	-0.3735058
10^{AT+B}	0.423149859
TVP	**25.38899151**

Table 3.6 *Calculation of Tier 2 NMVOC emission factor in category 1.B.2.a.v*

Category	Emission source	NMVOC default EF. (g/m³ throughput/ kPa TVP)	Abatement efficiency %	True Vapour Pressure (TVP). (kPa)	NMVOC EF g/m³ (EF abated*TVP)
Gasoline in service stations	Storage tank Filling with no Stage 1.B	24	95% (stage I)	25.4	30.48
	Storage tank Breathing	3		25.4	76.2
	Automobile refuelling with no emission controls in operation	37	85% (stage II)	25.4	140.97
	Automobile refuelling: drips and spills	2		25.4	50.8
				SUM:	**298.5 g/m³**

Using the assumption: *"The assumed liquid gasoline density is 730 kg/m³"* (2019 EMEP/EEA Guidebook - 1.B.2.a.v. chapter 3.3.2.3.) the 298.5 g/m³ results **0.4088 kg NMVOC /t gasoline.**

Activity data

Data on total sold gasoline is available from IEA Energy statistics.

The following statements of the 2016 EMEP/EEA Guidebook are confirming that significant part of the emissions is reported in this way:

"Due to the volatility of gasoline, the majority of NMVOC emissions in the distribution of oil products occur during its storage and handling, and thus this chapter focuses on gasoline distribution." (2019 EMEP/EEA Guidebook 1.B.2.a.v, chapter 2*)*

Time series using the methodology described above are presented in the following Figure.

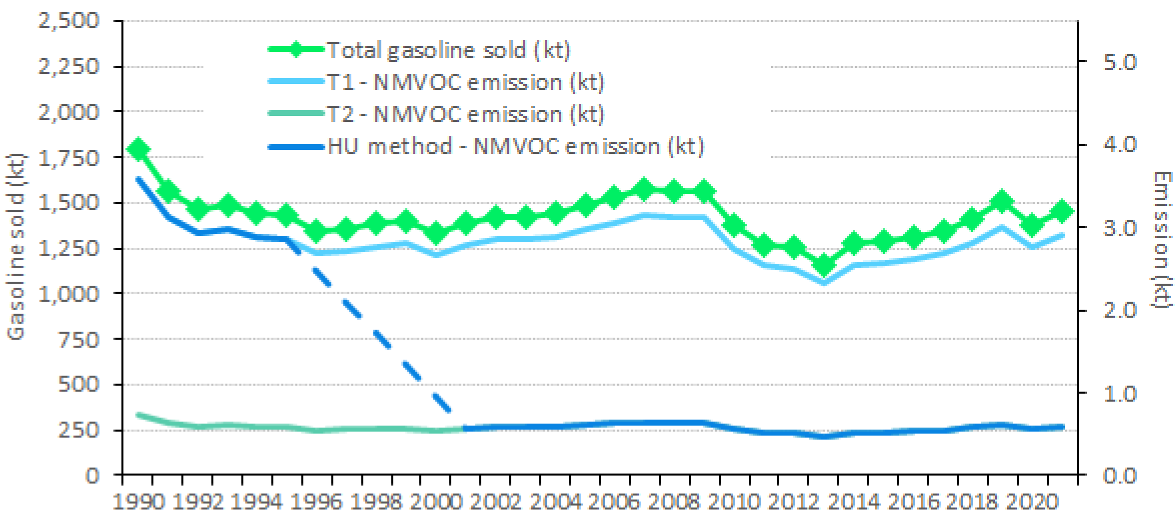


Figure 3.6 *Comparison of the time series calculated with or without adjustment*

Recalculations, QA/QC activities and planned improvements

Yearly average temperature instead of climatic average temperature is planned to applied for the next submission. Resulted changes are assumed to be lower than 10% of the actual emission of the category. Inclusion of refinery dispatch stations is planned if data will be available.

3.7.3.3 Natural gas (NFR sector 1.B.2.b)

Last update: 03.2023

Reported Emissions: NMVOC

Measured Emissions: none

Methods: T2

Emission factors: T2

In this category NMVOC emission from natural gas production, processing, transmission, distribution and storage are reported using Tier 2 methodology. Venting and flaring emissions are reported in category 1B2c.

Natural gas is not a significant natural resource of Hungary, either, although it is more important than oil. Production is declining as it is possible to see in the following figure (Figure 3.7); therefore, also emissions are decreasing.

Emission factor

Tier 2 emission factor of the 2019 EMEP/EEA Guidebook (i.e. 0.1 g NMVOC/m3 gas) is used for production of gas since it is obvious that all production occurs on-shore in Hungary.

Activity data

Activity data of natural gas production is available from IEA Energy Statistics.

Recalculations, QA/QC activities and planned improvements

None.

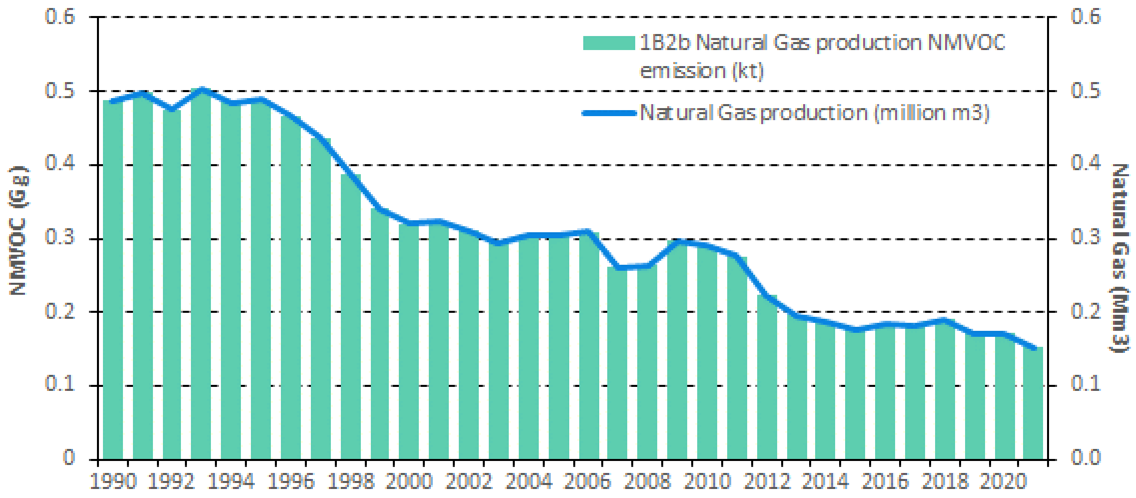


Figure3.7 *Natural gas indigenous production and NMVOC emissions*

3.7.3.4 Venting and flaring (NFR sector 1.B.2.c)

Last update: 03.2020

Reported Emissions: NO_X, SO_x, CO, NMVOC, TSP, PM10, PM2.5, BC, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, PAHs

Measured Emissions: none

Methods: T1, T2

Emission factors: T1, T2

Key source: Trend SO_x, Cd, Hg

This section includes emissions arising from venting and flaring during gas and oil and gas extraction and refinery processes. Tier 1 methodology contains emission factor for natural gas and oil production and refinery venting and flaring. In addition to NMVOC, also NOX, SOx, and CO are reported based on the suggestion of 2019 EMEP/EEA Guidebook.

Emission factor

Tier1 emission factor is used for emissions from gas production venting and flaring provided in the 2019 EMEP/EEA Guidebook.

In case of oil refinery flaring only NMVOC and SOx emissions are calculated with Tier 1 emission factors from 2019 EMEP/EEA Guidebook, Tier 2 emission factors were used for all other pollutant.

Please note that the implied emission factor calculated simply based on NMVOC emission and AD reported in NFR Table might be misleading since gas flared in natural gas production is only one of the several activity data to be taken into account in this category.

Activity data

Activity data (Natural Gas flared, Crude Oil production, Crude Oil refined) is available from IEA Energy Statistics.

Please note that activity data reported in NFR Table Crude oil production but total emissions from subsector 1.B.2.c contain also emissions from gas production flaring and oil refinery flaring.

Activity data for Tier 2 method in case of oil refinery flaring is the annual flared amount for each refinery. Since 2006 this information can be found in EU ETS database. For years before 2006 extrapolation was applied using the ratio of measured flared amount and IEA refinery intake.

Recalculations, QA/QC activities and planned improvements

Collection of plant specific information on oil refinery venting and flaring in Hungary would allow more realistic estimation of emissions. NOX, SOx and CO emissions are reported to the LAIR database also by oil and gas production sites. It could be included instead of Tier 1 emissions, but further investigation is needed to decide whether all sites are reported to the database. In addition, data are available only for 2004 and after 2007.

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4 INDUSTRIAL PROCESSES AND PRODUCT USES (NFR sector 2)

4.1 Overview of sector

In this chapter the methodologies of estimating emissions originating from the industrial processes and product uses sector (*hereinafter: IPPU*) are described. Methodologies are based on the 2019 EMEP/EEA Guidebook.

It is very important to emphasize that as it is suggested by the 2019 EMEP/EEA Guidebook and earlier versions of the Guidebook, all emissions originating from combustion during industrial processes are reported in sector 1A, as the separation of combustion emissions and process emissions are not possible in most cases. That is why NO_X, SO_x and CO are reported in sector 1.A.2., while NMVOC, PMs and other pollutants are reported in sector 2 following the recommendation of the 2019 EMEP/EEA Guidebook. In the case any NO_x, SO_x, or CO emissions are reported in sector 2, these are always process emissions separated from combustion emissions. The only exception is chemical industry where also combustion emissions are reported together with process emissions in sector 2, where process emissions occur. Combustion emissions from the section of chemical industry without process emissions are still included in 1A2c. The reason for this change is the consistency with the allocation required by 2006 IPCC Guidelines.

As it is described in the general chapter, different data sources for activity data and emission factors are taken into account to prepare NFR. The data sources for activity data include: Hungarian Central Statistical Office (HCSO), activity data reported by companies for UNFCCC reporting purposes and other international statistics (FAOStat, EUROSTAT). Emission factors used are taken from 2019 EMEP/EEA Guidebook and 2006 IPCC Guidelines.

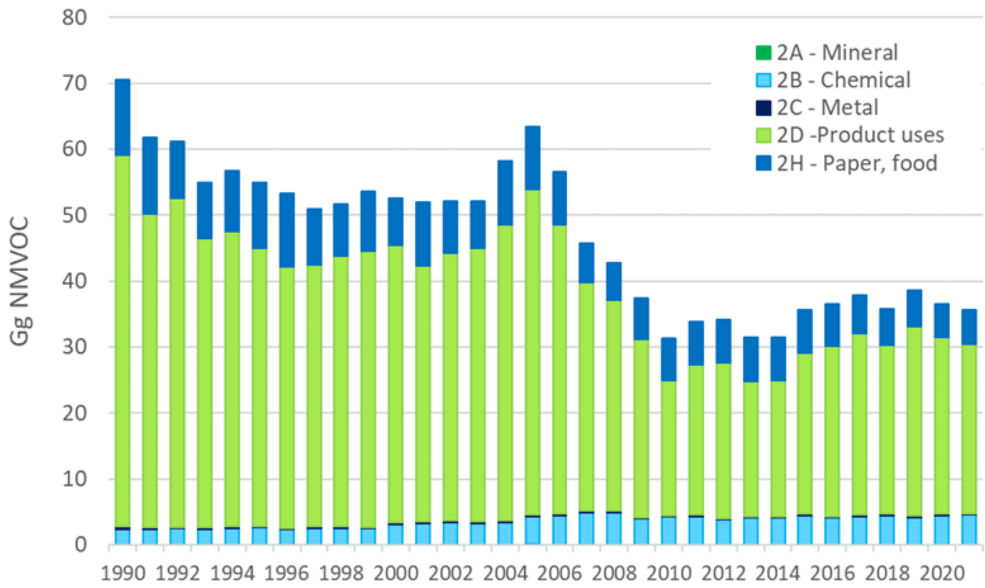
In several cases emission data reported directly by individual companies are taken into account. This data is available in the LAIR (Hungarian Air Emissions Information System) and/or in E-PRTR reporting (please see more detailed description in chapter 1.5). Where directly reported data is used, activity data is taken either from statistics or it is also reported by companies for UNFCCC (and EU ETS) purposes.

In several significant sectors of the Industrial Processes only 1-4 producing companies are present in Hungary that are also well known and they usually report in E-PRTR and EU ETS, too. This is especially true for sectors: Cement and Lime production, Ammonia, Nitric Acid production, Iron and Steel industry. This situation provides the possibility of verification of the directly reported data so in these cases the use of LAIR or direct reporting of companies result a more realistic data.

Hungary became Member State of the EU in 2004. So, the relevant environmental regulation of the EU (including Integrated Pollution Prevention and Control directive prescribing the use of BAT for the installations under its scope and E-PRTR Regulation) is implemented and enforced. Compliance and reporting of emissions are regularly checked by the Department of Environmental Protection and Nature Conservation of the regional Government Offices. So, in the cases when emission factors are differentiated for Eastern European countries/ EU countries, Hungary has to apply the latter at least from 2004.

Pollutants

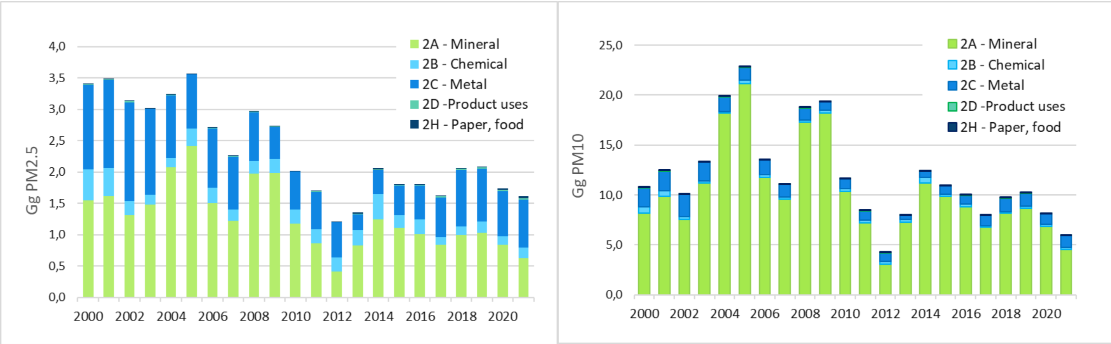
NMVOC emissions determined usually by using default emission factors provided in the 2019 EMEP/EEA Guidebook have the biggest volume in this sector. Direct reporting of NMVOC emission is usually not available because in the LAIR (see description in chapter 1.5 of the IIR) NMVOCs are usually not reported in group but several organic compounds are reported separately (depending on the content of the environmental permit of the given installation).



4.1. Figure: Trend of NMVOC emissions of subsectors within IPPU

In the case of particulate matter emissions, we adopted the approach that TSP (Total Suspended Particles) includes PM_{10}, PM_{10} includes $PM_{2.5}$, and $PM_{2.5}$ includes BC. This means that there is always TSP emission when either PM_{10} or $PM_{2.5}$ or BC emissions are present.

In LAIR the companies are reporting only TSP (Total Suspended Particles) emission and no PM_{10} and/or $PM_{2.5}$. (This is probably due to the fact that nor IPPC, neither E-PRTR regulation indicate explicitly the disaggregation of the particulate matter emissions.) In these cases, the emission data is regarded as TSP and PM emissions are calculated based on TSP/ PM_{10}/ $PM_{2.5}$ proportion of emission factors. In LAIR several companies are reporting “soot”, but it is not yet verified, what it exactly means in LAIR and whether any relationship with BC in NFR might be stated. Therefore, BC is always reported based on default EFs (percentage of $PM_{2.5}$) from the Guidebook.



4.2. Figure: *Trend of $PM_{2.5}$ and PM_{10} emissions of subsectors within IPPU*

Trend

The declining trend of emission is probably due to the restructuring of industrial sectors on one hand because the most emitting sectors have fallen or ceased after or around the change of regime in Hungary. On the other hand, the improvement and spread of emission control technologies play also a significant role partly introduced following the evolution of environmental regulations.

Volume indices of industrial production in general show a really instable trend, therefore correlation between emissions and industrial production can only be found in subsector level.

PM emissions are determined mostly by mineral industry, especially the category of construction and demolition.

General description of sectors reported in industry and other products use category

OTHER categories in the 2023 submission include:

2.B.10.a Other chemical industry: Production of sulfuric acid, chlorine, carbon black, ethylene, propylene, 1,2 diclorethane and vinilcloride balanced, PE (LD and HD), PP, PVC, polystyrene, formaldehyde, urea, ammonium nitrate and other fertilizers

2.C.7.c Other metal products: Coating (galvanizing) of metals and casting

2.D.3.g Other chemical products: Manufacture of shoes, manufacture of pharmaceutical products, paints and glues and processing of foams

2.D.3.i Other solvent and product use: Fat, edible and non-edible oil extraction from oil seeds including sunflower, rape, soybean and maize.

2.G Other Product use: Consumption of tobacco, use of fireworks

The sectors not described in the chapters following are not reported because they are assumed to be negligible or not occurring in Hungary. Please see the reasons in the following table.

4.1. Table: Sectors not reported in the 2022 submission

Sector	Explanation
2.A.5.c Storage, handling and transport of mineral products	"It is assumed that these emissions are accounted for in the relevant mineral chapter". (2019 EMEP/EEA Guidebook)
2.A.6 Other mineral products	No method available.
2.B.3 Adipic acid production	Not occurring in Hungary.
2.B.5 Carbide production	Not occurring in Hungary.
2.B.6 Titanium-dioxide production	Not occurring in Hungary.
2.B.10.b Storage, handling and transport of chemical products:	Emissions are not to be reported in this category in the case of application of Tier 2 methodology since they are included in the specific sectors due to the 2016 EMEP/EEA Guidebook.
2.C.2 Ferroalloys production	No data is available on occurrence.
2.C.5 Lead production	No data is available on occurrence.
2.C.6 Nickel production	No data is available on occurrence.
2.C.7.d Storage, handling and transport of metal products	"It is assumed that emissions from storage. handling and transport of metal products are included in the Tier 1 from the relevant chapter in the metal industry" (2016 EMEP/EEA Guidebook)
2.J Production of POPs	Not occurring in Hungary.
2.L Other production, consumption, storage, transportation or handling of bulk products	"The contribution of this source category is thought to be insignificant". (2019 EMEP/EEA Guidebook)

Time series consistency and recalculations in recent years

Before the 2014 May submission, no time-series were submitted. Emissions were calculated for individual years using different methods in several years. The calculation methods of old submissions were not documented in detail. Due to restructuring of the inventory compilation system, significant changes occurred since 2012. As the compilation of NFR has become the task of the same unit of HMS and the same experts as the UNFCCC reporting, the practice and QA/QC and a lot of data became available and were imported. In 2014 May submission Hungary submitted whole recalculated time series based on 2009 EMEP/EEA Guidebook and CLRTAP Reporting Guidelines (ECE/EB.AIR/97).

In 2015 submission the time-series have been recalculated based on 2013 EMEP/EEA Guidebook, the new version of CLRTAP Reporting Guidelines (EME/EB.AIR/125) and using the calculation methods described below.

These recalculated time series are now fully consistent with the time series reported in UNFCCC GHG Inventory of Hungary in the case of IPPU sector. However please note that several subsectors are aggregated in the UNFCCC GHG inventory as CRF reporter software does not always follow the allocation of NFR Table.

The 2023 submission relied mostly on the 2019 EMEP/EEA Guidebook.

In the recent submission, the following recalculations were done:

2.A.5.a – Activity and emission data were recalculated for every year and every pollutant based on the 2019 EMEP/EEA Guidebook Tier 2 template.

2.A.5.b – Activity and emission data were recalculated for every pollutant and for years 2018-2020 using a new method for calculating the affected area by road construction.

2.C.1 – TSP emissions were corrected for years 2019 and 2020.

2.D.3.a – Emission factors and thus NMVOC emissions were recalculated using a higher (Tier 2) methodology from the year 2016.

2.D.3.h – Emission factors and thus NMVOC emissions were recalculated using a higher (Tier 2) methodology for every year.

2.D.3.i – Emissions from new pollutants (TSP, PM_{10} and $PM_{2.5}$) were calculated from the year2000 using a Tier 3 method.

2.L – Notation key 'NA' was changed for 'NO' for all years and pollutants.

4.2 Mineral products (NFR sector 2.A)

4.2.1 Cement Production (NFR sector 2.A.1)

Last update: 15.03.2023.
Reported Emissions: TSP, PM_{10}, $PM_{2.5}$, BC
Measured Emissions: TSP
Methods: T3, T1
Emission factors: PS
Key source: Trend PM_{10}, $PM_{2.5}$

Cement production is a typical case where combustion emissions and process emissions are non-separable. Reporting follows the recommendation of the 2016 EMEP/EEA Guidebook, so the NO_X, SO_2, CO emissions originating from cement production are reported in sector 1.A.2. In sector 2.A.1 only TSP, PM_{10} and $PM_{2.5}$, and BC emissions are reported as it is suggested by the 2016 EMEP/EEA Guidebook.

It is important to state that the 5 cement producing plants in Hungary – which are included in the time series – are regulated based on EU requirements. In 2011 one of the 5 plants was closed down and a new one was opened. Since 2014 there are only 3 cement producing plants (2 companies) in Hungary. All have Integrated Pollution Prevention and Control permit which describes the use of BAT. Compliance is regularly checked by the regional Inspectorates for Environment and Nature.

The decreasing trend of emissions (especially the solid particles) is reflecting the improvement of abatement technologies and the very strong decline of mineral industries production in Hungary. This strong decline stopped in 2014 and a rise has begun since then. The decrease in the emissions of mineral industry (mainly in cement production) in 2020 proved to be temporary, and in 2021 it increased again by 2% compared to the previous year.

There is only 3 cement producing plants and statistics are confidential, therefore activity data and implied emission factors have not been reported since 2018 submission, because one of the plants did not give permission for disclose even the aggregated production data.

Methodological issues

Tier 3 methodology is applied using facility level data. Emissions reported to LAIR by the cement producing companies of Hungary are used. However, only TSP data is reported. PM emissions are calculated based on TSP/ PM_{10}/ $PM_{2.5}$ / BC proportion of Tier 1 emission factors (applicable for EU countries) of PMs presented in the following Table.

Emission factor

4.2. Table: Proportion of size fractions calculated from Tier 1 default emission factors

TSP	100.0%
PM10	90.0%
PM2.5	50.0%
BC	1.5%

Implied emission factors for the Hungarian cement industry derived from reported emissions and reported clinker production are summarized in the table below. In 2018, IEF is C again because of the confidential activity data. At the end of the time-series IEFs are very close to the ones described in the EU BAT Ref. document (2013).

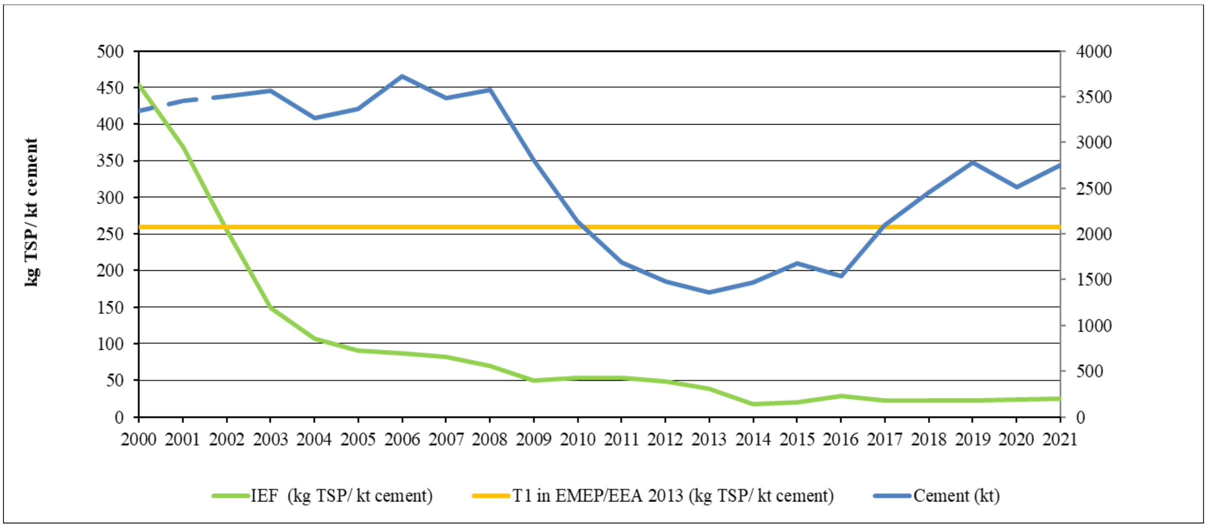
4.3. Table: Implied emission factors for cement production in Hungary, 2000-2019

	2000	***2001***	***2002***	***2003***	***2004***	***2005***	***2006***	***2007***	***2008***
IEF (g TSP/t clinker)	599	504	333	198	139	129	128	111	101
	2009	***2010***	***2011***	***2012***	***2013***	***2014***	***2015***	***2016-2021***	
IEF (g TSP/t clinker)	75	80	82	54	51	24	26	C	

As plant specific data is usually available only from 2002, extrapolation is needed for the years before 2002. Extrapolation was performed in 2014 submission and kept henceforward using data by plant (as IEF by plant are quite different).

IEF of 2002 is applied for extrapolation for 2000 and 2001 in the case:

- 2002 IEF is higher than T1 emission factor from 2009 EMEP/EEA Guidebook (it is still relevant because IEFs are also higher than EF in 2016 EMEP/EA Guidebook), or
- documented information is available on the presence of the same abatement option in 2000 than in 2002.



4.3. Figure: Activity data and implied emission factor in sector 2.A.1 Cement production (2000-2021)

Activity data

Cement production data is available both from the HCSO and from the individual companies. Also, EU ETS reports of all companies are checked for production data. Latter is used in NFR table as activity data and for the calculation of IEF consistent with UNFCCC GHG Inventory reporting. Since 2018 one of the companies has been reporting activity data in the LAIR system, not in EU ETS marking it as confidential.

Uncertainty, recalculations, QA/QC activities and planned improvements

There was no recalculation in the 2022 submission.

Further verification of plant specific data is planned: since LAIR database also contains data about the filtered TSP, use of these data to verify the efficiency of abatement technology and the plant specific emissions are possible.

4.2.2 Lime production (NFR sector 2.A.2)

Last update: 15.03.2022.
Reported Emissions: TSP, PM_{10}, $PM_{2.5}$, BC
Measured Emissions: TSP, PM_{10} (from 2013)
Methods: T3, T2
Emission factors: T3, T2
Key source: none

Reporting follows the recommendation of the 2016 EMEP/EEA Guidebook. So, the NO_X, SO_2, and CO emissions originating from lime production are reported in sector 1.A.2. In sector 2.A.2 only TSP, PM_{10} and $PM_{2.5}$ and BC emissions are reported. Three lime producing companies of Hungary - which are included in the time-series - are also covered by IPPC directive, also application of BAT is required. Since 2013 only two companies exist.

Methodological issues

Tier 3 methodology is applied by using facility level data, Tier 2 methodology is applied in all other cases. Emissions reported to LAIR by the 3 (nowadays 2) lime producing companies of Hungary are used.

Emission factor

Only TSP data is reported directly for all plants. In 2011 reported PM_{10} emission turned up in case of one plant in the LAIR database. For the first two years (2011 and 2012) proportions of measured PM_{10} and TSP were very low (15% and 40% on the average), then this proportion stabilized around at 50% - which is the default value in the Guidebook, as well -, so only the measurements after 2012 were taken into account in the calculations. For the other lime works the original calculation was kept. Besides this PM emissions are calculated based on TSP/ PM_{10}/ $PM_{2.5}$ / BC proportion of Tier 2 emission factors of PMs presented in the following Table (Table 4.4.) that is the same in 2009, 2013 and 2016 versions of the Guidebook.

4.4. Table: Proportion of size fractions calculated from Tier 2 (controlled) default emission factors

TSP	100.0%
PM_{10}	50.0%
$PM_{2.5}$	7.5%
BC	3.45%

Please note that in this sector Tier 1 emission factors in 2016 EMEP/EEA Guidebooks do not include abatement option (uncontrolled process) therefore they are much higher than Tier 3 implied emission factor. The directly reported plant specific emissions correspond to the Tier 1 emission factor with cc. 90% abatement efficiency.

As plant specific data is usually available only from 2002 a linear extrapolation is used for the years before 2002.

Activity data

Lime production data is provided both by the HCSO (for the years until 2013) and from the individual companies. The latter is used as activity data in NFR table and for the calculation of implied emission factor consistent with UNFCCC GHG Inventory reporting. Production is declining until 2013 with the number of lime works. In recent years production fluctuates according to the demand of construction.

Despite the fact that there are only 2 factories activity data – aggregated production data - are presented with the permission of the plants in the NFR and limes IIR, as well.

Uncertainty, recalculations, QA/QC activities and planned improvements

Recalculation was made for the 2003-2017 period, because TSP emissions from a calcium hydroxide plant of one of the companies were not taken into calculation, however it was reported in the LAIR. Another recalculation was made for 2017 based on reported PM10 data from a new furnace of the other company, when TSP data were calculated based on the proportion of size fractions calculated from Tier 2 (controlled) default emission factors.

4.5. Table: Recalculation in lime production

Years	Changes in TSP emission of lime production in kt	Changes in TSP emission of lime production in %
2003	0.00147	5.7
2004	0.00136	5.3
2005	0.00037	0.2
2006	0.00044	0.5
2007	0.00083	2.5
2008	0.00065	2.5
2009	0.00071	7.1
2010	0.00005	0.3
2011	0.00005	0.3
2012	0.00008	1.0
2013	0.00009	0.6
2014	0.00018	1.0
2015	0.00035	1.7
2016	0.00034	1.8
2017	0.00886	41.0

4.2.3 Glass production (NFR sector 2.A.3)

Last update: 15.03.2022.
Reported Emissions: NMVOC, NH3, TSP, PM10, PM2.5, BC, HMs
Measured Emissions: NMVOC, TSP
Methods: T1, T2, T3
Emission factors: T1, T2, T3
Key source: Level Cd

In this sector only process emissions originating from Glass production are reported.

Flat glass, container glass, other glass (technical), glass wool and mineral wool production are all present in Hungary, although production is declining. Since disaggregated activity data is available, Tier 2 methodology can be used for estimating process emissions.

Emissions from mineral wool production are reported for the first time in 2015 submission using plant-specific data as it is available from LAIR.

Also, in this subsector combustion related emissions are reported in sector 1.A.2. In sector 2A3 the following pollutants are reported: NMVOC, NH_3, TSP, PM_{10}, $PM_{2.5}$, BC and HMs.

Emission factor

Tier 2 technology specific emission factors of 2013 EMEP/EEA Guidebook are used.

No further abatement efficiency is taken into account due to absence of data. Plant specific emissions from mineral wool production are available for TSP, NH_3 and organic compounds. The sum of organic compounds is reported as NMVOC while PM emissions are calculated based on TSP/ PM_{10}/ $PM_{2.5}$ / BC proportion of Tier 2 emission factors of Glass wool production.

Activity data

Technology specific, disaggregated activity data is available from HCSO and LAIR database for several years. Unfortunately, more and more data from HCSO is missing from official report due to declining number of producers.

More detailed data request was sent to HCSO to verify the information from LAIR database. Also glass manufacturers were asked to declare their used technology and amount of production for the calculation of GHG inventory. The recalculation of CO_2 emission did not affect the calculation of air pollutant, because in most cases T3 - measured emissions have been reported in this inventory for several years. Activity data are different for the two inventories, because this inventory includes manufacturing of safety glass and other technical glass, which does not involve CO_2 emission.

Uncertainty, recalculations, qa/qc activities and planned improvements

There was no recalculation in the 2023 submission.

4.2.4 Quarrying and mining of minerals other than coal (NFR sector 2.A.5.A)

Last update: 15.03.2023.
Reported Emissions: TSP, PM_{10} and $PM_{2.5}$
Measured Emissions: none
Methods: T2
Emission factors: T2
Key source: Level and trend TSP

Emission factor

Until the 2022 submission, Tier1 emission factors provided in 2016 EMEP/EEA Guidebook were used. In the 2023 submission, the 2019 EMEP/EEA Guidebook Tier 2 template for 2A5a was used for pollutants TSP, PM_{10} and $PM_{2.5}$, for years 2018, 2019 and 2020 and aggregated emission factors for 2005. For the other reported years, averaged for the years 2018-2020 emission factors were used for the above pollutants .

Activity data

Activity data is collected from HCSO database and contains the following categories of mining activities:

- ores
- stones (mostly limestone and dolomite), gypsum
- gravel, sand and clay
- other minerals
- minerals for chemical industry or fertilizer.

In the 2018 submission mining of peat was taken out of calculation assuming wet conditions without PM emission. Also, activity data were changed in the 2003-2008 period, because mining of ore was confidential in HCSO database, however the Mining and Geological Survey of Hungary (former Hungarian Office for Mining and Geology) published these data, so these data were included in this submission. Since there are confidential data is some categories, only aggregated activity data were used until the 2022 submission.

Recalculation of activity data

In the 2023 submission, the 2019 EMEP/EEA Guidebook Tier 2 template for 2A5a was used for years 2018, 2019 and 2020 for correcting the activity data. The template works with the following aggregate production data: crushed rock, sand&gravel and recycled aggregates. Based on data received directly from HCSO, crushed rock and sand&gravel data were aggregated for the years 2018, 2019 and 2020. Moreover, according to the announcement of the Concrete Technology Center, in 2015, 3.4% of all crushed rock and sand&gravel production was from the shredding of recycled aggregates - typically from demolished concrete. Based on this information, Tier 2 template was used for the years 2005, 2018, 2019, 2020 and 2021. For other years, activity data was corrected by the average deviation of the years calculated by the template.

Activity data used until the 2022 submission and recalculated activity data are presented in *Table 4.6.*

4.6. Table: Sum of mined amount of ores and minerals and recycled aggregates in Hungary (2000-2021) in Mt - before and after the recalculation

YEAR	AD in 2.A.5.a (Mt)		YEAR	AD in 2.A.5.a (Mt)	
	2022 subm	2023 subm		2022 subm	2023 subm
2000	27	28	**2011**	29	29
2001	32	34	**2012**	27	28
2002	32	33	**2013**	28	29
2003	31	32	**2014**	47	49
2004	35	36	**2015**	45	47
2005	42	44	**2016**	37	38
2006	38	39	**2017**	39	41
2007	42	43	**2018**	47	49
2008	42	44	**2019**	57	59
2009	42	44	**2020**	51	53
2010	34	35	**2021**		55

Uncertainty, recalculations, qa/qc activities and planned improvements

During the 2022 review for category NFR 2A5a and pollutants $PM_{2.5}$ and PM_{10} in all years the TERT noted that a Tier 1 method is used which is not best practice and could result in an over and/or under-estimate of emissions. In response to a question raised during the review, it was explained that emissions are predominantly from extraction of the minerals and primary processing stages such as crushing, therefore emissions are generally fugitive in nature and difficult to quantify. Subsequently, revised estimates were provided for years 2005, 2018, 2019 and 2020 using the 2019 EMEP/EEA Guidebook Tier 2 spreadsheet for 2A5a. The TERT agreed with the revised estimate and a technical correction was performed. After a review of the activity and assumptions applied in the Tier 2 methodology, the whole time series were recalculated for pollutants TSP, PM_{10} and $PM_{2.5}$, using recalculated activity data and averaged emission factors (see above).

Possibility of usage of the the 2019 EMEP/EEA Guidebook Tier 2 spreadsheet for the whole time series and calculating a revised estimate with the same methodology for every year is planned to perform in a medium term.

4.2.5 Construction and demolition (NFR sector 2.a.5.b)

Last update: 15.03.2023.
Reported Emissions: TSP, PM_{10}, $PM_{2.5}$
Measured Emissions: none
Methods: T1
Emission factors: T1
Key source: Level and trend PM_{10}

Methodological issues

TSP, PM_{10} and $PM_{2.5}$ are reported using Tier 1 method of 2016 EMEP/EEA Guidebook. The 2016 EMEP/Guidebook requires more detailed activity data compared the previous version in the following categories:

- residential housing, single- or two family
- residential housing, apartments
- non-residential building
- road construction.

Collection of required information was finished for the 2018 submission.

Activity data

Detailed annual statistics for residential housing is available from HCSO, but statistics about non-residential construction is very limited and road construction statistics is not available from this data source.

In case of residential housing number of completed residential buildings is reported in Yearbook of Housing Statistics (HCSO, 2000-2016) in 5 types of buildings: family house; group of buildings; multi-storey, multi-dwelling buildings; building in residenz' park; housing estate building. In all categories average useful floor area and duration of construction are also available. Average useful area is taken into account in case of the family house and group of buildings, for all other categories the affected area was calculated with default parameters for apartment on building basis (585 m^2/building). The average duration of construction in Hungary is quite long (700-800 days), especially in case of family houses, and also economic crisis has an important effect on all construction. Therefore, default duration length of Guidebook was applied, but affected area was modified with the area of those years on which the construction was started.

In case of non-residential construction number of new construction permits is available only, also the buildings' useful floor space is given in the statistics. Buildings for the following purposes: office, commercial, educational and health care, lodging and catering; were taken into consideration as apartment buildings by calculating the affected area. Affected area of all other type of buildings ("industrial", "agricultural" and "other" categories) was estimated using 0.8 m^2 footprint area per m^2 utility floor area as it was suggested in the 2016 Guidebook.

In road construction category only the total length of public road owned by the state is published, which is a small part of all national roads (state public roads, private roads and roads of local governments). Therefore, data request was sent to the National Infrastructure Developing Private Company Limited (NIF; 100% property of the Hungarian State, the ownership rights are controlled by the Ministry of Transport), which company is responsible for development of public roads and railways to calculate the total affected area of road construction in each year in the 2000-2016 period. Very detailed calculation was made by NIF for the whole time-series.

In Hungary duration of infrastructural investments could be as long as 2-3 years. In these cases, only those projects were taken into account where PM might be emitted. The affected area for road construction was estimated from the length of new road constructed multiplied with the appropriate width of exposed area of each road construction. Latter depends on the type of action, the topology and the horizontal and vertical alignment of road; so, the width of road was taken into account with 20, 25, 30, 50 or 60 m. According to the regulations included in contracts of construction entrepreneurs are bound to minimalize PM emissions both during extensive earthmoving and in case of maintenance of transport roads.

Activity data for road construction for 2017 and 2018 was estimated using databases of NIF, from where total length of new roads can be calculated. However, NIF has not sent us detailed road construction data from 2016 onward. Affected area was estimated using default width of exposed area from the 2016 Guidebook.

Activity data were reduced significantly using the 2016 Guidelines instead of the 2014 Guidelines. In specific years (2000, 2006 and 2012) the originally applied and in 2017 submitted activity data were obtained from CORINE land cover database. According to the 2018 calculations affected area are much lower than in CORINE land cover databases, while emissions increased significantly. Previously used method cannot be compared to the actual calculation, where country specific parameters have been taken into account instead of global average values.

Emission factor

Default PM_{10} emission factors for uncontrolled PM emissions from all types of construction activities were applied in the calculations according to the 2016 Guidebook.

Tier 1 method has four parameters which modify the emission factors profoundly.

One of these parameters is the correction factor for soil moisture, where precipitation-evapotranspiration index should be calculated for each year based on monthly average temperature and precipitation data. Nationwide average temperature and nationwide average precipitation data are available from the Hungarian Meteorological Service.

Soil silt content is another very important factor in Tier 1 calculation for all categories. The average silt content of soils in Hungary was calculated from the Digital Kreybig Soil Information System (Pásztor et al., 2012) which is the most detailed nationwide spatial dataset which covers the whole area of Hungary, using the Hungarian classification of soil texture to keep consistency. In Hungary the particle size of silt fraction varies between 0.02 and 0.002 mm. The resulted average silt content in Hungary is 22.2%.

Default values were kept for parameter of duration of construction in all categories due to the reasons mentioned at description of activity data and also for the control efficiency factor of applied emission reduction measures.

Uncertainty, recalculations, qa/qc activities and planned improvement

Remarkable changes due to methodological changes for the years before 2017 were reported in previous submissions. As the National Infrastructure Developing Private Company Limited (NIF) has not sent any data for 2017 and 2018, road construction data were estimated (and recalculated for 2017) based on publicly available data of NIF.

The 2021 and 2022 NECD reviews again addressed the issue that a Tier 1 method is used for a key category. The TERT noted that the issue is below the threshold of significance for a technical correction.

Hungary uses Tier 1 method in category 2A5b because activity data are hardly available. Some basic annual data for the algorithm of Tier 1 method (area affected by construction activity and duration of construction for construction of houses, apartments, non-residential construction as well as Thorntwaite index) are available from the Hungarian Central Statistical Office. The same for road construction is not available from 2017 as the former source, the National Infrastructure Developer Ltd has not responded to any inquiries and finally ceased to exist in 2021. Because of this situation, application of AP42 method is not possible at all.

Nevertheless, in 2023 we started to develop a mathematical method for calculating the length and thus the affected area of constructed roads based on price- and volumenindexes published by the HCSO. As we could get an information on that no public roads were built in 2023 with state funding, the area affected by road construction for years 2018, 2019 and 2020 was recalculated and for 2021 was calculated with the new method. Thus, TSP, PM_{10} and $PM_{2.5}$ emissions for the 2D2b source category for years 2018, 2019 and 2020 were recalculated as well using the new activity data and the old method and emission factors.

For the next submission we would like to extend the new method for calculating the affected area for the other years and for the construction of buildings as well.

4.3 Chemical industry (NFR sector 2.B)

Ammonia, hydrogen, nitric acid production and activities classified as Other Chemical Industry are present in Hungary. Other chemical industry sector (2B10a) includes the following processes: production of sulfuric acid, chlorine, carbon black, ethylene, propylene, 1.2 diclorethane and vinilcloride balanced, PE (LD and HD), PP, PVC, polystyrene, formaldehyde, urea, ammonium nitrate and other fertilizers.

No emissions are reported in sector 2.B.10.b – Storage and handling of chemical products since it is assumed that emissions arising during storage and handling are included in emissions of the specific subsectors based on statement of the 2016 EMEP/EEA Guidebook.

Different from other subsectors, in the case of chemical industry also combustion emissions are reported together with process emissions in this sector, where process emissions occur. Combustion emissions from the section of chemical industry without process emissions are still included in 1A2c. The reason for this change is the consistency with the allocation required by 2006 IPCC Guidelines.

In this industrial sector many changes have been taking place since 1980 because older factories were closed down in the 1990's and significant emission reductions were achieved by the plants still operating.

In the case of ammonia and nitric acid production directly reported emission data is used. In this case the quality of the data is verifiable since the same data is reported to E-PRTR, too. Well known company having IPPC permit (including BAT prescribed) and the abatement technology causing a significant reduction of NO_X and N_2O was implemented by the means of a well-documented (partly publicly available) JI project. Further details are described in chapter 4.3.2 – Nitric acid production.

4.3.1 Ammonia production (NFR sector 2.B.1)

Last update: 15.03.2023.

Reported Emissions: NMVOC, NO_x, CO, SO_x, NH_3

Measured Emissions: NO_x, CO, SO_x, NH_3

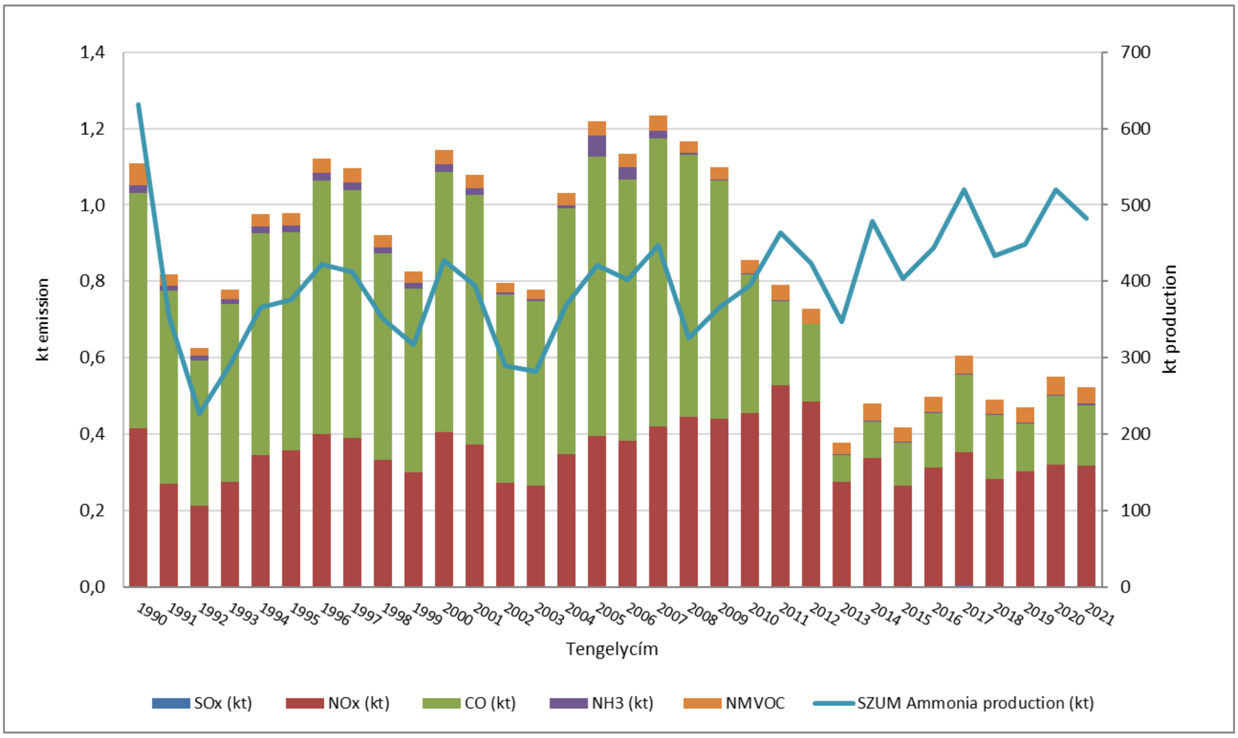
Methods: T2, T3

Emission factors: T2, T3

Key source: none

In 1990 three ammonia producers were operating in Hungary, at the moment two companies are working. One of them produces hydrogen (and synthesis gas) within the plant while the other one acquires hydrogen from a different company.

The strong interannual changes in the time-series of emissions are related to the changes of the production, e.g. decline in 1992 is caused by the strong decrease of the production, and in addition one of the tree production sites was also closed.



4.4. Figure: Emissions and production of ammonia

In the 2015 submission time-series have been recalculated as the allocation rules of combustion and process emissions are slightly changed in 2006 IPCC Guidelines, as it is stated in chapter 1.2.1 of Vol.3.:

"Combustion emissions from fuels obtained directly or indirectly from the feedstock for an IPPU process will normally be allocated to the part of the source category in which the process occurs."

Therefore, in the case of ammonia production all emissions from Natural gas use are reported in 2B1 sector in the GHG inventory. In order to remain consistent, we follow the same allocation here. So, in this sector also combustion emissions are reported. In addition, the natural gas used for hydrogen production is also reported in the GHG inventory within this sector, so plant specific emissions reported by hydrogen producers has been included from 2016 submission.

Emission factor

NMVOC, NO_x, CO, NH_3 and SO_x are reported. The following table summarizes the used factors for each process.

4.7. Table: Used emission factors in 2.B.1 category

	Ammonia production	Hydrogen production
SO_x (kt)	T3	T3
NO_x (kt)	T2, T3	T3
CO (kt)	T2, T3	T3
NH_3 (kt)	T2, T3	-
NMVOC	T2	-

Activity data

Activity data for Tier 2 emission calculations are available from the HCSO and it is reported also by the companies for UNFCCC reporting purposes. Measured emissions are obtained from LAIR database.

Uncertainty, recalculations, QA/QC activities and planned improvements

There was no recalculation in the 2023 submission.

4.3.2 Nitric acid production (NFR sector 2.B.2)

Last update: 15.03.2022.

Reported Emissions: NO_x, NH_3

Measured Emissions: NO_x, NH_3

Methods: T3

Emission factors: T3

Key source: Trend NO_x

However only NO_X emission factor is provided in the EMEP/EEA 2016 Guidebook, also NH_3 process emissions are reported besides NO_X based on direct emissions reported by company in the LAIR.

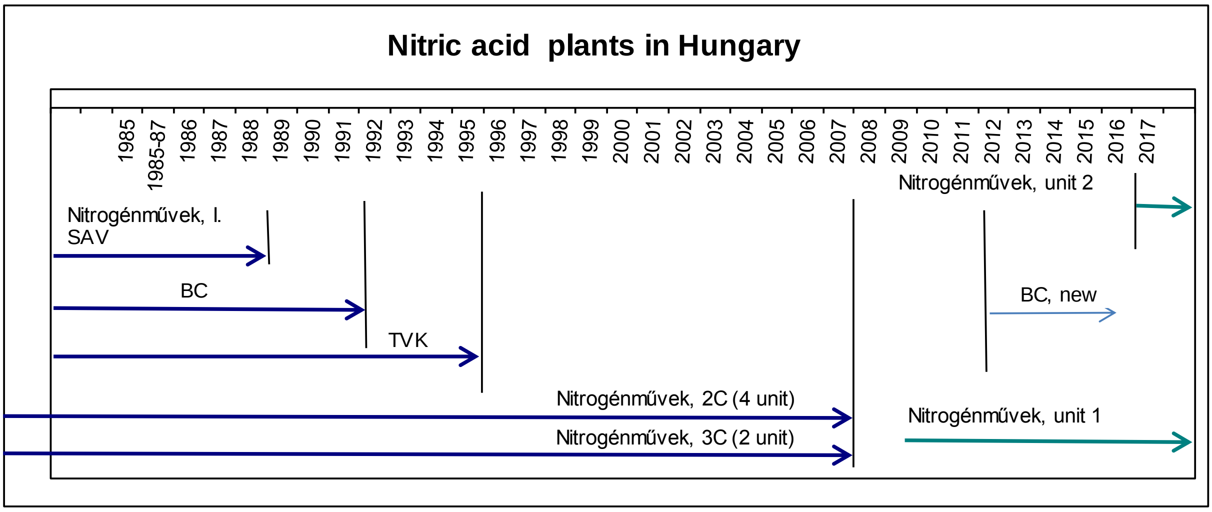
Nitric acid (HNO_3) is produced by oxidizing ammonia. The process end gas contains N_2O and NO_X. In order to control the emissions, the latter is reduced to nitrogen using natural gas and the carbon content of the natural gas is released in the form of carbon dioxide.

In this industrial sector many changes have been taking place since 1980. Among the old factories using obsolete technologies, one was abandoned in 1988, another in 1991, and a third in 1995.

Between 1996 and 2012 only one plant was operating. Until 2006 two production lines were operated in this plant – the older one was established in 1975 and used GIAP technology which consists of four units. These four units represented the major part (about 80%) of the production volume. Emissions from this process were measured from 2004. The other existing technology represented only 20% and had been operational since 1984 (combined acid factory producing diluted and concentrated nitric acid).

Since 1995 several abatement technologies have been introduced. Then, the implementation of a new and more advanced production technology was started in 2005 in the framework of a UNFCCC joint implementation project (further information please see below), and it was installed in September 2007. At the same time, the old production lines were closed down. Now a state-of-the-art technology is used therefore drastic emission reduction was achieved by application of the EnviNO$_X$ technology.

In 2012 another plant has been restarted using catalytic abatement technology as well based on its IPPC permit. However, the latter plant produces significantly lower volumes yet.



4.5. Figure: Nitric acid plants in Hungary (1985-2018)

Emission factor

Tier 3 method is used. Directly reported plant specific data on nitric acid process emissions is applied from 2007. For earlier years, implied emission factor was extrapolated as it was presented in the previous submission.

The low implied emission factor for NO$_X$ after 2008 is reflecting the state-of-the-art N_2O and NO$_X$ abatement technologies implemented by the main nitric acid producer company. The increase of NO$_x$ emission factor from 2011 is due to the restart of the other producer company. The sharp reduction in the last two years reported emissions from the reopened plant were investigated because the IEFs were very low. According to the information received from the plant, in August 2015 during the summer repairs the DeN$_2$O catalyst was removed and during the assembly of the reactor 50% of the catalysts were replaced by new catalysts. With the new catalysts N_2O and also NO$_x$ content of the flue gas reduced significantly. Further explanations and description of the EnviNOx technology was presented in the previous submissions.

Activity data

Activity data is available from the HCSO and it is reported also by the companies for UNFCCC GHG Inventory reporting purposes.

Uncertainty, recalculations, QA/QC activities and planned improvements

The dates of introduction of abatement technologies are published at the website of the producer operating continuously:

http://www.nitrogen.hu/index.php?option=com_content&view=category&layout=blog&id=9&Itemid=26

The significant reduction of NO_x emission in 2008 is justified by the introduction of EnviNO$_x$ technology by the company hosting the JI project mentioned above.

In 2016 submission it was stated that data for 2014 had been extrapolated using production volume and the implied emission factor of last year, because the reported plant specific data seemed to be outlier. Measured emissions were checked, and emissions were corrected for 2013 and 2014 according to the renewed LAIR database.

The sharp reduction in the last two years reported NOx emissions from the reopened plant were investigated because the IEFs were very low. The new catalyst has reduced N_2O and also NO_x emissions.

There was no recalculation in the 2023 submission.

4.3.3 Other chemical industry (NFR sector 2.B.10.a.)

Last update: 15.03.2023.

