Annex 1 – „Energy and fuels“

1 Introduction

This annex describes the pool „Energy and fuels“ and provides methodologies for the computation of the major nitrogen flows to the other pools of the NNB. It comprises methodologies for both a simplified approach in case of limited data availability based on default values (Tier 1) and a more detailed approach (Tier 2) that requires additional data and allows accounting for different types of combustion technologies and abatement techniques. In addition, the inherent uncertainties related to each of these approaches and data sources and limitations in the estimation of nitrogen flows and stock changes in the pool are documented.

2 Definition

2.1 Activities and flows encompassed by the pool

The pool „Energy and fuels“ comprises all fuel combustion and energy conversion activities.

- Energy conversion processes include heat and electricity production as well as refineries and other fuel production processes apart from biogas production from agricultural waste, which is accounted for in the pool Waste.
- Fuel combustion includes the transport sector, fuel combustion in industrial processes, in the commercial/institutional and in the residential sector.

The most important flows of reactive nitrogen originate from fuel combustion activities. During combustion processes, atmospheric nitrogen N_2 is transformed into reactive nitrogen species, such as NO_x, NH_3 and N_2O. Emissions of nitrogen oxides formed by thermal fixation of atmospheric nitrogen are also referred to as “thermal NO_x”. Besides fixation of atmospheric nitrogen, various types of fuels (e.g. coal) contain chemically bound nitrogen that is also emitted as NO_x during the combustion process. The weight fraction of chemically bound nitrogen varies depending on the fuel type. During combustion processes, chemically bound nitrogen is also converted to NO_x. These NO_x emissions are referred to as “fuel NO_x” (Note that thermal NO_x typically dominates the total NO_x emissions). Therefore, each nitrogen pool that provides a source of fuels is linked to the pool „Energy and fuels“ by a flow of nitrogen. This includes agricultural fuels, wood fuel, fossil fuels and waste fuels. All the flows entering the pool „Energy and fuels“ consist of non-reactive nitrogen. In addition, there are flows of non-reactive nitrogen from the pool “Energy and fuels” to the pools Agriculture and Waste, since production of certain biofuels (e.g. bioethanol, biodiesel) results in nitrogen containing residues (Yuan et al. 2015). These residues are transferred to the pool Waste (e.g. waste incineration plants, composting sites, landfills) and to the pool Agriculture (e.g. fertilizers or animal feed) (FAO 2012).

The nitrogen contained in fuels is released only in the combustion process and therefore reactive nitrogen compounds are exchanged only between the pool „Energy and fuels“ and the pool Atmosphere. All the other exchanges consist of inactive forms of nitrogen. Their quantification is not required (see ECE/EB.AIR/119, chp. V.A., „Energy and fuels“), but it is recommended to include these flows of nitrogen in order to achieve a more complete nitrogen balance. Therefore, the present guidance document also provides a method for assessing emission of inactive forms of nitrogen.

The nitrogen flows between the pool „Energy and fuels“ and the other pools of the NNB and the pool “Rest of the world” are represented in Figure 1. The methodology for estimating N flows is described in detail in section 4 of this Annex.

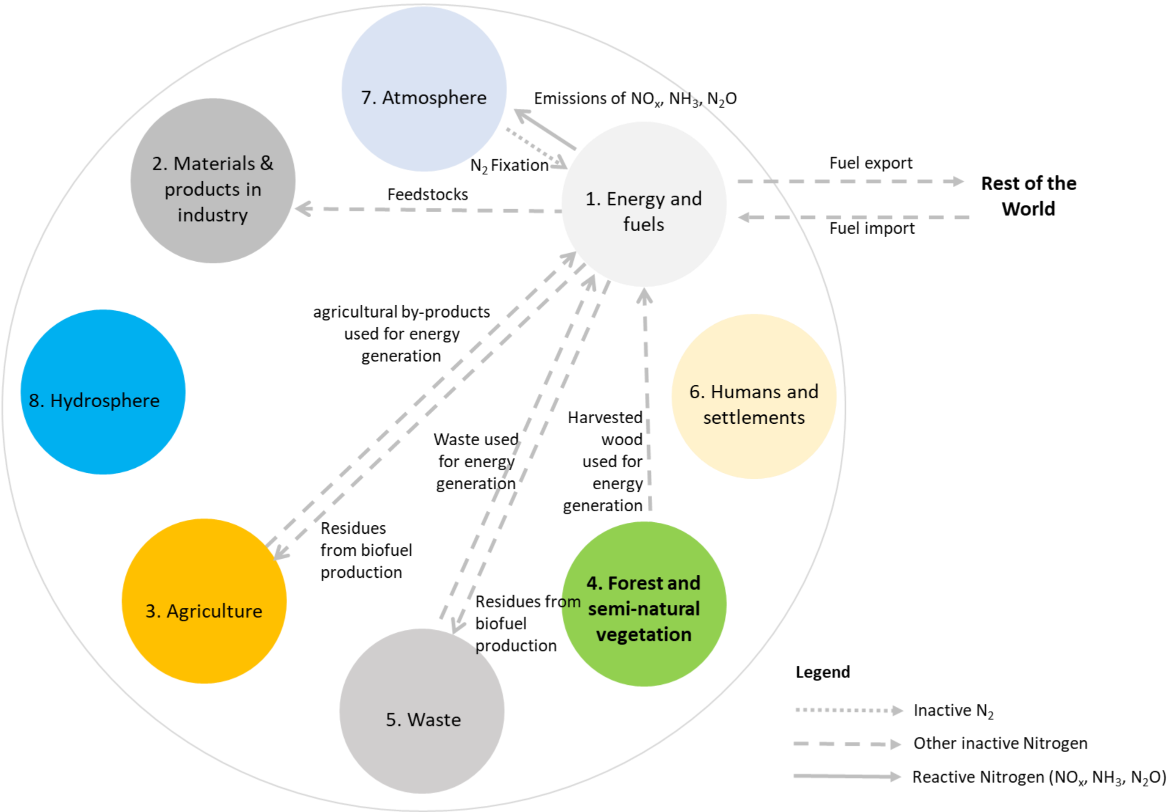

Figure 1: Nitrogen flows between the pool „Energy and fuels“ and the other pools of the NNB (including the pool “Rest of the world”). Solid arrows indicate flows of reactive nitrogen compounds (NO_x, NH_3, N_2O); dotted arrows represent flows of N_2, and dashed arrows indicate flows of other forms of inactive nitrogen (e.g. chemically bound nitrogen in fuels).

2.2 Nitrogen species involved

Table 1 summarizes the different nitrogen compounds that need to be accounted for in the exchanges with the pool „Energy and fuels“. The exchange with the pool Atmosphere includes emissions of gaseous forms of nitrogen, such as nitrous oxide (N_2O), ammonia (NH_3) and nitrogen oxides (NO_x) as well as fixation of N_2 during fuel combustion. Exchanges with other pools and within the pool „Energy and fuels“ occur in the form of chemically bound nitrogen contained in certain types fuels (e.g. coal, biofuels). The share of nitrogen contained in fuels varies depending on the fuel type and it can also vary within a given fuel type (see Table 2).

Table 1 - Forms of nitrogen present in the pool „Energy and fuels“.

