Informative Inventory Report for Malta 2018

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Glossary of terms

Term	Definition
WM	With Measures
WaM	With additional Measures
SCR	Selective catalytic reduction
AER	Annual Environment Report
TERT	Technical expert review team
HFO	Heavy Fuel Oil
GDO	Gas Diesel Oil
TSP	Total suspended particulates
EF	Emission factors
vkm	Vehicle/kilometres (mileage or activity)
EUROSTAT	Statistical office of the European Union
FAOSTAT	Food and Agriculture Organization Corporate Statistical Database
NFR-14	Nomenclature for reporting template 2014

Executive Summary

Malta's Informative Inventory Report (IIR) contains information on the emission inventories for air pollutants in the Maltese Islands, covering the years 1990 to 2018. It also outlines a description of the methodology applied, data sources used, and the trends analysed.

There have been major changes in some of the sectors making up the NFR-14 template from the previous submission. This was due to both a change in activity data sources, and a change in the methodology used. Most sub-categories making up the energy sector are based on the statistical fuel consumption. In the previous submission, the national fuel survey was used as activity data. However, the fuel survey did not cover the entire time series, as required by the NEC Directive. Hence, the activity data source was changed to Eurostat.

The manure management sector was recalculated through the N-flow tool, which included updated emission factors. Furthermore, emissions from solid waste disposal on land were also recalculated by exploring a relationship between the CH_4 emissions reported in the climate change model and nmVOC emissions.

1. Introduction

The Environment and Resources Authority (ERA) is entrusted with the role of compiling the national emission inventories and their submission to the European Commission as an obligation under the National Emission Ceilings Directive (NECD) and the Convention on Long-Range Transboundary Air Pollution (CLRTAP). This is Malta's sixth Informative Inventory Report (IIR). The emission inventory team at ERA is responsible for all the work related to the national emission inventory of air pollutants, including the estimation of emissions and respective drafting of reports.

1.1. National Emission Inventory Background and Institutional arrangements

The Emission Inventory is compiled on an annual basis. The activity data used for the preparation of this inventory was obtained from the National Statistics Office (Malta), the Energy and Water Agency (EWA), the Waste team at ERA, the Malta Resources Authority (MRA) as well as from other relevant public entities (such as Ministries, Departments, and Regulatory Agencies), private establishments and official published reports.

1.2 Inventory Preparation Process

The Inventory Team is responsible for the work on the emissions inventory, which includes data collection through the relevant authorities, calculating emissions and preparing relevant reports. During this process, meetings with the relevant officers from other public authorities were held.

1.3 Methods and data sources

The methodology used in compiling the 2018 emission inventory was mainly based on the 2019 EMEP/EEA Air Pollutant Emission Inventory Guidebook.

The basic equation for the compilation of the emission inventory is the following:

$$\textit{Emission load} = \textit{Activity Data} \times \textit{Emission Factor}$$

EQUATION 1: BASIC EQUATION TO ESTIMATE EMISSION LOADS

Emission projections of the relevant sectors were compiled based on the same methodology used for the historical inventory. All policies implemented prior to 2017 were included in the WM scenario while all policies planned for implementation as from 2017 onwards were included in the WAM scenario.

1.4 Key Category analysis

A key category is one that is prioritised 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 this submission, the *level of assessment* of emissions was calculated based on the approach found in the EMEP/EEA Air Pollutants Emission Inventory Guidebook 2019. The key category analysis below presents each pollutant, in Malta's emission inventory, and the sectors which contribute most to its emission.

TABLE 1: KEY CATEGORY ANALYSIS FOR 2018 DATA

Pollutant	NFR	NAME	% share
NO_x (as NO_2)	1A3biii	Road transport: Heavy duty vehicles and buses	24.9%
	1A3bi	Road transport: Passenger cars	19.8%
	1A3ai(i)	International aviation LTO (civil)	10.4%
	1A4ai	Commercial/Institutional: Stationary	9.6%
	1A3bii	Road transport: Light duty vehicles	9.5%
	1A3dii	National navigation (shipping)	6.5%
nmVOC	2D3a	Domestic solvent use including fungicides	19.3%
	1A3bv	Road transport: Gasoline evaporation	18.5%
	1A3bi	Road transport: Passenger cars	18.2%
	3B1a	Manure management - Dairy cattle	5.3%
	1B2av	Distribution of oil products	5.2%
	1A3dii	National navigation (shipping)	4.5%
	3B4gii	Manure management - Broilers	4.0%
	1A3biii	Road transport: Heavy duty vehicles and buses	3.2%
	2H2	Food and beverages industry	3.2%
SO_x (as SO_2)	1A3ai(i)	International aviation LTO (civil)	30.3%
	1A3dii	National navigation (shipping)	22.5%
	1A4ai	Commercial/Institutional: Stationary	21.3%
	1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	7.2%
NH_3	3Da2a	Animal manure applied to soils	36.1%
	3B4h	Manure management - Other animals (please specify in the IIR)	12.9%
	3B3	Manure management - Swine	9.8%
	3B1a	Manure management - Dairy cattle	8.9%
	3B1b	Manure management - Non-dairy cattle	6.1%

	3B4gi	Manure management - Laying hens	4.4%
	1A3bi	Road transport: Passenger cars	4.3%
$PM_{2.5}$	1A4bi	Residential: Stationary	12.8%
	1A3bi	Road transport: Passenger cars	12.0%
	1A3bvi	Road transport: Automobile tyre and brake wear	11.8%
	1A3dii	National navigation (shipping)	11.4%
	1A3bii	Road transport: Light duty vehicles	10.3%
	1A3biii	Road transport: Heavy duty vehicles and buses	10.3%
	2G	Other product use (please specify in the IIR)	8.1%
	1A4ai	Commercial/Institutional: Stationary	4.9%
PM_{10}	1A3bvi	Road transport: Automobile tyre and brake wear	15.4%
	1A4bi	Residential: Stationary	8.9%
	3Dc	Farm-level agricultural operations including storage, handling and transport of agricultural products	8.5%
	1A3bi	Road transport: Passenger cars	8.2%
	1A3dii	National navigation (shipping)	8.0%
	2G	Other product use (please specify in the IIR)	7.8%
	1A3bii	Road transport: Light duty vehicles	7.0%
	1A3biii	Road transport: Heavy duty vehicles and buses	7.0%
	1A3bvii	Road transport: Automobile road abrasion	6.0%
	5A	Biological treatment of waste - Solid waste disposal on land	4.9%
TSP	1A3bvi	Road transport: Automobile tyre and brake wear	15.0%
	3B4gi	Manure management - Laying hens	9.6%
	1A3bvii	Road transport: Automobile road abrasion	9.1%
	5A	Biological treatment of waste - Solid waste disposal on land	7.8%
	1A4bi	Residential: Stationary	7.2%
	2G	Other product use (please specify in the IIR)	6.3%
	1A3bi	Road transport: Passenger cars	6.2%
	1A3dii	National navigation (shipping)	6.1%
	1A3bii	Road transport: Light duty vehicles	5.3%
	1A3biii	Road transport: Heavy duty vehicles and buses	5.3%
	3B3	Manure management - Swine	5.2%
BC	1A3bi	Road transport: Passenger cars	26.9%
	1A3bii	Road transport: Light duty vehicles	22.0%
	1A3biii	Road transport: Heavy duty vehicles and buses	20.1%
	1A4ai	Commercial/Institutional: Stationary	12.1%
CO	1A3bi	Road transport: Passenger cars	68.9%
	1A3biii	Road transport: Heavy duty vehicles and buses	5.1%
	1A3biv	Road transport: Mopeds & motorcycles	4.5%
	1A3ai(i)	International aviation LTO (civil)	4.1%

Pb	1A3bvi	Road transport: Automobile tyre and brake wear	57.7%
	2G	Other product use (please specify in the IIR)	38.3%
Cd	2G	Other product use (please specify in the IIR)	44.6%
	2D3i	Other solvent use (please specify in the IIR)	31.5%
	1A4bi	Residential: Stationary	10.7%
Hg	2D3a	Domestic solvent use including fungicides	42.2%
	1A3bi	Road transport: Passenger cars	21.7%
	1A1a	Public electricity and heat production	16.2%
As	1A1a	Public electricity and heat production	49.3%
	1A3dii	National navigation (shipping)	18.6%
	1A4ai	Commercial/Institutional: Stationary	8.8%
	2G	Other product use (please specify in the IIR)	5.0%
Cr	1A3bvi	Road transport: Automobile tyre and brake wear	67.8%
	2D3i	Other solvent use (please specify in the IIR)	14.7%
Cu	1A3bvi	Road transport: Automobile tyre and brake wear	65.1%
	2D3i	Other solvent use (please specify in the IIR)	26.1%
Ni	1A4ai	Commercial/Institutional: Stationary	45.6%
	2D3i	Other solvent use (please specify in the IIR)	14.7%
	1A4ciii	Agriculture/Forestry/Fishing: National fishing	13.2%
	1A3dii	National navigation (shipping)	11.5%
Se	2D3i	Other solvent use (please specify in the IIR)	34.9%
	5C1bv	Cremation	21.8%
	1A3dii	National navigation (shipping)	19.2%
	1A3bvi	Road transport: Automobile tyre and brake wear	12.7%
Zn	1A3bvi	Road transport: Automobile tyre and brake wear	46.2%
	2D3i	Other solvent use (please specify in the IIR)	31.6%
	1A4ai	Commercial/Institutional: Stationary	4.7%
PCDD/ PCDF (dioxins/ furans)	5C1bv	Cremation	94.4%
benzo(a) pyrene	1A4bi	Residential: Stationary	51.4%
	1A4ai	Commercial/Institutional: Stationary	16.3%
	1A3bi	Road transport: Passenger cars	14.0%
benzo(b) fluoranthene	1A4ai	Commercial/Institutional: Stationary	33.4%
	1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	23.2%
	1A4bi	Residential: Stationary	23.0%
	1A3bi	Road transport: Passenger cars	7.8%
benzo(k) fluoranthene	1A4ai	Commercial/Institutional: Stationary	50.4%
	1A4bi	Residential: Stationary	17.2%
	1A3bi	Road transport: Passenger cars	9.2%
	5C2	Open burning of waste	8.6%
	1A4bi	Residential: Stationary	49.8%

Indeno (1,2,3-cd) pyrene	1A3bi	Road transport: Passenger cars	19.0%
	1A4ai	Commercial/Institutional: Stationary	14.4%
HCB	5C1bv	Cremation	98.3%
PCBs	5C1bv	Cremation	98.8%

1.5 QA/QC and Verification methods

The inventory team has identified the need for an ongoing development of a Quality Assurance/Quality Control (QA/QC) system within the national emission inventory. During the compilation of the inventory, efforts were made to ensure as high a level of quality and reliability as possible. Work to develop a QA/QC system has started, in order to ensure the quality and reliability of the activity data, emission factors and emission estimates, in line with the principles of transparency, accuracy, consistency, comparability and completeness. In this submission, the best available sources of data have been used and in specific sectors, such as power generation and cremation, in-situ monitoring data was used.

1.6 General uncertainty evaluation

In an inventory process, uncertainty estimates are an essential element. Uncertainties are associated with both the activity data and emission factors, and are therefore reflected in the final result. For this submission, Malta did not perform a quantitative uncertainty assessment for any pollutants in the emission inventory, however it is being envisaged to tackle this matter in future submissions.

1.7 General Assessment of Completeness

This submission includes the estimation of emissions from all the relevant sources and emissions listed in the NFR-14 template and explained in the EMEP/EEA air pollutant emission inventory guidebook 2019.

2. Explanation of Key Trends

2.1. Trends for Nitrogen Oxides emissions

The majority of NO_x emissions were generated from the energy sector (NFR Sector 1). The emissions of NO_x, as shown in the figure below, have decreased across the time series. The shift in fuel used, from heavy fuel oil to natural gas, within the public electricity generation sector (1A1a), was the greatest contributor to this decrease.

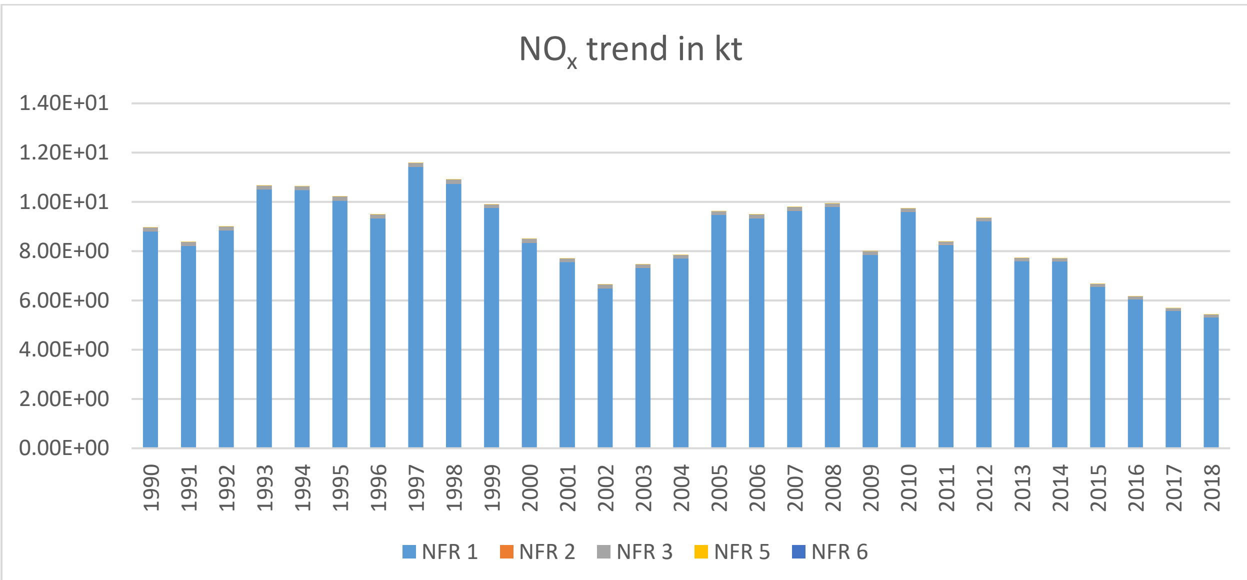

FIGURE 1: KEY TREND NO_x IN KT

3.2 Trends for Non-Methane Volatile Organic Compounds (NMVOC)

The Energy sector (NFR Sector 1) is the greatest contributor to NMVOC emissions; however, there are significant contributions from Industrial Processes and Product Use (NFR Sector 2), and Agriculture (NFR Sector 3). The figure below shows that NMVOC emissions have remained relatively stable since 2014, as emissions from the greatest contributors, i.e. domestic solvent use (2D3a) and road transport (1A3b), have also remained stable.

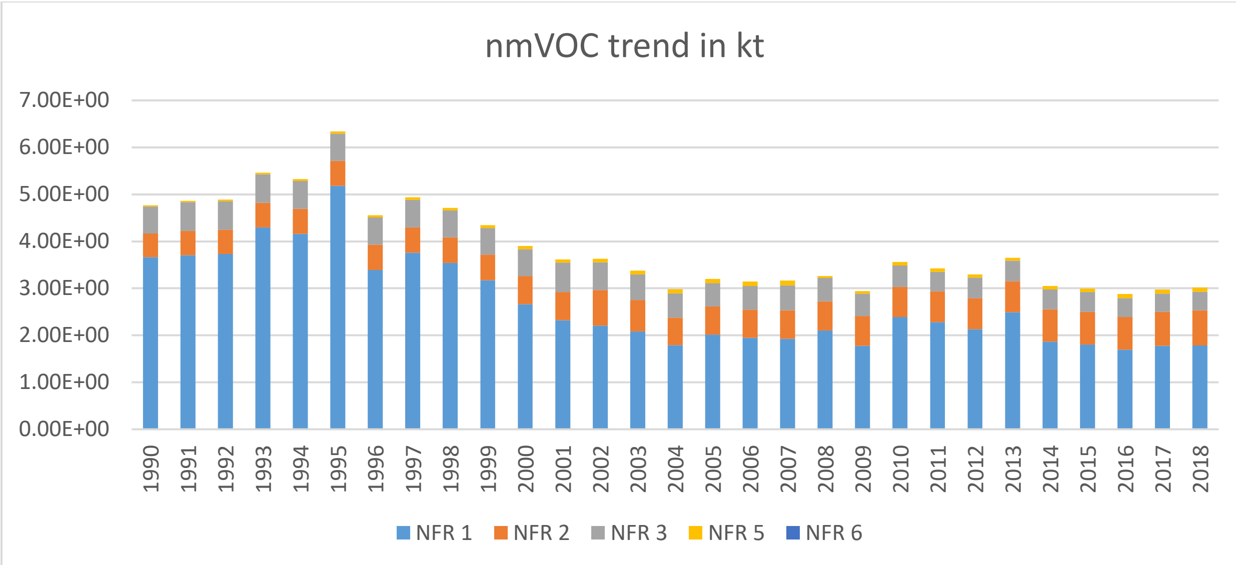

FIGURE 2: KEY TREND NMVOC IN KT

3.3. Trends for Sulphur Dioxide (SO_x)

The figure below shows that SO_x emissions steadily decreased from 1990 to 2018. The Energy sector (NFR sector 1) is the main contributor of SO_x emissions. The decrease in emissions is mostly attributed to the drastic reductions within the public electricity generation (1A1a) and road transport (1A3b) sectors.

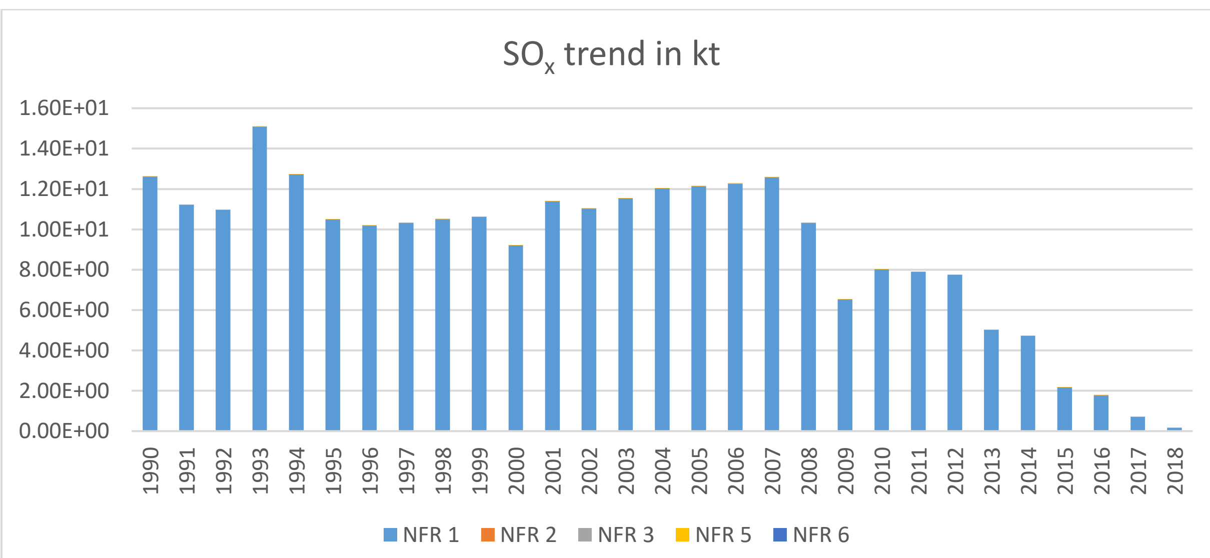

FIGURE 3: KEY TREND SO_x IN KT

3.4. Trends for Ammonia (NH_3)

The Agricultural sector (NFR sector 3) is the main contributor of NH_3 emissions. The figure below shows that NH_3 emissions decreased from 1990 to 2018, mostly as a result of a decrease in livestock numbers.

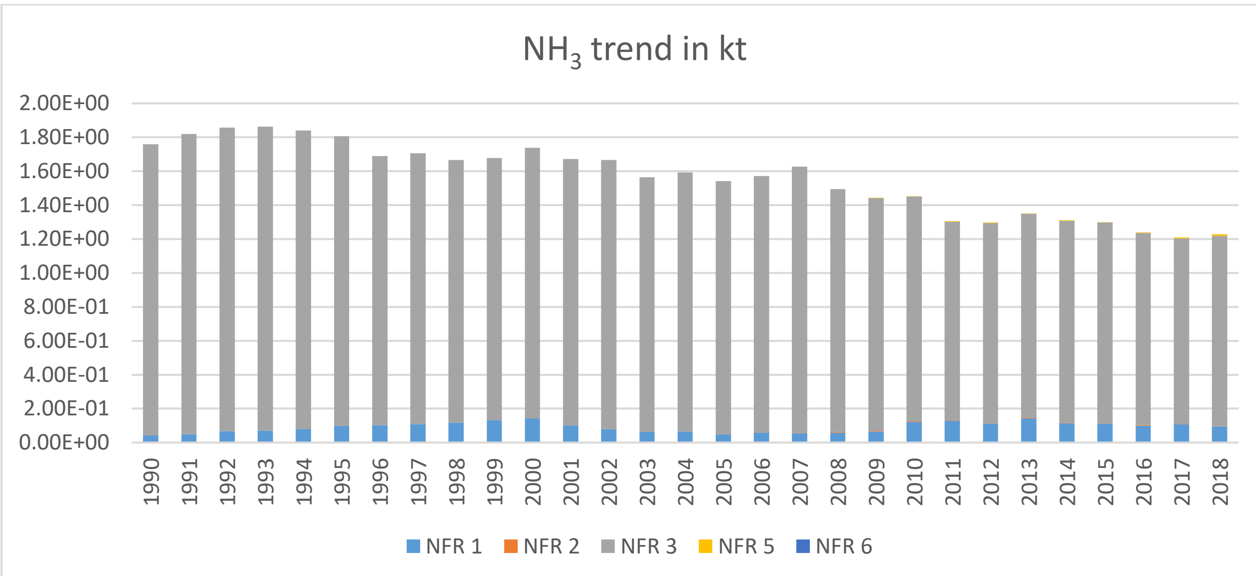

FIGURE 4: KEY TREND NH_3 IN KT

3.5. Trends for $PM_{2.5}$

The figure shows that $PM_{2.5}$ emissions decreased across the time series. The Energy sector (NFR sector 1) is the main contributor of $PM_{2.5}$ emissions. The trend is dependent on many sectors, however, it is worth noting the substantial decrease in emissions under the public electricity generation sector (1A1a).

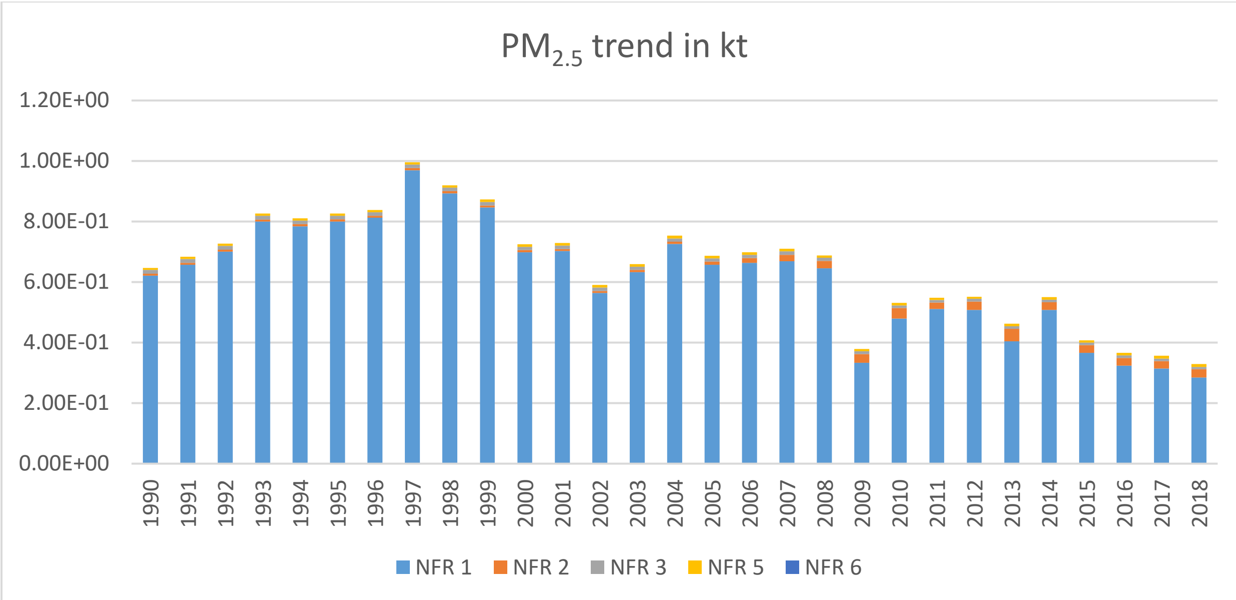

FIGURE 5: KEY TREND $PM_{2.5}$ IN KT

3. Energy (NFR 1)

This sector consists of categories from which fugitive or combustion emissions arise. The sub-categories estimated in this submission are listed below:

TABLE 2: NFR 1 ESTIMATED SECTORS

Aggregation	Sector	NFR code
Industry	Stationary combustion in manufacturing industries and construction; Other	1A2gviii
Aviation	International Aviation LTO (civil)	1A3ai(i),
	Domestic Aviation LTO (civil)	1A3ii(i)
Road transport	Passenger cars	1A3di
	Light duty vehicles	1A3dii
	Heavy duty vehicles and buses	1A3diii
	Mopeds and Motorcycles	1A3div
	Gasoline Evaporation	1A3dv
	Automobile tyre and Brake wear	1A3dvi
	Automobile road abrasion	1A3dvii
Shipping	National Navigation	1A3dii
Other Stationary Combustion	Commercial/Institutional: Stationary	1A4ai,
	Residential: Stationary	1A4bi
Off-road	Agriculture/forestry/Fishing: off-road vehicles and other machinery	1A4cii
Off-road	Agriculture/forestry/Fishing: National Fishing	1A4ciii
Fugitive	Distribution of oil products	1B2av

Furthermore, the notation key NO was used for the following sectors, as these sectors do not occur locally:

- 1A1b Petroleum refining
- 1A1c Manufacture of solid fuels and other energy industries
- 1A2a Stationary combustion in manufacturing industries and construction: Iron and steel
- 1A2b Stationary combustion in manufacturing industries and construction: Non-ferrous metals
- 1A2f Stationary combustion in manufacturing industries and construction: Non-metallic minerals
- 1A3c Railways
- 1A3di(ii) International inland waterways
- 1A3ei Pipeline transport
- 1A3eii Other (please specify in the IIR)
- 1A5a Other stationary (including military)
- 1A5b Other, Mobile (including military, land based and recreational boats)

- 1B1a Fugitive emission from solid fuels: Coal mining and handling
- 1B1b Fugitive emission from solid fuels: Solid fuel transformation
- 1B1c Other fugitive emissions from solid fuels
- 1B2ai Fugitive emissions oil: Exploration, production, transport
- 1B2aiv Fugitive emissions oil: Refining and storage
- 1B2b Fugitive emissions from natural gas (exploration, production, processing, transmission, storage, distribution and other)
- 1B2c Venting and flaring (oil, gas, combined oil and gas)
- 1B2d Other fugitive emissions from energy production

The pollutants covered in this chapter are NO_x, nmVOCs, SO_x, NH_3, $PM_{2.5}$, PM_{10}, TSP, BC, CO, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, PCDD/ PCDF, benzo(a) pyrene, benzo(b) fluoranthene, benzo(k) fluoranthene, Indeno (1,2,3-cd) pyrene, HCB, PCBs.

Of these pollutants, the energy sector is a key category for: NO_x, nmVOCs, SO_x, NH_3, $PM_{2.5}$, PM_{10}, TSP, BC, CO, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, benzo(a) pyrene, benzo(b) fluoranthene, benzo(k) fluoranthene, Indeno (1,2,3-cd) pyrene.

The relevant pollutant trends for key categories, as well as the methodologies used, are explained in the sections below:

1A1a: Public Electricity and heat production

NFR-Code	Name of sub-Category	Method	Activity Data	EF	Key Category	Year of last update
1A1a	Power Generation and Electricity Production	2019GB	AER & Eurostat	Tier 1, Tier 2, & Tier 3 (direct measurements)	Hg, As	2020 submission

Emissions estimated from this sector originated from the three companies responsible for the generation of electricity from different fossil fuels and were reported under NFR code 1.A.1a. Reported emission estimates were calculated either through the procedure outlined in the 2019GB or obtained directly through continuous emission monitoring systems (CEMS) for the year 2018.

The time series was updated for this submission, as emissions from 1990-2004 were estimated for the first time. These years were calculated through a Tier 1 methodology, by multiplying the total fuel by type, as found within the Eurostat Energy Balance, with the respective EF found within the 2019GB. Furthermore, emissions were also reported for projected years 2020, 2025 and 2030 for both the WM and WaM scenarios based on the latest fuel projections carried out by EWA.

Malta's electricity production has mostly relied on Heavy Fuel Oil (HFO) and Gasoil, with a small amount of coal utilized until 1995. However, a major change in local electricity production took place in 2017, with the introduction of two privately owned power plants running on natural gas; *Electrogas Malta* (EGM) and *D3 Power Generation Limited (D3pg*). Both plants joined Enemalta, i.e. the state owned energy producer, in the local production of electricity. Moreover, Enemalta also operates another power plant in Marsa, which contains one operating gas turbine (MPS5). This turbine is on standby and it is only permitted to operate for testing or emergency purposes. HFO was fully phased out in 2018.

The table below shows the set-up of the electricity generating plants present locally during 2018:

TABLE 3: SET-UP OF ELECTRICITY GENERATING PLANTS

Operator	Plant	Technology	Fuel
Electrogas Malta	CCGT 1	Combined Cycle Gas Turbines	Natural gas
	CCGT 2	Combined Cycle Gas Turbines	
	CCGT 3	Combined Cycle Gas Turbines	
Enemalta	DPS1	steam turbine (it was fully decommissioned by 2018)	HFO
	DPS2	gas turbine	Gasoil
	DPS3	gas turbine	
	DPS4	gas turbine	
	DPS5	gas turbine	
	DPS6 A	diesel engines	HFO/Gasoil

	DPS6 B	diesel engines	HFO/Gasoil
	MPS 5	gas turbine	Gasoil
D3pg (D3 Power Generation Limited)	DPS6 C	diesel engines	Natural gas/ Gasoil
	DPS6 D	diesel engines	
	DPS6 A	diesel engines	Natural gas
	DPS6 B	diesel engines	

In addition to gaseous and liquid fuel plants; the interconnector (electricity imported to Malta from mainland Europe); and renewable energy sources, such as photovoltaic (PV) cells, supply the remaining electricity entering the grid. The introduction of the interconnector in 2015, naturally decreased the amount of gasoil and HFO used. The share of electricity coming from the interconnector increased in 2016, and then decreased from 2017 onwards. Contribution from PVs in 2016 was very similar to that of 2017 and 2018.

The historical percentage share of the energy mix from 2013 to 2018 and the projected percentage share i.e. 2020, 2025 and 2030, can be observed below:

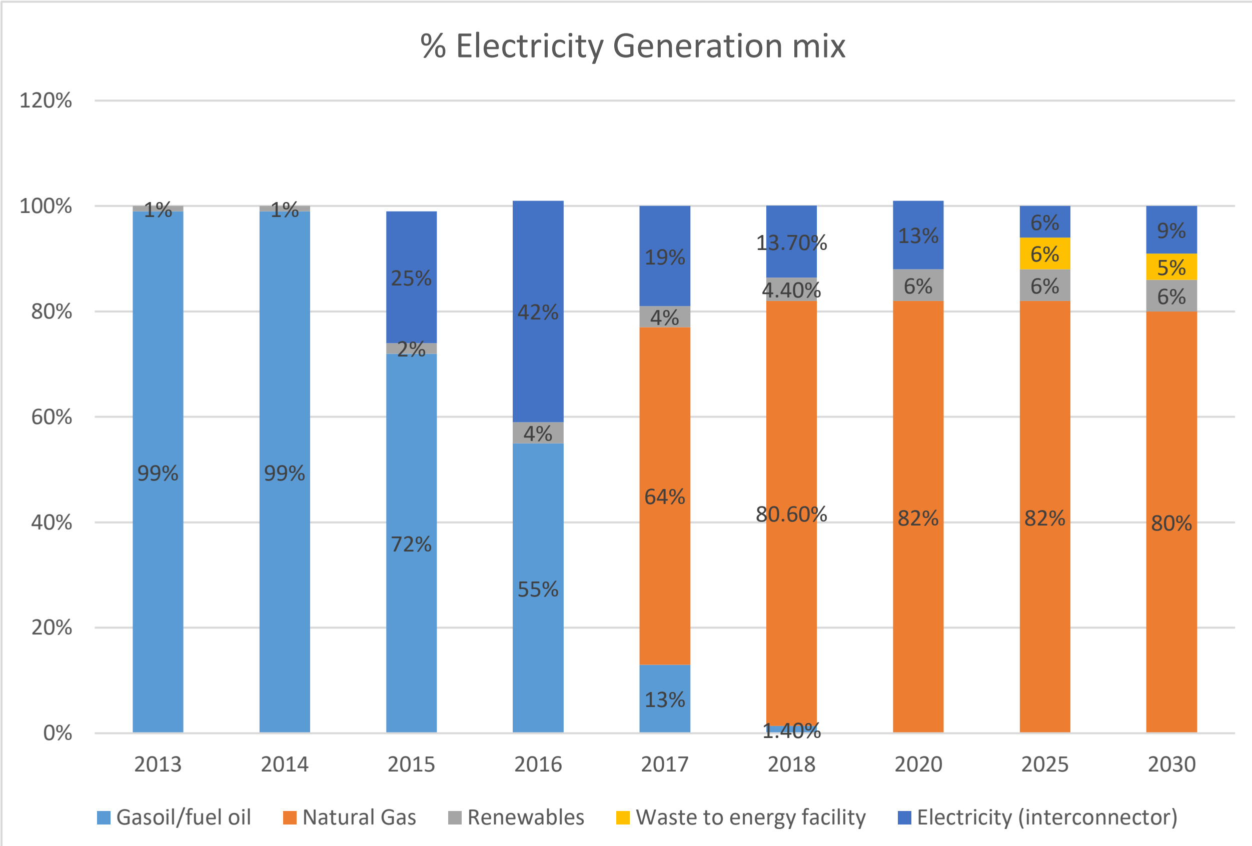

FIGURE 6: PERCENTAGE CONTRIBUTION OF ELECTRICITY SOURCE UNDER WAM SCENARIO (EWA)

The activity data for the four plants was obtained from the annual environment reports (AERs) submitted by Enemalta, Electrogas and D3 Power Generation Limited, as part of their obligations under the Industrial Emissions Directive.

