NATIONAL GREENHOUSE GAS EMISSIONS AND REMOVALS INVENTORY FOR MALTA
- 2016 -

ANNUAL REPORT FOR SUBMISSION UNDER THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE, THE KYOTO PROTOCOL AND THE EUROPEAN UNION MONITORING MECHANISM

The Malta Resources Authority
on behalf of the
Ministry for Sustainable Development, Environment and Climate Change

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PREFACE

This report, being Malta's submission pursuant to the European Union's Monitoring Mechanism[1], the Kyoto Protocol and the United Nations Framework Convention on Climate Change (UNFCCC) contains national estimates of greenhouse gas emissions from sources and removals by sinks for the period 1990-2014, and information on the methods and approaches used to produce the estimates. The report is prepared in accordance with Decision 24/CP.19[2] and follows the structure outlined in the Appendix to Annex I[3] to Decision 24/CP.19.

The Greenhouse Gas Inventory is compiled by the Climate Change Unit of the Malta Resources Authority. The GHG Inventory is compiled mainly according to 2006 IPCC Guidelines and the Good Practice Guidance; however, in some exceptional cases, the 1996 Revised Guidelines may have been used. Each year the inventory is updated to include the latest data available. Methodological changes are made to take account of new data sources, new guidance from IPCC or other specific issues.

In 2015, Malta submitted its inventory under UNFCCC but not under Kyoto Protocol, because the CRF Reporter could not deliver error free CRF tables for Kyoto Protocol LULUCF activities. The present report is an official inventory resubmission of Malta for the year 2016 under the UNFCCC and Kyoto Protocol and a resubmissions for the year 2015 under the Convention and the Kyoto Protocol.

[1] Regulation (EU) No 525/2013 of the European Parliament and of the Council of 21 May 2013 on a mechanism for monitoring and reporting greenhouse gas emissions and for reporting other information at national and Union level relevant to climate change and repealing Decision No 280/2004/EC. OJ L 165, 18.6.2013.

[2] FCCC Decision 24/CP.19: Revision of the UNFCCC reporting guidelines on annual inventories for Parties included in Annex I to the Convention. FCCC/CP/2013/10/Add.3, 31 January 2014.

[3] Annex I to FCCC Decision 24/CP.19: Guidelines for the preparation of national communications by Parties included in Annex I to the Convention, Part I: UNFCCC reporting guidelines on annual greenhouse gas inventories. FCCC/CP/2013/10/Add.3, 31 January 2014.

EXECUTIVE SUMMARY

ES.1 BACKGROUND INFORMATION ON GREENHOUSE GAS INVENTORIES AND CLIMATE CHANGE

The recognition that "*climate change is a common concern of mankind*[4]", and the acknowledgment that "*necessary and timely action should be taken to deal with climate change within a global framework*"[5] led to the adoption of the United Nations Framework Convention on Climate Change in 1992. A few years later saw the adoption of the Kyoto Protocol to the Convention, this protocol eventually coming into force in 2005.

The Convention and the Protocol together provide a basis for action on climate change on two main fronts: mitigation of climate change through the limitation or reduction of greenhouse gas emissions from anthropogenic activities, and adaptation to the climatic changes that have and will continue to occur in view of the accumulated greenhouse gases in the atmosphere.

Malta ratified the UNFCCC on 17th March 1994, originally as a non-Annex I party, and the Kyoto Protocol, under the same status, on 11th November 2001. The non-Annex I status meant that Malta was not set a quantified emission limitation or reduction target under the Kyoto Protocol. At the Conference of the Parties to the UNFCCC, serving as the Meeting of the Parties to the Kyoto Protocol (COP15/MOP5) held in Copenhagen in 2009, Malta made a request for its inclusion in Annex I, a request which was formally approved in 2010. The accession to Annex I status however was based on the understanding that until 2012, Malta would still not take on a quantified emission limitation or reduction target under the Protocol, a situation which changed as of 2013.

Among the obligations that the Convention and the Protocol set for Parties who have ratified these instruments, the reporting of emissions of greenhouse gases by sources and removals by sinks remains a fundamental element.

The obligation to present an annual report on anthropogenic greenhouse gas emissions and removals has been translated into European Union law. This submission is the first yearly submission provided for under the European Union's Monitoring Mechanism.

Malta's greenhouse gas inventory is compiled by the national greenhouse gas inventory team within the Climate Change Unit of the Malta Resources Authority. Overall responsibility for Malta's national greenhouse gas inventory lies with the Ministry for Sustainable Development, the Environment and Climate Change in its capacity as Single National Entity, as designated by national law.

This inventory submission contains greenhouse gas emissions and removals estimates for the period 1990 to 2014, and this written report provides the methodology underpinning the estimation of emissions and removals. This report complements the detailed data and information presented in the attached Common Reporting Format.

The inventory covers the direct greenhouse gases which currently fall within the scope of the Kyoto Protocol, namely carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF_6) and nitrogen trifluoride (NF_3), and the indirect

[4] United Nations General Assembly Resolution 43/53; 1988.

[5] Ibid.

greenhouse gases nitrogen oxides (NOx; reported as NO_2), carbon monoxide (CO) and non-methane volatile organic compounds (NMVOCs). Sulphur dioxide (SO_2) emissions are also covered by this inventory.

Sectors that either serve as sources of emissions or as sinks for removals of greenhouse gases are aggregated into the following categories:

- 1. Energy;
- 2. Industrial Processes;
- 3. Solvents and Other Products Use;
- 4. Agriculture;
- 5. Land Use, Land-Use Change and Forestry (LULUCF); and,
- 6. Waste.

Emissions from international bunkers, both aviation and marine related, are also estimated; however, these are not considered as being 'national' emissions.

This report is structured thus:

- Chapter 1 provides general background information on Malta and its approach to inventory preparation;
- Chapter 2 presents and discussed main emission trends for aggregated greenhouse gas emissions and removals, by sector and by gas;
- Chapters 3 to 9 discuss the separate main source categories listed above, providing detailed information on the methodologies applied to estimate emissions and removals from the various source categories under each sector (Chapter 3: Energy; Chapter 4: Industrial Processes; Chapter 5: Solvents and Other Product Use; Chapter 6: Agriculture; Chapter 7: Land Use, Land-use Change and Forestry; Chapter 8: Waste; Chapter 9: Other Sectors);
- Additional information is provided on further chapters and annexes.

ES.2 SUMMARY OF NATIONAL EMISSION AND REMOVAL TRENDS

Table ES-1 gives an overview of total gross (without LULUCF) and net (with LULUCF) national greenhouse gas emissions and emissions disaggregated by gas. The change in total emissions between base year and the latest reported year (2014) for the without-LULUCF estimates represents an increase of 48.94%, while for the with-LULUCF estimates this represents an increase of 48.99%. Carbon dioxide (CO_2) maintains its standing as the gas with the highest share of total national emissions, followed by hydrofluorocarbons (HFCs) and methane (CH_4). The substantial relative increase in emissions of HFCs is worth noting.

Table ES-1 Greenhouse gas emissions, by gas and total gross (without LULUCF) and net (with LULUCF), for the period 1990 to 2014

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
	Gg CO_2 equivalent												
CO_2 (without LULUCF)	1,857.90	2,310.57	2,411.64	2,735.68	2,777.45	2,834.06	2,821.81	2,683.63	2,687.69	2,783.20	2,866.10	2,473.50	2,481.19
CO_2 (with LULUCF)	1,860.47	2,313.22	2,414.28	2,738.36	2,780.17	2,836.81	2,824.60	2,686.43	2,690.52	2,786.07	2,869.00	2,476.37	2,484.02
CH_4	78.28	112.68	130.42	149.10	161.80	173.26	174.40	185.94	196.62	185.96	186.64	188.67	196.50
N_2O	61.49	73.35	75.92	71.07	72.50	74.76	72.02	69.23	63.82	63.23	63.88	64.48	64.54
HFCs	NO, NA, NE, IE	NO, NA, NE, IE	3.72	41.43	79.32	96.40	112.17	133.02	144.73	167.85	200.93	218.33	233.25
PFCs	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
SF_6	0.01	1.44	1.47	1.56	1.57	1.58	1.75	1.50	1.69	4.59	0.45	2.68	0.58
Total (without LULUCF)	2,000.25	2,500.69	2,625.81	3,001.53	3,095.37	3,182.81	3,184.94	3,076.12	3,097.38	3,207.70	3,320.90	2,950.52	2,978.89
Total (with LULUCF	1,997.68	2,498.04	2,623.16	2,998.85	3,092.65	3,180.05	3,182.14	3,073.32	3,094.55	3,204.84	3,318.00	2,947.66	2,976.06

ES.3 OVERVIEW OF SOURCE AND SINK CATEGORY EMISSIONS ESTIMATES AND TRENDS

Table ES-2 presents an overview of emission and removal trends by sector. Sector Energy, which includes, among others, energy industries and road transport, remains the sector with the highest contribution to national total emissions. The sector Industrial Processes and Product Use has the second highest contribution, in recent years surpassing other sectors such as Agriculture and Waste. The increase in emissions of the sector Industrial Processes and Product Use is due primarily to the increase in emissions of HFCs, as already noted above.

Table ES-2 Emissions of greenhouse gases by sector for the period 1990 to 2014

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
	Gg CO_2 equivalent												
Energy	1868.32	2323.51	2426.96	2752.72	2793.91	2852.01	2839.66	2700.38	2700.49	2796.94	2881.23	2487.71	2495.65
Industrial Processes and product use	7.49	8.94	11.85	48.59	86.98	103.86	119.48	139.85	151.02	177.43	206.34	225.54	238.13
Agriculture	82.00	108.00	112.26	102.90	104.08	108.21	101.83	98.21	94.89	88.65	87.55	90.11	88.86
LULUCF	-2.57	-2.65	-2.65	-2.68	-2.72	-2.76	-2.79	-2.79	-2.83	-2.87	-2.90	-2.87	-2.83
Waste	42.44	60.24	74.74	97.33	110.40	118.73	123.97	137.68	150.98	144.69	145.78	147.16	156.25
Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total (with LULUCF	**1997.68**	**2498.04**	**2623.16**	**2998.85**	**3092.65**	**3180.05**	**3182.14**	**3073.32**	**3094.55**	**3204.84**	**3318.00**	**2947.66**	**2976.06**

Chapter 1. INTRODUCTION

1.1 BACKGROUND INFORMATION ON GREENHOUSE GAS INVENTORIES AND CLIMATE CHANGE

1.1.1 BACKGROUND INFORMATION ON CLIMATE CHANGE

The Earth's climate, acting over long periods of time, is a principal determinant of the landscape and living organisms. It has, for much of humankind's prehistory and history, influenced to a marked extent the relationship between human beings and their surroundings.

It is well known that the Earth's climate has changed over time. For much of the planet's lifetime, such changes were due to natural causes. However, a significantly rapid change in climatic conditions has been observed over the course of the last 200 years or so. An unprecedented global warming trend has been measured. There is now widespread consensus that its main cause is anthropogenic: that is, human activities, such as the combustion of fossil fuels, releasing large quantities of greenhouse gases into the atmosphere, and deforestation, which represents the destruction of an important sink, trees having the faculty of being able to absorb carbon dioxide from the atmosphere, this chemical species being an important greenhouse gas.

The increase in atmospheric temperature brings with it important effects on weather patterns, with different regions experiencing different impacts. While in certain areas of the world, rates of precipitation may increase, possibly leading even to severe flooding, precipitation in other regions is observed to decrease, even drastically, leading to drought conditions. Both scenarios represent particular concerns to humans and ecosystems. Sea level rise is caused by thermal expansion of the ocean waters and the melting of glaciers and ice caps. Low lying areas are particularly susceptible to this effect of climate change. Impacts of climate change on agriculture, water resources, health and infrastructure are also cause for concern.

The United Nations Framework Convention on Climate Change (UNFCCC) was adopted in 1992 with the objective of achieving "*stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system*". The Kyoto Protocol to the Convention, adopted in 1997, was intended to make the Convention more effective by setting legally binding quantified emission limitation or reduction targets for a number of industrialised countries (the so-called Annex I Parties to the Convention, as opposed to the non-Annex I Parties which did not have binding emission related obligations). As the Protocol's first commitment period (2008-2012) elapsed, an extension to the Protocol was adopted until 2020. A new agreement (the so-called Paris Agreement) was adopted at the 21st Conference of the Parties held in Paris in 2015, and will replace the Kyoto Protocol after 2020.