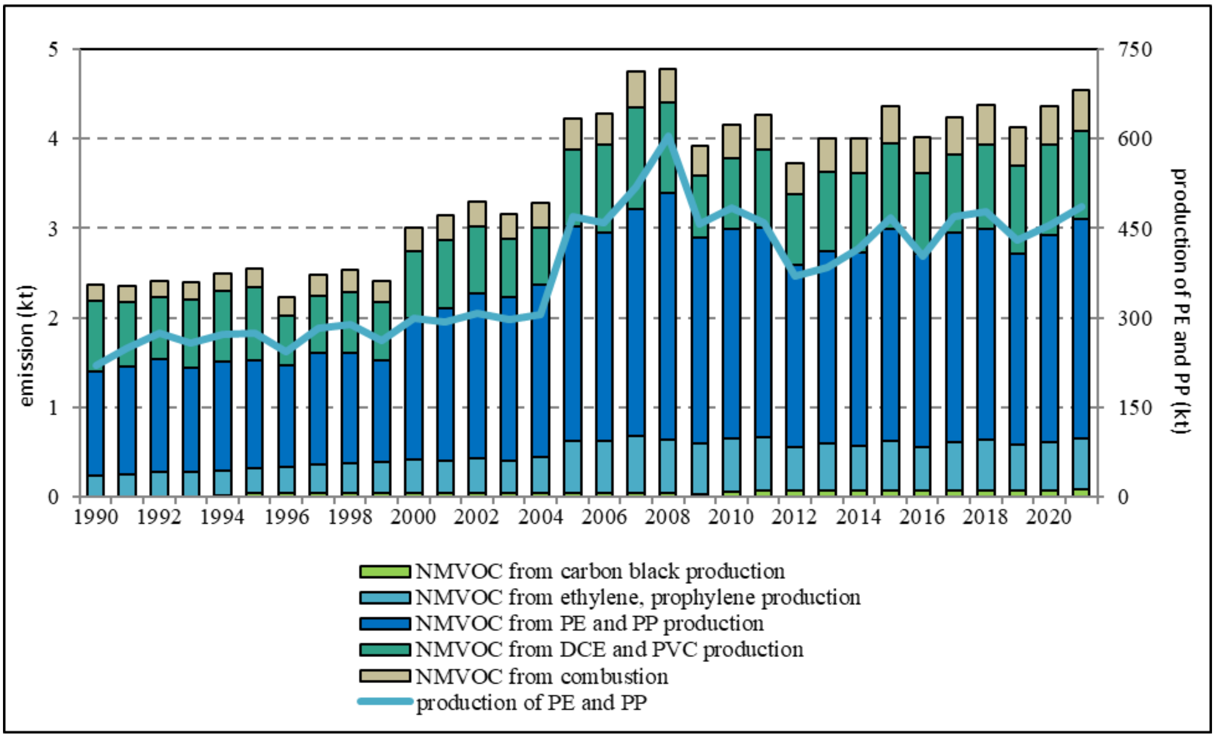
Reported Emissions: NO_x, NMVOC, SO_x, NH_3, $PM_{2.5}$, PM_{10}, TSP, BC, CO, Hg

Measured Emissions: NO_x, SO_x, NH_3, TSP, CO, Hg

Methods: CS, T2, T3

Emission factors: CS, T2, T3

Key source: Level NMVOC; Trend NH_3, Hg



4.6. Figure: NMVOC emissions in 2.B.10.a sector

Emissions from several inorganic and organic chemical activities are reported in this sector. The new allocation described in chapter *4.3.1 Ammonia production* above has resulted the inclusion of combustion emissions and thus the recalculation of time-series in previous submission.

However, the inclusion of combustion emissions did not result a significant change in this sector, especially not in the case of NMVOC, in which case the category is key as it is possible to see at the Figure above.

Activities, pollutants and the emission calculation methods used are presented in table below. In addition, all the combustion emissions are plant-specific data.

4.8. Table: List of processes and pollutants and emission estimation method used within 2.B.10.a Other Chemical industry sector

SNAP code. activity	Pollutant	Emission factor used
040401 Sulphuric acid	SO_x	**2002-2017: LAIR** 1990-2001: linear interpolation of the IEF between Tier 2 and 2002 LAIR
040413 Chlorine	Hg	**2005-2017: plant specific** (www.eurochlor.org) 1990-2004: linear interpolation of the IEF between Tier 2 and 2005 plant specific data
040409 Carbon black	NMVOC	**Tier 2**
	NO_X	**2005-2017: LAIR** 1990-2004: LAIR 2005 IEF
	SO_x	**2004-2017: LAIR** 1990-2003: LAIR 2004 IEF
	TSP	**2005-2017: LAIR** 2000-2004: LAIR 2005 IEF
	$PM_{2.5}$	CS: Tier 1 proportion of TSP (for gaseous fuel in 1.A.2) as a combined factor for process and combustion emissions
	PM_{10}	CS: Tier 1 proportion of TSP (for gaseous fuel in 1.A.2) as a combined factor for process and combustion emissions
	BC	CS: Tier 1 proportion of TSP (for gaseous fuel in 1.A.2) as a combined factor for process and combustion emissions
	CO	**2005-2017: LAIR** 1990-2004: LAIR 2006-2013 average IEF
040501 Ethylene	NMVOC	**Tier 2**
040502 Propylene	NMVOC	**Tier 2**
040505 1.2 dichloroethane + vinylchloride (balanced)	NMVOC	**Tier 2**
040506 Polyethylene Low Density + 040507 Polyethylene High Density	NMVOC	**Tier 2 for LD**
	TSP	**2005-2017: LAIR**

		2000-2004: LAIR 2005 IEF
040509 Polypropylene	NMVOC	**Tier 2**
	TSP	**2005-2017: LAIR** 2000-2004: LAIR 2005 IEF
040508 Polyvinylchloride	NMVOC	**Tier 2-(E-PVC)**
	TSP	**2005-2017: LAIR** 2000-2004: LAIR 2005 IEF
	$PM_{2.5}$	CS: Tier 1 proportion of TSP (for gaseous fuel in 1.A.2) as a combined factor for process and combustion emissions
	PM_{10}	CS: Tier 1 proportion of TSP (for gaseous fuel in 1.A.2) as a combined factor for process and combustion emissions
040511 Polystyrene	NMVOC	**Tier 2 (GPPS)**
	TSP	**2005-2017: LAIR** 2000-2004: LAIR 2005 IEF
040517 Formaldehyde	CO NMVOC TSP	**Tier 2 (EMEP/EEA Guidebook 2019 Chapter 2B Table 3.55)**
Fertilisers		
040405 Ammonium nitrate	NH_3	**2002-2017: LAIR** 1990-2001: linear interpolation of the IEF between Tier 2 and 2002 LAIR [1)]
	TSP	**2002-2017: LAIR** 1990-2001: linear interpolation of the IEF between Tier 2 and 2002 LAIR [1)]
040408 Urea	NH_3	**2002-2017: LAIR** 1990-2001: linear interpolation of the IEF between Tier 2 and 2002 LAIR [1)]
	TSP	**2002-2017: LAIR** 1990-2001: linear interpolation of the IEF between Tier 2 and 2002 LAIR [1)]
	$PM_{2.5}$	Tier 2 proportion to TSP
	PM_{10}	Tier 2 proportion to TSP
	BC	Tier 2
Other fertilizers	NH_3	**2002-2017: LAIR**

		1990-2001: linear interpolation of the IEF between Tier 2 and 2002 LAIR 1)
	TSP	**2002-2017: LAIR** 1990-2001: linear interpolation of the IEF between Tier 2 and 2002 LAIR 1)
	$PM_{2.5}$	Tier 2 proportion to TSP
	PM_{10}	Tier 2 proportion to TSP
	BC	CS: same as for urea production

1) *Extrapolation of fertilizers are performed together as activity data is not yet detailed by fertilizer type*

Please find the detailed description of LAIR database in Chapter 1.4 of the IIR.

Emission factor

Emission factors used are included in the Table above. Directly reported emission data is prioritized in every case it is available and verifiable (usually for TSP and NH_3). Default factors are used in other cases (usually for NMVOC). In LAIR only TSP data is reported, so PM emissions are calculated based on PM_{10}, $PM_{2.5}$ and BC proportion to Tier 2 emission factor of TSP, where available. This is the case by production of PVC and fertilizers.

As directly reported emissions are available usually only from 2002, extrapolation is needed in order to complete the time series. Extrapolation is performed in the following ways:

- in the case of TSP (and PMs calculated based on TSP) the earliest and/or highest available implied emission factor (usually data of year 2002) is used for the calculation of the years before 2002;

- in the case of carbon black SO_x and fertilizers NH_3, an implied emission factor calculated using a linear interpolation between the earlier available directly reported data and the Tier 2 emission factor is used.

- combustion emissions: using production volumes as surrogate data and implied factor of either 2005 or average of 2006-2013 in the case there is no trend.

Activity data

Activity data is available from the HCSO and in several cases it is reported also by the companies for UNFCCC GHG Inventory reporting purposes.

Uncertainty, recalculations, qa/qc activities and planned improvements

Since the coverage of the sector 2.B.10.a is very wide, continuous efforts are needed to explore further possible emitters in order to improve completeness. However, it should be taken into consideration that the eventually missing emissions are expected to be non-significant compared to the National Totals.

From 2018, CO_2 emissions have been reported in the ETS system from formaldehyde production. As the company have been producing formaldehyde from 1998, CO_2 emissions are reported in the IIR from formaldehyde production from 1998 onward. In the NFR, CO, NMVOC and TSP emissions are calculated and reported from 1998. Activity data is the produced amount of formaldehyde provided by the company. Emission factors for CO, NMVOC and TSP are from the EMEP/EEA 2019 Guidebook, 2B Chemical Industry, Table 3.55 (Tier 2 method, silver process, thermal or catalytic incineration).

There was no recalculation in the 2023 submission.

4.4 Metal production (NFR sector 2.C)

4.4.1 Iron and steel industry (NFR sector 2.C.1.)

Last update: 15.03.2023.

Reported Emissions: TSP, PM_{10}, $PM_{2.5}$, BC, Pb, Cu, Zn, NMVOC, Cd, Hg, As, Cr, Ni, Se, PCB, PCDD/F, HCB

Measured Emissions: TSP, Pb, Cu, Zn, PCDD/F

Methods: T1, CS, T3

Emission factors: T1, CS, T3

Key source: Level Pb, Hg, Cd, PCDD/F; Trend Cd

In this sector only process emissions from Iron and steel production are reported and NO_x, SO_x and CO are reported entirely in sector 1A as it is suggested by the 2016 EMEP/EEA Guidebook. Emissions from combustion during production of Iron and steel are reported in sector 1A2a. Combustion emissions from production of coke are reported in 1A2b and fugitive emissions arising during production of coke are reported in sector 1B1b.

In Hungary both pig iron and steel are produced and both basic oxygen furnace and electric arc furnace technologies are present.

Emission factor

Tier 3 method, i.e. direct emissions reported by companies are used in the case of **TSP, Pb, Cu and Zn**. PM emissions are calculated based on **PM_{10}, $PM_{2.5}$, BC** proportion to TSP of Tier 1 emission factors. As directly reported emission data in LAIR database is available only from 2002, extrapolation is applied by using IEF of year 2002 or the average of 2002-2003 or Tier 1 EF, whichever is the higher. Please find the implied emission factors in the following table.

4.9. Table: Comparison of Tier 1 and Tier 3 emission factors used for extrapolation for the years before 2002

	Tier 1 EF	**IEF applied for the years before 2002**	**source of the IEF**
	g/Mg steel		
TSP	***300***	1372	average of 2002-2003 LAIR
PM_{10}	***180***	823	
$PM_{2.5}$	***140***	640	
BC	*0,36% of $PM_{2.5}$ = 0.5*	2.3	
Pb	***4.6***	4.92	2002 LAIR
Cu	***0.07***	0.28	2002 LAIR
Zn	***4***	4.00	Tier 1

PCDD/F emissions are reported using E-PRTR data. As E-PRTR data is available usually only for year x-3, IEF of the year x-3 and activity data of year x-2 is used. Although the use of E-PRTR data results higher emission of PCDD/F than the use of Tier 1 default factor, former is applied to ensure consistency with E-PRTR reporting. It seems that emission factor from UNEP Toolkit 2005 was used to calculate PCDD/F emissions for E-PRTR reporting purposes.

NMVOC, As, Cr, Ni, Se and PCB emissions are estimated based on Tier 1 default factor of the 2016 EMEP/EEA Guidebook.

For Hg and Cd emissions, the 2020 NECD review proposed to calculate a revised estimation using Tier 2 method without abatement instead of the formerly used Tier 1 method. The revised estimate was accepted and recalculation was completed and reported for every year. The new estimation calculates Cd and Hg emissions according to Tier 2 (without specifications on abatement technologies) of EMEP/EEA 2016, 2C1 chapter, using the following tables: Table 3.2 for sinter production, Table 3.8 for pig iron production - blast furnace charging, Table 3.14 for BOF steel production and Table 3.15 for EAF steel production. However, during these calculations, the sinter and pig iron production were calculated following the next conversion ratios: for every kg pig iron produced, 1.16 kg sinter is used and for every kg steel produced, 0.94 kg pig iron is used.

Total PAH emissions have been reported in the Tutelae LAIR database by the BOF steel producing company from 2015. For calculating total PAH emissions before 2015, produced pig iron and the average emission factor of reported years were used.

The use of default factors for Total 1-4 PAHs emissions would result an unreasonable vast value and no directly reported data is available either, therefore no emissions are reported.

Activity data

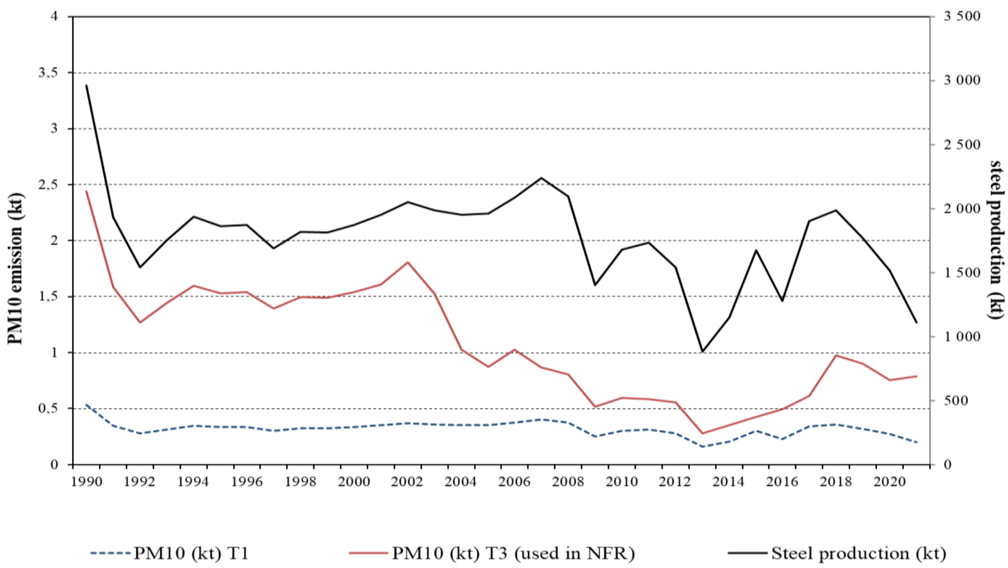


Figure 4.7 Production of steel in Hungary and comparison of PM10 time series calculated with T1 and T3 methods

Activity data is available from the HCSO and it is reported also by the companies for UNFCCC reporting purposes. In 2021, the production of pig iron fell sharply again due to problems in the operation of Hungary's only pig iron manufacturer, therefore the output of iron and steel production decreased by 24%.

Emission increased for almost all air pollutant (except for PCDD/F) in iron and steel industry subsector in 2017, where the favourable EU export market situation and competitiveness of Dunaferr Zrt. in this market resulted from the efficiency improvement measures taken by the company between 2014 and 2016. In 2018, the company begun to decline. Together with this, problems arised in the dust extraction equipment of the company have not been solved causing increasing TSP, PM and Pb emissions despite the decline in production.

Uncertainty, recalculations, qa/qc activities and planned improvements

Recalculation of Hg and Cd emissions was performed for every year because of changing emission factors from Tier 1 to Tier 2 (without abatement) method. Cd and Hg emissions were calculated for sinter production, blast furnace, BOF and EAF workshapes according to Tier 2 (without specifications on abatement technologies) of EMEP/EEA 2016, 2C1 chapter. Emission factors from Table 3.2 (sinter production without abatement technology), Table 3.8 (pig iron production, blast furnace charging), Table 3.14 (BOF steel production) and Table 3.15 (EAF steel production) were used for calculations. However, during these calculations, the sinter and pig iron production were calculated following the next conversion ratios: for every kg pig iron produced, 1.16 kg sinter is used and for every kg steel produced, 0.94 kg pig iron is used.

From 2015, total PAH emissions have been reported in the total LAIR database by the BOF steel producing company. For calculating total PAH emissions before 2015, produced pig iron and the average emission factor of reported years were used.

TSP was recalculated for years 2019 and 2020 as the EOF steel company corrected its emission values in the E-PRTR system based on direct emission measurements. This recalculation caused negligible effect on the national total.

4.4.2 Aluminium production (NFR sector 2.C.3.)

Last update: 15.03.2022.

Reported Emissions: TSP, PM_{10}, $PM_{2.5}$, PCDD/F, heavy metals

Measured Emissions: PCDD/F

Methods: T2, T3

Emission factors: T2, T3

Key source: Level and trend HCB

Process emissions from primary and secondary metal production are reported within this sector. Since 2006 there is no primary aluminium production in Hungary. However, alumina production is present in the country, these process emissions are not estimated due to absence of emission factors or directly reported emissions except for PCDD/F emissions. Combustion emissions of production of alumina are included in sector 1A.

The following pollutants are reported in this sector:

Primary aluminium (1990 - 2005): NO_x, SO_x, CO, PAH

Secondary aluminium (1990 -): TSP, PM_{10}, $PM_{2.5}$, PCDD/F, heavy metals, HCB.

Activity data

For primary aluminium production, activity data is available from HCSO. Reliable secondary aluminium production data are available only from 2003, also from HCSO. Extrapolation of secondary production for earlier years was based on the ratio of primary and secondary production during the 2003-2006 period assuming that the secondary aluminium production varied in proportion to primary production. Meanwhile, a new piece of information was found on that the total (primary and secondary) aluminium production in 1989 was the half of the total (only secondary) production of 2009. Production data for 1990 was calculated based on these information and secondary aluminium production data from 1991 to 2002 was calculated by interpolation.

Emission factor

Tier 2 default emission factors were used for process emissions of NOx, SOx, CO, PAH from primary aluminium production until 2005.

Tier 2 default emission factors are used for primary (2000-2005) and secondary (2000-) aluminium production for TSP, PM_{10}, $PM_{2.5}$ and BC emissions.

Tier 2 default emission factor is used for HCB emissions from secondary aluminium production from 1990 to 1995. IPPC permits are available from 2003 onwards in the LAIR database in case of aluminium plants. IPPC permits declare that in the second half of the 1990s, technology with current world standards was introduced in the metal purification process. In 2007, emission measurements were performed at the main secondary aluminium plant by accredited laboratories in the frame of the National POP Action Plan of Hungary. Based on these informations, a new, country specific emission factor was calculated from 2007 onward, and an interpolation was performed from 1995 to 2007.

Tier 2 revised emission factor is used for PCDD/F emissions from secondary aluminium production. Our investigation found that default Tier 2 emission factor - "Thermal Al processing, scrap pre-treatment, good controls, filters with lime injection" - could be valid only for one producer. The others belong to other emission factors defined in UNEP (2005) as " Optimized for PCDD/PCDF control – afterburners, lime injection, fabric filters and active carbon" or "Thermal de-oiling of turnings, rotary furnaces, afterburners, and fabric filters" with much lower emissions (two order of magnitude). Emission measurements can be found in the PRTR database for one, new producer for 2014-2018. Based on this information (and the new activity data), a revised estimation was calculated for every year, which was agreed by the TERT.

Heavy metals reported are the directly reported data by the secondary aluminium processing facilities.

Uncertainty, recalculations, qa/qc activities and planned improvements

HCB emission calculation is included in the NFR for the proposal of the 2020 NECD review. Estimation was made for 1990 based on revised secondary aluminium production data and revised Tier 2 emission factors. The new estimates were accepted and recalculation was completed for every year.

Secondary aluminium production data was estimated and recalculated from 1990 to 2002. Based on new activity data, TSP, PM10, PM2.5 and BC emissions were recalculated for 2000, 2001 and 2002 and PCDD/F emission was recalculated from 1990 to 2002 using original emission factors.

For PCDD/F, a new emission factor was calculated based on emission measurements reported in E-PRTR database. New EF was used for PCDD/F emissions from 2015 onward, while for 2003-2014 an extrapolation was performed.

There was no recalculation in the 2023 submission.

4.4.3 Copper production (NFR sector 2.C.7.a.) and zinc production (NFR sector 2.C.6)

Last update: 15.03.2022.

Reported Emissions: TSP, PM_{10}, $PM_{2.5}$, BC, Pb, Cd, Hg, Zn, As, Cu, Ni, PCB, PCDD/F, SO_x

Measured Emissions: none

Methods: T1

Emission factors: T1

Key source: none

Only process emissions from **secondary** metal production are reported within these sectors using default Tier 1 emission factors of the 2016 EMEP/EEA Guidebook.

Secondary copper: TSP, PM_{10}, $PM_{2.5}$, BC, Pb, Cd, As, Cu, Ni, PCDD/F.

Secondary zinc: TSP, PM_{10}, $PM_{2.5}$, BC, Pb, Cd, Hg, Zn, PCB, PCDD/F, SO_x

However, the companies processing non-ferrous metals (secondary production) in Hungary are reporting to LAIR but not all the substances where default EF is provided in the EMEP/EEA Guidebook (e.g. no reporting of PCDD/F, PCB, HCB, etc.). It might be the case that there is no emission at all from certain pollutants but in the absence of detailed information we have used default factors. So, the results are probably a very conservative overestimation of several substances.

SO_x emissions from secondary zinc production have been calculated from 1990 using Tier 1 methodology and default Tier 1 emission factor of the 2016 EMEP/EEA Guidebook. However, further investigation is needed concerning the overestimation of several substances mentioned in the previous paragraph.

Emission factor

In case of copper production PM10, Pb and As emission factor was changed in the guidebooks. In this submission emissions of these pollutant were recalculated according to Tier 2 (secondary production) methodology of the 2016 Guidebook. No abatement efficiency is taken into account neither of the reported pollutant due to absence of data.

There are significant changes between the EFs of 2009, 2013 and 2016 versions of the EMEP/EEA Guidebook in 2A6 Zinc production sector. As emission factors in the new guidebooks for unabated and current technology differ extremely. In this submission Tier 2 emission factors - valid for EU-28 current tech. level - from 2016 Guidebook were used. It was assumed that all installations in the EU must achieve the required standard of BAT Ref. Document. Investigating the reported abatement efficiency of selected non-ferrous metal producers in the LAIR database this assumption seems reasonable. Before 2004 the old calculation was kept, because Hungary became part of the EU in this year. In addition, uncertainty of all emissions before 2008 is very high in this category, because activity data is not available from the HCSO, for years before 2008 they were extrapolated with fuel consumption of non-ferrous metal producers as surrogate data.

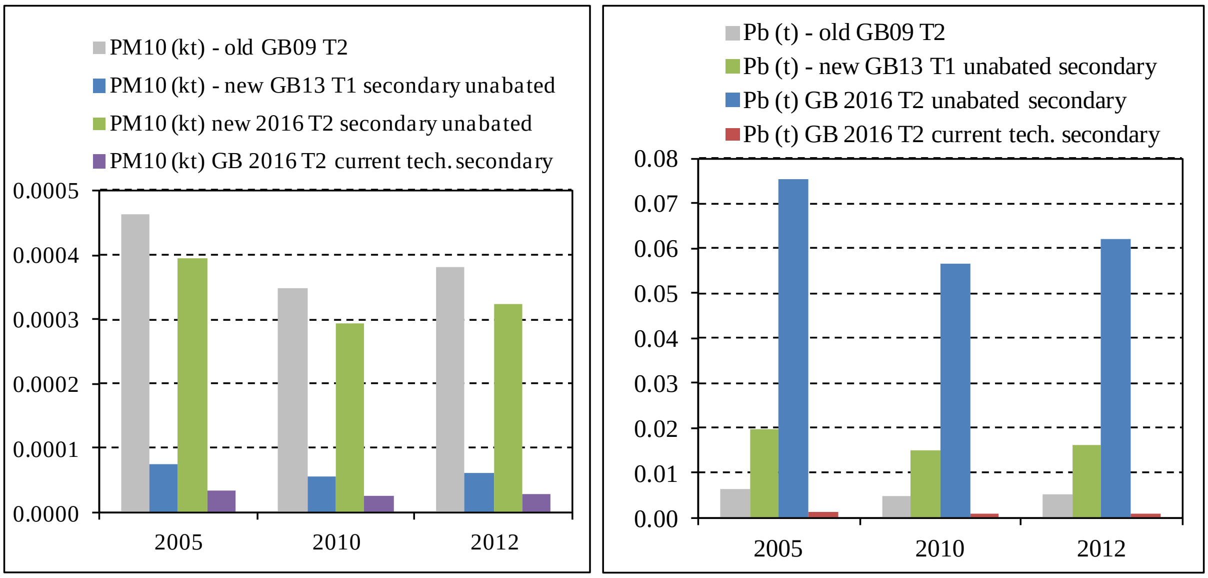


Figure 4.8 *Comparison of emissions for PM_{10} and Pb calculated using EMEP/EEA 2009(old GB09), 2013 (new GB13) and 2016 versions from 2C6 Zink Production (secondary)*

Activity data

Activity data is available from HCSO. Due to confidentiality problems activity data were reported in aggregated way as secondary zinc and copper production.

Uncertainty, recalculations, qa/qc activities and planned improvements

SO_x emissions from secondary zinc production have been calculated and provided for every year from 1990.

There was no recalculation in the 2023 submission.

4.4.4 Other metal production (NFR sector 2.C.7.c)

Last update: 15.03.2022.

Reported Emissions: Zn

Measured Emissions: Zn

Methods: T3

Emission factors: T3

Significant amount of zinc emissions is reported to the E-PRTR database from coating of metals and casting. However, the database is incomplete, there are years where no emissions were reported. To have complete and consistent time-series emission reports from coating (galvanizing) and casting were collected from LAIR database. Zinc emission from these sources is reported first time in the 2018 submission.

Emission factor

NMVOC emissions are reported using directly reported data from LAIR, where no activity data is reported.

Activity data

Activity data is created using the volume index of coting of metals from HCSO database.

Uncertainty, recalculations, qa/qc activities and planned improvements

Emissions of other pollutant of these sources will be included when complete time-series will be available.

There was no recalculation in the 2023 submission.

4.5 Product uses (NFR sector 2D)

The main difficulty in this sector is to gather activity data, since mostly consumption data is needed of a wide range of products that is usually not directly available from statistics. This is why several assumptions and estimation are needed which increases the uncertainty of the emissions reported.

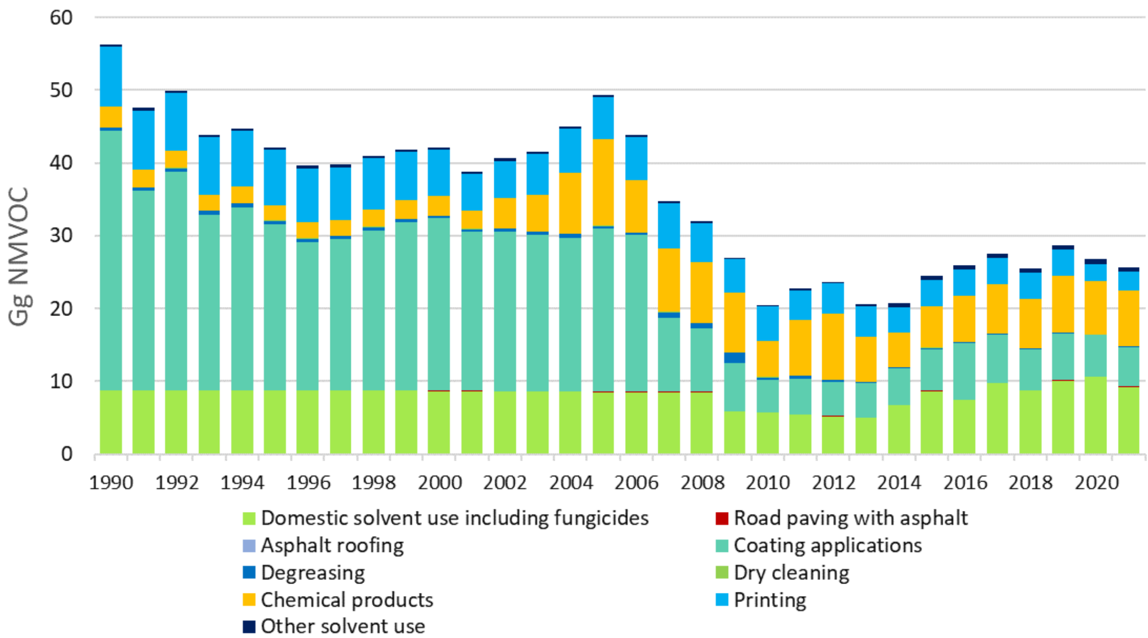


Figure 4.9 *NMVOC emissions of product uses*

4.5.1 Domestic solvent use (NFR sector 2.D.3.a)

Last update: 15.03.2023.

Reported Emissions: NMVOC

Measured Emissions: none

Methods: T1 (1990-2015), T2 (2016-)

Emission factors: T1 (1990-2015), T2 (2016-)

Key source: Level and trend NMVOC

The coverage of this sector is defined in 2019 EMEP/EEA Guidebook as follows:

"NMVOCs are used in a large number of products sold for use by the public. These can be divided into a number of categories.

- Cosmetics and toiletries: Products for the maintenance or improvement of personal appearance, health or hygiene;

- Household products: Products used to maintain or improve the appearance of household durables.

- Construction/DIY: Products used to improve the appearance or the structure of buildings such as adhesives and paint remover. This sector would also normally include coatings; however these fall outside the scope of this section and will be omitted.

- Car care products: Products used for improving the appearance of vehicles to maintain vehicles or winter products such as antifreeze."

"NMVOCs are mainly present in consumer products as solvents. In aerosols, NMVOCs such as butane and propane are also used as propellants. Propellants generally act as solvents as well". …"Emissions occur due to the evaporation of NMVOCs contained in the products during their use". …" There are only limited data available on the NMVOC species present in consumer products. …."

Please note that "*this section does not include the use of decorative paints*", it is included in sector 2D3d Coating applications.

Methodologies

During review 2020 TERT had noted that recommendation HU-2D3a_2017_0001 raised during the 2017, 2018 and 2019 review has not been implemented for category. In order to use a higher method, Hungary has investigated the issue and provided estimation based on the ESIG paper and TERT had accepted this new method.

This method mainly based on the published emission factors by ESIG for 2013 and 2015 (1.4; 2.4 kg NMVOC/capita) and total NMVOC emissions for 2008, 2009, 2013 and between 2015 and 2020 (23.8; 16.5; 14.4; 23.8; 25.8; 25.5; 26.02; 29.12, 30.05 kt NMVOC). ***Table 4.10.*** includes these values.

ESIG published a factor for Hungary for NMVOC emission per capita for 2013. John K. Pearson from ESIG presents a table in his paper (European solvent VOC emission inventories based on industry-wide information, Atmospheric Environment 204 (2019) pp 118-224, Table 6), which indicates a 0.5 domestic sector solvent emissions kg NMVOC/capita/year for 2013 (this factor is 1.4 for the whole 2.D.3) based on ESIG estimates saying that each country has a different gross domestic product (GDP) and culture. This means, that in 2013 the emission of NMVOC from domestic solvent use is 35.7 % of the total emission from 2.D.3. The study highlights the great uncertainty of these estimates. Despite uncertainty, as no other alternatives are known, Hungary use this factor also for other years. So, Hungary assumes that household solvent use accounted for 35.7 % of the total 2.D.3 in the following years as well. For year 2015, a factor of 2.4 kg NMVOC/capita was calculated by ESIG (2.63; 2.61 kg/capita provided by Hungary based on the total emission (ESIG) divided with the population for 2016, 2017, respectively).

Using this EF, emission from domestic solvent use is 10.40 kt for 2019.

Emission factors for the year 2005 is 2.37 kg NMVOC/capita for the whole sector 2D3. It’s important to clarify that this factor given for 2005 is the same as for 2008, as this is the earliest published data from ESIG. Hungary has no more exact values for these years. Therefore, emission factor for 2D3a is 0.85 kg NMVOC/capita for 2005.

Table 4.10 Emission factors used in the new methodology introduced in the 2021 submission

	Emission	EF		
	Submission 2021	**new EF for 2D3a**	**EF by ESIG for 2D3**	**Emission by ESIG for 2D3**
1990	8.78	0.85		
1991	8.78	0.85		
1992	8.78	0.85		
1993	8.77	0.85		
1994	8.76	0.85		
1995	8.75	0.85		
1996	8.73	0.85		
1997	8.72	0.85		
1998	8.70	0.85		
1999	8.68	0.85		
2000	8.65	0.85		
2001	8.63	0.85		
2002	8.61	0.85		
2003	8.58	0.85		
2004	8.56	0.85		
2005	8.53	0.85		
2006	8.53	0.85		

2007	8.52	0.85		
2008	8.50	0.85	2.37	23.80
2009	5.89	0.59	1.64	16.50
2010	5.66	0.57	1.58	
2011	5.43	0.54	1.52	
2012	5.18	0.52	1.46	
2013	4.95	0.50	**1.40**	14.40
2014	6.70	0.68	1.90	

In NECD review 2020, TERT agreed with the revised estimate provided by Hungary for years 2005, 2010, 2015, 2015, 2017 and 2018. Reported values provided by Hungary in this review differs from the current emission values because of ESIG has released a new study that already includes data for year 2018. (Submission 2021: 9.29 kt NMVOC, revised estimation in 2020: 9.08 kt NMVOC).

In NECD review 2022 the issue has been raised again, and the TERT decided to calculate a technical correction for the years 2018-2020 in the following way: ESIG 2D3a NMVOC per capita EFs for Hungary were obtained during the review. These EFs were then corrected in line with the 2019 EMEP/EEA Guidebook (Chapter 2.3.D.a, section 3.2.3, page 14) that provides a correction factor of 1.11 for non-solvent NMVOC emissions and a correction factor of 1.11 for solvents not considered in the ESIG methodology. These were used to estimate NMVOC emissions for 2018-2020. The 2020 NMVOC EF includes ethanol and thus the impact of hand sanitiser usage.

Hungary accepted the correction and could extend it to the years 2016 and 2017 as ESIG factors could be reached for these years. Year 2015 was slighly recalculated to smooth the data series. As ESIG factor was not available for 2021, average Ef of the years 2018-2020 was used. For earlier years EFs of the 2021 submission were used.

Table 4.11 (cont) Emission factors used in the recalculation in the 2023 submission

	Emission	EF
	Submission 2023	**new EF for 2D3a**
2015	8.64	0.88
2016	7.39	0.75
2017	9.69	0.99
2018	8.70	0.89
2019	10.11	1.04
2020	10.58	1.09
2021	9.22	0.95

Uncertainty, recalculations, QA/QC activities and planned improvements

Emission of Hg in this category is not reported since submission 2021. 2019 EMEP/EEA Guidebook is not containing an emission factor for Mercury emission from fluorescent tube or bulb – according to the Guidebook – due to the uncertainty of around these releases, so Hungary reports emission of Hg as 'NE'.

Further investigation is planned to improve NMVOC emissions in this category. Development of a higher Tier methodology needs serious investigations of possible data sources. In order to provide the best estimation of emissions from category 2D3a, Hungary has been joined to the project of Capacity building for emission inventories. According to the project team this sector also causes difficulties in other countries, so a new guidance is in progress, it will be taken to the TFEIP in May and Hungary will makes effort to apply the new methodology. In the mean time we keep contact with the ESIG and further investigate the 2D3 category and the possible allocation of sources and activities.

4.5.2 Road paving with asphalt (NFR sector 2.D.3.b)

Last update: 15.03.2022

Reported Emissions: NMVOC, TSP, PM_{10}, $PM_{2.5}$, BC

Measured Emissions: TSP

Methods: T2, T3

Emission factors: T2, T3

NMVOC is reported using Tier 1 method. In the 2015 submission, time series of TSP and PMs had been recalculated using the Tier 3 method, i.e. direct emissions reported by companies. In the LAIR system hot mix asphalt plants are reporting TSP. PM emissions are calculated based on PM_{10}, $PM_{2.5}$ and BC proportion to TSP of Tier 1 emission factors. As directly reported emission data in the LAIR database is available only from 2002, extrapolation is applied by using IEF of year 2002, as the trend of implied emission factors is decreasing over time.

Emission factor

Tier 1 EFs provided in the 2019 EMEP/EEA Guidebook are used for NMVOC, and the proportion of PM_{10}, $PM_{2.5}$and BC to TSP from the Guidebook Tier 1 factors. These are the same as in the earlier version of the Guidebook. Total TSP emission of the category is retrieved from LAIR database.

Activity data

Total Production of Hot Mix Asphalt in Hungary published by EAPA (European Asphalt Pavement Association: www.eapa.org) is used as activity data for the extrapolation before 2002 and for NMVOC calculation.

Uncertainty, recalculations, QA/QC activities and planned improvements

TSP (PMs and BC as well) emissions of the beginning of 2000s are significantly higher (also IEF is very high for 2002). Reported values were checked. These high values seem to be realistic as the emitters had to pay environmental penalty according to these reported emissions. Some of the emitters were also closed down in few years because they could not meet the environmental requirements.

There was no recalculation in submission 2023.

4.5.3 Asphalt roofing (NFR sector 2.D.3.c)

Last update: 15.03.2022.

Reported Emissions: NMVOC, CO, TSP, PM_{10}, $PM_{2.5}$, BC

Measured Emissions: none

Methods: T1

Emission factors: T1

NMVOC, CO and TSP emissions are reported as it is required by the 2019 EMEP/EEA Guidebook using Tier 1 emission factors and activity data from HCSO. Emission factors haven't changed compared to the old version of the Guidebook. Emission from this sector is not significant, all of the pollutants are generally below 0.1 Gg.

Activity data

Unfortunately, there are very few data available on production asphalt roofing material. The data used in this sector is provided by HCSO, however unfortunately it is consistent only for the years 2007-2010. Therefore, extrapolation is used for other years using volume index of "other mineral products" as surrogate data for the years 2011-2014. Since 2015 activity data from HCSO has been given in m^2 instead of tons, so data should be converted which increases the uncertainty of the calculation.

Uncertainty, recalculations, QA/QC activities and planned improvements

Activity data for 2019 was revised in the 2023 submission.

4.5.4 Coating application (NFR sector 2.D.3.d)

Last update: 15.03.2022

Reported Emissions: NMVOC

Measured Emissions: none

Methods: T2

Emission factors: CS

Key source: Level and Trend NMVOC

In this sector NMVOC emission from the use of several types of paints (including solvents) is reported.

In 2018 investigation was started to use higher Tier method and because Tier 1 method could not reflect changes in components of paints, especially the NMVOC contents controlled by the Directive 2004/42/CE of the European Parliament and of the Council. The effect of the abovementioned directive was significant, because the emission from coating application subcategory was reduced.

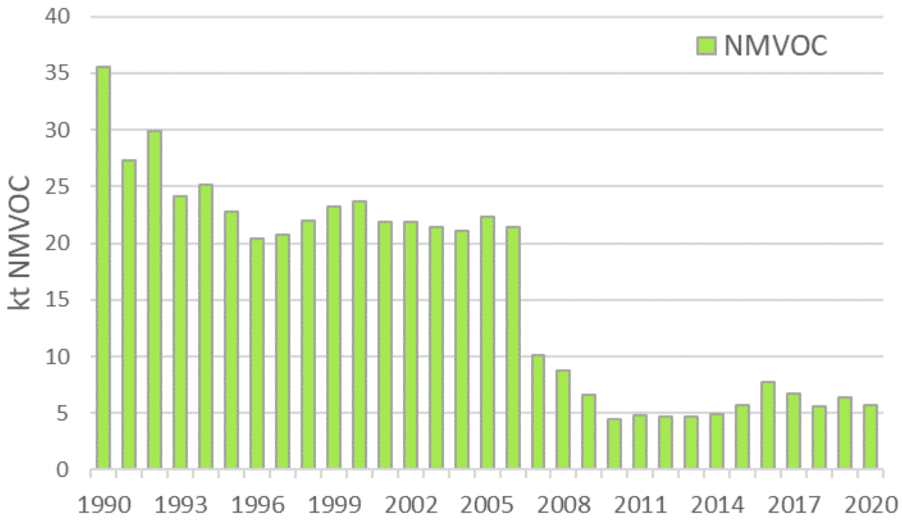


Figure 4.10 *Emission of NMVOC from 2.D.3.d between 1990 and 2020*

Calculations based on the amount of imported, exported and produced coatings. Data about content of NMVOC in paints is available for all the 3 types of paints. Between 1990 and 2006 amount of applied paint (imported-exported+produced) by types was multiplied by the values of NMVOC content by the appropriate type. After 2006, emission was taken into account as the quantity of NMVOC content of applied paints are reported by manufacturers or by first starters. The reporting is regulatory for those companies that manufacture or target more than 100 kg NMVOC content paints.

Emission factor

Hungary has used country specific values to give the emission from this activity, so Tier 2 methodology was used. According to this approach, quantity of emitted NMVOC is the same amount as the NMVOC content of the applied paints.

The expert judgement for solvent content for water-borne coating, solvent-borne coating and oil-colors is derived by an expert of Industrial Paint Research-Development and Entrepreneur Ltd., at the request of the Ministry of Environment. The following results are reported:

- water-borne coating: contains glycol ethers (5-6 %),
- solvent-borne coating (50%): contains xylene (22%), white spirit (22%) and esters and alcohols (6%)
- oil-colors: contains white spirit (25%)

4.12. Table: NMVOC content of several types of paints

Paint type	NMVOC content (%)
water-borne coating	6
solvent-borne coating	50
oil-colors	25

Activity data

Production data from HCSO PRODCOM (in Hungarian: ITO) categorization and trade data from HCSO – Eurostat Combined Nomenclature categorization was used. Activity data of applied paint is calculated as apparent consumption (e.g. import-export+production) until 2006, after 2007 Hungary has exact consumption data about the amount of applied paint (and about the paint's NMVOC content) according to 25/2006 Government Decree on the regulation of the organic solvent content of certain paints and varnishes and vehicle refinishing products. This decree is based on Directive 2004/42/EC of the European Parliament and of the Council of 21 April 2004 on the limitation of emissions of volatile organic compounds due to the use of organic solvents in certain paints and varnishes and vehicle refinishing products.

Hungary has used the sum of NMVOC contain of sold paints according to the Directive 2004/42/EC categories A. and B. (A. Paints and varnishes, B. Vehicle refinishing products). These values are available for 2007 and between 2011 and 2018.These activity data are also emission data from 2007 in the Hungarian inventory. Between 2008 and 2010 the overlap method was applied to complete the time series. To estimate emissions for these years, relationship between sold paints and used paints (imported-exported+produced) for 2007 and 2011 was used.

Uncertainty, recalculations, QA/QC activities and planned improvements

There was no recalculation in submission 2023.

4.5.5 Degreasing (NFR sector 2.D.3.e)

Last update: 15.03.2022

Reported Emissions: NMVOC

Measured Emissions: NMVOC

Methods: T3

Emission factors: T3

NMVOC emissions are reported using directly reported data from LAIR, where no activity data is reported. Therefore, no implied emission factor has been expressed.

Uncertainty, recalculations, QA/QC activities and planned improvement

There was no recalculation in the 2023 submission.

4.5.6 Dry cleaning (NFR sector 2.D.3.f)

Last update: 15.03.2022

Reported Emissions: NMVOC

Measured Emissions: none

Methods: T2

Emission factors: CS

From the 2020 submission, NMVOC emissions from dry cleaning are reported using Tier 2 approach based on technology-dependent emission factors and the quantity of material cleaned. Activity data are available from the year 2004, for earlier years an extrapolation was made based on an estimated factor of emission per capita using population data.

Emission factor

According to the 2019 EMEP/EEA Guidebook, a number of add-on technologies exist that are aimed at reducing the emissions of specific pollutants. The resulting emissions can be calculated by replacing the technology-specific emission factor with an abated emission factor as given in the formula:

$$EF_{technologyabated} = (1-\eta_{abatement}) \times EF_{technologyunabated}$$

The unabated emission factor for NMVOC is 177 g/kg textiles cleaned (2019 EMEP/EEA Guidebook, Chapter 2.D.3.f, Table 3-2), while the abatement efficiency ($\eta_{abatement}$) was calculated based on the analysis of the available technology data in Hungary. Activity data (quantity of material cleaned) is reported by the companies to the LAIR system, while technology data are partly available. The estimated abatement efficiency for Hungary is approximately 88 %. Further investigation is needed on technology data.

Activity data

Activity data from 2004 is the quantity of material cleaned reported by the companies to the LAIR system. For earlier years an extrapolation was made based on an estimated factor of emission per capita using population data. Data on population is available from HCSO.

Uncertainty, recalculations, QA/QC activities and planned improvements

Further investigation of the country-specific emission factor is planned.

There was no recalculation in the 2023 submission.

4.5.7 Chemical products (NFR sector 2.D.3.g)

Last update: 15.03.2022

Reported Emissions: NMVOC, benzo(a)pyrene

Measured Emissions: NMVOC

Methods: T2, T3

Emission factors: T2, T3

Key source: Level NMVOC

In spite of the name of the sector not exclusively chemical products has been reported here, but also shoes and production of foams based on suggestion of EMEP/EEA Guidebooks.

Although there are several potential sources included in the Guidebook, the estimation of emissions in this sector contains solely where both default emission factor and required activity data is available. Unfortunately, the availability of production (or consumption) data of these special products is poor.

The activity reported at the moment is manufacture of shoes, processing of polyurethane and polystyrene foams, manufacture of paint and glues (ink is not manufactured in Hungary), manufacture of pharmaceutical products and asphalt blowing.

The 2019 EMEP/EEA Guidebook provides an emission factor for chemical products manufacture where the unit of measure is g/kg solvents used. Unfortunately, the amount of the solvents used is not known in addition it is probably confidential information specific for every manufacturer, technology and process. So, it was not possible to use the default emission factor. However, in LAIR the emissions of several organic compounds are reported by the pharmaceutical products manufacturers. Due to absence of other methodology this data was aggregated and inserted within this sector.

Emission from asphalt blowing was not accounted until last submission because of the high value of emission factor for PAH. The emission factor for PAH was replaced in the 2019 EMEP/EEA Guidebook and it seems to be more correct than the previous in 2016 Guidebook. Emission of benzo(a)pyrene is appearing only between 1990 and 2002, because gases are treated with afterburner since 2002. According to the expert of one of the plants where this activity takes place the efficiency of afterburner is 100%. So, emission of PAH was not appeared after 2002 in this category.

Used activity data for subcategory paint production were revised for the 2020 submission. Emission from paints and glues manufacturing has been included into national inventory for the first time in the 2017 submission. The calculation is based on Tier 2 method. In 2019, more accurate data were collected about paints and varnishes based on polyesters, acrylic or vinyl polymers; oil paints and varnishes (including enamels and lacquers). In addition, data about manufacturing printing ink, artists' colours were collected as well. But activity manufacture of glaziers' putty, caulking compounds and mastics has been left out from activity data. Water-based paints are not included in the Hungarian inventory (as also TERT recommended it in Draft Review Report 2020).

Emission factor

Tier 2 default emission factor of 0.045 kg NMVOC/pair of shoes; 60 g NMVOC /kg polystyrene foam processed and 120 g/kg polyurethane foam processed; 11 g NMVOC/kg paint and glues manufactured and 2.55 g/Mg asphalt are used in addition to directly reported emission data from manufacturers of pharmaceutical products.

Activity data

Production data of shoes and of paints and glues are available from HCSO. Foam processed is calculated using import, export and production data from EUROStat Combined Nomenclature trade data. Production of asphalt (in tonne) is available directly from the manufacturer between 1990 and 2019.

Uncertainty, recalculations, QA/QC activities and planned improvements

Emission from pharmaceutical products manufacturing was recalculated between years 2014 and 2019. Checking of LAIR data caused the differences between submissions. The impact of this is around 0.01 kt between 2014 and 2018 and +0.8 kt in 2019.

4.13. Table: *Changes in NMVOC emissions in 2.D.3.g sector due to the recalculation between inventory years 2014 and 2019*

	submission 2022	submission 2021	difference
		kt NMVOC	
2014	4.741	4.748	-0.008
2015	5.664	5.668	-0.004
2016	6.320	6.332	-0.012
2017	6.851	6.855	-0.004
2018	6.864	6.859	0.005
2019	7.874	7.087	0.787

4.5.8 Printing (NFR sector 2.D.3.h)

Last update: 15.03.2023

Reported Emissions: NMVOC

Measured Emissions: none

Methods: T2

Emission factors: T2

Key source: Level NMVOC

Emission factor

Followed by the technical correction of the 2022 review of TERT, from the 2023 submission, Tier 2 emission factors taken from the 2019 EMEP/EEA Guidebook: Additional Guidance for Solvent and Product Use, Table 26 (page 24) are used. The EFs are available for 1990, 2000, 2010 and 2019. For the other years, linear interpolation and extrapolation have been applied.

Activity data

Printing ink applied was calculated as apparent consumption, e.g. import-export+production, Trade data from HCSO – EUROStat Combined Nomenclature categorization (code 3215) was used. Printing inks production data is the time-series of Prodcom Code 203 024.

Data of production of printing inks is available from HCSO from 1995 (before this submission data was available only from 2003, but due to the revision of timeseries is now available). In order to complete the timeseries, linear extrapolation was used for earlier years (using 1995-2019 time-series). Values of exported and imported inks are available from 2001 from PRODCOM statistics and between 1990 and 2001 also extrapolation was used.

In order to have a consistent timeseries, we were able to generate a new AD timeseries for production by contacting the HCSO again (for submission 2021). However, these activity data are more accurate than the previous unfortunately, a higher method was not improved until now, due to the lack of activity data.

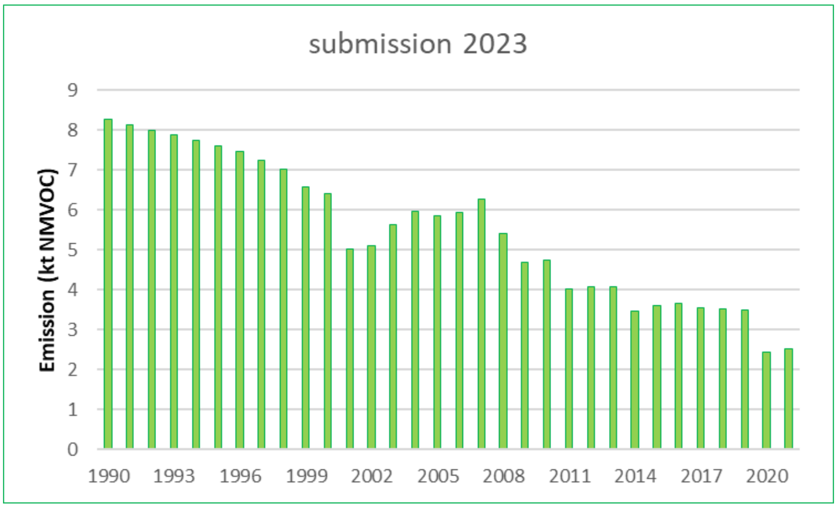


Figure 4.11 *Emission of NMVOC from 2.D.3.h between 1990 and 2021*

Uncertainty, recalculations, QA/QC activities and planned improvements

Followed by the technical correction of the 2022 review of TERT, from the 2023 submission, Tier 2 emission factors taken from the 2019 EMEP/EEA Guidebook: Additional Guidance for Solvent and Product Use, Table 26 (page 24) are used together with national consumption data. The EFs are available for 1990, 2000, 2010 and 2019. For the other years, linear interpolation and extrapolation have been applied.

4.5.9 Other solvent and product use (NFR sector 2.D.3.I)

Last update: 15.03.2023

Reported Emissions: NMVOC, TSP, PM_{10}, $PM_{2.5}$

Measured Emissions: TSP

Methods: T3

Emission factors: T3

This was a new source category in the 2019 submission and it was created to include emissions from "fat, edible and non-edible oil extraction". Hungary was the largest sunflower oil producer in the EU in 2017 (according to statistics of FEDIOL) and it was known that the largest plant in Hungary use solvents for oil extraction. Also, oil producers fall within the scope of the directive 2010/75/EU of the European Parliament and of the Council, so VOC balance and direct emissions are reported to the LAIR database from 2002. For years before 2002 emissions were calculated using oil seed production knowing the typical industrial consumption rate and applied abatement technologies.

Figure below shows activity data and NMVOC emissions of this source category.