NO_x, SO_x, and TSP emissions from D3 Power Generation Limited (D3pg), Delimara, and EGM were measured through CEMS and reported in their respective AER. Prior to 2017, the total emissions from As, Cr, Cd, Cu, Mn, Ni, Pb, Sb, and V were placed under Pb. This approach was preferred to the Tier 2 methodology within the 2019GB, as the emission estimates would have been severely overestimated. However, since the fuel used was changed in 2017, a Tier 2 methodology was used. The remaining pollutants were estimated through default factors obtained from the 2019GB.

Regarding projections, new fuel projected data was made available from the EWA. The only fuel type projected for future years was natural gas, as it was assumed that the Enemalta power station (running on GDO) will only be used in case of emergency. The main plants for producing electricity, namely EGM and D3pg, use natural gas. The emissions from NO_x, TSP, SO_x, CO, and heavy metals were projected by multiplying the projected fuel used by the country-specific EF for each plant. The remaining pollutants are calculated through a tier 2 methodology.

The graph below shows the trend of historical and projected fuel consumption in TJ. It is worth noting that source of fuel consumption differs as follows:

- fuel consumption from 1990-2004 is provided from Eurostat
- fuel consumption from 2005-2018 is provided by summing up data from each facility
- projected fuel consumption is provided by EWA

The difference in projected fuel consumption between the WM and WaM scenario is attributed to the use of renewable energy sources. The graph below clearly shows very little difference between both scenarios.

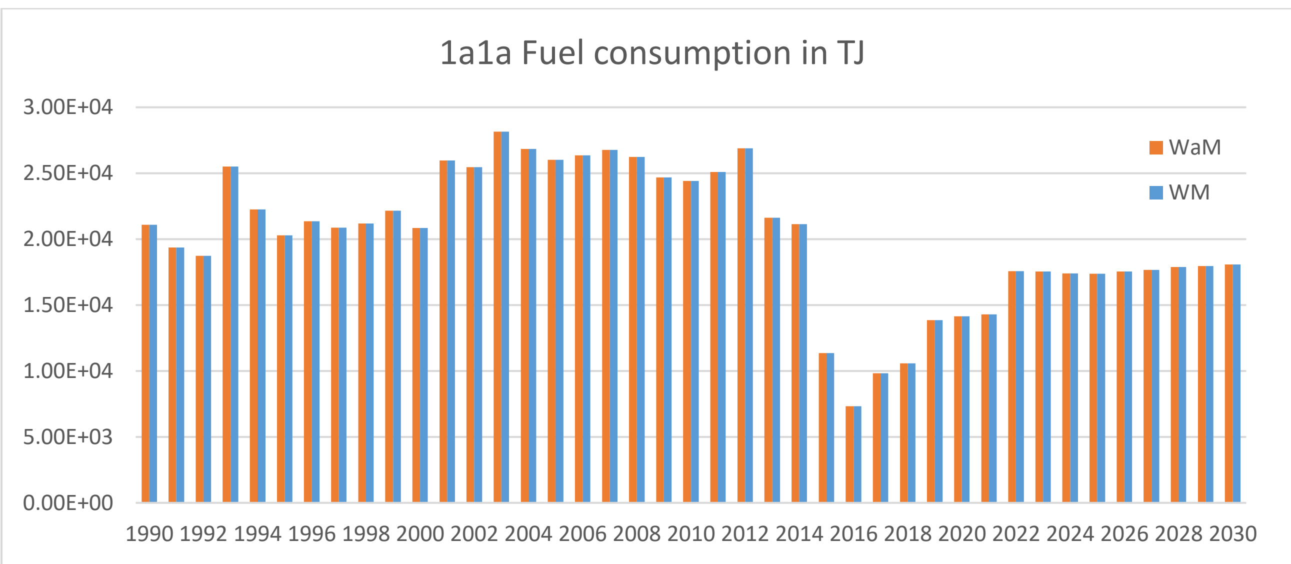

FIGURE 7: 1A1A HISTORICAL AND PROJECTED FUEL CONSUMPTION IN TJ (WM AND WAM)

The graphs below show the trend of emissions across the time series, 1990 to 2030:

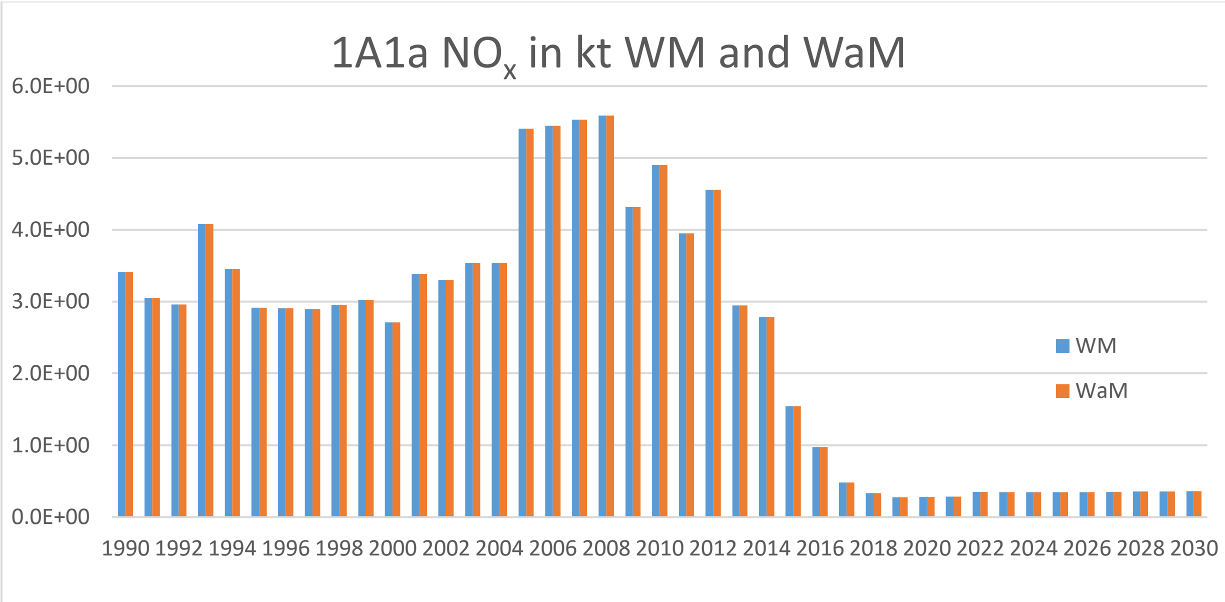

FIGURE 8: 1A1A NO_x IN KT TIME SERIES (WM AND WAM)

There has been an overall decrease in emissions with regards to NO_x, and this is most likely due to more efficient technologies, the use of the interconnector, and the use of SCR at the Delimara power station (DPS6) and D3pg. The contribution of liquid fuel combustion decreased significantly from 2017 to 2018, as most of the energy was produced at the two natural gas power stations, i.e. EGM and D3pg. This shift in fuel helps explain the decrease in NO_x emissions.

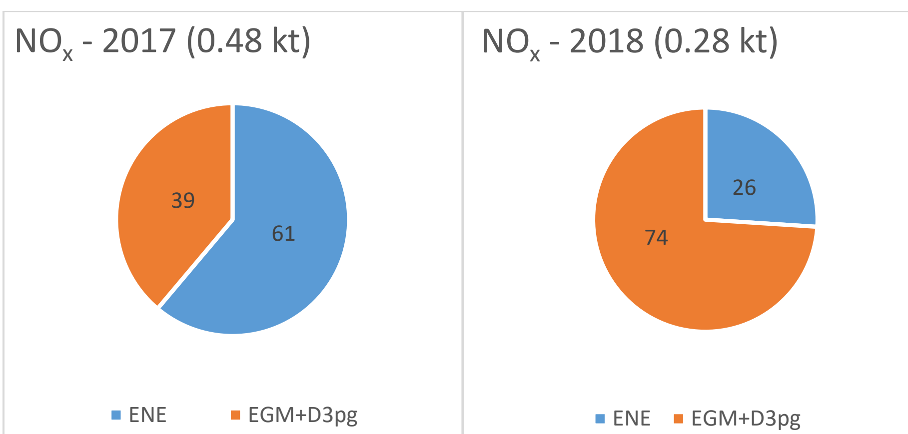

FIGURE 9: PERCENTAGE CONTRIBUTION OF NO_x FROM DIFFERENT ELECTRICITY GENERATING PLANTS.

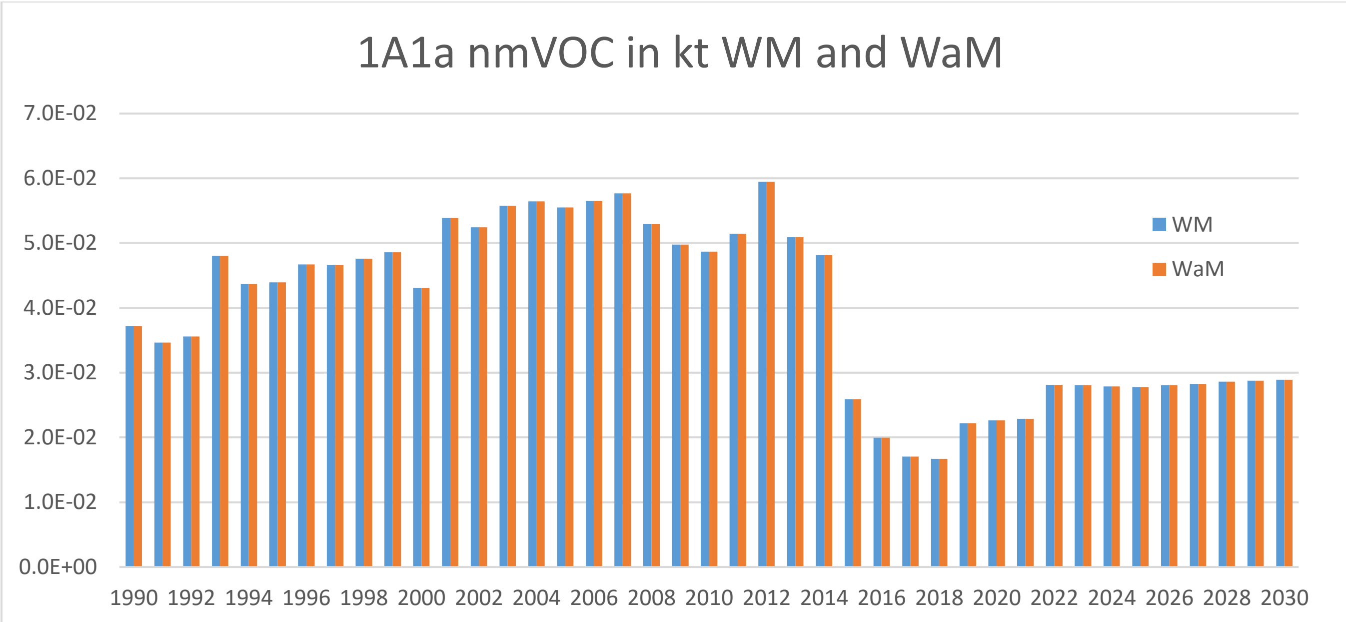

FIGURE 10: 1A1A NMVOC IN KT (WM AND WAM)

The time series shows an overall decrease in nmVOC emissions from 2013 until 2017, with an increasing trend till 2022, and then a constant trend until 2030. This was estimated from default factors hence emissions were directly proportional to activity or fuel consumed in GJ.

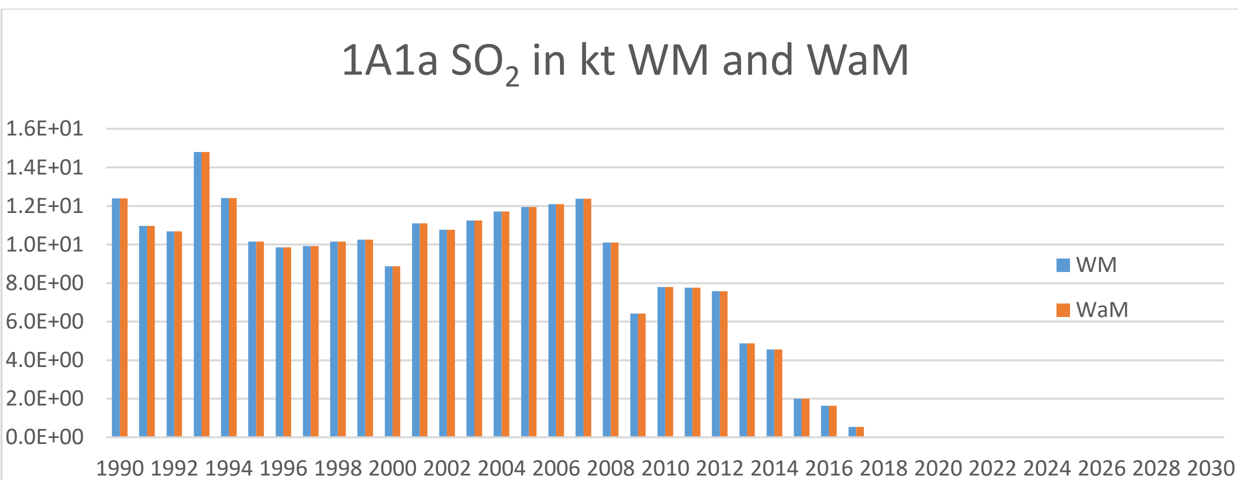

FIGURE 11: 1A1A SO_x IN KT (WM AND WAM)

From 2005 onwards, SO_x emission loads were provided directly by the facilities. The graph shows a drastic decrease in emissions along the years. The introduction of the interconnector, and the shift to natural gas, have reduced SO_x emissions to such an extent that this sector is no longer a key category for SO_x

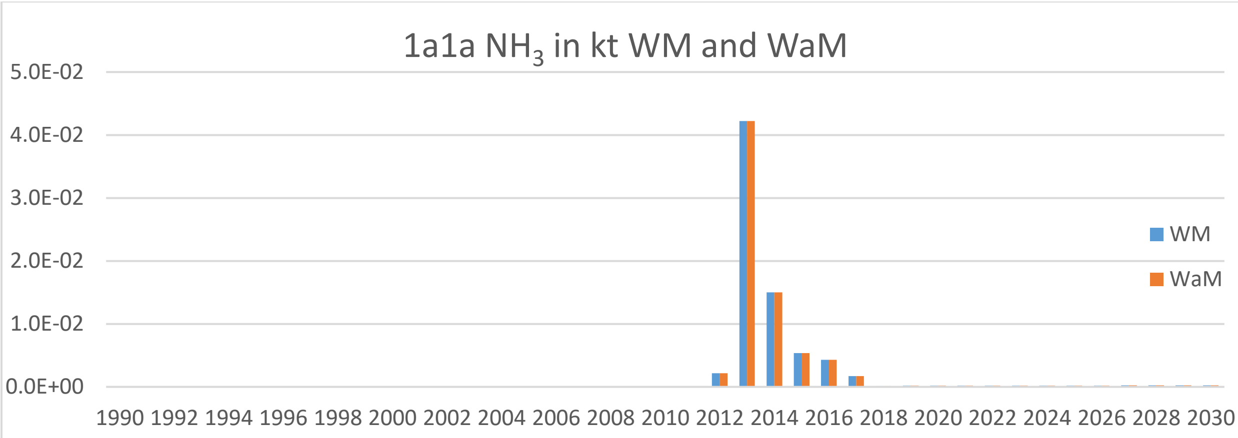

FIGURE 12: 1A1A NH_3 IN KT (WM AND WAM)

Selective catalytic reduction was present at the Delimara power station since 2012 but not available in any other plants. The high annual average of ammonia concentration recorded in 2013 was due to spent catalyst in NO_x abatement. An additional layer of new catalyst was installed and values were back to normal. This technology is currently present at the D3pg facility.

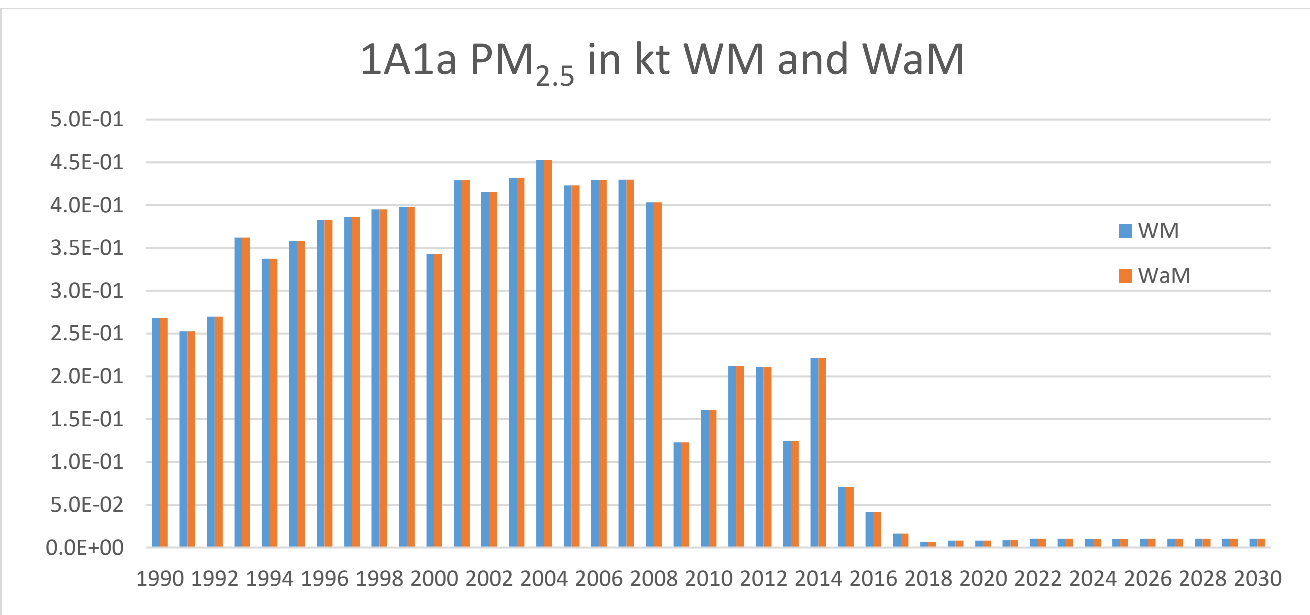

FIGURE 13: 1A1A $PM_{2.5}$ IN KT (WM AND WAM)

The trend in $PM_{2.5}$ emissions shows a substantial decrease of emissions from 2014 onwards, which could be linked to the introduction of the interconnector, and the subsequent change in fuel.

1A2gviii: Stationary Combustion in Manufacturing Industries and Construction

NFR-Code	Name of sub-Category	Method	Activity Data	EF	Key Category for pollutants	Year of last update
1A2gviii	Stationary Combustion in Manufacturing Industries and Construction: Other	2019GB	Eurostat	Tier 1	SO_x, benzo(b)fluoranthene	2020 submission

Emissions from 'Stationary Combustion in Manufacturing Industries and Construction' were reported under group sector 1A.2.g.viii. In this submission, the activity data was changed from the national fuel survey to the Eurostat Energy Balance.

Projected data was supplied by the Energy & Water Agency (EWA), as fuel use in Industry for the period 2019-2030.

The graph below shows the trend of fuel consumption for the historical and projected time series:

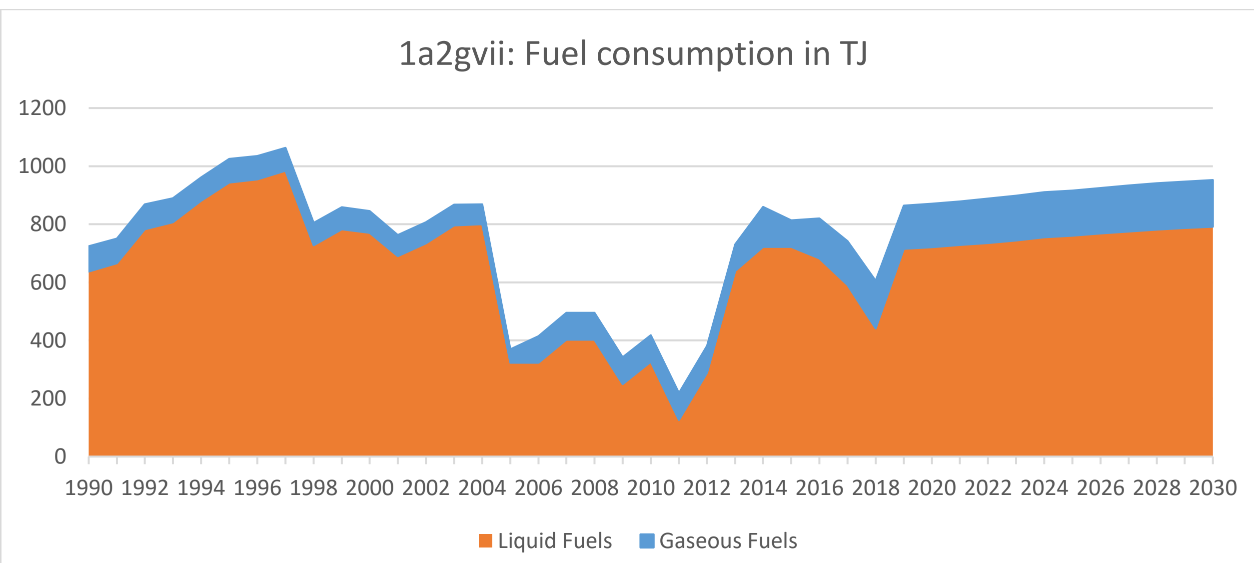

FIGURE 14: 1A2VGIII: FUEL CONSUMPTION IN TJ

As expected, emissions calculated show the same trend as that of fuel consumption. The percentage sulphur content obtained from the Regulator for Energy and Water Services (REWS) was used to estimate SO_x for some years and fuels. Data was available for 2014 to 2018. The average sulphur content from 2014 to 2018 was used prior to 2014.

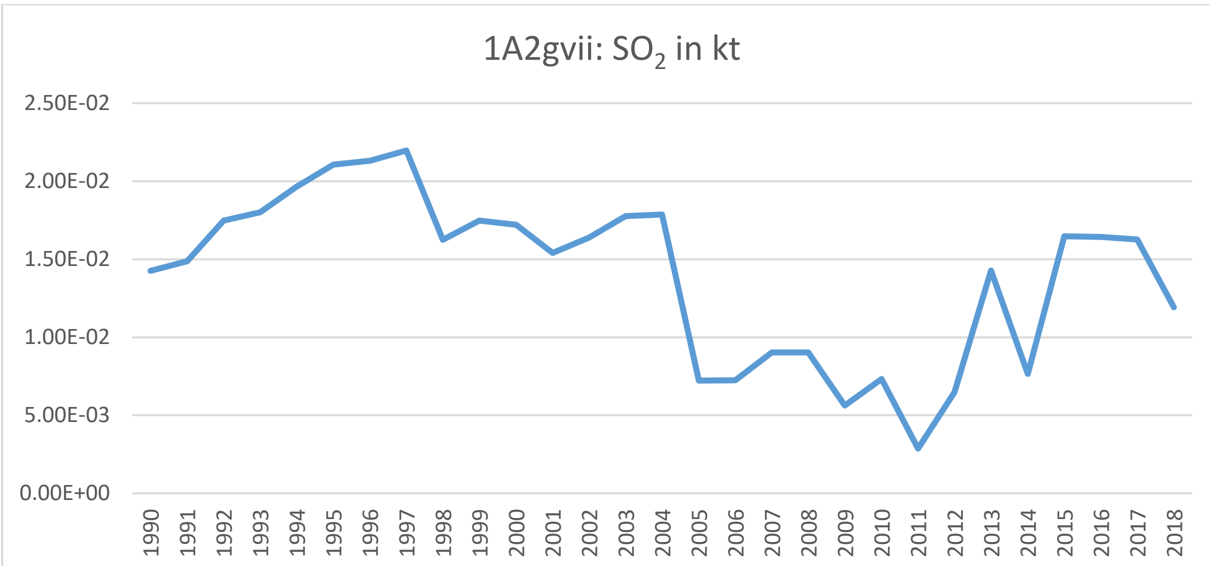

FIGURE 15: 1A2VGIII: SO_x (AS SO_2) IN KT

It is worth noting that NH_3 was not estimated, since no information on availability of selective catalytic reduction equipment was available.

1A3. Transport

The transport sector covered in this submission includes the following group of sectors; 1A3ai(i) International aviation LTO (civil), 1A3aii(i) Domestic aviation LTO (civil), 1A3bi-bvii Road transport and 1A3dii National navigation (shipping).

1A3a Aviation

NFR-Code	Name of sub-Category	Method	Activity Data Source	EF	Key Category for pollutants	Year of last update
1A3a	Domestic Aviation LTO (civil), International Aviation LTO (civil)	Master emissions calculator	Malta International Airport	Master emissions calculator (EUROCONTROL)	NO_x, SO_x, CO	2020 submission

Emissions were calculated separately for each of the following categories; Domestic Aviation LTO (civil) 1A3ai(i) and International Aviation LTO (civil) 1A3ii(i).

Domestic LTO is defined as the number of flights performed locally by flight schools and other trips around the Maltese Islands for leisure. All other flights, which departed from the Luqa international airport to land in foreign airports were considered as international.

This submission includes historical emissions of the time series ranging from 1990 to 2018. The only airport present on the island i.e. Malta International Airport (MIA) provided the number of LTO cycles split into domestic and international flights for 1999 to 2018 for each aircraft model. Furthermore, the number of LTO cycles for international flights from 1990 to 1998 was provided by the Civil Aviation Department at Transport Malta. No activity data was available for domestic flights prior to 1999, and consequently emissions from 1990 to 1998 were classified as 'NE'. The graph below provides a breakdown of domestic and international flights across the time series:

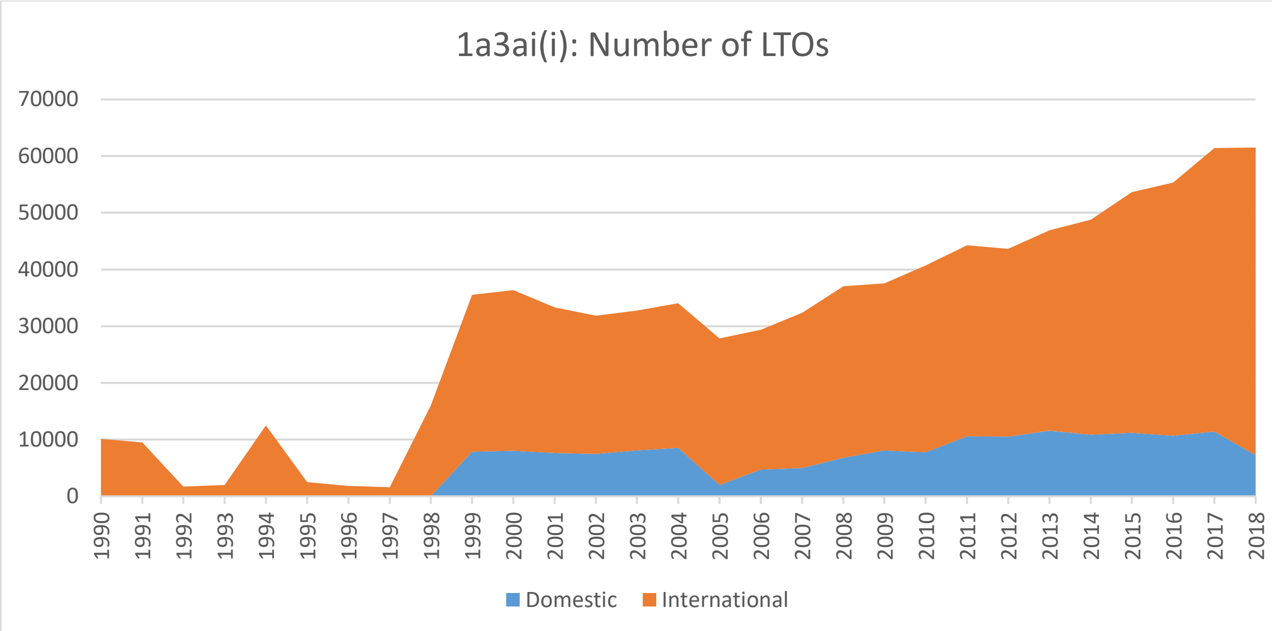

FIGURE 16: 1A3AI(I): NUMBER OF LTOS

Emissions factors were extracted from the model developed by EUROCONTROL known as 'Master emission calculator' and multiplied with the number of LTOs.

The emission factors were based on the following parameters:

TABLE 4: ICAO DEFAULT PARAMETERS

Phases	ICAO default
Taxi	00:26:00
Take off	00:00:42
Climb out	00:02:12
Approach	00:04:00
TOTAL	**00:32:54**

The emission factors sourced from the EMEP/EEA model were specific for certain pollutants (NO_x, SO_x, nmVOC, PM and CO) for only certain types of aircraft models. Hence, since a considerable number of emission factors associated with domestic and international flights are missing across the time series.