Nitrogen forms	Acronym	Chemical formula	N content [%]	State	Description
Nitrogen	N_2	N_2	100.00	Gas	Atmospheric nitrogen
Nitrogen oxides (expressed as mass of NO_2 by definition; see Annex 0, Tab. 4)	NO_x	NO_x	30.43	Gas	Emission of NO_x is generally in the form of nitric oxide (NO) with a small proportion present as nitrogen dioxide (NO_2). Emissions of NO_x are comparatively low in residential furnaces compared to larger furnaces, partly due to lower furnace temperatures in residential furnaces. The term NO_X, by convention, refers to the sum of NO (nitrogen monoxide) and NO_2 (nitrogen dioxide). In most combustion processes NO contributes to over 90 % of the total NO_X emissions. However, as it is rapidly oxidised to NO_2 in the atmosphere, emissions of NO are expressed as NO_2 (BAT, 2015).
Ammonia	NH_3	NH_3	82.35	Gas	Small amounts of ammonia may be emitted as a result of incomplete combustion process of all solid fuels containing nitrogen. This occurs in cases where the combustion temperatures are very low (fireplaces, stoves, old design boilers). NH_3 emissions can generally be reduced by primary measures aiming to reduce products of incomplete combustion and increase combustion efficiency. Emissions of NH_3 can be the result of an incomplete reaction of NH_3 additive in NO_x abatement systems - selective catalytic and non-catalytic reduction (SCR and SNCR) (BAT, 2015).
Nitrous oxide	N_2O	N_2O	63.64	Gas	Nitrous oxide emissions from the energy sector are formed during fuel combustion.
Nitrogen in fuels	fuel-N	fuel specific	fuel specific (see Table 2)	Solid/ Liquid	Nitrogen is chemically bound in solid and liquid fuels. Even though the nitrogen content of crude oil is low, it contains a number of nitrogen-organic compounds: pyridine, quinolone, azapyrine, pyrrole, indole, carbazole, tetrapyrrole macrocycle (porphyrin core), isobutyramide, hydroxyquinolone, pyrrolecarboxylic acid, imidazole, etc. (Prado, 2017).

2.3 Definition of boundaries

2.3.1 System boundaries of the pool „Energy and fuels“

NNBs are determined at the national level following the territorial principle (see Annex 0, chp. 1). Basis for the quantification of nitrogen flows is therefore the amount of fuel used within the territory rather than the amount of fuel sold. This implies that the amount of fuel sold needs to be corrected for all fuel exports and imports. Besides exports and imports provided by the customs statistics this includes also fuel tourism due to fuel price differences between countries, which is mostly relevant in the transport sector.

Data sources used for quantification of the NNB therefore need to be provided for the same system boundaries. National inventories on emissions of air pollutants and greenhouse gases differ in terms of their system boundaries. Under the United Nations Framework Convention on Climate Change (UNFCCC), the national total for assessing compliance is based on fuel sold within the national territory. Under the Convention on Long-range Transboundary Air Pollution (CLRTAP), two types of reporting occur based on fuel sold as under the UNFCCC and based on fuel used within the territory. Thus, transport fuel sold in a country but consumed abroad ("fuel tourism") is accounted for in greenhouse gas inventories, but not in every country reporting under the CLRTAP[1]. The system boundary for countries reporting under the CLRTAP based on fuel used is therefore consistent with the present guidance documents. For other countries, the national air pollutant and greenhouse gas inventories differ in terms of the amount of fuel consumed abroad and therefore the reported emissions of NO_x, NH_3 and N_2O need to be corrected for net import and export of fuels due to "fuel tourism".

2.3.2 Fuels covered in the pool „Energy and fuels"

The pool „Energy and fuels" covers emissions of nitrogen containing compounds (NO_x, NH_3 and N_2O) from fuel combustion processes. During the fuel combustion process, nitrogen fixation from the atmosphere as well as chemical transformation of nitrogen contained in the fuels result in emissions of reactive nitrogen to the atmosphere. Calculation of these emissions relies on fuel- and process-specific emission factors. A list of potentially relevant fuels is provided in Table 2.

Since most fuels contain chemically bound nitrogen, the flow of these fuels across the different pools and within the „Energy and fuels" pool should be accounted for as N flows as well (see Figure 1). For the most important fuel types, the Table 2 provides ranges of typical nitrogen contents. If no country-specific information is available on the nitrogen contents, it is recommended to apply average nitrogen contents provided in Table 2 as default values. This corresponds to the Tier 1 approach for calculating the N exchanges with the pool „Energy and fuels".

Table 2 – List of fuels according to IPCC 2006 Guidelines (IPCC 2006) and typical nitrogen contents. Where available, data on nitrogen contents [weight %] are taken from the Guidebook EEA 2013/2016, Vol. 1A1 Energy industries, appendix B.

Fuel class		**Fuel type**	**min [wt%]**	**max [wt%]**	**avg. [wt%]**	**Reference**
Liquid fossil	Primary fuels	Crude oil	0.1	2	1.05	Chempedia 2017
		Orimulsion	-	-	4.0	HUT 2017
		Natural gas liquids	-	-	*	-

[1] „For Parties for which emission ceilings are derived from national energy projections based on the amount of fuels sold, compliance checking will be based on fuels sold in the geographic area of the Party. Other Parties within the EMEP region (i.e., Austria, Belgium, Ireland, Lithuania, Luxembourg, the Netherlands, Switzerland and the United Kingdom of Great Britain and Northern Ireland) may choose to use the national emission total calculated on the basis of fuels used in the geographic area of the Party as a basis for compliance with their respective emission ceilings." (cit. from §23 of ECE/EB.AIR/125, 14.03.2014, UN ECE 2014)

Fuel class		Fuel type	min [wt%]	max [wt%]	avg. [wt%]	Reference
	Secondary fuels	Gasoline	-	-	0	Wielgosiński, G. (2012) (petrol)
		Jet kerosene	-	-	0.1	Flagan et al 1988
		Other kerosene				
		Shale oil	-	-	*	-
		Gas/diesel oil	-	-	0.0133	EV 2005
		Residual fuel oil	0.1	0.8	0.45	EEA 2013/2016 (heavy fuel oil)
		Liquefied petroleum gases (LPG)	-	-	*	-
		Ethane	0	0	0	-
		Naphtha	-	-	*	-
		Bitumen	0.2	1.2	0.70	AI (2015)
		Lubricants	-	-	*	-
		Petroleum coke	0.6	1.55	1.075	EEA 2013/2016
		Refinery feedstocks	-	-	*	-
		Other oil	0.005	0.07	0.0375	EEA 2013/2016 (fuel oil)
Other liquid fossil			-	-	*	-
Solid fossil	Primary fuels	Anthracite	0.2	3.5	1.85	EEA 2013/2016 (hard coal)
		Coking coal	0.57	1.68	1.04	Daishe et al. 2011
		Other bituminous coal	0.5	2.0	1.25	USE 2017a
		Sub-bituminous coal	0.5	2.0	1.25	USE 2017b
		Lignite	0.4	2.5	1.45	EEA 2013/2016
		Oil shale and tar sand	-	-	*	-
	Secondary fuels	BKB[2] and patent fuel	-	-	*	-
		Coke oven/gas coke	-	-	12	Wielgosiński, G. (2012)
		Coal tar	-	-	1.51	Kershaw et al. (1993)
Other solid fossil			-	-	*	-
Gaseous fossil		Natural gas (dry)	0	0	0	EEA 2013/2016
Other gaseous fossil			-	-	*	-
Waste (non-biomass fraction)			0.3	1.4	0.85	EEA 2013/2016 (waste)
Other fossil fuels			-	-	*	-
Peat			0.7	3.4	2.05	EEA 2013/2016
Biomass		Solid biomass	0.1	0.3	0.2	EEA 2013/2016 (wood)
		Liquid biomass	-	-	1	HUT 2017 (sewage sludge)
		Refined biogas	0	0	0	EEA 2013/2016 (natural gas)
		Other non-fossil fuels (biogenic waste)	-	-	*	-

* no default value available

3 Internal structure

The pool „Energy and fuels“ consists of four sub-pools (Figure 2) as described in Annex 0, Tab. 2. The sub-pool „Energy conversion“ (EC) comprises all fuel conversion activities, such as refining processes, manufacturing of solid fuels and heat and electricity production. It includes also production of biofuels other than biogas (e.g. biodiesel, bioethanol). The sub-pool „Manufacturing industries and construction“ (IC) includes all fuel combustion processes in the industrial sector and in construction. The sub-pool Transport (TR) comprises all fuel combustion in transport activities (land, water, air) and the sub-pool „Other energy and fuels“ (OE) accounts for all remaining fuel combustion processes out of which residential heating is one of the most important sources.