1.1.2 BACKGROUND INFORMATION ON MALTA

Malta is a group of islands situated in the central Mediterranean, some 90 kilometres to the south of Sicily and 290 kilometres north of the African mainland. The Maltese Islands include Malta, Gozo and Comino, the three inhabited islands, Malta being the largest, Comino the smallest. Smaller uninhabited islands (Cominotto, Filfla and St Paul's Islands) and a number of islets are situated close to the coastline. The islands together encompass an area of 316 square kilometres with a total shoreline of 271 kilometres.

The climate is typically Mediterranean, with hot, dry summers and relatively mild winters with fluctuating rain patterns. The general trend for climatic conditions normally sees the highest mean monthly air temperature in July and August (for 2013, 26.6°C and 27.5°C respectively), with the lowest monthly mean usually observed in January and February (for 2013, 13.3°C and 12.3°C respectively). Average monthly relative humidity typically varies between 60% (in summer months) and 80% (in winter months). Average annual total rainfall for the period 2009-2013 was 557 mm.

With a population standing at 429,344 in 2014, Malta is one of the most densely populated countries in the world, with a population density of 1,359 persons/km^2. Over the past 30 years or so, the islands' small and open economy has transitioned from one originally based primarily on manufacturing activity towards a greater emphasis on high value added activities such as tourism and services. The domestic market is relatively small and the insularity inherent in a small island state offers added challenges.

Malta is not immune to the impacts of climate change, and as a small island state it can be considered as being particularly vulnerable to such impacts. Indeed, events of high temperatures in summer, resulting in heat waves, are not a rare occurrence. Precipitation rates are of particular interest to the country. With no indigenous sources of readily available fresh water such as lakes or rivers, Malta is limited to extraction of water from the water table, replenished through rainfall, or, as has been the case in the recent few decades, desalination of sea water, a process that whilst satisfying more than half of the potable water requirements of the country at present, is also particularly energy intensive. The impact of changing climatic conditions in other areas of the world may also be felt by Malta. Its proximity to the North African coastline could make Malta a point of transit for migrants escaping the devastation that climate change can bring about in Africa. Malta's economy being highly dependent on trade with other countries, whether it is for imports and exports, or for tourism, the vulnerability of the country to the economic impacts of climate change cannot be ignored.

1.1.3 Background information on greenhouse gas inventories

Greenhouse gas (GHG) inventories of anthropogenic emissions by sources and removals by sinks are an important tool in climate policy, especially where this relates to greenhouse gas mitigation action. The UNFCCC establishes the basic principles of greenhouse gas inventories.

Article 4 of the Convention states that:

> "*1. All Parties, taking into account their common but differentiated responsibilities and their specific national and regional development priorities, objectives and circumstances, shall:*
>
> *(a) Develop, periodically update, publish and make available to the Conference of the Parties,* [...] *national inventories of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol, using comparable methodologies to be agreed upon by the Conference of the Parties*".

Article 12 continues thus:

> "*1. In accordance with Article 4, paragraph 1, each Party shall communicate to the Conference of the Parties, through the secretariat, the following elements of information:*
>
> *(a) A national inventory of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol, to the extent its capacities permit, using comparable methodologies to be promoted and agreed upon by the Conference of the Parties*".

The Kyoto Protocol furthermore requires Annex I Parties to:

> "*have in place* [...] *a national system for the estimation of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol*."

A submission of a greenhouse gas inventory by an Annex I Party incorporates a National Inventory Report (NIR) which includes, among others, a description of the methodologies used, sources of data and the national approach to inventory compilation, accompanied by detailed quantified data on emissions and removals in Common Reporting Format (CRF) tables.

1.1.3.1 Greenhouse gases reported

Two types of greenhouse gases are reported in national greenhouse gas inventories.

Direct greenhouse gases contribute directly to climate change due to their positive radiative forcing effect; that is, their presence in the atmosphere tends to lead to an increase in atmospheric temperature. Seven categories of such gases are covered by greenhouse gas inventories, namely:

- Carbon dioxide (CO_2);
- Methane (CH_4);
- Nitrous oxide (N_2O);
- Hydrofluorocarbons (HFCs);
- Perfluorocarbons (PFCs);
- Sulphur hexafluoride (SF_6); and,
- Nitrogen trifluoride (NF_3).

The radiative forcing effect for each greenhouse gas species is usually denoted as the Global Warming Potential (GWP). Global Warming Potentials of the direct greenhouse gases discussed in this inventory report are presented in Table 1-1.

As scientific knowledge on the effect of different gases has grown, the GWPs of many greenhouse gases previously established in the 2nd Assessment Report (2AR) of the Inter-Governmental Panel on Climate Change (IPCC) were updated in the 4th Assessment Report (4AR), published in 2007. Inventory submissions up to the 2014 (covering the years 1990 to 2012) used 2AR GWP values. This inventory submission uses 4AR GWP values, in accordance with the applicable decisions taken under the UNFCCC. Historic estimates of emissions and removals for the years up to 2012 have been recalculated to take into account the revised GWP values.

For purposes of aggregation of estimated emissions or removals of different greenhouse gases into a single total, and to facilitate comparison between different gases, quantities of greenhouse gases emitted or removed are often also presented in terms of 'CO_2 equivalents', whereby a quantity of a particular gas is multiplied by the GWP of that gas. Thus, 1 tonne of CH_4 can also be represented as 21 tonnes of CO_2 equivalents; 1 tonne of N_2O can be represented as 310 tonnes CO_2 equivalents, and so on.

Table 1-1 Global Warming Potentials (GWP) of direct greenhouse gases covered by this inventory report pursuant to IPCC Climate Change 2007 – The Physical Science Basis – WGI Contribution to the 4th Assessment Report

Chemical species	Chemical formula	GWP (time horizon: 100 years) based on Fourth Assessment Report
Carbon dioxide	CO_2	1
Methane	CH_4	25
Nitrous oxide	N_2O	298
Nitrogen trifluoride	NF_3	17,200
Hydrofluorocarbons:		
HFC-23	CHF_3	14,800
HFC-32	CH_2F_2	675
HFC-125	CHF_2CF_3	3,500
HFC-134a	CH_2FCF_3	1,430
HFC-143a	CH_3CF3	4,470
HFC-227ea	CF_3CHFCF_3	3,220
Perfluorocarbons:		
Perfluoroethane (PFC-116)	C_2F_6	12,200
Perfluoropropane (PFC-218)	C_3F_8	8,830
Sulphur hexafluoride	SF_6	22,800

Indirect greenhouse gases, also known as precursors, do not directly induce an increase in atmospheric temperature as such; however, their release into the atmosphere results in their chemical conversion into species that have an effect similar to the direct greenhouse gases mentioned above. The indirect greenhouse gases included in national greenhouse gas inventories are:

- Nitrogen oxides (NOx; reported as NO_2);
- Carbon monoxide (CO);
- Non-methane volatile organic compounds (NMVOCs);
- Sulphur dioxide (SO_2).

This latter group of gases, albeit subject to similar reporting requirements as for the direct greenhouse gases, are not however aggregated with the direct greenhouse gases and are usually discussed separately from the direct greenhouse gases.

1.1.3.2 Sectors reported

Six main sectors of sources and sinks of greenhouse gases are covered by the national GHG inventory. Each sector is further disaggregated into categories for each of which separate estimations of emissions or removals are carried out in accordance with accepted methodologies and depending on their occurrence in the country. These sectors are:

- 1. Energy;
- 2. Industrial Processes;
- 3. Solvents and Other Products Use;
- 4. Agriculture;
- 5. Land Use, Land-Use Change and Forestry (LULUCF); and,
- 6. Waste.

Also forming part of an inventory submission are estimates of emissions from a number of additional categories known as 'Memo Items'. Emission estimates for these categories which include, *inter alia*, emissions from international maritime and aviation bunkering activities, are however not considered as part of 'national totals' of emissions and removals.

1.2 DESCRIPTION OF THE NATIONAL INVENTORY ARRANGEMENTS

1.2.1 INSTITUTIONAL, LEGAL AND PROCEDURAL ARRANGEMENTS

A first national GHG inventory was compiled as a stand-alone exercise in the context of the preparation of Malta's First National Communication to the UNFCCC, submitted and published in 2004. At the time, Malta was a non-Annex I party to the Convention and reporting obligations were those applicable to such a status. This first inventory was carried out by a team of inventory compilers coordinated by the University of Malta.

In 2004, Malta acceded to full membership of the European Union (EU). Despite retaining the non-Annex I status under the UNFCCC, reporting obligations relating to greenhouse gas emissions and removals became more stringent, and in line with the EU's Monitoring Mechanism[6], which included the requirement to report a national GHG inventory on an annual frequency with strict timeframes, namely: the submission of a 'provisional' inventory on 15th January of each year to the European Commission, covering the time series from 1990 (as base year) to the year before last (X-2); a 'final' inventory submission by the following 15th March, that may include changes to the January submission; and the submission under the UNFCCC by 15th April.

As of 2010 Malta's status under the UNFCCC changed to that of Annex I Party, which means that reporting obligations relating to such a status became fully applicable to Malta.

The inventory reporting requirements under EU legislation, and then also under Annex I status, made it necessary to establish a process whereby annual inventory reporting could be fulfilled. The Malta Environment and Planning Authority (MEPA) was initially entrusted to take on this obligation, subsequently followed by a migration of this and other climate action responsibilities to the Malta Resources Authority (MRA) as of 2010, following a change in Ministerial portfolios at the time. Thus, the Climate Change Unit at MRA is currently responsible for the preparation of the national GHG inventory, including this submission.

Political ownership of the national GHG inventory is vested in the Ministry responsible for climate change policy, this being the Ministry for Sustainable Development, Environment and Climate Change (MSDEC). Official approval of the report prior to submission is a shared responsibility between MSDEC, the EU Secretariat within the Ministry for European Affairs and the Implementation of the Electoral Manifesto (MEAIM) and the Permanent Representation of Malta to the European Union. Figure 1-1 describes, in schematic manner, the various roles.

[6] Formerly Decision No 280/2004/EC of the European Parliament and of the Council of 11 February 2004 concerning a mechanism for monitoring Community greenhouse gas emissions and for implementing the Kyoto Protocol; replaced by Regulation (EU) No 525/2013.

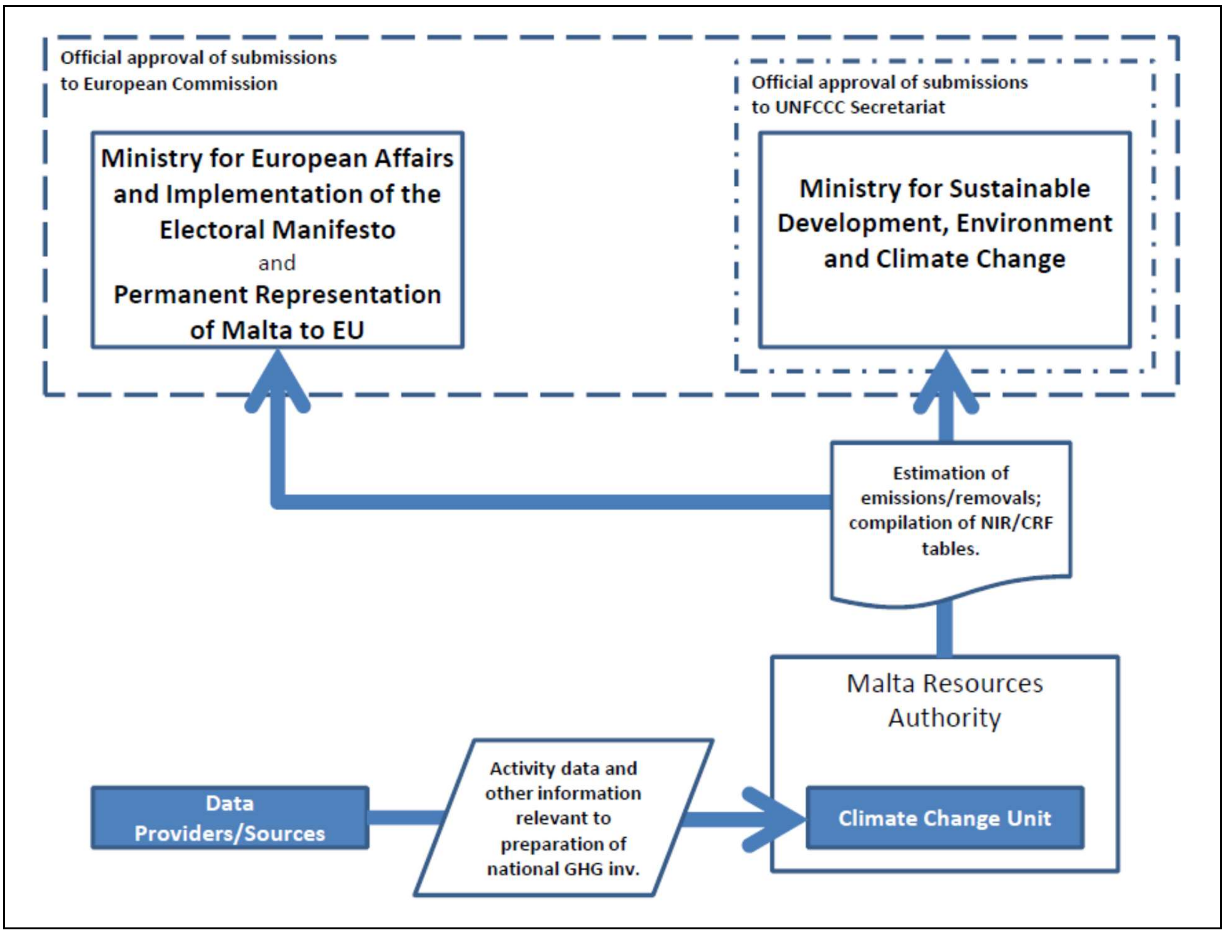

Figure 1-1 Schematic representation of the current institutional arrangements for the preparation and submission of national greenhouse gas inventories of Malta

Any Annex I Party to the UNFCCC has an obligation to establish a National Greenhouse Gas Inventory System, defined by decision 19/CMP.1 "Guidelines for national systems under Article 5, paragraph 1, of the Kyoto Protocol" as:

> "*all institutional, legal and procedural arrangements made within a Party included in Annex I for estimating anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol, and for reporting and archiving inventory information*."