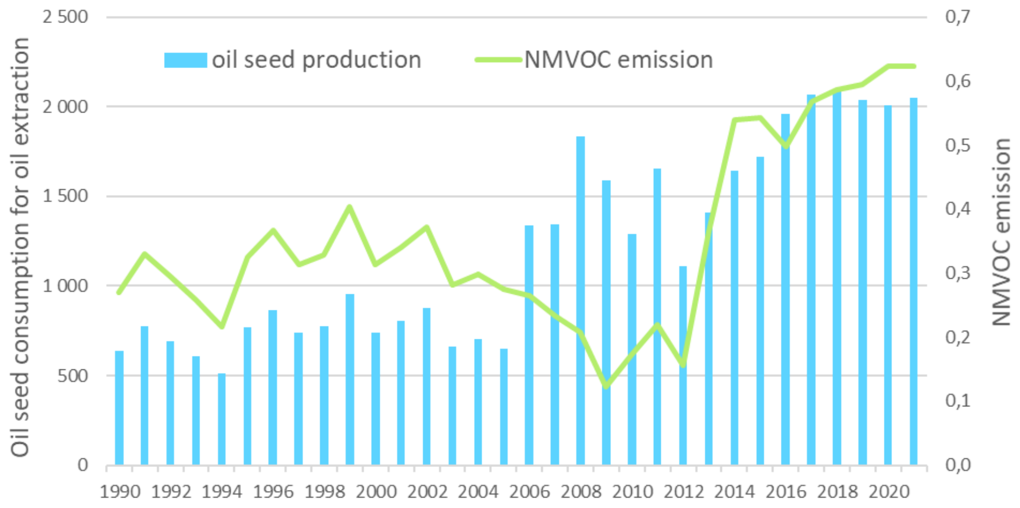


Figure 4.11 *Oil seed processed and NMVOC emissions (1990-2021)*

Emission factor - NMVOC

Tier 3 measured emissions are taken into account from 2002 onwards. Before that, implied emission factors and information about abatement technologies were used in the calculations.

Activity data - NMVOC

The amount of processed oil seeds is taken into account from 2002 onwards. Before that, data of oil seed production and rate of its industrial processing were used obtained from HCSO.

Emission factor – TSP, PM_{10}, $PM_{2.5}$

From the 2023 submission, TSP, PM_{10} and $PM_{2.5}$ emissions from fat, edible and not-edible oil extraction are estimated from the year 2000 using the same activity data as for NMVOC emissions. Hungarian oil producers report controlled TSP emissions to the LAIR database from 2014. Before that, implied emission factors and information about abatement technologies together with extrapolation based on acticity data were used in the calculations. Emission factors for PM_{10} and $PM_{2.5}$ were calculated based on the ratio of Tier 2 emission factors in the 2019 EMEP/EEA Guidebook.

Uncertainty, recalculations, QA/QC activities and planned improvements

TSP, PM_{10} and $PM_{2.5}$ emissions were reported first in the 2023 February submission using Tier 2 methodology which was recalculated with Tier 3 methodology in the 2023 March submission.

During the 2022 review, TERT noted that some activities have not been included in the estimates. This issue is flagged as recommendation, thus it is planned to include emissions from sub-categories in the 2D3i category in the next years.

4.6 Other product use (NFR sector 2.G)

Last update: 15.03.2021

Reported Emissions: NO_x, CO, SO_2, NH_3, NMVOC, TSP, PM_{10}, $PM_{2.5}$, BC, Cd, Ni, Zn, Cu, As, Cr, Hg, Pb, PCDD/F, PAHs

Measured Emissions: none

Methods: T2

Emission factors: T2

Key source: Level and trend Cd

Activities are reported within this sector in Hungary are the tobacco consumption and use of fireworks.

Emission factor

Tier 2 default emission factors for all pollutants are used from 2019 EMEP/EEA Guidebook.

Activity data

<u>Tobacco combustion:</u>

Production, import and export data of tobacco is published by HCSO. Two assumptions are made:

- Consumption of tobacco of a given year = Production-export+import;
- 1 piece of cigarette is 1g.

Use of fireworks:

Using the quantity of manufactured, imported and exported firework for these 2 years we can provide a first estimation of emissions. For these two years, the activity data would be 535 and 679 tonnes, respectively. By applying the Tier2 methodology from the 2019 EMEP/EEA Guidebook,

In response to a recommendation of TERT, after submission 2020 the emission from use of fireworks is included in the inventory. As database use of fireworks in Hungary is incomplete (only available for the years 2003 and 2004), to give an estimation for emission of pollutants from this category, calculation was made with the following assumptions. First of all, for those years when quantity of imported, exported and manufactured products is available, the quantity of export and production is quite the same. The quantity of exported fireworks is in the same order of magnitude as compared to the quantity of manufactured fireworks. Therefore, those years, when trade of these products and also production data is available, the activity data is calculated with the equation of import-export+ production. In that case if database is incomplete, the quantity of imported product is the activity data, moreover for some years Hungary used an interpolation method for consumption.

For 1990 and 1991 imported data is not available, so the emissions are estimated from 1992.

The following table includes the consumption of fireworks in Hungary (activity data).

4.14. Table: Consumption of fireworks in Hungary between 1990 and 2020

	Consumption (tonne)		Consumption (tonne)
1990	3.5	**2006**	711.3
1991	3.5	**2007**	727.7
1992	3.5	**2008**	838.0
1993	12.9	**2009**	522.5
1994	15.3	**2010**	564.4
1995	6.0	**2011**	606.4
1996	34.5	**2012**	648.3
1997	9.0	**2013**	690.3
1998	41.5	**2014**	732.2
1999	82.5	**2015**	774.2
2000	143.9	**2016**	816.1
2001	207.4	**2017**	858.1
2002	187.3	**2018**	900.0
2003	535.1	**2019**	1097.9
2004	678.6	**2020**	30.0
2005	695.0		

Emissions from use of fireworks has been significantly affected by the coronavirus epidemic. Due to government decisions and curfew, emissions have decreased significantly. For example, August 20 is on of the biggest public holiday, when fireworks are the special part of the holiday. In 2020, this programme was not organized. In addition, New Year's Eve fireworks were also cancelled due to curfew restrictions. According to the commercial director of the market leader in pyrotechnics in Hungary, thanks to the above mentioned measures, the market for fireworks has fallen to around 5% of the previous year. For this reason, our estimate is based on 5% of the volume of imported fireworks.

Uncertainty, recalculations, QA/QC activities and planned improvements

During the 2019 review the TERT notes with reference to category 2G that there may be an underestimate of emissions, so Hungary was made an effort to give the emission from use of fireworks. Emission from use of fireworks is not calculated until the 2019 submission because of lack of activity data. Using the quantity of manufactured, imported and exported firework for these 2 years we can provide a first estimation of emissions by applying the emission factors of Tier2 methodology from 2019 EMEP/EEA Guidebook.

There was no recalculation in this submission.

4.7 Pulp and paper (NFR sector 2.H.1)

Last update: 15.03.2023

Reported Emissions: NMVOC, TSP, PM_{10}, $PM_{2.5}$, BC

Measured Emissions: none

Methods: T2

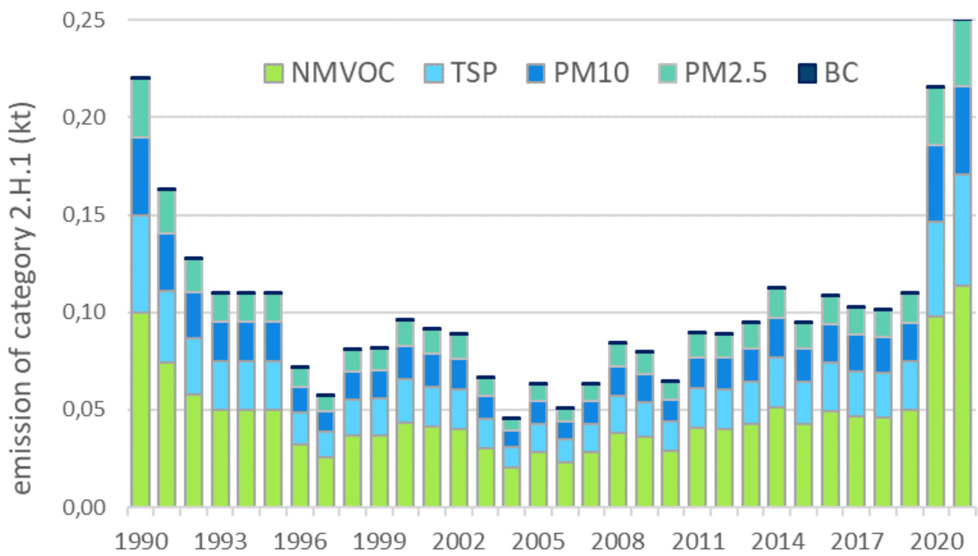
Emission factors: T2

Process emissions of NMVOC, TSP, PM_{10} and $PM_{2.5}$ and BC from Paper and Pulp Industry are reported using Tier 2 method. NO_x, CO, SO_x emissions are reported in sector 1A2, based on the general recommendation of the Guidebook.

Due to the limited number of paper producer companies of Hungary, the use of directly reported emission data in LAIR would have also been possible. On one hand the completeness was not satisfactory neither in the number of reporting companies nor the pollutants reported; on the other hand, combustion emissions were not separable from process emission in this case. In addition, the estimation using default factors seem to be quite realistic, since Tier 2 factors provided in the 2019 EMEP/EEA Guidebook are derived from BAT-BREF document including scrubber and electrostatic precipitator abatement technology, which is probably the case by the most paper and pulp producer facilities in Hungary.

Emission factor

Tier 2 default emission factors of the 2019 EMEP/EEA Guidebook for Kraft process are used, as this is the most common technology. The emission factors are the same as for Tier 1 methodology and as in the earlier version of the Guidebook. No further abatement efficiency is taken into account due to absence of data.



4.12. Figure: *Emission from 2.H.1 between 1990 and 2021*

Emissions almost doubled between 2019 and 2020, because of an additional company entered the market and started significant production in 2020. The quantity of production have been confirmed by the HCSO and also the company.

Activity data

Activity data on Pulp for paper of Hungarian Central Statistical Office (HCSO) was used. Between 2016 and 2018 activity data could be found in the E-PRTR reports and for these 3 years data from LAIR database was used last submission. Before this submission Hungary used FAOStat data before 2016. In order to have a consistent timeseries, we were able to generate a new AD timeseries for production by contacting the HCSO again. These data are more accurate than the previous.

Uncertainty, recalculations, QA/QC activities and planned improvements

In order to have a consistent data set, we were able to generate a new AD time series for production by contacting the statistical offices again.

Due to the limited number of paper producer companies of Hungary, the use of directly reported emission data would be an improvement. The use of this data is not yet feasible because combustion emissions are not separated from process emission in LAIR in this case.

4.8 Food and drink (NFR sector 2.H.2)

Last update: 15.03.2023

Reported Emissions: NMVOC

Measured Emissions: none

Methods: T2

Emission factors: T2

Key source: Level and trend NMVOC

NMVOC emissions are reported in this category, using Tier 2 method. Combustion emissions arising during production of food and drinks are reported in category 1.A.2.e.

Emission factor

Tier 2 default emission factors from 2019 EMEP/EEA Guidebook are used for the production of bread (Europe), sugar, coffee roasting, wine, champagne, beer and spirits. No abatement efficiency is taken into account due to absence of data.

Activity data

Activity data is available from HCSO database. Prodcom codes (ITO Code in Hungarian) and detailed time series of the activity data used is presented in Table 4.5.3.

Uncertainty, recalculations, QA/QC activities and planned improvements

Further verification and eventual consolidation of time series of the activity data would be needed due to the inconsistencies and code changes in production statistics.

***4.15. Table:** Activity data and NMVOC emissions in 2.H.2 Food production subsector*

PRODCOM 2012 Code	**107111 000 055**	**108110 000 055**	**108311 000 055**	**110212 000 703**	**110211 000 703**	**110510 000 703**	**110110 000 271**	
NMVOC T2 EF (kg/hl or t)	*4.5*	*10*	*0.55*	*0.08*	*0.035*	*0.035*	*15*	
	Bread	**Sugar**	**Coffee roasting**	**Wine of grape**	**Champagne white wine**	**Beer**	**Spirits**	**NMVOC emitted**
	t	t	t	hl	hl	hl	abs hl	**Gg**
1990	673000	512334	17600	1691920	284980	9917830	180182	**11.36**
1991	587000	605475	17400	1027670	178900	9569500	158236	**11.50**
1992	485000	399192	16900	1179460	300400	9161870	128513	**8.54**
1993	384000	392883	13600	1089380	358780	7877330	160994	**8.45**
1994	336000	439348	15800	1086830	324960	8081850	193474	**9.20**
1995	293000	479690	13700	992300	296150	7697440	225955	**9.87**
1996	283873	555538	25600	946520	284840	7270440	258436	**11.06**
1997	284232	487174	28300	809790	198050	6973180	121917	**8.31**
1998	285111	439421	21000	1074760	217100	7163970	122648	**7.87**
1999	381689	438277	26100	2220040	195820	6995860	156230	**8.89**
2000	334713	280466	27289	2137270	220390	7194280	153674	**7.06**
2001	356073	443447	53477	2252820	209080	7141920	204778	**9.58**
2002	346754	352201	30084	1961180	236020	7275280	149659	**7.76**
2003	344977	258600	27450	2189740	195320	7245110	161340	**7.01**
2004	367219	493440	23364	2095440	130350	6292000	177036	**9.65**
2005	351129	517049	12087	1984380	172680	6627630	153674	**9.46**
2006	327165	357282	11535	1700070	190860	7208200	170831	**8.01**
2007	295198	223092	11570	1715950	199450	7565700	125568	**5.86**
2008	334485	65874	11272	1765390	178560	7050340	206603	**5.66**
2009	326563	139873	10617	1741680	210430	6512130	202952	**6.29**
2010	332969	122723	10896	1074300	209390	6163570	217758	**6.31**
2011	352515	158585	9036	1201860	157200	6453280	202780	**6.55**
2012	358284	136902	9452	1665720	241300	6387650	202663	**6.39**
2013	476442	177152	8393	1884850	180790	5999990	157804	**6.65**
2014	495616	154123	2675	1820300	244420	5946360	161713	**6.56**
2015	465832	136637	1977	2344330	219440	5817700	170688	**6.42**
2016	326,359	165003	1,728	2,012,050	203790	6075130	193002	**6.40**
2017	316434	148275	4259	2237030	180680	6135930	162561	**5.75**
2018	319529	115880	3859	2712780	196470	5885480	162562	**5.47**
2019	304563	124504	3828	2076650	195410	5774190	162563	**5.43**
2020	299055	86705	3947	2654660	159410	5338140	162564	**5.06**
2021	276584	77328	2099	2839900	156630	5540520	167825	**5.04**

4.9 Wood processing (NFR sector 2.I)

Last update: 15.03.2023

Reported Emissions: TSP

Measured Emissions: none

Methods: T1

Emission factors: T1

Wood processing is only important for particulate emissions. This subcategory includes mainly the manufacture of plywood, fibreboard, chipboard, pallet and sawn timber products.

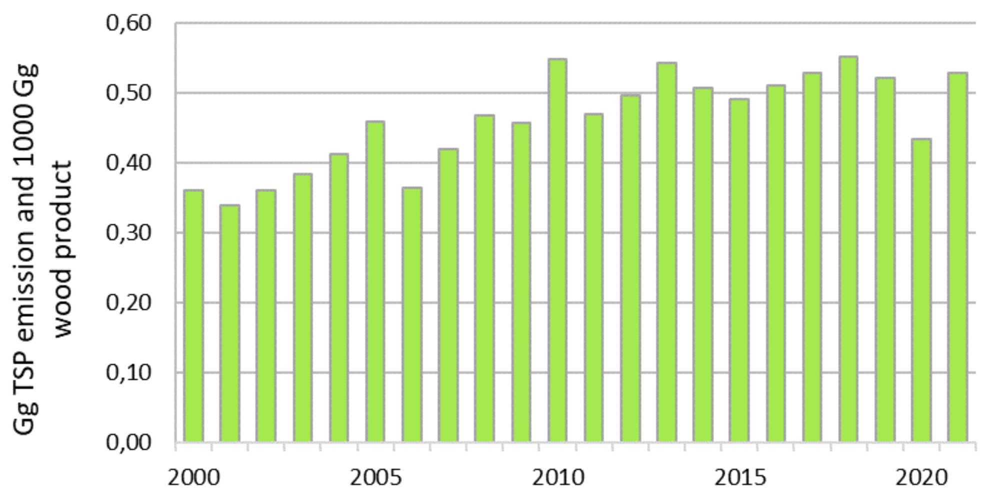
It is only a minor source of emissions and not a key category, thus Tier1 default approach suggested by EMEP/EEA air pollutant emission inventory guidebook 2019 was applied. So, the activity data is the mass of wood products processed.

Emission factor

According to the 2019 EMEP/EEA Guidebook, 1 kg TSP/Mg wood product was used as emission factor.

Activity data

Activity data for wood production have been taken from HCSO database.



4.13. *Figure:* *Wood production and TSP emission from NFR 2.I category*

Uncertainty, recalculations, QA/QC activities and planned improvements

None.

4.10 Consumption of pops and heavy metals (NFR sector 2.K)

Last update: 15.03.2022

Reported Emissions: Hg

Measured Emissions: none

Methods: T1

Emission factors: T1

Key source: Level Hg

The use of PCBs in open systems was banned by OECD in 1970s. Hungary was not produced PCB and consumption of PCBs from import was stopped in 1980s. From the beginning of 1990s only insignificant (1-2 kg) amount was used. PCB contained oils have not been filled into Hungarian produced electrical equipment since 1984.

Mercury emission arise mainly from the use of batteries, electrical equipment and lighting. Tier1 method was applied to estimate the emission of this substance.

Emission factor

For calculating Hg emission from this subcategory default emission factor from 2019 EMEP/EEA air pollutant emission inventory guidebook was used, which is 0.01 g Hg per capita.

Activity data

According to the guidebook emission was calculated by using the abovementioned emission factor and the country's total population.

Uncertainty, recalculations, QA/QC activities and planned improvements

It's a planned improvement to calculate the emission of PCB from the use of transformers and capacitors for the earlier years to have more accurate emissions data (emissions are not significant due to bans (in 2010) of use of PCB contained electrical equipment).

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5 AGRICULTURE (NFR sector 3.)

Last update: March 2023

Agriculture sector comprises NH_3, NO_x (as NO_2), NMVOC, SO_2, CO, particulate matter (PM), heavy metals (HM) and persistent organic pollutant (POP) emissions from the NFR sector 3. Agriculture. However, agriculture is a minor source of SO_2, CO, HM and POPs (except HCB) these emissions generate only from field burning.

The Hungarian national system takes advantage of parallel inventory preparation and reporting of greenhouse gases (GHG) and air pollutants ensuring efficiency and consistency in the compilation of emission inventories, because a wide range of substances using common datasets and inputs. Annual greenhouse gas reporting under the UNFCCC requires the reporting of indirect N_2O emissions through volatilization of NH_3 and NO_x. Therefore, a link is established between the NH_3, NO_x and N_2O emission estimates following the N-budget concepts in the agricultural emission inventories. Consequently, consistency between the two inventories is a principle of agricultural emission estimates.

5.1 Sector overview

This chapter contains emission estimations for source categories '3B Manure management', '3D Agricultural soils' and '3F Field burning of agricultural wastes. '3I Agriculture other' sector is not used in the Hungarian inventory therefore, emission estimates from these sources are reported as 'NO' (not occurring).

Under category '3B Manure management' emissions from Dairy cattle, Non-dairy cattle, Sheep, Swine, Buffalo, Goats, Horses, Mules and Asses, Laying hens, Broilers, Turkeys, Other poultry and Rabbits as 'Other animals' are reported. In the Hungarian inventory 'Other poultry' comprises Geese, Ducks and Guinea Fowls.

In sub-sector 3D emissions from '3Da1 Inorganic N-fertilizers (includes also urea application)', '3Da2a Animal manure applied to soils', '3Da2b Sewage sludge applied to soils', '3Da2c Other organic fertilizers 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' and '3Df Use of pesticides' are reported.

To give an overview of Hungarian agriculture the main characteristics are as follows:

In Hungary, agricultural production practically stopped growing in the late 1980's. This was followed by a dramatic drop in the 1990s, as a result of the economic and political transition taking place in the country. The gross value of agricultural production dropped, by 20 to 40 per cent from the level of the 1980s. The drop was smaller for crop production (10-30%) than for animal husbandry. The output of the latter was only two third or less of the level of 1990 (Laczka and Soós, 2003). The volume index of gross agricultural production reached a minimum in 1993 of 69.1 per cent of the level of 1990. The crop production has fluctuated considerably since 1993. It dropped in 2002-2003 and 2007 due to drought. In contrast, the agricultural production was relatively high due to the significantly high crop production in 2004 and 2008. The animal husbandry remained at a low level between 1993 and 2004 and decreased after the European Union accession (2004) (Laczka, 2007). In recent years swine population decreased furtherly, while cattle population increased as a result of the state incentives to promote the recovery of livestock sector. In 2021 the gross production of agriculture decreased by 0.7%. The largest falls in production were in fruit crops, fodder crops and in animal livestock. (HCSO, 2022).

5.2 Trends in emissions

5.2.1 Ammonia (NH_3)

Agriculture is the main source of NH_3 emissions, with 92.1% share of the national total in 2021 (***Table 5.1***). Agricultural soils accounts for the bulk of national total ammonia emissions in Hungary, it was responsible for 48.2% and 37.0 Gg share of national total in 2021. Fertilizer use at 31.1% (23.9 Gg) are the largest contributor to the national total ammonia emissions. Manure management contributed 43.9% (33.7 Gg) to national emissions in 2021. Under 3B Cattle, Poultry and Swine accounted for the majority of agricultural total NH_3 emissions. Distribution of main sources of ammonia from agriculture for 2021 is shown in ***Figure 5.1***.

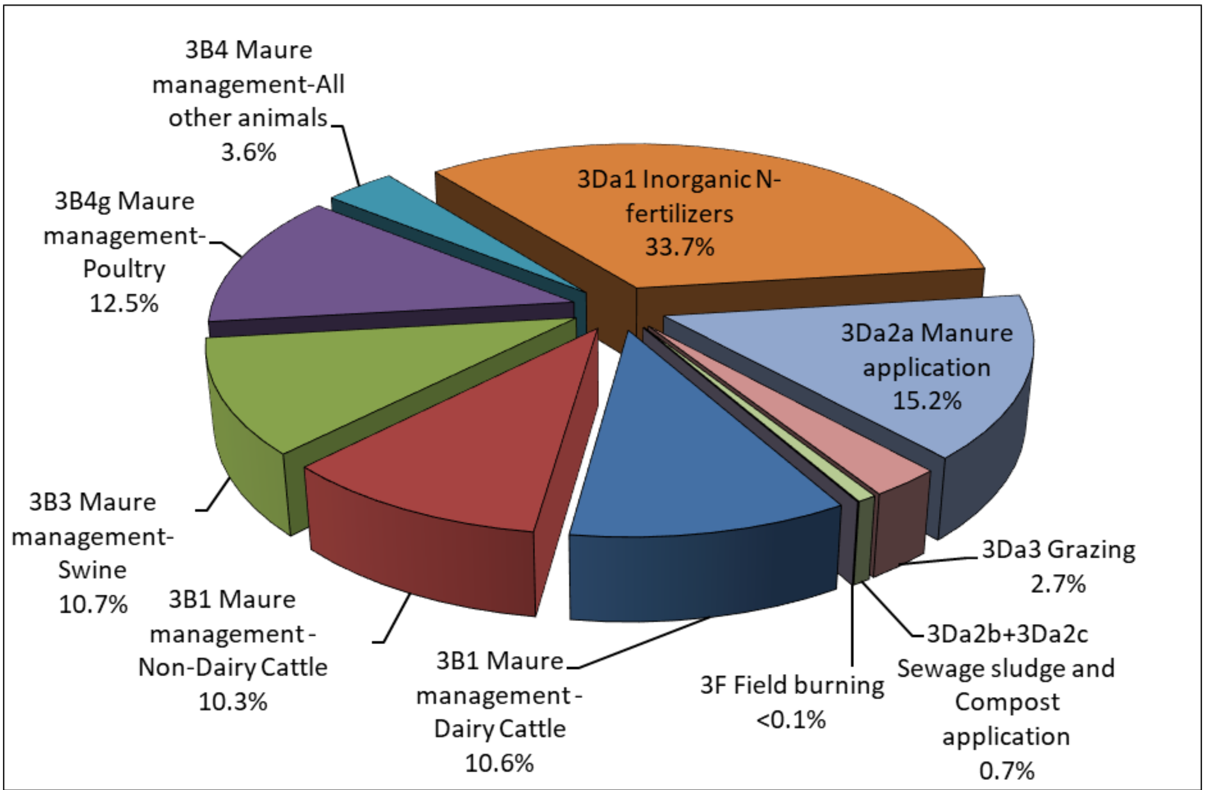

Figure 5.1 Ammonia emissions from Agriculture, 2021

Agricultural NH_3 emissions have decreased by 44.6% since 1990 and reduced by 4.8% in the period 2005-2021 (***Table 5.1*** and ***Figure 5.2***). The main drivers of this reduction are the significant decrease in the emissions form swine and cattle, due to the dramatic drop in livestock numbers at the beginning of the inventory period. Focusing on the period between 2005 and 2021 NH_3 emissions from the agricultural sector have also decreased due to the further shrinking animal livestock. However, in the last years a slight increase in the emissions has been detectable due to the increasing fertilizer use and Cattle, in particular beef-cattle livestock.

Table 5.1 Emission trend of ammonia 1990-2021

Year	3B Manure Management	3D Crop production and agricultural soils	3 Agriculture Total
		Gg	
1990	68.5	59.0	127.6
1991	62.0	43.0	105.0
1992	52.8	36.4	89.2
1993	45.9	32.9	78.8
1994	42.1	32.5	74.6
1995	42.6	32.3	74.9
1996	41.8	32.3	74.1
1997	40.7	32.3	73.0
1998	42.1	34.8	77.0
1999	42.7	35.3	78.0
2000	44.5	36.1	80.6
2001	43.2	36.4	79.6
2002	43.7	37.8	81.5
2003	44.1	37.5	81.6
2004	42.0	37.5	79.4
2005	39.6	34.7	74.3
2006	38.3	35.5	73.8
2007	38.0	36.0	74.0
2008	37.1	30.6	67.7
2009	35.3	28.1	63.3
2010	35.5	28.2	63.6
2011	34.7	28.8	63.5
2012	34.0	28.2	62.2
2013	33.3	30.7	64.0
2014	34.4	30.9	65.3
2015	35.2	33.5	68.7
2016	35.2	34.4	69.6
2017	34.1	36.6	70.6
2018	34.1	36.2	70.3
2019	34.0	36.0	70.0
2020	33.0	37.7	70.8
2021	33.7	37.0	70.8
Share in Hungarian total in 2021	**43.9%**	**48.2%**	**92.1%**
Trend 1990-2021	**-50.8%**	**-37.3%**	**-44.6%**
Trend 2005-2021	**-14.8%**	**6.6%**	**-4.8%**

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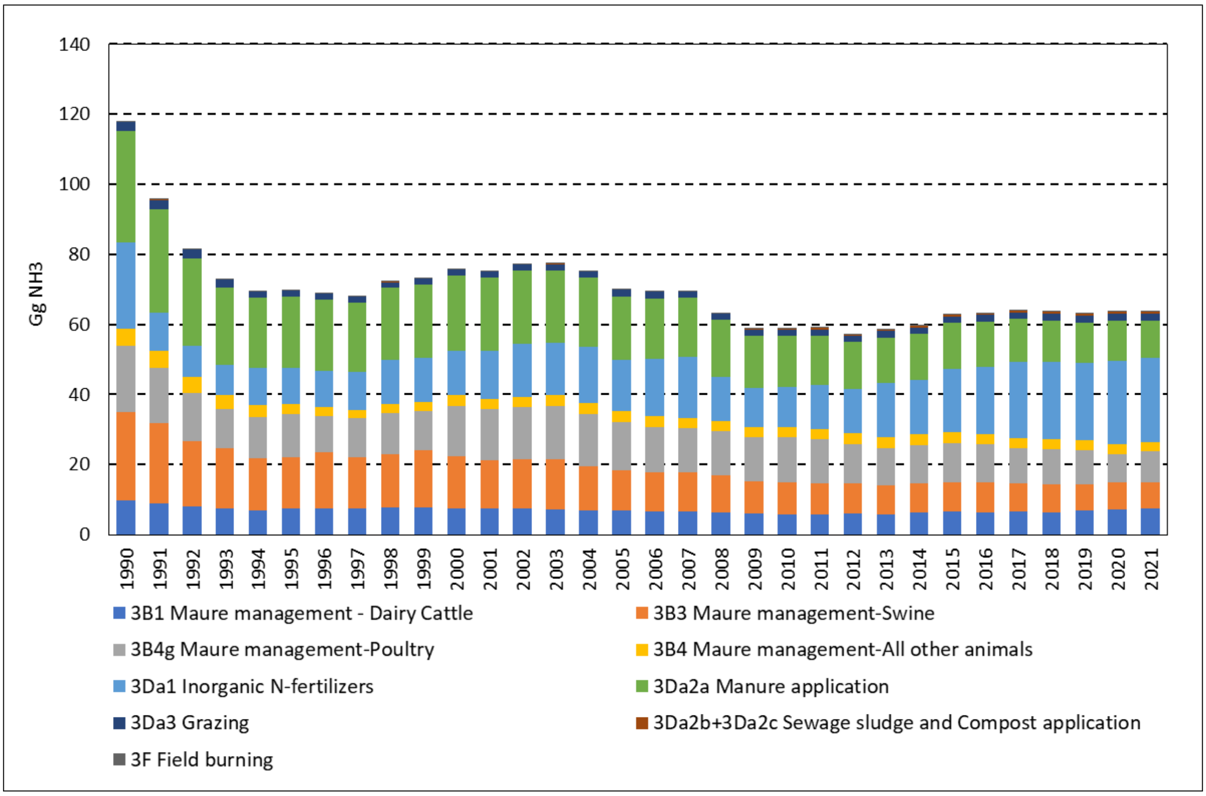

Figure 5.2. Emission trends in the main sources of NH_3, 1990-2021

The significantly shrinking solid urea use between 1990 and 2021 also contributes to the downward trend. Emissions from 3Da1 Fertilizer use have reduced by 2.9 per cent since 1990, despite the fact that the total N-content of the fertilizer applied has increased. Urea use reached its lowest level in 2009, but thereafter the urea consumption, in particular the use of urea solutions, increased strongly, contributing to the upward trend in NH_3 emissions from 3D Crop production. However, the reduction in livestock numbers and therefore in the amount of animal manure available for use, as well as the use of emission mitigation technologies in manure application, have significantly offset the increase in emissions from the use of synthetic fertilizers.

5.2.2 Particulate matter

In 2021 Agriculture accounted for 1.9% (0.7 Gg), 17.0% (9,0 Gg) and 18.7% (13.4 Gg) of the national total $PM_{2.5}$, PM_{10} and TSP emissions, respectively. Agriculture sector was a significant contributor to the PM_{10} and TSP emissions in 2021, because of the high emissions from crop production. The contribution of the 3Dc Farm-level agricultural operations including storage, handling and transport of agricultural products sector was 8.7% (6.3 Gg) to the national total PM_{10} emissions. The relatively high emission level from this source is reasonable, considering the fact that 45% of the total area of the country is cropland.

PM emissions from agriculture have decreased in the period 2000-2021 as a result of the continuously decreasing emissions from 3B Manure management. However, emissions from 3Dc Farm-level agricultural operations including storage, handling and transport of agricultural products have increased modestly, but this increase was offset by the decreasing livestock (Table 5.2 and Table 5.3). TSP emissions from Agriculture are shown in ***Figure 5.3*** and ***Table 5.4***.

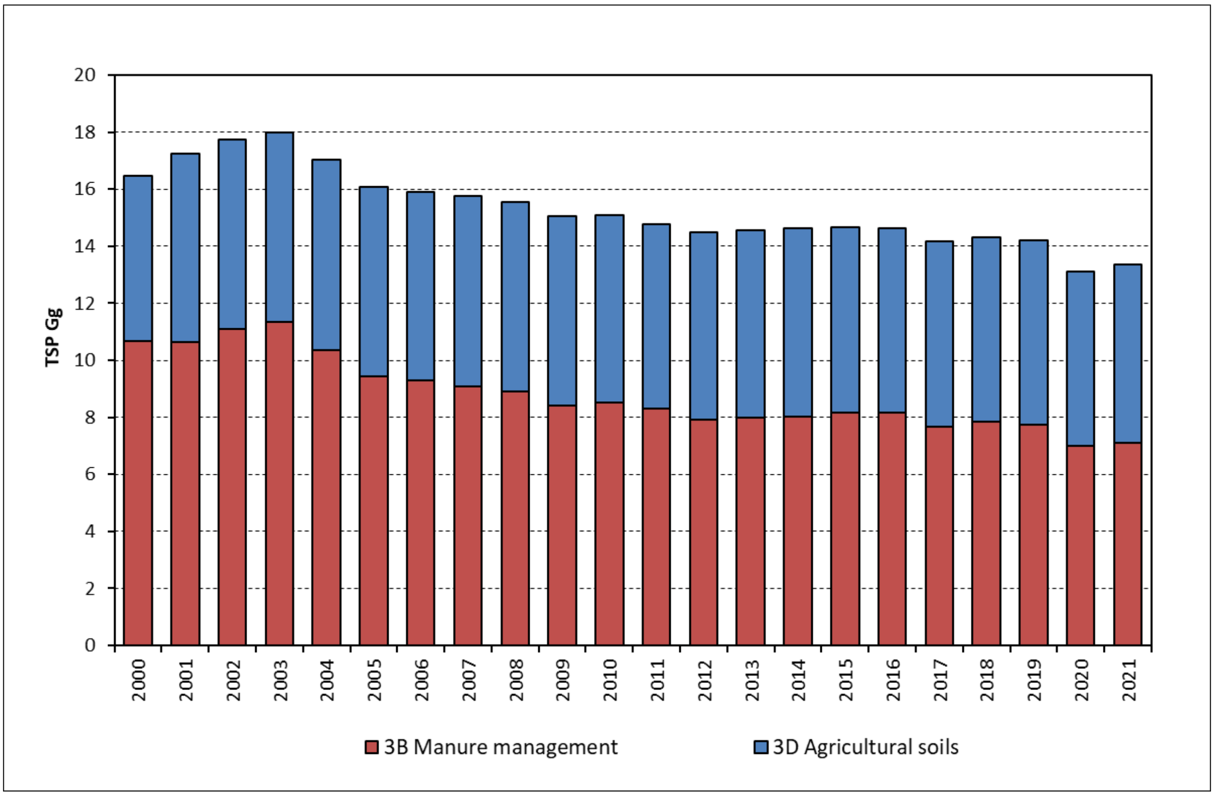

Figure 5.3 TSP emissions from Agriculture, 2000-2021

Table 5.2 Emission trends in agricultural $PM_{2.5}$ emissions, 2000-2021

Year	3B Manure Management	3D Crop production and agricultural soils	3F Field burning	3 Agriculture Total
	Gg			
2000	0.56	0.22	0.02	0.80
2001	0.55	0.25	0.01	0.82
2002	0.58	0.25	0.02	0.86
2003	0.60	0.26	0.02	0.87
2004	0.57	0.26	0.02	0.84
2005	0.51	0.26	0.02	0.79
2006	0.50	0.25	0.01	0.77
2007	0.49	0.26	0.02	0.77
2008	0.49	0.26	0.02	0.77
2009	0.49	0.26	0.02	0.76
2010	0.51	0.25	0.00	0.77
2011	0.51	0.25	0.02	0.78
2012	0.49	0.25	0.02	0.76
2013	0.49	0.25	0.02	0.77
2014	0.50	0.25	0.02	0.77
2015	0.50	0.25	0.02	0.77
2016	0.52	0.25	0.02	0.79
2017	0.48	0.25	0.02	0.75
2018	0.51	0.25	0.02	0.78
2019	0.51	0.25	0.02	0.77
2020	0.44	0.24	0.02	0.70
2021	0.46	0.24	0.02	0.72
Share in Hungarian total in 2021	**1.2%**	**0.6%**	**0.0%**	**1.9%**
Trend 2000-2021	**-18.0%**	**8.4%**	**-10.0%**	**-10.5%**
Trend 2005-2021	**-9.6%**	**-6.0%**	**0.8%**	**-8.2%**

Table 5.3 Emission trend in agricultural PM_{10} emissions, 2000-2021

Year	3B Manure Management	3D Crop production and agricultural soils	3F Field burning	3 Agriculture Total
	Gg			
2000	3.63	5.78	0.02	9.43
2001	3.63	6.60	0.01	10.24
2002	3.89	6.63	0.02	10.54
2003	4.03	6.64	0.02	10.70
2004	3.72	6.69	0.02	10.44
2005	3.30	6.67	0.02	9.98
2006	3.24	6.60	0.01	9.86
2007	3.17	6.69	0.02	9.88
2008	3.19	6.64	0.02	9.85
2009	3.13	6.65	0.02	9.79
2010	3.28	6.59	0.00	9.88
2011	3.29	6.48	0.02	9.78
2012	3.08	6.56	0.02	9.66
2013	3.12	6.55	0.02	9.69
2014	3.10	6.59	0.02	9.71
2015	3.11	6.49	0.02	9.62
2016	3.20	6.49	0.02	9.72
2017	2.93	6.51	0.02	9.47
2018	3.11	6.45	0.02	9.59
2019	3.08	6.47	0.02	9.56
2020	2.54	6.11	0.02	8.67
2021	2.71	6.27	0.02	8.99
Share in Hungarian total in 2021	**5.1%**	**11.8%**	**0.03%**	**17.0%**
Trend 2000-2021	**-25.4%**	**8.4%**	**-10.0%**	**-4.6%**
Trend 2005-2021	**-17.9%**	**-6.0%**	**0.8%**	**-9.9%**

Table 5.4 Emission trend in agricultural TSP emissions, 2000-2021

Year	3B Manure Management	3D Crop production and agricultural soils	3F Field burning	3 Agriculture Total
	Gg			
2000	10.68	5.78	0.02	16.48
2001	10.63	6.60	0.01	17.25
2002	11.11	6.63	0.02	17.75
2003	11.35	6.64	0.02	18.02
2004	10.35	6.69	0.02	17.06
2005	9.42	6.67	0.02	16.10
2006	9.28	6.60	0.01	15.90
2007	9.07	6.69	0.02	15.78
2008	8.89	6.64	0.02	15.55
2009	8.41	6.65	0.02	15.08
2010	8.51	6.59	0.00	15.11
2011	8.31	6.48	0.02	14.80
2012	7.91	6.56	0.02	14.49
2013	7.99	6.55	0.02	14.57
2014	8.02	6.59	0.02	14.63
2015	8.18	6.49	0.02	14.69
2016	8.15	6.49	0.02	14.66
2017	7.65	6.51	0.02	14.19
2018	7.85	6.45	0.02	14.32
2019	7.73	6.47	0.02	14.22
2020	6.98	6.11	0.02	13.11
2021	7.09	6.27	0.02	13.38
Share in Hungarian total in 2021	**9.9%**	**8.7%**	**0.2%**	**18.7%**
Trend 2000-2021	**-33.6%**	**8.4%**	**-10.0%**	**-18.8%**
Trend 2005-2021	**-24.7%**	**-6.0%**	**0.8%**	**-16.9%**

5.2.3 NO_X

In 2021 the NO_x emissions from agriculture amounted to 24.4 Gg and 22.2% of the national total emissions, which is 4.3% lower than the level of 1990. This decrease is the result of the reduction in livestock population and N-fertilizer use (***Table 5.5***). However, focusing on the period 2005-2021 a significant increase is detectable due to the increasing fertilizer use in the recent years.

Table 5.5 Trends in NO_x emissions, 1990-2021

Year	3B Manure Management	3D Crop production and agricultural soils	3 Agriculture Total
		Gg	
1990	2.4	23.1	25.5
1991	2.0	13.8	15.9
1992	1.8	13.0	14.8
1993	1.5	12.6	14.1
1994	1.4	14.4	15.8
1995	1.5	13.0	14.5
1996	1.3	13.4	14.7
1997	1.3	13.3	14.7
1998	1.4	15.1	16.5
1999	1.3	15.7	17.1
2000	1.5	15.7	17.2
2001	1.5	16.3	17.8
2002	1.5	17.4	18.9
2003	1.5	16.9	18.4
2004	1.4	17.0	18.4
2005	1.4	15.5	16.8
2006	1.3	16.5	17.8
2007	1.3	17.7	19.0
2008	1.3	16.6	17.9
2009	1.3	15.6	16.9
2010	1.3	15.9	17.2
2011	1.3	16.7	18.1
2012	1.3	17.2	18.5
2013	1.2	18.6	19.8
2014	1.3	18.6	19.9
2015	1.3	20.2	21.5
2016	1.3	21.2	22.5
2017	1.3	22.0	23.3
2018	1.3	21.9	23.2
2019	1.3	21.6	22.9
2020	1.2	22.7	23.9
2021	1.3	23.1	24.4
Share in Hungarian total in 2021	**1.2%**	**21.1%**	**22.2%**
Trend 1990-2021	**-47.2%**	**0.2%**	**-4.3%**
Trend 2005-2021	**-8.2%**	**49.7%**	**45.0%**

5.2.4 NMVOC

In 2021 Agricultural NMVOC emissions amounted to 28.4 Gg and 24.8% share of the national total (***Table 5.6***). The main agricultural source of MNVOC emissions is the 3B Manure management accounting for 21.8% of national total emission. NMVOC emissions from animal husbandry mainly originate from silage feeding and partly digested fat, carbohydrate and protein decomposition in the rumen and in the manure. Consequently, Cattle husbandry is the most important source of agricultural NMVOC emissions. While cultivated crops are an insignificant source with a share of 3.0% of national total. Agricultural NMVOC emissions have decreased by 47.6% over the period 1990-2021, as a result of the decreasing animal livestock.

Table 5.6 Emission trend for NMVOC from Agriculture, 1990-2021

Year	3B Manure Managemen t	3D Crop production and agricultural soils	3 Agriculture Total
		Gg	
1990	50.1	3.9	54.2
1991	45.5	3.9	49.4
1992	39.1	3.5	42.6
1993	33.5	3.3	36.8
1994	30.7	3.6	34.4
1995	30.5	3.7	34.3
1996	30.1	3.7	33.8
1997	29.6	3.7	33.4
1998	29.7	3.6	33.4
1999	29.7	3.2	33.0
2000	30.8	3.2	34.0
2001	29.9	3.6	33.5
2002	29.9	3.7	33.6
2003	29.5	3.7	33.2
2004	28.2	3.7	31.9
2005	26.8	3.7	30.5
2006	26.1	3.6	29.7
2007	25.9	3.7	29.6
2008	25.6	3.7	29.3
2009	24.9	3.7	28.6
2010	24.9	3.6	28.5
2011	24.7	3.6	28.2
2012	24.7	3.6	28.4

Year	3B Manure Management	3D Crop production and agricultural soils	3 Agriculture Total
		Gg	
2013	25.0	3.6	28.6
2014	25.4	3.6	29.0
2015	25.9	3.6	29.5
2016	26.0	3.6	29.6
2017	25.4	3.6	29.0
2018	26.1	3.6	29.7
2019	25.4	3.6	29.0
2020	24.6	3.4	28.0
2021	24.9	3.5	28.4
Share in Hungarian total in 2021	**21.8%**	**3.0%**	**24.8%**
Trend 1990-2021	**-50.3%**	**-12.2%**	**-47.6%**
Trend 2005-2021	**-7.0%**	**-6.0%**	**-6.9%**

5.3 NFR 3B MANURE MANAGEMENT

From category 3B Manure management emissions of NH_3, NO_x, NMVOC and PM are estimated.

5.3.1 Activity data

Activity data used in the agricultural air pollutant inventory are the same or consistent with those are used in the GHG-inventory as a result of streamlining effort has been made in the last years. The common approach to the UNFCCC and UNECE reporting enables to use the same country-specific values and research results.

5.3.1.1 Livestock population

The HCSO has been producing two censuses of animal numbers per year since 2009. One survey is conducted in June and the other in December. The annual average population for a certain year was calculated by using the chronological mean of censuses as follows:

$$NoA_t = \frac{(0.5 \cdot NoA_{Dec,t-1}) + NoA_{June,t} + (0.5 \cdot NoA_{Dec,t})}{2}$$

Where:

NoA_t = chronological mean of the annual population ofa livestock category in a year t (1,000 head)

$NoA_{Dec.t-1}$ = population of a livestock category in December of the year t-1 (1,000 head)

$NoA_{June.t}$ = population of a livestock category in June of the year t (1,000 head)

$NoA_{Dec.t}$ = population of a livestock category in December of the year t (1,000 head)

The method delineated above was suggested by the HCSO's expert (Tóth, 2004) to smooth out the seasonal changes in the livestock population.

Until the end of 2008 the HCSO collected data on animal livestock population three times a year. namely April, August and December. For the calculation of the annual average population for the years before 2009 the chronological mean was used similarly, based on the three surveys data.

In the case of swine the HCSO uses a livestock category 'piglets<20 kg', while the EMEP methodology provides emission factors for 'sows and pigs <8 kg' and 'finishing pigs 8-110 kg'. The piglet numbers under 20 kg has been splitted into piglets <8 kg and piglets between 8 and 20 kg. The share of piglets <8 kg was calculated on the basis of daily weight gain by Zs. Benedek, 2019.

The annual average livestock populations used to the calculations are provided in Table 5.7 to Table 5.10.

Table 5.7 Animal populations and their trends for 1990-2021

Year	Livestock numbers (1'000 head)									
	3B1a	3B1b	3B2	3B3	4B4a	3B4d	3B4e	3B4f	3B4g	3B4h
	Dairy cattle	Non-dairy cattle	Sheep	Swine	Buffalo	Goats	Horses	Mules and Asses	Poultry	Other (Rabbit)
1990	563.6	1,053.0	1,958.3	8,708.5	0.1	35.1	75.5	4.3	70,325.6	2,587.2
1991	526.6	1,017.8	1,898.4	7,809.1	0.1	39.3	78.0	4.2	58,827.4	2,629.5
1992	479.5	833.9	1,839.6	6,237.4	0.1	50.0	77.5	4.1	52,168.4	2,389.5
1993	436.3	648.5	1,314.6	5,805.4	0.1	60.6	73.0	4.1	43,429.1	2,149.5
1994	408.5	554.4	994.4	5,006.9	0.1	71.3	76.0	4.1	44,477.4	1,909.4
1995	394.5	548.8	1,025.9	5,023.0	0.2	76.1	76.0	4.1	44,874.5	1,669.4
1996	389.4	545.9	915.6	5,493.5	0.3	80.9	68.1	4.1	38,537.7	1,148.9
1997	387.8	520.8	900.9	5,012.7	0.4	85.7	71.0	4.1	40,416.6	1,071.3
1998	381.3	493.8	954.5	5,246.7	0.5	90.5	72.5	4.1	42,707.6	1,051.8
1999	385.0	488.5	980.7	5,609.0	0.6	95.3	73.5	4.1	40,260.3	1,040.4
2000	362.8	479.2	1,192.2	5,146.2	0.7	96.6	77.8	3.6	48,562.1	942.5
2001	353.0	443.3	1,162.8	4,823.3	0.8	107.2	67.5	3.5	51,074.0	1,087.2
2002	344.5	433.7	1,138.2	5,050.0	0.9	96.7	63.2	3.4	51,333.7	1,179.7
2003	330.0	433.2	1,226.5	5,077.5	1.0	94.5	62.5	3.3	52,486.2	1,088.8
2004	309.3	424.3	1,380.2	4,385.0	1.1	84.5	64.5	3.2	50,492.0	1,181.7
2005	299.8	419.7	1,446.7	4,021.7	1.2	77.8	67.0	3.0	46,404.7	1,002.7
2006	275.2	428.2	1,358.2	3,943.7	1.3	81.2	64.8	2.3	44,653.3	1,084.3
2007	267.5	442.3	1,300.7	4,039.0	1.4	71.5	59.0	2.1	43,159.7	1,055.0
2008	263.8	436.2	1,269.7	3,664.7	1.4	72.8	58.3	2.0	45,032.7	903.5
2009	257.5	444.3	1,260.8	3,248.0	1.5	65.0	59.8	1.9	44,789.3	871.3
2010	244.5	454.0	1,203.0	3,208.0	2.5	79.3	65.5	3.1	46,587.0	916.3
2011	250.6	440.2	1,159.1	3,131.3	3.7	83.8	73.0	3.5	46,283.8	949.1
2012	256.0	474.8	1,179.3	2,981.5	3.4	86.0	76.2	3.5	43,063.7	1,367.1
2013	248.5	518.7	1,204.9	2,943.9	3.7	85.2	66.1	2.7	41,674.3	1,560.1
2014	252.0	538.5	1,222.6	3,064.9	3.7	76.7	63.0	2.1	42,683.1	1,643.2
2015	252.1	562.8	1,193.9	3,127.0	3.7	79.5	61.3	2.5	44,459.1	1,610.4
2016	247.0	592.2	1,189.3	3,020.8	5.4	84.0	56.5	3.2	44,907.6	1,300.4
2017	244.8	617.7	1,160.3	2,847.6	6.1	85.0	53.7	4.1	42,711.1	1,149.9
2018	242.7	635.8	1,145.6	2,865.1	6.6	75.3	51.9	4.6	43,136.9	1,204.6
2019	243.9	660.0	1,100.3	2,796.4	6.9	69.0	51.6	5.0	42,875.1	1,195.7
2020	238.4	688.7	997.9	2,831.1	7.8	56.1	58.0	4.4	37,835.1	1,218.4
2021	245.4	679.2	936.9	2,837.2	7.9	50.8	59.5	3.0	40,244.0	1,183.2
Trend 1990-2021	**-56.5%**	**-35.5%**	**-52.2%**	**-67.4%**	**7775.0%**	**44.8%**	**-21.2%**	**-30.6%**	**-42.8%**	**-54.3%**
Trend 2005-2021	**-18.2%**	**61.8%**	**-35.2%**	**-29.5%**	**556.3%**	**-34.8%**	**-11.3%**	**1.5%**	**-13.3%**	**18.0%**

Table 5.8 Non-Dairy Cattle populations and their trends for 1990-2021

Year	Livestock numbers (1'000 head)							
	<1 year		1-2 year		>2 year			
	Bovines for slaughter and other calves (male)	Bovines for slaughter and other calves (female)	Bovines (male)	Heifers for slaughter and other heifers	First calf heifers	Mature Non-Dairy (male)	Heifers for slaughter	Beef Cow
1990	212.6	241.2	169.6	256.9	17.1	15.7	65.6	74.4
1991	204.7	237.8	162.2	251.9	16.4	14.9	61.8	67.9
1992	164.1	206.5	110.7	219.5	13.1	11.0	55.1	54.0
1993	128.7	162.9	86.2	170.9	9.7	7.0	44.7	38.5
1994	109.1	143.9	68.3	151.2	8.0	5.0	41.2	27.8
1995	107.4	143.4	65.9	149.1	7.9	4.9	42.7	27.5
1996	105.5	139.3	70.1	144.3	7.8	4.8	43.8	30.3
1997	99.5	133.0	63.5	138.8	7.4	4.3	47.3	27.0
1998	98.7	131.8	41.5	137.5	6.9	3.7	49.5	24.3
1999	97.4	130.1	47.8	135.7	6.8	3.6	44.3	23.0
2000	96.0	132.6	36.2	136.7	5.8	2.7	41.9	27.4
2001	88.0	125.9	29.4	131.4	4.8	2.7	37.1	24.0
2002	85.0	124.7	27.0	130.0	4.7	2.2	37.2	22.9
2003	87.8	121.4	26.6	124.4	4.5	2.3	36.0	30.1
2004	81.5	113.7	25.3	122.4	6.0	2.7	34.2	38.5
2005	84.7	109.2	22.6	119.1	5.8	2.0	32.8	43.4
2006	84.6	106.5	30.3	116.9	5.5	2.5	30.6	51.3
2007	86.6	106.2	37.0	116.4	6.2	2.2	33.0	54.7
2008	78.9	109.5	32.1	114.7	6.0	2.3	32.0	60.6
2009	81.5	108.2	31.7	120.2	6.5	2.0	32.5	61.7
2010	75.7	108.2	35.0	120.7	7.2	3.2	35.5	68.5
2011	74.5	105.6	26.4	115.7	7.0	2.6	35.6	72.8
2012	86.9	113.5	31.8	117.5	7.0	4.2	35.6	78.3
2013	89.1	119.6	41.5	130.1	8.2	4.3	35.3	90.5
2014	90.2	122.9	44.2	131.2	8.4	2.7	37.0	101.9
2015	90.3	129.9	43.2	135.7	9.2	3.7	38.3	112.5
2016	98.6	133.3	38.3	138.1	10.1	4.7	39.1	129.9
2017	104.0	138.9	37.8	137.4	10.5	5.2	37.8	146.2
2018	107.8	140.7	43.0	140.4	11.3	3.3	34.0	155.3
2019	107.4	146.7	44.9	146.4	11.1	4.3	33.3	166.0
2020	115.9	149.0	51.4	142.3	13.6	5.7	35.7	175.2
2021	116.6	159.4	39.2	129.6	16.8	19.1	27.8	170.7
Trend 1990-2021	**-45.1%**	**-33.9%**	**-76.9%**	**-49.5%**	**-1.7%**	**21.7%**	**-57.7%**	**129.5%**
Trend 2005-2021	**37.7%**	**46.0%**	**73.3%**	**8.8%**	**188.5%**	**856.5%**	**-15.3%**	**293.1%**

Table 5.9 Swine populations and their trends for 1990-2021

Year	Animal Population 1,000 head							
	Pigs<8 kg	Pigs 8-20 kg	Young pigs, 20-50 kg	Pigs for fattening over 50 kg	Breeding boars	Breeding sows	Guilts not yet mated	Sows mated for the first time
1990	1,008.0	945.0	2,626.3	3,239.6	27.2	657.5	116.3	88.5
1991	832.1	780.1	2,349.7	3,090.6	25.1	563.0	104.0	64.4
1992	676.2	633.9	1,844.5	2,436.3	20.4	486.7	81.7	57.8
1993	631.1	591.6	1,744.1	2,245.4	18.0	446.0	77.2	52.0
1994	541.9	508.0	1,499.5	1,958.4	15.4	372.5	66.4	44.8
1995	571.5	535.7	1,458.5	1,921.6	15.3	404.7	64.6	51.1
1996	648.7	608.1	1,523.9	2,146.8	15.7	429.8	67.5	53.0
1997	612.9	574.6	1,302.1	2,039.4	14.3	356.3	56.7	56.3
1998	643.8	603.6	1,407.0	2,073.5	14.0	364.0	65.0	75.8
1999	661.3	620.0	1,503.1	2,299.8	14.8	396.9	56.3	56.8
2000	623.5	584.5	1,302.8	2,143.5	14.2	359.8	56.7	61.2
2001	650.6	609.9	1,108.0	1,984.5	12.5	342.2	54.7	61.0
2002	702.6	658.6	1,136.7	2,043.0	12.8	368.0	60.3	68.0
2003	661.6	620.2	1,157.8	2,150.9	12.0	362.3	56.0	56.7
2004	549.3	515.0	1,015.0	1,885.3	9.8	309.2	50.0	51.3
2005	515.4	483.2	916.5	1,701.9	10.0	291.5	50.7	52.5
2006	503.7	472.2	933.1	1,635.4	8.7	282.2	54.8	53.5
2007	524.0	491.3	934.2	1,700.3	7.8	279.0	52.0	50.3
2008	452.9	424.6	848.3	1,595.3	6.8	249.7	46.3	40.7
2009	390.9	366.5	795.4	1,374.1	6.0	226.5	45.0	43.5
2010	394.0	369.4	751.7	1,374.1	6.5	225.2	42.2	44.7
2011	387.9	363.6	748.6	1,326.9	5.7	217.6	43.4	37.8
2012	365.0	342.1	726.7	1,256.8	5.0	205.8	42.0	38.1
2013	373.7	350.3	683.6	1,250.4	4.8	194.2	44.1	42.8
2014	392.9	368.4	725.0	1,288.5	4.9	198.5	43.5	43.2
2015	404.8	379.5	741.4	1,308.3	4.7	201.1	44.8	42.5
2016	366.9	344.0	665.9	1,370.3	4.2	184.9	43.7	40.9
2017	352.5	330.5	636.8	1,271.5	3.4	175.0	43.7	36.9
2018	359.2	336.7	633.9	1,275.1	3.0	176.6	43.7	36.4
2019	356.2	334.0	626.4	1,228.9	2.7	167.9	45.3	35.0
2020	377.1	353.5	574.1	1,277.3	2.7	164.2	46.1	36.1
2021	380.2	356.4	596.0	1,254.5	2.4	163.4	48.3	36.0
Trend 1990-2021	-62.3%	-62.3%	-77.3%	-61.3%	-91.3%	-75.2%	-58.5%	-59.3%
Trend 2005-2021	-26.2%	-26.2%	-35.0%	-26.3%	-76.2%	-43.9%	-4.7%	-31.4%

Table 5.10 Poultry populations and their trends for 1990-2021

Year	Livestock numbers (1'000 head)						
	3B4gi	3B4gii	3B4giii	3B4giv	3B4giv	3B4giv	3B4giv
	Laying hens	Broilers	Turkeys	Other poultry*	Ducks	Geese	Guinea Fowls
1990	22,735.0	40,178.1	1,772.6	5,639.9	2,463.6	2,926.5	249.8
1991	23,460.1	29,487.6	1,252.7	4,626.9	2,216.7	2,167.5	242.6
1992	20,187.3	27,392.8	916.7	3,671.7	1,969.9	1,459.2	242.6
1993	19,314.4	19,289.5	1,080.1	3,745.1	2,008.4	1,494.1	242.6
1994	17,092.6	21,666.5	1,288.8	4,429.4	2,339.1	1,854.9	235.5
1995	15,732.5	23,349.4	1,599.1	4,193.5	2,144.6	1,833.9	215.0
1996	16,368.0	16,430.5	1,979.1	3,760.1	1,955.3	1,616.4	188.3
1997	15,491.1	18,816.0	2,156.9	3,952.5	2,139.8	1,634.8	178.0
1998	15,824.0	20,158.3	2,156.9	4,568.4	2,725.7	1,623.8	219.0
1999	15,255.0	17,749.4	2,084.3	5,171.6	3,222.1	1,689.9	259.6
2000	13,744.3	24,223.7	4,029.8	6,564.3	3,249.5	3,080.3	234.4
2001	15,396.5	25,290.0	3,449.3	6,938.2	3,790.2	2,915.5	232.5
2002	16,051.5	23,327.7	3,789.8	8,164.7	4,490.0	3,474.3	200.3
2003	16,384.8	23,645.2	3,495.8	8,960.3	4,770.7	3,986.3	203.3
2004	15,398.8	23,187.2	4,637.3	7,268.7	3,898.0	3,177.3	193.3
2005	14,232.3	22,058.3	4,036.5	6,077.5	3,704.0	2,183.2	190.3
2006	14,424.7	20,268.5	4,270.3	5,689.8	3,117.3	2,387.3	185.2
2007	13,063.8	20,359.0	4,430.8	5,306.0	2,780.5	2,374.5	151.0
2008	13,376.3	21,865.8	4,071.2	5,719.3	3,070.0	2,487.8	161.5
2009	12,732.3	22,364.5	3,422.3	6,270.3	3,736.3	2,384.8	149.3
2010	12,544.5	23,163.5	3,365.0	7,514.0	5,155.0	2,211.3	147.8
2011	11,453.4	23,878.3	3,152.8	7,799.4	5,208.1	2,455.5	135.9
2012	11,088.8	22,003.7	3,023.6	6,947.6	4,489.2	2,311.0	147.4
2013	11,839.9	19,959.2	2,432.8	7,442.4	4,533.1	2,774.7	134.6
2014	11,291.9	21,505.5	2,692.7	7,193.1	4,781.3	2,280.7	131.1
2015	11,722.5	22,963.7	2,928.3	6,844.7	4,687.6	2,027.5	129.6
2016	11,246.6	23,307.9	3,022.3	7,330.8	4,854.5	2,354.1	122.3
2017	10,748.7	22,990.4	2,888.4	6,083.6	3,952.7	2,016.1	114.8
2018	10,891.7	22,118.3	2,834.1	7,292.9	4,898.8	2,290.3	103.8
2019	10,732.0	22,176.7	2,825.0	7,141.5	4,768.1	2,270.9	102.6
2020	9,312.4	21,176.9	3,013.8	4,332.0	2,829.6	1,404.9	97.6
2021	8,647.6	23,326.2	2,912.5	5,357.7	3,756.7	1,532.8	68.2
Trend 1990-2021	**-62.0%**	**-41.9%**	**64.3%**	**-5.0%**	**52.5%**	**-47.6%**	**-72.7%**
Trend 2005-2021	**-39.2%**	**5.7%**	**-27.8%**	**-11.8%**	**1.4%**	**-29.8%**	**-64.2%**

**Ducks, Geese and Guinea Fowls are reported here*

Animal livestock populations, which have significant influence on the air pollutant inventory, have decreased considerably over the period 1990-2021. The Swine population have decreased by 67%, whereas the Cattle population dropped by 43% over the period 1990-2021. However, animal livestock has started to increase in the recent years, thus Non-dairy Cattle livestock has shown a 62% increase over the period 2005-2021.