[2] Brown Coal Briquettes

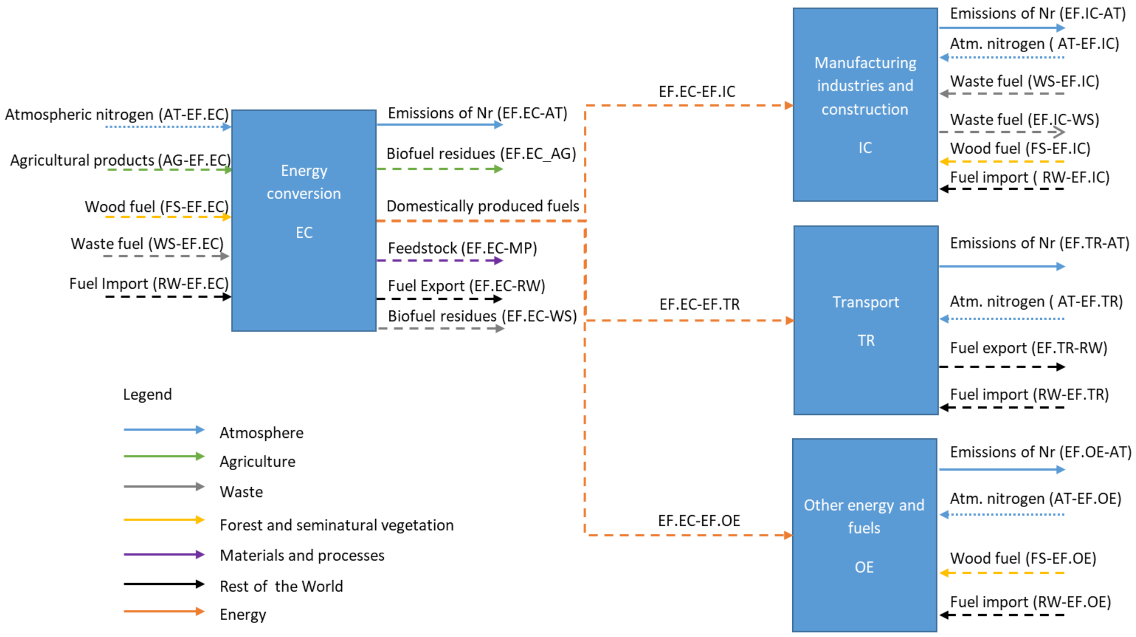

Figure 2: Schematic representation of the sub-pools within the pool „Energy and fuels“. Solid arrows indicate flows of reactive nitrogen compounds (NO_x, NH_3, N_2O); dotted arrows represent flows of N_2, and dashed arrows indicate flows of other forms of inactive nitrogen.

In some countries, the information necessary to differentiate between consumption of fuels that were imported and consumption of fuels that were produced within the country might not be readily available. Therefore, a simplified approach as shown in Figure 3 is recommended in cases where this information is missing. It covers the same sub-pools and exchanges with the other pools of the NNB, but it neglects exchanges within the pool „Energy and fuels“, i.e. the exchange between the sub-pool „Energy conversion“ and the other sub-pools within the pool „Energy and fuels“ (Manufacturing industry and construction, Transport, Other energy and fuels). This simplification does not affect the resulting N flow to the atmosphere, since the emission factors of fuel combustion processes provided in IPCC 2006 and EEA 2013/2016 account for total emissions of each nitrogen containing compound (NO_x, N_2O, NH_3). They do not distinguish between nitrogen originating from the atmosphere (N_2 fixation, thermal NO_x) and nitrogen contained in the fuel (fuel NO_x).

The nitrogen balance can be simplified even further. In the most basic approach, all N flows exclusively consisting of inactive forms of nitrogen (e.g. nitrogen contained in fuels) can be neglected. In this case, the only remaining N flows are the emissions of NO_x, NH_3 and N_2O to the atmosphere. In countries that dispose of national inventories of air pollutants and greenhouse gases the N flow to the atmosphere can directly be derived from these inventories. Calculation of the N flows does in this case not require any additional data collection.

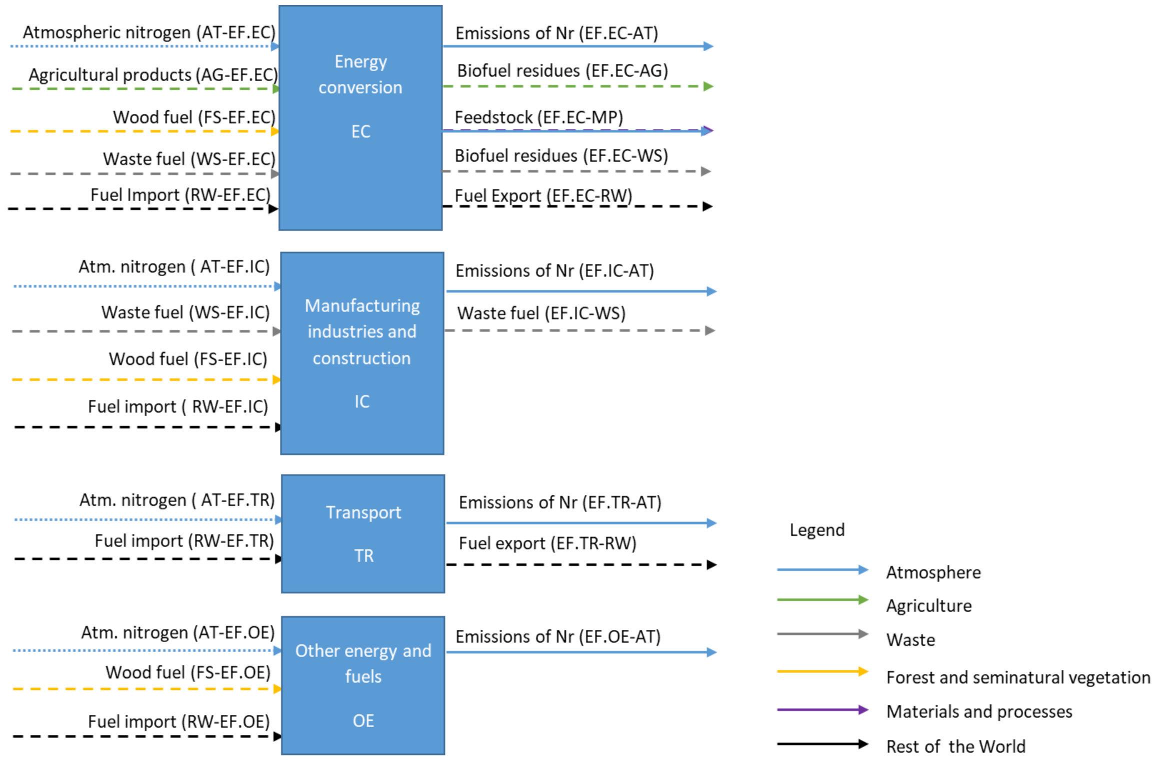

Figure 3: Simplified schematic representation of the sub-pools within the pool „Energy and fuels“. Solid arrows indicate flows of reactive nitrogen compounds (NO_x, NH_3, N_2O); dotted arrows represent flows of N_2, and dashed arrows indicate flows of other forms of inactive nitrogen.

The relevant fuel combustion processes and related emission factors of air pollutants and greenhouse gases are documented in the EMEP/EEA Guidebook (EEA 2013) and in the IPCC 2006 Guidelines (IPCC 2006) respectively. Both guidance documents provide a nomenclature for reporting (NFR), which assigns each process to a source category. They also provide a methodology for estimating related emissions.

Potentially relevant sources of nitrogen flows to the atmosphere can be identified from existing inventories of greenhouse gas and air pollutant emissions. Since the submissions of the European Union cover a wide range of different types of processes, potentially relevant sources of nitrogen emissions were identified based on the inventories of the EU[3] for the year 2016. The following section provides an overview of the relevant source categories.