This obligation has also been transposed into EU law.

A first recommendation for the setting up of a national inventory system was made in 2005, following discussions with inventory experts from the Federal Environment Agency of Austria. This led to the recruitment of staff to work on national inventories (greenhouse gases and air quality) and the first steps towards a more structured inventory compilation process. In 2007/2008 MEPA commissioned a more in-depth assessment of inventory compilation practices in place at the time in order to draw up recommendations for the formal establishment of a national inventory system that would be in accordance with requirements under the Kyoto Protocol; the intention was to integrate inventory reporting relating to both climate change and air quality obligations. Unfortunately, due to a number of reasons, this assessment and its recommendations could not be followed-up with concrete action.

Malta's accession to Annex I status, the ratification requirements of the Doha Amendments to the Kyoto Protocol and the obligations arising from EU law make it imperative that a fully functioning national inventory system that meets the requirements of decision 19/CMP.1 is established. To this effect, the Climate Change Unit at MRA had taken the initiative, in 2013 to submit a report "Establishing a National Greenhouse Gas Inventory System for Malta"[7] to the relevant local authorities in order to instigate and inform the decision-making process. As a result of this initiative, legislation has recently been published establishing a national system for greenhouse gas inventories[8]. The legal notice, among other aspects, formally identifies the Minister responsible for climate change as the Single National Entity in accordance with the relevant UNFCCC requirements and provides for the formal designation of an inventory agency. Under the same legal notice, the Malta Resources Authority has been designated as the Inventory Agency. The legal notice forms part of a wider legislative framework being established specifically for climate action in Malta, with the main underpinning legal instrument being the Climate Action Act, 2015 (Chap. 543)[9].

1.2.2 Overview of inventory planning, preparation and management

The Climate Change Unit at MRA is entirely responsible for the planning, preparation and management of the national GHG inventory. Four officers (that includes three sectoral inventory compilers) within the Unit perform duties related to the inventory, including: the preparation of the annual greenhouse gas inventory submission of Malta, performing most of the functions involved, starting from the gathering of data from the relevant data providers, to estimating sectoral emissions or removals of greenhouse gases; drafting of this report and the inputting of data into the CRF Reporter software; and, final submission to the European Commission, the European Environment Agency and the UNFCCC Secretariat. As necessary, the Unit also engages outside contributors to assist in the preparation of submissions.

The preparation of the annual inventory submission is spread over a whole year cycle. The conclusion of an inventory cycle, once the April submission to the UNFCCC Secretariat has been completed, is marked by an internal post-submission evaluation that identifies areas where improvements need to be carried out. This evaluation is further informed by the results of annual inventory peer reviews. Immediately afterwards work starts on the next year's submission. In summer, communications with data providers commence, with the quantification of emissions and removals done through the months leading to December, when the drafting of the inventory report and the inputting of data into the CRF Reporter software are carried out. Following the January submission, updating of the inventory to include any additional improvements that may be required is done, prior to finalizing the submissions of March and April respectively.

National legislation establishing a formal national inventory system provides a legal framework for the management of the inventory process by the Ministry and the Climate Change Unit. However, one must acknowledge that much remains to be done to consolidate processes from an administrative perspective. This is particularly evident in respect of gathering data, where efforts continue as to establish, to the

[7] Establishing a National Greenhouse Gas Inventory System for Malta; Climate Change Unit-Malta Resources Authority; 30th May 2013.

[8] Legal Notice 259 of 2015, National System For The Estimation Of Anthropogenic Greenhouse Gas Emissions By Sources And Removals By Sinks Regulations, 2015.

[9] Climate Action Act, 2015, Chapter 543; 7th July 2015.

extent possible, formal channels of data gathering to ensure timely provision of reliable data. The current approach to inventory compilation may be schematically represented as in Figure 1-2.

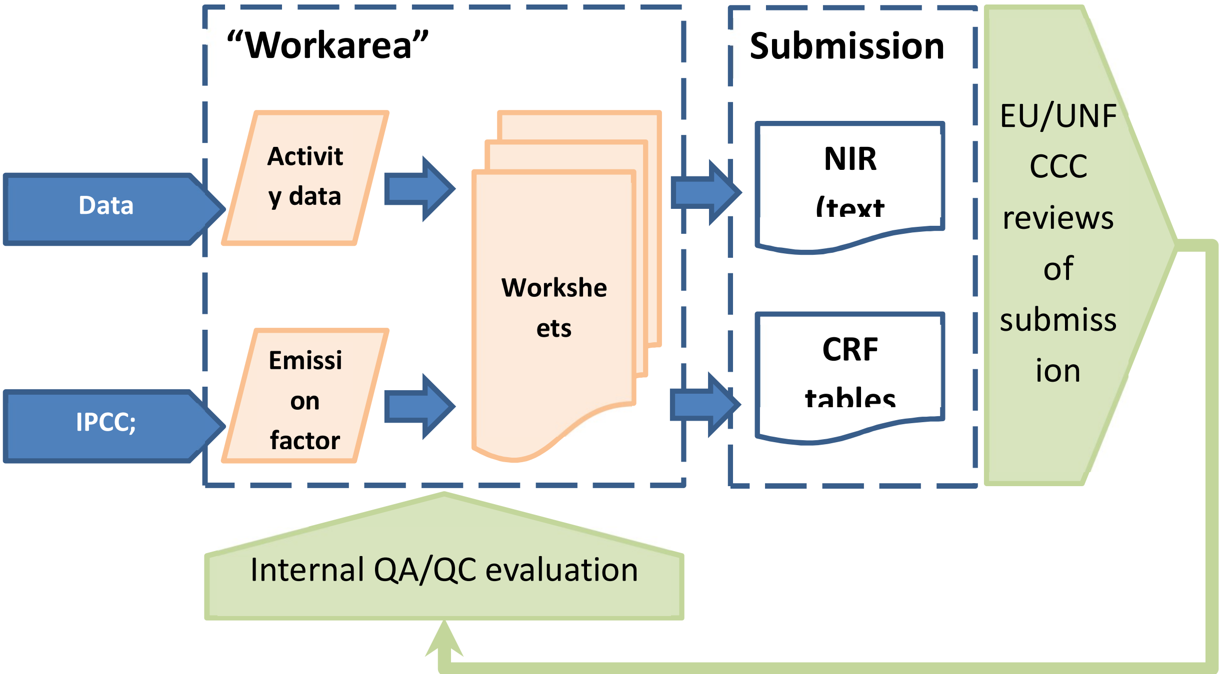

Figure 1-2 Schematic representation of the current approach to greenhouse gas inventory compilation applied by the Climate Change Unit.

1.2.3 QUALITY ASSURANCE, QUALITY CONTROL AND VERIFICATION PLAN

The inventory preparation and management process aims at ensuring the accuracy, comparability, consistency, completeness, transparency and timeliness of national inventory submissions. *"It is good practice to implement quality assurance and quality control (QA/QC) procedures in the development of national greenhouse gas inventories"*[10] in order to meet the listed quality criteria.

Admittedly, a formally documented greenhouse gas inventory QA/QC system for the inventory process remains still under development. However, this does not mean that quality checks are not carried out. Indeed, the inventory is subject to at least two peer review processes every year: a peer review in-line with requirements set out in the EU's Monitoring Mechanism and a peer review under UNFCCC rules. An important deliverable from these reviews is the publication of reports highlighting, in particular, those areas where the respective review teams feel that inventory compilation practices need to be further developed in order to ensure better-quality reporting. These review reports feed into the internal evaluations of inventory submissions performed by the inventory team itself and thus help guide the inventory team in its preparation of future submissions.

At the same time there is already a process for documenting the work performed by the Climate Change Unit in preparing an inventory submission. Besides the spreadsheets that are used to estimate emissions,

[10] Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (GPG2000, IPCC, 2000).

and to determine uncertainties and key categories, which therefore serve to document the estimation process itself, a number of additional ancillary forms are already in use. These include the forms listed in Table 1-2.

Table 1-2 List of QA/QC forms in use by the Climate Change Unit at MRA to document aspects of greenhouse gas inventory compilation

Name of form	Purpose
Inventory Tasks	To record the distribution of tasks related to the compilation of a year's inventory among the members of the inventory team.
Data Log	To document the collection of data used for the preparation of a year's inventory, including the source.
Emission Factors Log	To document the emission factors used in the preparation of a year's inventory, including the source.
Report Submission Log	To document the versions of reports prepared and submitted by the Climate Change Unit.
Annual Inventory Evaluation	To record findings from inventory peer reviews and/or internal evaluations and record decisions and actions taken accordingly.

1.2.4 Changes in the national inventory arrangements since the previous annual GHG inventory submission

As already mentioned above, legislation that establishing a national inventory system has been adopted, forming part of a body of legislative instruments under the Climate Action Act, 2015 (Chap. 543) that will provide a comprehensive legal framework for climate action in Malta.

It is also pertinent to note that a number of studies have been commissioned by MRA in recent years, aimed at addressing particular methodological issues in certain source and sink categories (F-gases; Agriculture; LULUCF). References to these studies are made in the respective sector chapters as relevant.

Furthermore, a project was carried out towards the end of 2014 whereby experts from the University of Malta undertook an external assessment of the national greenhouse gas inventory submission. This being a first such experience for all concerned, and thus to also serve as a means for expert capacity building, the first such assessment was undertaken on the 2014 inventory submission. The focus was on an overall assessment of the national inventory report with a detailed assessment of the sector Energy. As applicable, this assessment identified a number of potential risks in the inventory preparation process, proposed measures to avoid, prevent or reduce such risks, and proposed other improvements. The outcome of this project will feed into further consideration of continuing such collaboration between the inventory compilation team and the University of Malta.

Time constraints relating to the national inventory submissions of 2015 and 2016 unfortunately made it impossible to carry out similar exercises for the 2015 and 2016 inventories.

1.3 INVENTORY PREPARATION, AND DATA COLLECTION, PROCESSING AND STORAGE

Inventory preparation starts with communication with data providers that are the source of the all-important activity data, on the basis of which sectoral emissions and removals estimates can be performed.

Receipt of activity data is logged in order to ensure optimal traceability. The activity data received is then assessed for its validity as an input into the emission and removals estimation process. The estimations of emissions and removals are performed using spreadsheets developed internally and specifically for the national greenhouse gas inventory process; these spreadsheets describe the calculations involved in translating activity data and calculation factors (e.g. emissions factors, oxidation factors) into reportable emission and removal values. Each inventory compiler in the national greenhouse gas inventory team is responsible for a number of sectoral categories.