5.3.1.2 Animal waste management systems (AWMS)

Activity data on allocation of manure to animal waste management systems is based on processing and synthesizing of statistics from the HCSO's General Agricultural Censuses conducted in 2000, 2010 and 2020, Farm Structure Surveys, conducted in 2003, 2005, 2007, 2013 and 2016 annual data for the period 2004-2021 from the Nitrogen Database, reports on agricultural waste such as manure (such as the Hungarian Energy and Public Utility Regulatory Authority's (hereafter MEKH) annual report on agricultural waste treated in biogas plants).

In Hungary the first comprehensive study on animal waste management system distribution for emission inventory purposes was carried out by Ráky in 2003 based on the HCSO's General Agricultural Census 2000. This study focused on product producer farms and provides data by farm-size structure. The results of the HCSO's General Agricultural Census 2010 provided comprehensive information on the manure management distribution again. The census provide data on housing practices for cattle, swine and laying hens, and in addition on grazing for all animal species for the year 2010. The surveyed housing systems are as follows:

Cattle

- Tied systems, solid and liquid slurry system
- Tied systems, liquid slurry system
- Loose houses, solid and liquid slurry system
- Loose houses, liquid slurry system
- Other

Swine

- Partial grid floor
- Grid floor
- Deep litter
- Other

Farm Structure Survey data was applied to get representative activity data from the different datasets published by farm size structure, and it was applied as surrogate data to the interpolation of the 2000-2010 time series. Farm structure survey conducted in 2013 and 2016 contained a more detailed data collection on grazing than former surveys. These data on proportion of grazing animals as well as grazing period was also taken into account in the inventory preparation.

Agricultural census is taken every 10 years, thus for the recent years statistics from the Nitrogen Database provide the most reliable data on animal waste management system distribution. Annual statistics from the Nitrogen Database are supplied by the National Food Chain Safety Office (hereafter

NFCSO) to the inventory compilation. Data collection for the Nitrogen Database is based on the Decree of the Ministry of Agriculture and Rural Development No. 59/2008 (IV. 29). The Annex 6 of the Decree contains a questionnaire. Data supply obligation is prescribed for farmers, whose animal production exceeds the household requirements. The first version of this Decree (Government Decree No. 49/2001 (IV. 3)) entered into force in 2001. The collected data have been stored in a database since 2003. This database contains data on cattle and swine by sub-categories, poultry (laying hens, cocks and broilers, ducks, geese, turkey), sheep and goats, horse. Six different management systems were distinguished: liquid, solid, deep litter, grazing, farmyard/paddock and other. Amendments of this decree in 2008 resulted in a minor change in the structure of the data collection. Until 2007 only the livestock numbers for six housing systems were collected, while since 2008 the amount of the manure has also been surveyed. In 2009 a more detailed livestock characterization was introduced for cattle and swine. At the same time sheep and goats were separated into two different categories. The former paper questionnaires were replaced by on-line forms in 2014. This measure contributed to the improvement of the compliance with data provision obligations. In 2013 Hungary revised the area of the so-called 'Nitrogen Vulnerable Zones' (hereafter NVZs). Thus, the areas designated as NVZs increased to approximately 68-69% of the country from the former 47%, further increasing the number of farms under the data provision obligations.

In 2016 the data provision obligations of farmers were amended. The new regulations were developed in line with the data needs of emission inventories. The former six categories of management systems were improved by more detailed categories.

The number of the received questionnaire has been increasing since 2003, although the representativeness of this sample varies between different years and livestock categories. The dataset is most representative for cattle, swine and poultry, about 80-90 per cent of these livestock are covered. It can be considered to be reliable for sheep, too. About 60 per cent of the livestock is reported. It is least representative for goats and horse about 10 per cent coverage.

The applied data sources sometimes contain information on housing practices rather than manure management storage systems in many cases, therefore additional qualitative information was needed to define the relationship between the housing and manure management systems. Two studies (Mészáros, 2005 and Pazsiczky et. al, 2006) were applied to get additional information.

Despite the abovementioned methodological differences between the applied databases, the trend in the animal waste management systems distribution can be tracked.

Trends in manure management of Cattle and Swine

For cattle and swine, a slight increase of the liquid manure and the extensive housing technology i.e., grazing in the case of beef cattle can be identified. The former may be explained by the increasing proportions of the farms holding at least 100 animals. Increasing proportion of grazing probably is the results of the high fodder prices and increasing proportion of beef cattle.

Activity data for 1990, 2005 and 2021 are presented in ***Table 5.11*** - ***Table 5.13*** respectively. In case of cattle and swine interpolation and surrogate data were used to complete the time series.

Table 5.11 Animal waste management distribution for Cattle and Swine for the year 1990

1990	Building		Outside the building	
	Proportion of livestock housed on slurry-based system	Proportion of livestock housed on FYM-based system	Excreta on yards	Excreta on pasture
Dairy Cows	4.2%	95.8%	3.2%	8.0%
Non-dairy Cattle (Calves)	3.2%	96.8%	3.6%	14.9%
Non-dairy Cattle (all other cattle)	2.5%	97.5%	3.2%	15.8%
Breeding sows	39.3%	60.7%	1.3%	0.0%
Fattening pigs	40.7%	59.3%	1.5%	0.0%

Table 5.12 Animal waste management distribution for Cattle and Swine for the year 2005

2005	Building		Outside the building	
	Proportion of livestock housed on slurry-based system	Proportion of livestock housed on FYM-based system	Excreta on yards	Excreta on pasture
Dairy Cows	6.4%	93.6%	4.5%	8.1%
Non-dairy Cattle (Calves)	3.5%	96.5%	5.8%	13.4%
Non-dairy Cattle (all other cattle)	2.9%	97.1%	5.5%	15.7%
Breeding sows	54.6%	45.4%	1.8%	0.0%
Fattening pigs	63.4%	36.6%	1.3%	0.0%

Table 5.13 Animal waste management distribution for Cattle and Swine for the year 2021

2021	Building		Outside the building	
	Proportion of livestock housed on slurry-based system	Proportion of livestock housed on FYM-based system	Excreta on yards	Excreta on pasture
Dairy Cows	22.7%	77.3%	8.1%	4.7%
Non-dairy Cattle (Calves)	4.4%	95.6%	11.3%	12.7%
Non-dairy Cattle (all other cattle)	2.4%	97.6%	9.3%	27.0%
Breeding sows	72.0%	28.0%	2.5%	0.0%
Finishing pigs	67.8%	32.2%	1.9%	0.0%

The N-flow tool provided to the 2019 EMEP/EEA Guidebook differentiates between tied and loose housing systems regarding NH_3 emission factors for Dairy Cattle. As mentioned previously, the HCSO censuses provided data on tied and loose housing of Dairy Cattle in 2000 and 2020. Due to lack of data for the period 1990 and 2000, the data from the 2000 census was applied. (The period between 1990 and 2000 was the period after the change of regime, when the modernization of the stables was not common. This was the rationale behind using constant data.) Gaps in the time series were filled by interpolation between 2000 and 2020. For 2021, we used the 2020 data.

Time series of tied housing system is provided in ***Table 5.27***.

5.3.1.3 Anaerobic digestion

In Hungary, the first biogas plant utilizing animal manure was established in 2004, so the inventory takes into account the amount of manure treated in the biogas plants from 2004 onwards. Detailed data on agricultural wastes treated in biogas plants have been collected by the MEKH based on Regulation No 11/2017. (VIII. 25.) since 2017. However, according to the Hungarian Statistical Act (Act CLV of 2016 on Official Statistics), these detailed feedstock statistics are confidential, i.e., some feedstocks are used by less than three plants. Based on the amount of manure used in biogas plants, we determine the proportion of slurry and farmyard manure (FYM) treated in biogas plants for the N-flow NH_3 model and based on this data collection we also calculate the emissions from the application of biogas digestate for the 3Da2c sector. Proportions of slurry/FYM treated in biogas plants are shown in ***Table 5.14***.

Table 5.14 The proportions of slurry/solid manure used for biogas production

	2000	2005	2010	2015	2020	2021
xbiogas_slurry_Swine	0.0%	0.3%	2.9%	6.2%	5.9%	4.4%
xbiogas_solid_Swine	0.0%	0.0%	0.2%	0.4%	0.5%	0.5%
xbiogas_slurry_Cattle	0.0%	4.2%	30.0%	39.9%	25.9%	20.9%
xbiogas_solid_Cattle	0.0%	0.1%	0.9%	1.9%	1.7%	1.5%
xbiogas_solid_Broiler	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
xbiogas_solid_Turkey	0.0%	0.0%	0.4%	1.0%	1.0%	1.3%
xbiogas_solid_Laying_hen	0.0%	0.0%	0.1%	0.3%	0.5%	0.0%

The share of manure used in biogas plants peaked in 2018 and has declined slightly in recent years, on one hand due to a decrease in other biogas production (see also 5B2) and the other hand due to a decrease in the share of animal manure in other biogas production compared to other agricultural and food waste.

In Hungary, about 25% of the energy produced in "other biogas production" comes from animal manure.

The technological specificities of the use of animal manure in biogas plants were investigated by AKI in 2021. The study was financed by the Ministry of Agricultural and a report an "The Hungarian biogas plants technological survey" was submitted to the Ministry. The AKI's project found that slurry used in biogas plants is not stored on livestock farms, either on the site of the biogas facilities. In the biogas plant, manure is fed continuously, so the manure is transported via pipeline to the biogas plant, which is mostly located on the farm. Therefore, the proportions of manure used in the biogas plant (x_{biogas_slurry}) is subtracted from the amount of manure stored (x_{store_slurry}).

Most of the solid manure treated in biogas plants comes from calves and is stored for up to two weeks before being used in biogas plants. As this storage time is significantly shorter than for solid manure not treated in biogas plants, we do not count manure storage in this case either, so, as with slurry, the proportion of solid manure used in the biogas plant (x_{biogas_solid}) is subtracted from the amount of manure stored(x_{store_solid}).

N-input from straw

In line with the EMEP/EEA Guidebook (EEA, 2019) N input from straw use in manure management systems was taken into account. Due to lack of country-specific data on annual straw use in litter-based manure management systems, the N added in straw were estimated using the default values provided in Table 3.7 of the 2019 EMEP/EEA Guidebook.

5.3.1.4 Annual average nitrogen excretion rates

For values of annual average nitrogen excretion rates country specific (Tier 2) coefficients derived based on the Equation 10.31 of the 2006 IPCC Guidelines were used for Dairy Cattle, Non-dairy Cattle, Swine, Laying hens and Broilers. N-excretion rates for Dairy Cattle are up-dated annually, in line with the milk production and forage-to-concentrate ratio in the diet. For laying hens and broilers, the N-intakes and retention rates were up-dated annually for the period 1990-2021 as well. For pigs and breeding boars data were last updated for the year 2018. However, the annual data revealed that there is no significant change in the data year by year, therefore for the year 2019-2021 the data for the year 2018 were applied.

In calculation for breeding sows three different stages as gestation, lactation, and the period 'between weaning and mating' were distinguished. The daily nitrogen intake/retention was determined for each period and annual values were calculated as the weighted mean using the length of periods as weighting factors. According to the Hungarian practices the length of gestation and lactation are 114 and 21 days, respectively. While the period between two successive farrowing decreased gradually across the time series. Annual values for the period 1990-2018 are provided in ***Table 5.18***.

For broilers four-phase feeding was assumed for the period 2005-2021 and three phases from 2004 backwards. Time-series consistency was ensured based on the time series overlap approach of the 2006 IPCC Guidelines (Volume 1, Chapter 5). Therefore, for the years 2005-2007 the three- and four-phase feeding systems were assumed, parallelly.

There was no need to distinguish between different stages in case of laying hens.

Nitrogen intake

To the above equation Nitrogen intakes were determined from the crude protein content of the dietary components for all subcategories of these animals. The crude protein intakes were multiplied by 0.16, which is the fraction of nitrogen in protein, to convert the protein content into nitrogen. In the case of cattle and swine subcategories (breeding sows and breeding boars excepted) crude protein content in the diet was calculated from the feed ingredients. Data on crude protein contents of each component were taken from the so-called 'feed database' containing the laboratory measurements of all kinds of feed used for animal nutrition in Hungary. The feed database is available in the Hungarian Nutrition Codex, 2004.

In respect of breeding swine, laying hens and broilers data on crude protein content of the feed (CP%) in proportion of dry matter intake (DMI) was provided from the animal feed monitoring system operated by the AKI. Therefore, the nitrogen intake for a certain animal subcategory and stage was calculated using the following equation:

$$N_{intake(T,i)} = DMI_{T,i} \cdot \frac{\frac{CP\%_{T,i}}{100}}{6.25}$$

Where:

$N_{intake(T,i)}$= daily N consumed per animal of category (T) and stage (i), kg N animal^{-1} day^{-1}
$DMI_{T,i}$ = dry matter intake per animal in a certain stage (kg DMI animal day^{-1})
CP% $_{T,i}$= per cent crude protein in dry matter
6.25 = conversion from kg of dietary protein to kg of dietary N, kg feed protein (kg N)$^{-1}$

In Hungary a feed monitoring system started to operate in 2016, with a retrospective data collection for the year 2005. For the year 1990 standards of the DMI and CP% intakes taken from the Hungarian Nutrition Codex, 1990 were applied and interpolation was used to complete the time series. According to the expert opinions and the depth interviews of the AKI, the Hungarian Nutrition Codex provided the most appropriate values of DMI and CP% for swine. While for broiler and laying hens the breeder's guides seemed to be the most reliable sources before 2005. However, as the research of the AKI revealed, in the years between 2005-2007, the crude protein content of the laying hen and broiler diet could be slightly lower than as it is provided in the breeder's guides. Therefore, time series overlapping was applied to avoid time-series inconsistency arising from the use of data from two different sources.

Table 5.15 shows the trends in the crude protein content in the diet of breeding sows and breeding boars. For the year 2019 data for the year 2018 were applied. These trends in the CP% for sows are the result of two opposite effects. The rising productivity resulted in an increase in the protein demand and the nitrogen intake. This rising trend was maintained to 2010 after which the amino acid supplements lead to decreasing trends in the crude protein content in the breeding sow diet. Trends in the CP% for breeding boar shows a slight increase over the inventory period.

Table 5.15 Crude protein content in the diet of breeding sow and breeding boar in proportion of DMI BY, 1990-2018

Year	Gestating sow	Lactating sow	Weighted average for breeding sow	Breeding boar
	%			
BY	13.8	16.1	14.1	15.0
1990	13.8	16.1	14.1	15.0
1991	13.8	16.2	14.1	15.1
1992	13.9	16.2	14.2	15.1
1993	13.9	16.3	14.2	15.2
1994	13.9	16.4	14.2	15.2
1995	14.0	16.5	14.3	15.3
1996	14.0	16.5	14.3	15.3
1997	14.0	16.6	14.3	15.4
1998	14.1	16.7	14.4	15.4
1999	14.1	16.8	14.4	15.5
2000	14.1	16.8	14.5	15.5
2001	14.2	16.9	14.5	15.6
2002	14.2	17.0	14.5	15.6
2003	14.2	17.1	14.6	15.7
2004	14.3	17.1	14.6	15.7
2005	14.3	17.2	14.7	15.8
2006	14.3	17.2	14.7	15.8
2007	14.3	17.2	14.7	15.9
2008	14.3	17.2	14.7	15.9
2009	14.3	17.2	14.7	16.0
2010	14.3	17.2	14.7	16.0
2011	14.3	17.0	14.6	16.1
2012	14.0	17.1	14.4	16.1
2013	13.9	17.2	14.3	16.2
2014	13.7	16.9	14.1	16.2
2015	13.6	16.7	14.0	16.3
2016	13.4	16.7	13.8	16.3
2017	13.3	16.9	13.8	16.4
2018	13.4	16.9	13.9	16.4

Source: AKI

The trend in the N-intake of broiler (***Table 5.16***) is also driven by the abovementioned two contrary effects. The growing living weight result in an increase in the protein demand and the nitrogen intake.

In 2007 the N-intake reached a peak. After that N-intake decreased gradually, due to the amino acid supplements. Finally, the N-intake started to increase slightly again in the last two years.

The overall slightly decreasing trend in the N-intake of laying hens reflects the improvement of the feeding practices and the importance of the amino acid supplements (***Table 5.17***).

Table 5.16 Crude protein content in the diet of broilers in proportion of DMI BY, 1990-2021

Year	Crude protein content, % (breeder's recommendation)			Year	Crude protein content, % (AKI data collection)			
	Starter	Grower	Finisher		Starter	Grower I.	Grower II.	Finisher
BY	23.0	20.0	18.5	**2005**	22.1	20.3	20.2	19.4
1990	23.0	20.0	18.5	**2006**	22.0	20.3	20.0	19.2
1991	23.0	20.0	18.5	**2007**	22.0	20.3	19.9	19.1
1992	23.0	20.0	18.5	**2008**	22.0	20.3	19.7	19.0
1993	23.0	20.0	18.5	**2009**	21.9	20.3	19.6	18.9
1994	23.0	20.0	18.5	**2010**	21.9	20.3	19.5	18.7
1995	22.9	20.0	18.6	**2011**	21.9	20.2	19.2	18.6
1996	22.9	20.1	18.6	**2012**	21.6	20.1	19.0	18.4
1997	22.8	20.1	18.7	**2013**	21.4	19.9	19.1	18.3
1998	22.8	20.2	18.8	**2014**	21.3	19.8	19.0	18.5
1999	22.7	20.2	18.8	**2015**	21.1	19.9	18.9	18.3
2000	22.7	20.3	18.9	**2016**	21.2	19.8	19.0	18.2
2001	22.6	20.3	19.0	**2017**	21.4	20.0	19.3	18.3
2002	22.6	20.4	19.1	**2018**	21.5	20.1	19.4	18.5
2003	22.5	20.4	19.1	**2019**	21.4	20.0	19.2	18.4
2004	22.5	20.5	19.2	**2020**	21.5	21.5	21.5	21.5
2005	*22.4*	*20.5*	*19.3*	**2021**	21.6	20.1	19.3	18.5
2006	*22.4*	*20.6*	*19.3*					
2007	*22.3*	*20.6*	*19.4*					

Table 5.17 Crude protein content in the diet of laying hens in proportion of DMI BY, 1990-2021

Year	Crude protein content (breeder's recommendation)	Year	Crude protein content (AKI data collection)
	%		%
BY	17.4	**2005**	17.2
1990	17.4	**2006**	17.2
1991	17.5	**2007**	17.2
1992	17.6	**2008**	17.1
1993	17.6	**2009**	17.1
1994	17.7	**2010**	17.1
1995	17.8	**2011**	17.4
1996	17.6	**2012**	17.5
1997	17.5	**2013**	16.8
1998	17.4	**2014**	16.7
1999	17.4	**2015**	16.7
2000	17.4	**2016**	16.7
2001	17.4	**2017**	16.6
2002	17.4	**2018**	16.4
2003	17.4	**2019**	16.7
2004	17.4	**2020**	16.6
2005	*17.4*	**2021**	16.5
2006	*17.3*		
2007	*17.2*		

N retention

N retained by gestating sows and lactating sows were calculated using the following equation:

$$N_{retention,i} = N_{gain,i} + N_{piglets,i}$$

Where:

$N_{retention,i}$= amount of N retained by the sow in the stage i (head · day^{-1})

$N_{gain,i}$= amount of N retained in the sow in the stage i (head · day^{-1})

$N_{piglets,i}$ = amount of N in piglets in the stage i (heads · day^{-1})

i=stage (i=1 gestation, i=2 lactation, i=3 period 'between weaning and mating')

$$N_{piglets,i} = 0.0256 \cdot LITSIZE_i \cdot WG_{piglets,i}$$

Where:

$LITSIZE_i$ = litter size, in the stage i, heads;

$WG_{piglets,i}$ = weigh gain of piglets, in the stage i, head·day-1;

0.0256 = N-content of weight gain (kg/kg) Lfl, 2013

For sows in the period between two successive farrowing and breading boars the nitrogen retention was calculated based on the daily weight gain.

Background data as litter size, weaning weight and days between two successive farrowing are provided in ***Table 5.18***. Data was compiled by the HMS, based on the annual yearbooks of 'Results of Pig Breeding' 1985-2018, published by the NFCSO. Piglets weight at birth was assumed to be 1.3 kg.

Table 5.18 Background data to the calculation of nitrogen retention rate of breeding sows BY, 1990-2018

Year	Piglet weight at weaning	Number of piglets at birth	Number of piglets at weaning	Period between two successive farrowing
	kg	heads	heads	days
BY	5.9	9.8	8.9	178.4
1990	6.3	10.1	8.8	178.1
1991	6.2	10.1	8.9	178.8
1992	6.2	10.2	8.8	181.2
1993	6.2	9.8	8.5	181.2
1994	6.2	9.8	8.4	182.2
1995	6.4	10.0	8.4	181.3
1996	6.5	10.1	8.5	181.0
1997	6.5	10.1	8.5	182.9
1998	6.2	10.2	9.1	181.6
1999	6.2	10.3	9.3	178.6
2000	6.3	10.4	9.3	180.2
2001	6.4	10.3	9.2	173.4
2002	6.5	10.2	9.1	173.3
2003	6.3	10.2	9.2	172.1
2004	6.4	10.2	9.2	170.7
2005	6.6	10.2	9.2	170.6
2006	6.7	10.3	9.2	170.4
2007	6.8	10.3	9.4	169.1
2008	7.0	10.4	9.4	168.9
2009	7.3	10.4	9.5	167.5
2010	7.6	10.5	9.5	166.6
2011	7.7	10.6	9.6	166.0

Year	Piglet weight at weaning	Number of piglets at birth	Number of piglets at weaning	Period between two successive farrowing
	kg	heads	heads	days
2012	7.7	10.7	9.8	162.6
2013	7.7	10.9	9.9	162.2
2014	7.7	11.1	10.0	162.0
2015	7.8	11.2	10.1	161.9
2016	7.8	11.3	10.2	161.8
2017	7.8	11.5	10.3	161.4
2018	7.9	11.4	10.2	161.8

Source: NFCSO

N retention for laying hens was calculated from the production data using the following equation:

$$N_{retention} = \left[N_{LW} \cdot DWG + \left(\frac{N_{egg} \cdot EGG}{1000}\right)\right]$$

Where:

$N_{retention}$ = daily nitrogen retention of laying hens, kg N·head^{-1} ·day^{-1};

N_{LW} = average content of nitrogen in live weight, kg N·kg head^{-1}. Default value of 0.028 provided in the 2019 Refinement was applied;

DWG = average daily weight gain, kg·head^{-1}·day^{-1};

N_{EGG} = average content of nitrogen in eggs, kg N·kg egg^{-1}. Default value of 0.0185 provided in the 2019 Refinement was used.

EGG = egg mass production, g egg·head^{-1} ·day^{-1}.

Data on egg production was obtained from the HCSO (***Table 5.19***). Average daily weight gain (DWG) was calculated from the daily weight gain of the typical laying hen breeds, as Tetra, Lohman and Hy-Line. Data on the distribution of typical breeds in Hungary were provided by the Hungarian Poultry Board. The average egg weight was calculated similarly, based on the egg weight of the typical laying hen breeds.

Table 5.19 Background data to the calculation of nitrogen retention rate of laying hens BY, 1990-2021

Year	Egg production
	egg head^{-1}·year^{-1}
BY	206
1990	206
1991	189
1992	206
1993	218
1994	227
1995	220
1996	200
1997	212
1998	207
1999	202
2000	208
2001	213
2002	212
2003	210
2004	212
2005	208
2006	205
2007	218
2008	215
2009	215
2010	218
2011	214
2012	217
2013	208
2014	214
2015	218
2016	225
2017	227
2018	233
2019	240
2020	273
2021	293

Source: HCSO, 2022

Nitrogen retention for broilers was calculated using the following equation:

$$N_{retention} = \frac{(BW_{Final} - BW_{Initial}) \cdot N_{gain}}{production\ period}$$

Where:

N retention= amount of N retained in animal (head) day^{-1}

BW_{Final} = Live weight of the animal at the end of the stage (kg)

$BW_{Initial}$ = Live weight of the animal at the beginning of the stage (kg)

N_{gain} = the fraction of N (kg) retained per kg BW gain (kg· kg^{-1})

Production period = length of time from chick to slaughter (fattening period)

N_{gain} was assumed to be 0.0304 kg kg^{-1} based on Haenel et al., 2018 and Haenel és Dämmgen, 2009. Data on BW_{Final} was obtained from the slaughterhouse statistics of the AKI. This statistic provides data on living weight before slaughtering. The value of $BW_{initial}$ was estimated to be 0.042 kg based on expert judgement. Fattening period was estimated to be 49, 42, 40 and 41 days for the years 1994, 2007, 2018 and 2021 based on the Breeders Management Manuals of Arbor Acres and Aviagen, respectively; and interpolation was used to complete the time series. Background data to calculate nitrogen retention rate for broilers are shown in Table 5.20.

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Table 5.20 Background data to the calculation of the nitrogen retention rate in broilers BY, 1990-2021

Year	BW_{final}	Production period (fattening duration)
	kg	day
BY	1.9	49.0
1990	1.9	49.0
1991	1.9	49.0
1992	1.9	49.0
1993	1.9	49.0
1994	1.9	49.0
1995	1.9	48.5
1996	1.9	47.9
1997	1.9	47.4
1998	1.9	46.8
1999	2.0	46.3
2000	2.0	45.8
2001	2.0	45.2
2002	2.0	44.7
2003	2.1	44.2
2004	2.0	43.6
2005	2.0	43.1
2006	2.1	42.5
2007	2.1	42.0
2008	2.1	41.8
2009	2.2	41.6
2010	2.2	41.3
2011	2.3	41.1
2012	2.3	40.9
2013	2.3	40.7
2014	2.4	40.4
2015	2.4	40.2
2016	2.4	40.0
2017	2.5	40.0
2018	2.5	40.0
2019	2.5	40.3
2020	2.6	40.6
2021	2.6	40.9

Values of fraction of annual N-intakes that is retained by animals ($N_{retention}$) and their sources are summarized in ***Table 5.21***. The resulted values of N-excretion for Dairy Cattle and Non-dairy Cattle are provided in ***Table 5.27*** and ***Table 5.28***, respectively. While values of N excretion for Swine are presented in ***Table 5.22***.

Table 5.21 $N_{retention}$ rates and their sources

Animal species	$N_{retention}$	Source
Dairy Cattle	0.20	2006 IPCC GLs
Non-Dairy Cattle	0.07	2006 IPCC GLs
Swine		
Piglets under 20 kg	0.48	Fébel and Gundel, 2007
Young pigs, 20-50 kg	0.34	Fébel and Gundel, 2007
Pigs for fattening over 50 kg	0.34	Fébel and Gundel, 2007
Breeding sows, weighted mean	0.34	country-specific (calculated based on the Hungarian production data)
Gestating Sows	*0.30*	country-specific
Lactating Sows	*0.42*	country-specific
Sows between weaning and mating	*0.26*	country-specific
Breeding boars	*0.08*	country-specific (calculated based on the Hungarian production data)
Guilts not yet mated	0.34	Fébel and Gundel, 2007
Sows mated for the first time	0.34	Fébel and Gundel, 2007
Laying hens	0.34	country-specific (calculated based on the Hungarian production data)
Broilers	0.59	country-specific (calculated based on the Hungarian production data)

Table 5.22 Annual average Nitrogen excretion rates (N_{ex}) for Swine

Sub-categories	N_{ex}
	kg head^{-1} year^{-1}
Piglets under 20 kg	3.0
Young pigs, 20-50 kg	8.6
Pigs for fattening over 50 kg	12.3
Breeding sows (weighted average, 1990)	**15.7**
Gestating Sows	*13.3*
Lactating Sows	*33.7*
Sows between weaning and mating	*13.4*
Breeding sows (weighted average, 2021)	**15.8**
Gestating Sows	*12.6*
Lactating Sows	*38.1*
Sows between weaning and mating	*12.9*
Breeding boars (1990)	24.4
Breeding boars (2021)	22.1
Guilts not yet mated	9.9
Sows mated for the first time	13.8
Swine, weighted average (1990)	**9.5**
Swine, weighted average (2021)	**9.3**

For other livestock categories the default values of nitrogen excretion provided in Table 10.19 of the 2006 IPCC Guidelines were used except Buffalo for which the EMEP/EEA Guidebook (EEA, 2019) were applied (***Table 3.9***). Nitrogen excretion rates for 'Other animals' and the related body weights are shown in ***Table 5.23***.

Table 5.23 Annual average Nitrogen excretion rates (Nex) for 'Other livestock'

Animal Category	N_{ex} kg head^{-1} year^{-1}	Source
Buffalo	82	2019 EMEP/EEA Guidebook / 2006 IPCC GLs
Sheep	16	2006 IPCC GLs, Eastern Europe
Goats	18	2006 IPCC GLs, Eastern Europe
Horses	41	2006 IPCC GLs, Eastern Europe
Asses & Mules	14	2006 IPCC GLs, Eastern Europe
Poultry (2021)	0.73	Weighted average for 2020
Laying hens (2021)	*0.70*	*Country-specific, calculated annually*
Broilers (2021)	*0.49*	*Country-specific, calculated annually*
Turkey	*1.84*	*2006 IPCC GLs, Eastern Europe*
Ducks	*0.82*	*2006 IPCC GLs, Eastern Europe*
Geese	*0.55**	*2019 EMEP/EEA Guidebook*
Guinea Fowls	*0.36*	*as default for Broilers provided in the 2006 IPCC Guidelines*
Rabbit	8.1	2006 IPCC GLs

**There is no value provided in the 2006 IPCC GLs*

Typical animal weights to calculate the annual N-excretion per head are provided in ***Table 5.24***.

Table 5.24 Typical animal weight for other livestock

Livestock	Weight kg	Source/Note
Buffalo	380	Table 10A-6 of 2006 IPCC GLs
Sheep	48.5	Table 10A-9 of 2006 IPCC GLs
Goats	38.5	Table 10A-9 of 2006 IPCC GLs
Horses	377	Table 10A-9, Developed, 2006 IPCC GLs
Asses and Mules	130	Table 10A-9, Developed, 2006 IPCC GLs
Poultry	2.2	Weighted average for 2021
Laying hens (2021)	*2.0**	Country-specific
Broiler (2021)	*1.6**	Country-specific
Turkey	*6.8*	Table 10A-9 of 2006 IPCC GLs
Ducks	*2.7*	Table 10A-9 of 2006 IPCC GLs
Geese	*3.5*	*2019 EMEP/EEA Guidebook*
Guinea fowls	*0.9*	*Default for Broiler due to lack of information*
Rabbit	1.6	Table 10A-9 of 2006 IPCC GLs

**Please note that Tier 2 is applied, therefore TAM is not used in the calculation. These values are reported for information.*

5.3.1.5 Housing

For information on the proportion of manure deposited in the house, and within this the distribution of slurry and solid manure-based systems, see section 5.3.1.2

The 2019 EMEP/EEA Guidebook differentiates between tied and loose housing for Dairy Cattle which were considered in the emission estimate as well. Tied and loose housing for Cattle and Dairy Cattle are surveyed during agricultural censuses or the farm structure surveys.

A detailed survey of tied housing, distinguishing between dairy and other cattle, was carried out in Hungary in 2000 and 2021. The inventory therefore used the data from this survey and used interpolation in the intermediate period for gap filling. It should be noted that for the period 2000 to 2020 only the proportion of tied/loose housing was measured for the total cattle population, therefore in the previous submissions we used these data and trend extrapolation was applied for the period 2010 to 2019, expecting that the animal-welfare measures may have significantly reduced the proportion of tied cattle housing. However, the 2020 data for the dairy herd show that the proportion of tied housing in the dairy herd has stagnated or, rather, increased slightly. Proportions of tied dairy cattle housing are shown in ***Table 5.27***. Due to lack of new survey, for the year 2021 the data for the year 2020 was applied.

In addition, detailed information on housing technologies, such as flooring and air handling (ventilation and air scrubbing), which are crucial for the emission calculation, there are no systematic surveys in Hungary. The general agricultural censuses and farm structure surveys are used to assess the technologies used in cattle, pig and laying hen houses. Information on tied housing for dairy cows, partially slatted floor for pigs and (enriched) cages with manure belt for laying hens is taken from these censuses/surveys in the inventory. In addition, the Ministry of Agriculture commissioned detailed surveys on housing technology in 2003 and 2016 (Ráky, 2013 and NAK/MGI, 2016), these data and the related studies were used in the inventory to derive supplementary data on NH_3 abatement housing technologies.

Some emission abatement technologies in swine and poultry barns were also considered in the calculation. Abatement efficiency and the implementation rate for these technologies are provided in the ***Table 5.25***.

Table 5.25 NH_3 mitigation methods in animal house in Hungary

Abatement measure	Emission source	Abatement efficiency %*	Penetration (implementation) %				
			1990	2005	2010	2020	2021
Partly slatted floor with reduced pit	Piglets after weaning	30	9	15	20	18	18
Partly slatted floor with reduced pit	Growers-finishers	18	9	15	20	18	18
Enriched cages, ventilated manure belts, two removals a week	Laying hens	35	0	7	18	35	35
Aviaries	Laying hens	78	0	0	0	1	1
Non-leaking drinking system	Broiler	25	0	19	27	76	76

*Bitmann et. al, 2014. For intervals, the middle of the interval is taken into account

5.3.1.6 Storage

Manure storage – cattle, swine, Laying hens and Broiler

In the case of manure not used in biogas plant, manure storage is expected in the absence of adequate data. (x_{store_slurry}=1-x_{biogas_slurry} and x_{store_solid}=1-x_{biogas_solid} were used.)

As a result of improvements in recent years, this year's submission is the first to include the covering of manure stores in the calculation of NH_3 emissions. In previous submissions, only natural crust formation was considered, based on expert judgement, in the calculation of N_2O emissions during manure storage in the emission inventories. Data on slurry storage covering is provided by the Nitrate Database from 2015. Since slurry management is typical for pigs and cattle, it is considered for these two species.

As regards manure storage, there are regulations in Hungary since 2001 (Government Decree 49/2001 (IV.3) on the protection of waters against pollutions of agricultural origins, repealed by Government Decree 99/2008 (IV. 29.); the legislation currently in force is Ministry of Agriculture and Rural Development Decree 59/2008 (IV. 29.) on the detailed rules for the action program for the protection of waters against nitrate pollution from agricultural sources and on the procedure for the provision of data and record keeping), which made it necessary to modernize the former ground floor basins, thus allowing the manure storage systems to be covered. However, the problem in Hungary is still that most of the liquid manure stores are ground floor basins with plastic coating and are not suitable for covering. Therefore, the manure stores were considered uncovered until 2001, and linear interpolation was used for gap filling for the period 2001 and 2015. The implementation and the abatement efficiency for covering technologies of the different cattle and swine slurry storage systems are shown in ***Table 5.26***.

Table 5.26 Slurry storage covering technologies in Hungary

Mitigation	Emission source	Abatement efficiency %*	Penetration (implementation) %				
			1990	2005	2010	2020	2021
"Low technology" floating covers	Cattle	40	0	0	0	1	1
"Tight" lid, roof or tent structure		80	0	1	3	7	6
Plastic sheeting (floating cover)		60	0	1	2	12	9
Natural crust		40	0	52	52	35	35
"Low technology" floating covers	Swine	40	0	0	0	0	0
"Tight" lid, roof or tent structure		80	0	1	2	4	3
Plastic sheeting (floating cover)		60	0	1	1	1	1
Natural crust		40	0	53	53	58	58

5.3.2 NH_3

Manure management is a major source of NH_3 emissions, contributing 48% to agricultural NH_3 emissions in 2021. The main part of this emission relates to Cattle, Poultry and Swine housing, corresponding to 44%, 22% and 26% of the emissions from 3.B (Figure 5.4).

5.3.2.1 Methodological issues

Emissions from 3B1 Cattle, 3B2 Sheep, 3B3 Swine, 3B4gi Laying hens and 3B4gii Broilers are calculated based on the Tier 2 method of the EMEP/EEA Guidebook (EEA, 2019) and country-specific values whenever possible.

The N-flow tool provided for 2019 EMEP/EEA Guidebook (EEA, 2019) was used for the calculations. However, we have made it suitable to take into account NH_3 emission mitigation measures thanks to the 2021 EU capacity building. The emission factors for livestock housing, manure storage and application in the tool are therefore adjusted according to the efficiency and the implementation of the certain technologies.

Since we do not have detailed, farm-level surveys on the implementation of each NH_3 abatement technology at each stage of the N-flow but combine data from administrative, national-level surveys at each stage. Thus, we calculate a compound weighted mean from the penetration of each technology and its abatement efficiency and adjust the unabated emission factor by a compound adjustment factor. Abated emission factors for a certain stage (i) of the N-flow are calculated using the following equation:

$$EF_{abated,i} = (EF_{unabated,i} \cdot \sum_{j=1}^{n}(AE_{i,j} \cdot P_{i,j})) + (EF_{unabated,i} \cdot (1 - \sum_{j=1}^{n} P_{i,j}))$$

Where:

$EF_{abated,i}$=adjusted emission factor in the stage of the N-flow i, i=1,2,3 (1=housing, 2=storage, 3=manure application).

$EF_{unabated,i}$=Tier 2 emission factor in the stage i, i=1,2,3, taken from the Table 3.9 of the 2019 EMEP/EEA Guidebook.

$AE_{i,j}$=abatement efficiency of the abatement measure j, in the stage I, (j=1…n).

$P_{i,j}$=penetration of the abatement measure j, in the stage I, (j=1…n).

Unfortunately, the 2019 EMEP/EEA Guidebook (EEA, 2019) does not contain information on which technology the Tier 2 emission factors refer to and whether they are consistent with the technology considered as the reference technology in the NH_3 mitigation guidebook (Bittman et al, 2014). In the absence of this information, the guidelines were considered consistent, and the Tier 2 emission factors were considered as the emission factor for the reference technology.

In the N-flow tool values of the N-excretion, proportion of solid, liquid, yard manure, manure treated in aerobic digesters, etc. were replaced by the country-specific values year by year for each animal sub-category. The activity data and their sources are presented in Section 0

Proportions of manure deposited in the barn, open yard area and during grazing are applied directly to the model and the housing period is calculated just for information purposes. (The 2019 EMEP/EEA Guidebook (EEA, 2019) methodology assumes that no data on these ratios are available and determines the ratio of manure excreted in the barn, on the yard and during grazing based on the housing period.)

The resulted time for housing is significantly higher than the EMEP/EEA default values. In 2021, in case of Dairy Cattle 346 days were estimated whereas for Non-Dairy Cattle calves and all other cattle 310 and 257 days were assumed, respectively. The reason for the higher values is the low proportion of grazing in Hungary. In addition, it should be noted that since the housing period in the Hungarian inventory is indirectly estimated based on the proportion of the manure excreted, the calculated value assumes 24 hours of grazing, which also contributes to the high value by international comparison.

For the remaining input data as well as for the emission factors, standards and default values provided in the EMEP/EEA Guidebook (EEA, 2019) were applied.

For the other livestock the emission calculation is based on the Tier 1 methodology provided in the EMEP/EEA Guidebook (EEA, 2019).

5.3.2.2 Activity data

See Chapter 5.3.1

5.3.2.3 Emission factors

Cattle and Sow - Housing

For cattle and sheep, no emission reduction was considered in the house due to lack of available data, so the Tier 2 emission factors given in Table 3.9 of the EMEP/EEA Guidebook (EEA, 2019) were applied.

We also applied the default Tier 2 emission factors for sow, in which case we identified the use of "flushing gutters" as an accountable NH_3 emission reduction measure, but both its penetration and its emission reduction efficiency are so low that accounting for it would have an insignificant impact on emissions.

In the case of dairy cattle, the tied and loose housing were distinguished as it is required by the EMEP/EEA methodology. Proportions of tied housing together with the other key drivers of emissions from dairy cattle and the resulted implied emission factors for 3B1a Manure Management covering housing and storage are provided in ***Table 5.27***, and the ***Table 5.28*** shows the implied EFs for other cattle, as well as the typical body weight and N-excretion.

Table 5.27 Country-specific NH_3 emission factors for 3B1a Dairy Cattle and background data for the period 1990–2021

Year	Body Mass, Average	Milk Yield	N-excretion	Proportion of tied housing	Implied Emission Factor for 3B1a
	kg/head	kg/head/year	kg N / head*year	%	kg NH_3/ head*year
1990	633	13.78	83	*12.5%*	17.3
1991	636	12.91	81	*12.5%*	16.8
1992	639	13.10	82	*12.5%*	17.0
1993	641	13.03	82	*12.5%*	17.0
1994	641	12.92	82	*12.5%*	17.0
1995	641	13.67	88	*12.5%*	18.7
1996	640	13.87	89	*12.5%*	18.9
1997	640	14.01	90	*12.5%*	19.2
1998	641	15.10	94	*12.5%*	20.2
1999	639	14.94	94	*12.5%*	20.2
2000	641	16.13	97	*12.5%*	21.0
2001	641	16.58	99	12.7%	21.4
2002	641	16.86	100	12.8%	21.7
2003	642	16.86	100	13.0%	21.8
2004	642	16.80	103	13.2%	22.5
2005	642	17.61	106	13.3%	23.3
2006	642	18.37	109	13.5%	24.0
2007	643	18.83	111	13.7%	24.3
2008	643	19.10	112	13.9%	24.5
2009	642	18.67	110	14.0%	23.8

Year	Body Mass, Average	Milk Yield	N-excretion	Proportion of tied housing	Implied Emission Factor for 3B1a
	kg/head	kg/head/year	kg N / head*year	%	kg NH_3/ head*year
2010	642	18.84	110	14.2%	23.7
2011	640	18.73	109	14.4%	23.3
2012	639	19.46	112	14.5%	24.0
2013	641	19.55	112	14.7%	23.7
2014	641	20.39	115	14.9%	24.7
2015	642	21.10	119	15.0%	25.7
2016	643	21.28	120	15.2%	26.1
2017	643	22.02	123	15.4%	27.1
2018	643	22.00	119	15.5%	26.2
2019	643	22.05	125	15.7%	28.1
2020	643	23.14	132	15.9%	30.3
2021	640	23.23	131	15.9%	30.5

Table 5.28 Country-specific NH_3 emission factors and background data for 3B1b Non-dairy Cattle, 1990, 2005 and 2021

1990	Live weight	N excretion	NH_3 Emission Factor for 3B1b
	kg	kg N · head^{-1}·year^{-1}	kg NH_3 · head^{-1} · year^{-1}
Calves	182	42	8.73
All other cattle	437	46	9.61

2005	Live weight	N excretion	NH_3 Emission Factor for 3B1b
	kg	kg N · head^{-1}·year^{-1}	kg NH_3 · head^{-1} · year^{-1}
Calves	181	43	9.28
All other cattle	446	51	11.01

2021	Live weight	N excretion	Emission Factor for 3B1b
	kg	kg N · head^{-1}·year^{-1}	kg NH_3 · head^{-1} · year^{-1}
Calves	181	43	9.72
All other cattle	487	58	11.34

In the finishing pig's subcategory (covering piglets after weaning and growers, finishers), as well as for laying hens and broilers, as mentioned in the section of 5.3.1.5, low-ammonia emission housing technologies were accounted. In this case, the emission factors provided in the 2019 EMEP/EEA

Guidebook (EEA, 2019) were considered as unabated emission factors, and the abated emission factors were calculated in accordance with the 1820

The resulted abated emission factors and their trends are shown in ***Table 5.29***

Table 5.29 Abated NH_3 emission factors for housing (kg NH_3-N/kg TAN housing)

Source	1990	2000	2005	2010	2020	2021	Trend 1990-2021	Trend 2005-2021
Swine (finishing pigs), slurry	0.27	0.27	0.26	0.26	0.26	0.26	-1.8%	-0.7%
Laying hens, solid	0.20	0.20	0.20	0.19	0.17	0.17	-12.7%	-10.5%
Broilers, solid	0.21	0.21	0.20	0.20	0.17	0.17	-19.0%	-15.0%

In the case of Swine-finishing pigs, solid housing systems the Tier 2 emission factors provided in Table 3.9 of the EMEP/EEA Guidebook (EEA, 2019) was applied.

Sheep – Housing

The Tier 1 emission factor for Sheep assumes a 30-day long housing period according to the Table 3.7 of the EMEP/EEA Guidebook (EEA, 2019). In Hungary the length of the housing period is significantly longer, 135 days in a year. Thus, an adjustment was made to the Tier 1 emission factor, using the Manure Management N-flow tool. In the Excel spreadsheet, the housing period was replaced by the country-specific value, and the default values were used for the other parameters. This correction resulted in a value of 1.63 kg NH_3 a^{-1} AAP^{-1} for the emission factor for 3B, Housing, Storage and Yard.

Cattle and Swine – Storage

As described in section 5.3.1.6, covering of slurry storages in the cattle and pig categories were also considered as NH_3 reduction methods. Consequently, emission factors given in Table 3.9 of the EMEP/EEA Guidebook (EEA, 2019) were adjusted as described in section 5.3.2.1. The resulting reduced emission factors are summarized in ***Table 5.30Table 5.30***.

Table 5.30 Abated NH_3 emission factors for slurry storages (kg NH3-N/kg TAN housing)

Source	1990	200 0	200 5	201 0	202 0	2021	Trend 1990-2021	Trend 2005-2021
Dairy cattle, slurry	0.20	0.20	0.19	0.19	0.18	0.19	-5.3%	-3.3%
Non-dairy cattle, slurry	0.20	0.20	0.19	0.19	0.18	0.19	-5.3%	-3.3%
Non-dairy cattle (calves), slurry	0.20	0.20	0.19	0.19	0.18	0.19	-5.3%	-3.3%

For storage of solid manure, no emission reduction technologies were considered, and the Tier 2 emission factors given in the EMEP/EEA Guidebook (EEA,2019) were applied.

Sheep, Laying hens and broilers – Storage

In these categories only solid manure is used, and the Tier 2 emission factors of the EMEP/EEA Guidebook (EEA, 2019) were applied.