3.1 Sub-pool “Energy conversion” (EC)

This sub-pool comprises all domestic heat and electricity production, except waste incineration plants, which are included in the pool Waste (Annex 5). Fuel production processes (e.g. refining of petroleum, biofuel production, manufacturing of solid fuels) is also accounted for in this sub-pool. Biogas production forms an exception since it is accounted for in the pool Waste.

[3] UNFCCC Submission 2016 European union: http://unfccc.int/files/national_reports/annex_i_ghg_inventories/national_inventories_submissions/application/zip/eua-2016-crf-9sep16.zip
UNECE Submission 2016 European union: http://webdab1.umweltbundesamt.at/download/submissions2016/EU_NFR2016.zip?cgiproxy_skip=1

Furthermore, emissions from flaring processes and fugitive emissions from fuels are also covered in the pool “Energy and fuels”.

Oil refining: Oil represents the most important source of energy in Europe. About 94 % of the fuels required for transport originated from oil products. In 2012, there were 655 refineries worldwide, with a total capacity of around 4,400 million t / yr (BAT, 2015). The oil industry uses a wide range of processes. Petroleum refining processes require a large amount of thermal energy, which is obtained by burning different fuels. As part of the technological processes at the refinery, there are three main categories that are relevant for the pool “Energy and fuels”:

1. Separation processes of crude oil into boiling fractions. The main amount of reactive nitrogen is released when fuel is burned. A small amount of reactive nitrogen can also be formed when the crude oil and its fractions are heated;
2. Oil processing processes stabilize and improve petroleum products. Undesirable elements, such as nitrogen, are removed from the intermediates. In the industry, the hydrotreating method is mainly used. At the hydrotreatment stage, nitrogen is released from the oil fractions in the reactive form (ammonia). The obtained purified products are sent to other pools (sub-pools) for use or to the next stage of processing;
3. Deasphalting is used to separate asphalt from other products. The basic source of bitumen or asphalt is the residue remaining after vacuum distillation of crude. Asphalt is sent to the “Material and products in industry” (MP) pool, where it is used to create pavements. Asphalt contains the residues quantity of nitrogen, which can form reactive nitrogen when heated. The flow of nitrogen contained in the asphalt is described in the Annex “Energy and fuels”.

When constructing the nitrogen budget of the pool “Energy and fuels”, it is necessary to consider reactive nitrogen released during fuel combustion processes (N_2O, NO_x) as described in the IPCC Guidelines for National Greenhouse Gas Inventories and the EMEP EEA Guidebook 2013/2016 for air pollutants.

In addition, emissions of ammonia (NH_3) result from an incomplete reaction of NH_3 additive in NO_x abatement systems, i.e. selective catalytic and non-catalytic reduction (SCR and SNCR). These emissions also need to be accounted for in the NNB (BAT, 2015). The Tier 2 methodologies described in the EMEP EEA Guidebook 2013/2016 account also for emissions from application of abatement technologies, such as SCR and SNCR. In addition, reactive nitrogen is formed in the purification of certain fuels in the so called hydrotreating process (BAT, 2015). Examples of air emissions generated by hydrotreatment units are provided in BAT 2015, Table 3.65 chp. 3, p.228.

Table 3 – Assignment of NFR sectors to the sub-pool “Energy conversion” (EC). Potentially relevant emission sources, according to greenhouse gas (GHG) and air pollutant inventories of the EU in 2016, are indicated with “x”. NE indicates that the emissions are “not estimated” within the existing inventories.

NFR sectors to be reported		**Compound**		
		N_2O	**NO_x**	**NH_3**
NFR Code	**Description**			
1A1a	Public electricity and heat production	x	x	x
1A1b	Petroleum refining	x	x	x

NFR sectors to be reported		Compound		
		N_2O	NO_x	NH_3
NFR Code	Description			
1A1c	Manufacture of solid fuels and other energy industries	x	x	x
1B1a	Fugitive emission from solid fuels: Coal mining and handling		x	x
1B1b	Fugitive emission from solid fuels: Solid fuel transformation	x	x	x
1B1c	Other fugitive emissions from solid fuels	x	x	NE
1B2ai	Fugitive emissions oil: Exploration, production, transport	x	x	x
1B2aiv	Fugitive emissions oil: Refining / storage	x	x	x
1B2av	Distribution of oil products	x	x	NE
1B2b	Fugitive emissions from natural gas (exploration, production, processing, transmission, storage, distribution and other)		x	NE
1B2	Venting and flaring (oil, gas, combined oil and gas)		x	x
1B2d	Other fugitive emissions from energy production		NE	NE

3.2 Sub-pool “Manufacturing industries and construction” (IC)

This sub-pool accounts for all fuel combustion processes in the manufacturing industry and construction sector, such as iron and steel production, non-ferrous metal industry, chemical industry, pulp and paper production, food processing and production of non-metallic minerals. Besides stationary combustion, mobile combustion from machinery and vehicles operating on construction sites as well as industrial vehicles are included in this sub-pool.

Note that potential N flows from the manufacturing industry that do NOT originate from fuel combustion activities, are reported in the pool 2 Materials and products in industry.

Table 4 – Assignment of NFR sectors to the sub-pool “Manufacturing industry and construction” (IC). Potentially relevant emission sources, according to GHG and air pollutant inventories of the EU in 2016, are indicated with “x”.

NFR sectors to be reported		Compound		
		N_2O	NO_x	NH_3
NFR Code	Description			
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	x	x	x
1A2b	Stationary combustion in manufacturing industries and construction: Non-ferrous metals	x	x	x
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	x	x	x
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	x	x	x
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	x	x	x
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	x	x	x
1A2gvii	Mobile Combustion in manufacturing industries and construction: (please specify in the IIR)	x	x	x
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	x	x	x

3.3 Sub-pool Transport (TR)

This sub-pool covers all fuel combustion activities within the transport sector. This includes road and rail transport as well as shipping and aviation. Pipeline transport is also included in this sub-pool.

Table 5 – Assignment of NFR sectors to the sub-pool Transport (TR). Potentially relevant emission sources, according to GHG and air pollutant inventories of the EU in 2016, are indicated with “x”. NE indicates that the emissions are “not estimated”.

NFR sectors to be reported		Compound		
		N_2O	NO_x	NH_3
NFR Code	**Description**			
1A3ai(i)	International aviation LTO (civil)	x	x	x
1A3aii(i)	Domestic aviation LTO (civil)	x	x	x
1A3bi	Road transport: Passenger cars	x	x	x
1A3bii	Road transport: Light duty vehicles	x	x	x
1A3biii	Road transport: Heavy duty vehicles and buses	x	x	x
1A3biv	Road transport: Mopeds & motorcycles	x	x	x
1A3bv	Road transport: Gasoline evaporation		NE	NE
1A3bvi	Road transport: Automobile tyre and brake wear		NE	NE
1A3bvii	Road transport: Automobile road abrasion		NE	NE
1A3c	Railways	x	x	x
1A3di(ii)	International inland waterways	x	x	x
1A3dii	National navigation (shipping)	x	x	x
1A3ei	Pipeline transport	x	x	x
1A3eii	Other (please specify in the IIR)	NE	x	x

3.4 Sub-pool “Other energy and fuels” (OE)

This sub-pool accounts for all energy combustion activities that are not already covered in one of the other sub-pools. The most important activity is stationary fuel combustion in the residential and commercial sector. Furthermore, this sub-pool includes emissions from mobile sources, such as off-road vehicles and other machinery used in the commercial and residential sector (i.e. household devices and gardening equipment) as well as in the agriculture, forestry and fishing sector.

Table 6 – Assignment of NFR sectors to the sub-pool “Other energy and fuels” (OE). Potentially relevant emission sources, according to GHG and air pollutant inventories of the EU in 2016, are indicated with “x”.