Once the quantification of emissions and removals is concluded, the next phase entails the drafting of the national inventory report (this written report) and the inputting of the quantified results of the estimation of emissions and removals into the CRF Reporter software. The written report provides detailed information on the overall set-up of inventory preparation in the country, the approach used to estimate emissions and removals and other information as required by the relevant reporting rules and legislation. The CRF reporting system serves to bring together, in a sequence of detailed spreadsheets, the relevant quantitative information on emissions and removals as estimated, and activity data and calculation factors as used in the compilation of the inventory, covering the whole time series, starting from 1990 (as base year) until the last but one year from the year of submission (year X-2).

The data and spreadsheets that form the crucial basis for any inventory submission are held on secure systems maintained by MRA. The server handling this material is housed in a location within MRA offices that has restricted access, protected with advanced antivirus and firewall systems that are updated on a regular basis. Backups are performed on a daily basis onto separate backup hard drives. Access to the folder in which the relevant inventory files are held is limited to the staff within the Climate Change Unit; access by all staff of MRA to the Authority's servers is restricted by passwords which have to be changed regularly. These features, and the fact that the server system has no direct link with the outside, not only further enhance the security of the inventory compilation process but also ensure confidentiality of inventory-related information, at least where such information is not already available in the public domain. Furthermore, all MRA staff and any contracted external experts (including any external experts contributing to the preparation of the national greenhouse gas inventory) are required to sign up to a confidentiality agreement.

Following official consideration and approval of the report and CRF tables, submissions are made to the European Commission through the EIONET web-system of the European Environment Agency and the UNFCCC Secretariat.

As already indicated above, a first submission to the European Commission is made by not later than mid-January, including both the written report and the CRF tables. It is sometimes the case that revised or previously missing data is found following this provisional submission, which justifies revisions to the estimations previously performed. There may also be instances where a change in the methodological approach is identified after the January submission which could improve the greenhouse gas inventory estimation process and which thus would also warrant an update of the inventory report and the CRF tables. Such updates[11] are often carried out during the period of weeks leading up to mid-March, when a final submission of the national inventory report and final CRF tables to the European Commission have to be submitted.

A final submission is then prepared so as to be submitted to the UNFCCC Secretariat by mid-April. To the extent possible, this submission is maintained the same as that made in the previous March to the European Commission. There are however occasions where some amendments either to the text of the report or even changes to estimations of emissions and removals of greenhouse gases are done in order to ensure the continued relevance of the submission.

It is to be noted that the inventory submissions made by the European Union Member States to the European Commission serve as the basis for the latter's compilation and submission of the Union greenhouse gas inventory to the UNFCCC Secretariat, in the context of the European Union's reporting obligations as an Annex I Party in its own right to the UNFCCC and the Kyoto Protocol.

1.4 BRIEF GENERAL DESCRIPTION OF METHODOLOGIES (INCLUDING TIERS USED) AND DATA SOURCES USED

Detailed information on the methodological approaches applied to estimate emissions and removals for the various source and sink categories covered by this inventory can be found in the respective sector-specific chapters.

In general, methodologies were primarily derived from the '2006 IPCC Guidelines for National Greenhouse Gas Inventories' unless otherwise stated in the methodological descriptions. It is worth noting that following the first use, in the 2014 submission, of the COPERT estimation modelling system to estimate non-CO_2 emissions from the road transport sector for the year 2012, the use of this tool has now been applied to cover the years 2010 to 2014 in this submission.

Key data providers include the National Statistics Office (NSO), governed by the Malta Statistics Authority Act, 2000 (Chap. 422)[12] and serving as the main body responsible for the collection, compilation, analysis and publications of statistical information related to Malta. Ministries and Departments, regulatory authorities and agencies, public entities and private establishments and industry organizations also provide important sources of data, and in certain cases, added technical expertise in matters relating to specific sectors. Reports published by various entities are also sourced in some instances. A list of key data providers, by sector, is presented in Table 1-3.

[11] The updates referred to in this instance do not relate to recalculations. Recalculations represent updates in inventory estimations taking place between one year and the other.
[12] Malta Statistics Authority Act, 2000, Chapter 422; 1st March, 2001.

Table 1-3 Key data providers relevant for this inventory submission

Sector	Data providers
1. **Energy (including 'Memo Items')**	Enemalta Corporation Fish and Farming Regulation and Control Gozo Channel Individual private industrial establishments Malta International Airport Malta Maritime Authority Malta Resources Authority National Statistics Office Transport Malta Tug Malta
2. **Industrial Processes**	Enemalta Corporation Foundation for Medical Services Individual private industrial establishments National Statistics Office Transport Malta
3. **Solvent and Other Product Use**	Malta Federation of Industry National Statistics Office
4. **Agriculture**	National Statistics Office
5. **Land Use, Land-use Change and Forestry**	Malta Environment & Planning Authority Ministry for Gozo Ministry for Sustainable Development, Environment and Climate Change (formerly Ministry for Resources and Rural Affairs)
6. **Waste**	Malta Environment & Planning Authority Malta Resources Authority Malta Shipyards Ministry for Energy and Health WasteServ Malta Ltd

1.5 BRIEF DESCRIPTION OF KEY CATEGORIES

A 'key category' is an individual source or sink category that warrants prioritisation within the national inventory system because it has a significant influence on the national inventory concerned, in terms of the absolute level of emissions or removals, the trend in emissions or removals, or both. It was previously usually referred to as 'key source category'[13], which was limited to emission source categories. More recently, the reference to 'source' has been largely discontinued in order to also cover LULUCF removals by sinks.

To-date, Malta utilises a Tier 1 method for identifying key categories. This approach assesses the influence of different categories of emissions and removals on the level of the national inventory, and where possible, on the trend of the inventory. This assessment is usually presented as a listing of all those

[13] Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (GPG2000, IPCC, 2000).

categories that cumulatively account for up to 95% of the total inventory when summed up in descending order of magnitude. The with-LULUCF key category assessment includes values relating to estimated removals in the LULUCF sector, taking into consideration the quantified values without due account to the sign (removals can be considered as being equivalent to negative emissions). The without-LULUCF assessment excludes estimates of removals from the LULUCF sector.

1.5.1 Key categories: level assessment

The level assessment represents the contribution of each source or sink category to the total national inventory level. A detailed level assessment of key categories is presented in Annex 1 to this report.

1.5.2 Key categories: trend assessment

A trend assessment takes into account the trend in emissions or removals of a category over time in addition to the level of emissions or removals for that category. This assessment approach can highlight categories that may not appear to be key categories under a level assessment but whose trend is significantly divergent from that of the overall inventory, thus requiring further attention. As a trend assessment requires an analysis against a previous year's inventory (usually against the base year), a trend assessment for 1990 cannot of course be presented. A detailed trend assessment of key categories is presented in Annex 1 to this report.

1.6 GENERAL UNCERTAINTY EVALUATION, INCLUDING DATA ON THE OVERALL UNCERTAINTY FOR THE INVENTORY TOTALS

The measure of every quantity that serves as input data for the estimation of emissions and removals in greenhouse gas inventories is subject to some degree of 'uncertainty'. Uncertainty reflects the lack of absolute certainty on the true value of a variable parameter. A greenhouse gas inventory is also prone to uncertainty and it is good practice for an uncertainty analysis to be carried out.

A Tier 1 approach, in accordance with the IPCC Good Practice Guidance[14] is applied to uncertainty assessment for this submission. A detailed representation of uncertainties is included in Annex 2 to t his report.

1.7 GENERAL ASSESSMENT OF COMPLETENESS

A *'complete'* inventory refers to an inventory which includes estimates for all relevant sources and sinks and gases, and that covers all the applicable geographic area of the country concerned.

Malta's inventory strives to include the most complete picture of emissions and removals from all known sources and sinks within the whole Maltese territory.

An assessment of completeness of reporting is being submitted as a separate file to this report.

[14] Ibid.

Chapter 2. TRENDS IN GREENHOUSE GAS EMISSIONS

2.1 DESCRIPTION AND INTERPRETATION OF EMISSION TRENDS FOR AGGREGATED GREENHOUSE GAS EMISSIONS

Annual national emissions of greenhouse gases over the time series covered by this inventory submission, 1990 to 2014, are presented in Table 2-1. Emission trends by gas and total annual with- and without-LULUCF estimates are also provided in this table and represented in the figures underneath.

Table 2-1 Greenhouse gas emission trends by gas for 1990-2014.

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
	Gg CO_2 equivalent												
CO_2 (without LULUCF)	1,857.90	2,310.57	2,411.64	2,735.68	2,777.45	2,834.06	2,821.81	2,683.63	2,687.69	2,783.20	2,866.10	2,473.50	2,481.19
CO_2 (with LULUCF)	1,860.47	2,313.22	2,414.28	2,738.36	2,780.17	2,836.81	2,824.60	2,686.43	2,690.52	2,786.07	2,869.00	2,476.37	2,484.02
CH_4	78.28	112.68	130.42	149.10	161.80	173.26	174.40	185.94	196.62	185.96	186.64	188.67	196.50
N_2O	61.49	73.35	75.92	71.07	72.50	74.76	72.02	69.23	63.82	63.23	63.88	64.48	64.54
HFCs	NO, NA, NE, IE	NO, NA, NE, IE	3.72	41.43	79.32	96.40	112.17	133.02	144.73	167.85	200.93	218.33	233.25
PFCs	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
SF_6	0.01	1.44	1.47	1.56	1.57	1.58	1.75	1.50	1.69	4.59	0.45	2.68	0.58
Total (without LULUCF)	2,000.25	2,500.69	2,625.81	3,001.53	3,095.37	3,182.81	3,184.94	3,076.12	3,097.38	3,207.70	3,320.90	2,950.52	2,978.89
Total (with LULUCF	1,997.68	2,498.04	2,623.16	2,998.85	3,092.65	3,180.05	3,182.14	3,073.32	3,094.55	3,204.84	3,318.00	2,947.66	2,976.06

It is pertinent to note that the discussion in this chapter is restricted to national emissions, that is, not including emissions from the so-called ‘memo items’, unless otherwise indicated in the text or captions.

The change in total emissions between base year and the latest reported year (2014) for the without-LULUCF estimates represents an increase of 48.94%, while for the with-LULUCF estimates this represents an increase of 48.99%.

The general trend for combined emissions remains one of increase up until 2012 with a marked drop in 2013 reflecting improvements in the generation efficiency within the energy sector. This trend can be more easily observed in Figure 2-1 and Figure 2-2, which represent the overall trend and trends for each gas (to be discussed in a subsequent section of this chapter) for the without-LULUCF and the with-LULUCF estimations respectively.

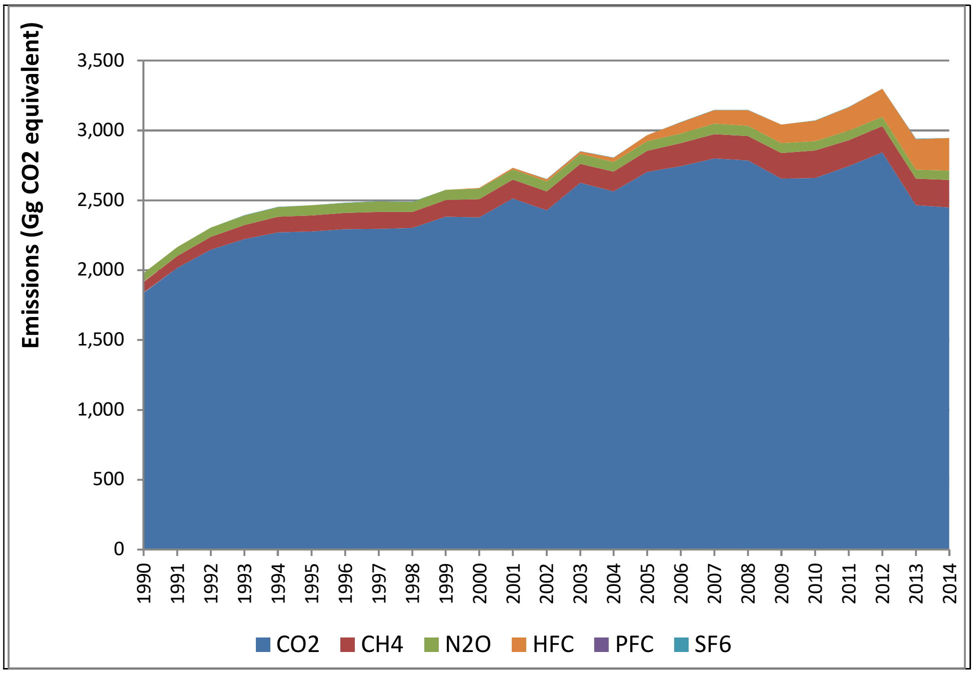

Figure 2-1 Emissions of greenhouse gases by type of gas, excluding LULUCF, for 1990 - 2014