Other livestock (Laying hens and Broilers excluded) – Housing and Storage

This section covers the 3B4a Buffalo, 3B4d Goats, 3B4e Horses, 3B4f Mules and asses, 3B4giii Turkeys, 3B4giv Other poultry and 3B4h Other animals (Rabbits) NFR categories. Emission factors were taken from Table 3.2 of the EMEP/EEA Guidebook (EEA, 2019), using a Tier 1 methodology. The EMEP/EEA Guidebook (EEA, 2019) does not provide emission factor for Rabbits; therefore, the emission factor published in Italy's IIR, 2014 was applied.

5.3.2.4 Emissions

NH_3 emissions from 3B Manure management decreased by 50.8% and 14.8% over the period 1990-2021 and 2005-2021, respectively. The decrease in the emissions over the period 1990-2013 is the effect of the fall in the animal livestock. Although, in the case of Dairy cattle the increasing milk production per cow partly offset the impact of decreasing animal livestock. Despite the implementation of the 'Pig Farming Strategy' accepted in 2012 in Hungary the swine livestock and the emissions have further decreased in the recent years. Therefore, the contribution of pigs to emissions from manure management is decreasing. In contrast, other cattle, including beef cattle, have become an increasingly important source of NH_3 emissions due to the increase in other cattle, including beef cattle. Trends in emissions from 3B Manure management are shown in ***Figure 5.4***.

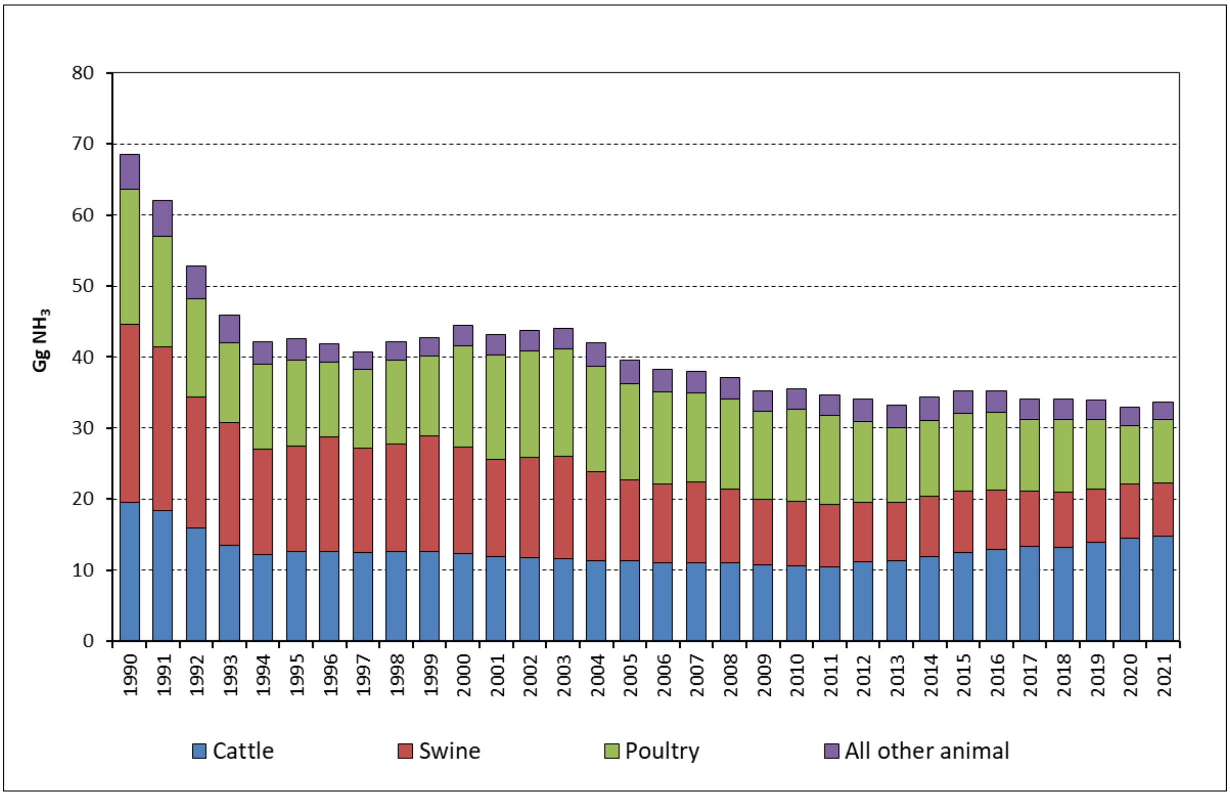


Figure 5.4 NH_3 emissions from manure management 1990-2021

5.3.3 NO_X

Manure management is an insignificant source of NO_x emissions. In 2021, 5.1% of the agricultural total NO_x emissions generated in the Manure management.

5.3.3.1 Methodological issues

Emissions were calculated using the Tier 1 methodology provided in the EMEP/EEA Guidebook (EEA, 2019).

5.3.3.2 Activity data

See chapter 5.3.1.

5.3.3.3 Emission factors

Emission factors were taken from the Table 3.3 of the EMEP/EEA Guidebook (EEA, 2019), using a Tier 1 methodology in line with the manure type. Two housing types was distinguished for Cattle liquid (slurry-based) and solid-manure-based housing. For swine three housing types were taken into account, namely liquid (slurry-based), solid-manure-based housing and outdoor (yard). The characteristic manure type for each animal livestock was determined according to the Hungarian manure management system usage data, as it is outlined in Section 5.3.1.2.

5.3.3.4 Emissions

NO_x emissions from manure management decreased by 47.2% and 8.2% for the periods 1990-2021 and 2005-2021 respectively. The main reasons for this decrease are the reduction in livestock numbers, mainly poultry and pig, and the increase in the proportion of slurry-based manure management systems in dairy cattle. Only NO_x emissions from other cattle husbandry increased between 2005 and 2021, due to the increase in livestock.

5.3.4 NMVOC

The main source of agricultural NMVOC emissions is the Cattle husbandry. In 2021, 21.8% of the national total NMVOC emissions related to the manure management and 65% of the emission from manure management generated in the Cattle husbandry.

5.3.4.1 Methodological issues

Following the recommendation from the NECD Review, 2017 Tier 2 technology-specific approaches in EMEP/EEA Guidebook (EEA, 2019), were used for NFR categories 3B1a Dairy Cattle, 3B1a Non-dairy Cattle and 3B4giv Other poultry and the Tier 1 methodology was applied for the ‘remaining’ livestock categories.

5.3.4.2 Activity data

See chapter 5.3.1.

5.3.4.3 Emission factors

Cattle

NMVOC emissions from Cattle (3B1) are estimated using Tier 2 emission factors, calculated in accordance with the Equations 48-54 of the EMEP/EEA Guidebook (EEA, 2019). Estimates are made for silage stores, silage feeding, livestock housing, manure storage and application. The EMEP methodology for Cattle is based on feed intake, for which country-specific values taken from Hungary's GHG-emission inventory was applied. Data used for UNFCCC reporting was multiplied by 365 to obtain feed intake in MJ per head per year.

Proportions of time cattle spend in the animal house in a year (x_{house}) are the same as those used to estimate the Tier 2 emission factors for NH_3 emissions.

$Frac_{silage}$ was calculated from the fraction of silage in the dry matter during housing divided by the maximum proportion of silage possible in the feed composition. Data on silage content in feed rations by sub-categories were taken from the GHG inventory. The maximum proportions of silage in feed rations are also used in the GHG inventory for quality check. These values were calculated using the following assumptions: according to the Hungarian animal feeding practices, the maximum proportion of silage in feed rations of cattle depends on the quality, dry matter, and acidic acid content of the silage. Based on the acidic acid content of silage used in Hungary for cattle feeding and the acidic acid tolerance of the Hungarian cattle species the maximum amount of the silage was assumed to be about 55 g good quality (maze) silage per body weight per day for Dairy cattle. In the case of Non-dairy Cattle, an average of 35 g silage per body weight per day was assumed as the maximum.

For $Frac_{silage\_store}$ the default value of 0.25 from the EMEP/EEA Guidebook (EEA, 2019) was used for all sub-categories.

Emission factors ($EF_{NMVOC\_silage\_feeding}$, $EF_{NMVOC\_building}$, EF_{NMVOC_graz}) were based on the defaults provided in the Table 3.11 of the EMEP/EEA Guidebook (EEA, 2019).

Parameters used to estimate NMVOC emissions from Dairy cattle and Non-dairy cattle are shown in ***Table 5.31*** and ***Table 5.32***, respectively.

Table 5.31 Parameters used to estimate NMVOC emissions from manure management of Dairy Cattle, 1990-2021

Year	Feed intake	X_{house}	$Frac_{silage}$	$E_{NMVOC,\ sillage\_store}$	$E_{NMVOC,\ sillage\_feeding}$	$E_{NMVOC,\ house}$	$E_{NMVOC,\ manure\_store}$	$E_{NMVOC,\ appl}$	$E_{NMVOC,\ graz}$
	MJ yr^{-1} $head^{-1}$	%	%	kg yr^{-1} $head^{-1}$					
1990	92,998	0.89	0.64	2.64	10.55	2.92	7.51	6.20	0.07
1991	89,748	0.89	0.62	2.46	9.83	2.81	7.20	5.95	0.07
1992	89,647	0.88	0.61	2.44	9.74	2.80	7.21	5.97	0.07
1993	89,088	0.88	0.61	2.41	9.63	2.78	7.16	5.94	0.07
1994	88,685	0.88	0.61	2.38	9.53	2.76	7.13	5.92	0.07
1995	90,300	0.88	0.59	2.35	9.39	2.80	7.43	6.16	0.07
1996	90,937	0.88	0.59	2.36	9.42	2.82	7.50	6.22	0.08
1997	91,294	0.88	0.59	2.35	9.40	2.83	7.55	6.27	0.08
1998	93,931	0.88	0.58	2.40	9.60	2.91	7.86	6.52	0.08
1999	93,980	0.88	0.58	2.40	9.59	2.91	7.85	6.53	0.08
2000	96,271	0.88	0.58	2.45	9.81	2.98	8.11	6.74	0.08
2001	97,536	0.88	0.58	2.48	9.94	3.01	8.16	6.83	0.08
2002	98,665	0.87	0.58	2.51	10.04	3.05	8.18	6.74	0.09
2003	98,749	0.87	0.58	2.51	10.03	3.04	8.10	6.56	0.09
2004	98,238	0.87	0.57	2.46	9.84	3.03	8.03	6.42	0.09
2005	100,370	0.87	0.57	2.50	10.01	3.09	8.17	6.40	0.09
2006	102,144	0.87	0.57	2.54	10.16	3.15	8.28	6.36	0.09
2007	104,038	0.87	0.57	2.58	10.30	3.21	8.39	6.35	0.09
2008	105,137	0.87	0.56	2.59	10.35	3.24	8.44	6.32	0.09
2009	104,496	0.87	0.56	2.55	10.18	3.22	8.32	6.15	0.09
2010	105,659	0.87	0.55	2.56	10.22	3.26	8.38	6.08	0.09
2011	105,807	0.87	0.55	2.54	10.17	3.26	8.40	6.00	0.09
2012	108,225	0.87	0.55	2.59	10.36	3.34	8.46	5.86	0.09
2013	108,602	0.87	0.54	2.59	10.35	3.35	8.68	5.93	0.10
2014	110,220	0.87	0.54	2.62	10.47	3.40	8.58	5.78	0.10
2015	112,493	0.87	0.54	2.67	10.67	3.47	8.53	5.66	0.10
2016	114,101	0.87	0.54	2.69	10.77	3.52	8.43	5.57	0.10
2017	115,339	0.87	0.53	2.67	10.70	3.56	8.32	5.44	0.10
2018	116,364	0.87	0.62	3.15	12.58	3.59	7.99	5.26	0.10
2019	115,011	0.87	0.53	2.66	10.66	3.55	7.70	4.97	0.10
2020	117,650	0.87	0.50	2.59	10.38	3.63	7.64	5.07	0.10
2021	120,707	0.87	0.54	2.84	11.34	3.72	7.53	4.50	0.11

Table 5.32 Parameters used to estimate NMVOC emissions from manure management of Non-Dairy cattle, 2021

Parameters	**Unit**	**Cattle <1 year**		**Cattle 1-2 year**		**Cattle> 2 year**			
		Male	**Female**	**Male**	**Female**	**Male**	**Heifer for slaughter**	**Other heifers**	**Cows, beef**
Feed intake	MJ yr^{-1} $head^{-1}$	34,369	34,296	58,795	59,443	72,531	69,584	70,156	58,984
$\mathbf{X_{house}}$	%	0.81	0.81	0.76	0.77	0.70	0.70	0.70	0.48
$\mathbf{Frac_{silage}}$	%	0.80	0.83	0.73	0.70	70%	0.77	0.75	0.69
$\mathbf{E_{NMVOC,\ sillage\_store}}$	kg yr^{-1} $head^{-1}$	1.12	1.16	1.63	1.62	1.76	1.86	1.84	0.98
$\mathbf{E_{NMVOC,\ sillage\_feeding}}$	kg yr^{-1} $head^{-1}$	4.49	4.62	6.51	6.47	7.03	7.43	7.36	3.91
$\mathbf{E_{NMVOC,\ house}}$	kg yr^{-1} $head^{-1}$	0.99	0.99	1.58	1.62	1.78	1.71	1.72	1.01
$\mathbf{E_{NMVOC,\ manure\_store}}$	kg yr^{-1} $head^{-1}$	2.76	2.75	4.75	4.88	5.36	5.14	5.19	3.02
$\mathbf{E_{NMVOC,\ appl}}$	kg yr^{-1} $head^{-1}$	1.29	1.28	2.13	2.19	2.40	2.31	2.33	1.36
$\mathbf{E_{NMVOC,\ graz}}$	kg yr^{-1} $head^{-1}$	0.04	0.04	0.10	0.09	0.15	0.15	0.15	0.21

Other poultry

Tier 2 approach for other animals slightly differs from the methodology for cattle. It is based on the volatile solid excretion rate (VS) instead of gross energy intake. Equations of Tier 2 approach require preferably country-specific values of VS. NFR category 3B4giv Other poultry covers geese, ducks, and guinea fowls, in Hungary. These livestock species share of agricultural total emissions is rather low in the air pollutant- as well as the GHG inventory, therefore country-specific values are not available. Therefore, default values of VS from Table 10A-9 of the 2006 IPCC Guidelines were used to calculate the tier 2 emission factors. VS and NMVOC Tier 2 EFs for Geese and Guinea Fowls, since IPCC default values are not available, were taken as values provided for Ducks and Broilers, respectively. IPCC default values of VS were multiplied by 365 to get kg per year values.

Table 5.33 summarizes parameters used in the equations 55-60 of the EMEP/EEA Guidebook (EEA, 2019) to calculate NMVOC emissions from Other poultry.

Table 5.33 Parameters used to estimate NMVOC emissions from 3B4giv Manure management of Other poultry, 2021

Parameters	Unit	Ducks	Geese	Guinea Fowls	Source
X_{house}		1	1	1	Based on defaults from Table 3.9 of EMEP/EEA Guidebook (EEA, 2019)
VS	kg yr^{-1} $head^{-1}$	7.3	7.3	3.65	Based on Table 10A-9 of the 2006 IPCC Guidelines. Geese as Ducks and Guinea Fowls as Broilers due to lack of information
$Frac_{silage}$		0	0	0	silage is not used for poultry feeding
$E_{NH3storage}$	kg NH_3-N (kg $TAN)^{-1}$	0.24	0.57	0.21	Defaults from Table 3.9 of EMEP/EEA Guidebook (EEA, 2019)
$E_{NH3building}$	kg NH_3-N (kg $TAN)^{-1}$	0.24	0.16	0.3	Defaults from Table 3.9 of EMEP/EEA Guidebook (EEA, 2019)
$E_{NH3appl}$	kg NH_3-N (kg $TAN)^{-1}$	0.54	0.45	0.38	Defaults from Table 3.9 of EMEP/EEA Guidebook (EEA, 2019)
$EF_{NMVOC, silage feed}$	kg NMVOC (kg VS $excreted)^{-1}$	0	0	0	Defaults from Table 3.9 of EMEP/EEA Guidebook (EEA, 2019)
$EF_{NMVOC, building}$	kg NMVOC (kg VS $excreted)^{-1}$	0.0057	0.0057	0.009	Defaults from Table 3.12 EMEP/EEA Guidebook (EEA, 2019)
$EF_{NMVOC, Grazing}$	kg NMVOC (kg VS $excreted)^{-1}$	0	0	0	Defaults from Table 3.9 of EMEP/EEA Guidebook (EEA, 2019)

Other animals (Swine, Buffalo, Goats, Horses, Laying hens, Broilers, Turkeys, Rabbit)

NMVOC emissions from 3B Manure management of other animals than Cattle and Other poultry were calculated using the Tier 1 approach and default emission factors outlined in the EMEP/EEA Guidebook (EEA, 2019). The EMEP methodology distinguishes emission factors ‘with silage feeding’ from values ‘without silage feeding’. To get the most reliable emission estimate, emission factors used in the Hungarian inventory were calculated from default values weighted by the length of the ‘silage feeding’ and ‘without silage feeding’. The assumed length of ‘with’ and ‘without silage feeding’ for sheep and goats were estimated as 145 and 220 days, for the remaining livestock species silage feeding was not assumed. The resulted emission factors are shown in Table 5.34.

Table 5.34 Implied Tier 1 emission factors for NMVOC emissions from 3B Manure management

NFR category	Livestock	Emission Factor kg NMVOC/ head
3B3	Fattening pigs	0.55
3B3	Sows	1.70
3B2	Sheep	0.21
3B4e	Horses	5.67
3B4gi	Laying hens	0.17
3B4gii	Broilers	0.11
3B4giii	Turkeys	0.49
3B4h	Rabbit	0.06
3B4d	Goats	0.57
3B4f	Mules and asses	2.08
3B4a	Buffalo	6.24

5.3.4.4 Emissions

NMVOC emissions from manure management have decreased significantly since 1990 (Figure 5.5). The most significant decrease in emissions occurred in the early 1990s due to a significant reduction in livestock numbers following the change of regime. Emissions then stagnated until 2003, before falling again following EU accession in 2004. In the early 2010s, a slight temporary increase was observed, but in recent years a slight decrease has been noticed again. Although there is a small increase in 2021 compared to 2020. The trends in recent years have been driven not only because of the reduction in animal numbers, but also to the introduction of covered manure storage facilities.

Cattle husbandry is the main source of NMVOC emissions. However, while emissions from dairy cattle have been steadily decreasing slightly, emissions from non-dairy cattle have been increasing significantly since the 2010s.

5.3.5 Particulate matter ($PM_{2.5}$, PM_{10}, TSP)

In 2021 manure management contributed 8.1% to the national total PM emissions given as TSP 53.4% of the sectorial emissions relates to the poultry production. The second largest contributors are pigs with its 36.8% share of PM emissions from 3B.

5.3.5.1 Methodological issues

Emission estimation is based on the Tier 1 methodology of the EMEP/EEA Guidebook (EEA, 2019).

5.3.5.2 Activity data

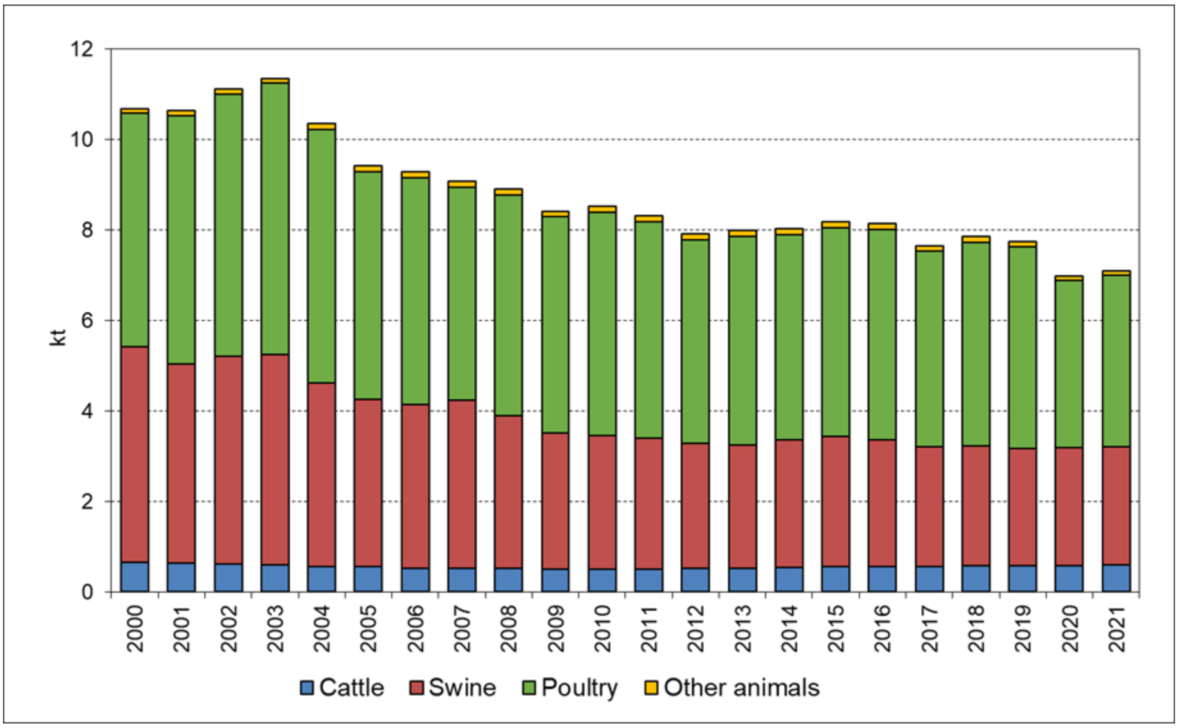
See chapter 5.3.1

5.3.5.3 Emission factors

$PM_{2.5}$, PM_{10} and TSP emission factors were taken from the Table 3.5 of the EMEP/EEA Guidebook (EEA, 2019), using the default emission factors of the Tier 1 methodology. Particulate matter emissions from rabbit are not reported, because there no emission factor provided in the EMEP/EEA Guidebook (EEA, 2019).

5.3.5.4 Emissions

After a small, temporary increase in the early 2000s, PM emissions (given in TSP are shown in Figure 5.6) declined after 2004 due to a reduction in the number of animals in the transition period following EU accession. Thereafter, emissions stagnated and then decreased to a lesser extent in recent years and to a greater extent in 2020. Then in 2021 there is a slight increase compared to 2020. The most important source of PM emissions in Hungary is poultry husbandry, therefore the reduction in animal numbers due to avian influenza in 2020 contributed significantly to the decrease in emissions.



TSP emissions from manure management 1990-2021

5.4 NFR 3D agricultural soils

NFR sector 3D contains NH_3 and NO_x emissions from Inorganic N-fertilizer (3Da1), Animal manure applied to soils (3Da2a), Sewage sludge applied to soils (3Da2b), Other organic fertilizers applied to soils (3Da2c), Urine and dung deposited during grazing (3Da3) as well as PM and NMVOC emissions from Farm-level agricultural operations including storage, handling, and transport of agricultural products (3Dc), Crop production (3De) and HCB emissions from 3Df Use of pesticide are reported.

5.4.1 NFR 3Da1 inorganic n-fertilizers

NH_3 and NO_x emissions are estimated from this source. Ammonia emissions from synthetic fertilizer use are a key source in Hungary, 33.7% of the agricultural total ammonia emissions derive from inorganic fertilizers. Fertilizer use is the most important source of NO_x from agriculture, contributing to 74.8% of agricultural total.

5.4.1.1 Methodological issues

The Tier 2 methodology provided in the EMEP/EEA Guidebook (EEA, 2019) is applied to estimate NH_3 emissions from inorganic fertilizers. Thus, emissions were estimated based on the N content of fertilizers by main types, climate zones and soil pH. Whereas calculation of NO_x emissions is based on the total amount of N in synthetic fertilizers consumption, according to the Tier 1 methodology.

5.4.1.2 Activity data

Data on mass of fertilizer type consumed nationally was derived from sales statistics by product lines. Annual synthetic fertilizer consumption data by so detailed manner as it is required to the emission estimate is not available for Hungary. Amounts of sold fertilizer are reported quarterly, and annually by the Institute of Agricultural Economics Nonprofit Kft (hereafter AKI). The data collection is executed in the frame of the National Statistical Data Collection Program (OSAP). The HCSO publishes only the total amount of inorganic N-fertilizers, based on this data collection.

Mass of fertilizer type *i* consumed nationally, which is required to the emission estimate, was determined from the amount and the N-content of sold fertilizer products. In the case of mixed fertilizers, the N-content was taken into account according to the proportion of the individual fertilizer components. (E.g. 'DASA' is a mixture of ammonium sulphate and ammonium nitrate; hence, the total N-content of this fertilizer was disaggregated into ammonium sulphate and ammonium nitrate according to the proportion of the two compounds.)

The EMEP/EEA Guidebook (EEA, 2019) requires data on mass of fertilizer by type as well as by region. In Hungary further disaggregation of mass of fertilizer type is not applicable.

Table 5.35Table 5.35 shows the distribution of fertilizer N used by major fertilizer types, such as solid and solution urea and other fertilizer N. Although, fertilizer N data are available more disaggregated level by fertilizer types for the emission estimate, here is published aggregated, because of data confidentiality. (According to the Hungarian Statistical Law (Act No. CLV of 2016) data is confidential if it was derived from data of less than three data suppliers. This is the case of Anhydrous ammonia; therefore, all non-Urea fertilizers are published aggregated here.)

Table 5.35 Trends in nitrogen fertilizer application by sources 1990-2021

Year	1'000 t N			
	Solid Urea-based Fertilizers N	Urea Solution Fertilizers	Other Fertilizer N	Total N-content
1990	102.8	9.2	246.0	358.0
1991	48.0	4.4	87.7	140.0
1992	34.0	4.0	110.0	148.0
1993	28.8	2.2	130.1	161.0
1994	28.3	0.0	193.7	222.0
1995	27.5	8.8	154.7	191.0
1996	27.1	7.4	168.5	203.0
1997	28.0	7.7	170.3	206.0
1998	29.7	10.9	207.4	248.0
1999	30.6	14.3	217.0	262.0
2000	29.9	21.6	206.6	258.0
2001	31.8	23.0	220.2	275.0
2002	35.1	25.3	242.6	303.0
2003	40.3	0.0	248.7	289.0
2004	48.5	17.1	227.5	293.0
2005	46.6	16.7	196.7	260.0
2006	51.8	18.5	218.7	289.0
2007	47.7	24.5	247.8	320.0
2008	13.8	30.0	250.1	294.0
2009	12.6	28.9	233.5	275.0
2010	16.2	25.0	239.8	281.0
2011	22.0	27.6	252.2	301.8
2012	19.3	30.0	263.7	312.9
2013	29.8	38.5	274.7	342.9
2014	24.2	44.0	273.0	341.2
2015	34.7	51.3	292.3	378.3
2016	34.4	53.6	316.0	404.0
2017	41.0	61.8	321.7	424.5
2018	34.4	70.3	319.6	424.3
2019	35.0	73.4	307.5	415.9
2020	42.8	83.6	318.8	445.2
2021	36.0	86.6	333.8	456.3
Trend 1990-2021	**-65.0%**	**843.1%**	**35.7%**	**27.5%**
Trend 2005-2021	**-22.8%**	**419.3%**	**69.6%**	**75.5%**

Both the total amount of fertilizer N and the types of the fertilizer applied has changed significantly over the period 1990-2021 affecting a considerable change in the NH_3 emissions. The most marked change is the sudden drop of Urea use in 1991 and 2008 (***Table 5.35Table 5.35***). At the same time, the use of the Calcium ammonium nitrate (CAN) and the Nitrogen solution fertilizer has increased gradually over the time series, but the CAN fertilizers are not a significant source of ammonium emissions having the lowest emission factor among the fertilizers.

While the overall amount of solid urea fertilizer has decreased over the time series, the use of urea solution has increased significantly, more than tripled. The amount of N from other fertilizers also shows an increase, contributing to the increase in the total fertilizer N, both for the period 1990-2021 and for the period 2005-2021.

In 2021, 8% of the N content of the fertilizer used came from solid urea and 19% from urea solution.

5.4.1.3 Emission factors

NH_3

For the calculation of NH_3 emissions from synthetic fertilizers country-specific emission factors were applied. Method provided in the EMEP/EEA Guidebook (EEA, 2019) gives specific NH_3 emission factors for different types of synthetic fertilizers depending on the climate and soil acidity. To summarize, NH_3 emissions can be calculated by means of the following equation:

$$E_{fert_{NH3}} = \sum_{i=1} \sum_{j=1} m_{fert_{i,j}} \circ EF_{i,j}$$

Where:

$E_{fertNH3}$*= NH_3 emission from fertilization (kg a^{-1} NH_3)*

m_{fert_i}*= mass of fertilizer type i consumed nationally (kg a^{-1} N)*

$EF_{i= EF}$ *= for fertilizer type i in region j (kg NH_3 (kg $N)^{-1}$)*

Definitions of climate zones of the EMEP/EEA Guidebook (EEA, 2019) are the same as those of 2006 IPCC Guidelines. According to the Guidebook, cool climate zone has an annual mean temperature below 15°C. The annual mean temperature in most parts of Hungary is between 10 and 11 °C, therefore, the emission factors given for cool climate zone were applied for the whole country.

Proportion of soil with normal pH and high pH was determined based on the most up-to-date high resolution (250 m) soils map (Tóth, G. et al., 2015), shown in ***Figure 5.5***. 41% of the areas as identified from the soil map was allocated to the normal soil pH (pH≤7), and 59% to the high pH (pH >7).

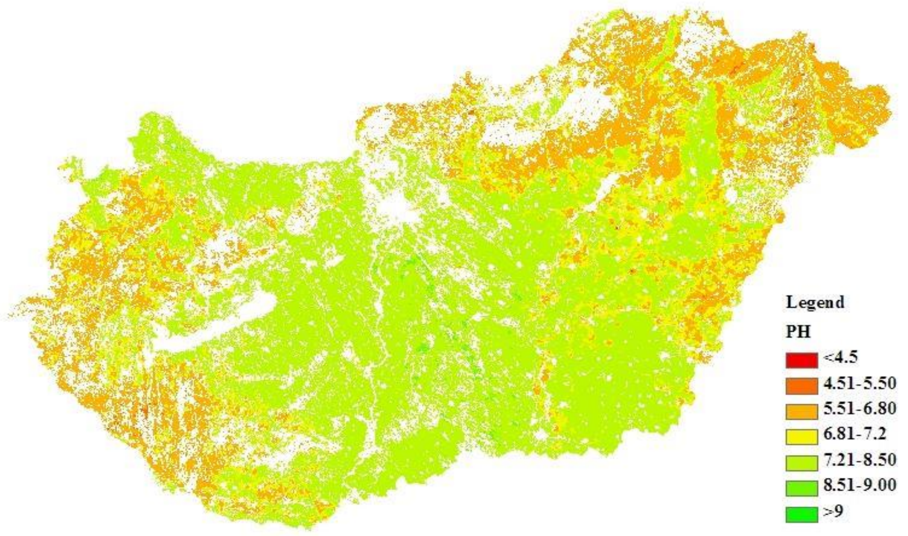


Figure 5.5 Soil acidity in Hungary

Emission factors provided by soil pH in the EMEP/EEA Guidebook (EEA, 2019) were weighted by the resulted proportions and weighted national average emission factors, given in ***Table 5.36Table 5.36***, were calculated for each fertilizer types.

Table 5.36 Emission factors for NH_3 emissions from 3Da1

Fertilizers	IEFs by soil pH kg NH_3 kg^{-1} N
Ammonium nitrate	0.025
Anhydrous ammonia	0.028
Ammonium phosphate, NP	0.074
Ammonium sulphate	0.134
Calcium ammonium nitrate	0.013
Other straight N compounds (Calcium nitrate)	0.015
Nitrogen solutions	0.096
Urea	0.160
NK mixtures	0.025
NPK mixtures	0.074
Implied EF (2020)	**0.048**

NO_x

The Tier 1 methodology of the EMEP/EEA Guidebook (EEA, 2019) and the default emission factors provided in Table 3.1 of the Guidebook was applied.

5.4.1.4 Emissions

NH_3 emissions have decreased since 1990, because of the significant drop in N-fertilizer, in particular solid urea use in 1991. However, focusing on the period 2005-2021, there is an increase of 64% (***Table 5.37***).

This is due not only to the increase in the fertilizer used and its N content, but also to the very high increase in the use of urea solution. In 2021, 24% of the emissions from fertilizers came from solid urea, 35% from urea solutions and the remaining 41% from other fertilizers N. In contrast, in 1990 and 2005, the contribution of urea solutions to NH_3 emissions from fertilizers was 4% and 11% respectively.

Table 5.37 NH_3 emission and trends by fertilizer types 1990-2021

Year	Gg			
	Solid Urea-based Fertilizers N	Urea Solution Fertilizers	Other Fertilizer N	Total NH_3-emission
1990	16.5	0.9	7.2	24.6
1991	7.7	0.4	2.7	10.9
1992	5.5	0.4	3.1	9.0
1993	4.6	0.2	3.9	8.8
1994	4.5	0.0	6.2	10.7
1995	4.4	0.8	5.1	10.3
1996	4.3	0.7	5.1	10.1
1997	4.5	0.7	5.5	10.8
1998	4.8	1.0	6.8	12.6
1999	4.9	1.4	6.3	12.6
2000	4.8	2.1	6.0	12.9
2001	5.1	2.2	6.4	13.7
2002	5.6	2.4	7.0	15.1
2003	6.5	1.9	6.5	14.9
2004	7.8	1.6	6.7	16.1
2005	7.5	1.6	5.5	14.6
2006	8.3	1.8	6.1	16.2
2007	7.7	2.4	7.2	17.2
2008	2.2	2.9	7.5	12.6
2009	2.0	2.8	6.3	11.1
2010	2.6	2.4	6.4	11.4
2011	3.5	2.7	6.4	12.6
2012	3.1	2.9	6.5	12.5
2013	4.8	3.7	6.9	15.4
2014	3.9	4.2	7.4	15.5
2015	5.6	4.9	7.6	18.1
2016	5.5	5.2	8.3	19.0
2017	6.6	5.9	9.3	21.8
2018	5.5	6.8	9.6	21.8
2019	5.6	7.1	9.3	22.0
2020	6.9	8.0	9.0	23.9
2021	5.8	8.3	9.8	23.9
Trend 1990-2021	**-65.0%**	**843.1%**	**35.6%**	**-2.9%**
Trend 2005-2021	**-22.8%**	**419.3%**	**77.6%**	**63.8%**

NO_x emissions after the significant drop in the early 90's started to increase, and due to the continuous increase in the N-content of the synthetic fertilizer applied in the recent years, NO_x emissions have exceeded the level seen in 1990 ***(Figure 5.6***).

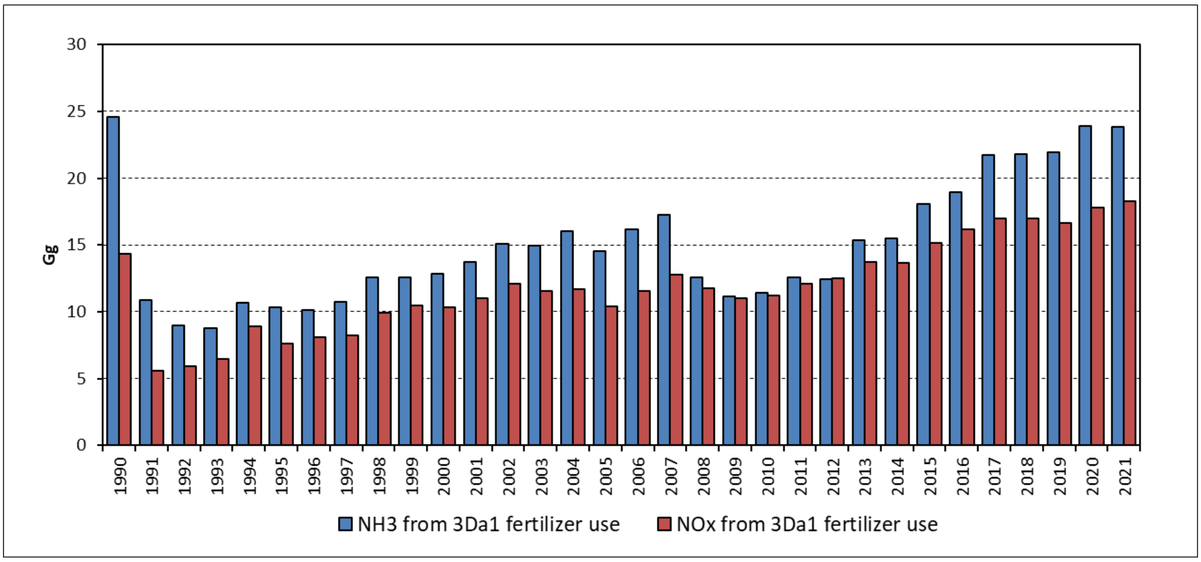


Figure 5.6 NH_3 and NO_x emissions from 3Da1 Inorganic N-fertilizers, 1990-2021

5.4.2 NFR 3Da2a animal manure applied to soils

In this sector NH_3 and NO_x emissions from animal manure applied to soils are estimated.

In 2021 Animal manure use contributed 15.2% and 15.9% to agricultural emissions of NH_3 and NO_x, respectively.

5.4.2.1 Methodological issues

NH_3

Cattle, Swine, Sheep, Laying hens and Broiler

NH_3 emissions were calculated using the N-flow tool provided to the EMEP/EEA Guidebook (EEA, 2019), similarly, to the calculation of emissions from housing and storage. For more details see also Section 5.3.2.1

As with housing and manure storage, both slurry and solid manure application we considered NH_3 reduction measures and the emission factors of manure application were adjusted according to the penetration and abatement efficiency of the given solid/liquid manure application technology, using 0.

Other animals (Buffalo, Goats, Horses, Turkey, Other Poultry, Rabbit)

Tier 1 method provided in the EMEP/EEA Guidebook (EEA, 2019), and default emission factors given in Table 3.2 were applied.

NO_x

NO_x emissions from animal manure applied to soils are estimated using the Tier 1 method given in the EMEP/EEA Guidebook (EEA, 2019).

5.4.2.2 Activity data

NH_3

The input parameters for the N-flow model as well as the Tier 1 calculations, such as animal numbers, share of liquid and solid manure, N-excretion etc., are given in 5.3.1.

Slurry application technologies – cattle and swine

In the case of Cattle and Swine low-emission liquid manure application technologies were accounted.

Hungary started a regular data collection on liquid manure spreading technologies in 2016. In this data collection, the amount of manure applied, and the size of the application area are collected according to application technologies.

In Hungary, the Nitrate database has been collecting data on slurry application technology since 2016. Therefore, we have estimated the implementation of the different low-NH_3 fertilizer application technologies for the years before 2016, considering the following information:

The first regulation on fertilizer application entered into force in 2001 (Government Decree 49/2001 (IV.3) on the protection of waters against pollutions of agricultural origins, repealed by Government Decree 99/2008 (IV. 29.); the legislation currently in force is Ministry of Agriculture and Rural Development Decree 59/2008 (IV. 29.) Therefore, for the period 1990-2001 the broadcast application not followed by incorporation was assumed, exclusively, while for the period 2001-2015 interpolation was applied for gap filling. Data on the abatement efficiency was taken from the Ammonia Mitigation Guidebook (Bittman et. al, 2014). Time series of capacities controlled and abatement efficiency for application of cattle and swine liquid manure are shown in ***Table 5.39***.

The implementation and the abatement efficiency for slurry and solid manure application technologies are shown in ***Table 5.38Table 5.38***

Table 5.38 Animal manure application technologies in Hungary

Mitigation	Emission source	Abatement efficiency %	Penetration (implementation) %				
			1990	2005	2010	2020	2021
Band spreading with a trailing hose	Cattle, liquid manure	33	0	6	13	19	20
Incorporation of surface applied slurry, immediately		88	0	3	6	13	14
Incorporation of surface applied slurry, within 24 hours		30	0	7	15	25	24
Deep injection (12-18 cm)		90	0	2	5	8	8
Shallow injection (5-8 cm)		80	0	2	4	13	15
Band spreading with a trailing shoe		45	0	1	2	1	5
Band spreading with a trailing hose	Swine, liquid manure	33	0	5	12	24	24
Incorporation of surface applied slurry, immediately		88	0	1	3	12	14
Incorporation of surface applied slurry, within 24 hours		30	0	7	17	20	15
Deep injection (12-18 cm)		90	0	3	7	11	11
Shallow injection (5-8 cm)		80	0	5	12	21	20
Band spreading with a trailing shoe		45	0	1	2	2	3
Immediate ploughing	Cattle, Swine, Laying hen, Broiler, solid manure	90	0	6	14	29	29
Incorporation within 4 hours		55	0	3	6	13	35
Incorporation within 24 hours		30	0	9	21	45	28

Cattle, Sheep, Swine, Laying hens and Broilers – solid manure application

Emission reduction technologies for solid manure application for the animal species listed in the title are considered for the first time in this submission. This was made possible by the assessment of different solid manure application technologies in the course of the 2020 General Agriculture Survey. In Hungary, the 2001 Government Decree, mentioned earlier, included a requirement for the application of manure as soon as possible (unfortunately, this legislation does not yet include a specific time limit for the maximum time between the application and the incorporation of the manure). Therefore, it was assumed that the solid manure was applied without incorporation before 2001 and an interpolation was applied for gap filling for the period 2001-2020.

In September 2021, the Decree No. 59/2008. (IV. 29.) of the Ministry of Agriculture was amended, and the amended regulation requires the application of manure within 4 hours on nitrate sensitive areas.

As the legislation was amended in the middle of the year, it was assumed that in the first half of 2021 the rate of penetration of certain manure application technologies was the same as in the 2020 census, and in the second half of the year it was in line with the amended regulation.

This explains the significant increase in the manure application rate within 4 hours from 2020 to 2021 for the solid manure in ***Table 5.38***.

NO_x

In accordance with the Tier 1 methodology, animal numbers are used as the activity data, which can be found in chapter 5.3.1.1.

5.4.2.3 Emission factors

NH_3

In the case of cattle and swine liquid and cattle, swine, laying hens and broiler solid manure low-ammonia emission manure application technologies were accounted. In these cases, the emission factors provided in the Table 3.9 of the EMEP/EEA Guidebook (EEA, 2019) were considered as unabated emission factors, and the abated emission factors were calculated in accordance with the Equation 5.6.

The resulted abated emission factors and their trends are shown in ***Table*** 5.40

Table 5.39 Abated NH_3 emission factors for liquid manure application (kg NH3-N/kg TAN applic)

Source	1990	2000	2005	2010	2020	2021	Trend 1990-2021	Trend 2005-2021
Swine (finishing pigs)	0.40	0.40	0.35	0.29	0.20	0.19	**-52%**	**-45%**
Swine (sows)	0.29	0.29	0.25	0.21	0.14	0.14	**-52%**	**-45%**
Cattle	0.55	0.55	0.49	0.42	0.32	0.29	**-48%**	**-42%**

Table 5.40 Abated NH_3 emission factors for solid manure application (kg NH3-N/kg TAN applic)

Source	1990	2000	2005	2010	2020	2021	Trend 1990-2021	Trend 2005-2021
Cattle	0.68	0.68	0.61	0.53	0.37	0.32	**-53%**	**-29%**
Swine	0.45	0.45	0.41	0.35	0.24	0.21	**-53%**	**-19%**
Laying hen	0.45	0.45	0.40	0.35	0.24	0.21	**-53%**	**-18%**
Broiler	0.38	0.38	0.34	0.30	0.20	0.18	**-53%**	**-16%**

Other animals (Buffalo, Goats, Horses, Turkey, Other Poultry, Rabbit)

Tier 1 method, and default emission factors given in Table 3.2 were applied to calculate NH_3 emissions from 3Da2a Animal manure application.

The EMEP/EEA Guidebook (EEA, 2019) does not provide emission factor for Rabbits; hence, the emission factor (0.54 kg NH3 $\cdot a^{-1} \cdot AAP^{-1}$) published in Italy's IIR, 2014 was applied.

NO_x

The default emission factor of 0.04 kg NO_2/kg fertilizer N given in EMEP/EEA Guidebook (EEA, 2019) was used.

5.4.2.4 Emissions

NH_3

NH_3 emissions from manure application decreased by 66.2% between 1990 and 2021 and by 40.9% between 2005 and 2021. The reasons for this significant decrease are a significant reduction in animal livestock on the one hand, and stricter manure application rules since 2001 on the other.

NO_x

NO_x emissions from manure spreading decreased by 48.7% in the period 1990-2021 and by 8.8% from 2005-2021 due to a reduction in livestock numbers.

5.4.3 NFR 3Da2b sewage sludge applied to soils

Under sector 3Da2b NH_3 and NO_x emissions from sewage sludge application are estimated. Emissions of NH_3 and NO_x from sewage sludge applied to soils contributed less than 1% to the emissions from agriculture in 2021 ***(Figure 5.11)***

5.4.3.1 Methodology

NH₃

As with the application of animal manure, the emissions from the application of sewage sludge were calculated using NH_3 mitigation technologies. Therefore, the 'base' emission factor (0.13 kg NH_3 per kg N applied) provided in the EMEP/EEA Guidebook (EEA, 2019) was adjusted according to the Equation 5.6 to account for the emission reduction technologies and their efficiency.

NO_x

In accordance with the Tier 1 methodology the N-content of the sewage sludge is multiplied by the emission factor given in the Table 3.1 of the EMEP/EEA Guidebook (EEA, 2019)

5.4.3.2 Activity data

Amount of sewage sludge N applied

Data on annual amount of total sewage N that is applied to agricultural soils has been available in the Urban Wastewater Information System (UWIS) since 2011. For the period 1994-2010 data were taken from the EUROSTAT statistics. The EUROSTAT provides data on sewage sludge disposal for agricultural use, but these statistics also contains the sewage sludge disposal for recultivation. 40% of the reported disposed sewage sludge based on expert judgment was assumed to be applied on agricultural lands and the remaining 60% for recultivation. Activity data was extrapolated for the period 1990-1994. The N-content of sewage sludge was assumed to be 4.2% in line with the measured data provided by the NFCSO. The resulted activity data for the period 1990-2021 are shown in ***Table 5.41***.

Table 5.41 Activity data to estimate emissions from 3Dab2 Sewage sludge applied to soils, 1990-2021

Year	Sewage sludge 1'000 t d.m.	N 1'000 t
1990	4.71	0.20
1991	5.59	0.23
1992	6.47	0.27
1993	7.35	0.31
1994	10.00	0.42
1995	13.36	0.56
1996	12.44	0.52
1997	10.32	0.43
1998	12.52	0.53
1999	9.84	0.41
2000	10.84	0.46
2001	10.56	0.44
2002	11.80	0.50
2003	11.52	0.48
2004	13.28	0.56
2005	22.40	0.94
2006	21.20	0.89
2007	20.16	0.85
2008	24.72	1.04
2009	25.36	1.07
2010	22.72	0.95
2011	20.27	0.85
2012	18.50	0.78
2013	13.55	0.57
2014	15.07	0.63
2015	14.24	0.60
2016	17.69	0.74
2017	15.69	0.66
2018	16.35	0.69
2019	17.67	0.74
2020	17.59	0.74
2021	15.01	0.63
Trend 1990-2021	**219.0%**	**219.0%**
Trend 2005-2021	**-33.0%**	**-33.0%**

NH_3 abatement technologies

Hungary has had legislation (Government Decree 50/2001 (IV.3.)) on the rules for the agricultural use and treatment of wastewater and sewage sludge since 2001. According to this legislation, sewage sludge must be either injected deep into the soil or incorporated into the soil immediately after the applied sludge has desiccated. As with slurry application, the nitrate database has been collecting data on sewage sludge application technologies since 2016. Therefore, surface application of sewage sludge was assumed before 2001, linear interpolation was used between 2001 and 2016, and from 2016 onwards the ratio of injection to surface application was determined using the nitrate database data. ***Table 5.42*** shows the penetration of the sewage sludge application technologies in Hungary.

Table 5.42 Sewage sludge application technologies in Hungary

Abatement measure	Abatement efficiency %	Penetration%					
		1990	2000	2005	2010	2020	2021
Incorporation of surface applied sewage sludge within 24 hrs	30%	100%	100%	96%	91%	58%	34%
Deep injection	90%	0%	0%	4%	9%	42%	66%

5.4.3.3 Emission factors

NH_3

The value of 0.13 kg NH_3 (kg N applied)$^{-1}$ given on Table 3.1 of the EMEP/EEA Guidebook (EEA, 2019) was used as unabated emission factor and the unabated emission factor was multiplied by the weighted averages of abatement efficiency and the penetration. ***Table 5.43*** provides abated emission factors for NH_3 emissions from sewage sludge application.

Table 5.43 Abated emission factors for 3Da2b Sewage sludge application

	1990	2000	2005	2010	2020	2021
Abated emission factors 3Da2b	0.13	0.13	0.09	0.08	0.06	0.04

NO_x

The value of 0.04 kg NO_2 (kg N applied)-1 provided in Table 3.1 of the EMEP/EEA Guidebook (EEA, 2019) was applied to calculate NO_2 emissions.

5.4.3.4 Emissions

As can be seen from the ***Figure 5.7***, the trend of NO_x emissions follows the trend of the amount of sewage sludge applied. The same is true for NH_3 emissions until 2000. However, from 2001 onwards, in addition to the change in the amount of sludge applied, the use of low-NH_3 emission technologies has also had an impact on the downward trend in emissions, which has stagnated in recent years.

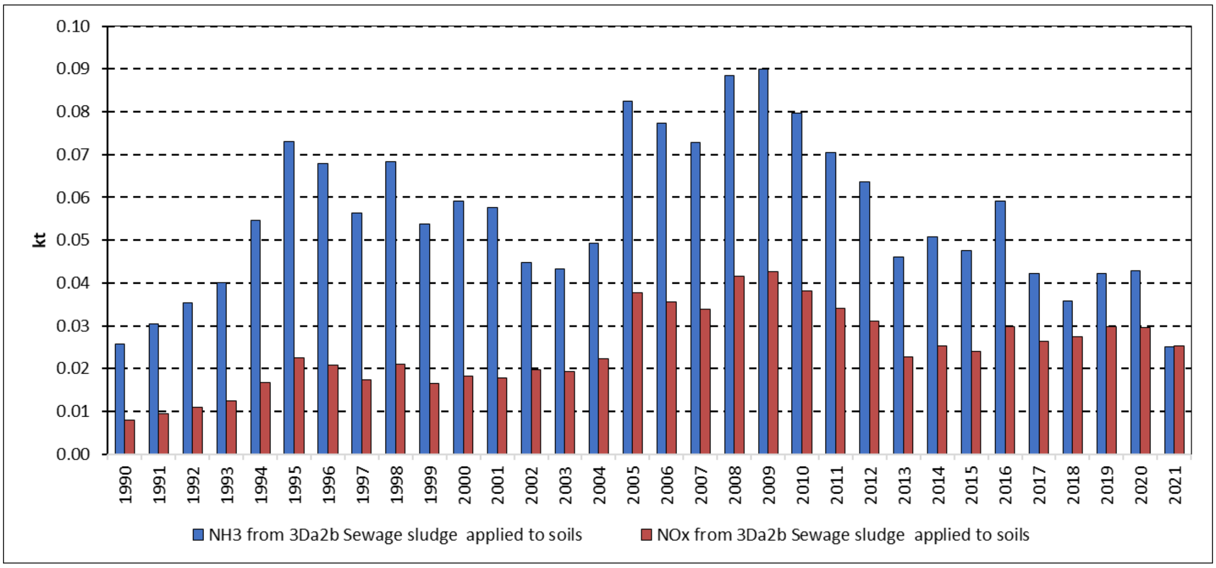


Figure 5.7 NH_3 and NO_x emissions from 3Da2b Sewage sludge application, 1990-2021

5.4.4 NFR 3Da2c other organic fertilizers applied to soils (including compost)

Under sector 3Da2c NH_3 and NO_x emissions from compost application are estimated. The compost covers here the composted sewage sludge/municipal solid waste (hereafter MSW) and the digestate from anaerobic digestion. Emissions of NH_3 and NO_x from compost applied to soils contributed less than 1% to the emissions from agricultural soils in 2021 (***Figure 5.1***)

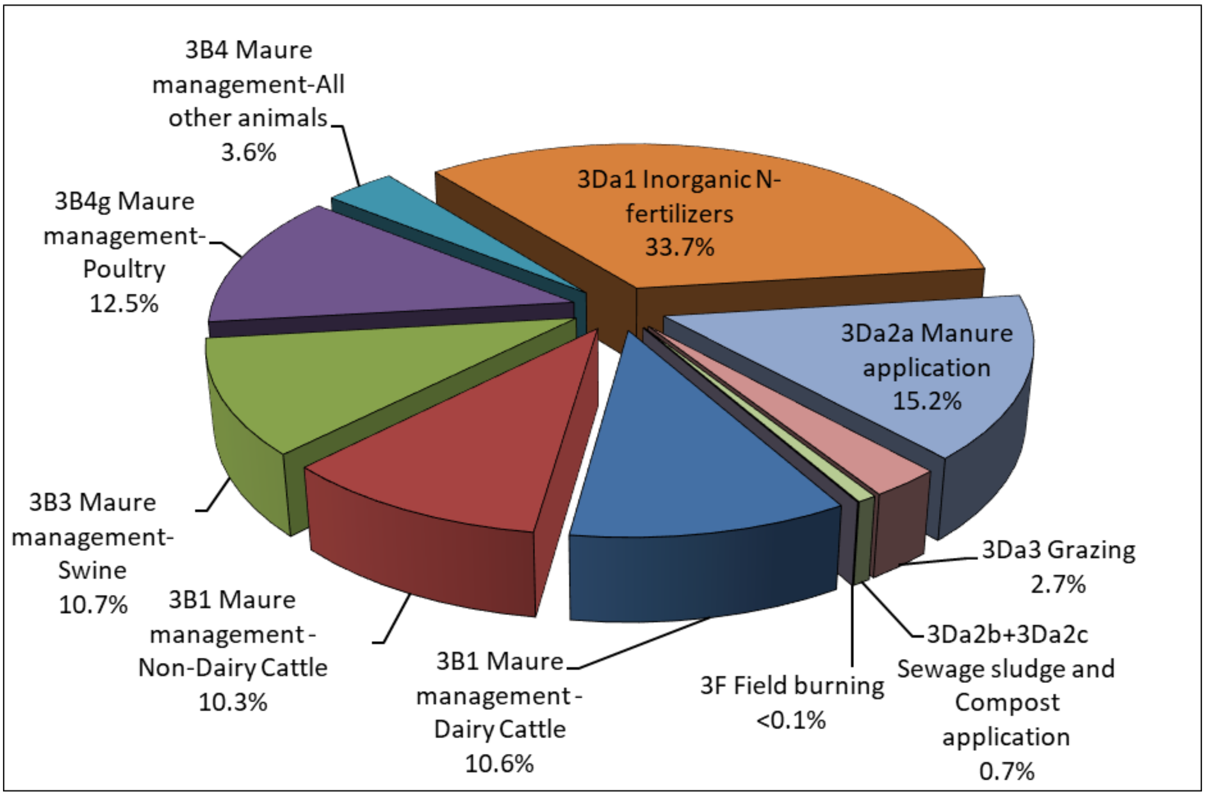


Figure 5.1

5.4.4.1 Methodology

The Tier 1 methodology of the EMEP/EEA Guidebook (EEA, 2019) was applied. The N content of compost was multiplied with the default emission factors.