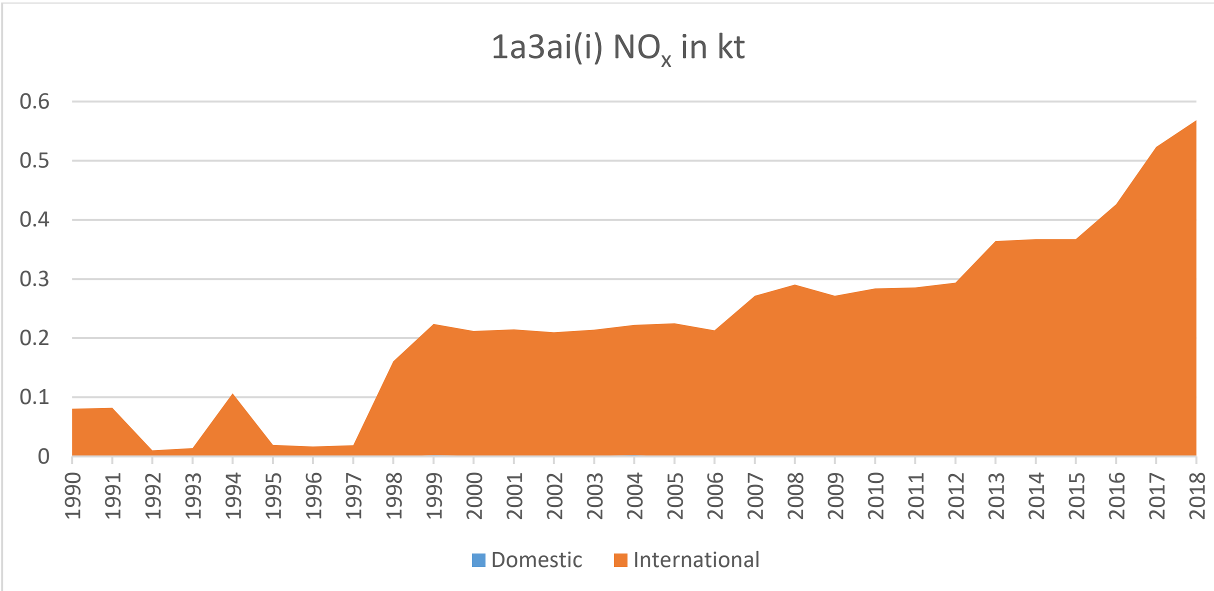

FIGURE 17: 1A3AI(I): DOMESTIC AND INTERNATIONAL NO_x IN KT

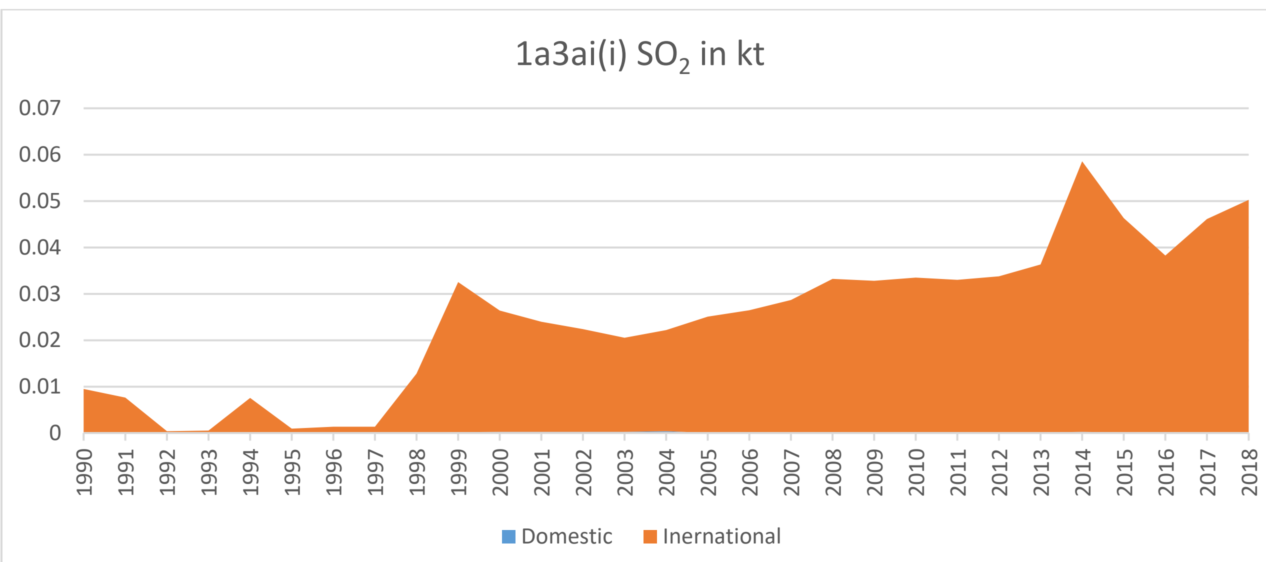

FIGURE 18: 1A3AI(I): DOMESTIC SO_x IN KT

International aviation is clearly the major source of emissions from the aviation industry for each pollutant since the degree of activity (LTOs) is much higher than that of domestic aviation.

Concerning projections, the total number of LTOs was not available. Therefore the projected fuel use in aviation provided by the Energy & Water Agency (EWA) was used. The percentage increase in fuel used was applied to LTOs, such that LTOs would increase in line with the projected fuel use.

1A3b: Road Transport

NFR-Code	Name of sub-Category	Method	Activity Data Source	EF	Key Category for pollutants	Year of last update
1A3b	Road Transport	COPERT 5.3	EWA, TM, REWS, MRA	Tier 3	NO_x, nmVOC, NH_3, $PM_{2.5}$, PM_{10}, TSP, BC, CO, Pb, Hg, Cr, Cu, Se, Zn, Benzo(a)pyrene, Benzo(b)flouranthene, Benzo(k)flouranthene, Indeno (1,2,3-cd) pyrene	2020 submission

Emissions from motorised road vehicles in Malta were reported under group sector, 1A.3.b. Emissions estimated under this sector were based on the vehicle fleet circulating on public roads, excluding agricultural and military transport.

Emissions were calculated for each of the following categories:

- 1A.3.bi, Passenger Cars;
- 1A.3.bii, Light Duty Vehicles;
- 1A.3.biii, Heavy-Duty Vehicles and Buses;
- 1A.3.biv, Mopeds and Motorcycles;
- 1A.3.b.v, Gasoline Evaporation;
- 1A.3.b.vi, Tyre & brake Wear;
- 1.A.3.b.vii, Road Surface Abrasion

In this submission, road transport emissions were estimated by means of COPERT 5.3 for the years 1990-2018.

The updated parameters are listed in the table below:

TABLE 5: COPERT PARAMETERS USED

Parameters used for historical input parameters	Source of parameters used
Environmental Information	Data was obtained from the climate change team at MRA, who obtained the data from the National Meteorological Office
Trip Characteristics (average trip duration and average trip length)	Transport Malta (TM) – National Transport Model
Fuel Specification	• 1990-2003: Values for 2004 for diesel, and 2005 for petrol, were carried backwards. • 2004-2007: Reporting under Directive 98/70/EC, provided by the Malta Resources Authority (MRA). • 2008-2013: These values were extrapolated. • 2014-2018: Percentage sulphur content in fuel was obtained from the Regulator of Energy and Water Services (REWS). • 2019-2030: Average percentage sulphur content from 2014-2017 was used.
Statistical consumption	Eurostat
Reid Vapour Pressure	COPERT 5 Default figure – EMISIA S.A
Stock and Activity	• 1990 to 2009: Data from the climate change team at MRA was used for both stock and total mileage. • 2010 to 2030: Model developed by the Energy and Water Agency generated historical and projected data for both stock and total mileage
Circulation (Average speed and percentage mileage share per road type)	Transport Malta (TM)
Fuel blend	Regulator for Energy and Water Services; E0 and B7
Lifetime cumulative mileage	Energy and Water Agency

Load and road slope	Are assumed to be 50% and 0% respectively, since no actual data was available

Circulation data was provided by TM. Each of the road types in COPERT (urban, rural, and highway) have both a speed and a respective mileage share driven. TM also provided both morning and evening peak hour speed data for every road type. No distinction was made between different vehicle types since the information was not available at this level of detail.

The table below presents the data inputted into COPERT:

TABLE 6: CIRCULATION DATA

urban peak % share	urban off peak % share	rural % share	highway % share	urban peak speed km/hr	urban off peak speed km/hr	rural speed km/hr	highway speed km/hr
6	38	21	35	15.6	16.8	13.2	53.3

Other parameters included in COPERT such as average trip length and distance, were obtained from the national road transport model and kept the same for all projected years and scenarios, since no better data was available.

As described in Table 5, the sulphur content was only available for a limited number of years. The 2004 value for diesel was carried backwards, since the limits for sulphur content under Directive 98/70/EC were revised in 2005, and therefore values from 2005-2007 would not be representative of data which pre-dates 2004. The sulphur content in petrol for 2004 was not available, and therefore the value from 2005 was carried backwards to 1990. A linear extrapolation was used between 2008 and 2013, and an average for the data from 2014-2018 was used for projected data. The sulphur content of petrol and diesel can be observed in Figures 19 and 20 below.

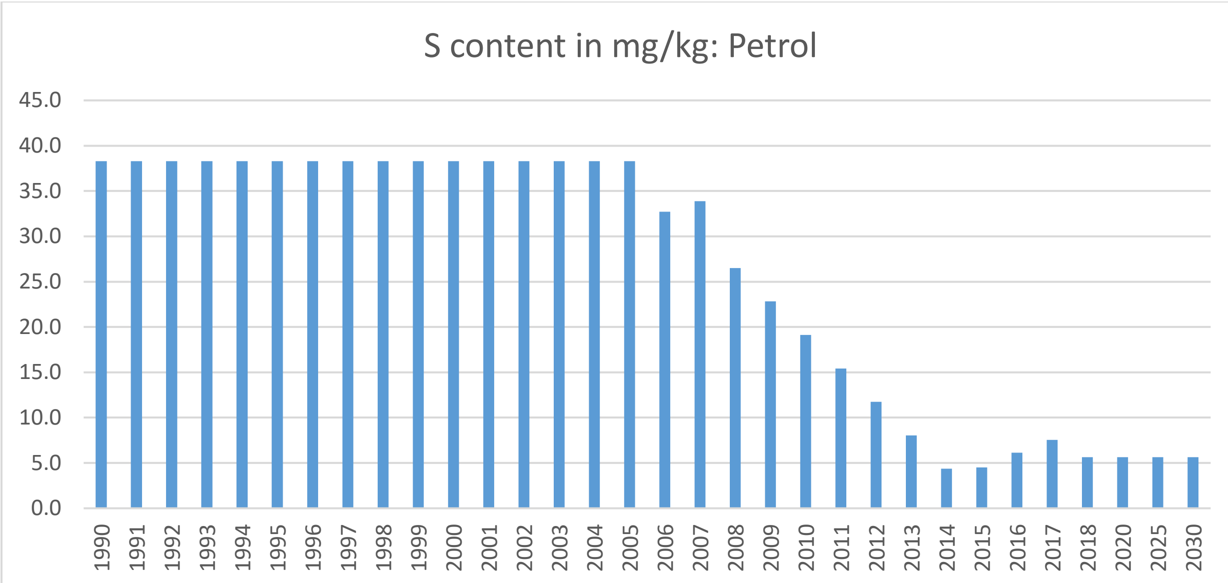

FIGURE 19: SULPHUR CONTENT IN MG/KG IN PETROL

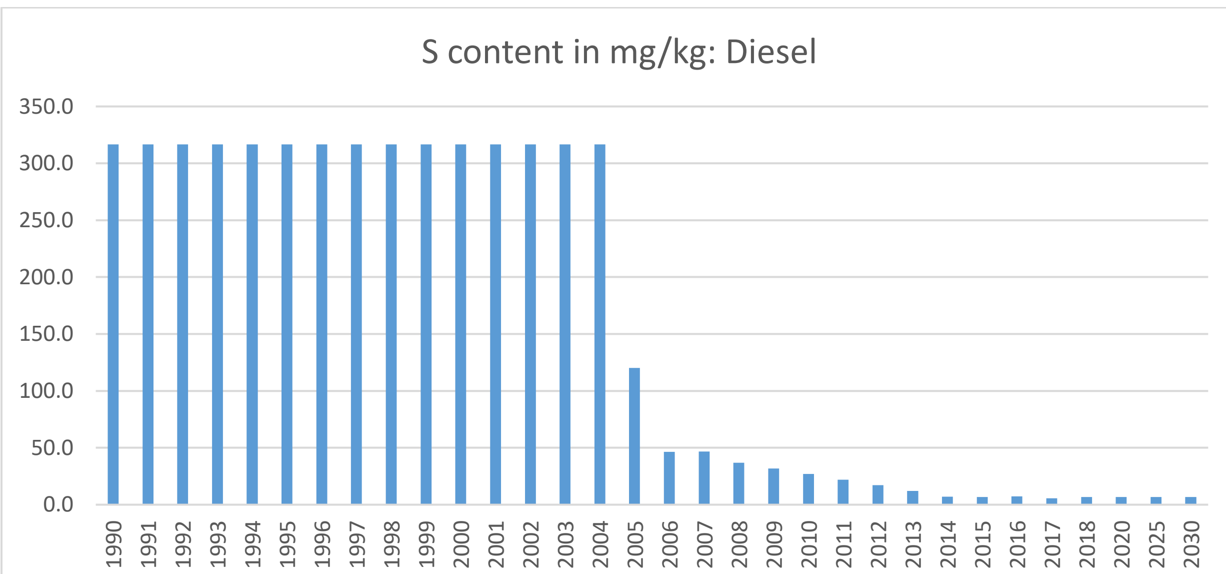

FIGURE 20: SULPHUR CONTENT IN MG/KG IN DIESEL

The fuel balance function was checked for the years 1990-2009, as data related to stock and statistical consumption was more representative of the local scenario than the actual mileage. From 2010 onwards, the fuel balance function was not checked, as the actual mileage data was considered sufficiently representative of the real scenario. SCR, A/C usage and mileage degradation functions were checked and default factors were used when running the model with the above input parameters.

Historical fuel consumption was provided through the Eurostat Energy Balance, whereas projected fuel consumption was provided by the EWA. This data consisted of consumption of petrol, diesel, biodiesel and LPG. However, only petrol and diesel were projected for the WM scenario, while petrol, diesel and biofuels were projected for the WAM scenario. The decision to extend the substitution of conventional fuels through the use of biofuel was taken after 2017, and therefore such a consideration could only apply for the WaM scenario. The graphs below show the fuel mix projected both for the WM and WaM scenario:

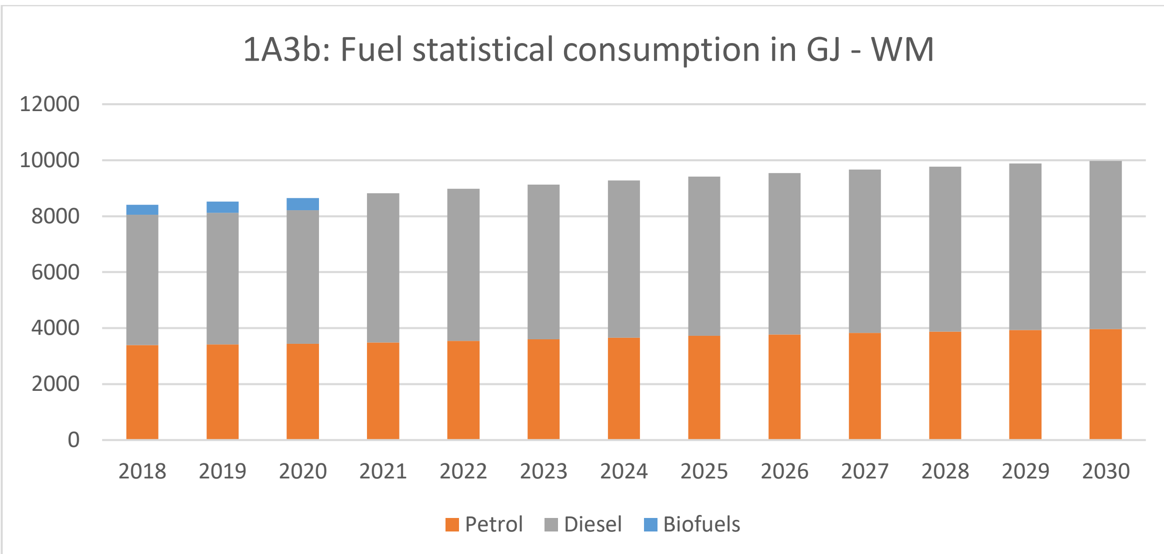

FIGURE 21: 1A3B: FUEL STATISTICAL CONSUMPTION IN TJ - WM

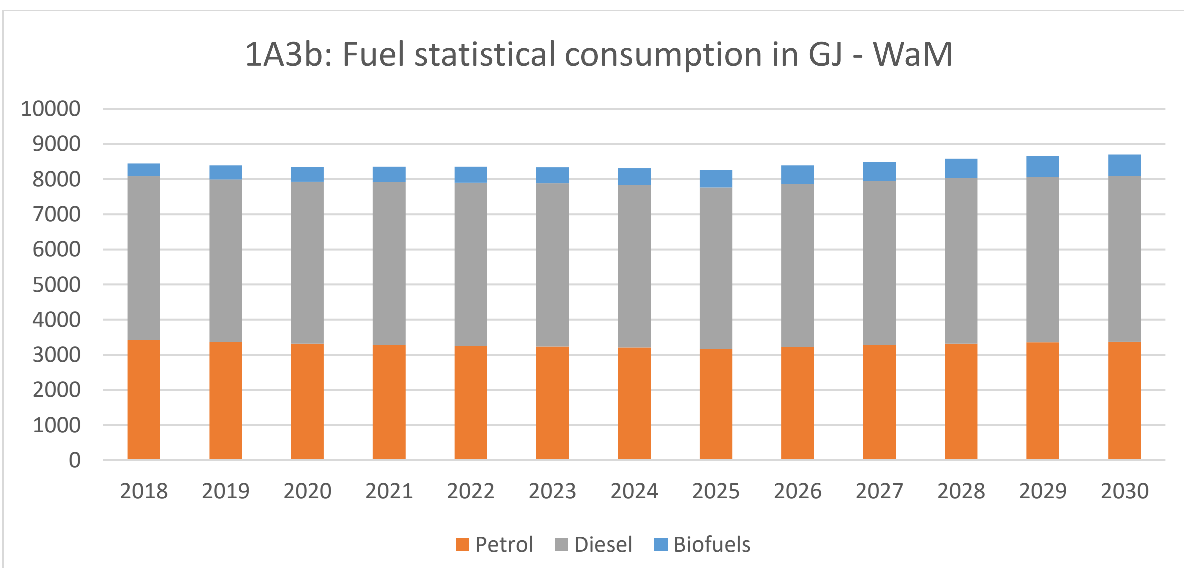

FIGURE30: 1A3B: FUEL STATISTICAL CONSUMPTION IN TJ - WAM

The following text is a summary of the procedure followed by the EWA to generate the stock and mileage databases from NSO data. This information was sourced from the Methodological Note of the road transport model developed by the EWA:

Annual Average vehicle per km (vkm)

The 2017 - 2018 VRT (Vehicle Roadworthiness Testing) data provided by NSO to EWA included vkm data. This data was used to determine the annual mean mileage a vehicle is expected to drive, based on its year of manufacture. A database was generated with the total mileage of each car aged between 4 and 100 years. Outliers were eliminated, and data on vehicles older than 25 years was ignored, as the sample size was not significant. Furthermore, vehicles under 5 years of age were not subject to a VRT. Hence, a constant vkm figure was used for these vehicles. The resulting normalized plot indicated that as a vehicle gets older, the respective annual mileage decreases.

The cumulative mileage was calculated by summing up the annual mean mileage of each year the vehicle has been on the road.

Total vehicle kilometres

Moreover, total vkm were projected for each of the five major vehicle categories. These projections made use of historical information to estimate the elasticity of total vkm of each vehicle type against a macroeconomic indicator.

TABLE 7: MACROECONOMIC DRIVERS USED TO PROJECT VKM

Vehicle category	Macroeconomic driver to estimate total vkm
New PC	Population
New LDV	Wholesale and Retail GVA
New HCV	Wholesale, Retail and construction GVA
New MC&QUAD (L-category)	Population
New Buses	MB: Population (4 -15 years) CPB: Inbound tourists (Air passengers)

	RB: No driver used

The total mileage of each of the five vehicle types between 2018 and 2040 was estimated using the following equation;

$$VKM_t = VKM_{t-1} + (1 \times m \times g_t)$$

EQUATION 2: EQUATION TO ESTIMATE TOTAL MILEAGE BY VEHICLE TYPE

Where:

- VKM_t = The estimate of total VKM driven by a vehicle category at period *t*;
- VKM_{t-1} = The estimate of total VKM driven by a vehicle category at period *t-1*;
- m = The elasticity of total VKM of a vehicle category against a macroeconomic indicator which is expected to drive the demand for that vehicle's use;
- g_t = annual growth rate of the indicator between period *t-1* and *t*

The model was used to estimate annual vkm between 2010 and 2017 for each vehicle category. The resultant data was used to calibrate the model against energy balance statistics. The projected vkm for 2018 - 2040 was considered to be equivalent to the demand to be matched by what remains of the stock as at end of 2017.

Stock of vehicles

Vehicle stock data was provided by NSO for the five main vehicle categories (Passenger cars, Light Duty Vehicles, Heavy Duty Vehicles, Buses, and L-categories) and aggregated by fuel type and year of manufacture (YOM). The stock profile of the 2010-2017 database was extracted and used to create a survival profile for each vehicle type using the below equation:

$$Survival\ rate_v = Average\left(\frac{Stock_v - Stock_{v-1}}{Stock_v}\right) * (1 + Survival\ rate_{v-1})$$

EQUATION 3: EQUATION FOR THE SURVIVAL RATE PROFILE OF VEHICLES

v = vehicle's age

The survival profile was used to generate both historical and projected stock. The number of new vehicles being introduced on the market was estimated by finding the difference between the total vehicle demand and the actual service demand provided by the existing stock.

Further manipulation of data was required to organize data into COPERT format:

- Each subcategory was further broken down into the respective Euro standards based on the year of manufacture of the vehicle.
- The total mileage generated for each vehicle category was multiplied with the mileage share of each sub-category aggregated by Euro standard of the vehicle stock reported in 2017. The list of sub-categories can be found below:

TABLE 8: VEHICLE SUB-CATEGORIES

Vehicle category	COPERT classification
Passenger Cars	Small (0.8 - 1.4L)
	Medium (1.4-2.0L)
	Large (Large (>2.0L)
Light Commercial Vehicles	N1-I (GVW<=1305kg)
	N1-II (1305kg<GVW<=1760kg)
	N1-III (1760kg<GVW<=3500kg)
Heavy Commercial Vehicles	Rigid <=7,5 t
	Rigid 7,5 - 12 t
	Rigid 12 - 14 t
	Rigid > 14 t
L-Category	Motorcycles < 50 cm^3
	Motorcycles > 50 cm^3
	Motorcycles < 250 cm^3
	Quad and ATVs
Buses	Coaches Standard <=18 t
	Urban Buses Standard 15-18 t
	Urban Buses Midi <=15 t

- The total mileage of each sub-category aggregated per Euro standard was divided by the stock to get the average annual vkm.

The following section provides a set of graphs to help illustrate the historical and projected trends related to road transport. As a general note, the main parameters affecting changes within COPERT are, for the most part, related to changes in:

- total vehicle kilometres

- speed (this is constant – therefore was not a variable)
- fuel consumption
- stock – including the penetration of new vehicle technologies with lower emission levels

Concerning NO_x, the graphs below show that NO_x emissions have remained mostly stable post-2010, i.e. when EWA data is used. There is also a projected decrease under both WM and WaM scenarios.

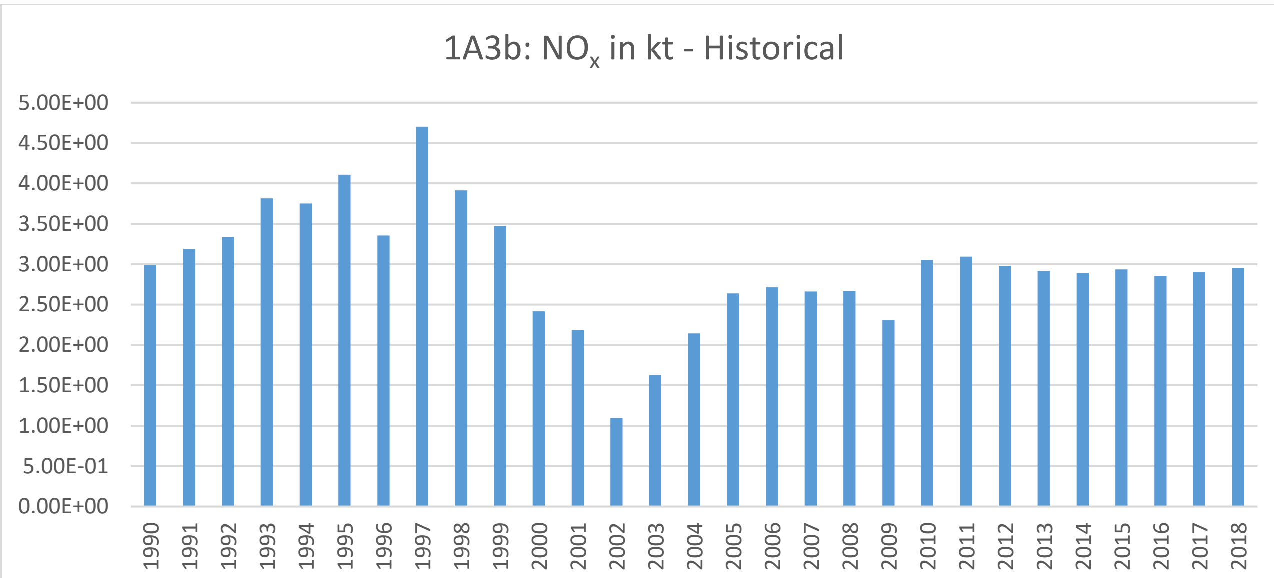

FIGURE 22: 1A3B: NO_x IN KT - HISTORICAL

FIGURE 23: 1A3B: NO_x IN KT FOR 2018, 2020, 2025, 2030 (WM AND WAM)

The graphs below for nmVOC show a decreasing trend across both the historical and projected time series, under both WM and WaM scenarios.

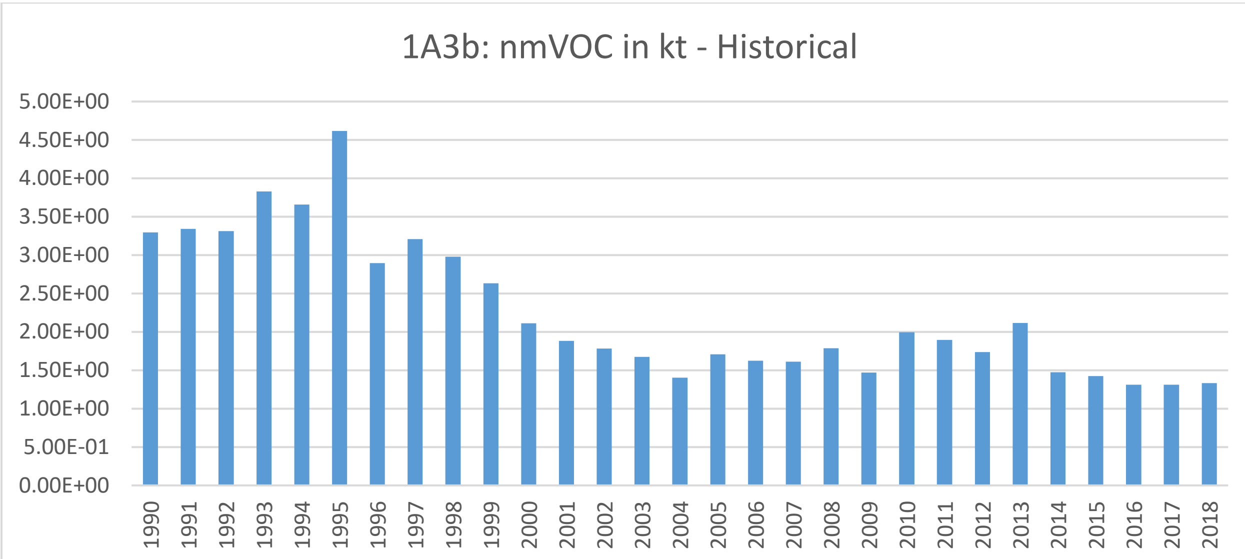

FIGURE 24: 1A3B: NMVOC IN KT - HISTORICAL

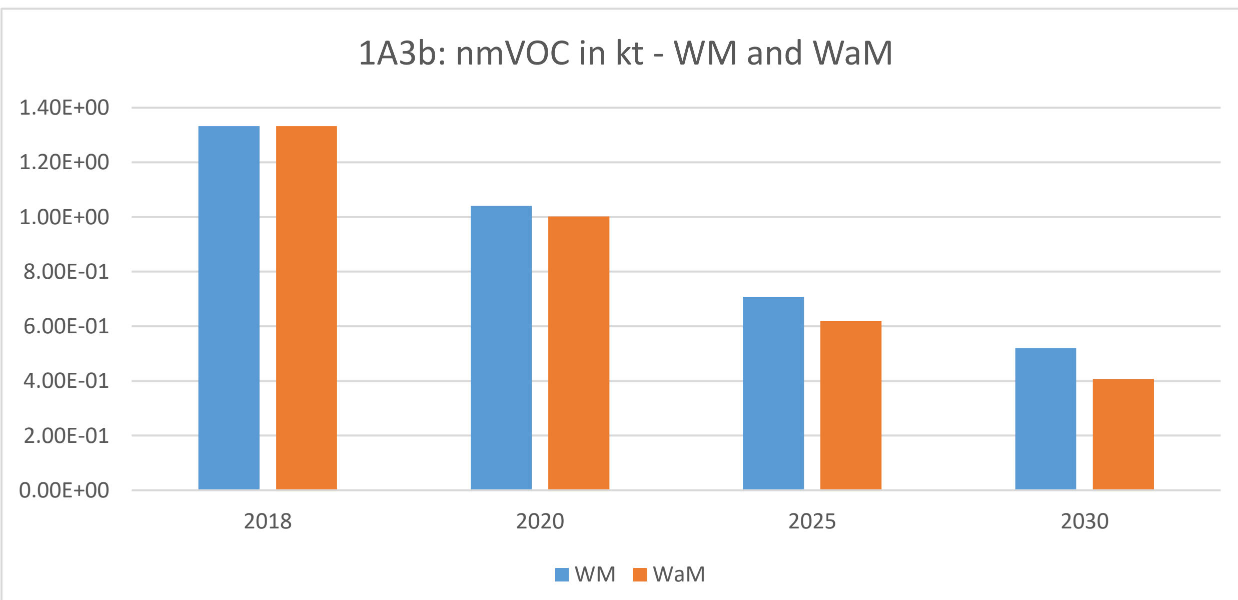

FIGURE 25: 1A3B: NMVOC IN KT FOR 2018, 2020, 2025, 2030 (WM AND WAM)

The graphs below show a decreasing trend in SO_x emissions for both historical and projected emissions, closely following the trend of sulphur in fuels presented in Figures 19 and 20.

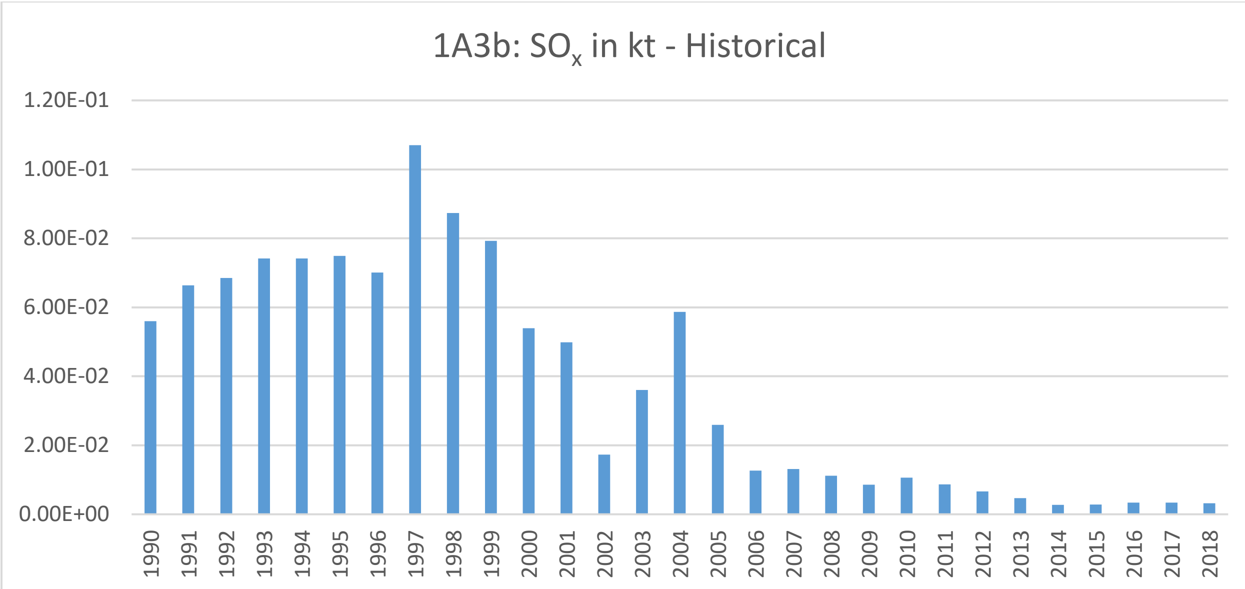

FIGURE 26: 1A3B: SO_X IN KT - HISTORICAL

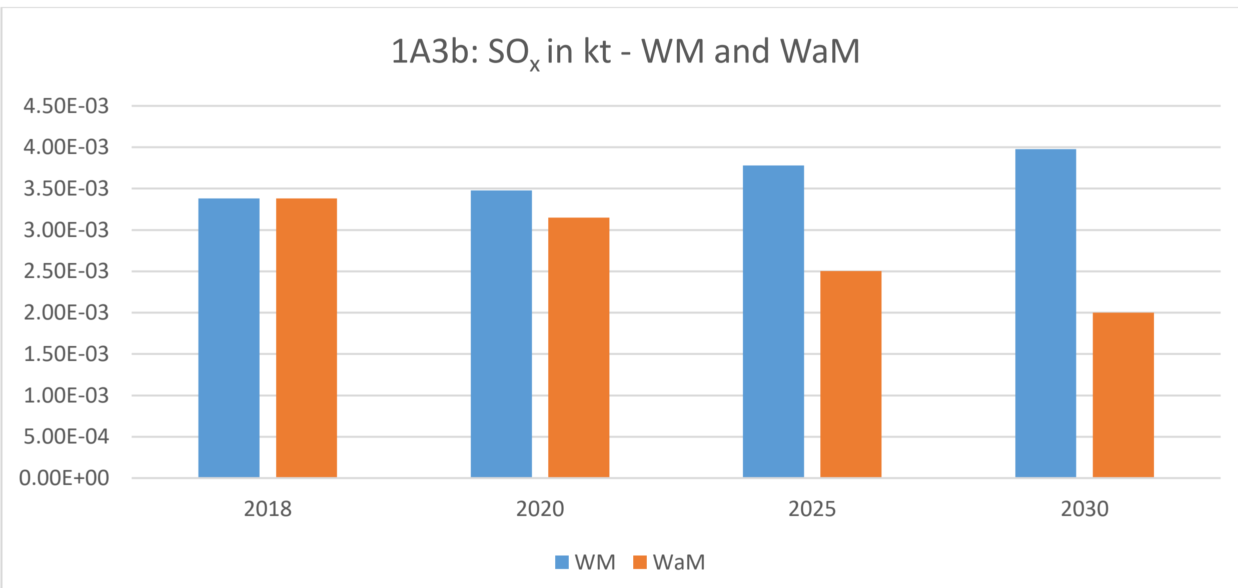

FIGURE 27: 1A3B: SO_X IN KT FOR 2018, 2020, 2025, 2030 (WM AND WAM)

NH_3 emissions also show a decrease post-2010 in both the historical and projected time series. It is worth noting that the decrease observed in the WaM scenario is visibly greater than that under the WM scenario.