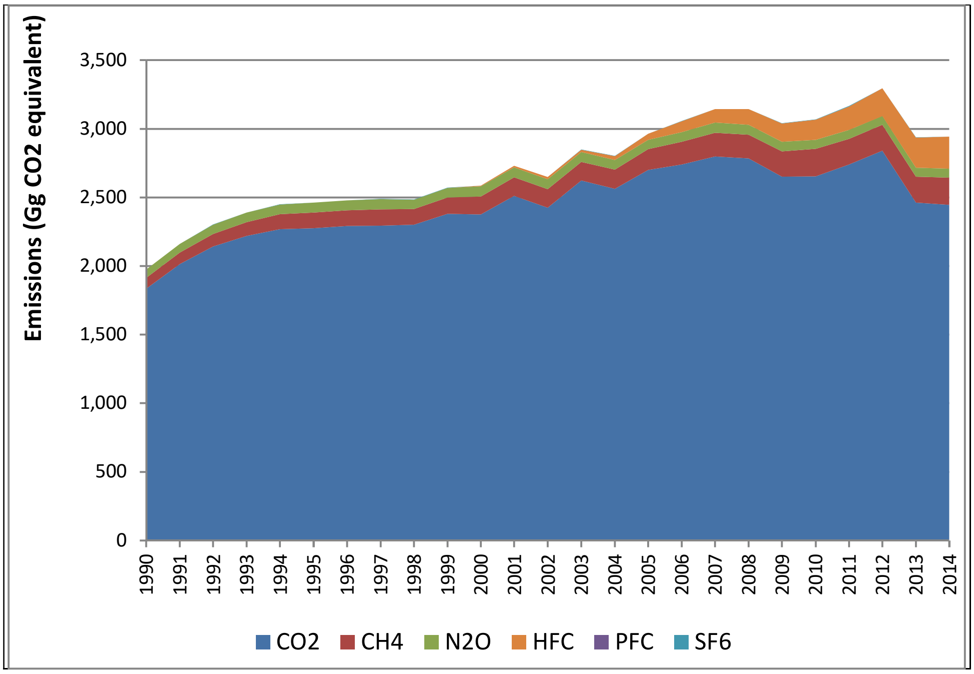

Figure 2-2 Emissions of greenhouse gases by type of gas, including LULUCF, for 1990 - 2014

The year-on-year increases (or decreases) in the overall emissions (with-LULUCF) are illustrated in Figure 2-3. It reflects the overall trend in total emissions as shown in Figure 2-2, for the years up to and including 2014. As can be seen, the majority of the year-on-year changes are positive (i.e. year-on-year increases). One may however note that despite the large variation in the level of individual year-on-year changes, the general trend is that the year-on-year increases observed in the later years are lower than for earlier years. Indeed, the occurrence of year-on-year decreases in emissions also tends to increase with time.

A substantial decrease in year-on-year emissions can be observed for 2012-2013, to the extent that it is also significantly higher than any year-on-year increase observed in previous years while the year-on-year emissions for 2013-2014 are very close to nil.

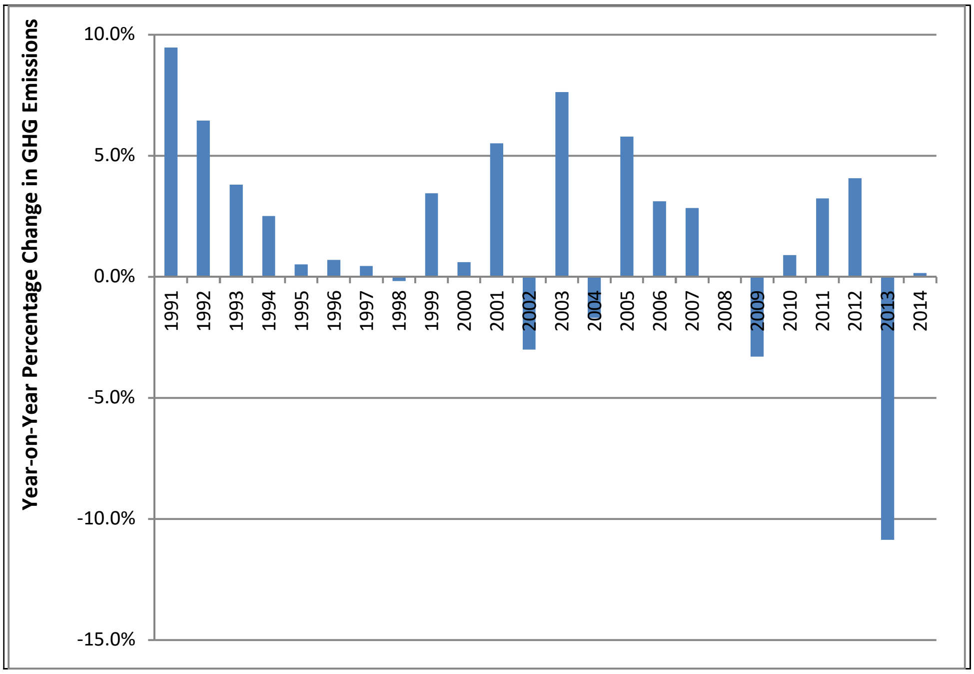

Figure 2-3 Annual percentage increase or decrease in total greenhouse gas emissions (based on total emissions including LULUCF)

2.1.1 Trends in GHG emissions per Capita

Comparing emissions with the demographic development of a country can serve as a useful indicator of the progress in emissions control over a set period of time. Malta's population has seen a sustained growth over the period covered by this inventory submission and there is a robust correlation between population growth and greenhouse gas emissions, as shown in Figure 2-4.

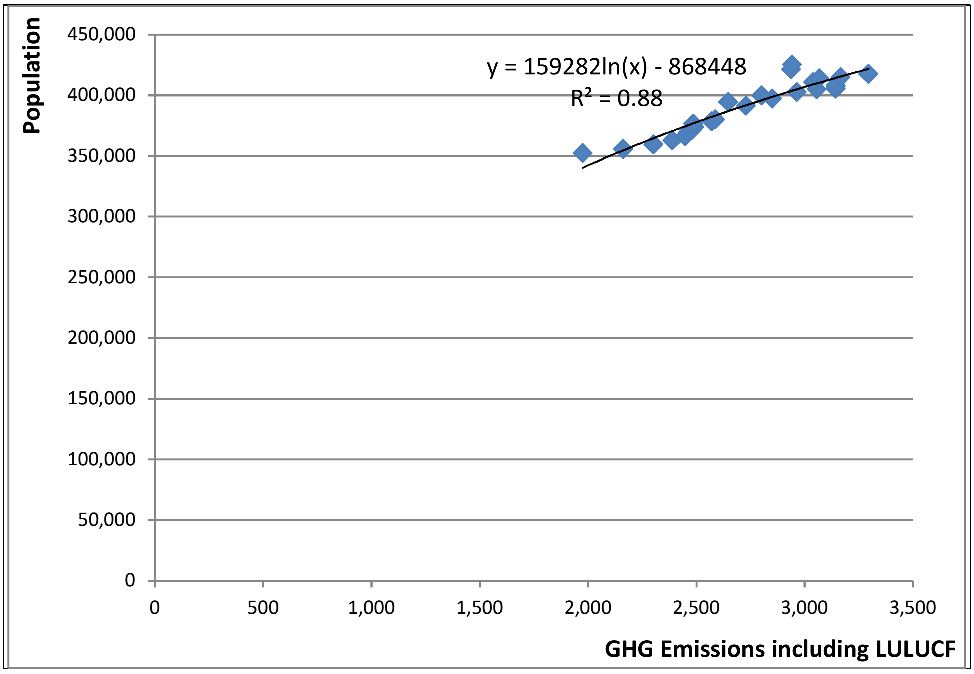

Figure 2-4 Correlation between population growth and greenhouse gas emissions

The overall trend in per capita emissions is one of a general increase until 2012, with a number of instances where the per capita emissions show a slight annual decrease (Figure 2-5). In 1990, the per capita emissions stood at 5.6 tonnes of CO_2 equivalents and this increased to 7.9 tonnes of CO_2 equivalents per capita in 2012, representing an overall increase of 41%. The trend is however markedly reversed for 2013 and 2014, with the substantial decrease in total national emissions also translating itself into a decrease in per capita emissions, at almost 12% less than the value for 2012. The level of per capita emissions in 2014 is the lowest since 1999 and stood at 6.9 tonnes of CO_2 equivalents per capita.

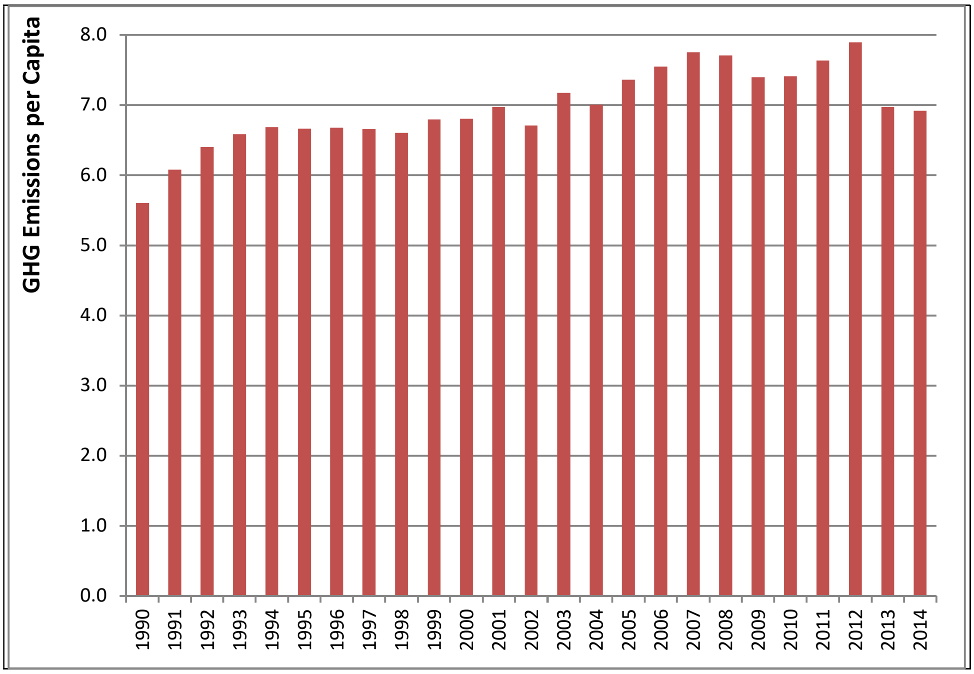

Figure 2-5 GHG emissions per capita [Source of population data for 1990 to 2014: Eurostat, accessed 01/03/2016]

2.1.2 Trend in overall emissions compared to Gross Domestic Product

Another important indicator compares the trend in emissions of greenhouse gases and the economic activity of the country, the latter being represented in terms of Gross Domestic Product (GDP). The correlation between these two parameters, or the 'emissions intensity' of Malta's economy, is presented in Figure 2-6.

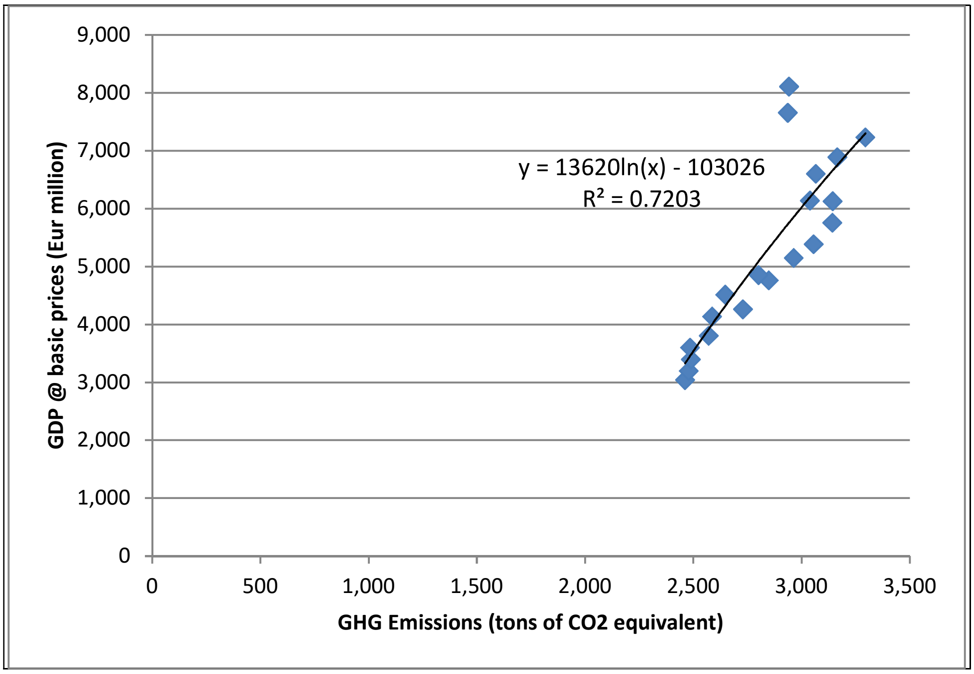

Figure 2-6 Correlation between GDP and greenhouse gas emissions

Contrary to the situation for per capita emissions, the emissions intensity of the Maltese economy has seen a generally consistent downward trend, as clearly seen in Figure 2-7. This can be interpreted as a decoupling of national greenhouse gas emissions from the country's economic development trends.