5.4.4.2 Activity data

Composted sewage sludge

For the calculation of emissions from the application of sewage sludge compost, the amount of composted sewage sludge reported as activity data in the NFR sector 5B1 is used. The Wastewater Sludge Processing and Use Strategy 2014-2023 (General Directorate of Water Management, 2013) shows that 38% of composted sewage sludge is used in agriculture. The N content of the sewage sludge compost was assumed to be 2% based on the Table 4.1 of the Vol. 5. Ch. 4 of the 2006 IPCC Guidelines.

Composted MSW

Activity data was taken from the NFR sector 5B1. The IPCC default parameters on moisture content and N in dry matter given in Table 4.1 of the Vol. 5. Ch. 4 of the 2006 IPCC Gls was used. According to the NHKV (National Coordination of Waste Management and Asset Management Plc.) reports for the last years, loss during composting approximately 25% and 50% of the sewage sludge compost generated is used for agricultural purposes (NHKV, 2020).

Digestate (other than animal)

As a result of inventory improvements for the previous year, anaerobic digestion has been included in the agricultural emission inventories, and in parallel, emissions from the application of digestate are also taken into account under NFR sector 3Da2c. The N content of the biogas compost applied is calculated based on the N content of feedstock. As biogas feedstock statistics are only available from 2017 onwards, the N consumption per TJ energy production was determined for the previous years based on the feedstock consumption in the period 2017-2021. N per TJ are estimated to 4.1 tones N per TJ based on average of N in feedstock and energy production in 2017-2021.

The resulted activity data for the period 1990-2021 are provided in Table 5.44.

Table 5.44 Activity data to estimate emissions from 3Da2c Other organic fertilizers applied to soils (including compost), 1990-2021

Year	Composted sewage sludge N	Composted MSW N	Digestate (other than animal manure) N	Total N applied
	kg N			
1990	152,000	-	-	152,000
1991	152,000	-	-	152,000
1992	152,000	-	-	152,000
1993	152,000	-	-	152,000
1994	152,000	-	-	152,000
1995	212,800	-	-	212,800
1996	220,400	54,000	-	274,400
1997	197,600	57,000	-	254,600
1998	174,800	54,000	-	228,800
1999	243,200	54,000	-	297,200
2000	228,000	51,000	-	279,000
2001	205,200	51,000	-	256,200
2002	281,200	141,000	-	422,200
2003	425,600	141,000	-	566,600
2004	182,058	117,000	217,194	516,252
2005	399,932	123,000	207,045	729,977
2006	326,414	174,000	261,851	762,265
2007	388,672	192,000	507,463	1,088,136
2008	469,573	255,000	994,628	1,719,201
2009	683,795	270,000	1,489,912	2,443,707
2010	624,935	444,000	1,822,808	2,891,743
2011	618,408	552,000	2,711,883	3,882,291
2012	685,342	548,619	2,242,987	3,476,948
2013	708,761	561,990	4,144,959	5,415,710
2014	739,125	708,261	4,092,183	5,539,569
2015	754,845	691,785	3,966,332	5,412,962
2016	773,726	881,907	3,988,661	5,644,293
2017	779,684	927,369	4,952,498	6,659,551
2018	749,154	931,353	4,489,892	6,170,399
2019	695,815	1,058,415	4,038,852	5,793,082
2020	704,836	1,124,847	4,150,223	5,979,906
2021	705,265	1,148,169	4,114,909	5,968,343

5.4.4.3 Emission factors

The emission factors for NH_3 and NO_x emission from compost applied to soil was taken from the Table 3.1 of the EMEP/EEA Guidebook (EEA, 2019). A value of 0.08 kg NH_3 per kg N applied was used for NH_3 and 0.04 kg NO_2 per N applied to calculate NO_2 emissions.

5.4.4.4 Emissions

Figure 5.99 shows emissions from the use of organic waste. The emission trend follows the trend of the N content of the applied organic waste. The emission trend is determined by the biogas compost. Emissions are thus low and stagnant between 1990 and 2001, and then increased significantly between 2001 and 2013, mainly due to the increasing use of agricultural waste in biogas plants and have stagnated in recent years as the energy production of biogas plants, and thus the use of feedstock, has stagnated or slightly decreased in recent years.

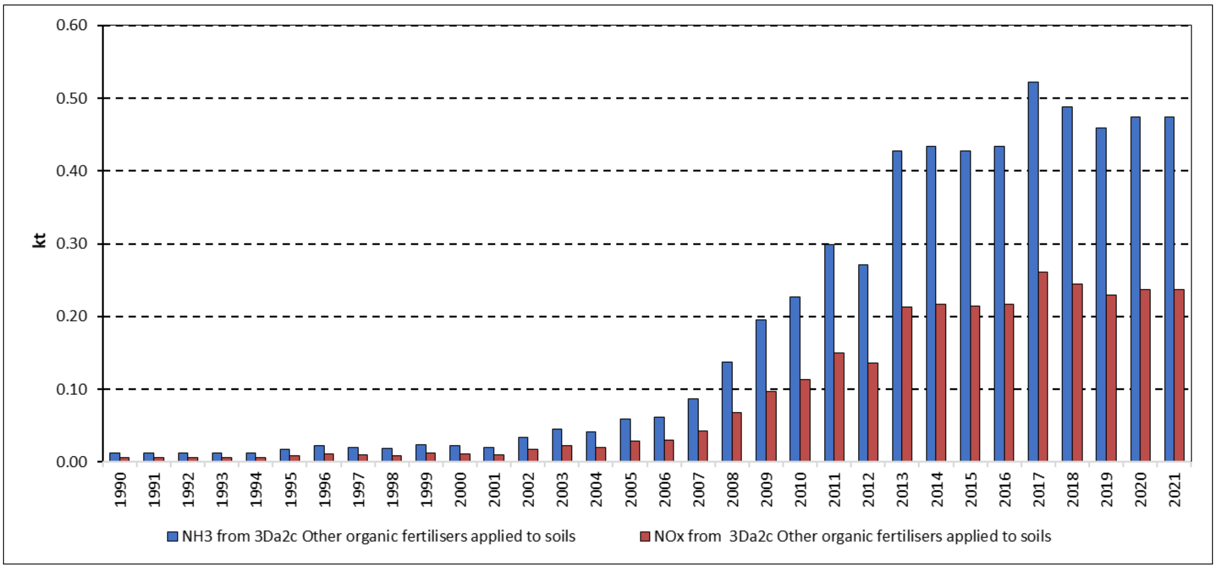


Figure 5.9 NH_3 and NO_x emissions from 3Da2c Other organic fertilizers applied to soils (including compost), 1990-2021

5.4.5 NFR 3Da3 urine and dung deposited by grazing animals

For this sector, NH_3 and NO_x emissions from urine and dung deposited by grazing animals are estimated.

Emissions of NH_3 from urine and dung deposited by grazing animals contributed in 2021 with 2.7% of the NH_3 emissions from the agriculture sector. Emissions of NO_x from urine and dung deposited by grazing animals contributed in 2021 with 3.1% of the NO_x emissions from the agriculture sector.

5.4.5.1 Methodology

NH_3 - Dairy cattle, Non-dairy Cattle and Sheep

In accordance with the Tier 2 methodology emission of urine and dung deposited by grazing cattle and sheep are based on N excreted by animals and length of grazing period. Calculations are performed in the N-flow tool.

NH_3 - Other animals

For other animals the Tier 1 methodology and the default emission factors provided in the EMEP/EEA Guidebook (EEA, 2019) is applied.

NO_2 - all livestock

Tier 1 methodology given in the EMEP/EEA Guidebook (EEA, 2019) is applied for all livestock categories.

5.4.5.2 Activity data

The activity data (livestock numbers, N-excreted and proportions of N-excreted during grazing) are provided in Section 5.3.1.

5.4.5.3 Emission factors

NH_3 emission factors for Cattle and Sheep

The Tier 2 emission factors provided in the Table 3.9 of the EMEP/EEA Guidebook (EEA/2019) are used.

NH_3 emission factors for other animals

Default emission factors provided in the Table 3.2 of the EMEP/EEA Guidebook (EEA, 2019) are applied.

NO_x emission factors

The default emission factor (0.04 kg NO_2 per N excreted during grazing) given in the EMEP/EEA Guidebook (EEA, 2019) is applied for all livestock species.

5.4.5.4 Emmissions

The emissions of NH_3 and NO_x from grazing are largely determined by the number of grazing animals, mainly other cattle. Emissions decreased significantly in the early 1990s due to a drastic decline in livestock numbers, stagnated from the mid-1990s until around 2012 and increased slightly thereafter, mainly due to an increase in beef cattle numbers. Trend in NO_x and NH_3 emissions are shown in ***Figure 5.8***.

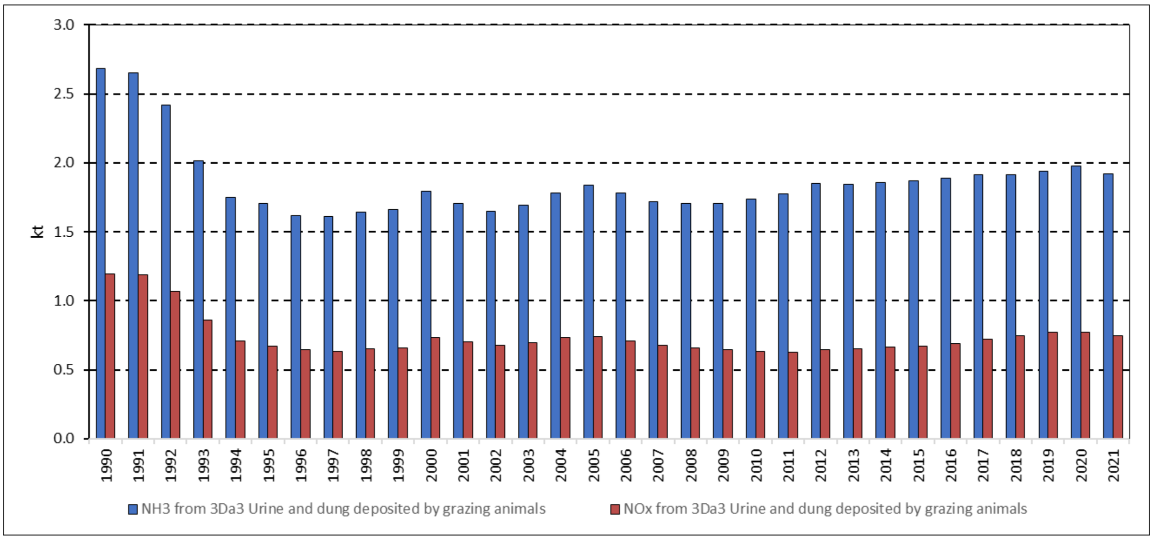


Figure 5.8 NH_3 and NO_x emissions from 3Da3 Urine and dung deposited by grazing animals, 1990-2021

5.4.6 NFR 3Dc farm-level agricultural operations including storage, handling and transport of agricultural products

PM emissions from field operations during the usage of machines on agricultural soils are reported here.

TSP emissions from field operations contributed 46.8% to agricultural TSP emissions.

5.4.6.1 Methodology

The Tier 1 method provided in the EMEP/EEA Guidebook (EEA, 2019) is used to estimate PM emissions.

5.4.6.2 Activity data

Area covered by crops, derives from the HCSO's annual statistics for 'sown area of main crops'. Data on 'sown area of main crops' contains temporary grasslands, areas of greenhouses and plastic tunnels, nursery gardens, fallow lands and areas of extinct plants. Therefore, this data cannot be used directly as activity data in the air pollutant inventory. Areas listed above were subtracted from the total 'sown area of main crops' to get the required activity data. ***Table 5.45*** shows the estimation of the activity data from the HCSO's statistics for 2021.

Table 5.45 Estimation of area covered by crops for 2021

Sown areas	Areas ha
Total sown area of main crops	4,145,275
Greenhouse and plastic tunnels	2,132
Nursery gardens	3,152
Fallow lands	122,880
Area covered by crops (calculated)	**4,017,112**

Based on HCSO, 2022

5.4.6.3 Emission factors

Particulate Matter ($PM_{2.5}$, PM_{10}, TSP)

For each pollutant the Tier 1 method and default emission factors provided in the EMEP/EEA Guidebook (EEA, 2019) were used.

5.4.6.4 Emissions

PM emissions given in TSP have increased by 8.4% from 2000 to 2021, due to the increase in the area of cultivated crops (Figure 5.3)

5.4.7 NFR 3De cultivated crops

NMVOC emissions from crop production are reported under 3De Cultivated crops.

NMVOC emissions from crops contributed 12.2% to agricultural NMVOC emissions in 2021.

5.4.7.1 Methodology

Emissions were estimated using the Tier 1 methodology.

5.4.7.2 Activity data

Area covered by crops, derives from the HCSO's annual statistics for 'sown area of main crops'. Derivation of activity are same as those outlined above in Section 5.4.6.2.

5.4.7.3 Emission factors

Tier 1 method given in the EMEP/EEA Guidebook (EEA, 2019) was applied.

5.4.7.4 Emissions

NMVOC emissions from crops cultivation have reduced by 12.2% and 6.0% over the periods 1990-2021 and 2005-2021, respectively.

5.4.8 NFR 3Df use of pesticides

The use of the most dangerous pesticides has been prohibited by international agreement; therefore, only emissions related to pesticide use that shall be reported are the HCB emissions from the HCB contamination of the used pesticides (EEA, 2019).

HCB emissions from use of pesticides contributed to the national total HCB emissions with 7% share in 2021.

5.4.8.1 Methodology

A Tier 1 methodology provided in the EMEP/EEA Guidebook (EEA, 2019) is used for calculating emissions from 3Df Use of pesticides.

5.4.8.2 Activity data

Data on the amount of active substances (as Atrazine, Clopyralid, Chlorothalonil, Endosulfan, Lindane and Picloram) in the used pesticides was given by the Department of Plant Protection Product and Yield Enhancing Substance Authorization of the Directorate of NFCSO, which is the licensing authority for pesticides. In accordance with the information provided by the Plant Protection Authority, DCPA, Dachtal, Chlothaldimethyl, Pentachloronitrobenzene, Propazine, Simazine and Pentachlorophenol were not in use in Hungary over the period 1990 and 2021.

In accordance with the Hungarian Statistical Law (Act No. CLV of 2016) the quantities of the sold Picloram for the years 2017 and 2018 are confidential, therefore the aggregated activity data on the total amount of the active substances are provided in the NFR Table as well as in ***Table 5.46***.

Table 5.46 Activity data and HCB emissions from 3Df Use of pesticide, 1990-2021

Year	Total amount of active substances kg	Total HCB emissions
1990	993,937	4.63
1991	966,920	6.61
1992	696,706	4.19
1993	876,142	2.46
1994	559,205	2.52
1995	380,487	2.68
1996	292,945	2.36
1997	301,900	2.33
1998	479,230	2.04
1999	660,530	2.51
2000	841,830	2.81
2001	937,671	2.55
2002	626,252	2.81
2003	623,426	1.82
2004	620,601	1.10
2005	540,384	0.67
2006	460,168	0.67
2007	346,252	0.52
2008	39,636	0.29
2009	43,647	0.32
2010	77,178	0.66
2011	95,072	0.84
2012	116,171	1.02
2013	123,380	1.14
2014	161,190	1.58
2015	151,307	1.43
2016	153,143	1.49
2017	156,229	1.56
2018	122,853	1.24
2019	166,128	1.68
2020	66,848	0.66
2021	12,263	0.12
Trend 1990-2021	**-98.8%**	**-97.5%**
Trend 2005-2021	**-97.7%**	**-82.6%**

5.4.8.3 Emission (IMPURITY) factors

Impurity factors for different ingredients were taken from the Table 4 of the EMEP/EEA Guidebook (EEA, 2019), except the impurity factor of Chlorothalonil for the period 2010 and 2019, for which the Department of Plant Protection Product and Yield Enhancing Substance Evaluation of the Directorate of the NFCSO provided data based on the information given from the pesticide producer. Impurity factors used in the emission estimate are provided in ***Table 5.47***.

Table 5.47 Impurity factors to calculate HCB emissions from 3Df Use of Pesticides

Active substance	1990	1995	2000	2005	2010-2019	2020	2021
Atrazine	2.5	1.0	1.0	1.0	use stopped	use stopped	use stopped
Clopyralid	not used	not used	2.5	2.5	2.5	2.5	2.5
Chlorotalonil	300.0	300.0	155.0	10.0	*10.0*	*10.0* *use stopped in May 2020*	use stopped
Endosulfan	0.1	0.1	0.1	0.1	use stopped	use stopped	use stopped
Lindane	100.0	50.0	50.0	50.0	use stopped	use stopped	use stopped
Picloram	50.0	50.0	50.0	50.0	50.0	50.0	50.0

Impurity factors in italics are country-specific values.

5.4.8.4 Emissions

As the ***Table 5.46*** reveals the total amount of active ingredients has decreased by across the time series, however the active substances have used since 2005 contains higher proportion of impurities, leading to increase in the emissions.

HCB emissions from the use of pesticide reduced by 97.5% over the period 1990-2021, and 82.6% over the period 2005-2021. Between 2019 and 2020, HCB emissions from pesticides decreased significantly, as EU Member States had to withdraw authorizations for the fungicide chlorothalonil by 20 November 2019 but were still allowed to use existing stocks until 20 May 2020. (See also Commission Implementing Regulation (EU) 2019/677 of 29 April 2019.) The use of chlorothalonil was therefore stopped in 2021.

5.5 NFR 3F field burning of agricultural residues

This category comprises the field burning due to plant protection reasons. In Hungary open burning of standing crops and crops residues is legally banned, the plant protection reason could be the only exception when the authority can issues a permits for an exemption from the ban of field burning.

In Hungary, the first legislation in order to control field burning of agricultural residues entered into force in 1986. According to the regulation No. 21/1986. (VI. 2.) of the Council of Ministers a burning permit was required from the local authority for crop residue burning. This legislation had been in force until 2001, when the Government Decree No. 21/2001. (II. 14.) was issued. The new decree bannned the field burning of agricultural crop residues, unless otherwise provided by law. Plant health emergency was the special exception, when burning of crop residues had been allowded. This Government Decree was amended at the end of 2010. The Government Decree No. 306/2010. (XII.23.) is currently in force, which explicitly ban the field burning of crop residues. According to this, field burning of standing crops and crop residues are prohibited unless otherwise provided by law. The only exception is if there is a plant deseases on the agricultural field that can only be eliminated by field burning. In this case the plant protection authority – the county government office – in principle may issue a burn permit. In practice such permits are issued rarely. According to the information and data provided by the plant protection authority burn permits have been issued for only rice lands due to infection of 'Pyricularia oryzae' or 'Helminthosporium oryzae'.

5.5.1.1 Methodology

Emissions from 3F Field burning was estimated using the Tier 1 method from the EMEP/EEA Guidebook (EEA, 2019).

5.5.1.2 Activity data

To estimate the emissions from rice field burning the Directorate of the NFCSO, which is the plant protection authority provided data on the areas for which burn permits were issued for the period 2010-2016. Due to unavailability of data for other years the time series from the 1990 to 2009 was gap-filled by calculating an average proportion of the rice cropping area affected by plant disease from the available data. The burnt areas for the period 2017-2021 was estimated similarly.

In 2021, 900 ha was burnt in Hungary, which equates to 0.02% of the areas covered by crops in 2021. Activity data to the calculation of emissions from 3F Field burning are shown in ***Table 5.48.***

Table 5.48 Activity data to the calculation of emissions from 3F Field burning BY, 1990-2021

Year	Rice field area burnt ha
BY	3,985
1990	3,974
1991	2,980
1992	1,656
1993	1,656
1994	1,656
1995	1,325
1996	1,031
1997	726
1998	937
1999	748
2000	1,067
2001	775
2002	696
2003	848
2004	932
2005	882
2006	799
2007	867
2008	839
2009	898
2010	257
2011	882
2012	1,037
2013	1,089
2014	993
2015	932
2016	1,034
2017	916
2018	971
2019	877
2020	989
2021	900

Data on average yield on rice (kg ha^{-1} fresh weight) was taken from the HCSO's statistics. For the ratio between the mass of crop residues and the crop yield (Y), the dry matter content of the yield (d) and the combustion factor (C_f) the IPCC default values of 1.4, 0.85 kg dm·kg fresh $weight^{-1}$ and 0.8 were taken, respectively. Proportion of those residues thar are burned (p_b) was assumed to be 1 due to the plant protection reasons.

5.5.1.3 Emission factors

Tier 1 default emission factors provided for rice from the Table 3.1 of the EMEP/EEA Guidebook (EEA, 2019) was used.

5.5.1.4 Emissions

Emissions from field burning are insignificant for all pollutants. It contributes about 0.04% of national total $PM_{2.5}$ emissions.

5.6 Uncertainties

For the 2023 inventory period, the most significant improvement for the agricultural emission inventory is the implementation of uncertainty assessments. The calculations are currently available for the year 2021 and have been made available using the Tier 1 methodology.

Table 5.49 shows the estimated uncertainties for activity data and emission factors for each agricultural sources and pollutants.

5.6.1 NH_3

3B Manure Management

Activity data for manure management covers the livestock number for cattle and swine housing/manure type, because the livestock numbers for cattle and swine should also be stratified by slurry and solid manure and incase of dairy cattle by tied and untied housing systems. For grazing animals, the length of housing period also affects the emission estimate.

The uncertainties in livestock numbers are provided by the HCSO for each livestock category and survey. The uncertainties for the most important livestock categories are rather low e.g., for cattle and swine the uncertainties are estimated as 1.8% and 1.0%, respectively. The uncertainty is similarly low, for the key poultry subcategories, as laying hens (0.8%) and broilers (0.7%), but higher for less important poultry subcategories as waterfowls (5.1 and 7.3%, respectively) and turkey (2.5%). The uncertainties are also higher for sheep, goats, buffalo, and horses, ranging from 4.9-8.9%. The overall uncertainty for livestock numbers is estimated as 1.4%.

The allocation of cattle and swine housing and manure management systems is based on data provided from the Nitrate Database which is handled by the NFCSO. All livestock farms above 5 livestock unit (hereafter LSU), and in the case of poultry 3 LSU must report annually on the livestock population and the amount of manure produced according to the animal housing technologies. The exclusion of herds with less than 5 LSU from the database does not increase the uncertainty of the data, as it is known that such small farms use solid type manure management systems. Therefore, the uncertainty of these data is estimated to be low, around 5-10%. The uncertainties in housing/manure type are not considered for poultry, because the animal population do not need to be stratified by the type of manure.

Thus, uncertainties for activity data are the uncertainties in livestock numbers and in the case of cattle, swine, and other grazing animals the combined uncertainty of livestock numbers and manure management system usage, resulting in an overall weighted mean of combined uncertainties for activity data 1.9%.

The uncertainty for the emission factor covers the nitrogen excretion and TAN, housing period and NH_3 emission factors for housing and storage of the manure. For cattle, pig, laying hen and broiler country-specific N-excretion rates are applied and the emission factors for housing and manure storage are refined according to the abatement measures applied. However, there are no specified uncertainty estimates for the derived country-specific emission factors, therefore based on the information provided in the EMEP/EEA Guidebook (EEA, 2019) an overall 30% uncertainty is assumed for the country-specific Tier 3 EFs and a significantly higher 60% for the others.

3Da1 Inorganic N-fertilizers

The activity data for emissions from inorganic fertilizers are the N content of fertilizers sold by fertilizer type. The uncertainty in the N content of fertilizers sold is estimated as 2%. To which is added the uncertainty in the classification of the fertilizers sold into the type as defined in the EMEP/EEA Guidebook (EEA, 2019) Therefore, the uncertainty of the activity data is estimated as 3%.
There are no uncertainty values for the emission factor provided in the EMEP/EEA Guidebook (EEA, 2019). Considering that the EFs, given in the EMEP/EEA Guidebook (EEA, 2019) were estimated a large number of measurements we assumed the uncertainties in the EFs cannot be higher than 25%, considering, that country-specific data on soil pH was also used to determine the country-specific EFs.

3Da2a Animal manure applied to soils and 3Da3 Urine and dung deposited by grazing livestock

The activity data for emissions from the application of animal manure and grazing are the N content of the manure produced by each animal species in the case of Tier 2/ Tier 3 estimates. The uncertainty of the activity data was determined as the combined uncertainty of animal numbers, N excretion rates and the manure management system usage data for Cattle, Swine and Poultry. For the uncertainties in livestock data see 3B Manure Management. The uncertainties in the N excretion rates were assumed to be 10% for the country-specific values in accordance with the 2006 IPCC Guidelines. The uncertainties in the proportion of liquid/solid manure were estimated to be 5-10% for all animals.

In the case of the Tier 1 estimates, the uncertainty in the activity data is equal with the uncertainty in the animal numbers (in these cases, the uncertainty in N-excretion and manure management is included in the uncertainty in EFs).

The uncertainty of emission factors was estimated to be 30%, similarly to the EFs for 3B Manure Management in the case of Tier 2/ Tier 3 estimates and 60% for the Tier 1 emission factors. The Tier 2 EFs were refined in line with the manure application technologies for solid and liquid manure as well.

Since in this case emission is calculated per animal, and thus the uncertainty in emissions derives from the sum of the emissions per animal, in ***Table 5.49Table 5.49*** only the combined uncertainty in the emissions can be reported, therefore in column E zero is entered.

3Da2b Sewage sludge applied to soils

Wastewater treatment plants must carry out laboratory tests on sewage sludge sold for agricultural use, including the determination of the N content. At the same time, farmers must obtain a permit from the soil protection authority for the use of sewage sludge on agricultural land. Therefore, the uncertainty of the activity data should not be higher than 2% in accordance with the EMEP/EEA Guidebook (EEA, 2019).
The EMEP/EEA Guidebook (EEA, 2019) does not provide information on the uncertainty of the emission factor, so it was assumed to be relatively high as 50%.

3Da2c Other Organic fertilizers applied to soils

The uncertainty for this source was estimated in a similar way as for sewage sludge, with the difference that a slightly higher uncertainty (5%) was assumed for the activity data. This is since the N content of the applied compost is estimated based on the composted waste rather than the applied compost, which slightly increases the uncertainty of the activity data. However, the increase in the uncertainty could not be significant due to this approach, because the loss in the N-content of the composted waste during composting cannot be significant.

3F Field burning of agricultural residues

An uncertainty of 25 % for the activity data for field burning of agricultural residues was assumed. This uncertainty is a combination of the uncertainty of area of rice, amount of crop residue and yield burnt. The uncertainties for the emission factors for each pollutant are calculated based on the upper and lower limit of the 95% confidence intervals for EFs provided in the EMEP/EEA Guidebook (EEA, 2019).

5.6.2 PM

Uncertainties in activity data for 3B Manure Management are the combined uncertainties in the livestock population and manure type, similarly to NO_x and NH_3 emissions. The uncertainty of EFs is estimated to be very high (300%).

The activity data for 3D Cultivated Crops is the sowing area of crops, which uncertainty is estimated as 5%. The uncertainties for the PM emission factors have been calculated from the upper and lower limit of the 95% confidence intervals provided in the EMEP/EEA Guidebook (EEA, 2019).

5.6.3 Other pollutants

For NO_x and NMVOC emissions from Manure Management, the activity data is the livestock number, and the proportion of solid/liquid manure. Therefore, the uncertainty in the activity data is estimated similarly to the NH_3 and PM emissions.

The uncertainty for the NO_x and NMVOC emission factor is based on expert judgement. (EFs for NO_x is estimated to be -50-100% and for NMVOC as 200-300%.)

Emission of BC, CO, SO_2, heavy metals, dioxin, PAHs, HCB and PCB from the agricultural sector originates from field burning of agricultural residues. The uncertainty for activity data for these emissions is a combination of the uncertainty for crop production, which is low and the uncertainty of the amount of crop residues, which is high. The uncertainties for the emission factors are based on EMEP/EEA Guidebook (EEA, 2019). All uncertainties for field burning are relatively high.

The uncertainty for activity data for the emission of HCB from pesticides are estimated to 2% and the uncertainty for the emission factor is estimated to be 30%.

Table 5.49 Estimated uncertainty associated with activities and emission factors for the Agriculture sector, 2021

Pollutants	NFR Sector	Emissions (2021) kt	$U(AD_i)$ %	$U(EF_i)$ %	Combined Uncertainty %
NOx	3B Manure Management	1.3	0.0	55	54.5
	3Da1 Inorganic N-fertilizers (includes also urea application)	18.3	3.0	160	160.0
	3Da2a Animal manure applied to soils	3.9	7.3	160	160.2
	3Da2b Sewage sludge applied to soils	0.0	2.0	160	160.0
	3Da2c Other organic fertilisers applied to soils (including compost)	0.2	5.0	160	160.1
	3Da3 Urine and dung deposited by grazing animals	0.7	24.0	160	161.8
	3F Field burning of agricultural residues	0.0	25.0	26	36.1
	Agricultural total	**24.4**			**122.5**
NMVOC	3B Manure Management	24.9	0.0	103	102.7
	3De Cultivated crops	3.5	5.0	300	300.0
	3F Field burning of agricultural residues	0.0	25.0	60	65.0
	Agricultural total	**28.4**			**97.3**
SO_2	3F Field burning of agricultural residues	0.0	25.0	40	47.2
	Agricultural total	**0.0**			**47.2**
NH_3	3B Manure Management	33.7	0.0	13	13.5
	3Da1 Inorganic N-fertilizers (includes also urea application)	23.9	3.0	25	25.2
	3Da2a Animal manure applied to soils	10.7	0.0	15	14.8
	3Da2b Sewage sludge applied to soils	0.0	2.0	50	50.0
	3Da2c Other organic fertilisers applied to soils (including compost)	0.5	5.0	50	50.2
	3Da3 Urine and dung deposited by grazing animals	1.9	0.0	24	24.0
	3F Field burning of agricultural residues	0.0	25.0	50	55.9
	Agricultural total	**70.7**			**10.9**
$PM_{2.5}$	3B Manure Management	0.5	0.0	125	124.7
	3Dc Farm-level agricultural operations including storage, handling and transport of agricultural products	0.0	5.0	400	400.0
	3F Field burning of agricultural residues	0.2	25.0	24	34.7
	Agricultural total	**0.7**			**81.5**

Pollutants	NFR Sector	Emissions (2021) kt	U(ADi) %	U(EFi) %	Combined Uncertainty %
PM_{10}	3B Manure Management	2.7	0	131	131.5
	3Dc Farm-level agricultural operations including storage, handling and transport of agricultural products	6.3	5.0	400.0	400.0
	3F Field burning of agricultural residues	0.0	25.0	24.6	35.0
	Agricultural total	**9.0**			**281.6**
TSP	3B Manure Management	7.1	0.0	0.0	143.3
	3Dc Farm-level agricultural operations including storage, handling and transport of agricultural products	6.3	5.0	400.0	400.0
	3F Field burning of agricultural residues	0.0	25.0	22.4	33.6
	Agricultural total	**13.38**			**202.2**
BC	3F Field burning of agricultural residues	0.0015	25.0	100.0	103.1
Pb	3F Field burning of agricultural residues	0.0002	25.0	100.0	103.1
Cd	3F Field burning of agricultural residues	0.0005	25.0	100.0	103.1
Hg	3F Field burning of agricultural residues	0.0001	25.0	100.0	103.1
As	3F Field burning of agricultural residues	0.0003	25.0	100.0	103.1
Cr	3F Field burning of agricultural residues	0.0003	25.0	100.0	103.1
Ni	3F Field burning of agricultural residues	0.0001	25.0	100.0	103.1
Se	3F Field burning of agricultural residues	0.0001	25.0	100.0	103.1
Zn	3F Field burning of agricultural residues	0.0028	25.0	100.0	103.1
PCDD/F	3F Field burning of agricultural residues	0.0002	25.0	100.0	103.1
Benzo(a)pyrene	3F Field burning of agricultural residues	0.0004	25.0	99.7	102.8
Benzo(b)fluoranthene	3F Field burning of agricultural residues	0.0003	25.0	100.0	103.1
Benzo(k)fluoranthene	3F Field burning of agricultural residues	0.0002	25.0	100.0	103.1
Indenol(1,2,3-cd)pyrene	3F Field burning of agricultural residues	0.0000	25.0	100.0	103.1
HCB	3Df Use of pesticides	0.12	2	30.0	30.1

5.7 QA/QC and verification

General QA/QC procedures of emission inventories for Agriculture sector are described in Chapter 5 of the Hungarian National Inventory Report, 2020-submitted under the UNFCCC.

For all activity data, as livestock populations, fertilizer use, AWMS system usage etc. consistency is maintained with data application for GHG inventory.

As a standard QA/QC procedure Tier 2 emission factors were compared with the default emission factors and reasons for differences were justified. The following sections discuss the verification of Tier 2 emission factors used to estimate NH_3 emissions.

5.7.1 Verification of TIER2 NH_3 emission factors for cattle and swine

Tier 2 emission factors were compared with the default values given in the EMEP/EEA Guidebook (EEA, 2019). As the NH_3 emissions are calculated following the N-flow, the total emission factors, calculated for the whole life cycle of manure were compared.

Dairy Cattle

The country-specific value of NH_3 emission factor for Dairy Cattle is increasing over the inventory period and is out of the range of default values provided in the EMEP/EEA Guidebook (EEA, 2019) for the years, at the end of the inventory period (Figure 5.9). This trend is a direct result of the increase in N excretion, reflecting the rising milk production per Cow. In the Hungarian inventory the N excretion ranged from 83 to 131 kg N head^{-1} year^{-1} between 1990 and 2021. While a significantly lower value of 105 kg N head^{-1} year^{-1} was applied in the calculation of the default emission factors in the EMEP/EEA Guidebook (EEA, 2019). The higher country-specific value of N excretion partially justifies the higher emission factors at the end of the inventory period. The other key underlying data of the NH_3 emission factors is the length of housed period. The EMEP/EEA Guidebook (EEA, 2019) assume 180 days a^{-1} as a default, which is significantly lower than the country-specific average value of 346 days a^{-1}. The significantly longer housed period is the main reason for the higher NH_3 emissions from Dairy Cattle.

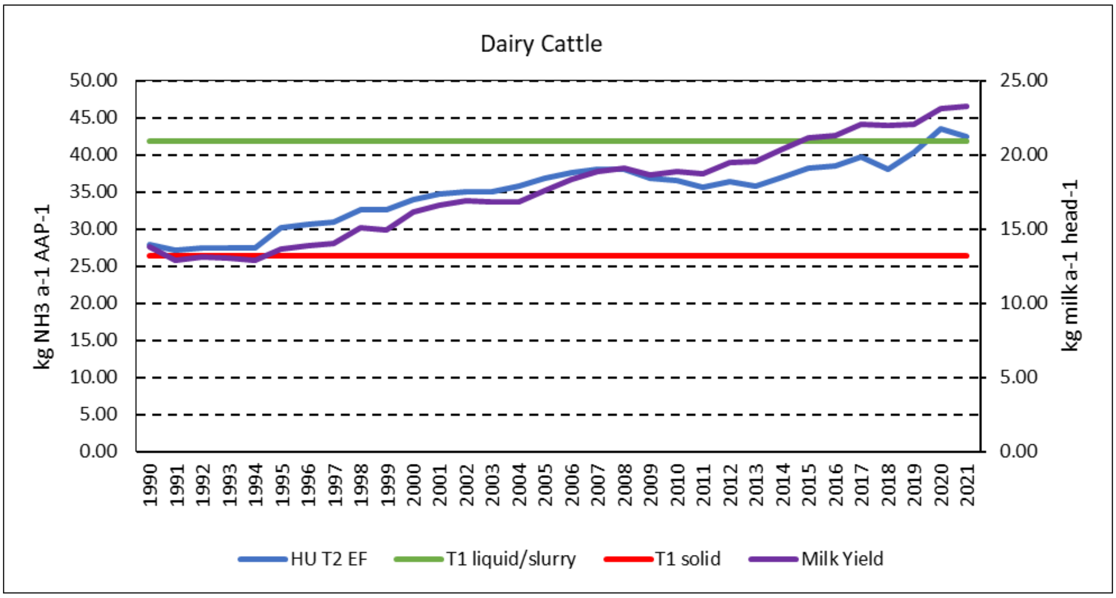


Figure 5.9 Comparison of NH_3 emission factors for Dairy Cattle, 1990-2021

Non-dairy Cattle

The country-specific values of IEFs for total NH_3 emissions from Non-dairy Cattle slightly increasing. At the beginning of the time series the country-specific values are approximately equal with the default value for liquid/slurry, while in the second half of the time series the country-specific emission factors are higher than the EMEP/EEA default Tier 1 values given in the in the Table 3.2 of the EMEP/EEA Guidebook (EEA, 2019) (Figure 5.10). The reasons for the higher EFs in Hungary are, similarly to the Dairy Cattle, the higher N-excretion rates and the longer housed periods. Country-specific N excretion rates ranged from 44 to 53 kg N a^{-1} $head^{-1}$ between 1990 and 2021. In contrast, the default value is 41 kg N a^{-1} $head^{-1}$ in the EMEP/EEA Guidebook (EEA, 2019). It is worth noting that the IPCC default value is 50 kg N a^{-1} $head^{-1}$ for the Eastern-European Non-dairy Cattle according to the 2006 IPCC Guidelines. Therefore, the EMEP/EEA default value seems to be extremely low, for the Hungarian Non-dairy Cattle livestock. The contrast between the lengths of housed period is similarly striking. The EMEP/EEA default is 180 day a^{-1}, in contrast with 231-324 days Hungarian country-specific values depending on Non-dairy Cattle subcategories. Significantly higher N-excretion values, the longer housing period result in significantly higher NH_3 emission factors than the default values. The country-specific total NH_3 emission factors are in the range of 14.8 to 16.1 kg NH_3 a^{-1} $head^{-1}$ over the inventory period, whereas the default values are 10 and 15 kg NH_3 a^{-1} $head^{-1}$ for solid and slurry, respectively. Considering the differences between the background parameters, the difference seems to be reasonable.

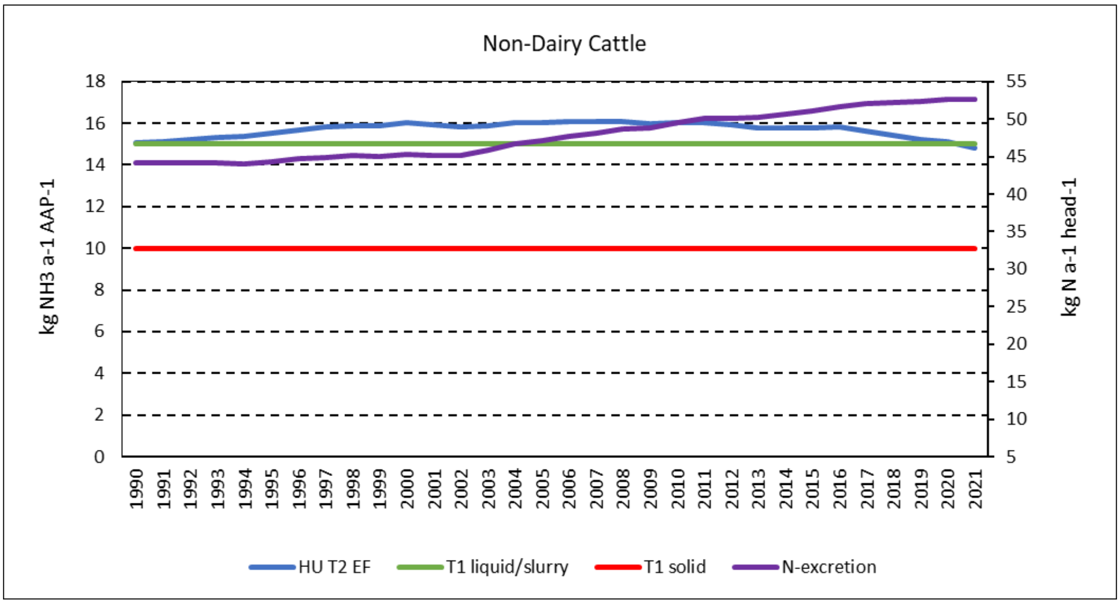


Figure 5.10 Comparison of NH_3 emission factors for Non-dairy Cattle, 1990-2021

Swine

The EMEP/EEA Guidebook (EEA, 2019) provides NH_3 emission factors for sows and fattening pigs separately, differentiating solid and slurry-based manure management systems from which weighted averages was derived for swine. (Figure 5.11). The implied value of default N excretion rates are in the range of 13.6 to 14.1 kg N a^{-1} $head^{-1}$ for the period 1990-2021. In contrast, the Hungarian country-specific value ranged from 10.2 to 10.4 kg N a^{-1} $head^{-1}$ over the inventory period. The slightly decreasing trend reflects the slightly decreasing trend in final weights of fattening pigs and the decrease in the crude protein intake due to the amino-acid supplements. The lower N excretion rates in the Hungarian inventory led to significantly lower NH_3 emission factors for Swine than the EMEP/EAA default. The reported emission abatement techniques during the manure application also contribute to the lower emissions.

Though the default N excretion rates were sourced from the 2006 IPCC Guidelines according to the foot note of the EMEP/EEA Guidebook (EEA, 2019), neither our calculation nor the FAO GHG database justify the EMEP/EEA defaults. Default values on N-excretion rates and weights provided in the 2006 IPCC Guidelines result in 7.7 and 9.3 for Market Swine and 17.3 and 27.6 kg N a^{-1} $head^{-1}$ for Breeding Swine for Western- and Eastern-Europe, respectively. Consequently, the NH_3 emission factors for Swine, in particular for Sows in the EMEP/EEA Guidebook (EEA, 2019) seem to be overestimated for the Hungarian swine livestock.

The recent results of the examination of Hungarian pig feeds also strengthen that the N Intake of pigs is relatively low in Hungary.

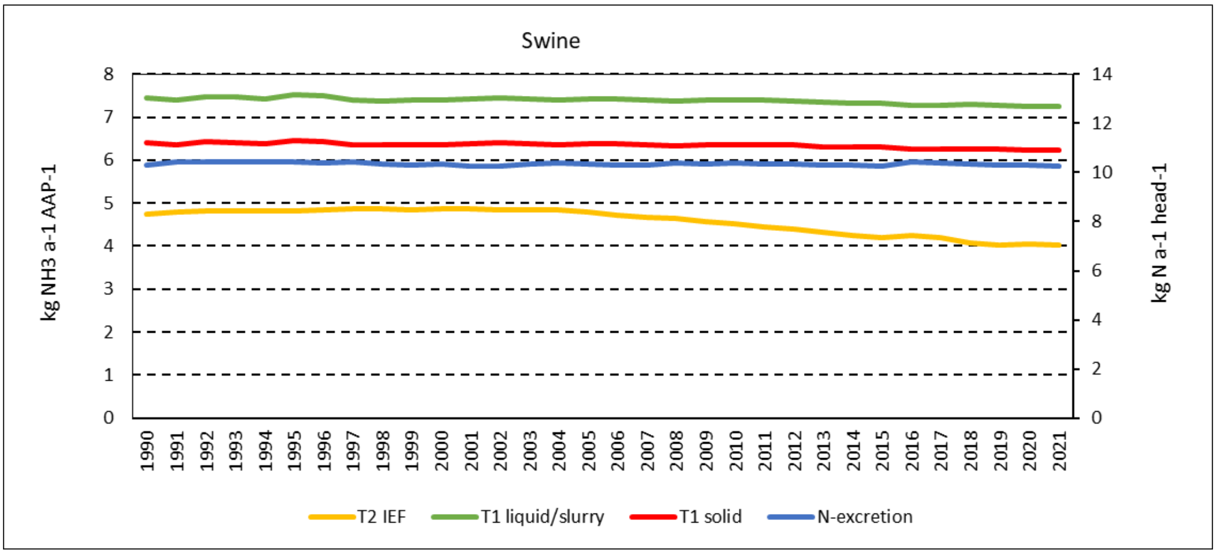


Figure 5.11 Comparison of NH_3 emission factors for Swine, 1990-2021

5.7.2 Verification of TIER2 efs for NH_3 emissions from 3Da1

The use of Tier 1 default emission factor indicates lower emissions than the country-specific value at the beginning of the inventory period, when the proportion of urea N was about 30% in the total fertilizer N. The difference is negligible in the period between 1993 and 2002, during which period proportion of solid urea-N decreased from 29% to 12% in the total fertilizer N. According to the Table A1.2 of the EMEP/EEA Guidebook (EEA, 2019), the default emission factor was developed based on IFA sales data for the year 2014, and the Urea N was 38% on average, of the total fertilizer N in the applied statistics. The same proportion for Urea N justifies the quasi-equal emission factors for the beginning of the time series.

Between 2003 and 2007, the Tier 2 methodology results in slightly higher emissions than Tier 1, despite an average solid urea share of 17%, as the increasing share of urea solution fertilizers of 6-8% during this period also contributes to the relatively high implied EF.

In the period 2008-2016, especially at the beginning of the period due to the economic downturn, the share of solid urea fertilizers continues to decrease and even the share of liquid urea fertilizers is barely above 10%, so the Tier 2 methodology results in slightly lower emissions than Tier 1.

Between 2017 and 2021, the share of solid urea again reached around 10%, while the share of liquid urea steadily increased, reaching close to 20%, resulting in higher Tier 2 IEFs than Tier 1 default EF.

Comparison of NH_3 emissions from 3Da1 Inorganic fertilizers, calculated with Tier 1 and Tier 2 emission factors are presented in Figure 5.12.

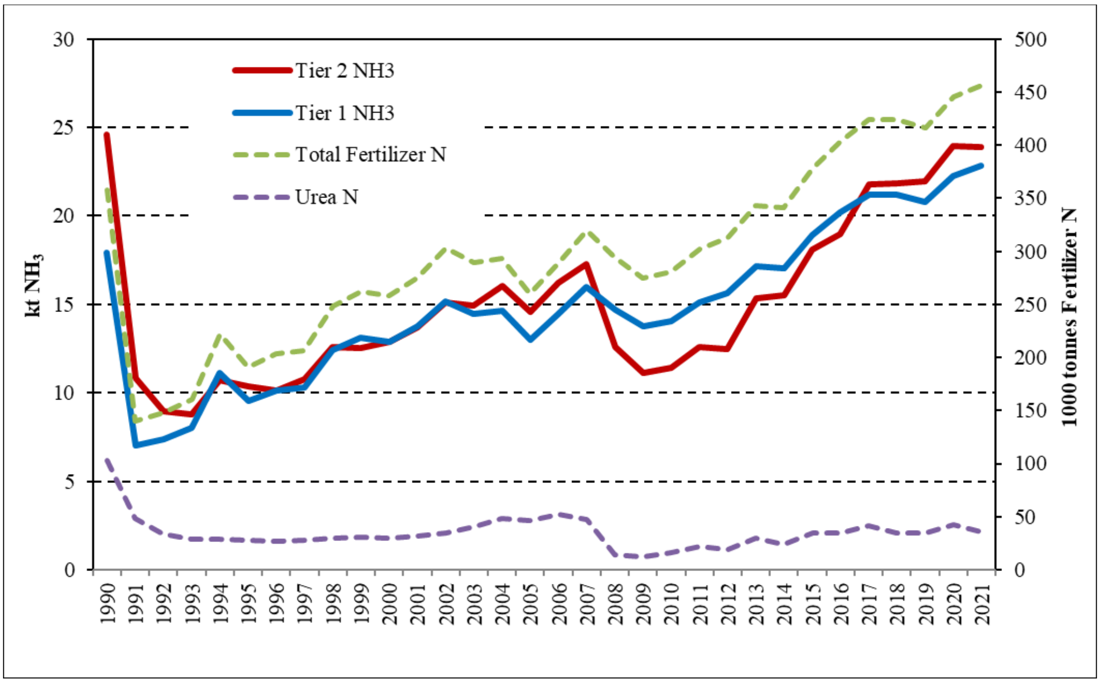


Figure 5.12 Comparison of NH_3 emissions from 3Da1 Inorganic fertilizers, calculated with Tier 1 and Tier 2 emission factors, 1990-2021

5.8 Recalculations

Table 5.20 summarizes the overall changes in the NH_3, NO_x, NMVOC and PM emissions compared to the 2022 submission. Revisions caused an increase by 2.2% on average in the total NH_3 emissions over the inventory period. NO_x emissions have changed slightly for the years 2004-2020. NMVOC emissions increased insignificantly between 2002 and 2020, except in 2017, when there was a negligible decrease. For PM emissions, a minor correction caused an insignificant increase in emissions. The main reasons for the recalculations are the revision of activity data for synthetic fertilizer for the year 2020 and the anaerobic digested manure for the period 2004-2019 and the N-excretion rate for broilers and layers for the period 2017-2020, and the revision of some calculation error of which the revision of the calculation for NH_3 emissions from NPK fertilizers caused the most significant change in emissions.

Table 5.50 Changes in NH_3, NO_x NMVOC and PM emissions in the 3.Agriculture sector between the 2022 and the 2023 submissions

NH_3	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020
2022 Submission	125.56	74.60	79.22	73.00	61.87	66.65	67.20	67.89	67.58	68.14	68.88
2023 Submission	127.57	74.87	80.57	74.29	63.65	68.74	69.60	70.64	70.34	70.00	70.75
Difference %	1.60%	0.37%	1.70%	1.77%	2.86%	3.15%	3.57%	4.05%	4.09%	2.72%	2.72%

NO_x	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020
2022 Submission	25.49	14.53	17.20	16.83	17.23	21.54	22.53	23.25	23.22	22.90	23.89
2023 Submission	25.49	14.53	17.20	16.83	17.23	21.54	22.53	23.26	23.22	22.87	23.92
Difference %	0.00%	0.00%	0.00%	0.00%	-0.01%	0.03%	0.02%	0.02%	-0.01%	-0.15%	0.13%

NMVOC	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020
2022 Submission	54.14	34.28	33.98	30.45	28.52	29.46	29.61	29.06	29.62	28.97	27.95
2023 Submission	54.15	34.30	34.00	30.46	28.54	29.49	29.64	29.05	29.66	29.00	27.98
Difference %	0.03%	0.05%	0.05%	0.06%	0.08%	0.10%	0.10%	-0.02%	0.11%	0.11%	0.12%

$PM_{2.5}$	2000	2005	2010	2015	2016	2017	2018	2019	2020
2022 Submission	0.81	0.79	0.77	0.77	0.79	0.76	0.78	0.78	0.70
2023 Submission	0.80	0.79	0.77	0.77	0.79	0.75	0.78	0.77	0.70
Difference %	-0.26%	-0.23%	-0.18%	-0.21%	-0.19%	-0.19%	-0.19%	-0.19%	-0.24%

PM_{10}	2000	2005	2010	2015	2016	2017	2018	2019	2020
2022 Submission	9.46	10.01	9.90	9.65	9.74	9.49	9.61	9.59	8.70
2023 Submission	9.43	9.98	9.88	9.62	9.72	9.47	9.59	9.56	8.67
Difference %	-0.33%	-0.27%	-0.20%	-0.25%	-0.22%	-0.22%	-0.23%	-0.24%	-0.29%

TSP	2000	2005	2010	2015	2016	2017	2018	2019	2020
2022 Submission	16.55	16.16	15.15	14.75	14.71	14.24	14.38	14.28	13.18
2023 Submission	16.48	16.10	15.11	14.69	14.66	14.19	14.32	14.22	13.11
Difference %	-0.43%	-0.38%	-0.30%	-0.40%	-0.36%	-0.36%	-0.37%	-0.39%	-0.49%

5.8.1 NH3

The detailed reasons for the recalculating NH_3 emissions are as follows.