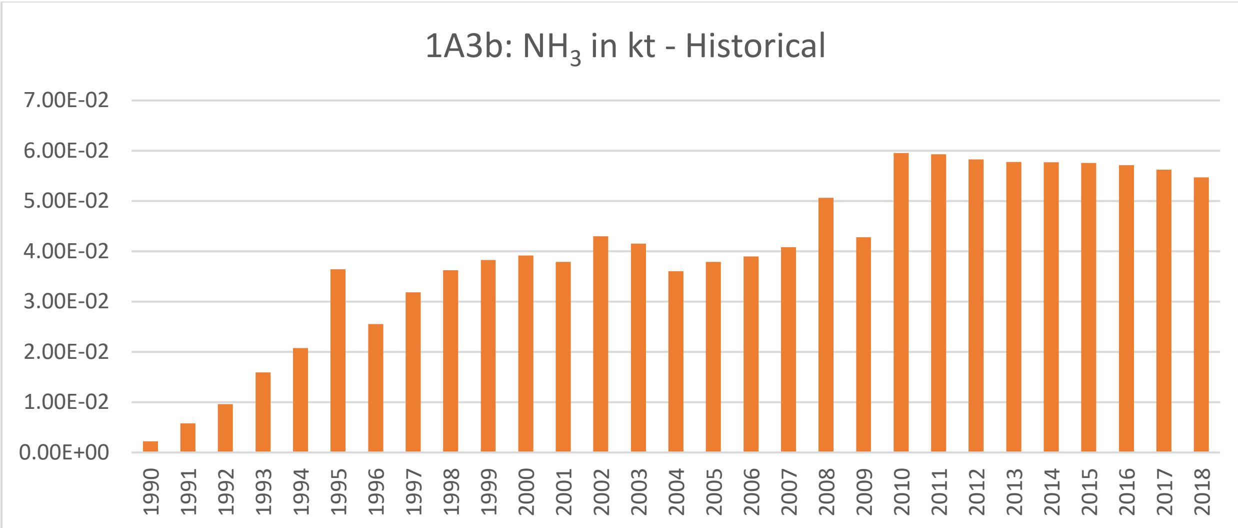

FIGURE 28: 1A3B: NH_3 IN KT - HISTORICAL

FIGURE 29: 1A3B: NH_3 IN KT FOR 2018, 2020, 2025, 2030 (WM AND WAM)

$PM_{2.5}$ emissions differ from the other main pollutants, as they are not solely generated through Internal Combustion Engine (ICE) vehicles, rather Electric Vehicles (EVs) also generate $PM_{2.5}$ emissions. The vkm of EVs till 2018 is assumed to be zero, and therefore no emissions from EVs were recorded in the historical time series. A decreasing trend of $PM_{2.5}$ emissions post-2010 within the historical time series, as can be observed from the graph below.

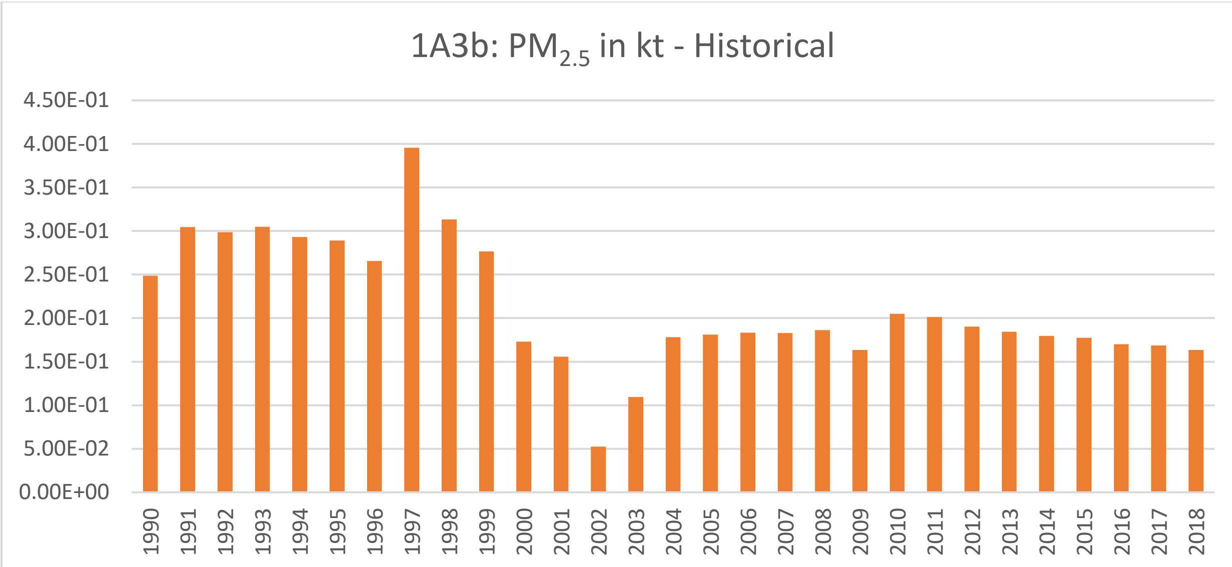

FIGURE 30: 1A3B $PM_{2.5}$ IN KT - HISTORICAL

The mean mileage was projected for electric vehicles post-2018, and these emissions were therefore included within the projected time series. Emissions from electric vehicles are attributed to sector '1A.3.b.vi, Automobile Tyre & brake wear', and sector '1.A.3.b.vii, Automobile Road Surface Abrasion'. At present, the COPERT stock dataset template does not include electric vehicles. Thus, in order to include the contribution of electric vehicles in the above mentioned sectors, an alternative methodology was used.

Timmers and Achten (2016) conducted a study on emissions from electric vehicles and the set of default factors made available from this research was used to estimate emissions from this sector.

TABLE 9: PM EMISSION FACTORS FOR EVS

Pollutants	EVs EF from Tyre Wear	EVs EF from Road Wear
PM_{10}	7.2 mg/vkm	8.9 mg/vkm
$PM_{2.5}$	3.7 mg/vkm	3.8 mg/vkm

The annual mean mileage of electric vehicles was multiplied by the EFs above, and the results summed to the emissions of PM_{10} and $PM_{2.5}$ generated by ICE vehicles. The drawback of this approach is that no emission factors were available for TSP, and there were no differences in EFs for the different vehicle categories.

FIGURE 31: 1A3B: $PM_{2.5}$ IN KT FOR 2018, 2020, 2025, 2030 (WM AND WAM)

The figure above shows a decreasing trend under both scenarios. However, the emissions under WaM scenario show a greater increase in the long run. It is also worth noting that since the vkm was projected post-2018, the emissions for the year 2018 only include emissions from ICE vehicles, whereas emissions from 2020 onwards include both ICE and EV emissions.

1A3dii National Navigation

NFR-Code	Name of sub-Category	Method	Activity Data	EF	Key Category for pollutants	Year of last update
1.A.3dii	National Navigation	2019GB	Eurostat	Tier 1 & 2	NO_x, nmVOC, SO_x, $PM_{2.5}$, PM_{10}, TSP, As, Ni, Se	2020 submission

This submission includes an update of the National Navigation sector for the years 1990 to 2018. The main activities comprising this sector in Malta are the recreational crafts, and the Gozo channel ferry (main ferry connecting Malta to Gozo). In addition to these activities, two new services will be introduced in future years; a fast ferry, which will start operating in the future for commuters crossing the Maltese Islands and a tunnel connecting Malta to Gozo which will start operating by the end of 2026 (simultaneous to the outmoding of the fast ferry).

The EEA/EMEP model made available in the 2019GB also has the function to generate fuel consumption based on vessel power data. An attempt was made to calculate emissions through this methodology. However, the resulting fuel consumption differed significantly when compared to actual fuel data. Hence, the fuel consumption from the Gozo channel ferry activities was obtained from the Eurostat energy balance sheet (1990 to 2018), while the emission factors were obtained from the 2019GB (Tier 1).

The Figures below provide the historical fuel consumption by type for the WM and WaM scenarios. GDO and Diesel are the main fuel sources for this sector.

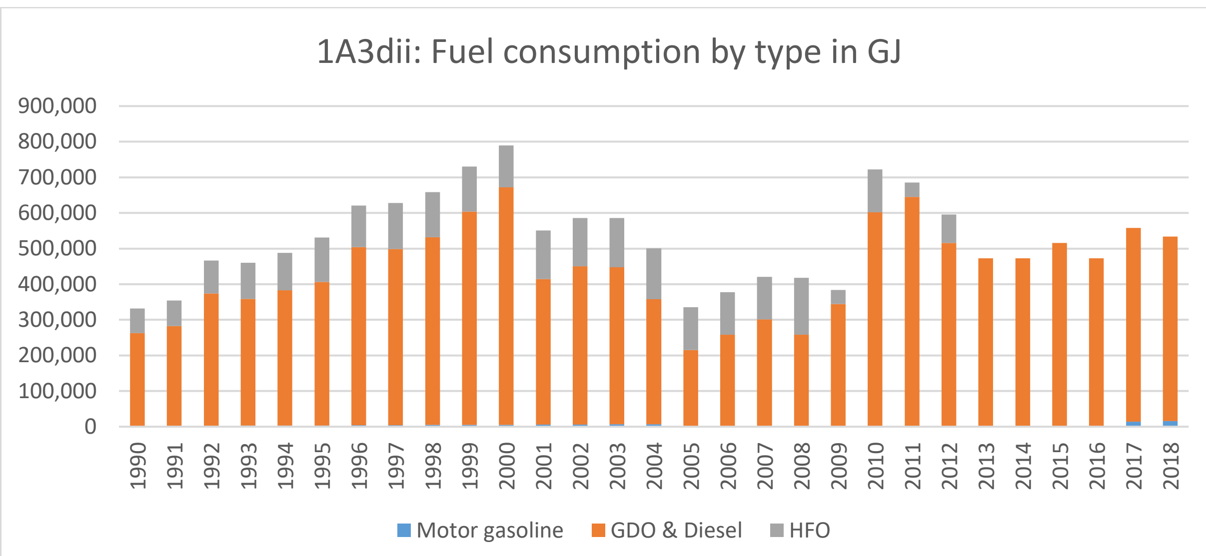

FIGURE 32: 1A3DII: FUEL CONSUMPTION BY TYPE IN GJ

The split between recreational crafts and the Gozo Channel ferry can be visualised in Figure 33 No fuel consumption data was available for the Gozo Channel ferry prior to 2002. Hence, all the fuel, as reported by Eurostat, was attributed to recreational crafts from 1990-2001. From 2002 onwards, the total fuel from the Gozo Channel ferry was provided by the Gozo Channel. The fuel used by recreational crafts was obtained by subtracting the fuel reported by the Gozo Channel from the total fuel reported under Eurostat.

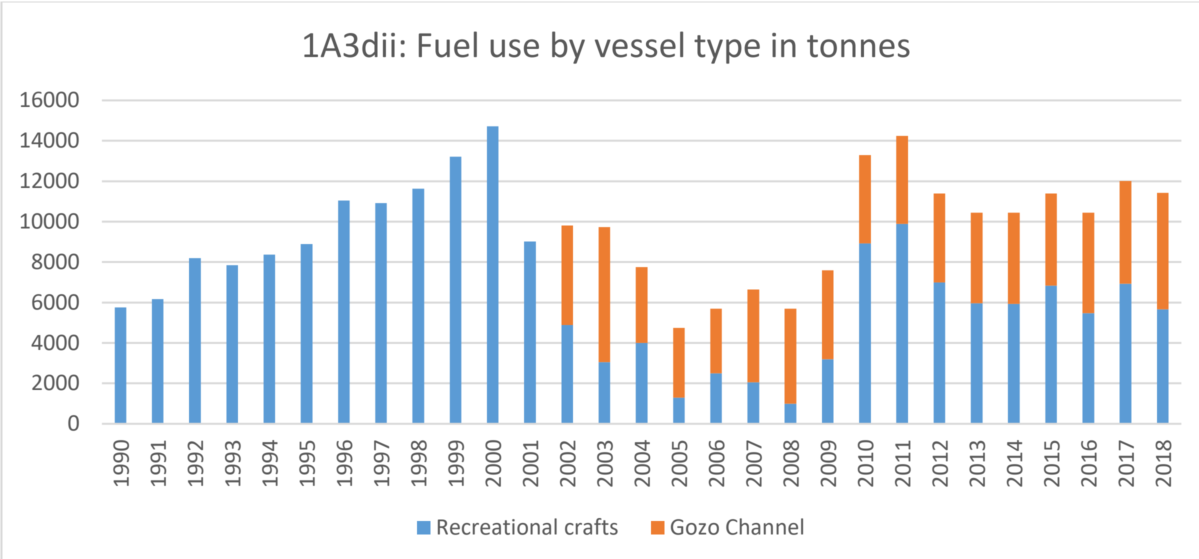

FIGURE 33: 1A3DII FUEL USE BY VESSEL TYPE IN TONNES

The graphs below show the overall trend of main pollutants across the time series. NO_x, SO_x, and $PM_{2.5}$ tend to follow the general fuel trend. However, Figure 35 shows how unlike other pollutants, nmVOC is heavily influenced by motor gasoline in particular. The quantities of motor gasoline used is much lower than GDO & Diesel. However, motor gasoline has a much higher EF than other fuels, and therefore even a moderate increase in the quantity of motor gasoline will result in a considerable emission increase.

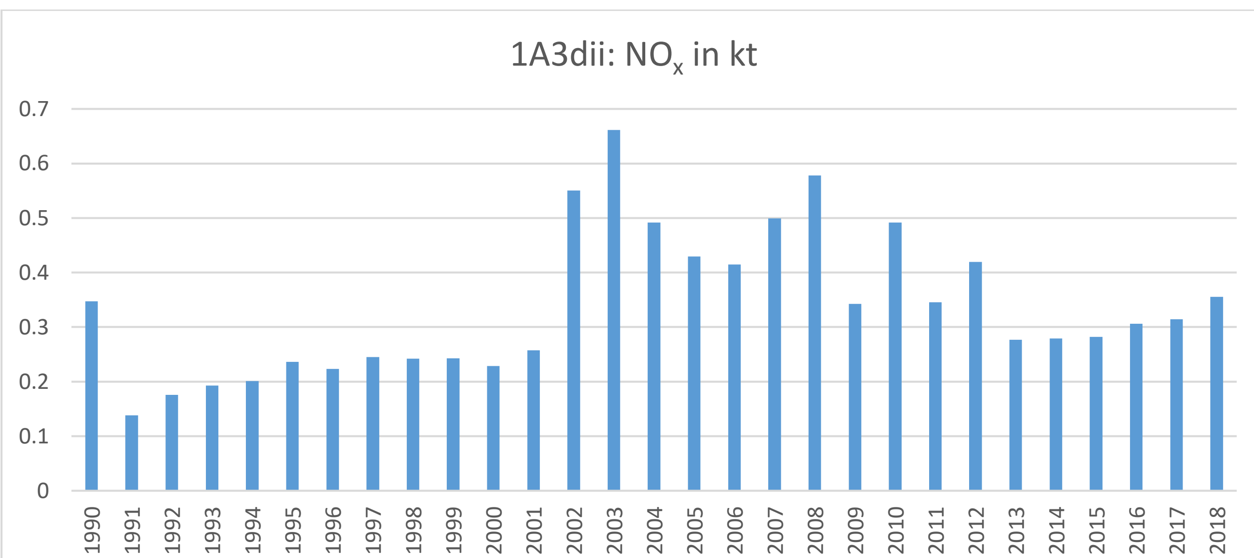

FIGURE 34: 1A3DII: NO_x (AS NO_2) IN KT

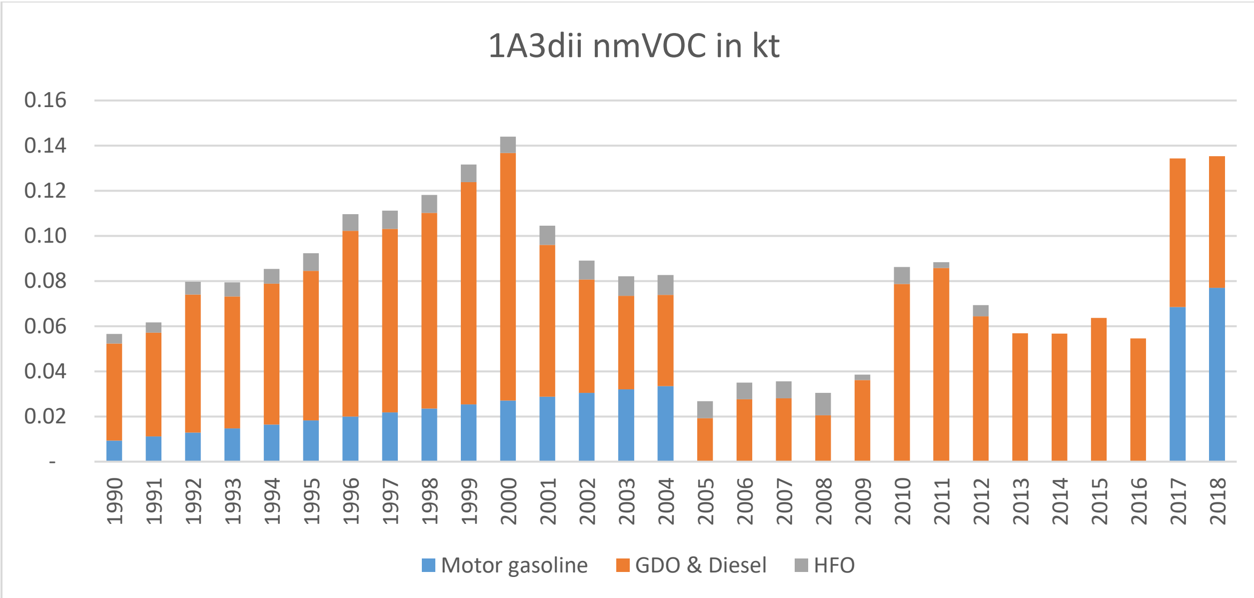

FIGURE 35: 1A3DII: NMVOC IN KT

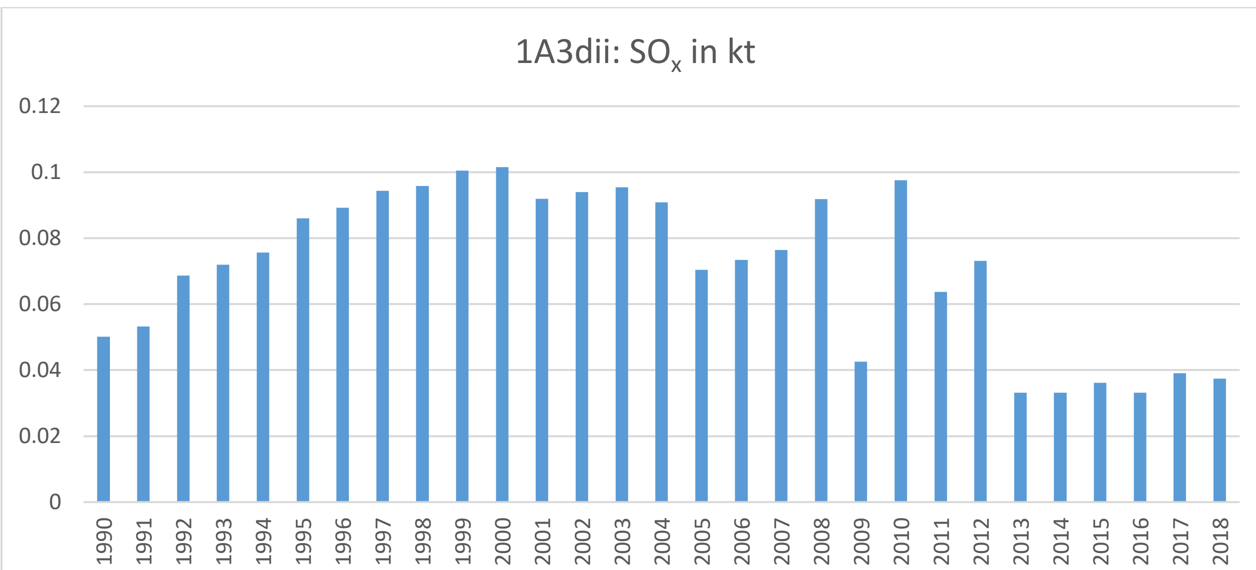

FIGURE 36: 1A3DII: SO_X IN KT

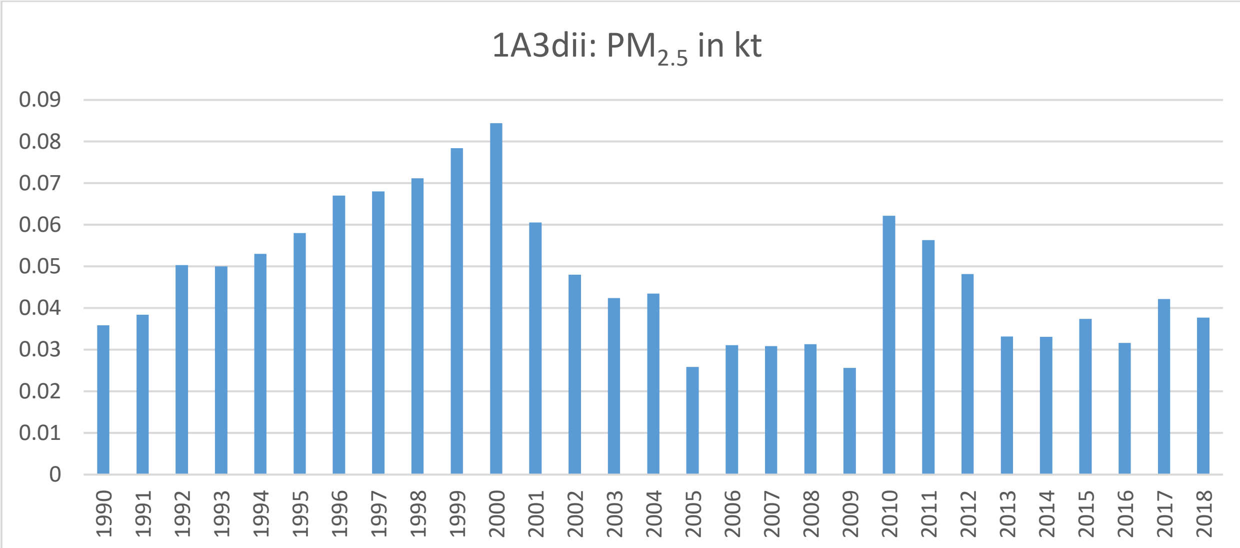

FIGURE 37: 1A3DII: $PM_{2.5}$ IN KT WM

With regards to projections, the projected fuel data did not differentiate between the Gozo Channel ferry and recreational crafts. Therefore, to identify the specific fuel consumption of each, the mean percentage share of fuel consumed by the Gozo Channel ferry was calculated for the WM scenario. This figure was then multiplied by the projected fuel consumption for the national navigation sector. To calculate emissions from the WaM scenario, the fuel used for recreational crafts under the WM scenario was assumed to be equal to that in the WaM scenario. The fuel used for recreational crafts was then subtracted by the total GDO & Diesel used, to obtain the total fuel used by the Gozo Channel and the Fast ferry.

The main difference between the WM and WAM scenarios is shown in the table below:

TABLE 10: NATIONAL NAVIGATION WM AND WAM SCENARIOS

Activity	**WM**	**WAM**
Recreational crafts	Same amount of fuel for both scenarios	
Gozo channel ferry	• 3 Gozo Channel ferries in operation	• 1 fast ferry in operation post 2020 till 2026

		• Reduced operation of the Gozo Channel ferry service as from 2027 (1 Gozo Channel ferry)

The introduction of the fast ferry will result in increased fuel consumption in the WAM scenario, as observed in Figure 38 below, but this will last only for the duration of its operation, i.e. post 2020 to 2026.

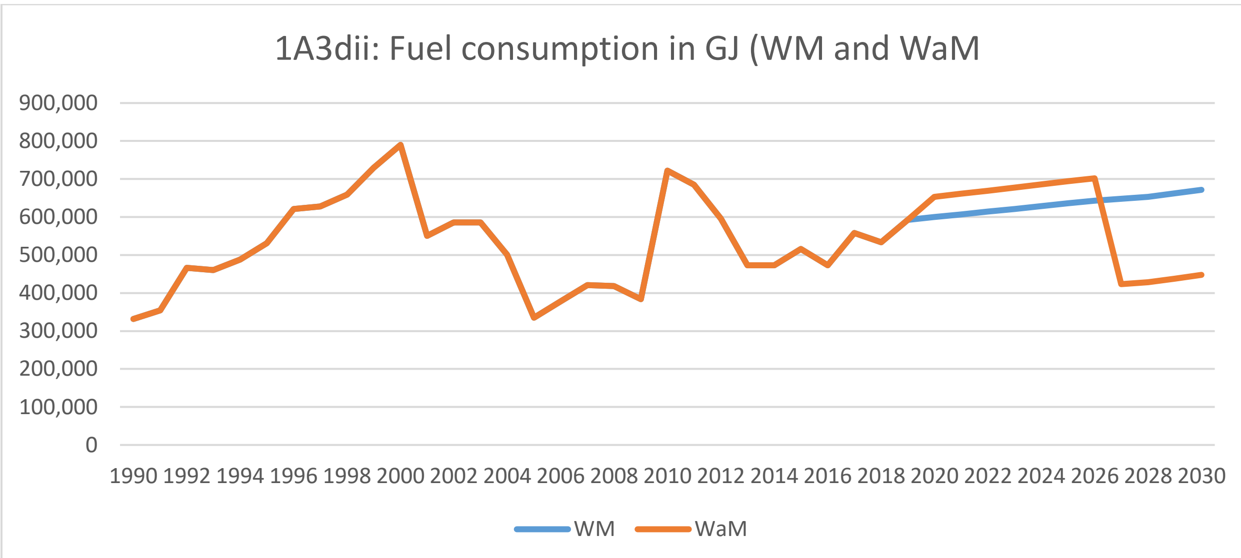

FIGURE 38: 1A3DII: NATIONAL NAVIGATION FUEL CONSUMPTION IN GJ (WM VS WAM)

The operation of the Malta to Gozo tunnel in 2027, will lead to the termination of the fast ferry service, and a reduction in the activity of the Gozo Channel ferry. Therefore, the projected fuel consumption in the WaM scenario is expected to decrease significantly.

1A4ai: Commercial/institutional: Stationary

NFR-Code	Name of sub-Category	Method	Activity Data	EF	Key Category for pollutants	Year of last update
1.A.4.ai	Commercial/institutional: Stationary	2019GB	Eurostat	Tier 1 & 2	NO_x, SO_x, $PM_{2.5}$, BC, As, Ni, Zn, benzo(a)pyrene, benzo(b) fluoranthene, benzo(k) fluoranthene, Indeno (1,2,3-cd) pyrene	2020 Submission

Emissions from 'Commercial/institutional: Stationary', and 'Commercial/institutional: Mobile' were reported under group sector 1A.4.ai. Estimates were calculated for the entire time series, i.e. 1990 to 2018 and projected for 2020, 2025 and 2030.

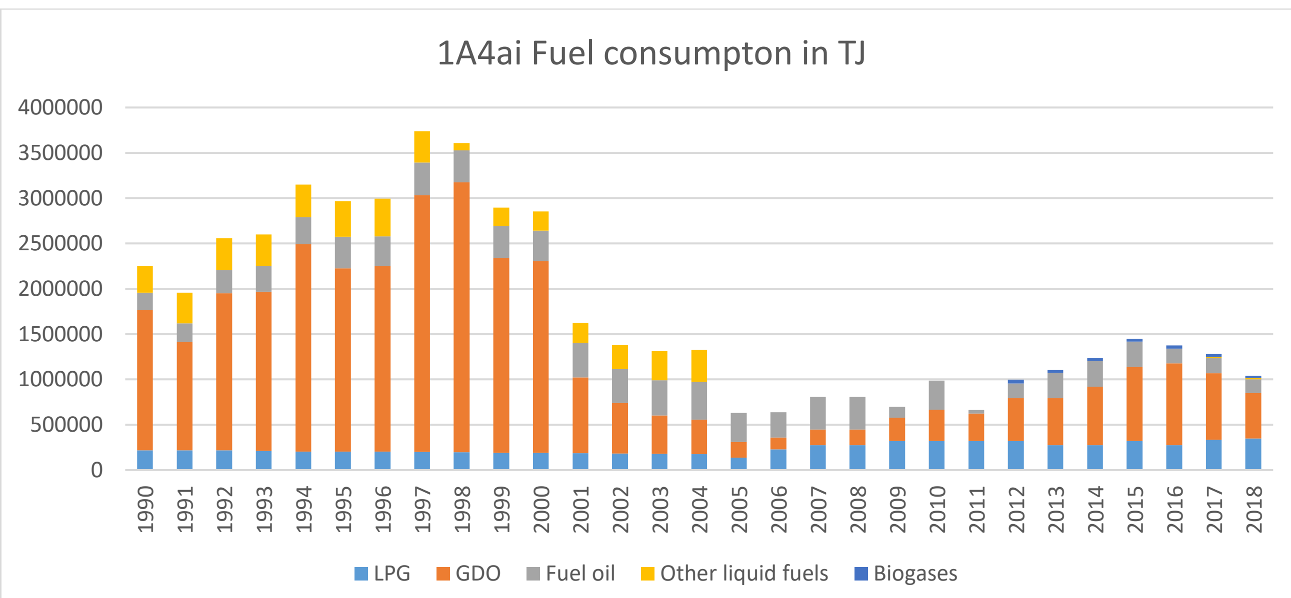

FIGURE 39: 1A4AI FUEL CONSUMPTION IN TJ

The activity data for estimating historical emissions (1990–2018) was changed with this submission. The fuel consumption is reported as 'Commercial' within the Eurostat Energy Balance (as observed in Figure 39) is now being used instead of the EWA/NSO fuel survey. The fuel reported for this activity was LPG, motor gasoline, kerosene, gas oil and diesel oil, fuel oil, and biogas. The sulphur content of gas oil and diesel oil for 2014-2018 was provided by REWS. The average sulphur content for 2014-2018 was then applied to previous years. All the other emission factors were obtained from the 2019GB.

Projected data was supplied by the Energy & Water Agency (EWA), as fuel use in Commercial & public services, for the period 2019-2030.

The graphs below show the historical trends for the main key categories. While both NO_x and $PM_{2.5}$ follow the fuel trend, SO_x shows a different trend to that of fuel consumption between the years 2014-2018. The reason for this difference can be attributed to the variation of sulphur content in gas oil and diesel oil.