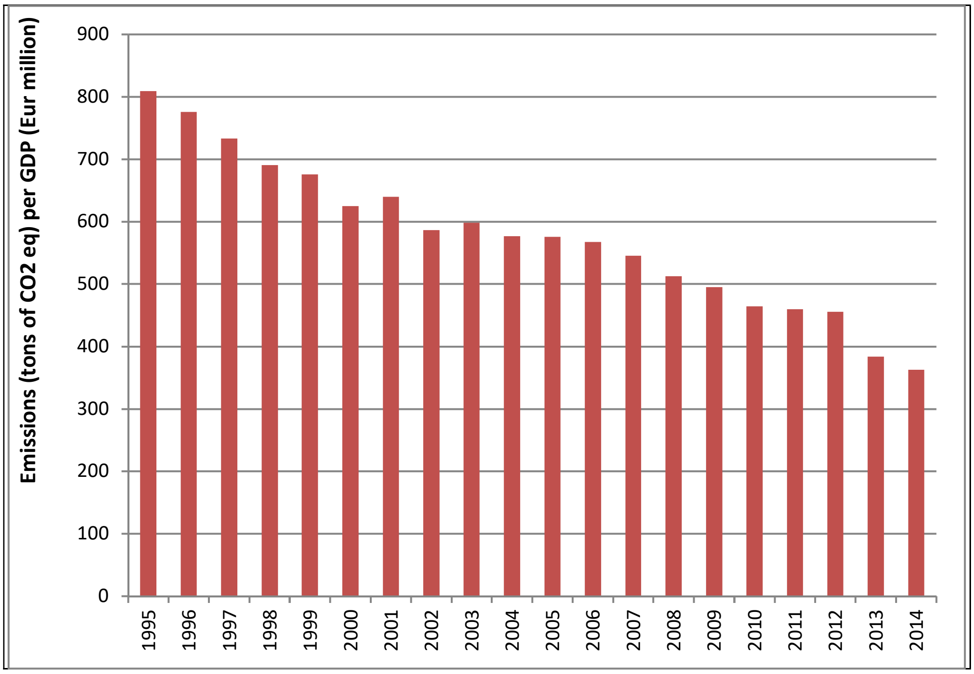

Figure 2-7 GHG emissions per unit GDP

It is not clear whether this improvement is due to an increase in productive efficiency by the economic sectors or due to a switch to cleaner fuels. The likelihood is that both factors play a key role in this observed downward trend in emissions per unit of GDP.

2.1.3 Trend in overall emissions compared with the Gross Value Added of the Economic Sectors.

A more in-depth analysis of the relationship between economic activity and greenhouse gas emissions highlights those sectors of the economy which are more (or less) 'emissions intensive' for each unit of value added to the economy. As shown in Figure 2-8, the *Agriculture, Forestry and Fishing sector* (NACE A) has, by far, the largest 'carbon footprint' for each million euro of value added, followed by *Transportation and Storage sector* (NACE H) and the Manufacturing & Construction industries (NACE B – F). Notwithstanding, it is pertinent to note that the overall trend in greenhouse gas emissions for all economic sectors is decreasing, reflecting the general downward trend shown in Figure 2-7 above.

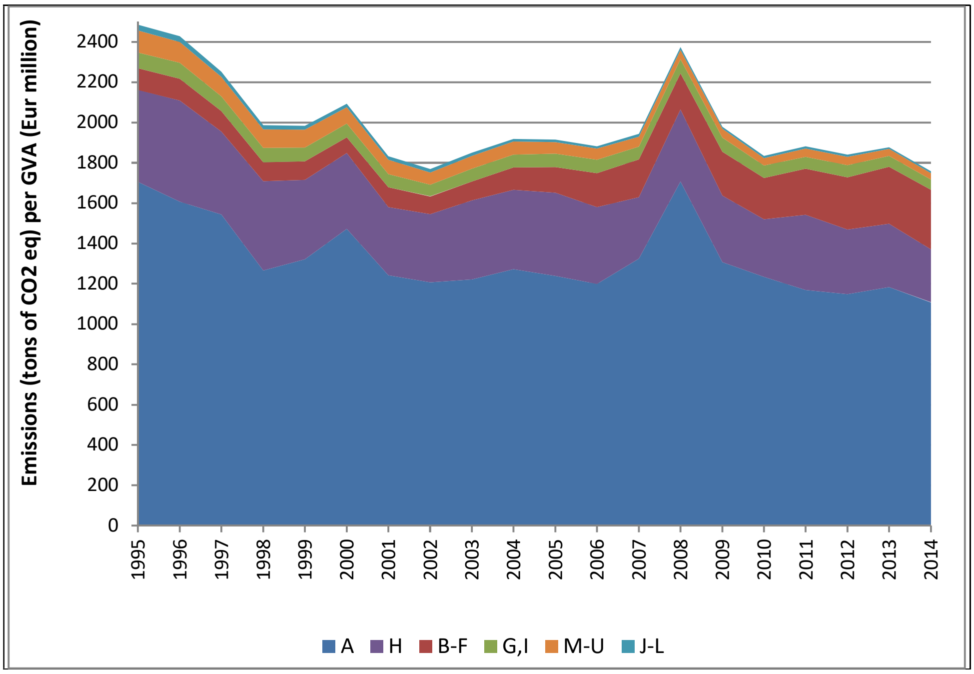

Figure 2-8 Relationship between economic activity of different sectors with respective sector's GHG emissions

Note: NACE A includes direct emissions from the agricultural sector (CRF sector 4) and NACE Section B-F includes direct emissions from Industrial Processes and Product Use (CRF sector 2). Emissions from power generation (CRF Sector 1a1) and waste (CRF Sector 6) are not included since these emission sources could not be disaggregated by NACE category.

A comparison of the individual NACE categories (Figure 2-9) for the latest year under review (2014) indicates that there are three sectors that have an emissions intensity that is greater than 10%, namely the *Agriculture, Forestry and Fishing* sector, the *Manufacturing* sector and the *Other Service Activities* sector. The latter consists of those industries engaged in equipment and machinery repairing, provision of dry-cleaning and laundry services and other services. The relatively high greenhouse gas emissions per unit of GVA in this particular sector are mainly attributable to the widespread use of fuel oil in some of its sub-sectors.

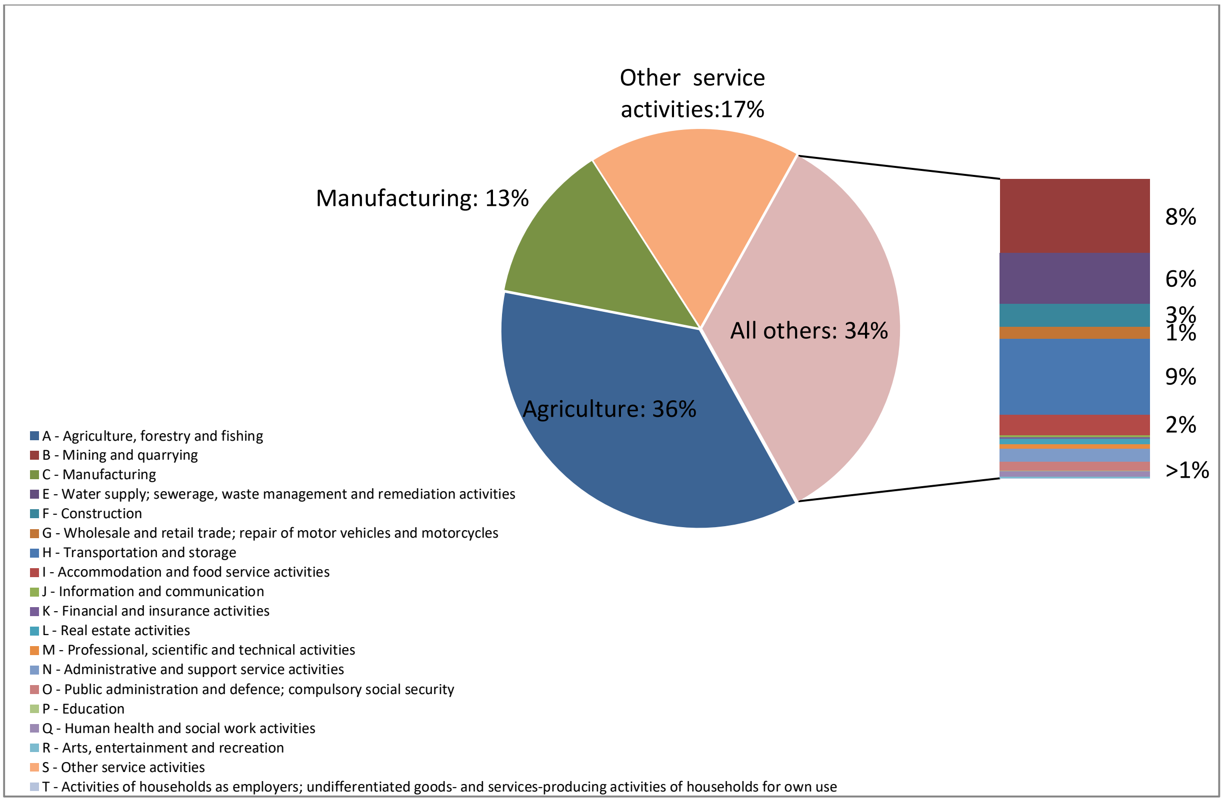

Figure 2-9 Emissions per unit GVA for NACE categories for 2014

Note: NACE A includes direct emissions from the agricultural sector (CRF sector 4) and NACE Section B-F includes direct emissions from Industrial Processes and Product Use (CRF sector 2). Emissions from power generation (CRF Sector 1a1) and waste (CRF Sector 6) are not included since these emission sources could not be disaggregated by NACE category.

2.2 DESCRIPTION AND INTERPRETATION OF EMISSION TRENDS BY GAS

2.2.1 GENERAL DISCUSSION OF EMISSION TRENDS BY GAS.

Emission trends for each greenhouse gas covered by this inventory are presented in Table 2-1 above. Table 2-2 provides an overview of the changes in emissions between the latest year covered by this inventory and the base year 1990.

Table 2-2 Emissions of greenhouse gases by gas for the years 1990 and 2014.

	1990	2014	% change 1990-2014
	Gg CO_2 equivalent		
CO_2 (without-LULUCF)	1,860.47	2,484.02	33.52
CO_2 (with- LULUCF)	1,857.90	2,481.19	33.55
CH_4	78.28	196.50	151.02
N_2O	61.49	64.54	4.97
HFCs	NO, NA, NE, IE	233.25	---
PFCs	NA	0.00	---
SF_6	0.01	0.58	5,402.78
Total (without-LULUCF)	2000.25	2,978.89	48.93
Total (with-LULUCF)	1,997.68	2,976.06	48.98

Table 2-1 and Table 2-2 highlight the major contribution that carbon dioxide has in total national emissions. The status of this green house gas as the highest contributor has been maintained throughout the years. This can also be observed in Figure 2-10. The relative contribution of CO_2 emissions to total national emissions represents the strong influence that this gas has on the national emissions trends, to the extent that the trend for national emissions runs almost parallel to the trend for CO_2 emissions (see Figure 2-1 and Figure 2-2). One does however note that with time, the relative contribution of CO_2 has tended to decrease, in conjunction with changes in relative contributions of other emitted gases, primarily the substantial increase in the share of emissions of HFCs.