3B manure management

The most noticeable recalculations occurred in the category *3B4gi Manure management – Laying hens and 3B4gii Manure management – Broilers* due to the update of the N excretion rates for the years 2017-2020. The latest results of the animal feed monitoring system operated by the AKI and the updating of the production parameters (body weight and egg production) have allowed these values to be updated. The application of the updated N excretion rates caused a slight reduction in NH_3 emissions. This reduction in emissions was partly offset by a minor revision of the data on the amount of anaerobic digested manure, while for broilers it resulted in a further negligible reduction in emissions over the period 2004-2020. The minor revision in the amount of manure used in biogas plants affected not only poultry but also swine and cattle. This revision was necessary, on one hand because the data provider authority Hungarian Energy and Public Utility Regulatory Authority (MEKH) revised its former statistics. On the other hand, to ensure full inconsistency with the Waste sector.

Overall, as a result of the revisions, emissions from 3B Manure management increased by 0.1 kt on average for the years 2004-2016 and decreased by 0.1 - 0.7 kt (0.3-1.9%) over the period 2017-2020

3D Agricultural soils

3Da1 Inorganic n-fertilizers (includes also urea application)

The minor revision of fertilizer sales statistics by the AKI for 2020 resulted in an insignificant increase in the emission for that year. In addition, the revision of NPK fertilizer emissions caused a more significant increase in the overall time series. NH_3 emissions increased by 0.3-2.9 kt (2.7%-20.0%) in the time series.

3Da2a Animal manure applied to soils

Due to the interlinking between the 3B and 3Da2a sectors, the revision in the 3B resulted in changes in the 3Da2a for the period 2004-2020 as well. Additionally, the clarification of the abatement efficiency of the immediate incorporation of solid manure also resulted in a smaller increase in the emissions. (In the previous submission immediate incorporation by ploughing was assumed, while in this submission the immediate incorporation by non-inversion cultivation was also distinguished considering the soil tillage methodologies.)

Consequently, between 2002 and 2018 emissions increased by 0.03kt (0.2%) on average, and between 2019 and 2020 decreased by 0.03 kt (0.3%).

3Da2c other organic fertilisers applied to soils

A minor revision of the amount of the manure used in anaerobic digesters by the MEKH and an additional revision of activity data to ensure full consistency with the Waste sector resulted in slight changes in the reported emissions.

Recalculations have led to a combined increase in 3D emissions of between 4-9%.

5.8.2 NO_x

3B Manure management

Revision was made to the 3B4gi Manure Management-Laying hens for the period 2011-2020 due to correction of a calculation error regarding the proportion of liquid/slurry and solid manure resulting in 0.2-0.5% increase in the emissions.

3Da1 Inorganic n-fertilizers

A minor revision to the amount of fertilizer sold for the year 2020 by the AKI resulted in an insignificant increase in the emission for that year.

3Da2a Animal manure applied to soils

The above-mentioned changes in national NH_3 emission estimates are responsible for the recalculation of the NO_x emissions from 3Da2a Animal manure applied to soils because changes in the N-losses result in changes in the N-content of the animal manure applied. NO_2 emissions from 3Da2a decreased by less than 1%.

3Da2c Other organic fertilizers applied to soils

As a consequence of the revision to the anaerobic digested manure, the compost application was recalculated. The effect of this recalculation was negligible.

5.8.3 NMVOC

The above-mentioned changes in NH_3 emission estimates are partially responsible for the recalculation of the NMVOC emissions from manure management from Dairy cattle and Non-dairy cattle, because in accordance with the EMEP/EEA Guidebook (EEA, 2019) the NMVOC emission factors should be derived based on the ratios of NH_3 emissions between different stages of the manure. In addition a minor calculation error regarding the Tier 2 methodology for Guinea Fowls were also corrected, leading to a negligible increase in the emissions.

NMVOC emissions from 3 Agriculture changed in the range of -0.02-0.12%.

5.8.4 PM

A minor revision was made to the calculation of PM emissions from Swine, leading to a slight decrease in the PM emissions.

5.9 Planned improvements

Participation in the EU review mechanisms, provides an opportunity for examination of individual NFR sectors and particular issues relating to methodologies, country-specific emission factors and coefficients. Issues of planned improvements will be assigned largely in accordance with the outcome of the NECD review.

Accounting for NH_3 abatement emission technologies will continue to be a priority. In the next submission, we plan depending on the data availability further revision of feeding data for animal feedings. According to the feeding monitoring program of AKI, the next inventory report is planned to reflect the effect of low protein feeding and animal feeding supplements.

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6 WASTE

Emissions relating to MSW deposition and composting, wastewater handling, incineration of different waste categories are presented in this chapter. It has to be noted that although emissions from waste incineration for energy recovery are allocated to the energy sector as required by the guidebook, the methodological description and background data of all incineration is discussed here.

6.1 Biological treatment of waste - solid waste disposal on land (NFR Code 5A)

Reported Emissions: NMVOC, Particulate Matter
Measured Emissions: None
Methods: CS, Tier 1
Emission factors: D
Key source: -

A major but decreasing part of municipal solid wastes (MSW) is treated by managed disposal and a smaller part by reuse, incineration or other means. The average specific municipal household waste generation rate decreased from 1.3 to 1.0 kg/capita/day in the last few years. The total amount of MSW was 3,546 Gg in 2020. (The 2021 data is expected to be published by the Statistical Office in May 2023.) Out of this, 1,171 Gg (33%) was recovered by recycling and composting, 601 Gg (17%) was incinerated for energy purposes, and 1,770 Gg (50%) went to landfills.

In case of managed disposal, the waste is disposed in landfills where it is compacted and covered. Under these circumstances *anaerobic* degradation occurs during which mostly methane and carbon dioxide is emitted. Degradation requires several decades and occurs at varying rates.

Methodological issues

Considering NMVOC emissions, the following assumptions were made. The EMEP/EEA Guidebook states, based on the evaluation of the US Environmental Protection Agency, that 98.7 % of the landfill gas is methane and 1.3 % are other VOCs such as perchlorethylene, pentane, butane, etc. Thus, our NMVOC emission estimates were based on methane emission calculations in line with the UNFCCC requirements. Once we had the results for methane emissions, the above-mentioned share of NMVOC (1.3% of all VOCs) was used.

Methane emissions were calculated using a first order decay (FOD) methodology applied by the IPCC Waste Model from the 2006 IPCC Guidelines. The FOD method produces a time dependent emission profile which may better reflect the true pattern of the degradation process.

For particulate matter emissions, Tier 1 method from the EMEP/EEA Guidebook was applied.

Activity data

The calculation method requires total amount of disposed waste. For the NMVOC emission calculation, disposed amount of municipal solid waste was used with some additional industrial waste with high degradable organic content (agriculture, food processing, wood products etc.). The IPCC Waste model was used for emission calculation and the resulting methane emissions served as input for NMVOC emissions estimates.

For particulate matter emissions, total amount of disposed waste was taken into account, including relatively large amounts of non-degradable industrial waste. In 2021, altogether 3998 kt waste was disposed.

Emission factors

In case of PM emissions, default T1 emission factors were applied from the relevant chapter of the 2019 Guidebook.

Uncertainties and time-series consistency

The time series is most probably consistent. As regards NMVOC emissions, a consistent time series is presented in *Figure 6.1.*

Source-specific QA/QC and verification

None.

Source-specific recalculations

No change in methodology, only activity data (landfilled waste) has been updated.

Source-specific planned improvements

None.

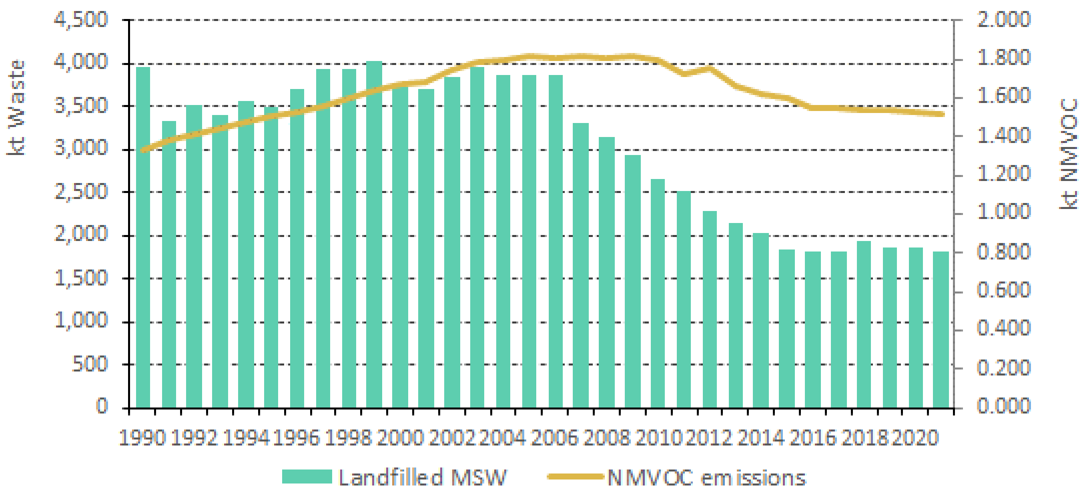

Figure 6.5.13 *Time series of NMVOC emissions from solid waste disposal*

6.2 Biological treatment of waste - Composting (NFR code 5B1)

Reported Emissions: NH_3
Measured Emissions: None
Methods: Tier 1
Emission factors: D
Key source: -

Methodological issues

Ammonia emissions from composting of both municipal waste and sewage sludge is reported here. Generally, the Tier 1 method was used with the default emission factor. This method is easy to apply for municipal waste. However, there is no default factor specifically for sewage sludge in the Guidebook therefore a more general EF on the basis of N content of any kind of waste composted was derived. Assuming 60% moisture and 2% N for organic municipal waste (see Table 4.1 in the Waste chapter of the 2006 IPCC Guidelines), the default mass-based EF for MSW (i.e., 0.24 kg NH3/Mg waste) was converted to an N-based EF as follows: 0.24/(40% x 2%) = 30 kg NH3/tonne N. Using this new EF, NH3 from composting of sewage sludge could be estimated with an assumed N-content of 4.2% (see: TABLE 2.4A in the 2019 Refinement).

Activity data

The amount of composted municipal waste was received from the Hungarian Central Statistical Office. In 2021, 383 kt waste was composted which represented 15% of all generated MSW. This is what is reported as AD in the NFR table. In addition, 93 kt sewage sludge (in dry matter) was composted in 2021. Further activity data for selected years are presented in the table below.

COMPOSTING (kt)	1990	1995	2000	2005	2010	2015	2020	2021
Municipal solid waste	0	0	17	41	148	231	375	383
Sewage sludge (d.m.)	20	28	30	53	82	99	93	93

Emission factors

The default value i.e. 0.24 kg/Mg organic waste was used from the Guidebook. For sewage sludge, an N-based EF was used: 30 kg NH3/tonne N.

Uncertainties and time-series consistency

The time series is most probably consistent.

Source-specific QA/QC and verification

None.

Source-specific recalculations

A calculation error has been corrected. In the previous submission we used a wrong N-based emission factor (20 kg NH3/tonne N) instead of the above described 30 kg NH3/tonne N. Also, amount of composted MSW has been updated for 2020.

Source-specific planned improvements

None.

6.3 Biological treatment of waste - anaerobic digestion at biogas facilities (NFR code 5B2)

Reported Emissions: NH_3
Measured Emissions: None
Methods: Tier 1
Emission factors: D
Key source: -

Methodological issues

In this source category, ammonia emissions are estimated from (A) biogas plants using diverse feedstock including manure, crops from agriculture, wastes from food processing industries, sewage sludge, and municipal organic wastes, and (B) anaerobic digestion of sewage sludge at wastewater treatment plants.

Starting with general biogas facilities (A), a very detailed database on various feedstock used for anaerobic digestion was analyzed for the period 2015-2021. This database contained information on more than 40 types of feedstocks, including fresh weight and dry matter content. Nitrogen content was then calculated by using mostly the default values from Table 3.7 of the EMEP/EEA Guidebook ("N content for various feedstock categories"). With the resulting total N amount, NH3 emission was directly calculated using the default emission factor. For earlier years, total N amount was derived from biogas production data as described later in this chapter.

As for sewage sludge gas (B), our starting point was the energy statistics, i.e., sewage sludge gas production from the IEA/Eurostat Annual Questionnaire for Renewables. From biogas data, the N content of sludge was estimated, and then the same method could be applied as for agricultural wastes described above in part (A).

Activity data

In case of general biogas plants, we had an estimate of the total N-content of feedstock for the period 2017-2021 varying between 7853 t N and 9651 t N. At the same time, the produced biogas (as "other biogases from anaerobic fermentation" taken from the IEA/Eurostat Annual Questionnaire for Renewables) varied between 1932 TJ and 2297 TJ. Combining these two datasets, an average factor of 4.1 t N/TJ could be derived which then could be used for backward extrapolation of N content of feedstock for the period 2000-2016 using the available energy statistics on biogas production. Please note that biogas production data refers to the energy content in biogas (and not to the power produced from biogas).

In case of wastewater plants, N content of sewage sludge going into biogas plant had to be derived. First, the same assumption of 4.2% N in dry matter was used as elsewhere in the inventories. However, the amount of sewage sludge was not known. From the literature, the following parameters were taken (see table below):

(1) methane yield = 21 liter/kg sludge in fresh weight (from the range 11-30). Further, 34 MJ/m3 as a net calorific value of methane was assumed. From these two values, a biogas yield of 0.714 MJ/kg fresh sludge could be estimated (21 x 34 / 1000).

(2) dry matter content of sewage sludge = 7.5% (from the range 5-10%).

Combining these two parameters, we got an estimated biogas yield of 9.5 MJ / kg sludge in dry matter (0.714/0.075).

In 2021, 1263 TJ sewage sludge gas was produced. Using the above parameters, for this amount of biogas 132.95 kt (d.m.) sewage sludge was needed (1263/9.5=132.95) that had a N content of 5.58 kt (132.95x4.2%=5.58).

Table 3
Biomethane yield from selected feedstocks.

	DM	VS	methane yield	methane yield
	%	% Of DM	l CH_4/kg VS	l CH_4/kg fresh
pig slurry	3-8%	70-80%	250–350	6–22
cattle slurry	6-12%	70-85%	200–250	8–25
poultry manure	10-30%	70-80%	300–350	21–84
maize sillage	30-40%	90-95%	250–450	68–170
grass	20-30%	90-95%	300–450	55–128
alfaalfa	20-25%	90-95%	300–500	57–118
potatoes	20-30%	90-95%	280–400	54–128
sugar beet	15-20%	90-95%	230–380	31–72
straw	85-90%	80-90%	200–250	136–202
vegetable waste	85-90%	80-90%	200–251	136–203
organic waste	10-40%	75-90%	350–450	26–180
sloutherhouse residues	35%	90-95%	550–650	173–216
sewage sludge	5-10%	75%	300–400	11–30

DM- Dry Matter; VS - Volatile Solids.
Source: [46–53].

Source: https://www.sciencedirect.com/science/article/pii/S096014811830301X

Emission factors

The default value (0.0275 kg NH_3-N/kg N in feedstock) was used from the Guidebook.

Uncertainties and time-series consistency

The time series is most probably consistent.

Source-specific QA/QC and verification

None.

Source-specific recalculations

The N-content of some types of feedstock has been revised which affected slightly the parameter for backward extrapolation (changed from 4.15 to 4.1 t N/TJ). Total dry matter of all feedstock and sewage sludge is reported in the NFR.

Source-specific planned improvements

None.

6.4 Waste incineration (NFR code 5C1)

Reported Emissions: Main Pollutants except NH_3, Particulate Matter, CO, Heavy Metals, POPs
Measured/Plant-level Emissions: NO_X, SO_X, TSP, CO, (Pb, Cd, Hg, As, Cu, Ni, PCDD/F)
Methods: Tier 1 / Tier 3
Emission factors: D, CS
Key source: Hg, HCB.

Methodological issues

In accordance with the Guidebook, if there is heat recovery in the incineration process it is good practice to report the emission in the relevant combustion sector in the combustion section (1A). If no heat recovery occurs, it is good practice to report the emission in the waste incineration sector (5C1). Following the above recommendation, the categories under 5C1 cover only emissions from thermal waste treatment without energy recovery. However, the used method was more or less the same for waste incinerated both in the energy and waste sectors. Similarly, to other parts of the inventory, a mixture of the default Tier 1 methodology was used together with Tier 3 facility level measured data.

Activity data

For our calculations, five main data sources were used. First of all, the Hungarian Waste Management Information System (HIR) that comprises facility level data on mass and composition of waste in line with the European Waste Catalogue (EWC codes) and with European Waste Classification (EWC-Stat) but also on waste management methods in accordance with the Waste Framework Directive which made it possible to distinguish between waste incineration on land (D10) and use of waste principally as a fuel or other means to generate energy (R1). Our second data source was the Waste Incineration Works (FKF) of Budapest which is the biggest (and for long time the only one) municipal waste incinerator in Hungary. (The MSW incinerator in Budapest was reconstructed between 2002 and 2005.) Thirdly, also ETS data were taken into account, e.g. data reported by Mátra Power Plant, the biggest co-incinerator plant or by the four large cement factories in the country. Our fourth data source was the often-referred Hungarian Air Emissions Information System (LAIR). Input data for cremation (number of bodies) were received from the Hungarian Central Statistical Office.

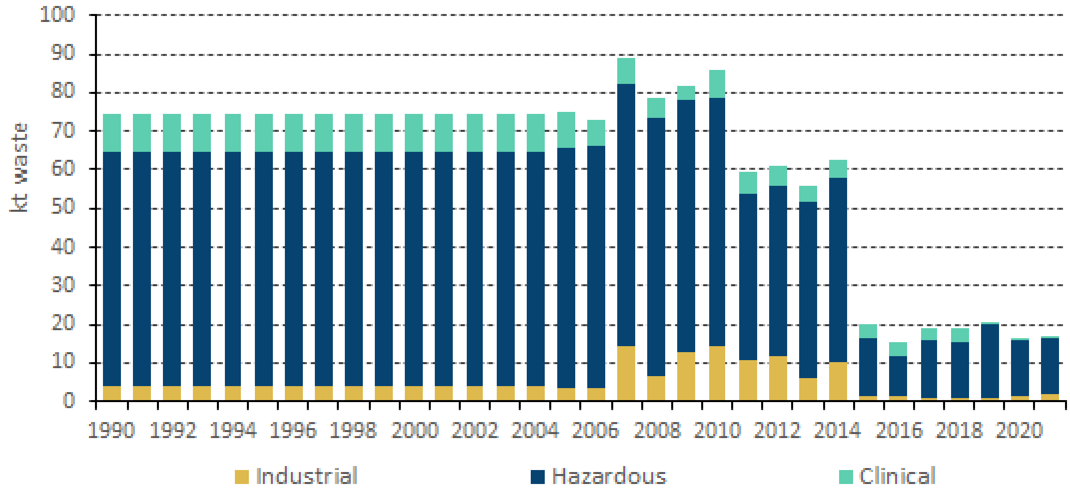

Figure 6.2 *Activity data used for emission calculations (1990-2021)*

As emissions are to be reported separately for different waste categories, the classification system of wastes in HIR according to EWC-Stat was used. In the NFR tables, the following waste categories are reported:

- Industrial waste incineration: all non-hazardous waste;
- Hazardous waste incineration: defined as all hazardous waste except clinical.
- Clinical waste incineration: defined as EWC-Stat code W05 (Health care and biological wastes);
- Cremation

It might be an interesting fact that 82 to 97 per cent of all incinerated waste in this source category was hazardous waste of which most part was liquid. Incinerating sewage sludge is not a common practice in Hungary. The above categories might however include some industrial sludges. Emissions from municipal waste incineration are reported under the source category 1A1a.

Based on information from the Hungarian Central Statistical Office, on average 1250 kt waste was treated either with energy recovery or incinerated without energy recovery between 2004 and 2019 out of which only 8% was burned without energy recovery.

Emission factors

As a general rule, default Tier 1 emission factors were applied with quite a few exceptions as summarized in the following.

In Hungary, waste incineration is regulated by law. For example, all incinerators burning hazardous waste need to operate with an afterburner with temperatures at least 1100°C for at least two seconds. The current legislation (Decree 29 of 2014 (XI.28.) FM of the Ministry of Agriculture concerning technical requirements, operational conditions and technological emission limit valued of waste incineration) contains the following emission limit values: 0.1 ng/m3 for PCDD/F, 0.05 mg/m3 for both Cd and Hg, and 0.5 mg/m3 for Sb, As, Pb, Cr, Co, Cu, Mn, Ni, V altogether. These ELVs are valid since the second half of 2005. Assuming a calorific value of 10 GJ/t, these emission limit values could be converted to emission factors as follows: 0.546 µg/t for PCDD/F, 0.273 g/t for Cd and Hg, and 2.73 g/t for the remaining heavy metals. Especially for dioxins and furans generally and heavy metals in case of clinical waste, these values are lower than the default T1 emission factors. Consequently, the following approach was applied.

For *industrial and hazardous* waste, default T1 emission factors from Table 3-1 of the Guidebook are used for the main pollutants (NOx, CO, NMVOC, SOx). For particulate matter, somewhat higher than the default are applied (i.e. 0.04 kg/t for TSP). Default emission factors were kept for heavy metals, PAHs and HCB. For PCDD/F, an EF of 0.55 µg/t (coming from the emission limit value) is applied from 2006 on. When measured emissions were available (this was mostly the case for incinerators with energy recovery reported in the energy sector), these were used to the extent possible.

As regards *clinical waste,* different emission factors were used for the periods before and after 2005. In the early period of the time series, the default emission factors from Table 3-1 of the Guidebook were applied with the exception of PCDD/F for which a country-specific value of 30 µg/t was used. From 2006 on, the following non-default EFs are applied derived from the average IEF of a clinical waste incinerator from the years 2010-16: 1.3 kg/t for NOx, 0.2 kg/t for CO, 0.335 kg/t for SO2, and 0.045 kg/t for TSP. As for heavy metals, the used EFs are as follows: 1.031 g/t for Pb, 0.003 g/t for As, 0.033 g/t for Cr, 1.629 g/t for Cu and 0.033 g/t for Ni. All these values were derived from the emission limit value from the ministerial decree for Sb, As, Pb, Cr, Co, Cu, Mn, Ni, V altogether (i.e. 2.73 g/t). For Hg, an EF of 0.029 g/t was used derived from measured emissions. For Cd, Tier 2 EF was applied assuming an abatement efficiency of 98% [3 g/t x (1-98%) = 0.06 g/t]. Our PCDD/F emission factor is again based on measurements (0.22 µg/t), and for HCB an abatement efficiency of 99.9% was assumed (0.1 mg/t).

Coming to *municipal waste* incineration, as almost all municipal waste is incinerated by one plant, the Waste Incineration Works in Budapest, its measured emission data were used extensively (either directly or for deriving country specific emission factors) for the following pollutants: NOx, SOx, CO, TSP, Pb, Cd, Hg, As, and PCDD/F. Due to more stringent legislation and reconstruction of the plant, the implied emission factors show mostly significantly decreasing values, for example:

- NOx: from 1.8 kg/t before 1992 to 1.3 kg/t between 1992 and 2002 to around 0.7 kg/t in recent years;
- SOx: from 1.8 kg/t before 1992 to 0.5-0.8 kg/t between 1992 and 2002 to less than 0.2 kg/t in recent years;
- CO: from 0.7 kg/t up to 1991 to less than 0.1 kg/t in recent years;
- Particulate matter: from 0.3 kg/t to close to 0.001 kg/t

As for heavy metals, the following country-specific emission factors could be derived from measurements: 0.141 g/t for Pb, 0.025 g/t for Cd, 0.026 g/t for Hg, 0.03 g/t for As, 0.034 g/t for Cr and Cu, and 0.046 g/t for Ni. For the remaining heavy metals, the default T1 emission factors were applied. The above values are valid only for the period after reconstruction of the incineration plant (i.e. after 2005). For previous years, as we assume abatement efficiencies of 90%, the applied EFs are an order of magnitude higher, (or T1 emission factors from a previous guidebook were used).

For dioxins and furans, measure data indicate an IEF of 0.023 µg/t after 2005, and an IEF of 30 µg/t before 2005.

Although emissions are allocated to the energy sector, it is worth mentioning that co-incineration occur both in power sector and in cement plants. As regards industrial waste, 95% of all incinerated waste came from the biggest co-incinerator plant (Mátra Power Plant) whose measured NOx, SOx, CO, and TSP emissions were anyhow included under 1A1a regardless of the burned fuel. In source category 1A2f, 64% of the incinerated wastes allocated here were from cement factories. All the rest was wood waste. Measured NOx, SOx, CO, TSP, and Hg emissions from cement factories were taken into consideration.

For the source category 5C1bv *Cremation*, the default methodology with default EFs were applied. Only emissions from incineration of human bodies in a crematorium is included. It was previously assumed that one quarter of deaths are subject of cremation but later surveys indicate a much higher share (64.4% in 2019).

Uncertainties and time-series consistency

The time series are most probably consistent.

Source-specific QA/QC and verification

None.

Source-specific recalculations

None.

Source-specific planned improvements

None.

6.5 Open burning of waste (NFR code 5C2)

Reported Emissions: NOx, SOx, NMVOC, Particulate Matter, CO, Heavy Metals, POPs
Measured/Plant-level Emissions: NA
Methods: Tier 1 and Tier 2
Emission factors: D
Key source: -

Methodological issues

Tier 2 method was used with the default emission factors.

Activity data

Data on the amount of slash burned on site was received directly from the Forestry Directorate of the Hungarian National Land Centre.

The amount of waste from orchard and vine pruning was estimated based on area data of orchards and vineyards provided by the Hungarian Central Statistical Office and country specific data found in Hungarian literature (Baglyas et al, 2011; Juhász, 2005; Juhos and Tőkei, 2013; Marosvölgyi, 2002; Pintér and Brazsil 2013; Zanathy, 2007) on the amount of pruning waste produced per hectar of land. According to the above-mentioned data the average amount of residues from orchard pruning are 2.23 tonnes/ha while residues from vine pruning amount to 3 tonnes/ha. In order to estimate the proportion of pruning waste burned on site we also used data provided by the Hungarian State Treasury on orchards and vineyards supported by EU agricultural subsidies. As burning of agricultural residues on subsidized areas is strictly prohibited it was assumed that burning in these areas does not take place. Regarding orchard and vineyard areas not subject to EU subsidies it is assumed that 70% of pruning waste is open burned in the period 1985-2007 (Gergely, 2005). For years after 2007 it is assumed that open burning of agricultural residues takes place in orchard and vineyard areas not subject to EU subsidies.

The total amount of garden waste was estimated based on data on the number of households with garden collected by the Hungarian Central Statistical Office. An average garden waste production rate of 288 kg per year (Eades, 2020) was assumed. In order to estimate the proportion of burned garden waste a survey on waste burning practices of the Hungarian population was used which was made by Kantar Hoffman LTD (2017) together with two Hungarian NGOs the Clean Air Action Group and the Anti-Poverty Network. According to this survey 17% of the population open burns garden waste which means that 30% of households owning a garden burn garden waste outdoors. According to the survey 90% of garden waste burners do this activity half-yearly or even more rarely and only 10% burns it monthly or weekly. Based on data collected in this survey it was assumed that households practicing open burning of garden waste burn on average 3.6 times yearly. Taking into account the unpublished results of a survey of the University of Miskolc it was also assumed that 50 kg garden waste is burned per occasion. Based on these amounts it was calculated that 63% of the amount of garden waste is open burned in households which do burn garden waste outdoors. This leads to the conclusion that 19% of the total amount of garden waste available is burned outdoors.

Data provided by Hungarian Central Statistical Office on separate collection of garden waste is available from 2009 onwards. The amount of garden waste collected separately has an increasing trend. In year 2020 310,917 tonnes of garden waste were collected separately.

Based on the above-mentioned data it was assumed that 19% of the amount of garden waste remaining in gardens (ie. not collected separately) is open burned.

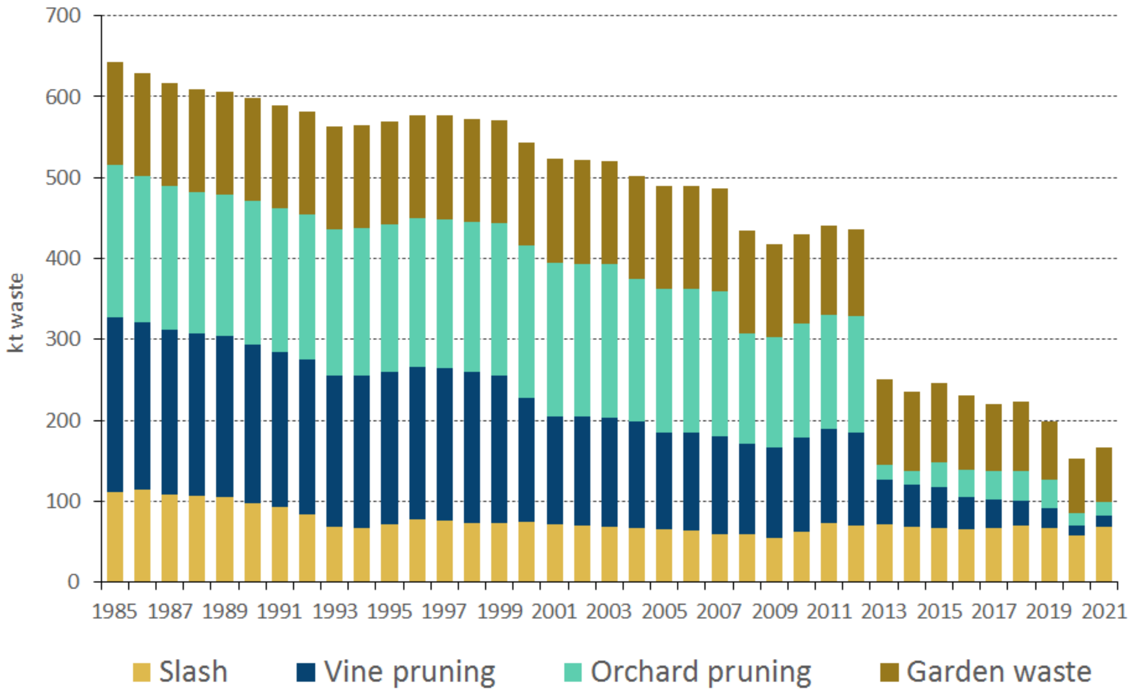

Figure 6.3 *Activity data used for emission calculations: amount of waste open burned (1985-2021)*

Please note that in the NFR tables there is only one cell for activity data therefore only the amount slash is reported there. However, emissions are calculated from the incineration of all above mentioned agricultural and garden wastes.

Further note on completeness: In 1986 a decree on the protection of air quality came into force, under which waste incineration (of any kind) required authorization. In 2001, decree 21/2001 (II.14) came into force explicitly prohibiting the open burning of waste, including burning in household furnaces. The same prohibition was included in the current Government Decree on air protection (306/2010 (XII. 23.). Based on the recent Government Decree, open burning of waste (or incineration of waste in an installation that does not comply with the legislation setting the conditions for incineration of waste), with the exception of household waste paper and incineration of untreated non-hazardous wood waste is prohibited. In outside areas, as a general rule, open burning of standing vegetation, stubble and waste from crop production is prohibited. However, as an exemption, Regulation 54/2014 of the Ministry of Interior on national fire protection, the owner and user of the property may carry out controlled incineration with the permission of the fire protection authority. This permission is usually given in case of plant diseases. (According to the information and data provided by the plant protection authority, incineration permits have been issued only some rice lands, and the corresponding emissions are reported under 3F.) We would also like to stress, that incineration of straw is prohibited without exemption. So, we believe that by estimating emissions from orchards and vineyards, we might include all emissions from agricultural waste burning (including possibly also some illegal activities).

Emission factors

For open burning of forest residues, the default Tier 2 emission factors valid for forest residues were used from Table 3.3 of the 2019 Guidebook.

For orchard and vine crops the default Tier 2 emission factors valid for orchard crops were used from Table 3.3 of the 2019 Guidebook.

For open burning of garden waste, the default Tier 1 emission factors were used from Table 3.1 of the 2019 Guidebook.

Uncertainties and time-series consistency

The time series is most probably consistent.

Source-specific QA/QC and verification

None.

Source-specific recalculations

-.

Source-specific planned improvements

None.

6.6 Wastewater handling (NFR code 5D)

Reported Emissions: NMVOC, NH_3
Measured Emissions: None
Methods: Tier 1. Tier 2
Emission factors: D
Key source: -

Following the latest EMEP/EEA Guidebook, NMVOC emissions are calculated from wastewater handling. In addition, NH3 emission from latrines is taken into account. The resulting emissions are almost negligible.

Methodological issues

Tier 1 (NMVOC) and Tier 2 (NH_3) methods were used with default emission factors.

Activity data

For the calculation of NMVOC emission, treated wastewater in m^3 collected and published by the Hungarian Central Statistical Office was used as activity data. Only at least biologically treated wastewater was taken into account (which meant basically all wastewater in the last three years). On average, around 500 million m^3 wastewater was treated (including also mechanical only) in the last 10 years. It is worth mentioning that the share of only mechanically treated wastewater dropped from 23% in 2009 to 3% in 2010 and further to 0.1-0.2% in 2012.

15.1.1.27. Municipal waste water treatment [thousand m3]					
Year	Discharged or transported to a public waste water treatment plant on a public sewerage network only with mechanical treatment technology	Discharged or transported to a public waste water treatment plant on a public sewerage network also with biological treatment technology	Discharged or transported to a public waste water treatment plant on a public sewerage network also with advanced treatment technology	Discharged or transported to a public waste water treatment plant on a public sewerage network total	USED
1990	475,968	280,426	22,979	779,373	**303,405**
1995	325,451	244,992	13,001	583,444	**257,993**
2000	168,910	252,978	57,304	479,192	**310,282**
2005	174,815	188,779	196,784	560,378	**385,563**
2010	17,607	280,760	255,008	553,375	**535,767**
2015	745	63,437	418,269	482,452	**481,706**
2020	551	44,248	488,232	533,031	**532,480**
2021	588	44,613	479,672	524,873	**524,285**

Source: https://www.ksh.hu/stadat_files/kor/en/kor0027.html

Activity data for NH_3 emission estimation is the number of people using latrines (see Table 3-2 of the Guidebook). For our recent calculation, it was assumed that tenants of urban flats and country houses with either no connection to the public sewerage system or no domestic sewerage system have to use latrines outside the house. It was assumed that 87.7% of all dwellings were connected to the public sewerage network in 2021 whereas 10.3% used some domestic sewerage. Thus, we assumed that 2.0% of the total population (194,615 people) use latrines. For earlier part of the time series much higher numbers are assumed: 1990: 16% (1,691,502 people), 2000: 10% (1,025,951 people), 2005: 6% (587,704 people), 2010: 3% (322,451 people), 2015: 2,8% (271,028 people).

Emission factors

The default values, i.e. 15 mg/m^3 (NMVOC) and 1.6 kg/person/year (NH3 from latrines) were used from the Guidebook.

Uncertainties and time-series consistency

A consistent time series of NMVOC emissions is presented in *Figure 6.4*.

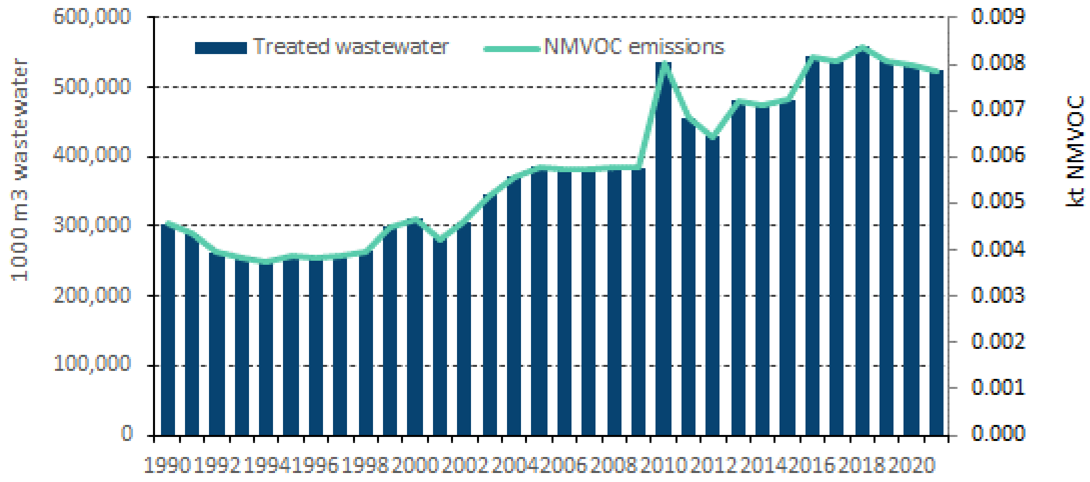

Figure 6.4 *Time series of NMVOC emissions from wastewater handling*

Source-specific QA/QC and verification

None.

Source-specific recalculations

No methodological change has been made. The amount of treated wastewater was updated on the basis of the latest HCSO data.

Source-specific planned improvements

We'll check the possibility to report emissions from industrial wastewater treatment separately.

6.7 Other waste (NFR code 5E)

Reported Emissions: PM, heavy metals, PCDD/F

Measured Emissions: None

Methods: Tier 2

Emission factors: D

Key source: DIOX, PM2.5

In this source category, emissions from car and house fires are reported.

Methodological issues

The Tier 2 approach was applied as suggested by the EMEP/EEA Guidebook. Activity data were stratified basically into three categories: house fires, industrial building fires, and car fires.

Activity data

Two sources have been used for activity data: (1) Hungarian Central Statistical Office (for total number of fires, 1990-2020, and fires in dwellings, 2000, 2005, 2010-2020), and (2) National Directorate General for Disaster Management, Ministry of the Interior (for car fires and other building fires, from 2013). Due to incomplete information, the time series, as shown in Fig. 6.5, contains also intra- and extrapolated data.

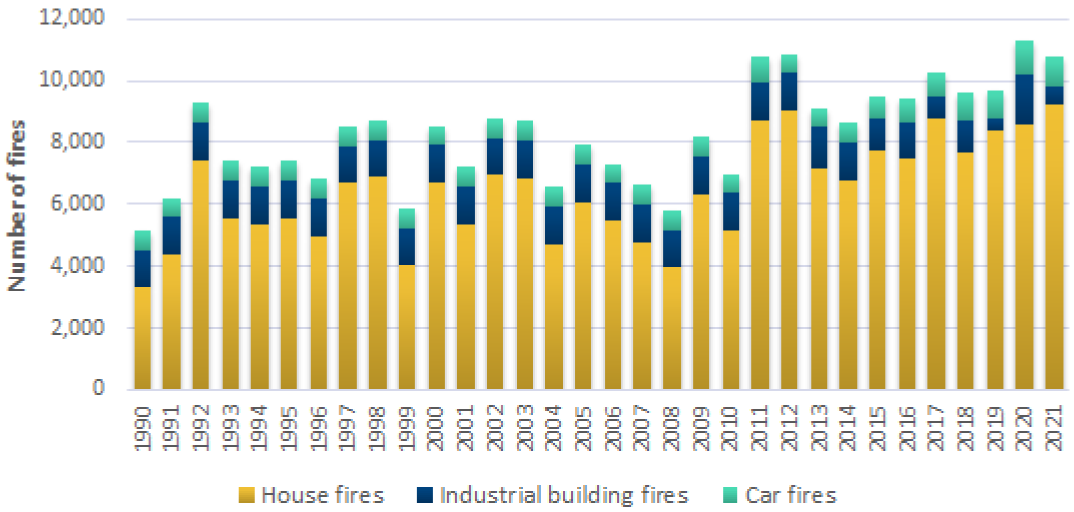

Figure 6.5 *Number of fires (1990-2021)*

Emission factors

The used default emission factors were taken from Tables 3-2, 3-3, 3-5, and 3-6. It was assumed that 60% of house fires were from detached houses, and the remaining 40% from apartment buildings.

Uncertainties and time-series consistency

The time series can be regarded as consistent

Source-specific QA/QC and verification

None.

Source-specific recalculations

No methodological change has been made.

Source-specific planned improvements

None.

6.8 References

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7 OTHER AND NATURAL EMISSIONS

Emissions from NFR 7. Other Natural emissions are not estimated for Hungary.

8 RECALCULATIONS AND IMPROVEMENTS

8.1 Recalculations

Information is provided in the sectoral chapter above.

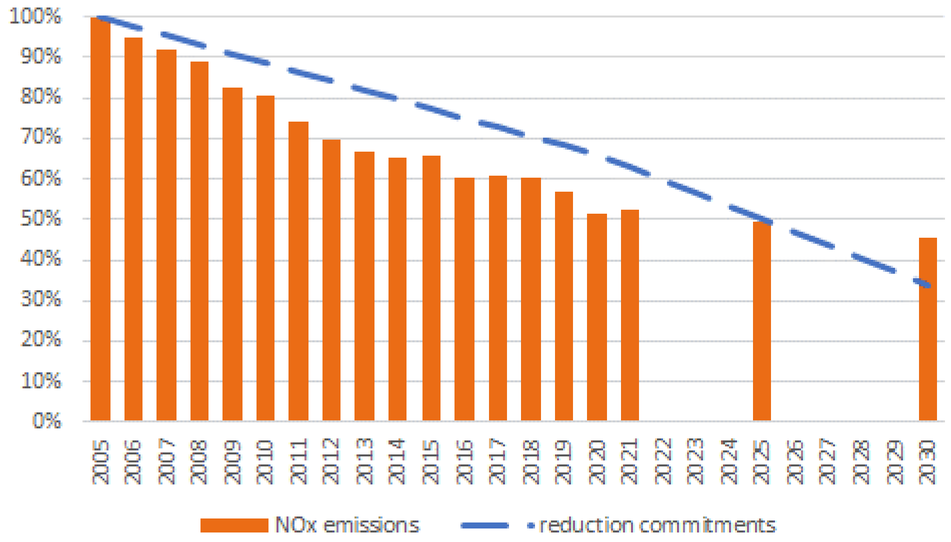
8.2 Planned improvements

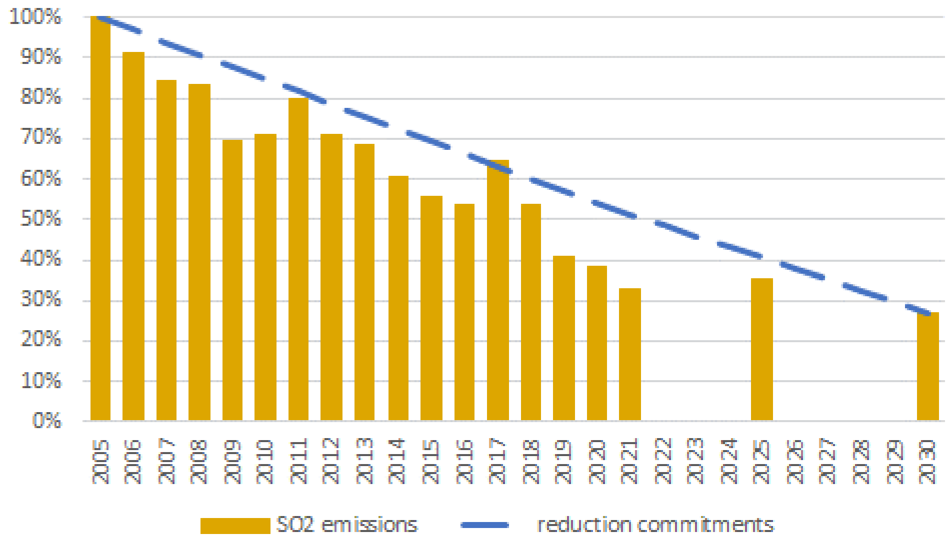
- quantitative uncertainty analysis

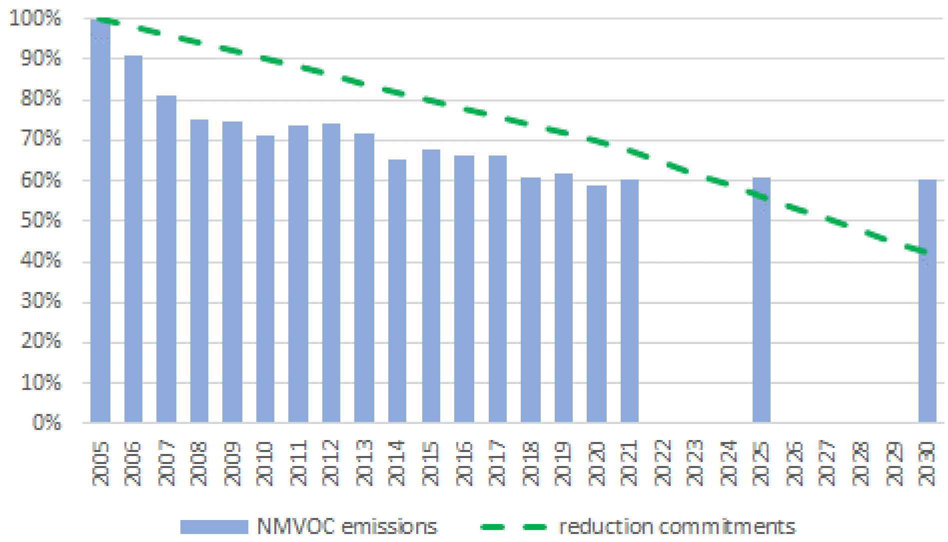
9 PROJECTIONS

In this section, a short summary will be given on the most important assumptions regarding the main trends, data sources used and methodologies applied for the calculation of projected emissions. Emphasis will be placed on the WEM (with existing measures) scenario, as - at the time of writing this chapter – Hungary has not yet updated its National Air Pollution Control Programme.

The following figures show show the expected trend of emissions for each pollutant in the WEM scenario. Reduction commitments for 2020 to 2029 and 2030 are illustrated as linear dotted lines, although reduction will not necessarily follow a linear path. Nevertheless, it can clearly be seen that additional measures will be needed to meet the reduction commitments for almost all pollutant except for SO2.



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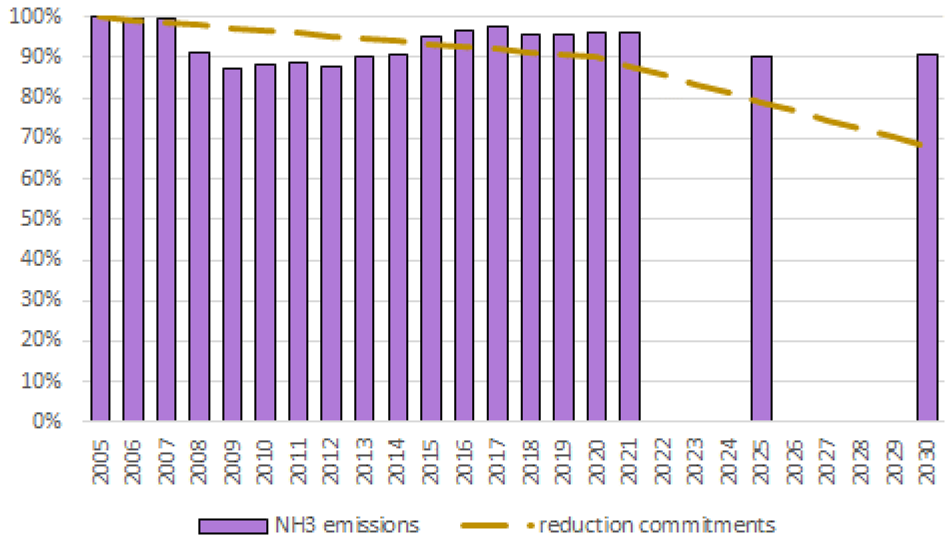
NMVOC emissions
reduction commitments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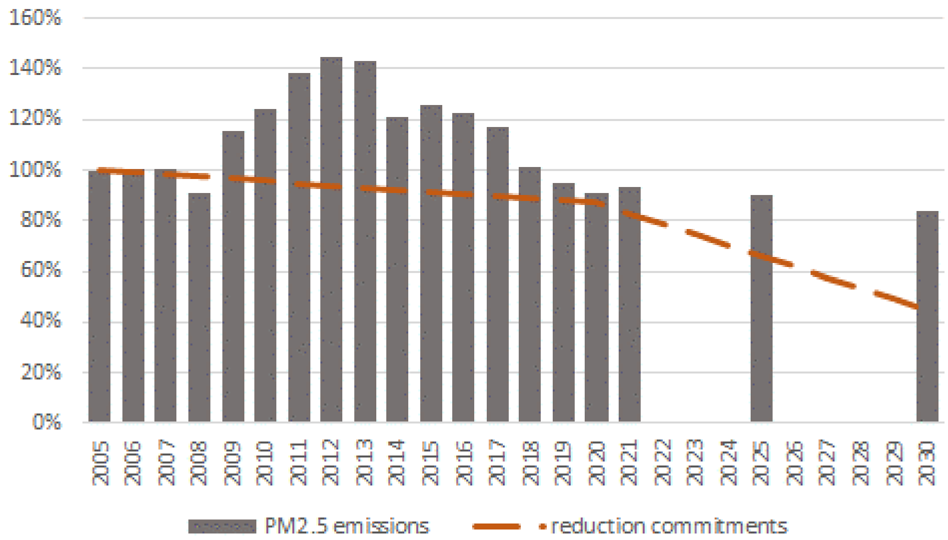
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PM2.5 emissions
reduction commitments

9.1 ENERGY

Projections in the energy sector were generally harmonized with the integrated national energy and climate progress report under the energy governance regulation. This meant in practice that the underlying activity data, i.e., energy consumption, were the same in the emission calculations (except for the transport sector).

The HU-TIMES model was used in the modelling. This model has been used on several occasions to perform background calculations for national strategy documents, including the current National Energy and Climate Plan.

The TIMES (The Integrated MARKAL-EFOM System) model is an internationally used and accepted model, which was developed from the MARKAL model developed by the International Energy Agency over several decades. The robustness and flexibility of the model is illustrated by numerous research examples, whether the approach is global, international, national or regional.

The HU-TIMES model is a TIMES model developed by REKK, Regional Centre for Energy Policy Research, for the entire Hungarian energy sector which includes the technological and cost-side characteristics of the Hungarian electricity and district heating generation plants, as well as the technological and demand-side characteristics of the end-user sectors under study. In order to use the Hungarian TIMES model as accurate and up to date as possible, information from industry players and data from national and international literature was used to apply the most accurate values possible for both supply and demand side characteristics. For the main input factors, the values recommended by the Commission were used. These include population, carbon quota price, real GDP growth, and natural gas, oil and coal prices.

In addition to the above input parameters, several assumptions have been made in the forecast that have a decisive influence on the results. One of the most important of these is that an upper limit on the use of solid biomass has been set. This was done based on the FOX model developed by REKK. Based on the results of the FOX model, the following limit was set for solid biomass that can be used in Hungary in each year: initially, the total use in the energy sector should not exceed 104 PJ, decreasing linearly to 84 PJ by 2050 (which means 97 PJ in 2030).

As requested by the Ministry for Energy Affairs, the following exogenous investments and conditionalities have been fixed:

- Both the two new nuclear power plant units (Paks2) will be operational in 2030;

- Operation time of the existing nuclear power plant units (Paks1) will be extended until 2050;

- 3 new CCGT units with a total capacity of 1.5 GW are expected to be built in 2028

The modelling results can be summarized as follows.

Final energy consumption would only slightly decrease (from 746 PJ in 2019 to 736 PJ) until 2030 but will fall significantly in the following decades to 634 PJ in the WEM scenario. Until 2030, residential energy consumption would decrease by 15% whereas industrial energy use would increase almost by a third.

In contrast to final energy use, primary energy use is expected to increase peaking in 2030, when both Paks power plants will be operating at maximum capacity, while the processes that reduce end-use energy consumption have not yet fully taken effect.

The variability of coal use is the result of two processes: on the one hand, the coal (=low quality domestic lignite) units of the Mátra power plant will be phased out by 2030, resulting in a reduction in coal use. At the same time, with the continuous increase in demand for pig iron production, the use of coking coal for the production of coke and blast furnace gas will continue to increase.

Energy industries:

Pursuant to the intergovernmental agreement between Hungary and the Russian Federation, two new nuclear power plant units will be built in Hungary by 2030, each with a capacity of 1200MW (Paks 2). The new nuclear power plant units will allow the phasing out of coal-based power generation in Hungary. In parallel with the existing policy measures, by 2030 coal-based power generation will be limited to power plants supplying lower capacity industrial heat and district heating. We can also expect a significant increase in PV until 2030, the installed capacity will increase close to 9 GW by 2030, but no new solar power plants will be built after that. Biomass capacities are continuously being built, while the development of gas capacities is very hectic: while the older gas capacities are continuously being phased out, three new CCGT power plants will be built at the end of the 2020s.

Thanks to the growing PV production, net imports of electricity will constantly be decreasing, and in the 2030s, thanks to the new blocks in Paks and the new gas power plants, Hungary will already be a net exporter, despite the fact that electricity consumption will also increase (by 12% until 2030 and up to 62% by 2050).

Buildings (households and the tertiary sector):

In the tertiary sector, rising demand will be offset by energy efficiency investments, so that in 2030 (and also in 2050) energy use will be close to today's levels. Natural gas use declines slightly, replaced by heat pumps and other electricity use. Biomass use is considered marginal, while district heating consumption increases slightly and will remain at a significant level even in 2050.