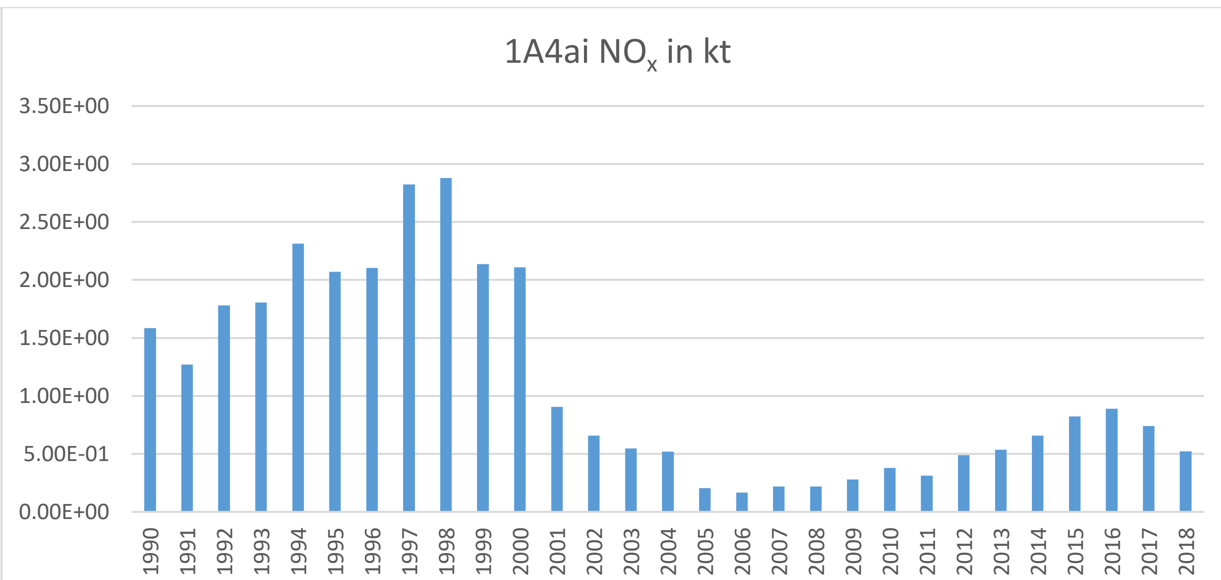

FIGURE 40: 1A4AI NO_x IN KT

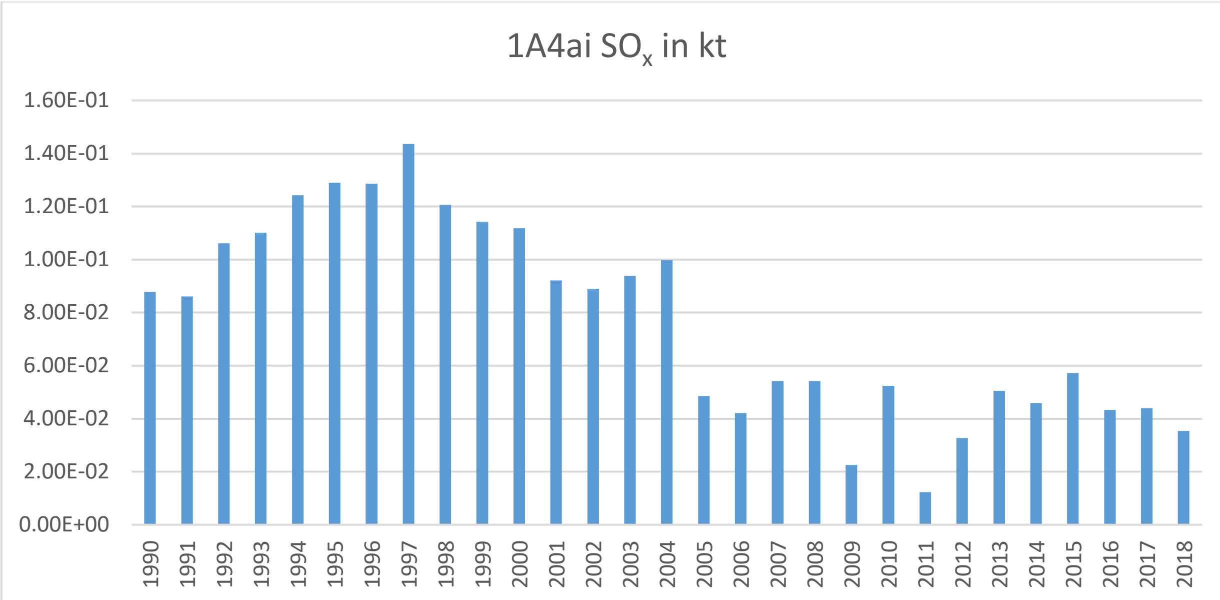

FIGURE 41: 1A4AI SO_X IN KT

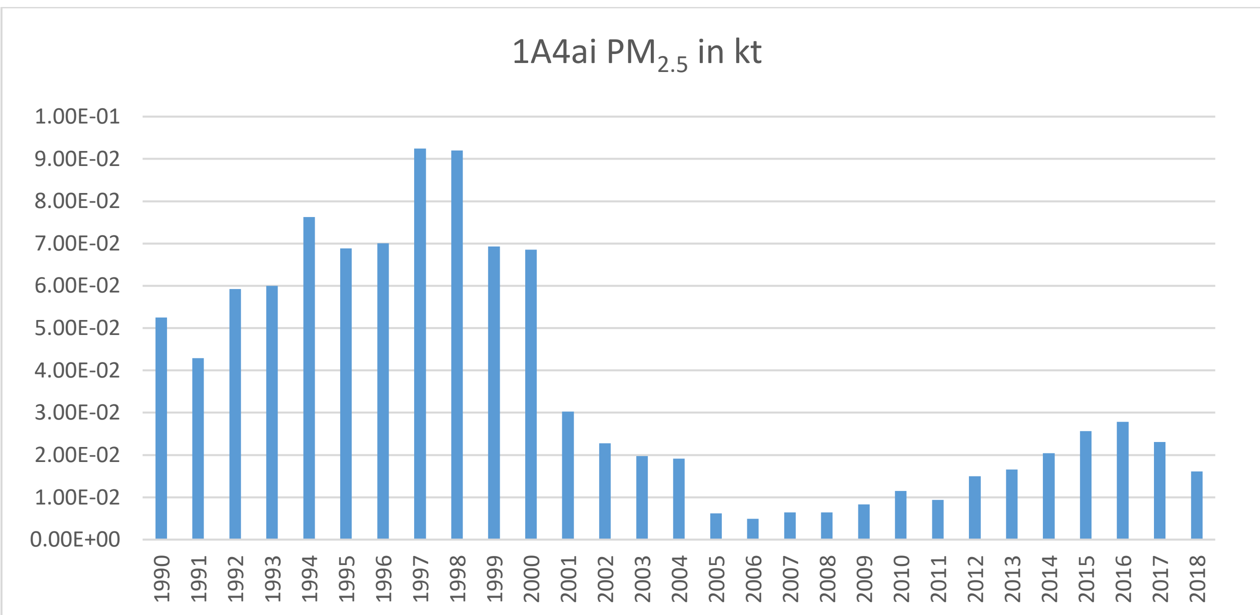

FIGURE 42: 1A4AI $PM_{2.5}$ IN KT

1A4bi Residential: Stationary

NFR-Code	Name of sub-Category	Method	Activity Data source	EF for pollutants	Key Category	Year of last update
1A4bi	Residential: Stationary	2019GB	Eurostat	Tier 1	$PM_{2.5}$, PM_{10}, TSP, Cd, Benzo(a) pyrene, benzo(b) fluoranthene, benzo(k) fluoranthene, Indeno (1,2,3-cd) pyrene	2020 submission

Emissions from combustion in the residential sector were reported under NFR code 1A4bi. This sub-category includes emissions from small combustion activities, such as domestic internal heating.

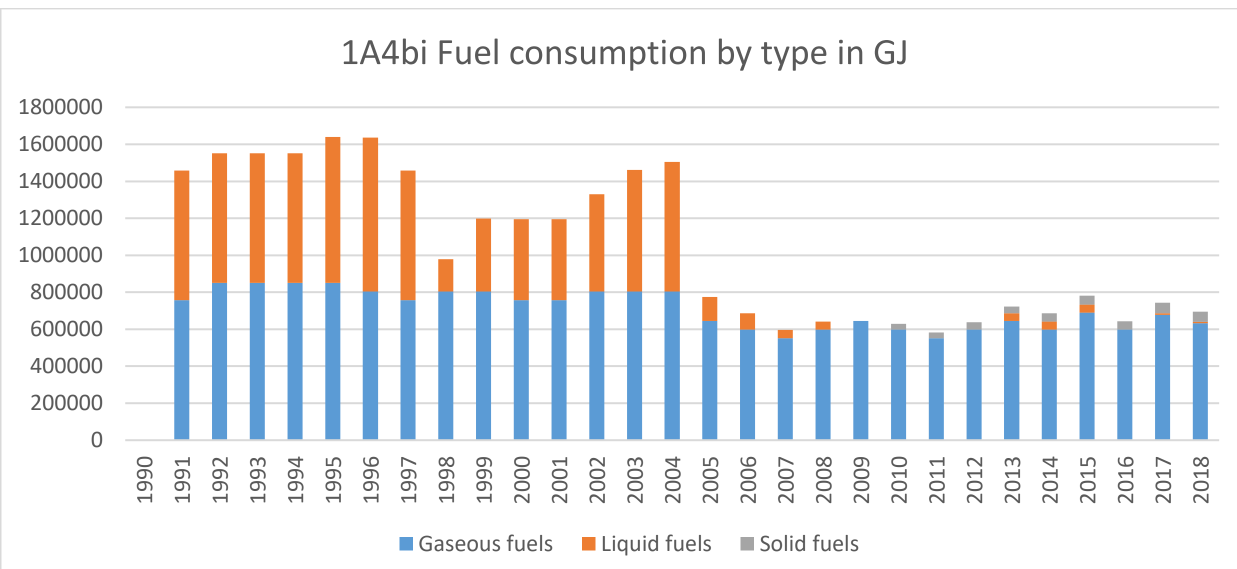

FIGURE 43: 1A4BI FUEL CONSUMPTION BY TYPE IN GJ

Estimates were calculated for the years 1991 to 2018 and projected for 2020, 2025 and 2030. No data on fuel consumption from the residential sector was available for the year 1990, and therefore the notation key 'NE' was used. The activity data for estimating historical emissions was changed with this submission. The fuel consumption reported as 'Residential' within the Eurostat Energy Balance is now being used instead of the EWA/NSO fuel survey. Figure 43 shows the trend for the different types of fuels consumed across the time series.

The sulphur content of liquid fuels from 2014 to 2018 was provided by REWS. The average sulphur content for the period 2014-2018 was then applied to previous years. All the other emission factors were obtained from the 2019GB.

Projected data was supplied by the Energy & Water Agency (EWA), as fuel use in Households for the period 2019-2030.

The figure below shows the trend for $PM_{2.5}$, for which this sector is a key category. The drastic emission increase from 2010 onwards coincides with an increase in the use of solid biofuels. The emissions from these biofuels were estimated by using the EF attributed to solid fuels. Efforts will be made in the future to obtain a more representative EF. No data on solid fuels is currently available pre-2010.

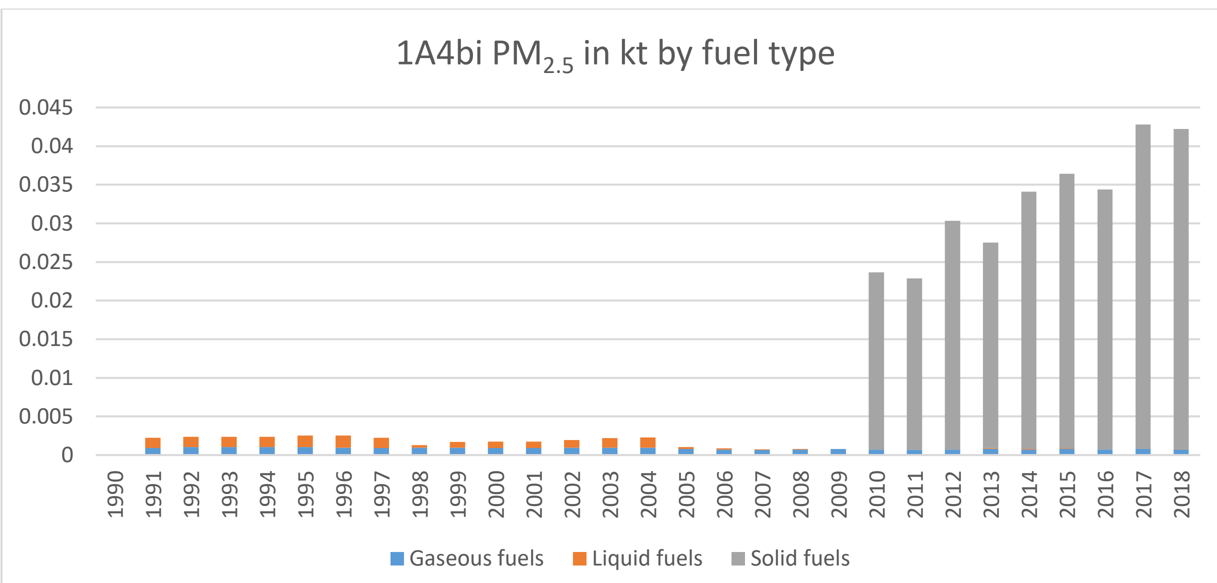

FIGURE 44: 1A4BI $PM_{2.5}$ IN KT BY FUEL TYPE

1A4cii: Agriculture/Forestry/Fishing: Off-road vehicles and other machinery

NFR-Code	Name of sub-Category	Method	Activity Data	EF	Key Category for pollutants	Year of last update
1.A.4cii	Off-road vehicles and other machinery	2019GB	Eurostat	Tier 1	NA	2020 submission

Estimates were calculated for the entire time series i.e. 1990 to 2018 and projected for 2020, 2025 and 2030. The activity data for estimating historical emissions (1990 – 2018) was changed with this submission. The fuel consumption reported as 'Agriculture and Forestry' within the Eurostat Energy Balance is now being used instead of the EWA/NSO fuel survey.

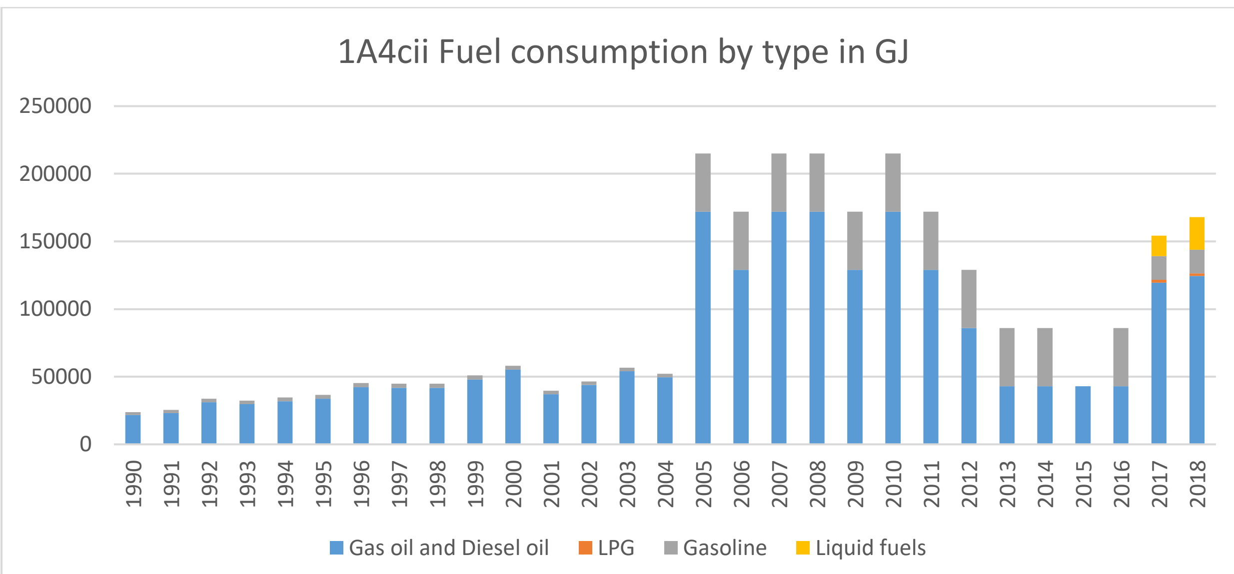

FIGURE 45: 1A4CII FUEL CONSUMPTION BY TYPE IN GJ

Projected data was supplied by the Energy & Water Agency (EWA), as fuel use in Agriculture and Forestry for the period 2019-2030.

1A4ciii: Agriculture/Forestry/Fishing: National fishing

NFR-Code	Name of sub-Category	Method	Activity Data	EF	Key Category for pollutants	Year of last update
1.A.4ciii	National fishing	2019GB	Eurostat	Tier 1	Ni	2020 submission

Estimates were calculated for the entire time series i.e. 1990 to 2018 and projected for 2020, 2025 and 2030. The activity data for estimating historical emissions (1990–2018) was changed with this submission. The fuel consumption as reported as 'Fishing' within the Eurostat Energy Balance is now being used instead of the EWA/NSO fuel survey.

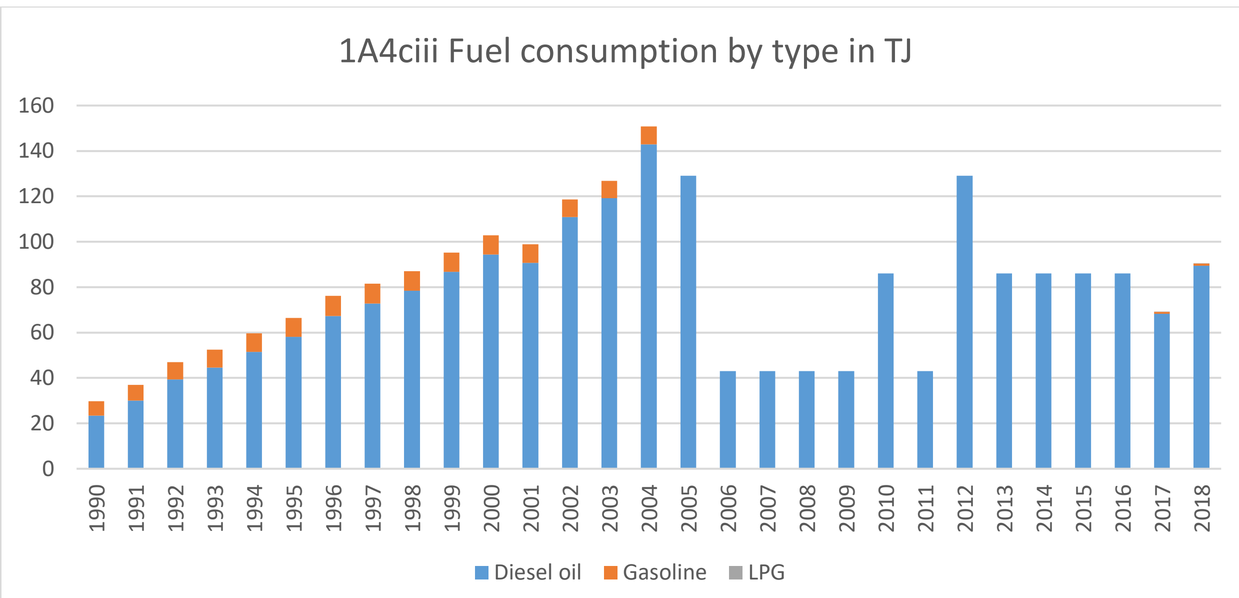

FIGURE 46: 1A4CIII FUEL CONSUMPTION BY TYPE IN TJ

Projected data was supplied by the Energy & Water Agency (EWA), as fuel use in Fishing for the period 2019-2030. The Emission factors were obtained from the 2019GB.

1B2av: Distribution of oil products

NFR-Code	Name of sub-Category	Method	Activity Data	EF	Key Category for pollutants	Year of last update
1B2av	Distribution of oil products	2019GB	Eurostat	Tier 1	nmVOC	2020 Submission

Emissions estimated in this sector originated from the gross inland consumption of gasoline (gasoline without bio component and aviation gasoline) consumed locally. This activity data was obtained from Eurostat for 1990 to 2018, and the nmVOC emission factor was obtained from the 2019GB. This approach was suggested by TERT during the 2017 review. No projected values were available, and therefore the 2018 value was carried forward for the projected years 2020, 2025 and 2030.

This category is a key source for nmVOC and the graph below shows the emission profile across the historical and projected time series.

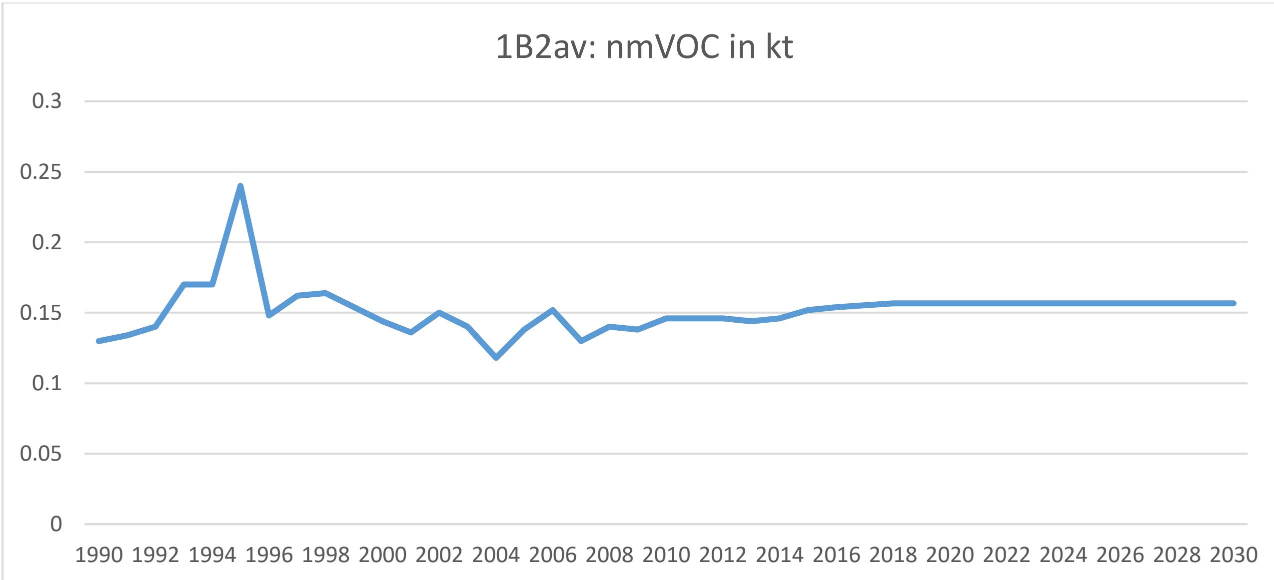

FIGURE 47: 1B2AV: NMVOC IN KT

4. Industry (NFR 2)

This sector consists of categories from which fugitive or combustion emissions arise. The sub-categories present locally and of which emissions were estimated in this submission are listed below:

TABLE 11: NFR 2 ESTIMATED SECTORS

Aggregation	Sector	NFR code
Solvents	Domestic solvent use including fungicides	2D3a
	Other product use (please specify in the IIR)	2G
Industry	Storage, handling and transport of chemical products (please specify in the IIR)	2B10b
	Road paving with asphalt	2D3b
	Food and beverages industry	2H2

The notation key NO was used for the following sectors, as these sectors do not occur locally:

- 2A1 Cement production
- 2A2 Lime production
- 2A3 Glass production
- 2A5a Quarrying and mining of minerals other than coal
- 2A5b Construction and demolition
- 2A5c Storage, handling and transport of mineral products
- 2A6 Other mineral products (please specify in the IIR)
- 2B1 Ammonia production
- 2B2 Nitric acid production
- 2B3 Adipic acid production
- 2B5 Carbide production
- 2B6 Titanium dioxide production
- 2B7 Soda ash production
- 2B10a Chemical industry: Other (please specify in the IIR)
- 2C1 Iron and steel production
- 2C2 Ferroalloys production
- 2C3 Aluminium production
- 2C4 Magnesium production
- 2C5 Lead production
- 2C6 Zinc production
- 2C7a Copper production
- 2C7b Nickel production
- 2C7c Other metal production (please specify in the IIR)

- 2C7d Storage, handling and transport of metal products
- 2D3c Asphalt roofing
- 2H1 Pulp and paper industry
- 2H3 Other industrial processes (please specify in the IIR)
- 2I Wood processing
- 2J Production of POPs
- 2K Consumption of POPs and heavy metals
- 2L Other production, consumption, storage, transportation or handling of bulk products

The notation key NE was used for the following sectors, as no activity data was available:

- 2D3d Coating applications
- 2D3e Degreasing
- 2D3f Dry cleaning
- 2D3g Chemical products
- 2D3h Printing

The pollutants covered in this chapter are: NO_x, nmVOC, SO_x, NH_3, $PM_{2.5}$, PM_{10}, TSP, BC, CO, Pb, Cd, Hg, As, Cr, Cu, Ni, Zn, PCDD/ PCDF, benzo(a) pyrene, benzo(b) fluoranthene, benzo(k) fluoranthene, Indeno (1,2,3-cd) pyrene.

Of these pollutants, this sector is a key category for nmVOC, $PM_{2.5}$, PM_{10}, TSP, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn.

The relevant pollutant trends for key categories, as well as the methodologies used are explained in the sections below:

2B10a: Storage, handling and transport of chemical products

NFR-Code	Name of sub-Category	Method	Activity Data	EF	Key Category for pollutants	Year of last update
2.B.10.a	Storage, handling and transport of chemical products	NA	NA	NA	NA	NA

This sector generates nmVOC emissions, which have been carried forward from previous submissions. Efforts will be made to update this sector in the future.

2D3a: Domestic solvent use including fungicides

NFR-Code	Name of sub-Category	Method	Activity Data	EF	Key Category for pollutants	Year of last update
2.D.3.a	Domestic solvent use including fungicides	2019GB	World Bank	Tier 1	nmVOC, Hg,	2019 submission

Emissions from 'Domestic Solvent use including fungicides' were reported under group sector 2.D.3.a. Emissions estimated in this sector were calculated by multiplying the total population of the Maltese Islands with an emission factor for nmVOC (1.2kg/capita, 2019GB). This approach was suggested by the TERT during the 2017 review. The chart below shows the emission load for nmVOC across the time series:

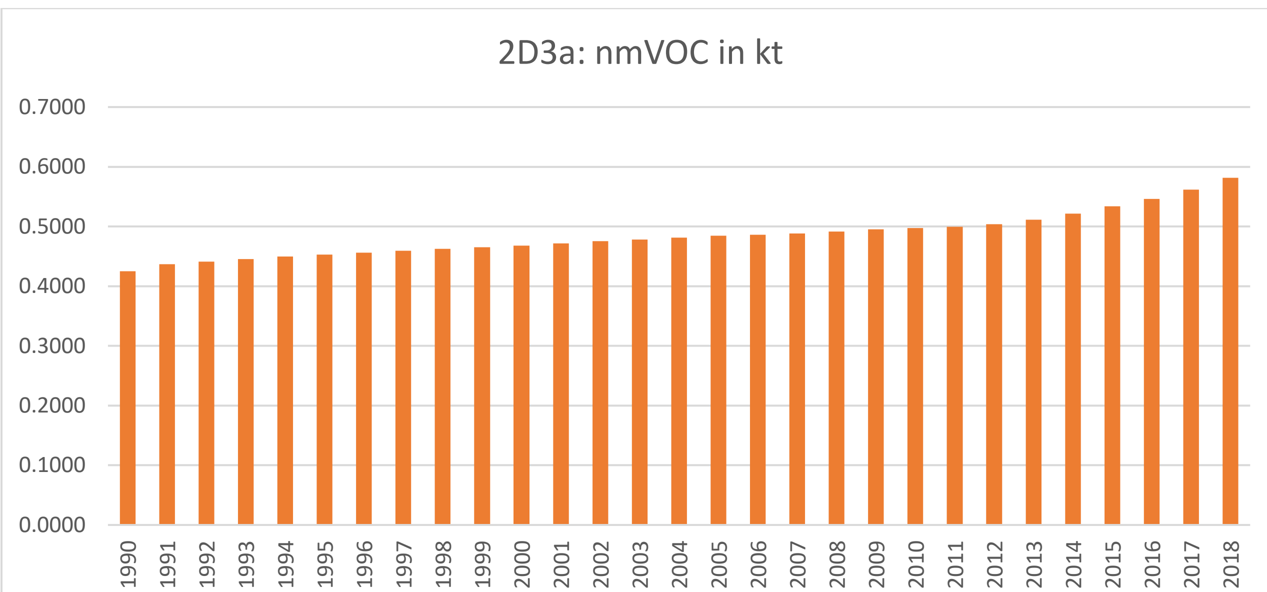

Figure 48: 2D3a nmVOC in kt

Since no projected activity data was available, the 2018 value was carried forward for the projected years 2020, 2025, and 2030. Efforts will be made to develop a better methodology in the future.

2D3b: Road paving with asphalt

NFR-Code	Name of sub-Category	Method	Activity Data	EF	Key Category for pollutants	Year of last update
2.D.3.b	Road paving with asphalt	NA	NA	NA	NA	NA

This sector generates nmVOC emissions, which have been carried forward from previous submissions. Efforts will be made to update this sector in the future.

2G. Other product use (NFR 2)

NFR-Code	Name of sub-Category	Method	Activity Data	EF	Key Category for pollutants	Year of last update
2G	Other product use; Use of fireworks, Tobacco combustion	Scientific paper by Camilleri. R and Vella (2016) and AFM (Fireworks) and 2019GB (Tobacco)	Armed forces of Malta (fireworks), and Eurostat (tobacco & fireworks)	Tier 2	$PM_{2.5}$, PM_{10}, TSP, Pb, Cd, As,	2020 Submission

Emissions from 'Use of fireworks' and 'Tobacco combustion' were reported collectively under sector 2G: Other Product Use. The time series was updated with this submission, as emissions were calculated from 1990-1999 for the first time. No projected activity data was available, and therefore the 2018 emission load was carried forward for 2020, 2025 and 2030.

1. Use of fireworks

Fireworks are commonly let off during local village feasts. Most fireworks are manufactured locally by using the raw materials, which are purchased from the Armed Forces of Malta. The rest are imported from foreign countries.

The data on imported fireworks and flares was obtained from Eurostat, rather than the NSO. Following communication with the NSO, it was established that the NSO provides general trade statistics, whereas Eurostat provides special trade statistics. The use of special trade statistics was preferred, as general trade statistics may include products that have not yet, and may not, be placed on the market. The total mass of materials used was calculated by subtracting the mass of exports by the total imports of the following CN codes:

- 36041000 (fireworks)
- 36049000 (Signalling flares, rain rockets, fog signals and other pyrotechnic articles (excl. fireworks and cartridge blanks)

Finally, the total mass of pyrotechnical products was multiplied by the EF provided within the 2019GB.

The amount of fireworks manufactured locally was not available. Hence, the amount of raw material used to manufacture them had to be used, and this was provided by the Armed Forces of Malta. This amount was then estimated through the methodology used within a national study by Camilleri and Vella (2016).

The data for potassium chlorate and potassium nitrate was available from 2011 to 2017. Data for previous years, and for 2018, was extrapolated. Missing quantities for aluminium powder were replaced with a two year annual average available in the study by Camilleri and Vella (2016), and this value was applied for the entire time series.

TABLE 12: ANNUAL AVERAGE OF IMPORTED OXIDANTS & FUELS IN FIREWORK MANUFACTURING FROM 2012-2014

Potassium Chlorate in kg	Q1	15050
Aluminium in kg	Q2	2035
Potassium Nitrate in kg	Q3	60325

The list of equations below was used to estimate quantities of flash crackers, coloured stars and black powder in Malta:

TABLE 13: CALCULATIONS AND ASSUMPTIONS FOR ESTIMATING THE YEARLY AVERAGE QUANTITIES OF FLASH CRACKERS, COLOURED STARS AND BLACK POWDER USED IN MALTA FROM 2012-2014

Type of firework	Equation to determine annual quantities in kg each firework type
Flash Crackers in kg	Q4=Q2/0.3
Flash Crackers in kg	Q4=Q2/0.3
OX used for flash comp in kg	Q5=0.7Q4
OX used for star comp in kg	Q6=Q1-Q5
OX used for red STARS in kg	Q7= Q6/3
OX used for blue STARS in kg	
OX used for green STARS in kg	
Red stars in kg	Q8=Q7/0.7
Blue stars in kg	Q9=Q7/0.65
Green stars in kg	Q10=Q7/0.833
Black Powder	Q11=Q3/0.75
OX used for flash comp in kg	Q5=0.7Q4
OX used for star comp in kg	Q6=Q1-Q5
OX used for red STARS in kg	Q7= Q6/3
OX used for blue STARS in kg	
OX used for green STARS in kg	Q8=Q7/0.7
Red stars in kg	Q9=Q7/0.65
Blue stars in kg	Q10=Q7/0.833
Green stars in kg	Q11=Q3/0.75

Once the total quantity of manufactured and imported fireworks was calculated, these were multiplied by the respective 2019GB EFs. The 2018 emissions estimates were assumed to remain the same in 2020, 2025 and 2030.