NFR sectors to be reported		Compound		
		N_2O	NO_x	NH_3
NFR Code	**Description**			
1A4ai	Commercial/institutional: Stationary	x	x	x
1A4aii	Commercial/institutional: Mobile	x	x	x
1A4bi	Residential: Stationary	x	x	x
1A4bii	Residential: Household and gardening (mobile)	x	x	x
1A4ci	Agriculture/Forestry/Fishing: Stationary	x	x	x
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	x	x	x
1A4ciii	Agriculture/Forestry/Fishing: National fishing	x	x	x
1A5a	Other stationary (including military)	x	x	x
1A5b	Other, Mobile (including military, land based and recreational boats)	x	x	x

4 Description of flows

4.1 Overview of the nitrogen flows

This section describes the major flows of nitrogen between the pool „Energy and fuels“ and the other pools[4] of the NNB, specifying when possible the flows per sub-pool. It also provides information on possible approaches and data sources for quantifying these flows. An overview of the nitrogen flows between the pool „Energy and fuels“ and the other pools of the NNB is presented in Table 7.

Besides exchanges with other pools, there are also N flows within the pool “Energy and fuels” to be accounted for, notably the exchange between the sub-pool “Energy conversion” (EC) and the sub-pools “Manufacturing industry and construction” (IC), Transport (TR) and “Other energy and fuels” (OE).

As described in Annex 0, the Annex „Energy and fuels“ only provides a methodology for quantifying N flows, which originate from the pool „Energy and fuels“ except for the fixation of atmospheric nitrogen, which is also described in the Annex „Energy and fuels”. The methods for quantifying N flows entering the pool „Energy and fuels“ are described in the Annexes of the pools from which these N flows originate.

[4] Acronyms of the different pools used in the National Nitrogen Budget (NNB) are documented in Annex 0, Tab. 1

Table 7 - Nitrogen flows between the pool „Energy and fuels“ and the other pools and sub-pools of the NNB

Flow name	Pool		Pro-cess	Major N forms	Sub-pools involved	Flow Codes	Description	Annex describing the method
	Out	In						
		Materials & Products						
EF_MP	EF	MP	Feedstock	N feedstock	EC	EF.EC_MP.OP	Fuels used as feedstock in industrial processes	Annex EF
		Agriculture						
AG_EF	AG	EF	Agricultural fuels	N fuel	EC	AG_EF.EC	Agricultural products used for energy generation and fuel production	Annex AG
EF_AG	EF	AG	Digestate	N_{org}	EC	EF.EC_AG	Residues from biofuel production that are used as animal feed	Annex EF
		Forest and semi-natural vegetation						
FS_EF	FS	EF	Wood fuel	N fuel	EC, IC, OE	FS.FO_EF.EC FS.FO_EF.IC FS.FO_EF.OE	Direct use of wood fuel and use of wood fuel in energy conversion processes	Annex FS
		Waste						
WS_EF	WS	EF	Waste fuel	N fuel	IC	WS_EF.IC	Direct use of waste fuel in industrial processes	Annex WS
EF_WS	EF	AG	Digestate	N_{org}	EC	EF.EC_WS	Residues from biofuel production that are incinerated in waste incineration plants or transferred to landfills or composting sites	Annex EF
		Atmosphere						
EF_AT	EF	AT	Emissions	NH_3, NO_x, N_2O	EC, IC, TR, OE	EF.EC_AT EF.IC_AT EF.TR_AT EF.OE_AT	Release of reactive nitrogen species during fuel combustion processes	Annex EF
AT_EF	AT	EF	N fixation	N_2	EC, IC, TR, OE	AT_EF.EC AT_EF.IC AT_EF.TR AT_EF.OE	Technical Fixation of nitrogen during fuel combustion processes	Annex EF
		Rest of World						
RW_EF	RW	EF	fuel import	N fuel	EC, IC, TR, OE	RW_EF.EC RW_EF.IC RW_EF.TR RW_EF.OE	Import of fuels	Annex EF
EF_RW	EF	RW	fuel export	N fuel	EC, IC, TR, OE	EF.EC_RW EF.IC_RW EF.TR_RW EF.OE_RW	Export of fuels	Annex EF

Theoretically, the nitrogen budget of the pool „Energy and fuels“ should be closed. According to the balance equation, the sum of the net nitrogen flows between the pool „Energy and fuels“ and the other pools (EF_{net}, kgN/yr) and the change in stocks (ΔStock, kgN/yr) should equal zero:

$$EF_{net} + \Delta Stock = 0 \quad \text{(Eq1)}$$

EF_{net} is defined as the sum of the net nitrogen flow between the pool „Energy and fuels" and each of the other pools:

$$EF_{net} = EF\_AT_{net} + EF\_MP_{net} + EF\_AG_{net} + EF\_FS_{net} + EF\_WS_{net} + EF\_RW_{net} \qquad (Eq2)$$

However, a lack of information, inconsistent data, unaccounted flows and errors can affect the NNB and contribute to its uncertainty (UN ECE 2013, ECE/EBAIR/119).

4.2 Exchanges with the pool Atmosphere (EF_AT)

The net N flow between the pool „Energy and fuels" and the pool Atmosphere (EF_AT_{net}) is defined as:

$$EF\_AT_{net} = AT\_EF - EF\_AT \qquad (Eq3)$$

AT_EF indicates N flows related to the processes of fixation of atmospheric nitrogen and EF_AT comprises the emissions from fuel combustion. These emissions cover on one hand gaseous nitrogen compounds originating from nitrogen that is chemically bound in the fuels ("fuel NO_x") and on the other hand emissions that result from fixation of N_2 during the combustion process ("thermal NO_x"). The emission factors provided in the Guidebook (EEA 2013) and Guidelines (IPCC 2006) provide only information on the total NO_x emissions. They do not distinguish between NO_x originating from nitrogen that is chemically bound in the fuel and from fixation of N_2 from the atmosphere.

The flow from the atmosphere to the pool „Energy and fuels" consists of inactive nitrogen (N_2). It can be quantified based on a mass balance. The total emissions of nitrogen from fuel combustion processes (EF_AT) must be equal to the sum of nitrogen contained in the fuel (N_{fuel} = Activity data x nitrogen content, f_N) and the fixation of atmospheric nitrogen. Since the nitrogen content of different fuel types is known (see Table 2 for default values), the amount nitrogen from the atmosphere can be estimated by computing the total emissions of nitrogen from fuel combustion (EF_AT) and subtracting the nitrogen that originated from the fuel (N_{fuel}).

Table 8 – Overview of N exchanges with the pool Atmosphere

Flow name	Description	Method of computation	Suggested data sources
AT_EF	Fixation of N_2	EF_AT – N_{fuel}	This flow consists of fixation of unreactive nitrogen (N_2) during fuel combustion. This flow can be computed from a mass balance: Total emissions of nitrogen from fuel combustion (EF_AT) minus nitrogen contained in the fuels (N_{fuel} = AD x f_N) equal fixation of atmospheric nitrogen. • AD (Activity data): National statistics • f_N (N content): EEA 2013 1A1 Energy industries, appendix B, scientific literature, measurements of fuel composition (see Table 2 for default values)
EF_AT	Emissions of NO_x, NH_3 and N_2O	AD (activity data) x EF	1) If national inventories are available: • NH_3, NO_x: CLRTAP Inventory Submissions[5]

[5]http://www.ceip.at/status_reporting/

Flow name	Description	Method of computation	Suggested data sources
	from fuel combustion.		• N_2O: UNFCCC National Inventory Submissions[6] 2) If no national inventories are available: • AD (activity data): National statistics on fuel consumption • EF (emission factor): o NH_3, NO_x: EMEP/EEA Guidebook 2013/2016 o N_2O: IPCC Guidelines 2006

Methodology

The N flows from the pool „Energy and fuels" to the atmosphere can be quantified based on the amount of fuel consumed (activity data, AD) and the emission factors (EF) of all nitrogen containing compounds formed in the combustion process.

$$EF\_AT = AD \cdot EF \qquad \text{(Eq4)}$$

The emission factors of gaseous nitrogen compounds formed in combustion processes differ depending on the fuel type and depending on the combustion process and technology applied. Therefore, the corresponding N flows need to be determined for each type of combustion process separately accounting for country-specific circumstances in terms of combustion technologies that are applied.