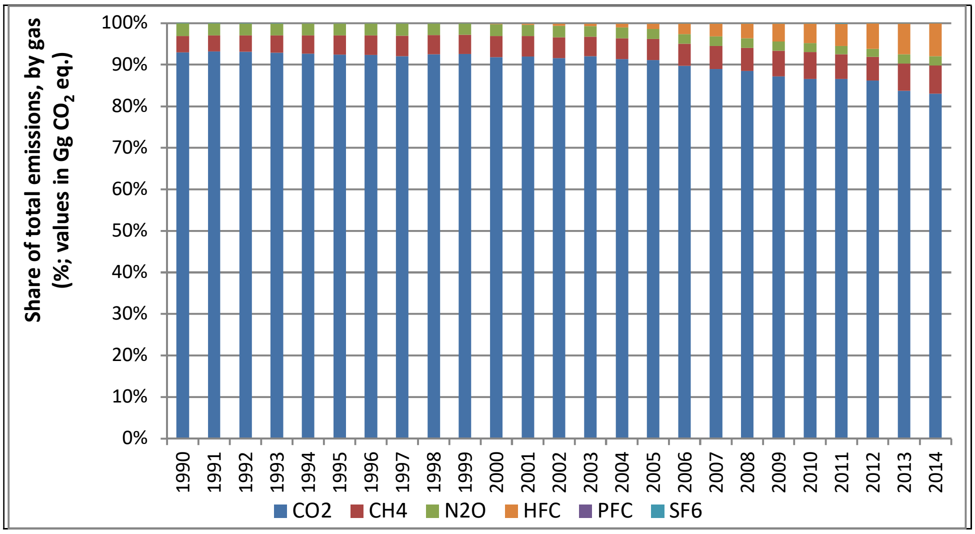

Figure 2-10 Percentage contribution of each greenhouse gas to total national greenhouse gas emissions (with-LULUCF).

2.2.2 CARBON DIOXIDE EMISSIONS AND REMOVALS.

The overall profile of carbon dioxide emissions by sources and removals by sinks is presented in Figure 2-11. It is obvious that emissions far outweigh removals – indeed, removals of carbon dioxide by the LULUCF sector only offset a very minimal amount of emissions of this gas.

Sectorally, the principal contributor to carbon dioxide emissions is sector Energy (CRF sector 1). Carbon dioxide emissions from this sector account for 99.9% of total gross national carbon dioxide emissions. Within this sector, the source category Energy Industries (1A1) represents the highest overall contribution of carbon dioxide emissions, followed by source category Transport (1A3).

2.2.3 METHANE EMISSIONS.

For most of the period under consideration, methane had the second highest share of national total emissions (in terms of CO_2 equivalent). This situation has however changed since 2012, with HFCs now ranked as the second highest contributor to overall national emissions (see Figure 2-10).

The trend in methane emissions (in Gg CH_4), including sectoral contributions is presented in Figure 2-12. The general trend up to 2010 reflected an increase in emissions of methane; this however has changed in subsequent years. This change is due to the reduction in emissions of this greenhouse gas from the sector Waste (CRF sector 6), as a result of increased flaring of methane in local managed landfilling activities - category Managed Waste Disposal on Land (5A1).

Sector 4: Agriculture is another important emitter of methane through emissions from source categories Enteric Fermentation (4A) and Manure Management (4B). Estimated absolute emissions of methane from this sector peaked in 2000, with estimated emissions in 2012 being the lowest recorded since 1990.

2.2.4 NITROUS OXIDE EMISSIONS.

Until 2005, nitrous oxide was the gas with the third highest share of total national emissions (in terms of CO_2 equivalent), being then superseded by emissions of HFCs (Figure 2-10).

Figure 2-13 presents the general trend of nitrous oxide emissions (in Gg N_2O). Estimated emissions peaked in 1995. Sectorally, the highest contributor is sector Agriculture (CRF sector 4), with emission of this greenhouse gas mainly from source category Agricultural Soils (4D), and, to a lesser extent, source category Manure Management (4B). Further contributions to national total nitrous oxide emission are given by sectors Waste (CRF sector 6), Energy (1) and Industrial Processes and Other Product Use (2).

2.2.5 EMISSIONS OF FLUORINATED GASES.

Whereas for a large part of the period covered by this report, fluorinated greenhouse gas emissions had a minimal share in total national emissions, their contribution increased significantly in more recent years, to the extent that the combined share of such gases (in terms of CO_2 equivalent) in total national emissions in 2013 was second highest behind carbon dioxide. The main driving force behind this change is the substantial increase observed for hydrofluorocarbons (see Figure 2-14) with their utilisation of such gases as replacements for ozone depleting substances and increased volumes in refrigeration equipment. The high global warming potentials of fluorinated gases further bolster their overall share in total emissions.

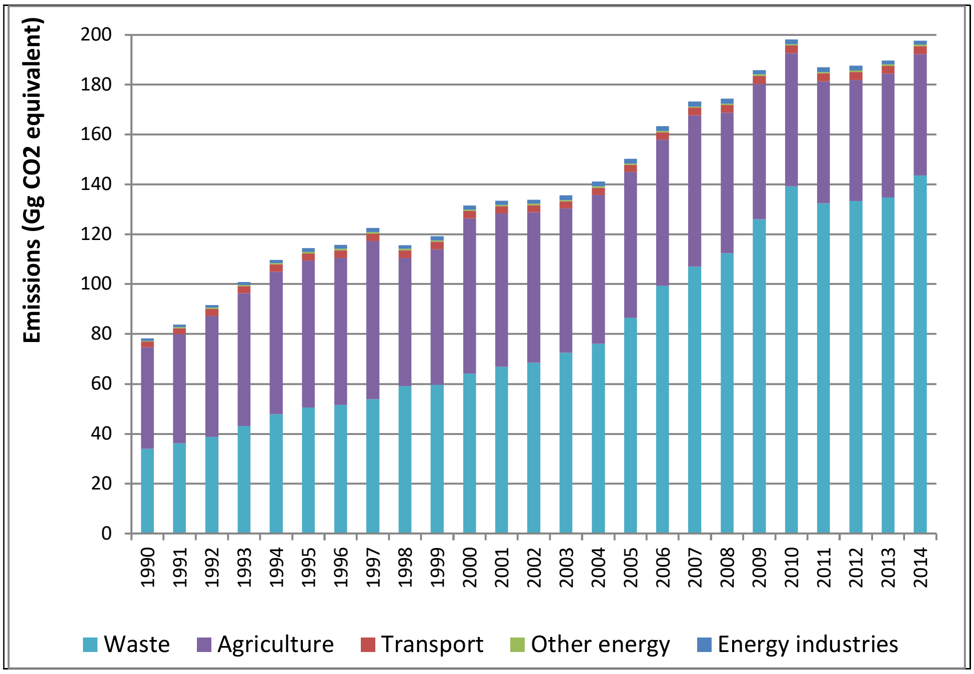

Figure 2-11 Trends in emissions by sources and removals by sinks for carbon dioxide.

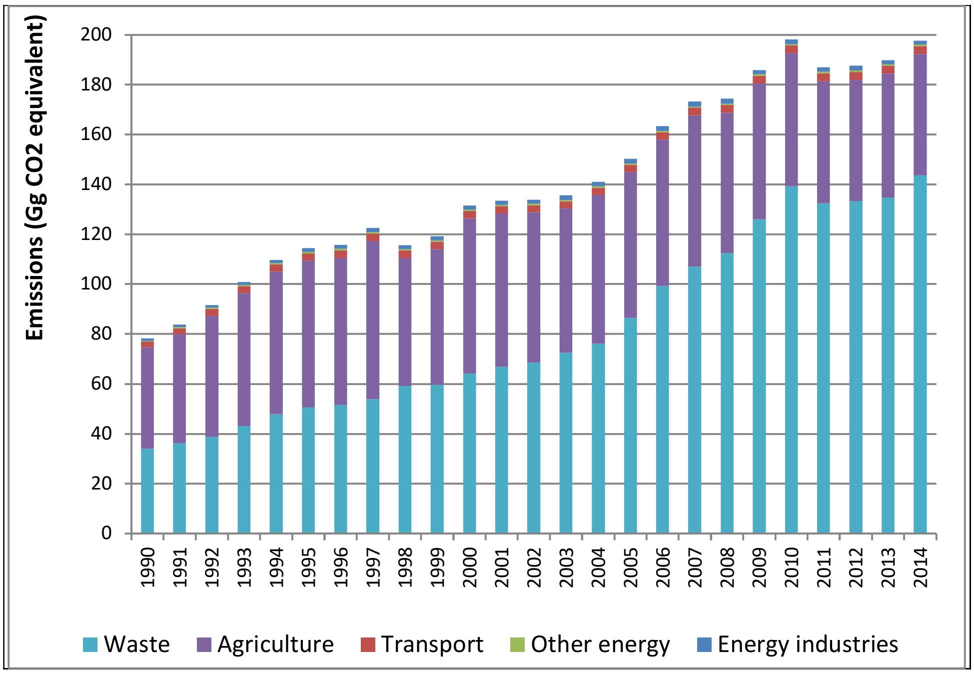

Figure 2-12 Trend in total and sectoral emissions of methane.

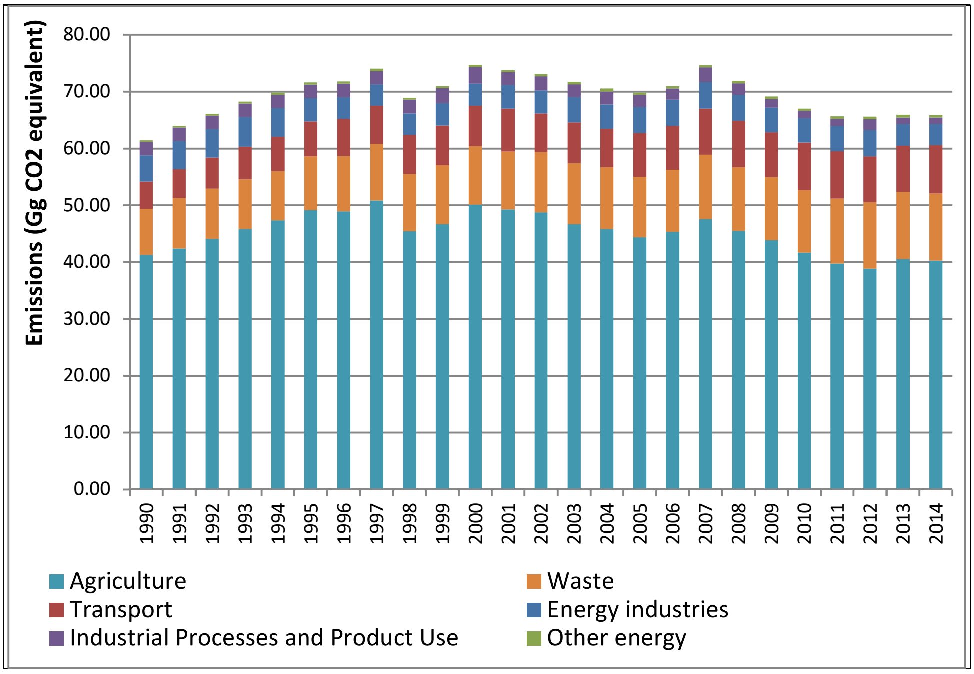

Figure 2-13 Trends in total and sectoral emissions of nitrous oxide.

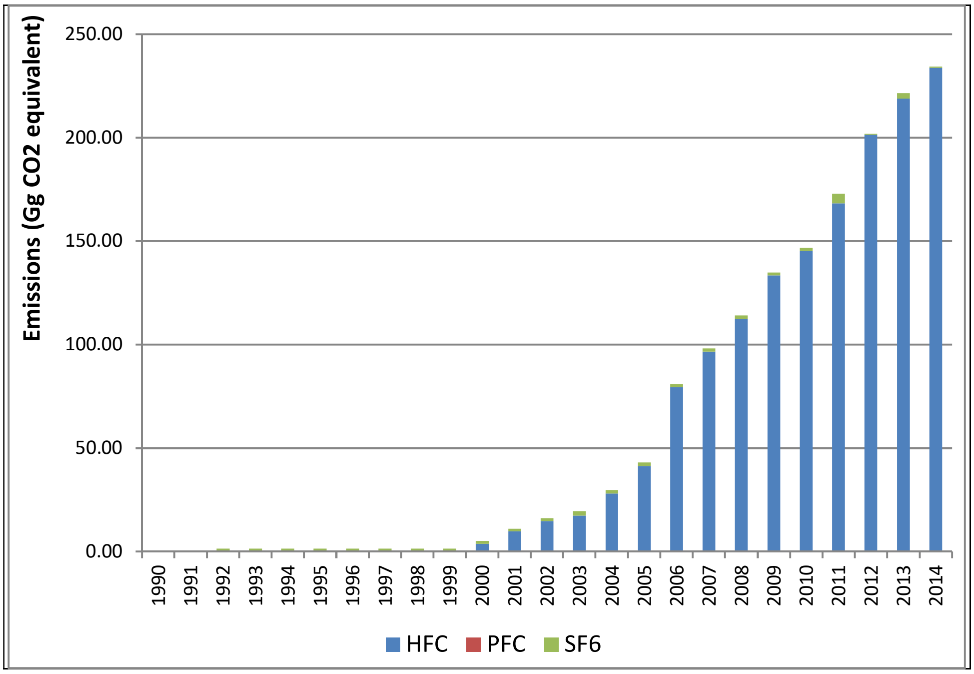

Figure 2-14 Trends in emissions of fluorinated greenhouse gases.