2. Tobacco combustion

The methodology to estimate emissions from tobacco combustion was obtained from the 2019GB. The quantity of tobacco combusted locally was obtained from Eurostat, rather than the NSO. As with fireworks and flares, it was established that the NSO provides general trade statistics, whereas Eurostat provides special trade statistics. The use of special trade statistics was preferred, since general trade statistics may include products that have not yet, and may not, be placed on the market. The CN codes related to this activity were:

- 24022090 (cigarettes, containing tobacco (excl. containing cloves))
- 24021000 (cigars, cheroots and cigarillos containing tobacco)
- 24029000 (cigars, cheroots, cigarillos and cigarettes consisting wholly of tobacco substitutes).

The total amount of exports was subtracted by the imports, and the result was assumed to be equal to the amount of tobacco combusted locally. Emission factors from the EU 2019GB were used to estimate emissions. The 2018 emissions estimates were assumed to remain the same in 2020, 2025 and 2030.

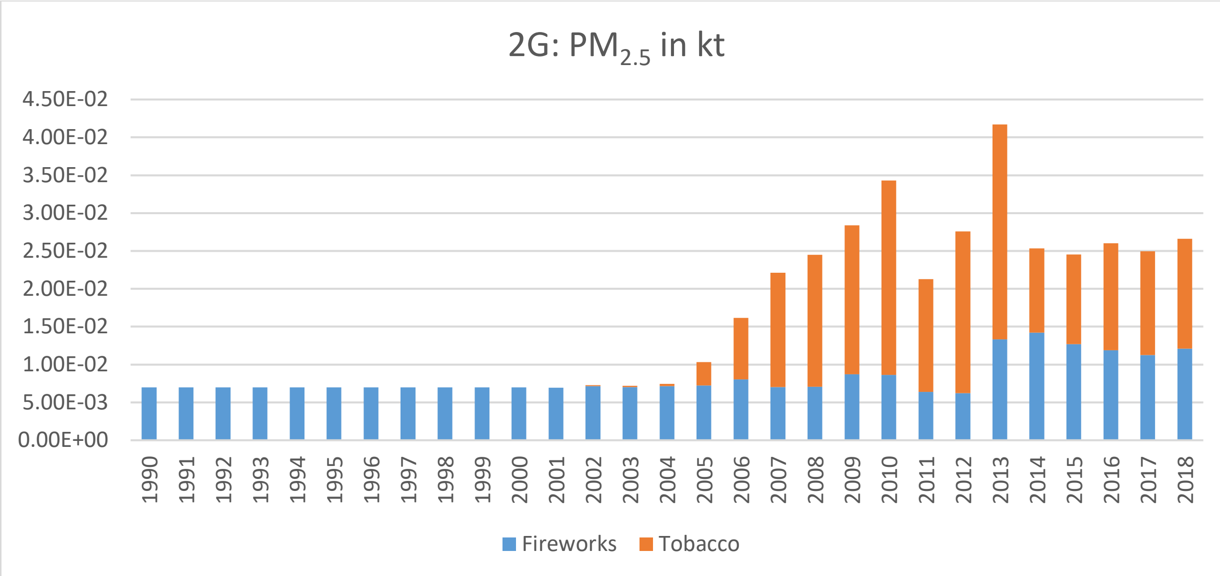

FIGURE 49: 2G $PM_{2.5}$ IN KT

2H2. Industrial Processes and Product Use (NFR 2)

NFR-Code	Name of sub-Category	Method	Activity Data	EF	Key Category for pollutants	Year of last update
2H2	Industry	2019GB	NSO	Tier 2	nmVOC	2020 submission

The National Statistics Office provided most of the activity data, in particular; data from 1995-2018 for production of home killed meat, poultry, fish, and for seafood landed; and data from 2003 onwards for the animal feed produced. The total mass of bread produced was not available. Hence, the total imported flour of common wheat and spelt and rye flour were used to calculate the mass. In this respect, data on flour was only available from 2004-2018. Previous communication with the Malta Bakers' Cooperative had established that a sack of flour weighing 50kg would produce approximately 100 loaves. In turn, each baked loaf weighs around 540g. The calculation can be visualised below:

First, the weight of flour per loaf was calculated:

$$1\ sack = \frac{50kg\ of\ flour}{100\ loaves} = 500g\ of\ flour\ per\ loaf$$

Equation 4: Equation to calculate the weight of flour per loaf

Then, the number of loaves was calculated:

$$Number\ of\ loaves = \frac{x\ kg\ of\ flour}{500g\ of\ flour}$$

Equation 5: Equation to calculate the number of loaves

Finally, the mass of bread was calculated:

$$Mass\ of\ bread\ produced = number\ of\ loaves * 540g\ (mass\ per\ loaf)$$

Equation 6: Equation to calculate the mass per loaf

Concerning beverages, no information was available on the amount of wine and beer produced locally. Beer production could not be estimated due to the confidentiality of the activity data. However, the volume of wine produced was calculated by converting the mass of wine crops processed, as provided by Food and Agriculture Organization Corporate Statistical Database (FAOSTAT) for the years 1990 until 2014. A conversion factor of 140kg of crop for 1hl of wine was used, as provided in the Oxford Companion to Wine (Robinson, 2006).

The data used in missing years, for all categories, was extrapolated by using a moving average. The emission factors used were derived from the 2019GB.

The chart below shows the trend for nmVOC from 1990 until 2018. The main two sources of emissions are the production of animal feed, and the production of bread. Whereas the emissions from the production of animal feed have remained stable across the time series, bread production emissions have steadily increased. As a result, the total emissions from the food & beverage sector have increased across the time series.

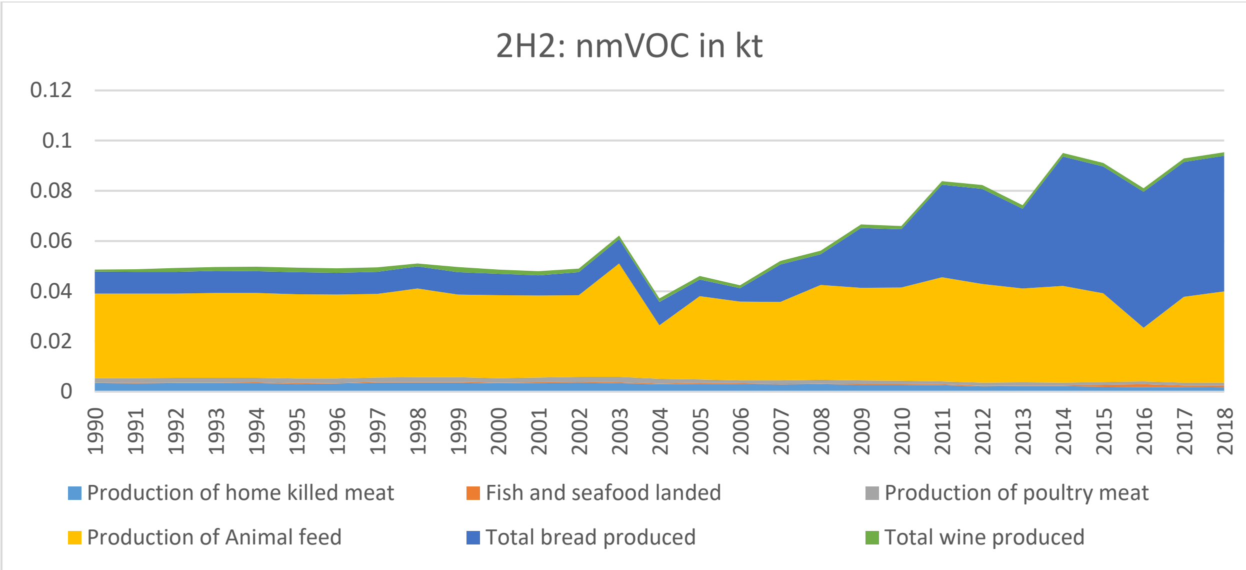

FIGURE 50: 2H2 NMVOC IN KT

No projected data was available for the years 2018-2030. A relationship was sought between historical data and past GDP and population data; however there was no relationship between the food and beverage sector, and either one of these variables. As a result, the values for all the food and beverage types were kept constant.

5. Agriculture (NFR 3)

The agricultural chapter (NFR 3) includes emissions from sub-chapters:

- 3B Manure Management
- 3D Crop production and agricultural soils
- 3F Field burning of agricultural residues.

The annotation key 'NE' was assigned to sub-chapter 3Df Pesticides, as no activity data was available. Sector 3I Agriculture other was classified as 'NO', since no activity takes place locally. The table below provides a breakdown of the sectors covered:

TABLE 14: NFR 3 ESTIMATED SECTORS

Aggregation	Sector	NFR code
AgriLivestock	Manure management - Dairy cattle	3B1a
	Manure management - Non-dairy cattle	3B1b
	Manure management - Sheep	3B2
	Manure management - Swine	3B3
	Manure management - Goats	3B4d
	Manure management - Horses	3B4e
	Manure management - Laying hens	3B4gi
	Manure management - Broilers	3B4gii
	Manure management - Other poultry	3B4giv
	Manure management - Other animals (please specify in the IIR)	3B4h
AgriOther	Inorganic N-fertilizers (includes also urea application)	3Da1
	Animal manure applied to soils	3Da2a
	Farm-level agricultural operations including storage, handling and transport of agricultural products	3Dc
	Cultivated crops	3De
	Field burning of agricultural residues	3F

The pollutants covered in this sector are NO_x, nmVOC, NH_3, $PM_{2.5}$, PM_{10}, TSP, and CO.

Of these pollutants, the agricultural sector is a key category for nmVOC, NH_3, PM_{10} and TSP.

The relevant pollutant trends for key categories, as well as the methodologies used are explained in the sections below:

3B: Manure Management

NFR-Code	Name of sub-Category	Method	Activity Data	EF	Key Category for pollutants	Year of last update
3B1a, 3B1b, 3B2,3B3,3B4d, 3B4e,3B4gi, 3B4gii, 3B4giii, 3B4giv, 3B4h	AgriLivestock	2019GB	NSO	Tier 1, 2	nmVOC, NH_3, TSP	2020 submission

NH_3 emissions from sub-chapter 3B was recalculated through the Manure Management N-flow tool, as supplied with the 2019GB. The previous submission was also based on a Tier 2 methodology, however, the EFs for this chapter have been updated. A number of comparative graphs are presented later in this section, to explain the effect of these recalculations.

The notation NO was provided for the following categories: 3B4a 'Buffalo', 3B4f 'Mules and Asses', and 3B4giii 'Turkeys', since there was no activity data. The graph below shows a decreasing trend in NH_3 emissions across the time series, as a result of a decrease in livestock numbers (AAP).

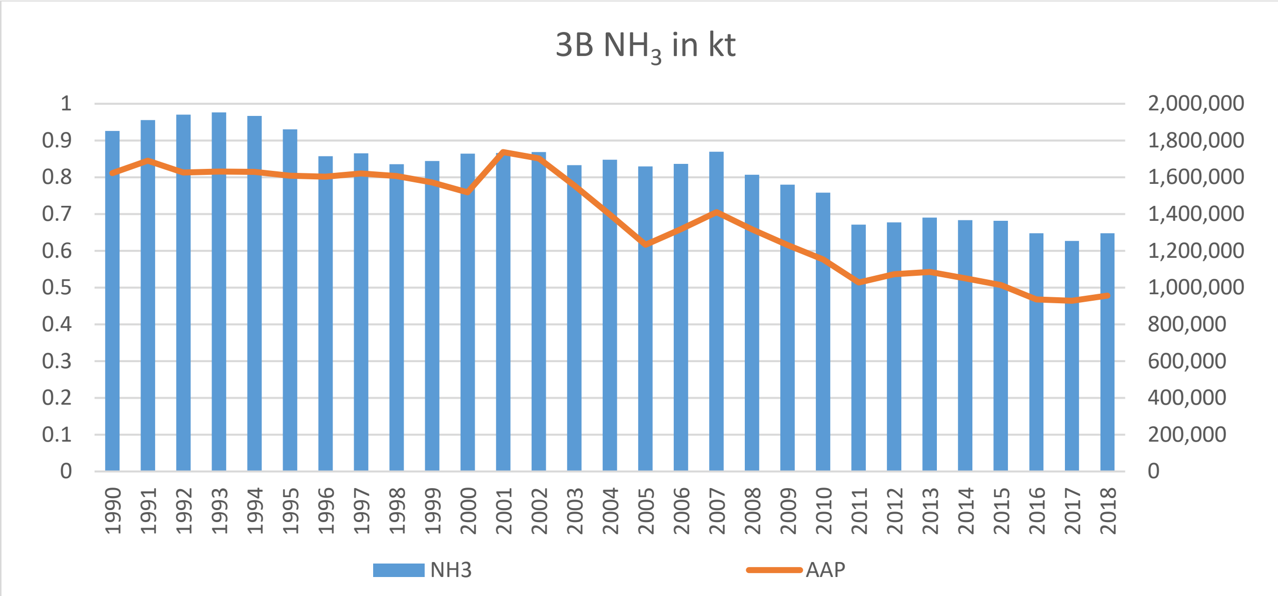

FIGURE 51: 3B NH_3 IN KT

The number of animal heads was provided by the NSO, and was in line with the climate change (MRA) model, to ensure consistency between both models. The data for livestock was more detailed than that requested by the 2019GB. Non-dairy cattle, sheep, and swine were further subdivided into different categories. The total number of non-dairy cattle and sheep was obtained by summing up the different sub-categories. However, swine have a different EF according to whether they are classified as either sows, or fattening pigs. Therefore, the different sub-categories had to be classified as pertaining to either one of these classifications. The table below shows how these sub-categories were assigned to sows and fattening pigs respectively.

TABLE 15: SWINE CLASSIFICATION - SOWS AND FATTENING PIGS

Sows	Fattening pigs
• Piglets <20kgs • Breeding females - breeding sows	• Young pigs 20-50kgs • Fattening pigs>50kgs • Breeding females – gilts • Breeding boars

The animal weight for cattle, sheep, swine, horses, and goats as communicated by Koperattiva Produtturi tal-Ħalib (KPH) to the MRA was used. The default weight as provided in the 2019GB was used for the other livestock categories.

The following data providers provide data, which is used by the Malta Resources Authority and the Environment and Resources Authority, for the climate change and air quality models respectively:

- National Statistics Office for the number of animal heads, and the total cow and milk produced;
- Malta Dairy Products (MDP) provides the cow milk fat content (%);
- The KPH (Milk breeders' co-operative) provides the animal weight for cattle, sheep, goats, and the protein content (%) in the feed;
- The Pig Breeders Co-operative provides the animal weight for swine;
- Agricultural Department provides the proportion of solid/slurry that is either stored or spread, and the proportion of housed livestock

The table below shows country-specific activity data for animal weight, compared with the default factors in the EEA Guidebook. A weighted average was used to calculate the average weight of non-dairy cattle, sheep, swine (finishing pigs), and swine (sows), as each of these livestock types was further subdivided into livestock categories.

TABLE 16: ANIMAL WEIGHT PER LIVESTOCK TYPE

Livestock type	MT: Animal weight (kg)	2019GB: Animal weight (kg)	Source
Dairy cattle	550	600	KPH (Milk breeders co-operative)
Non-dairy cattle	512.9	340	KPH (Milk breeders co-operative)
Non-dairy cattle (calves)	200	150	KPH (Milk breeders co-operative)
Sheep	47.6	50	KPH (Milk breeders co-operative)
Swine (finishing pigs)	62.8	65	Pig Breeders Co-operative
Swine (sows)	175	225	Pig Breeders Co-operative

Goats	35	50	KPH (Milk breeders co-operative)
Horses	500	500	EEA Guidebook
Laying hens	2.2	2.2	EEA Guidebook
Broilers	1	1	EEA Guidebook
Other poultry	3.5	3.5	EEA Guidebook
Other animals (fur animals)	1.6	1.6	EEA Guidebook

Following communication with the Agricultural Directorate, it was assumed that according to S.L. 549.66 all animal holdings and passageways are to be covered at all times, indicating that livestock is constantly kept under housing. However, 9% of beef cattle, and 35% of sheep and goats, are exempt from the regulation, and are kept in yards.

TABLE 17: HOUSING PERIOD PER LIVESTOCK TYPE

Livestock type	MT: Housing period (days)	2019GB: Housed period (days)	MT source
Dairy cattle	365	180	Agricultural Department
Non-dairy cattle	332.15	180	Agricultural Department
Sheep	237.25	30	Agricultural Department
Swine (finishing pigs)	365	365	Agricultural Department
Swine (sows)	365	365	Agricultural Department
Goats	237.25	30	Agricultural Department
Horses	365	180	Agricultural Department
Laying hens	365	365	Agricultural Department
Broilers	365	365	Agricultural Department
Other poultry	365	365	Agricultural Department
Other animals (fur animals)	365	365	Agricultural Department

Moreover, the manure type produced per livestock type was determined following consultation with the Department of Agriculture and is shown below:

TABLE 18: PROPORTION OF MANURE TYPE BY LIVESTOCK

Livestock	Manure type	Proportion by manure type
Cattle	solid	50%
	slurry	50%
Fattening pigs	solid	5%
	slurry	95%
Sows	solid	5%
	slurry	95%
	outdoor	N/A
Layers	(Semi) solid	100%

Additionally, Nitrogen excretion (Nex) values were calculated using the equation in chapter 10 of the IPCC 2006 Guidelines. Local values for Nex of 0.87kg N/place, were taken from the Sustech (2008) report for laying hens. The default values within the Manure Management N-flow tool were used for the other livestock types.

The proportions of solid manure and slurry that are stored, or spread are provided by the Agricultural Department. The proportion of manure diverted to the anaerobic digester is not known, so it is assumed to be 0. All slurry is assumed to be stored, since slurry spreading is prohibited under S.L. 549.66. Concerning solid manure, S.L. 549.66 states that manure has to be stored between the 16^{th} October and the 14^{th} of March, and that manure can be applied from the 15^{th} of March till the 15^{th} of October. Hence, manure is stored for 5 months a year (41.7%), and spread for 7 months a year (58.3%).

The key source categories for this chapter were as follows: 3B1a, 3B1b, 3B3, 3B4gi, and 3B4h for NH_3, 3B1a and 3B4gii for nmVOC. The graphs below show the trend of emissions for each key source:

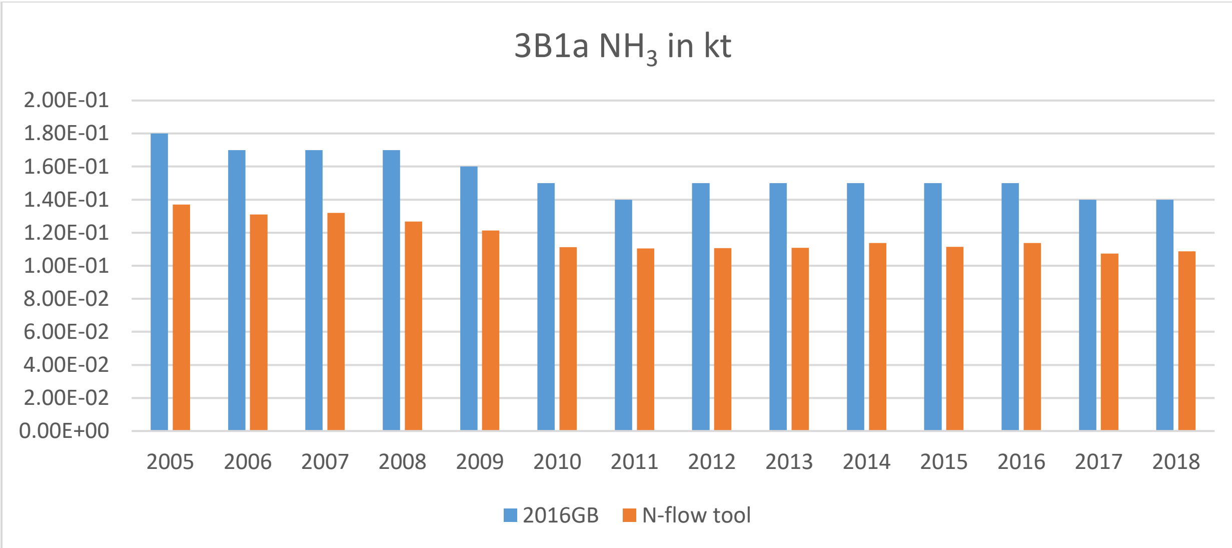

FIGURE 52: 3B1A NH_3 RECALCULATION IN KT

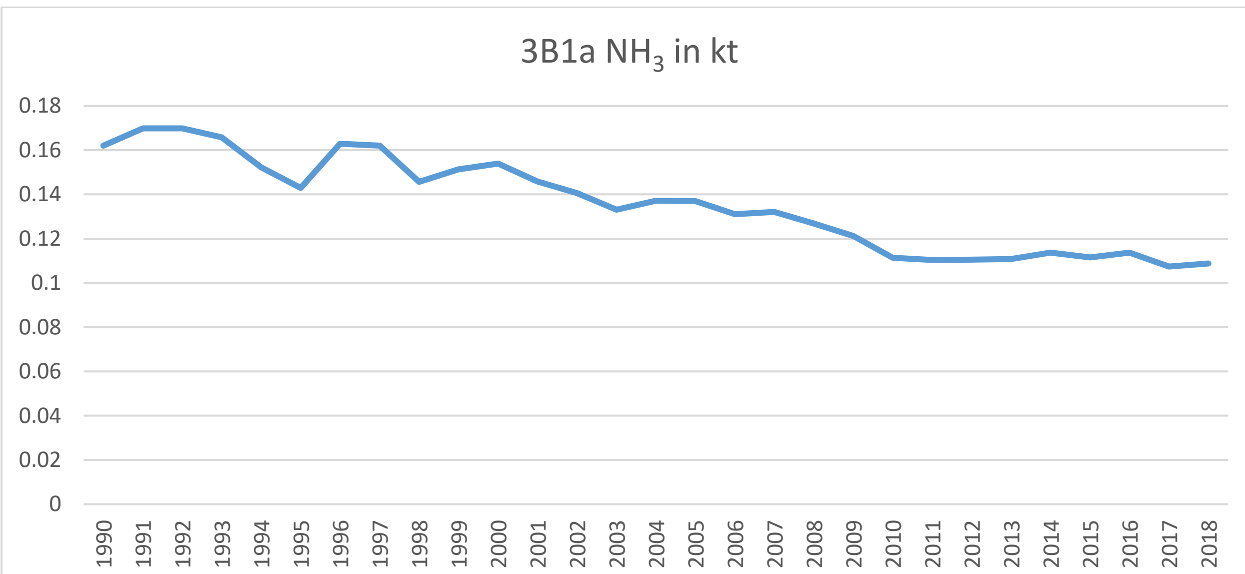

FIGURE 53: 3B1A NH_3 TREND IN KT

NH_3 emissions from dairy cattle have decreased across the time series. The recalculation with the N-flow tool shows a decrease in emissions.

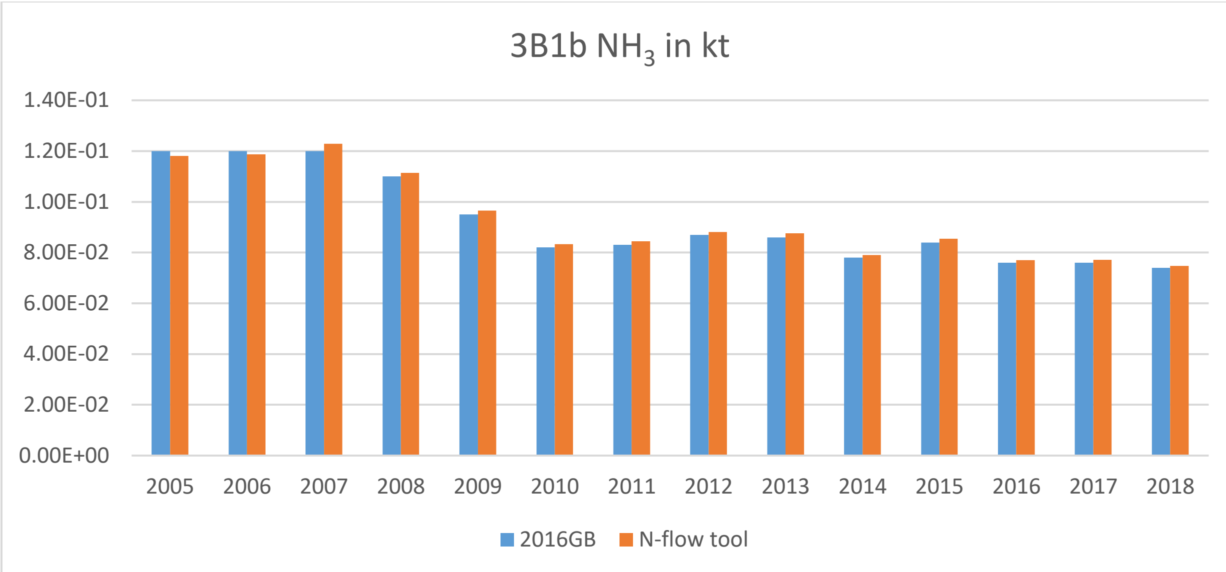

FIGURE 54: 3B1B NH_3 RECALCULATION IN KT

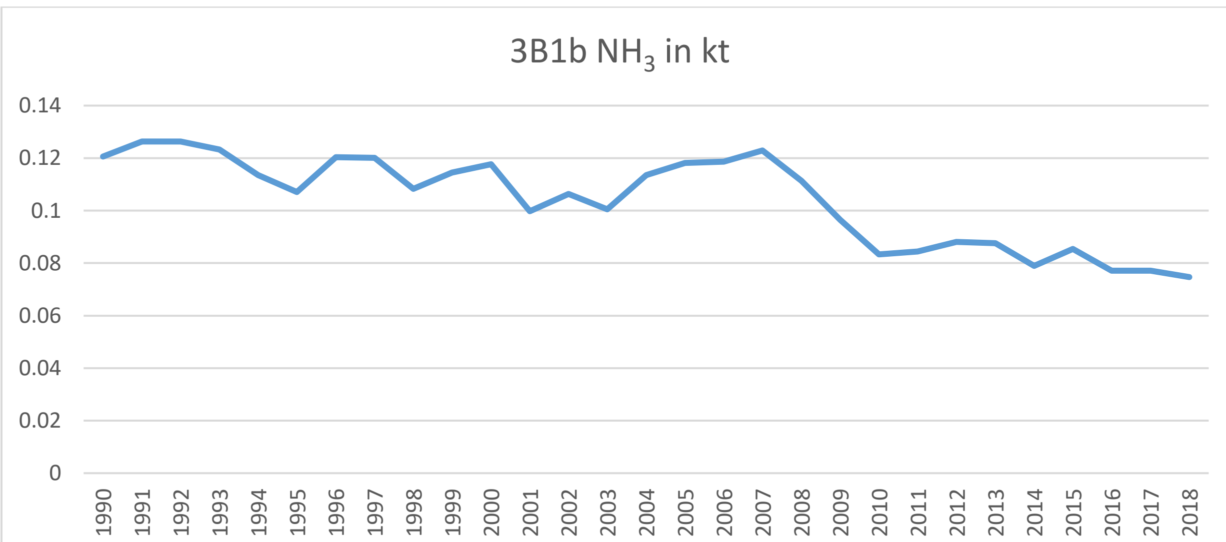

FIGURE 55: 3B1B NH_3 TREND IN KT

The trend for non-dairy cattle NH_3 emissions is similar to the one for dairy cattle. A decrease is observed across the time series. The recalculation with the N-flow tool shows a small increase in emissions.

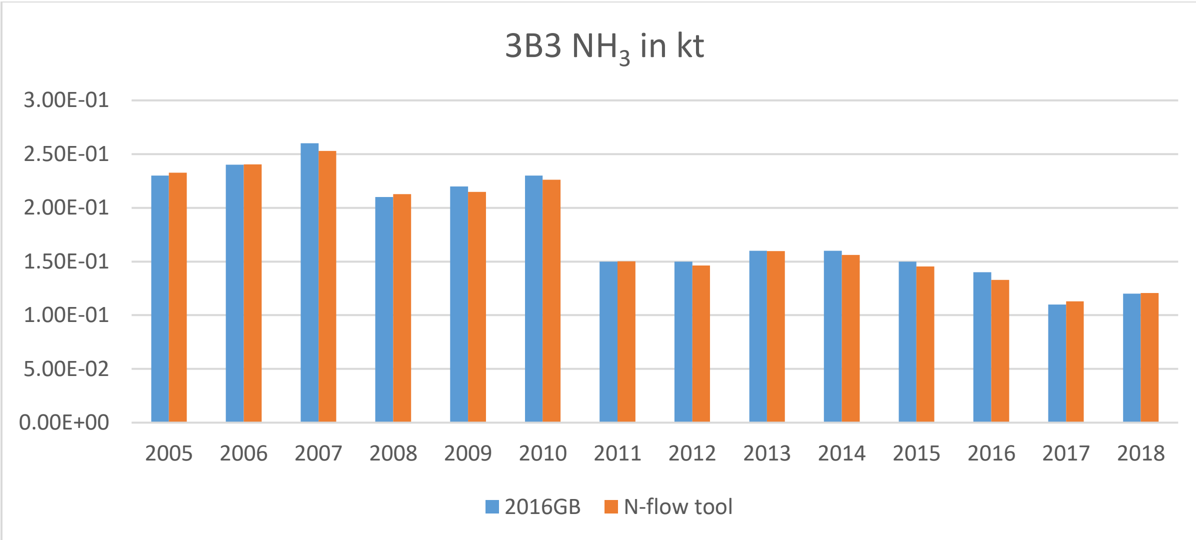

FIGURE 56: 3B3 NH_3 RECALCULATION IN KT

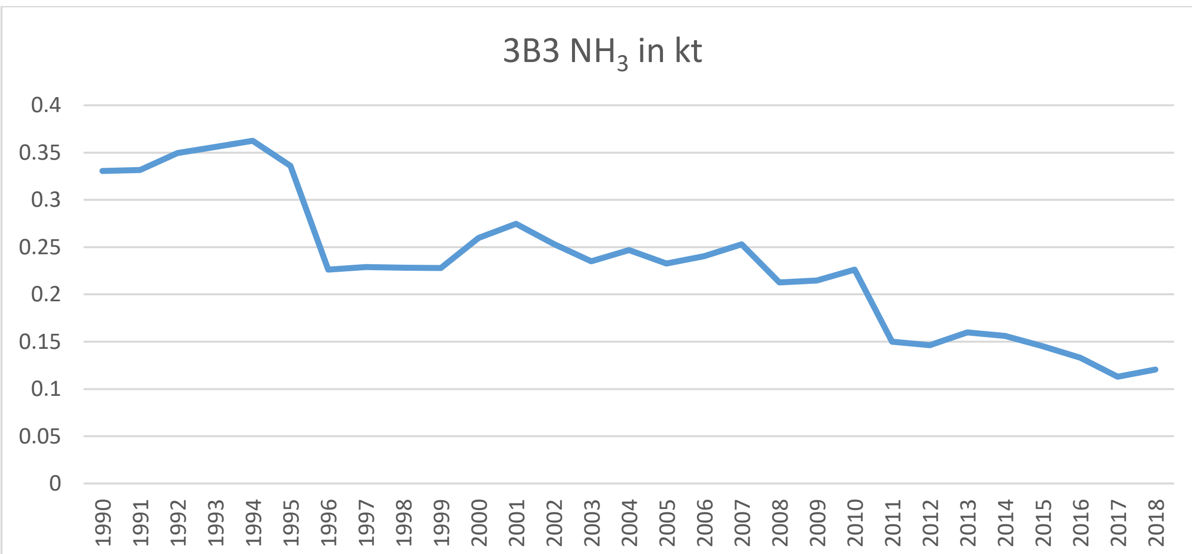

FIGURE 57: 3B3 NH_3 TREND IN KT

Swine NH_3 emissions have decreased along the time series. Furthermore, the recalculation with the N-flow tool resulted in small emission decreases.