The N flow from each sub-pool to the atmosphere (EF_AT) consists of the sum of N flows from each combustion process (j) covered by the sub-pool, fuel (i) and pollutant/GHG (k). Activity data need to be disaggregated according to combustion process (j) and fuel type (i) and corresponding emission factors depend on the combustion process (j), the fuel type (i) and the pollutant/GHG (k).

$$EF\_AT = \sum_i \sum_j \sum_k EF_{i,j,k} \cdot AD_{i,j} \qquad \text{(Eq5)}$$

Emissions of NO_x, NH_3, N_2O occur in each of the four sub-pools of the pool „Energy and fuels" ("Energy conversion" EC, "Manufacturing industries and construction" IC, Transport TR and "Other energy" OE). Table 3 - Table 6 summarize, which source categories are covered in each sub-pool and which nitrogen containing compounds need to be accounted for in each source category (i.e. NO_x, NH_3, N_2O).

The methodology for estimating the N flow from the pool „Energy and fuels" to the pool Atmosphere is based on the EMEP/EEA Guidebook (EEA 2013/2016) for NO_x and NH_3 and on the IPCC 2006 Guidelines 2016 (IPCC 2006) for N_2O. These documents provide default emission factors for all relevant chemical compounds (NO_x, NH_3, N_2O) for commonly applied combustion process and technologies. To derive the flow of nitrogen, the emissions of each nitrogen containing compound need to be converted into the respective amount of nitrogen based on the stoichiometric conversion factors as shown in Table 1.

For each source category, both a simplified method based on default values (Tier 1) and a more elaborate method based on technology- or country-specific emission factors (Tier 2 or Tier 3) is provided in the guidance documents. For estimating nitrogen flows at a Tier 1 level

[6] http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/9492.php

it is recommended to apply a Tier 1 method as described in the EMEP EEA Guidebook (EEA 2013/2016) and IPCC 2006 Guidelines (IPCC 2006) respectively. For estimating nitrogen flows at a Tier 2 level, it is recommended to estimate emissions at a Tier 2 or 3 level according to the Guidebook/Guidelines.

The methodology for estimating the N flow from the pool Atmosphere to the pool „Energy and fuels“ is based on a mass balance. Total emissions of nitrogen from fuel combustion processes (EF_AT) must be equal to the sum of nitrogen contained in the fuel (N_{fuel} = AD x f_N) and the fixation of atmospheric nitrogen.

Based on the nitrogen content of different fuel types (see Table 2), the amount nitrogen from the atmosphere can be estimated as follows. The amount of atmospheric fixation of nitrogen corresponds to the difference between total emissions of nitrogen from fuel combustion (EF_AT, see Eq5) and the amount of nitrogen originating from the fuel (N_{fuel}) itself. The latter is estimated based on the amount of fuel used (AD) and its nitrogen content (f_N).

AT_EF = EF_AT – N_{fuel}

AT_EF = $\sum_i \sum_j \sum_k EF_{i,j,k} \cdot AD_{i,j} - \sum_i \sum_j f_i \cdot AD_i$ (Eq6)

Data sources

For countries that submit national greenhouse gas inventories and air pollutant inventories, emission data are readily available from the UNFCCC and EEA websites respectively:

- Data on NO_x and NH_3 emissions can be downloaded from emission database of EMEP (Co-operative programme for monitoring and evaluation of long range transmission of air pollutants in Europe) link: http://www.ceip.at/status_reporting/
- The N_2O emissions can be quantified by following the IPCC guidelines for National Greenhouse Gas Inventories (IPCC, 2006). Related emission data can be downloaded from the UNFCCC website. link: http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/10116.php

If a country does not submit an air pollutant or a greenhouse gas inventory, the corresponding emissions need to be calculated according to the Tier methods described in the EMEP EEA Guidebook (EEA2013/2016) and IPCC 2006 Guidelines (IPCC 2006). For a Tier 1 approach based on default emission factors, the only data requirement are fuel quantities consumed in each process. For higher Tier methods, additional information on combustion technologies used and application of abatement technologies is required. In addition, higher Tier methods may require country-specific emission factors.

The flow AT_EF can be quantified based on activity data for the fuel consumption from industry statistics. The nitrogen content of the fuels can be determined either by scientific literature (Tier 1) or by measurements (Tier 2).

Uncertainties

Table 5 in Annex 0 provides guidance on how to assess uncertainties.

- If emissions of gaseous nitrogen compounds are estimated primarily based on a Tier 1 method, an uncertainty level of 3 or 4 is recommended, since the method relies on default emission factors, which might not be representative of the national situation. An uncertainty level of 3 is recommended, if mostly official, up to date statistics or measurements are used to determine activity data. Otherwise, the recommended uncertainty level is 4.
- If primarily a Tier 2 method (i.e. Tier 2 or Tier 3 according to the EMEP EEA Guidebook 2013/2016 or IPCC 2006 Guidelines) is applied, the uncertainty level is likely to be 1 or 2. An uncertainty level of 1 is recommended, if mostly official, up to date statistics or measurements are applied. Otherwise, the recommended uncertainty level is 2.

4.3 Exchanges with the pool Agriculture (EF_AG)

Exchanges with the pool Agriculture comprise the use of agricultural products for energy generation. The net nitrogen flow between the pool „Energy and fuels“ and the pool Agriculture (EF_AG_{net}) is defined as:

$$EF\_AG_{net} = AG\_EF - EF\_AG \qquad (Eq7)$$

The N flow AG_EF comprises the flow of nitrogen contained in agricultural by-products that are used for energy generation. This excludes production of biogas, which is accounted for in the Annex WS.

Residues from the anaerobic digestion process in biofuel production (digestate) are used as animal feed in the agricultural sector. The N flow EF_AG accounts for nitrogen contained in these residues from biofuel production other than biogas production. Energy combustion in the agricultural sector itself is covered in the sub-pool EF.OE.

Table 9 – Overview of N exchanges with the pool Agriculture

Flow name	**Description**	**Method of computation**	**Suggested data sources**
AG_EF	Biomass fuels from the pool Agriculture	Annex AG	see Annex AG
EF_AG	Digestate/Residues from biofuel production that are used as animal feed in the pool Agriculture	AD x f_N	AD (Activity data): industry statistics f_N (N content): scientific literature, measurements

Methodology

It is assumed that agricultural fuels are used solely in the sub-pool “Energy conversion”. Therefore, only the flow AG_EF.EC needs to be accounted for.

$$AG\_EF = AG\_EF.EC \qquad (Eq8)$$

As this flow originates from the pool agriculture, the method of computation can be found in the corresponding Annex AG.

The flow EF_AG consists of residues from biofuel production that are used as animal feed in the pool Agriculture. This nitrogen flow can be quantified based on the amount of digestate produced in the sub-pool “Energy Conversion” (activity data, AD) and the respective nitrogen content (f_N) of the digestate. The nitrogen content needs to be determined based on scientific literature or country-specific measurements.

$$EF\_AG = EF.EC\_AG = AD \times f_N \qquad \text{(Eq9)}$$

Data sources

For quantification of the flow AG_EF, see Annex AG.

The flow EF_AG can be quantified based on activity data for the biofuel residues from industry statistics. The nitrogen content of the residues can be determined either by scientific literature (Tier 1) or by measurements (Tier 2).

Uncertainties

For quantification of uncertainties in the flow AG_EF, see Annex AG.

Table 5 in Annex 0 provides guidance on how to assess uncertainties.

- If emissions are estimated based on a Tier 1 method, an uncertainty level of 3 or 4 is recommended, since the method is based on default nitrogen content of biofuel residues, which might not be representative of the national circumstances. An uncertainty level of 3 is recommended, if official, up to date statistics or measurements are used to determine activity data. Otherwise, the recommended uncertainty level is 4.
- If a Tier 2 method is applied, the uncertainty is likely to be 1 or 2. An uncertainty level of 1 is recommended, if official, up to date statistics or measurements are applied. Otherwise, the recommended uncertainty level is 2.