In contrast to the service sector, energy consumption of households will be reduced, slightly by 15% until 2030 and more significantly afterwards. In addition to energy efficiency, there is also a significant change in fuel: the role of natural gas will remain significant even in 2050, accounting for nearly 50% of total energy consumption. This is partially replaced by heat pumps.

Unfortunately, firewood consumption that causes most of the sectors's and also national PM emissions would not change much by 2030 (only a 5% decrease is expected) but will be halved by 2050. Moreover, only a moderate yearly replacement rate (1-2%) of heating appliances is assumed in the coming years therefore with existing measures PM2.5 emissions will only decrease slowly.

Industry

In the case of industry, energy consumption is increasing significantly, from the initial value of 186 PJ in 2019 to 244 PJ in 2030 (and to 276 PJ in 2050). Although very significant energy efficiency investments are being made, these cannot offset the significant increase in demand.

Transport

For the most part, calculations for the transport sector were made by KTI Hungarian Institute for Transport Sciences and Logistics Non Profit Limited Liability Company.

Fuel consumption in the transport sector dynamically increased in the years preceding the economic crisis, then significantly declined during the crisis. After 2013, energy consumption in the transport sector sharply increased as a result of rapidly growing household income and rising investment, and again exceeded the value for 2005 in 2015. Under the existing policy measures, in 2030 energy consumption in the transport sector will be one and a half times higher than in 2015 as a result of the dynamically growing GDP and incomes, becoming the sector with the highest energy demand. Traditional petrol and diesel fuel will continue to account for more than 90% of consumed energy quantities despite the promotion of alternative propulsion and other efforts aimed at reducing vehicle use.

According to the vehicle stock, mileage and fuel consumption data, a linear and exponential trend series were created up to 2030 considering changes of previous years. In the case of vehicle stock and mileage, the COPERT categorization of all vehicle classes, types and Euro classifications were taken into account. Regarding the fuel consumption, the national total consumed fuel of gasoline, diesel, LPG, CNG, biodiesel and bioethanol data were determined up to 2030. Finally, maximal and minimal mean temperature and humidity of previous years were considered and data were created up to 2030 as well. However, in the case of weather data climate change and any other weather modifying factors were not taken into consideration.

By looking at the vehicle stock data we can conclude a trend from the previous year's data. Vehicles with Euro 0, 1, and 2 showed a decreasing trend without a doubt. Vehicles with Euro 3 and 4 showed a slight reduction although Euro 4 showed slight stagnation in certain cases. This is because of the import second-hand diesel vehicles coming from the western countries of EU. Vehicles with Euro 5 and 6 showed an increasing trend.

Regarding the scenarios, the abovementioned trends were considered as the input data for the WEM scenario. In case of the WAM scenario, in addition to the trends, multiplication factors were used for the EURO categories. The lower EURO categories of vehicles were reduced more, as the result of negative multiplication factors, and higher number of alternative vehicles (mainly electric and hybrid vehicles) were estimated using the national estimation for 2025 and 2030 specified in the Alternative Fuels Infrastructure Regulation. All the input data were transferred to the COPERT program and emissions were calculated for 2025 and 2030.

It is also worth to mention that vehicle stock data were modified without taking into account the new "Regulation (EU) 2019/631 of the European Parliament and of the Council of 17 April 2019 setting CO2 emission performance standards for new passenger cars and for new light commercial vehicles, and repealing Regulations (EC) No 443/2009 and (EU) No 510/2011".

(The new CO2 regulation will require a huge step towards electric / hybrid vehicles and alternative fuel vehicles will be less widespread in order for manufacturers to meet the CO2 targets set by the regulation. In the light of the strict limits, it is estimated that by 2025, about one third of new passenger cars will have to be electric and hybrid in order to meet the targets set by the regulation. As a result, the regulation will have a significant influence on the development of passenger cars as electric vehicles, leaving little room for other alternative propulsion systems. Although the regulation states a neutral technology, in practice it can only be accomplished with an electric / hybrid vehicles.)

9.2 INDUSTRIAL PROCESSES AND PRODUCT USE

The key driver in IPPU sector in Hungary is the compliance with air quality standards, GHG and air pollutant projections were harmonized, which means the same activity data and same projection pathways. Activity data used for projection of IPPU emissions was based on projection results of the National Energy and Climate Plan compiled by the Regional Centre for Energy Policy Research (hereinafter: REKK) on behalf of the Energy Ministry of Hungary using the National Clean Development Strategy 2020-2050 also. Projections calculated by the aid of the TIMES-HU model which is a bottom-up equilibrium optimization model for calculating the emission pathways.

Energy use in the industrial sector develops differently in the WEM and WAM scenarios examined in the model calculations. In the WEM scenario, a continuous increase in the energy consumption of the industrial sector is experienced. On the other hand, in the case of the WAM scenario, a constant energy consumption occurs after 2030, which is due to significant energy efficiency investments. Fossil energy carriers are not replaced in any of the scenarios and the use of electricity and natural gas remains significant in the industrial sector.

For industrial production forecasts, statistical regression models were used by the REKK, and the choice of technology, and thus the energy consumption were considered as well. An energy efficiency investment option was taken into account in each sub-segment. However, there is no difference between the industrial production volumes of the WEM and WAM scenarios at least until 2030. In the present report only the WEM scenario for 2025 and 2030 was used to calculate activity data.

2A1: As a basis for the 2A mineral industry source, cement production was calculated for 2025 and 2030 based on the WEM production projection of REKK. As a basis, time series of activity data was calculated until 2050, where REKK projections were corrected with the Baseline of Clean Air Outlook scenario of the GAINS model. Since the GAINS model calculates with an unchanged emission factor for cement and lime in all scenarios until 2050, we calculated with the GAINS emission factor for PM2.5 and BC emissions.

2A2: Lime production was calculated as a proportion of cement production, and PM2.5 and BC emissions were calculated using the GAINS emission factor.

2A3: Glass production was calculated based on the cement production time series as described at 2A1. Some emission reduction development was carried out until 2021 in the sector, and we do not expect any other improvement in emission factors in the short term (at least until 2030), therefore source specific emission factors of the year 2021 were used to calculate emissions.

2A5a: Mining activity was calculated based on the cement production time series as described at 2A1. PM2.5 emissions were calculated using Eclipse V6b_CLE_base emission factors of the GAINS model.

2A5b: Building construction activity was calculated based on the cement production time series as described at 2A1. The length of roads handed over in Hungary has decreased significantly by 2021, which is why we used the average of the years 2015-2020 as activity data. PM2.5 emissions were calculated using Eclipse V6b_CLE_base emission factors of the GAINS model.

2B: For every segment of the chemical industry, the WEM scenario of REKK for 2025 and 2030 was used to calculate activity data. Plant specific emission factors of the most recent historic year were used to calculate emissions data.

2C1: As a basis for the 2C metal industry source, steel and pig iron productions were calculated for 2025 and 2030 based on the WEM production projection of REKK. Changes in the activities of the other sources are proportional to this. Plant specific and source specific emission factors of the most recent historic year were used to calculate emissions data.

2.D.3.a: Hungary estimates emission based on the ESIG paper and the number of inhabitants. Emission of NMVOC is the product of ESIG emission factor averaged for the years 2018-2020 and the projected number of inhabitants.

2.D.3.b: The trend of road construction was taken into account (same as in category 2A5a). NMVOC emission was estimated with T1 default factor as in the inventory; projected PM and BC emissions are estimated with the growing values of NMVOC.

2.D.3.c: Projected emission from asphalt roofing was determined based on trend of construction industry, because there is a high relationship (0.83) between the last 11 years (2011-2021).

2.D.3.d: Assuming that solvents for coating is mostly used during construction, emission trend is based on the projection of construction industry.

2.D.3.e-f: As these categories are small emitters and not key categories in 2021, activity and emission data were changed in proportion of the changes in the number of inhabitants.

2.D.3.g: As between NMVOC emission and the use of energy consumption of the chemical industry is in a good relationship, consumption data were estimated by using the trends of the value added of the construction industry (mentioned at 2A5a).

2.D.3.h: Calculations are based on the projection of the paper industry production forecast of REKK, using the new emission factors described in Chapter 4.5.8.

2.D.3.i: Growing production of edible vegetable fats was calculated based on the REKK projections using the emission factor of the most recent historic year.

2.G: A decrease of tobacco consumption proportional to the number of inhabitantas, while constant value of firework consumption was calculated for 2025 and 2030 using the emission factors of the most recent historic year.

2.H.1: Calculations are based on the projection of the paper industry production forecast of REKK using the emission factors of the most recent historic year.

2.H.2: Since this source category did not show any significant trend in the last 20 years, activity and emission values of the most recent historic year were predicted for 2025 and 2030.

9.3 AGRICULTURE

Agricultural emission projections for sources of ammonia (NH3), nitric oxide (NOx), non-methane volatile organic compounds (NMVOC) and particulate matter (PM2.5) were prepared in 2023, based on the year 2020, up to 2030. Populations of cattle, swine, sheep, layers, broilers, turkeys, and other poultry species (i.e. geese and ducks) were estimated by using different methodologies, while populations of goats, buffaloes, mules, asses, and rabbits were assumed to remain the same as in 2020 through the projection period between 2020 and 2030. To calculate the emissions from livestock farming activities, changes in milk yields, N-excretion rates, the proportion of manure and slurry, the use of housing technologies and slurry application technologies were also estimated. Fertilizer use is an important contributing factor to ammonia emissions; therefore, changes in the use of the main nitrogen fertilizers were estimated as well.

9.3.1 KEY ASSUMPTIONS, TRENDS AND SOURCES USED TO PREPARE WEM SCENARIO

Populations of dairy cattle and non-dairy cattle, sheep, and swine were projected by using the AGMEMOD *(**AG**ricultural **ME**mber State **MOD**elling)* model, as recommended by the European Commission for agricultural policy and market impact assessments. In addition, historical data of the Hungarian Central Statistical Office (HCSO) and the number of animals for which production coupled support was paid were also taken into account. In the case of poultry species, estimates were based on the long-term population data from the HCSO, as the equations for the Hungarian poultry sector in the AGMEMOD model were under revision and improvement by AKI at the time of preparing this report. Milk production projection were based on the results of the AGMEMOD model but also taking into consideration the forecast by the IFCN Dairy Research Network (IFCN, 2022) for milk yields in Hungary. For the livestock projections, the medium-term outlook by the European Commission (EC, 2022) has also been taken into account.

Livestock populations

<u>Assumptions underlying the WEM scenario:</u>

- The dairy cattle population is expected to decrease, while milk production per cow to show a slight increase. A 1 percent annual increase in milk yields was based on a long time series trend.
- A slight decrease in swine and sheep populations was assumed.
- A slight increase was expected in the beef cattle populations.
- Egg yield per hen was assumed to increase by 1 percent annually, based on HCSO data for the period 2000-2020.

Milk production could fall by 0.2 percent per year in the EU-27 until 2032, mainly due to a decline in the dairy cow herd, as environmental and animal welfare concerns lead to a reduction in the size and intensity of milk production. However, genetic progress and more efficient feeding strategies may contribute to increasing yields. The dairy cow herd in the EU-27 could be up to 10 percent smaller in 2032 than in 2020-2022 (EC, 2022). In Hungary, the decline in the dairy cow herd has been below the EU average in recent years, due to intensive and concentrated production and coupled income support. Consequently, a more moderate decline in the Hungarian dairy cow herd is expected in the medium term (-0.6 percent/year until 2030).

Meat consumption is expected to fall in the EU-27 (-1.5 kg/person/year), with beef in particular affected. The total cow herd in the EU-27 could fall by 2.8 million head (9.1 percent) by 2032, with different degrees of decline in EU countries. Export opportunities may improve in the medium term but will be offset by a decline in live animal exports due to increased competition and animal welfare concerns over long-distance transport (EC, 2022). In Hungary, beef cattle population has been growing dynamically over the last few years, due to direct payments and strong export demand for live cattle. Relative favourable demand for live cattle in traditional export markets outside the EU could sustain a stagnation or further mild growth in beef cattle herd in the medium term (between 0.4 and 0.6 percent/year until 2030).

The results of the AGMEMOD model and the projections of the European Commission were used as a basis for the projection of changes in the pig population. The projected total number of pig herds in the AGMEMOD model (which shows more than a 3 percent decrease between 2020 and 2030) was proportioned with the 2020 pig herd data (by age group) of the HCSO. According to the European Commission's medium-term projection, pork production in the EU could decrease by 9 percent by 2030 compared to 2020. The decrease is due, among other factors, to increasingly strict animal welfare regulations, narrowing export opportunities (due to the growing Chinese pig population), lower supply of pigs for slaughter due to producers abandoning pig fattening, increasing production costs for slaughter pigs, societal criticisms of intensive production systems, and the presence and spread of African swine fever. The forecast predicts a 3 percent decrease in pork meat consumption by 2030 compared to 2020, which can be explained by the changes in consumer habits due to health, environmental, and societal concerns.

Contrary to declining trend of recent years, EU sheep and goat meat production is expected to increase slightly by 0.2 percent per year until 2032. This is mainly driven by a continuing increase in the EU-13 (0.7 percent/year). Coupled income support, a tight global supply-demand situation and favourable prices for producers should support this trend (EC, 2022). In Hungary, demand for live lamb, both in traditional and new export markets, is expected to remain favourable in the medium term. However, deteriorating environmental conditions and rising production costs could have a strong negative effect in the sector. A possible shift towards intensive production systems could partly offset the negative effects. Overall, these factors are expected to lead to a slight reduction in the Hungarian sheep herd in the medium term (-0.3 percent/year until 2030).

Based on the HCSO data period for 2000-2020, a yearly increase of 0.5 percent for broilers and geese was estimated, while a yearly increase of 1.5 percent is estimated for ducks, but a yearly decrease of 1 percent for turkeys and 0.5 percent for laying hens is projected until 2030. The impact of avian influenza on poultry populations is also considered in 2020, mostly the water fowl population was affected by the bird flu. According to the medium-term projection of the European Commission, per capita poultry meat consumption in the EU could be increased by about 3 percent between 2022 and 2032. Behind this growing trend is the positive consumer perception of poultry meat compared to other meat (Figure 9.14).

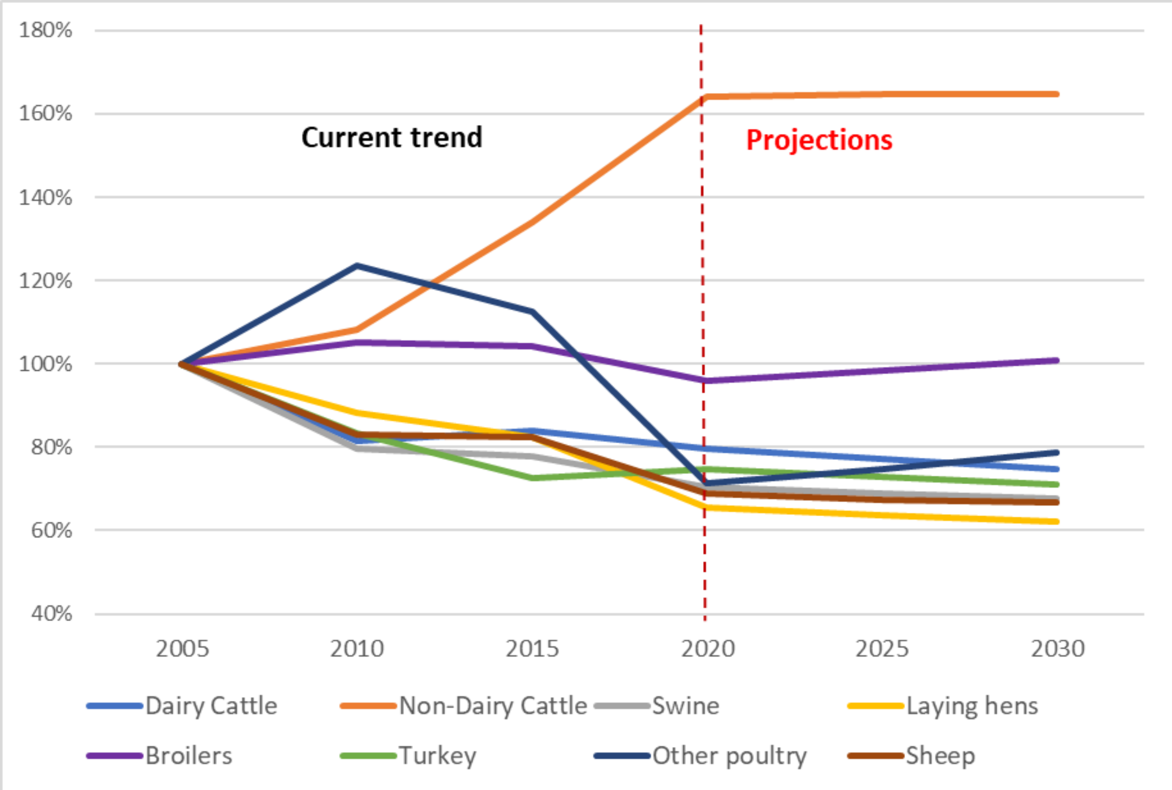

Figure 9.14 Trends in livestock populations under the WEM scenario for the period 2005-2030 in relation to 2005

Synthetic fertilizer assumptions

Assumptions underlying the WEM scenario:

- The use of urea-based and CAN fertilizer is slightly increasing.

According to the long-term forecast of *Fertilizers Europe*, the use of the most important nitrogen fertilizers in Hungary is expected to increase by approximately 4-5 percent between 2022 and 2032 (Fertilizers Europe, 2022). Due to the multiple increases in energy prices in Hungary, the cost of fertilizers has increased during the first three quarters of 2022 compared to the same period of the previous year, causing the price of certain N-based fertilizers to approach that of the most expensive but highest active substance-containing urea. Farmers preferred urea fertilizers. Since spring 2022, the prices of nitrogen and other fertilizers on the world market have been steadily decreasing, and the effects of this trend are expected to appear on the domestic market (AMIS, 2023). Expectations on the stock exchange (TTF) indicate a reduction in the quotation of natural gas, one of the main raw materials used for the production of N fertilizers, which may lead to a decline in fertilizer prices until around 2025. This would create space for demand recovery and a reordering of prices and the ratio of different fertilizers in consumption. After the reordering of prices, there may be a slight decrease in demand for urea (Figure 9.15).

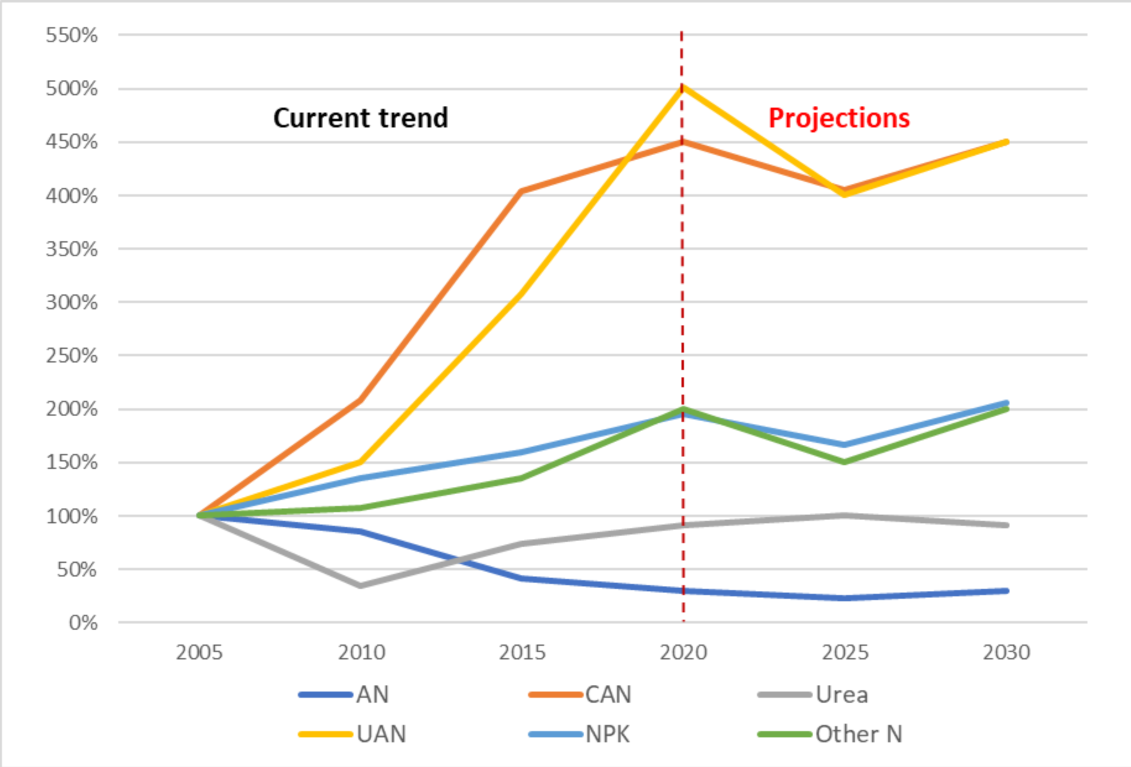

Figure 9.15 Trends in synthetic fertilizer use under the WEM scenario for the period 2005-2030 in relation to 2005

Manure management

Types of manure (cattle and swine)

Assumptions underlying the WEM scenario:

- In the case of new investments in swine farming, slurry-based technology is applied. As a result, the spread of this technology on a broader scale is expected.
- For cattle, solid manure systems (with bedding such as straw, sawdust, sand, etc.) are more commonly used than the slurry-based system, therefore only minimal growth is expected.

The result of the projection based on the assumptions above are presented in Table 9.51.

Table 9.51 Proportion of livestock housed on slurry-based system in Hungary

Source	Proportion %			
	2005	2020	2025	2030
Dairy cattle	6	20	20	20
Non-dairy cattle (all other cattle)	3	2	3	3
Non-dairy cattle (calves)	4	4	4	4
Finishing pigs	55	65	67	69
Breeding sows	63	70	72	74

Manure application technologies

Assumptions underlying the WEM scenario:

- In the case of slurry, new machinery purchases will increase the proportion of injection and manure application with a trailing hose.
- The Nitrates Decree of the Minister for Agriculture and Rural Development amended in 2021, requires solid manure to be applied within 4 hours.

The penetration of different manure application technologies for cattle and swine is projected. The implementation and the abatement efficiency for slurry and solid manure application technologies are shown in Table 9.52.

Table 9.52 Animal manure application technologies in Hungary

Mitigation	Emission source	Abatement efficiency %	Penetration (implementation) %			
			2005	2020	2025	2030
Band spreading with a trailing hose	Cattle, slurry	33	6	19	22	25
Incorporation of surface applied slurry, immediately	Cattle, slurry	88	3	13	15	17
Incorporation of surface applied slurry, within 24 hours	Cattle, slurry	30	7	25	28	32
Deep injection (12-18 cm)	Cattle, slurry	90	2	8	9	10
Shallow injection (5-8 cm)	Cattle, slurry	80	2	13	14	16
Band spreading with a trailing shoe	Cattle, slurry	45	1	1	1	1
Band spreading with a trailing hose	Swine, slurry	33	5	24	25	27
Incorporation of surface applied slurry, immediately	Swine, slurry	88	1	12	13	14
Incorporation of surface applied slurry, within 24 hours	Swine, slurry	30	7	20	21	23
Deep injection (12-18 cm)	Swine, slurry	90	3	11	11	12
Shallow injection (5-8 cm)	Swine, slurry	80	5	21	22	23
Band spreading with a trailing shoe	Swine, slurry	45	1	2	2	2
Immediate ploughing	Cattle, Swine, Laying hen, Broiler, solid manure	90	6	29	29	29
Incorporation within 4 hours	Cattle, Swine, Laying hen, Broiler, solid manure	55	3	13	57	57
Incorporation within 24 hours	Cattle, Swine, Laying hen, Broiler, solid manure	30	9	45	11	11

Manure Management Systems

<u>Assumptions underlying the WEM scenario:</u>

- The current, usually uncovered manure storages were installed by 2015, and as their expected life cycle is at least 20 years, their replacement is not expected until 2030.
- The proportion of „low-technology" floating covers is expected to slightly decrease in long term, as their load-bearing capacity limits their applicability. A technological shift to higher-quality technology requires significant investment. However, no change is expected until 2030.
- The use of "tight" lid, roof or tent structure is typically in the case of concrete manure storage silos. As this technology is implemented in new investments, their proportion is expected to slightly increase in long term. However, stagnation is expected until 2030.
- The proportion of plastic sheeting (floating cover) is affected by the problematic implementation, however, compliance with Best Available Techniques (BAT) reference document for the intensive rearing of poultry or pigs may contribute to its wider spread in long term. However, experts do not expect any change until 2030.
- The long-term goal is to reduce the proportion of uncovered storage.

The results of the projection based on the assumptions above are presented in Table 9.53.

Table 9.53 Slurry storage covering technologies in Hungary

Mitigation	Emission source	Abatement efficiency %*	Penetration (implementation) %			
			2005	2020	2025	2030
"Low technology" floating covers	Cattle	40	0	1	1	1
"Tight" lid, roof or tent structure		80	1	7	7	7
Plastic sheeting (floating cover)		60	1	12	12	12
Natural crust		40	52	35	35	35
"Low technology" floating covers	Swine	40	0	0	0	0
"Tight" lid, roof or tent structure		80	1	4	4	4
Plastic sheeting (floating cover)		60	1	1	1	1
Natural crust		40	53	58	58	58

Housing

<u>Assumptions underlying the WEM scenario:</u>

- Tied housing of dairy cows is contrary to animal welfare, therefore, its growth cannot be expected due to animal welfare legislation.
- For laying hens, there is no measures are currently in force which would increase the proportion of animals kept in manure belt cages. However, a significant new aviary investment was made in 2022 in Hungary (240,000 hens), so a slight increase in the proportion of non-cage housed (aviary system) animals is likely.

- According to our expectations, the use of a non-leaking drinking system will reach 100 percent in intensive broiler farming by 2030.
- In piglet and fattening pig stables, the use of partially slatted floors is expected to decrease as it is an outdated technology. However, there will be other technologies with similar emission reduction efficiency, such as flushing manure channels, that will replace this technology.

Table 9.54 shows the outcome of the projection that is founded on the above assumptions.

Table 9.54 Housing technologies in Hungary

Mitigation	Emission source	Proportion %			
		2005	2020	2025	2030
Tied housing dairy cows	Cattle	13	16	16	16
Cages with manure belt	Laying hen	7	35	35	35
Aviary system		0	1	2	2
Non-leaking drinking system	Broiler	74	76	83	90
Partially slatted floors	Swine	15	18	18	18

9.3.2 METHODOLOGY

The methodology used to estimate the projected emissions is the same as in the annual emission inventories. The methodology provided in the 2019 EMEP/EEA Guidebook was used. The NH3 abatement techniques were calculated according to the Ammonia Guidance Document (UNECE, 2011). Thus, similar activity data was used and the same unabated emission factors. In case of improvement of the applied technologies, an adjustment of the emission factor was applied.

9.3.3 PROJECTED EMISSION FACTORS

Housing

In the case of dairy and non-dairy cattle, implied emission factors for 3B1a and 3B1b Manure Management covering housing and storage are provided in Table 9.55. This table also shows the typical body weight and N-excretion. For dairy cows, the rate of tide housing is also accounted.

Table 9.55 Country-specific NH3 emission factors and background data for Dairy cattle and Non-dairy cattle, 2005, 2020, 2025, 2030

2005	Live weight	N excretion	NH_3 Emission Factor
	kg	kg N · head^{-1}·year^{-1}	kg NH_3 · head^{-1} · year^{-1}
Dairy cattle	642	106	23.26
Calves	181	43	9.28
All other cattle	446	51	11.01

2020	Live weight	N excretion	NH_3 Emission Factor
	kg	kg N · head^{-1}·year^{-1}	kg NH_3 · head^{-1} · year^{-1}
Dairy cattle	643	132	30.29
Calves	180	43	9.60
All other cattle	491	59	11.15

2025	Live weight	N excretion	Emission Factor
	kg	kg N · head^{-1}·year^{-1}	kg NH_3 · head^{-1} · year^{-1}
Dairy cattle	643	135	31.24
Calves	181	43	9.60
All other cattle	493	59	10.91

2030	Live weight	N excretion	Emission Factor
	kg	kg N · head^{-1}·year^{-1}	kg NH_3 · head^{-1} · year^{-1}
Dairy cattle	643	142	32.96
Calves	182	43	9.59
All other cattle	495	59	10.35

Low-ammonia emission housing technologies are considered for finishing pigs (covering piglets after weaning and growers, finishers), laying hens, and broilers, as mentioned in Table 9.54. The abated emission factors are given in Table 9.56. The emission factor is expected to slightly decrease in the case of broilers due to the wider use of an on-leaking drinking system.

Table 9.56 Abated NH_3 emission factors for housing (kg NH3-N/kg TAN housing)

Source	2005	2020	2025	2030
Swine (finishing pigs), slurry	0.26	0.26	0.26	0.26
Laying hens, solid	0.20	0.17	0.17	0.17
Broilers, solid	0.20	0.17	0.17	0.16

Covering slurry stores in cattle and pig farms is also considered an NH_3 reduction method. Based on the projection in Table 9.53, the resulting emission factors are summarized in Table 9.57. The emission factors have not changed for the period 2020-2030, but experts forecast a change in the spread of the applied techniques only in the long term.

Table 9.57 Abated NH_3 emission factors for slurry storage (kg NH3-N/kg TAN housing)

Source	2005	2020	2025	2030
Dairy cattle, slurry	0.19	0.18	0.18	0.18
Non-dairy cattle, slurry	0.19	0.18	0.18	0.18
Non-dairy cattle (calves), slurry	0.19	0.18	0.18	0.18

In the case of slurry (cattle and swine) and solid manure (cattle, swine, laying hens and broiler), low-ammonia emission manure application technologies are considered. Based on the projection in Table 9.52, the abated emission factors are given in Table 9.58. The emission factors are expected to slightly decrease in the case of slurry due to the improvement of slurry application techniques.

Table 9.58 Abated NH_3 emission factors for manure application (kg NH3-N/kg TAN applic)

Source	Manure application	2005	2020	2025	2030
Swine (finishing pigs)	Slurry	0.35	0.20	0.18	0.17
Swine (sows)		0.25	0.14	0.13	0.12
Cattle		0.49	0.32	0.28	0.25
Cattle	Solid manure	0.61	0.37	0.27	0.27
Swine		0.41	0.25	0.18	0.18
Laying hen		0.41	0.25	0.18	0.18
Broiler		0.34	0.21	0.15	0.15

9.3.4 RESULTED EMISSIONS

Agricultural NH3 emissions under the WEM scenario are projected to be 66.1 kt in 2025. Post 2025, emissions increase slightly to 66.7 kt in 2030. Hungary's 2030 emission reduction target of 32% compared with 2005 levels results in a distance of 16 kt to the emission reduction target in 2030 under the WEM scenario. Consequently, compliance with the NEC targets poses a challenge for Hungary due to the significantly increasing non-dairy cattle population and synthetic fertilizer use.

The total emission of NH3 from agriculture is expected to decrease by 10.3% from 2005 to 2030 under the WEM scenario, which is significantly higher than the 2030 target (Figure 9.16).

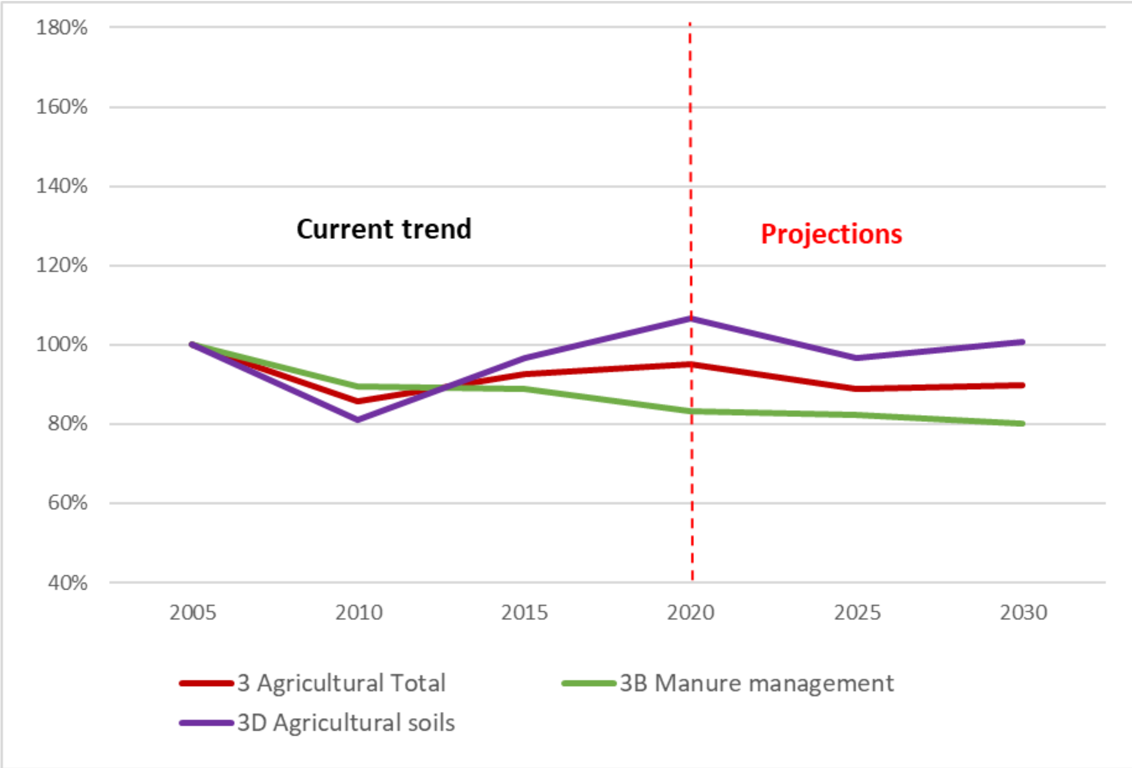

Figure 9.16 NH_3 emissions from the agriculture sector, 3D and 3B category under the WEM scenario for the period 2005-2030 in relation to 2005

Emission from manure management contributes to around 50% of the total NH3 emissions from the agriculture sector. Emission from manure management is expected to decrease by 20.0% from 2005 to 2030 under the WEM scenario, but emission from non-dairy cattle manure management is expected to increase by 62.4%. This is mainly due to the increase in the number of non-dairy cattle. The livestock population of non-dairy cattle is expected to increase by 64.8% over the period 2005-2030. Emission from synthetic fertilizer use is expected to increase by 59.0% over the period 2005 to 2030, due to the significant increase in synthetic fertilizer use, in particular the use of urea solutions, whose use will more the period examined (Figure 9.17)

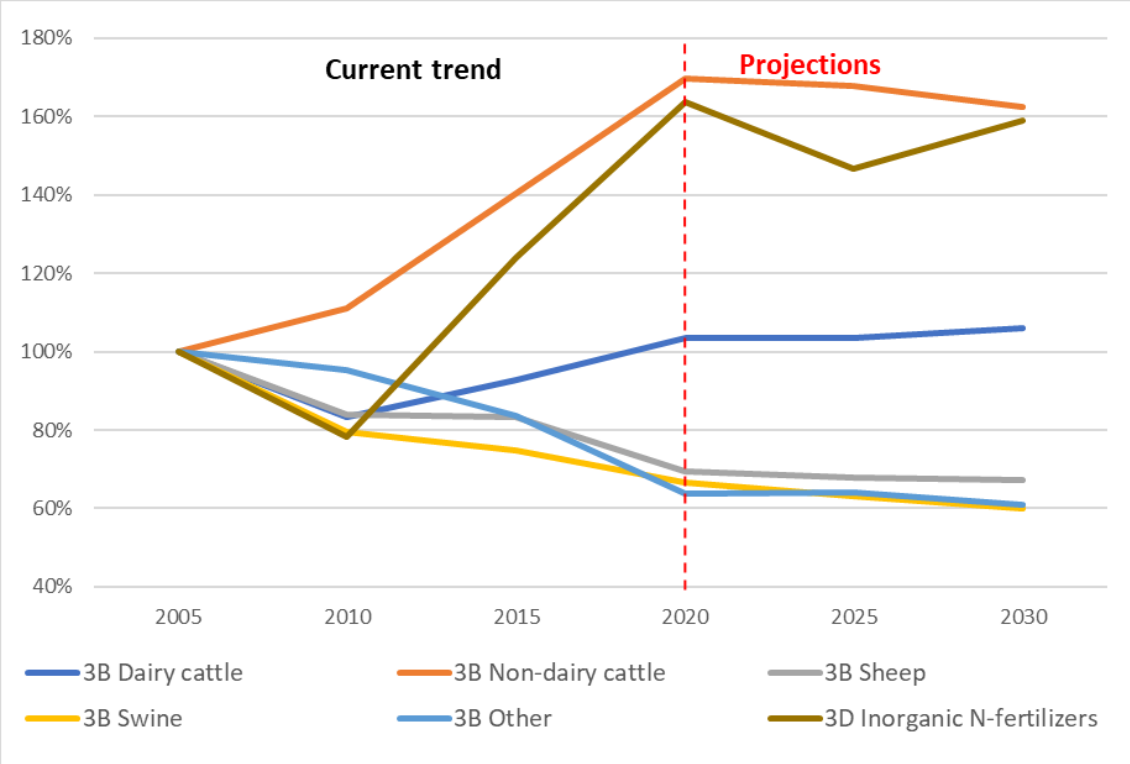

Figure 9.17 NH_3 emissions from manure management and inorganic N-fertilizers under the WEM scenario for the period 2005-2030 in relation to 2005

The total emission of NMVOC is expected to decrease slightly under the WEM scenario from 2005 to 2030. About 88% of the agricultural NMVOC emission comes from the 3B Manure management. Despite the increasing emission levels from broiler and other poultry husbandry due to the increasing livestock population, NMVOC emissions will decrease over the period 2020-2030 due to the decrease in swine livestock. The emission of NMVOC from cultivated crops seems to be quasi-stable.

The total emission of NOx is expected to increase by 40.1 percent from 2005 to 2030, under the WEM scenario. This is mainly due to the increase in emissions of NOx from synthetic fertilizer use over the period 2005-2020. After 2021 NOx emissions from synthetic fertilizer use will decrease under the WEM scenario. Emission of NOx from animal manure applied to the soil will decrease by 11.8 percent over the period 2005-2030 due to the overall decrease in the emissions from the animal livestock and the amount of N applied.

The total emission of PM2.5 is expected to decrease by 10.5 percent from 2005 to 2030 under the WEM scenario due to the overall decrease in the swine and poultry livestock and the increase in the slurry-based management systems. The emission of PM2.5 from field operations is expected to decrease due to a minor decrease in the agricultural area until 2030.

9.3.5 REFERENCES

AMIS (2023): AMIS Market Monitor, No. 105 February 2023. https://www.amis-outlook.org/fileadmin/user_upload/amis/docs/Market_monitor/AMIS_Market_Monitor_Issue_105.pdf

EC (2022), EU agricultural outlook for markets, income and environment 2022-2032. European Commission, DG Agriculture and Rural Development, Brussels. https://agriculture.ec.europa.eu/data-and-analysis/markets/outlook/medium-term_en

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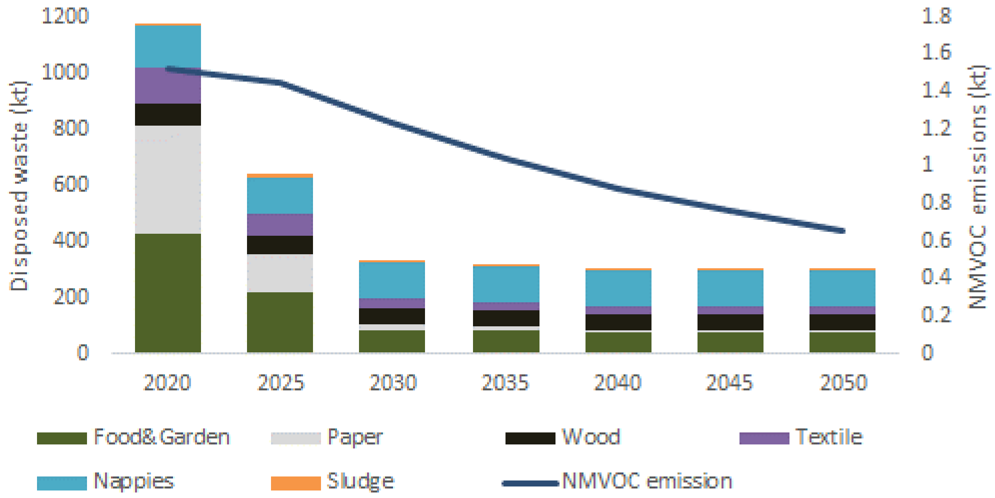
9.4 WASTE

For the projections, basically the same methodologies were used as for the inventory. More specifically, NMVOC emissions from for ***solid waste disposal*** were calculated from estimated methane emissions. Methane emissions, in turn, were estimated using the IPCC Waste Model. As for activity data (i.e., amount of disposed waste), information received from the ministry responsible for waste management was taken into account. The main underlying assumption was that the amount of waste disposed would be significantly reduced and the reduction would be especially significant for degradable organic waste (e.g., food and garden waste), paper, and textile in the period between 2020 and 2030. As a consequence, methane (and consequently NMVOC) generation potential will decrease and so will the amount of recovered biogas. Projected amount of the main degradable waste types disposed together with the resulting NMVOC emission is summarized in the figure below.



In the source categories ***biological treatment of waste***, ammonia emissions from composting of both municipal solid waste and sewage sludge (5B1) and from anaerobic digestion at biogas facilities including wastewater treatment plants (5B2) were considered. As generally Tier 1 method with default emission factors was applied, the trend was determined by changes in activity data. Information received from the ministry responsible for waste management was taken into account. It was assumed that composted municipal waste would increase from 353 kt in 2019 to 405 kt in 2025 and 455 kt in 2030 and would remain at the same level afterwards. As for sewage sludge composting, a 4.4% increase per 5 years was assumed. Projection of biogas production seems to be quite uncertain for the moment. Nevertheless, based on the TIMES-HU model used for projections in the energy sector, a quite significant increase of biogas production is expected from 2025.

As a general practice, ***waste incineration*** in Hungary occurs with energy recovery. Consequently, waste incineration without energy recovery (5C1) contributes only with a small fraction to total emissions. As we did not expect any significant changes in this field, we did not introduce any trend and kept average values of the last three years (2019-2021) from the inventory up to 2030. The same approach was applied to open burning of slash (5C2), too. As regards garden waste burning, it is assumed that this practice be phased out so we expect the amount of incinerated yard waste will be halved by 2030.

As for ammonia emission from latrines, it was assumed that parallel to the increasing share of dwellings connected to the public sewerage network, the use of latrines will diminish to 1 per cent maximum by 2030. The almost negligible NMVOC emissions from ***wastewater treatment*** are expected to remain at the same level.

No trend was excepted for PM2.5 emissions from ***building and car fires***, the average value of the last three year (2019-2021) served as projection here.

TABLE A6.1 INCLUSION/EXCLUSION OF THE CONDENSABLE COMPONENT FROM PM10 AND PM2.5 EMISSION FACTORS

NFR	Source/sector name	PM emissions: the condensable component is		EF reference and comments
		included	excluded	
1A1a	Public electricity and heat production			Stack measurements from LPS installations are used. Unknown for the moment whether condensable component is included. (probably yes)
1A1b	Petroleum refining			Unknown.
1A1c	Manufacture of solid fuels and other energy industries			Unknown.
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals			Unclear. EFs from the 2019 EMEP/EEA Guidebook are used.
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print			Unclear. EFs from the 2019 EMEP/EEA Guidebook are used (except of one LPS plant.)
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco			Unclear. EFs from the 2019 EMEP/EEA Guidebook are used.
1A2gvii	Mobile combustion in manufacturing industries and construction (please specify in the IIR)	X		2019 EMEP/EEA Guidebook
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)			Unclear. EFs from the 2019 EMEP/EEA Guidebook are used.
1A3ai(i)	International aviation LTO (civil)			Unknown. Eurocontrol data are used.
1A3aii(i)	Domestic aviation LTO (civil)			Unknown. Eurocontrol data are used.
1A3bi	Road transport: Passenger cars	X		COPERT 5.5.1
1A3bii	Road transport: Light duty vehicles	X		COPERT 5.5.1
1A3biii	Road transport: Heavy duty vehicles and buses	X		COPERT 5.5.1
1A3biv	Road transport: Mopeds & motorcycles	X		COPERT 5.5.1
1A3c	Railways			Unclear
1A3di(ii)	International inland waterways			IE
1A3dii	National navigation (shipping)			Unknown. EFs from the 2019 EMEP/EEA Guidebook are used.
1A3ei	Pipeline transport			Unclear. EFs from the 2019 EMEP/EEA Guidebook are used
1A4ai	Commercial/Institutional: Stationary			Unknown.
1A4bi	Residential: Stationary	X		For biomass: included. For natural gas: unclear.
1A4bii	Residential: Household and gardening (mobile)	X		2019 EMEP/EEA Guidebook
1A4ci	Agriculture/Forestry/Fishing: Stationary			Unckown. EFs from the 2019 EMEP/EEA Guidebook are used
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	X		2019 EMEP/EEA Guidebook
1A4ciii	Agriculture/Forestry/Fishing: National fishing			Unknown.

NFR	Source/sector name	PM emissions: the condensable component is		EF reference and comments
		included	excluded	
1A5a	Other stationary (including military)			Unknown
1A5b	Other, Mobile (including military, land based and recreational boats)			Unknown
1B2c	Venting and flaring (oil, gas, combined oil and gas)			Unclear.
2A1	Cement production		X	EF Reference: EMEP/EEA 2019 Guidebook
2A2	Lime production		X	EF Reference: EMEP/EEA 2019 Guidebook
2A3	Glass production		X	EF Reference: EMEP/EEA 2019 Guidebook
2A5a	Quarrying and mining of minerals other than coal		X	The processes which result in particulate emissions are largely low-temperature mechanical activities, and emissions are unlikely to include substantial quantities of condensable particulate material. (EMEP/EEA Guidebook, 2019)
2A5b	Construction and demolition		X	The processes which result in particulate emissions are largely low-temperature mechanical activities, and emissions are unlikely to include substantial quantities of condensable particulate material. (EMEP/EEA Guidebook, 2019)
2A5c	Storage, handling and transport of mineral products			IE
2A6	Other mineral products (please specify in the IIR)			IE
2B1	Ammonia production			IE
2B10a	Chemical industry: Other (please specify in the IIR)			Unknown
2B10b	Storage, handling and transport of chemical products (please specify in the IIR)			IE
2C1	Iron and steel production			Unknown
2C3	Aluminium production		X	EF Reference: EMEP/EEA 2019 Guidebook, 2.C.3. Table 3.3
2C6	Zinc production		X	EF Reference: EMEP/EEA 2019 Guidebook
2C7a	Copper production		X	EF Reference: EMEP/EEA 2019 Guidebook
2C7d	Storage, handling and transport of metal products (please specify in the IIR)			IE
2D3b	Road paving with asphalt		X	EF Reference: EMEP/EEA 2019 Guidebook - filterable
2D3c	Asphalt roofing		X	EF Reference: EMEP/EEA 2019 Guidebook -unknown
2G	Other product use (please specify in the IIR)		X	EF Reference: EMEP/EEA 2019 Guidebook -unknown
2H1	Pulp and paper industry		X	Unknown
2I	Wood processing		X	No condensable component exist.
3Dc	Farm-level agricultural operations including storage, handling and transport of agricultural products		X	The processes which result in particulate emissions are largely low-temperature mechanical activities, and emissions are unlikely to include

NFR	Source/sector name	PM emissions: the condensable component is		EF reference and comments
		included	excluded	
				substantial quantities of condensable particulate material. (EMEP/EEA Gb, 2019)
3F	Field burning of agricultural residues			There is no information availavle in the EMEP/EEA Gb, 2019
5A	Biological treatment of waste - Solid waste disposal on land		X	No condensable component.
5C1bi	Industrial waste incineration		X	EF Reference: EMEP/EEA 2019 Guidebook Table 3-1
5C1bii	Hazardous waste incineration		X	EF Reference: EMEP/EEA 2019 Guidebook Table 3-1
5C1biii	Clinical waste incineration		X	EF Reference: EMEP/EEA 2019 Guidebook Table 3-1
5C1bv	Cremation		X	EF Reference: EMEP/EEA 2019 Guidebook Table 3-1
5C2	Open burning of waste			EF Reference: EMEP/EEA 2019 Guidebook Tables 3-1, 3-2 and 3-3. It is unclear whether the EFs represent filterable PM or total PM (filterable and condensable) emissions.
5E	Other waste (please specify in the IIR)			EF Reference: EMEP/EEA 2019 Guidebook Tables 3-2, 3-3, 3-5, and 3-6 It is unclear whether the EFs represent filterable PM or total PM (filterable and condensable) emissions.

ABBREVIATIONS

EF - emission factor

IEF- implied emission factor (emission/activity data)

AD – activity data

GHG- Greenhouse gas

GDP - gross domestic product

NCV - net calorific value

QA - quality assurance

QC - quality control

LAIR = Air pollution segment of the National Environmental Information System (partly available for the public at: http://okir.kvvm.hu/lair/)

HMS = Hungarian Meteorological Service

HCSO = Hungarian Central Statistical Office

Guidebook - EMEP/EEA 2009 = EMEP/EEA air pollutant emission inventory guidebook (European Environmental Agency Technical Report No 9/2009)

http://www.eea.europa.eu/publications/emep-eea-emission-inventory-guidebook-2009

NFR - Nomenclature for Reporting (Required table format of reporting under CLRTAP and NEC) (NFR tables are available at: http://www.ceip.at/submissions-under-clrtap/2012-submissions/)

CLRTAP - UNECE Convention on Long-range Transboundary Air Pollution

NEC – National Emission Ceiling Directive (Directive 2001/81/EC of The European Parliament And Of The Council of 23 October 2001 on national emission ceilings for certain atmospheric pollutants – NEC Directive)

EMEP - Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe

EEA - European Environment Agency (www.eea.eu)

IIASA – International Institute for Applied Systems Analysis (http://www.iiasa.ac.at/)

SNAP - Selected Nomenclature for reporting of Air Pollutants

UNFCCC reporting = reporting required by the United Nations Framework Convention on Climate Change (GHG inventories are available at: http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/5888.php)

CRF - Common Reporting Format ((Required table format of reporting under UNFCCC)

NIR - National Inventory Report (Submission under the United Nations Framework Convention on Climate Change)

IPCC - Intergovernmental Panel on Climate Change

IPPC - Integrated pollution prevention and control Regulation based on Council Directive 2008/1/EC of 15 January 2008 replaced by Directive on industrial emissions 2010/75/EU (IED)

BAT - Best Available Techniques

BREF - Best Available Techniques Reference documents available at: http://eippcb.jrc.es/reference/

E-PRTR - The European Pollutant Release and Transfer Register (Data is available at: http://prtr.ec.europa.eu/)

EU ETS – European Union Emission Trading Scheme

CORINE: CORINE Land Cover Inventory (CLC2000 project with 26 participating countries in Europe)

IEA - International Energy Agency

FAO – Food and Agricultural Organization

Chemical formulas

Definitions of pollutants to report are provided in Guidelines for Reporting Emission Data under the Convention on Long-range Transboundary Air Pollution (ECE/EB.AIR/97 - available at: http://www.ceip.at/fileadmin/inhalte/emep/reporting_2009/Rep_Guidelines_ECE_EB_AIR_97_e.pdf)

C carbon

CH_4 methane

CO carbon monoxide

CO_2 carbon dioxide

HFCs hydrofluorocarbons

NMVOC non-methane volatile organic compound

N_2O nitrous oxide

NO_X nitrogen oxide

NH_3 ammonia

PFCs perfluorocarbons

SO_2 sulphur dioxide

HM – heavy metals (Pb. Cd. Hg. *As. Cr. Cu. Ni. Se. Zn*)

PM_{10} – particulate matter

$PM_{2.5}$ – particulate matter

TSP – Total Suspended Particles

POP – Persistent Organic Pollutants

PAH – Polycyclic aromatic hydrocarbons

HCB - Hexachlorobenzene

PCBs - polychlorinated biphenyls

HCH- hexachlorocyclohexane

PCDD/F - dioxins/furans

$CaCO_3$ calcium carbonate. limestone

$MgCO_3$ magnesium carbonate

CaO calcium oxide. quicklime

$Ca(OH)_2$ slack lime

HNO_3 nitric acid

Units

PJ petajoule (10^{15} J)

TJ terajoule (10^{12} J)

Gg gigagram (10^{9} g)

kt kilotonnes (1000 t)

g I-Teq – gramm toxic equivalent

Notation key of NFR Table recommended by ECE/EB.AIR/97. Guidelines

(NE) Not estimated: Emissions occur, but have not been estimated or reported.

(IE) Included elsewhere: Emissions for this source are estimated and included in the inventory but not presented separately for this source. The source where these emissions are included should be indicated.

(C) Confidential information: Emissions are aggregated and included elsewhere in the inventory because reporting at a disaggregated level could lead to the disclosure of confidential information.

(NA) Not applicable: The source exists but relevant emissions are considered never to occur.

(NO) Not occurring: An source or process does not exist within a country.

(NR) Not relevant: According to paragraph 9 in the Emission Reporting Guidelines. emission inventory reporting should cover all years from 1980 onwards if data are available. However. “NR” (not relevant) is introduced to ease the reporting where emissions are not strictly required by the different protocols. e.g. for some Parties emissions of NMVOCs prior to 1988.