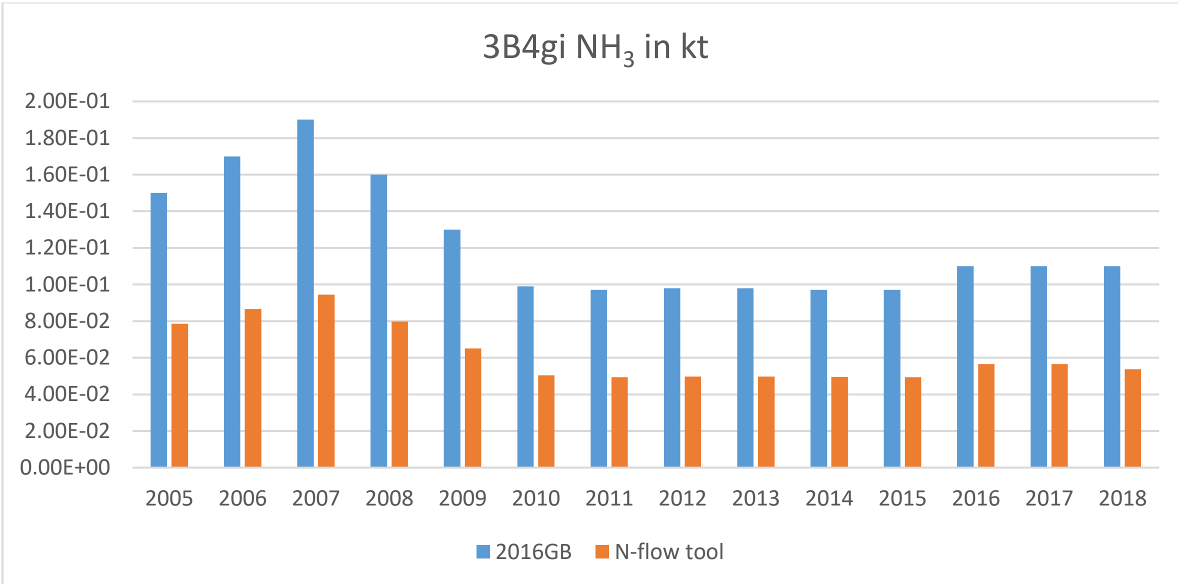

FIGURE 58: 3B4GI NH_3 RECALCULATION IN KT

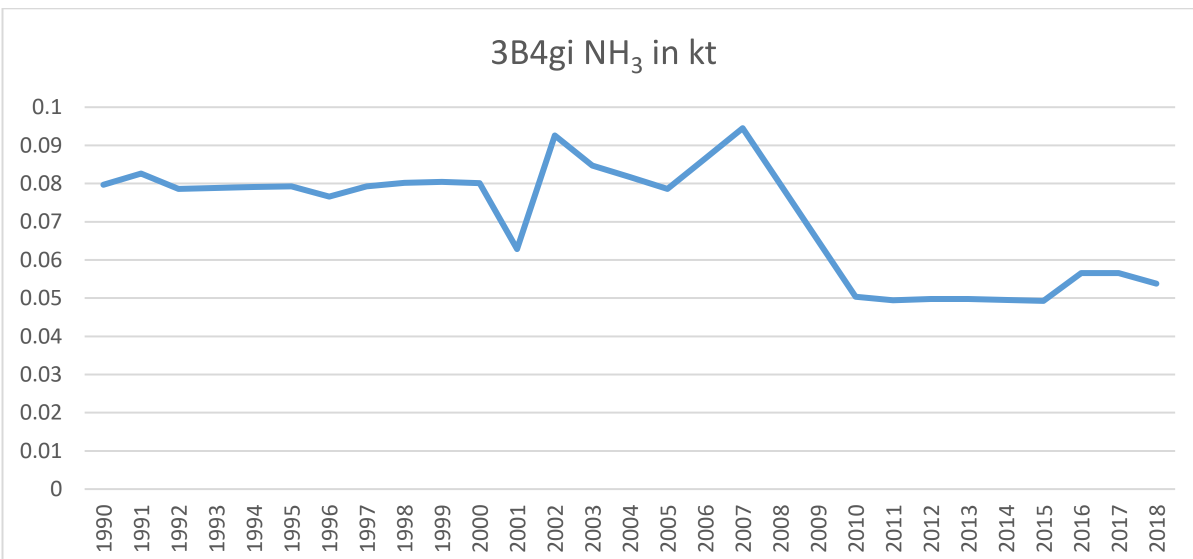

FIGURE 59: 3B4GI NH_3 TREND IN KT

NH_3 emissions from laying hens decreased overall across the time series. The recalculation with the N-flow tool resulted in a decrease in emissions.

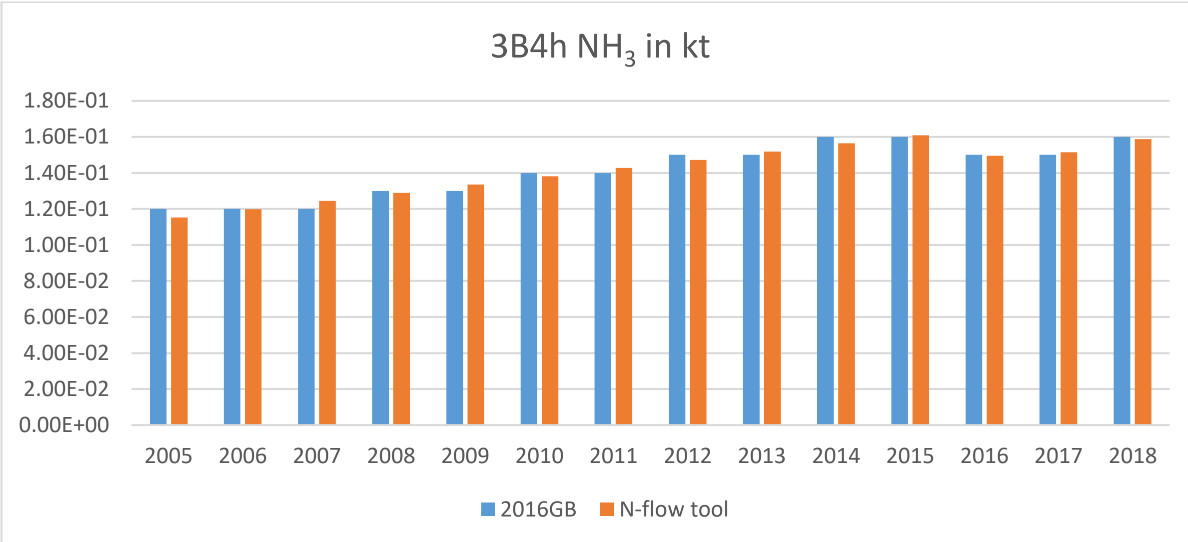

FIGURE 60: 3B4H NH_3 IN KT TIME SERIES

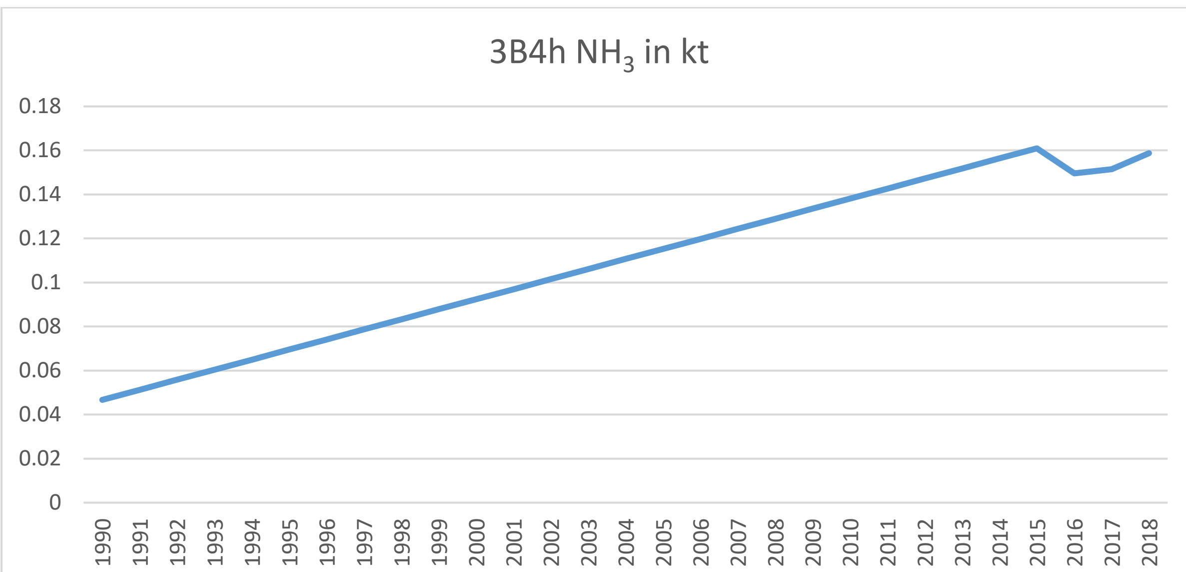

FIGURE 61: 3B4H NH_3 TREND IN KT

NH_3 emissions from other animals refer to emissions from rabbits. The trend shows an increasing trend across the time series. The shift to the N-flow tool decreased emissions slightly.

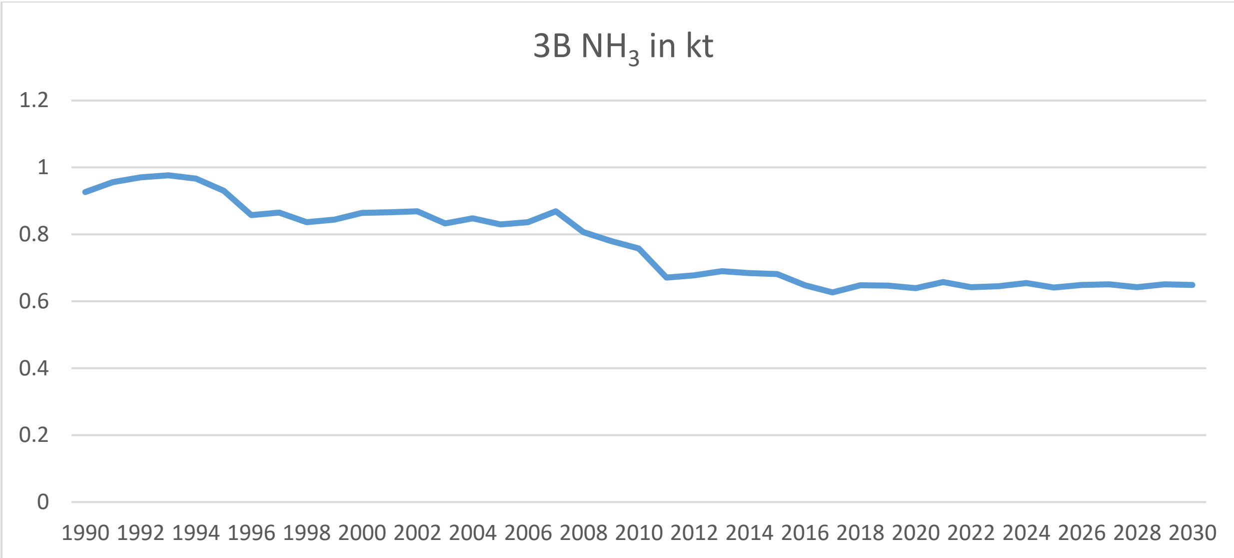

FIGURE 62: 3B NH_3 IN KT (WM AND WAM)

Concerning projections, Chapter 3B was a key category for NH_3. No projected activity data was available, therefore the historical activity data, such as livestock numbers and Nex values, was extrapolated in line with the climate change (MRA) model. Furthermore, the WM and WAM scenarios were assumed to be identical, as there was no projected activity data. The graph above shows a stable trend for NH_3 emissions.

nmVOC emissions from sub-chapter 3B Manure Management were calculated through a Tier 1 and 2 methodologies provided in the 2019GB, as shown in the tables below:

TABLE 19: 3B NMVOC TIER USED

NFR	Description	Tier
3B1a	Dairy Cows	Tier 2
3B1b	Non-dairy cows	Tier 2
3B2	Sheep	Tier 1
3B3	Swine – Sows	Tier 2
3B3	Swine - Fattening pigs	Tier 2
3B4a	Buffalo	NO
3B4d	Goats	Tier 1
3B4e	Horses	Tier 1

3B4f	Mules and Asses	NO
3B4gi	Laying hens	Tier 2
3B4gii	Broilers	Tier 2
3B4giii	Turkeys	NO
3B4giv	Other Poultry	Tier 1
3B4h	Other animals (Rabbits)	Tier 1

Both Tier 1 and Tier 2 calculations make use of the number of animal heads, which as mentioned previously, are provided by the NSO. In addition, Tier 2 calculations take into consideration other parameters, including the assumption that no grazing takes place locally, and livestock housing period is provided within table 19. No activity data on silage was available, and thus it was assumed to be 0. The Gross Feed Intake (GE) for cattle was provided by the NSO, while the Volatilized Solids (VS) for the remaining livestock types were taken from the UNFCCC guidelines, and both these values were in line with the climate change model.

Dairy cattle and broilers were the key categories for nmVOC. The emissions were calculated through a Tier 2 methodology, and the trends for these two categories can be observed below:

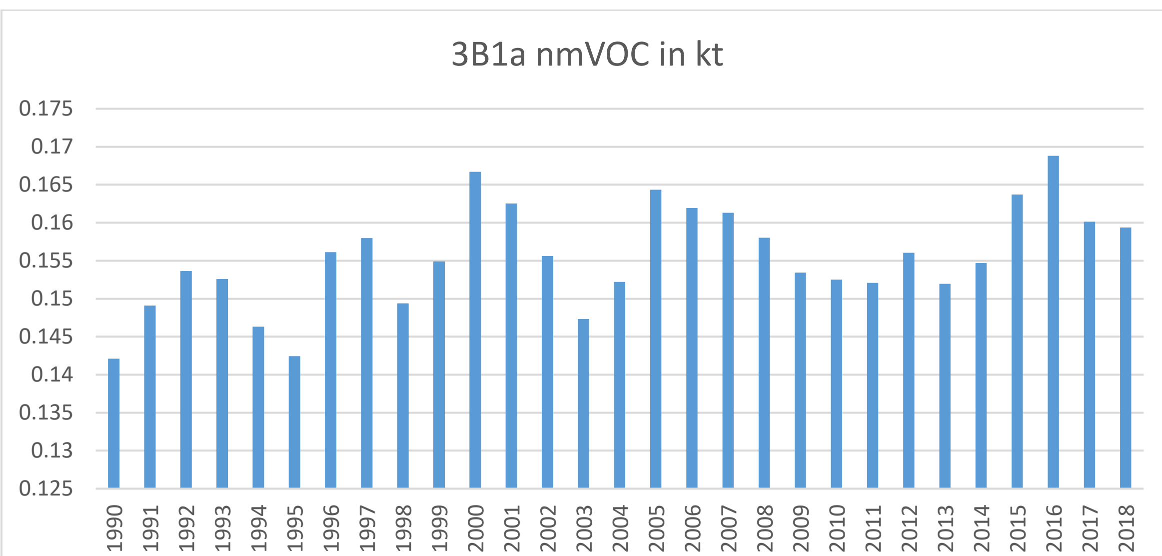

FIGURE 63: 3B1A NMVOC IN KT

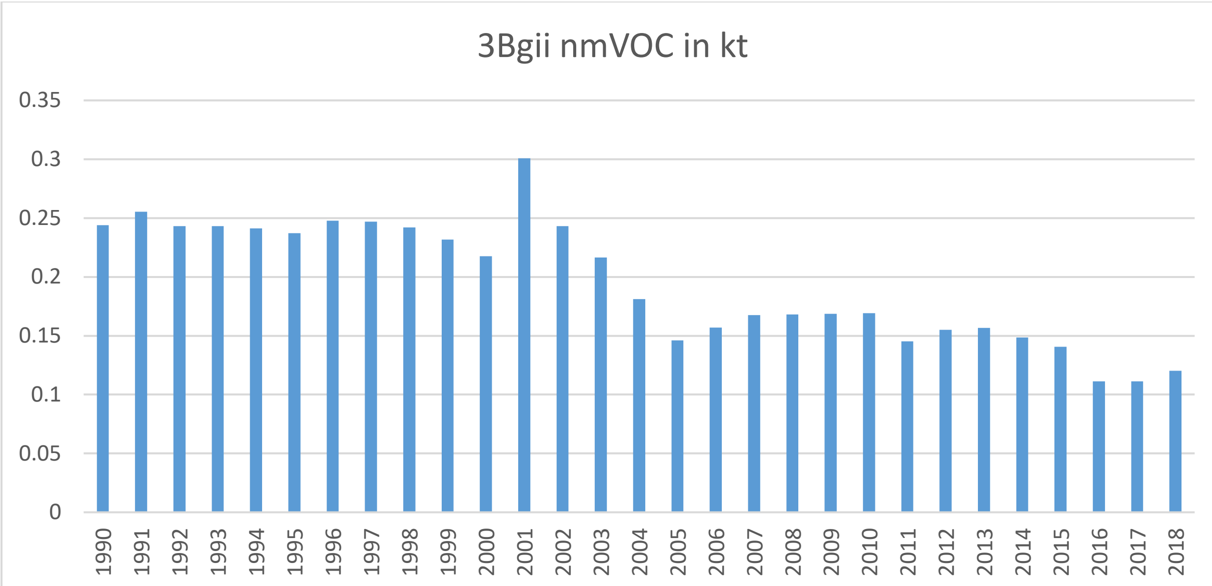

FIGURE 64: 3BGII NMVOC IN KT

3D: Crop production and agricultural soils

NFR-Code	Name of Category	Method	Activity Data	EF	Key Category for pollutants	Year of last update
3Da1, 3Da2a, 3Da2b, 3Da2c, 3Da3, 3Da4, 3Db, 3Dc, 3Dd, 3De	AgriOther	2019GB	NSO	Tier 1, 2	NH_3, PM_{10}	2020 submission

Emissions from sector 3Dc 'Farm-level agricultural operations, including storage, handling and transport of agricultural products', and 3De 'Cultivated crops', were estimated through a Tier 2 methodology in line with the 2019GB. Sector 3Da2a 'Livestock manure applied to soils' was also estimated through a Tier 2 methodology, by the Manure Management N-flow tool provided within the 2019GB. Furthermore, sector 3Da1 'Inorganic N fertilisers (includes urea) was calculated using a Tier 1 methodology.

Sector 3Da2c 'Other organic fertilisers applied to soils' was classified as IE, as these are sent to a landfill, and are thus covered under chapter 5A 'Biological treatment of waste - Solid waste disposal on land'. The annotation 'NO' was used for sector 3Da2b 'Sewage sludge applied to soils', as sewage sludge is not applied to soil in Malta. Similarly, emissions from 3Da3 'Urine and dung deposited by grazing animals' were also classified as NO, since grazing activity is negligible. Furthermore, 3Da4 'Crop residues applied to soils', 3Db 'Indirect emissions from managed soils', and 3Dd 'Off-farm storage, handling and transport of bulk agricultural products' were classified as NA, as no methodology was available.

3Da1: Inorganic N fertilisers (includes urea)

This sector was calculated through a Tier 1 methodology provided within the 2019GB. The nitrogen input to soil from synthetic fertilisers was required as activity data, and the main pollutants emitted from this sub-category were NH_3 and NO.

Regarding activity data, synthetic fertiliser application rates were not available over a time series. However, an annual figure was obtained through an estimation carried out within the climate change (MRA) model. The NSO study on the Gross Nitrogen Balance for Malta conducted in 2007 served to provide the N input from synthetic fertilisers for that year, and is used as a basis for estimating the N input across the entire time series. The utilised agricultural area (UAA), as provided by NSO, is available for the entire time series. Hence, an average value of N input of 60.3 kg N per ha of UAA in 2007 was applied across the entire time series, and then modified according to fertiliser consumption rates. The average N input value for a specific year is then multiplied by the UAA. Nevertheless, it is worth noting that the UAA, which is provided by the NSO through its Farm Survey, is only available from 2001 onwards. Furthermore, it is only calculated every 2 or 3 years. FAOSTAT data is used for filling of gaps in the 1990-2000 period. Interpolation is used for years where no statistics are available.

3Da2a: Livestock manure applied to soils

This sector was recalculated to a Tier 2 level through the Manure Management N-flow tool. The activity data used within the N-flow tool, and the relevant explanations are presented in Chapter 3B: Manure Management.

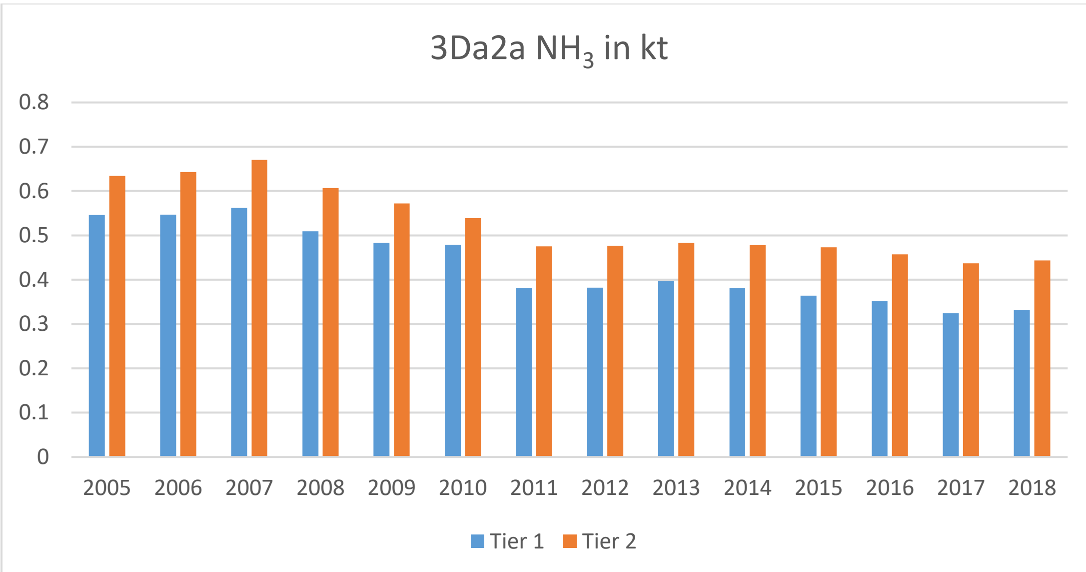

FIGURE 65: 3DA2A NH_3 RECALCULATION IN KT

The recalculation to a Tier 2 methodology increased emissions from this sector. Nevertheless, it is worth highlighting that the Tier 1 results presented within the figure above are based on the 2016GB. If the new Tier 1 EFs provided in the 2019GB were to be used, the emissions presented within the figure above might have been different.

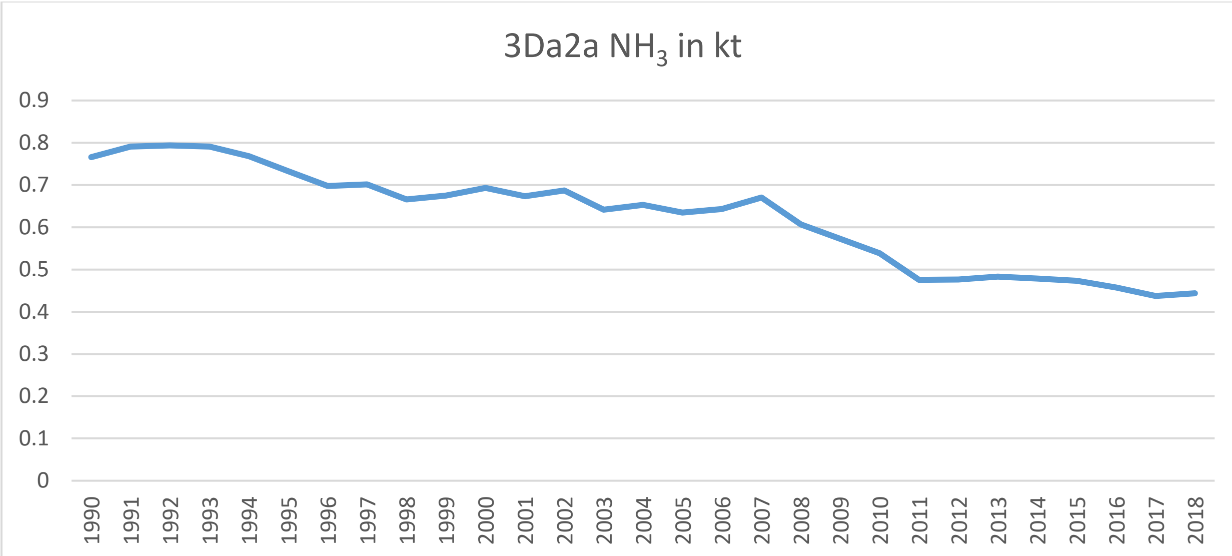

FIGURE 66: 3DA2A NH_3 TREND IN KT

The figure above shows a steady decrease of NH_3 emissions across the time series, which is attributed to a decrease in livestock numbers.

3Dc: Farm-level agricultural operations including storage, handling and transport of agricultural products

$PM_{2.5}$, PM_{10} and TSP emissions from this sector were calculated through the Tier 2 methodology provided by the 2019GB. The land area by crop type was provided by NSO & FAOSTAT and is in line with the climate change (MRA) model. The table below shows how local crop types are classified according to the categories provided within the 2019GB. The dry climate EFs were used, as Malta has a semi-arid climate (Galdies, 2011).

TABLE 20: CROP TYPE FOR EACH CATEGORY UNDER 3DC

Category in 2019GB	Crop type
Wheat	Land area under wheat
Barley	Land area under barley
Other arable	Land area under bean, potato, carrot, clover + vetch (sulla)
Grass	Land area under fodder + other fodder

3De: Cultivated crops

nmVOC emissions from this sector were calculated through the Tier 2 methodology presented in the 2019GB. The land area by crop type was provided by NSO & FAOSTAT and is in line with the climate change (MRA) model. The table below shows how local crop types are classified according to the categories provided within the 2019GB. The EF for Grass 25°C was used to better represent Malta's Mediterranean climate (Galdies, 2011).

TABLE 21: CROP TYPE FOR EACH CATEGORY UNDER 3DE

Category in 2019GB	Crop type
Wheat	Land area under wheat
Other arable	Land area under barley, bean, potato, carrot, clover + vetch (sulla)
Grass 25°C	Land area under fodder + other fodder

3D: Projections - Plant production and agricultural soils

Categories under Chapter 3D: Crop production and agricultural soils are all reported under Chapter 3D: Plant production and agricultural soils. This sector is a key category for NH_3 in 2030. The chapter covered all the sectors used for estimating historical emissions. As for Chapter 3B, no projected activity data was available. The historical data such as livestock numbers, nitrogen excretion (Nex) values, and the utilised agricultural area (UAA), was extrapolated in line with the climate change (MRA) model. Furthermore, since no projected data was available, the WM and WAM scenarios were assumed to be equal. The figure below shows a stable trend from 2018 to 2030.

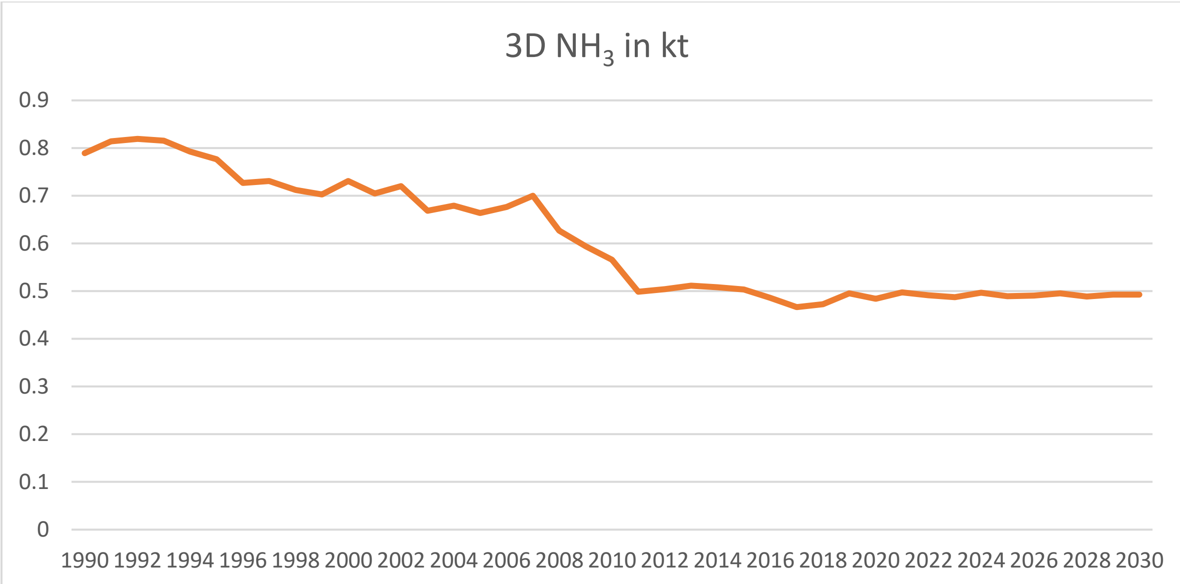

FIGURE 67: 3D NH_3 IN KT TIME SERIES

3F Field burning of agricultural residues

NFR-Code	Name of sub-Category	Method	Activity Data	EF	Key Category for pollutants	Year of last update
3.F	Field burning of agricultural residues	NA	NA	NA	NA	NA

NOx, nmVOC, SO_x, NH_3, and CO emissions are reported under this sector. At present, no activity data is available. However, previous inventory submissions had reported recurring figures for field burning under NFR 6 Other. These recurring figures are being reported under sector 3F for the first time in this submission.

6. Waste (NFR 5)

The waste chapter (NFR 5) includes emissions from the sectors in table 24. Sector 5C2: Open burning of waste was first calculated with this submission. The notation key 'NO' was used for sector 5B1: Biological treatment of waste – Composting, 5C1biv: Sewage sludge incineration, and 5C1bvi: Other waste incineration, since these activities do not take place locally.

TABLE 22: NFR 5 ESTIMATED SECTORS

Aggregation	Sector	NFR code
Waste	Biological treatment of waste - Solid waste disposal on land	5A
	Biological treatment of waste - Anaerobic digestion at biogas facilities	5B2
	Cremation	5C1bv
	Open burning of waste	5C2
	Other wastewater handling	5D3
	Other waste	5E

The pollutants covered in this chapter are NO_x, nmVOCs, SO_x, NH_3, $PM_{2.5}$, PM_{10}, TSP, BC, CO, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, PCDD/ PCDF, benzo(a) pyrene, benzo(b) fluoranthene, benzo(k) fluoranthene, Indeno (1,2,3-cd) pyrene, HCB, PCBs.

Of these pollutants, the waste sector is a key category for: nmVOC, PM_{10}, TSP, Se, PCDD/PCDF, benzo(k) fluoranthene, HCB, and PCBs.

The relevant pollutant trends for key categories, as well as, the methodologies used are explained in the sections below:

5A Biological treatment of waste – Solid waste disposal

NFR-Code	Name of Category	Method	Activity Data	EF	Key Category for pollutants	Year of last update
5A	Waste	2019GB	AER	Tier 3	PM_{10}, TSP	2020 submission

nmVOC emissions were recalculated through a methodology proposed by the TERT, which based its estimation on the CH_4 emissions reported in the UNFCCC Framework. CH_4 emissions were provided by the MRA. The volume of CH_4 in m^3 was then calculated through the equation below:

Equation 7: Calculate volume of CH_4

$$Total\ CH4\ *\ CH4\ molecular\ density\ (0.714) = Volume\ of\ CH4$$

The volume of biogas in m^3 was then calculated through the equation below, the fraction of CH_4 in biogas was taken from the IPCC 2006 Guidebook:

Equation 8: Calculating volume of biogas

$$\frac{Volume\ of\ CH4}{Fraction\ of\ CH4\ in\ biogas\ (50\%)} = Volume\ of\ biogas$$

Finally nmVOC was calculated through the equation below, the fraction of nmVOCs was taken from the 2019GB:

Equation 9: Calculating nmVOC emissions

$$Volume\ of\ biogas * Fraction\ of\ nmVOCs\ in\ biogas\ (5.65g/m3) = NMVOC\ emissions$$

The results from the recalculation shown in the graphs below indicate that emissions have decreased significantly through the new methodology.

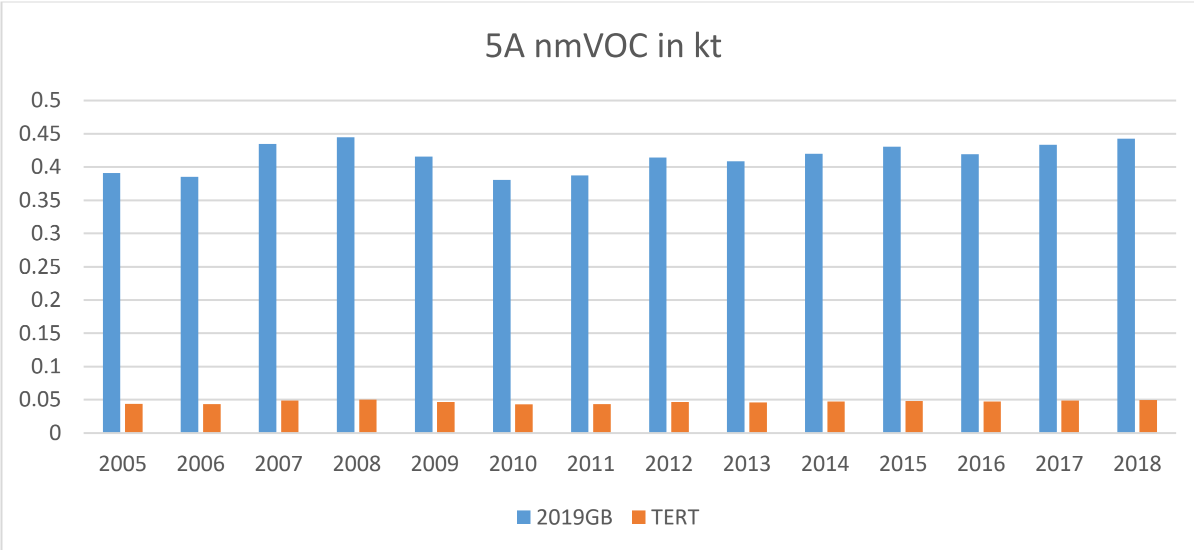

FIGURE 68: 5A NMVOC RECALCULATION IN KT

Concerning emissions from $PM_{2.5}$, PM_{10}, and TSP, these were calculated through the Tier 3 methodology used in previous submissions. The activity data consists of waste disposed of in landfills, excluding anaerobic digestate and animal manure. The emissions from these two contributions were already estimated in other sectors. The Waste Team at the Environment & Resources Authority (ERA) provided this data. Additionally, the mean wind speed was taken from a study by Galdies (2011), and a default factor provided in the 2019GB was used for the moisture content of the materials landfilled.