4.4 Exchanges with the pool “Forest and semi-natural vegetation” (EF_FS)

The net nitrogen flow between the pool „Energy and fuels“ and the pool “Forest and semi-natural vegetation” (EF_FS_{net}) is defined as:

$$EF\_FS_{net} = FS\_EF \qquad \text{(Eq10)}$$

The N flow FS_EF comprises the flow of nitrogen contained in biomass from the pool “Forest and semi-natural vegetation” that is used as fuel to the pool „Energy and fuels“. No flow exists from the pool „Energy and fuels“ to the pool “Forest and semi-natural vegetation”.

Table 10 – Overview of N exchanges with the pool Forest and semi-natural vegetation

Flow name	Description	Method of computation	Suggested data sources
FS_EF	Biomass fuels from the Forest and semi-natural vegetation pool	Annex FS	Annex FS

Methodology

As the flow FS_EF originates from the pool “Forest and semi-natural vegetation”, the method of computation can be found in the corresponding Annex FS.

The partitioning of this flow into the different sub-pools of the „Energy and fuels“ pool corresponds to the shares of biomass that is consumed in the different sub-pools. Biomass from the pool “Forest and semi-natural vegetation” is used mainly in the sub-pools “Energy conversion” (EC), “Manufacturing industries and construction” (IC) and “Other energy and fuels” (OE). The total N flow can therefore be partitioned as follows:

FS_EF = FS_EF.EC + FS_EF.IC + FS_EF.OE (Eq11)

By defining for each fuel i used in sub-pool j a corresponding share $C_{i,j}$, the total N flow can be calculated by the following equation:

FS_EF = $\sum_i \sum_j C_{i,j} \cdot \mathrm{FS\_EF}$ (Eq12)

Thus for each sub-pool, the corresponding N flow can be computed as follows:

FS_EF.EC = $\sum_i C_{i,EC} \cdot \mathrm{FS\_EF}$ (Eq13)

FS_EF.OE = $\sum_i C_{i,OE} \cdot \mathrm{FS\_EF}$ (Eq14)

FS_EF.IC = $\sum_i C_{i,IC} \cdot \mathrm{FS\_EF}$ (Eq15)

Data sources

see Annex FS

Uncertainties

see Annex FS

4.5 Exchanges with the pool “Materials and products” (EF_MP)

The net nitrogen flow between the pool „Energy and fuels“ and the pool “Material and Products” (EF_MP_{net}) is defined as:

EF_MP_{net} = EF_MP (Eq16)

EF_MP_{net} equals the N flow from the pool „Energy and fuels“ to the pool “Materials and processes” (EF_MP). This flow comprises the non-energy use of fuels, which includes for example the use of bitumen and asphalt for road paving and roof covering or the use as lubricating oil in engines as well as other uses of oils and greases for industrial purposes (e.g. heat transfer, cutting oil). Production of these fuels is covered in the sub-pool “Energy conversion” and the use of these fuels is accounted for in the pool “Materials and processes”. The nitrogen compounds contained in these fuels is considered inactive. To improve completeness of the NNB, it is recommended to include these nitrogen flows as well. There are no flows from the pool Materials and processes and the pool „Energy and fuels“.

Table 11 – Overview of N exchanges with the pool Materials and products

Flow name	Description	Method of computation	Suggested data sources
EF_MP	Non-energy use of fuels in industrial processes (lubricants, bitumen)	AD x f_N	AD (Activity data): National energy balances, industry statistics, UNFCCC National Inventory Submissions f_N (N content) EEA 2013, 1A1 Energy industries, appendix B, scientific literature, measurements (see Table 2 for default values)

Methodology

Fuels used in industrial processes originate only from the sub-pool "Energy conversion". Therefore, only the flow from this sub-pool (EF.EC_MP) needs to be accounted for.

$$EF\_MP_{net} = EF.EC\_MP \qquad \text{(Eq17)}$$

The exchange of nitrogen with the pool "Materials and processes" is computed by multiplying for each type of fuel, i, the amount of fuel (AD) with the respective N content (f_N). The total flow corresponds to the sum over all fuel types.

$$EF.EC\_MP = \sum_i AD_i \cdot f_{N,i} \qquad \text{(Eq18)}$$

Data sources

Tier 1:

- Nitrogen content (f_N): For a Tier 1 approach the nitrogen content can be estimated using default values for the N content provided in Table 2.
- Activity data (AD): The quantities of fuel used in non-energy uses can be taken from UNFCCC national inventory submissions, national energy balances or industry statistics.

Tier 2:

- Nitrogen content (f_N): In a Tier 2 approach, the nitrogen content is determined based on country-specific data for each type of fuel.
- Activity data (AD): see Tier 1.

Uncertainties

Table 5 in Annex 0 provides guidance on how to assess uncertainties.

- If emissions are estimated based on a Tier 1 method, an uncertainty level of 3 or 4 is recommended, since the method is based on default nitrogen content of fuels, which might not be representative of the national circumstances. An uncertainty level of 3 is recommended, if official, up to date statistics or measurements are used to determine activity data. Otherwise, the recommended uncertainty level is 4.

- If a Tier 2 method is applied, the uncertainty is likely to be 1 or 2. An uncertainty level of 1 is recommended, if official, up to date statistics or measurements are applied. Otherwise, the recommended uncertainty level is 2.

4.6 Exchanges with the pool Waste (EF_WS)

The net nitrogen flow between the pool „Energy and fuels“ and the Waste pool (EF_WS_{net}) is defined as:

$$EF\_WS_{net} = WS\_EF - EF\_WS \qquad \text{(Eq19)}$$

WS_EF is the flow of nitrogen contained in waste fuels used as fuel in industrial combustion processes (e.g. cement production). The flow EF_WS accounts for nitrogen contained in the digestate and residues of biofuel production that is generated as a by-product in the sub-pool „Energy conversion” and transferred to the pool Waste, e.g. to waste incineration plants, landfills or composting sites.

Waste incineration plants are not included in the pool „Energy and fuels“, independent of whether the energy produced in the waste incineration process is recovered or not. All waste incineration plants are accounted for in the pool Waste.

Table 12 – Overview of N exchanges with the pool Waste

Flow name	Description	Method of computation	Suggested data sources
WS_EF	Combustion of waste fuels excluding waste incineration plants	Annex WS	Annex WS
EF_WS	Digestate/Residues as by-products from biofuel production that are transferred to waste incineration plants, landfills or composting sites.	Activity data (AD) x Nitrogen content (f_N) AD x f_N	AD (Activity data): industry statistics f_N (N content): scientific literature, measurements

Methodology

Waste fuels are primarily used in the sub-pool “Manufacturing industry and construction” (EF.IC). Therefore, only the flow WS_EF.IC needs to be accounted for.

$$WS\_EF = WS\_EF.IC \qquad \text{(Eq20)}$$

The nitrogen flow from the pool waste to the pool „Energy and fuels” (WS_EF.IC) is quantified in the Annex WS.

The flow from the pool „Energy and fuels” to the pool waste (EF.EC_WS) consists of digestate that is incinerated in waste incineration plants or digestate that is composted. These flows are computed by multiplying the activity data (amount of digestate incinerated in waste incineration plants or amount of composted digestate) and the corresponding nitrogen content of the digestate (f_N).

$$EF\_WS = EF.EC\_WS = AD \times f_N \qquad \text{(Eq21)}$$

Data sources

For quantification of the flow WS_EF, see Annex WS.

The flow EF_WS can be quantified based on activity data for the biofuel residues from industry statistics. The nitrogen content of the residues can be determined either by scientific literature (Tier 1) or by measurements (Tier 2).

Uncertainties

For quantification of uncertainties in the flow WS_EF, see Annex WS.

Table 5 in Annex 0 provides guidance on how to assess uncertainties.