5B2: Biological treatment of waste – anaerobic digestion at biogas facilities

NFR-Code	Name of Category	Method	Activity Data	EF	Key Category for pollutants	Year of last update
5B2	Waste	2019GB	AER	Tier 2	NA	2019 submission

This submission includes NH_3 emissions from biological treatment of waste - anaerobic digestion (AD) at biogas facilities for the period ranging from 2011 to 2018. The Waste Team at the Environment & Resources Authority (ERA) provided this data. The Sant'Antnin Waste treatment facility was established in 2010; however, no data for that year was made available, and therefore emissions were calculated as from 2011. In addition, Malta North Waste treatment facility commenced operations in 2016, however data was made available as from 2017.

A tier 2 methodology based on the 2019GB was used to estimate emissions. The following equation was used to estimate NH_3 emissions:

EQUATION 10: EQUATION TO CALCULATE NH_3 EMISSIONS FROM ANAEROBIC DIGESTION

$$E_{NH3} = AR_{feedstock} * \sum_{stages} EF_{NH3\text{-}N,\ stage\ I} * 17/14$$

Where, *AR feedstock* refers to the total annual amount of N in feedstock (organic fraction entering the biogas facility). This was estimated by multiplying the organic fraction made available in the AER with the respective N content default factor made available in the 2019GB. The organic fraction entering the Anaerobic Digester was provided for 2011-2017 at Sant' Antnin waste treatment facility, and for all years at Malta North waste treatment facility. The 2018 figure at Sant' Antnin was estimated by taking an average fraction of the total waste from the Dry MTP that entered the AD for the years 2011-2017, and then applying that fraction to the total weight of waste entering the Dry MTP in 2018. The total amount of waste entering the AD can be observed in the graph below:

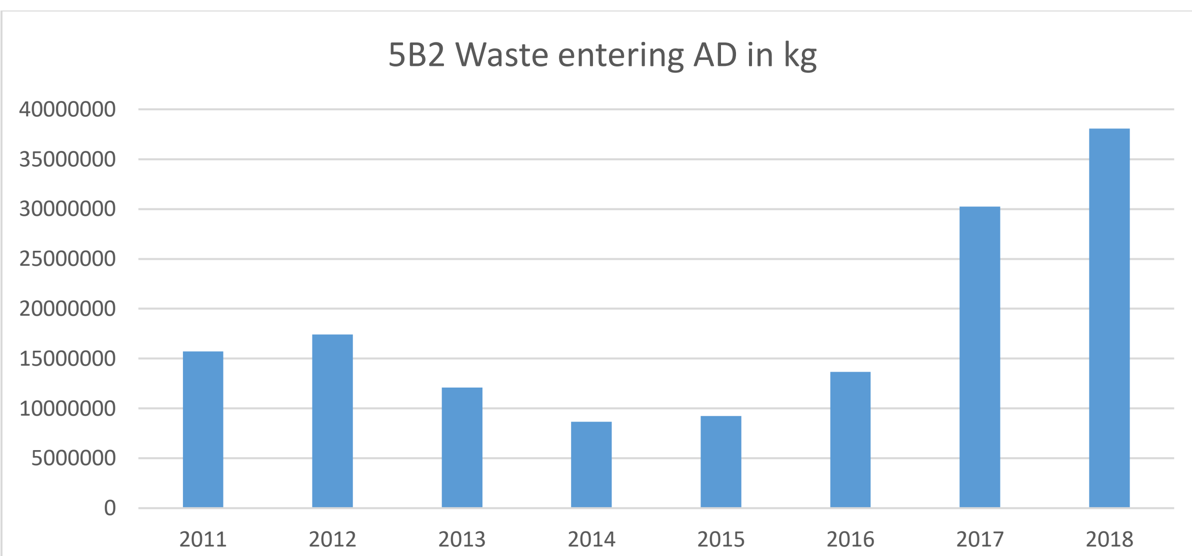

FIGURE 69: 5B2 WASTE ENTERING AD IN KG

Emission factors of NH_3, *stage i* refers to NH_3 emission factors at different stages. The pre-storage and storage of non-separate digestate were the only two stages considered to be relevant for local practices. This sector is not a key source to any of the pollutants in the national emission inventory.

5C1bv Cremation

NFR- Code	Name of sub-Category	Method	Activity Data	EF	Key Category for pollutants	Year of last update
5C1bv	Waste	2019GB	AER	Tier 1, 3	Se, PCDD/PCDF, HCB, PCBs	2019 Submission

Waste covered in the following categories within the 2019GB: Municipal Solid Waste (5C1a); Industrial Waste (5C1b); Clinical waste (5C1biii); and Cremation (5C1bv) are incinerated together within the Marsa Thermal Treatment Facility (MTTF). Thus, the emissions were all added to the Cremation sector (5C1bv), and the other categories, namely: 5C1a, 5C1b, and 5C1biii are all classified as IE.

The facility commenced its operation in late 2007; however, the first activity data available is from 2009. The Waste Team at the Environment & Resources Authority (ERA) provided the activity data, and emissions from continuous monitoring were available from the AERs. A Tier 3 methodology was used for the following pollutants, as the emissions were directly measured at the site: NO_x, nmVOC, SO_x, NH_3, $PM_{2.5}$, PM_{10}, TSP, CO, Pb, Cd, Hg, As, Cr, Ni, PCDD/PCDF. Certain pollutants had missing data for some years. In these cases, a country-specific emission factor was calculated, by obtaining an average emission load per mass of waste entering the facility. The mass of waste entering the facility in a year was then multiplied by the country-specific emission factor.

No direct emissions data was available for other pollutants, and thus these emissions had to be calculated using the Tier 1 methodology provided in the 2019GB. The pollutants whose emissions were calculated in this manner are as follows: BC, Se, Zn, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Indeno(1,2,3-cd)pyrene, Total 4 PAHs, HCB, PCBs.

The total waste entering the facility was classified according to EWC code. The EWC was then used as a guidance, to separate the waste into four categories: Municipal solid waste (5C1a), Industrial waste (5C1b), Clinical waste (5C1biii), and Cremation (5C1bv). The mass of waste from each category was multiplied by the relevant emission factor. The emissions from the four categories were summed to obtain a single emission load per pollutant.

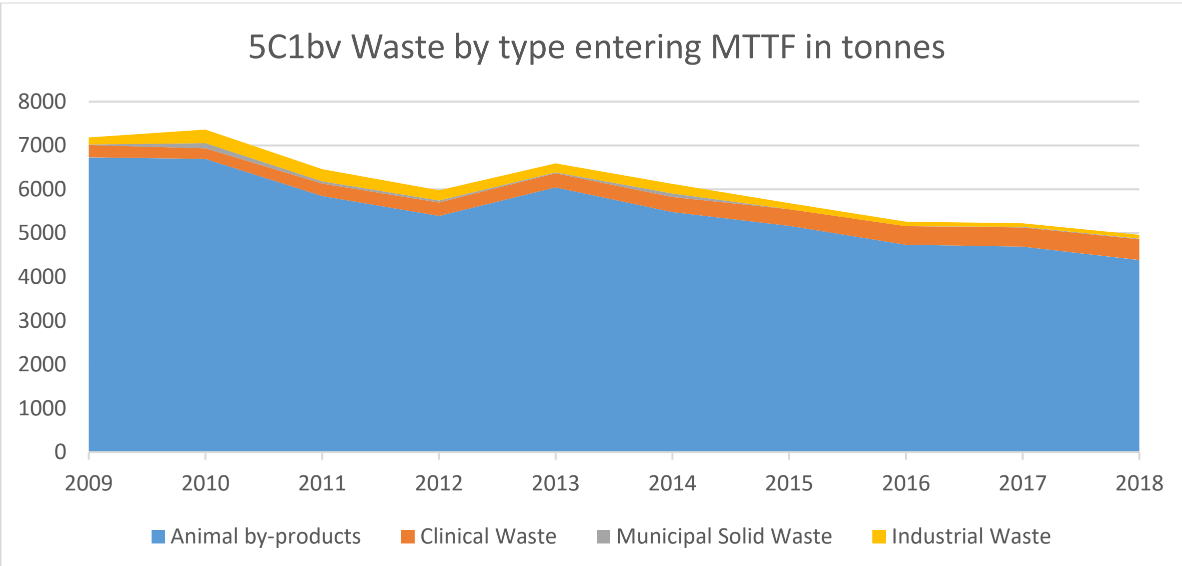

FIGURE 70: 5C1BV WASTE TYPE ENTERING THE THERMAL TREATMENT FACILITY

The chart above shows the waste entering the MTTF, classified by waste type. The largest waste type is animal waste, which is closest to the waste described in the Cremation sector (5C1bv). Clinical waste is the second largest source of waste, while municipal solid waste and industrial waste are considerably smaller. The general trend shows a decrease in waste entering the facility, mostly attributed to the cremation sector. In contrast, clinical waste has increased across the time series.

5.C.2 Open burning of waste

NFR- Code	Name of sub-Category	Method	Activity Data	EF	Key Category for pollutants	Year of last update
5C2	Waste	2019GB	AER	Tier 1	benzo(k) fluoranthene	2020 Submission

Emissions from open burning of waste were calculated for the first time with this submission. The amount of waste burnt was not available. However, the 2019GB provides a Tier 1 methodology that estimates the total waste burnt by multiplying the total arable area by a factor of 25kg/ha. The arable area was assumed to be equal to the UAA, which was previously described in Chapter 3D.

5.D Wastewater handling

NFR- Code	Name of sub-Category	Method	Activity Data	EF	Key Category for pollutants	Year of last update
5D	Waste	2019GB	AER	Tier 1	NA	2020 Submission

This section covers emissions from treated wastewater, as estimated through a Tier 1 methodology provided in the 2019GB. The activity data consisted of the total wastewater treated annually from 1990-2018 at four facilities: Ta' Barkat, Iċ-Ċumnija, Sant' Antnin (Malta) and Ras il-Ħobż (Gozo). The Water Services Corporation (WSC) provided the activity data. This sector generates nmVOC emissions, and these were calculated by multiplying the activity data with the Tier 1 emission factors in the 2019GB. This sector is not a key source for any of the pollutants in the national inventory.

5E. Other Waste

NFR- Code	Name of sub-Category	Method	Activity Data	EF	Key Category for pollutants	Year of last update
5E	Waste	2019GB	Civil Protection Department (CPD)	Tier 2	NA	2020 Submission

The Civil Protection Department (CPD) provided the activity data from 2000-2018. Data for the remaining historical years was extrapolated. The tier 2 approach provided in the 2019GB was used, and this sector was not a key source for any pollutant.

The activity data made available did not differentiate between different types of dwellings. Hence, the share of dwellings provided within the NSO (2011) census was used to determine the share of detached houses, undetached houses, and apartments catching fire. Furthermore, no EF was provided for hotels, therefore the EF for apartments was used, since hotels tend to comprise of small rooms that are most similar to apartments. The number of car and industrial building fires was provided directly by the CPD.

The CPD indicated that when a fire takes place, only 1 or 2 rooms actually catch fire. Furthermore, the entire car tends to be burnt in the event of a fire, while 60% of industrial buildings tend to catch fire. Considering this information, and taking the average number of rooms as provided by the 2011 NSO census, the percentage of car or building burnt was calculated as shown below:

Parameter	**Rooms burnt**	**Number of rooms**	**% of vehicle/building burnt**
Car	N/A	N/A	100.0%
Undetached house	2	9	22.2%
Detached house	2	12	16.6%
Apartment	2	5	40.0%
Hotel/Guest house	2	112	1.8%
Industrial building	N/A	N/A	60.0%

FIGURE 71: 5E SHARE OF VEHICLES & BUILDINGS BURNT

Waste Projections

Projections from all waste categories are reported together under Chapter 5: Waste. The projected activity data for: 5A, 5B2, and 5C1bv was provided by the Ministry for The Environment, Climate Change, and Planning (MECP), whereas projected activity data for 5D was provided by the Water Services Corporation (WSC). No projected activity data was available for sectors 5C2 and 5E, and therefore the 2018 value was carried forward for these sectors.

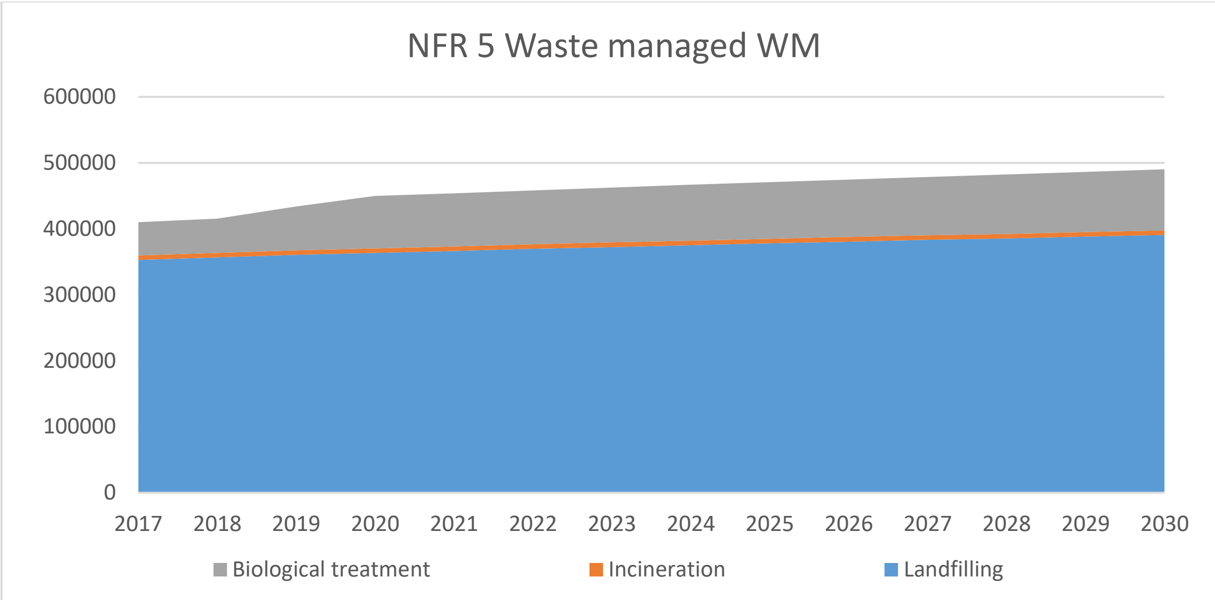

FIGURE 72: NFR 5 WASTE MANAGED IN DIFFERENT WASTE FACILITIES WM

The chart above for the with-measures (WM) scenario shows a moderate increase for all three waste categories.

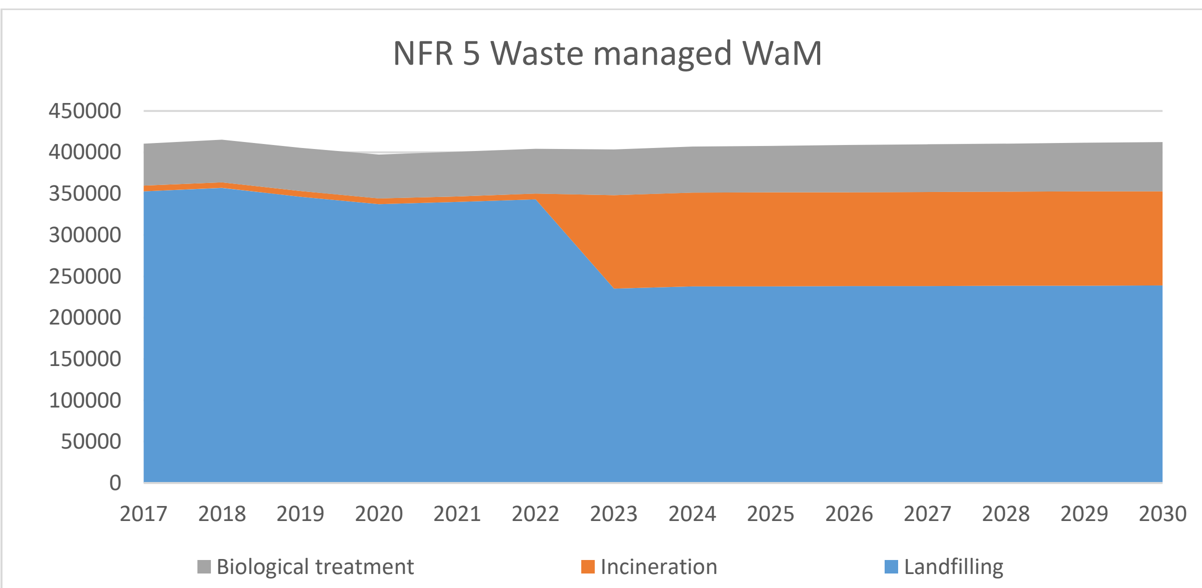

FIGURE 73: NFR 5 WASTE MANAGED TIME SERIES WAM

In contrast, the with-additional-measures (WaM) scenario shows a sudden decrease in landfilling at around 2023, since it is planned that a significant amount of previously landfilled waste will start entering a newly constructed Waste-to-Energy Facility. The EFs for the Waste-to-Energy Facility will be in line with the requirements of the Industrial Emissions Directive 2010/75/EU, and it will operate utilizing Best Available Techniques (BATs). The emission levels were therefore assumed to comprise of those in Best Available Techniques (BAT) Reference Document for Waste Incineration. Since these emission levels correspond to those used for the MTTF, the same emission factor was used.

Treated wastewater projected by WSC assumes that all wastewater will be treated prior to discharge to sea as required by the Urban Wastewater Treatment Directive. Moreover, the with-measures (WM) and with-additional-measures scenario (WaM) are identical.

8. Projections

8.1. Trends for NO_x

NO_x emissions are projected to decrease from 2018 to 2030, with the greatest decrease being emissions in the road transport sector (1A3b). The projections show that NO_x emissions under both the WM and WaM scenarios, will be lower than the 2020 ceiling but significantly higher than the 2030 ceiling. It is worth noting that the WaM scenario is higher than the WM scenario in both 2020, and 2025. This difference can be partially attributed to the increase in fuel use in the National Navigation (1A3dii) sector, with the operation of the fast ferry post 2020 to 2026.

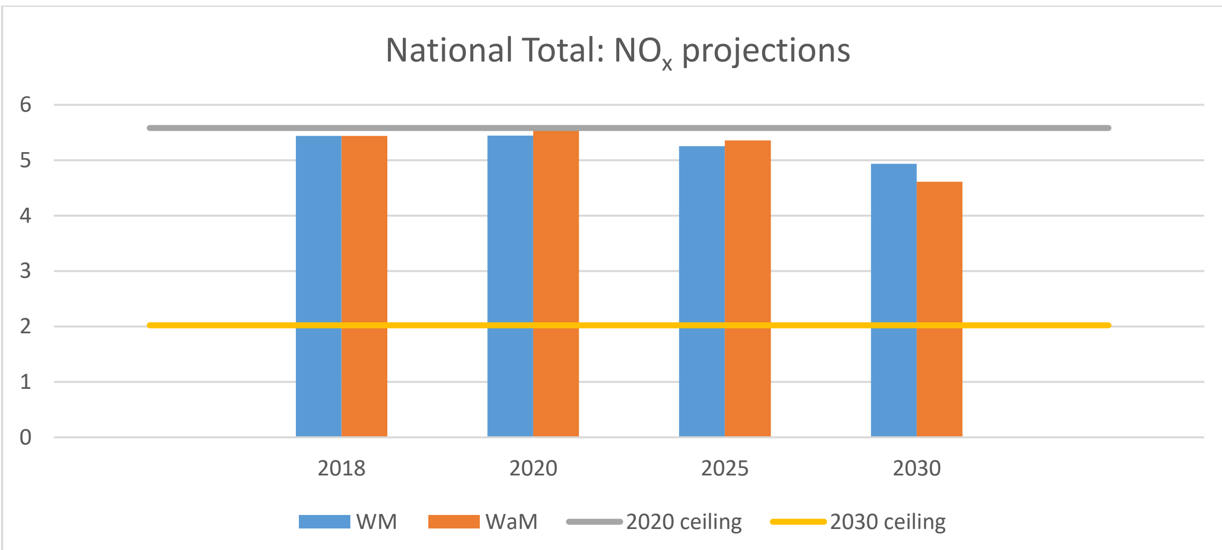

FIGURE 74: PROJECTIONS FOR NO_x IN KT FOR 2018, 2020, 2025, 2030 (WM AND WAM)

8.2. Trends for nmVOC

nmVOC emissions are projected to decrease from 2018 until 2030, with the greatest decrease being emissions in the road transport sector (1A3b). The projections show that nmVOC emissions, under both the WM and WaM scenarios, will be higher than the 2020 ceiling but lower than the 2030 ceiling.

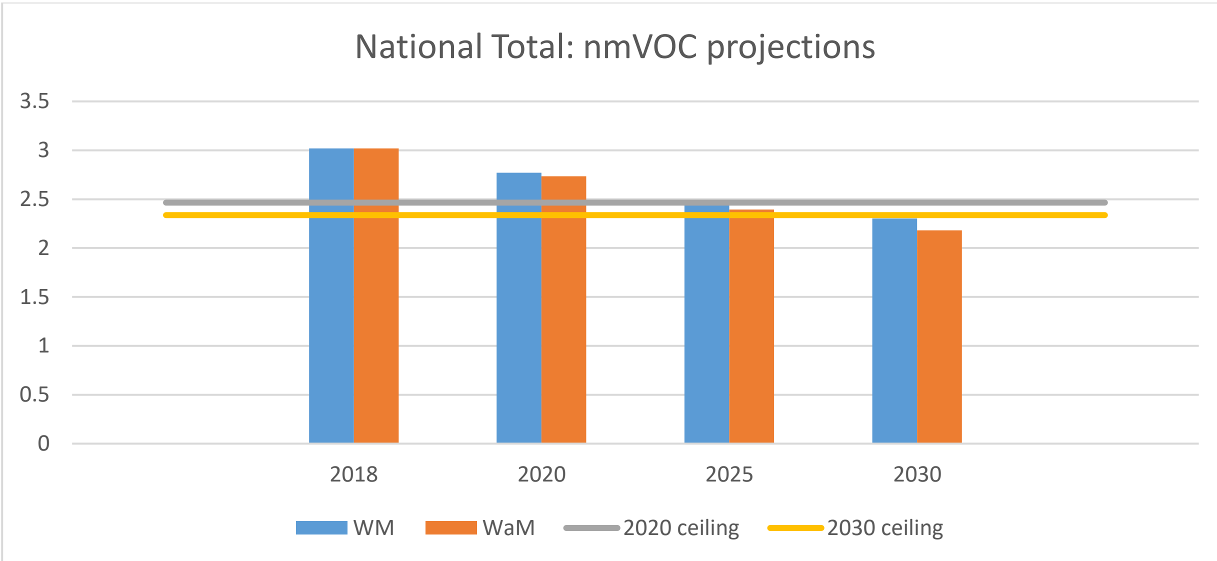

FIGURE 75: PROJECTIONS FOR NMVOC IN KT FOR 2018, 2020, 2025, 2030 (WM AND WAM)

8.3. Trends for SO_x

SO_x emissions are projected to remain stable across the time series. The projections show that SO_x emissions, will be significantly lower than both the 2020 and 2030 ceilings, under both the WM and WaM scenarios. It is worth noting that the WaM scenario is higher than the WM scenario in both 2020, and 2025. This difference can be partially attributed to the increase in fuel use in the National Navigation (1A3dii) sector, with the operation of the fast ferry between 2020 and 2026.

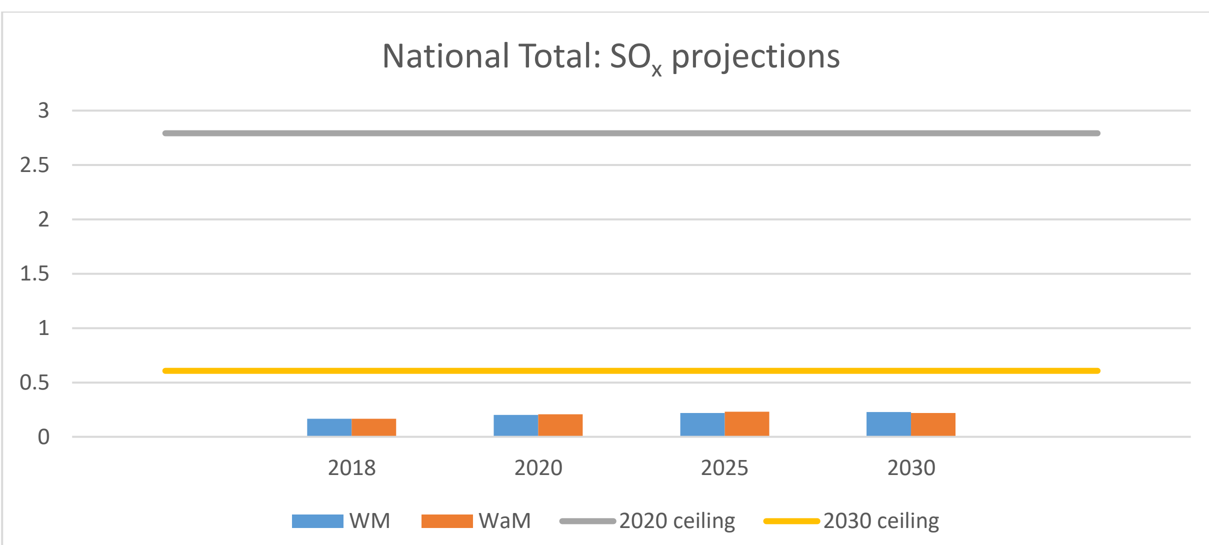

FIGURE 76: PROJECTIONS FOR SO_x IN KT FOR 2018, 2020, 2025, 2030 (WM AND WAM)

8.4. Trends for NH_3

NH_3 emissions are projected to remain stable across the time series, as the livestock numbers are projected to remain stable. The projections show that NH_3 emissions, will be lower than the 2020 ceiling, but slightly higher than the 2030 ceilings, under both the WM and WaM scenarios.

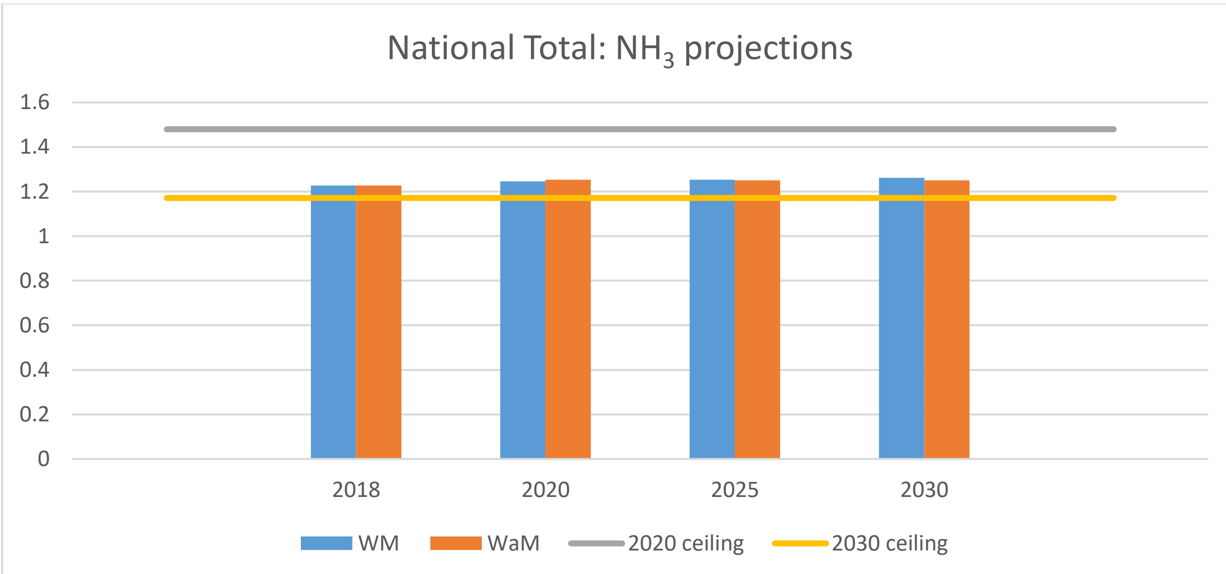

FIGURE 77: PROJECTIONS FOR NH_3 IN KT FOR 2018, 2020, 2025, 2030 (WM AND WAM)

8.5. Trends for $PM_{2.5}$

$PM_{2.5}$ emissions are projected to decrease from 2018 until 2030, with the greatest decrease being emissions in the road transport sector (1A3b). The projections show that $PM_{2.5}$ emissions, will be lower than both the 2020 and 2030 ceilings, for both the WM and WaM scenarios.

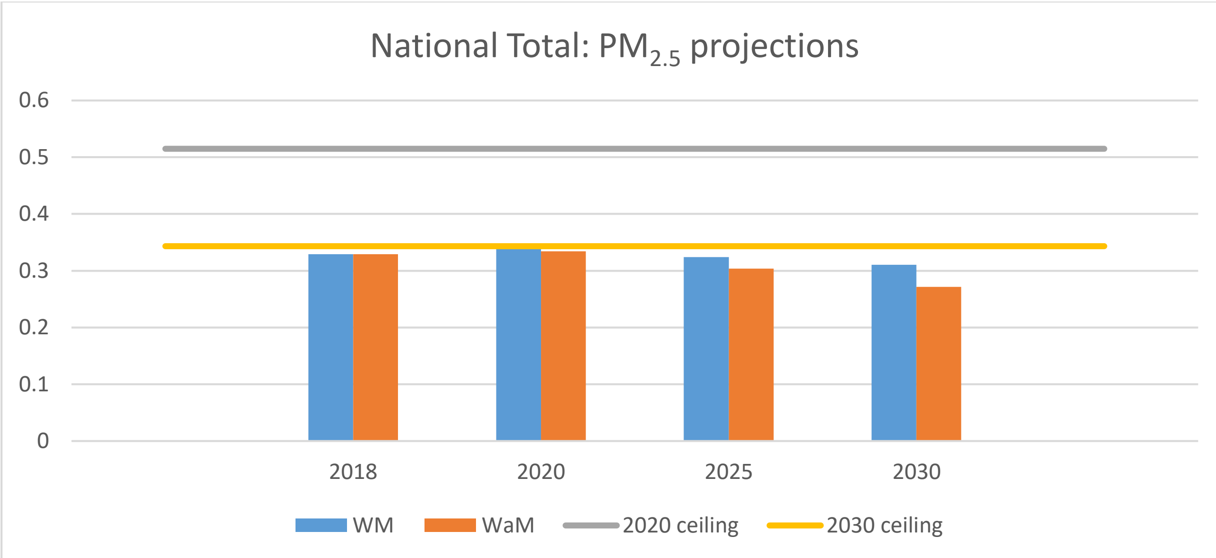

FIGURE 78: PROJECTIONS FOR $PM_{2.5}$ IN KT FOR 2018, 2020, 2025, 2030 (WM AND WAM)

9. References

Camilleri, R., & Vella, A. J. (2016). Emission Factors for Aerial Pyrotechnics and Use in Assessing Environmental Impact of Firework Displays: Case Study from Malta. *Propellants, Explosives, Pyrotechnics*, 273-280.

European Environment Agency. (2019). *EMEP/EEA air pollutant emission inventory guidebook: Technical guidance to prepare national emission inventories.* Copenhagen: Luxembourg: Publications Office of the European Union.

Galdies, C. (2011). *The Climate of Malta: statistics, trends and analysis, 1951-2010.* Valletta: National Statistics Office.

National Statistics Office (NSO). (2014). *Census of Population and Housing 2011: Final Report.* Valletta: Government Printing Press.

Robinson, J. (2006). *Oxford Companion to Wine (Third ed.).* Oxford: Oxford University Press.

Sustech Consulting. (2008). *Agricultural Waste Management Plan for the Maltese Islands.*

Timmers, V. R., & Achten, P. A. (2016). Non-exhaust PM emissions from electric vehicles. *Atmospheric Environment*, 10-17.