- If emissions are estimated based on a Tier 1 method, an uncertainty level of 3 or 4 is recommended, since the method is based on default nitrogen content of biofuel residues, which might not be representative of the national circumstances. An uncertainty level of 3 is recommended, if official, up to date statistics or measurements are used to determine activity data. Otherwise, the recommended uncertainty level is 4.
- If a Tier 2 method is applied, the uncertainty is likely to be 1 or 2. An uncertainty level of 1 is recommended, if official, up to date statistics or measurements are applied. Otherwise, the recommended uncertainty level is 2.

4.7 Exchanges with the pool "Rest of the world" (EF_RW)

Fuel imports can occur all sub-pools. Fuel exports are primarily relevant for the sub-pools "Energy conversion" and Transport (i.e. "fuel tourism").

The net nitrogen flow between the pool „Energy and fuels" and the Rest of the world pool (EF_RW_{net}) is defined as:

$$EF\_RW_{net} = RW\_EF - EF\_RW \quad \text{(Eq22)}$$

RW_EF and EF_RW are the N flows associated with the import and export across the national borders respectively.

Table 13 – Overview of N exchanges with the pool Rest of the world

Flow name	Description	Method of computation	Suggested data sources
RW_EF	Fuel import	Activity data (AD) x Nitrogen content (f_N) AD x f_N	AD (Activity data): Customs statistics f_N (N content): EEA 2013 1A1 Energy industries, appendix B, scientific literature, measurements of fuel composition (see Table 2 for default values)
EF_RW	Fuel export	Activity data (AD) x Nitrogen content (f_N) AD x f_N	AD (Activity data): Customs statistics, National energy balances, Sectoral energy statistics of transport sector f_N (N content): EEA 2013 1A1 Energy industries, appendix B, scientific literature, measurements of fuel composition (see Table 2 for default values)

Methodology

The exchange of nitrogen with the pool "Rest of the world" is computed by multiplying for each fuel, i, the amount of imported and exported fuel (AD) with the respective N content (f_N).

$$RW\_EF = \sum_i AD_i \cdot f_{N,i} \qquad \text{(Eq23)}$$

$$EF\_RW = \sum_i AD_i \cdot f_{N,i} \qquad \text{(Eq24)}$$

As these flows comprise only inactive nitrogen compounds, they do not need to be quantified (see ECE/EB.AIR/119, chp. V.A., „Energy and fuels"). However, it is recommended to include these N flows in the NNB to achieve a more complete balance.

The Tier 1 and Tier 2 approaches are both based on the same methodology. They differ only in terms of the data sources used for estimating the fraction of nitrogen.

Data sources

Tier 1:

- Nitrogen content (f_N): For a Tier 1 approach the nitrogen content can be estimated using default values for the N content provided in Table 2.
- Activity data (AD): The quantities of imported and exported fuel are provided in national customs statistics. Activity data in the sub-pool Transport consist of an estimate of the net amount of fuel imported or exported due to "fuel tourism". Corresponding data might be available in national energy balances or in sectoral energy statistics of the transport sector.

Tier 2:

- Nitrogen content (f_N): In a Tier 2 approach, the nitrogen content is determined based on country-specific data for each type of fuel.
- Activity data (AD): see Tier 1.

Uncertainties

Table 5 in Annex 0 provides guidance on how to assess uncertainties.

- If emissions are estimated based on a Tier 1 method, an uncertainty level of 3 or 4 is recommended, since the method is based on default nitrogen content of fuels, which might not be representative of the national circumstances. An uncertainty level of 3 is recommended, if official, up to date statistics or measurements are used to determine activity data. Otherwise, the recommended uncertainty level is 4.
- If a Tier 2 method is applied, the uncertainty is likely to be 1 or 2. An uncertainty level of 1 is recommended, if official, up to date statistics or measurements are applied. Otherwise, the recommended uncertainty level is 2.

4.8 Exchanges within the pool „Energy and fuels“ (EF_EF)

The net nitrogen flow within the pool „Energy and fuels“ consists of three flows from the sub-pool “Energy conversion” to the sub-pools “Manufacturing industry and construction”, “Transport” and “Other energy and fuels”:

EF_EF_{net} = EF.EC_EF.IC + EF.EC_EF.TR + EF.EC_EF.OE (Eq25)

These N flows account for the flow of nitrogen in fuels that are produced and consumed within the country.

Table 14 – Overview of N exchanges within the pool „Energy and fuels“

Flow name	Description	Method of computation	Suggested data sources
EF.EC_EF.IC	N flow from fuels produced within the country to the sub-pool “Manufacturing industry and combustion”	Activity data (AD) x Nitrogen content (f_N) AD x f_N	AD (Activity data): Sectoral energy statistics (IC) on amount of fuel produced and used in the country f_N (N content): EEA 2013/2016 1A1 Energy industries, appendix B; Measurements of fuel composition, scientific literature (see Table 2 for default values)
EF.EC_EF.TR	N flow from fuels produced within the country to the sub-pool Transport	Activity data (AD) x Nitrogen content (f_N) AD x f_N	AD (Activity data): Sectoral energy statistics (TR) on amount of fuel produced and used in the country f_N (N content): EEA 2013/2016 1A1 Energy industries, appendix B; Measurements of fuel composition, scientific literature (see Table 2 for default values)
EF.EC_EF.OE	N flow from fuels produced within the country to the sub-pool “Other energy”	Activity data (AD) x Nitrogen content (f_N) AD x f_N	AD (Activity data): Sectoral energy statistics (EO) on amount of fuel produced and used in the country f_N (N content): EEA 2013/2016 1A1 Energy industries, appendix B; Measurements of fuel composition, scientific literature (see Table 2 for default values)

Methodology

The exchange of nitrogen within the pool „Energy and fuels“ is computed by multiplying for each fuel, i, the amount of fuel (AD) consumed in each sub-pool with the respective N content (f_N). The same methodology can be applied for each nitrogen flow within the pool „Energy and fuels“ (EF.EC_EF.IC, EF.EC_EF.TR and EF.EC_EF.OE).

EF.EC_EF.IC = $\sum_i AD_i \cdot f_{N,i}$ (Eq26)

EF.EC_EF.TR = $\sum_i AD_i \cdot f_{N,i}$ (Eq27)

$EF.EC\_EF.OE = \sum_i AD_i \cdot f_{N,i}$ (Eq28)

As these flows comprise only inactive nitrogen compounds, they do not need to be quantified (see ECE/EB.AIR/119, chp. V.A., „Energy and fuels“). However, it is recommended to include these N flows in the NNB to achieve a more complete nitrogen balance.

The Tier 1 and Tier 2 approaches are both based on the same methodology. They differ only in terms of the data sources used for estimating the fraction of nitrogen.

Data sources

Tier 1:

- Nitrogen content (f_N): For a Tier 1 approach the nitrogen content is estimated using default values for the N content provided in Table 2.
- Activity data (AD): To quantify the nitrogen flows within the pool „Energy and fuels“ the amount of fuels produced and consumed within a country need to be determined. Furthermore, the amounts of fuels consumed need to be differentiated according to the sub-pools (Transport, Manufacturing industry and construction, Other energy). These data can be obtained from sectoral energy statistics.

Tier 2:

- Nitrogen content (f_N): In a Tier 2 approach, the nitrogen content is determined based on country-specific data for each type of fuel.
- Activity data (AD): see Tier 1.

Uncertainties

Table 5 in Annex 0 provides guidance on how to assess uncertainties.

- If emissions are estimated based on a Tier 1 method, an uncertainty level of 3 or 4 is recommended, since the method is based on default nitrogen content of fuels, which might not be representative of the national circumstances. An uncertainty level of 3 is recommended, if official, up to date statistics or measurements are used. Otherwise, the recommended uncertainty level is 4.
- If a Tier 2 method is applied, the uncertainty is likely to be 1 or 2. An uncertainty level of 1 is recommended, if official, up to date statistics or measurements are applied. Otherwise, the recommended uncertainty level is 2.

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6 Document version

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