2.3 DESCRIPTION AND INTERPRETATION OF EMISSION TRENDS BY CATEGORY

Greenhouse emissions from all sectors covered by this inventory (except for Memo Items) over the time series concerned are presented in Table 2-3 and illustrated in Figure 2-15.

Table 2-3 Emissions of greenhouse gases by sector for the years 1990 to 2014.

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
	Gg CO_2 equivalent												
Energy	1868.32	2323.51	2426.96	2752.72	2793.91	2852.01	2839.66	2700.38	2700.49	2796.94	2881.23	2487.71	2495.65
Industrial Processes and product use	7.49	8.94	11.85	48.59	86.98	103.86	119.48	139.85	151.02	177.43	206.34	225.54	238.13
Agriculture	82.00	108.00	112.26	102.90	104.08	108.21	101.83	98.21	94.89	88.65	87.55	90.11	88.86
LULUCF	-2.57	-2.65	-2.65	-2.68	-2.72	-2.76	-2.79	-2.79	-2.83	-2.87	-2.90	-2.87	-2.83
Waste	42.44	60.24	74.74	97.33	110.40	118.73	123.97	137.68	150.98	144.69	145.78	147.16	156.25
Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total (with LULUCF	**1997.68**	**2498.04**	**2623.16**	**2998.85**	**3092.65**	**3180.05**	**3182.14**	**3073.32**	**3094.55**	**3204.84**	**3318.00**	**2947.66**	**2976.06**

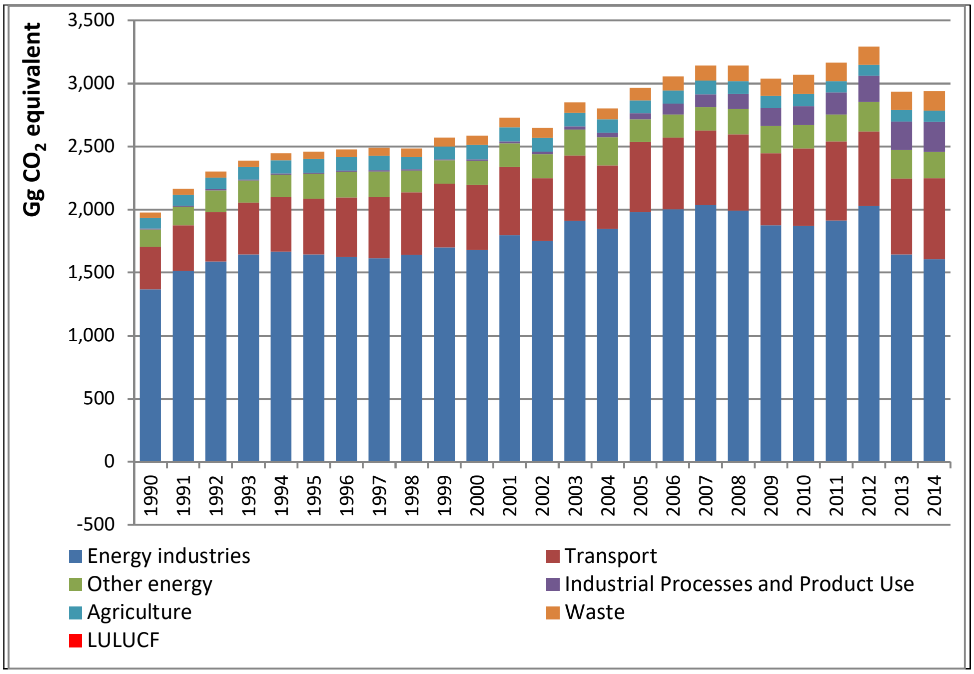

Figure 2-15 Emission trends by sector.

The most obvious feature that comes out of Table 2-3 and Figure 2-15 is the predominance of emissions from the energy sector in total national emissions. This has been the case throughout the period covered by this report. Indeed, there is a strong correlation between the profile of total national emissions and that of emissions from the energy sector, indicating that the volume of emissions attributed to this sector strongly determines the year-on-year trend in total national emissions. All other source sectors contribute substantially less to overall emissions, while LULUCF is associated with a minor removal effect.

Overall sectoral trends as a percentage change between year 1990 and year 2014 are provided in Table 2-4. The increase for the sector Industrial Processes and Other Product Use is explained by the substantial increase in emissions of HFCs, as already explained in an earlier section. Sectors Energy, Agriculture and Waste have experienced a more moderate, though still relevant, overall increase in emissions. The level of net removals from sector LULUCF can be said to have remained relatively stable over the time series, varying between a minimum 2.57 Gg CO_2 (1990) equivalent and a maximum 3.01 Gg CO_2 equivalent (2012). More information on the reasons underpinning the observed sectoral trends can be found in the subsequent chapters dealing with the respective sectors. These chapters will also provide an insight into the sub-sectoral disaggregation of emissions and the trends in emissions for different categories under each main sector.

Table 2-4 Emissions of greenhouse gases by sector for the years 1990 and 2014 and the corresponding change between the two years.

	1990	2014	% change 1990-2014
	Gg CO_2 equivalent		
Energy	1868.32	2495.65	33.58%
Industrial Processes and other product use	7.49	238.13	3078.78%
Agriculture	82.00	88.86	8.36%
LULUCF	-2.57	-2.83	9.95%
Waste	42.44	156.25	268.21%
Other	NA	NA	---
Total (with LULUCF)	1997.68	2976.06	48.98%

2.4 EMISSION TRENDS FOR INDIRECT GREENHOUSE GASES

Emissions of indirect greenhouse gases are illustrated in Figure 2-16. It is pertinent to note that the change in methodological approach applied in 2013, namely the utilisation of the COPERT model, has been applied for the years 2010 - 2014 (for more information refer to Chapter 3).

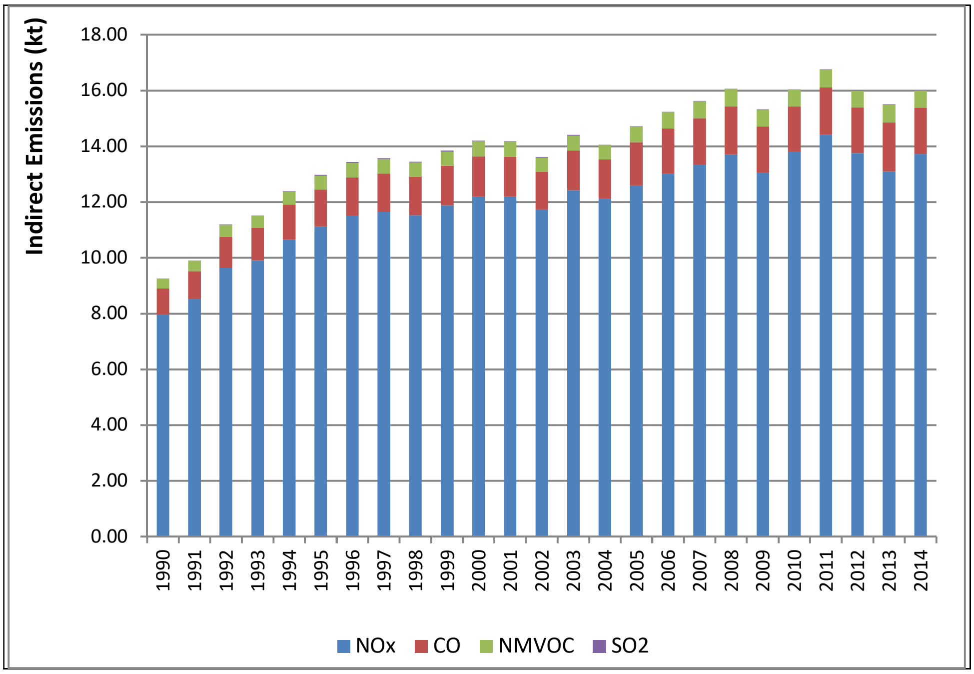

Figure 2-16 Emission trends for indirect greenhouse gases

Among these four gases, the most significant trends are those of CO and NOx. Both gases show trends that are closely correlated to the trends in activities that result in emissions of such gases, in particular energy generation (category 1A1a) and road transport (category 1A3b).

Chapter 3. ENERGY (CRF SECTOR 1)

3.1 OVERVIEW OF SECTOR

The Energy sector is the most significant contributor of greenhouse gas emissions in Malta. Emission trends for this sector, split by sub-sector categories, are presented in Figure 3-1.

In 2014, the category Energy Industries (1A1) accounted for 64.6% of the overall greenhouse gas emissions in the Energy sector as a whole. This category has the greatest influence on the overall energy emission trends, and due to the relative importance of the Energy sector, it also influences national emission trends.

The second highest contributor under this sector is Transport (1A3), incorporating Road Transport (1A3b), National Navigation (1A3dii) and Domestic Aviation (1A3aii). Cumulatively, this sector accounts for 25.8% of total national emissions. Transport is thus another major contributor to the overall national emissions.

The Manufacturing Industries category (1A2) accounts for 1.3% of the energy sector emissions, while the Commercial/Institutional (1A4a), Residential (1A4b) and Agriculture, Forestry & Fisheries (1A4c) sectors account for 4.8%, 3.0% and 0.7% of the energy sector emissions respectively.

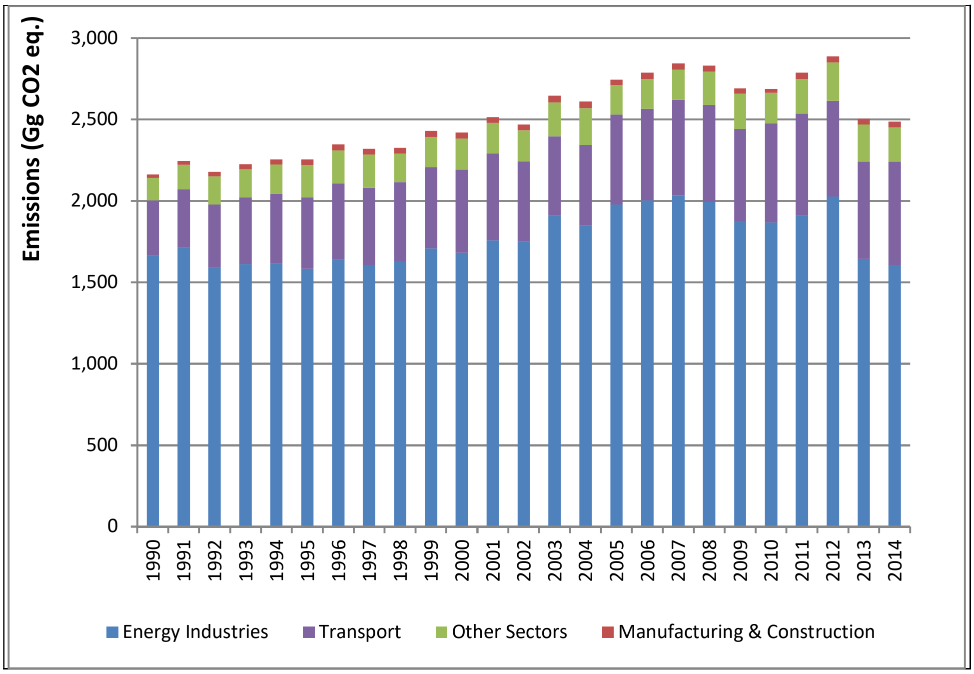

Figure 3-1 Emission trends in the sector Energy, by source category

Emissions from fossil fuel combustion account for all the fossil fuel related emissions, since no fuel oil production, oil refining or coal mining activities, are carried out on the Maltese Islands.

Unless otherwise stated, an Oxidation factor of 1.00 is used across the whole energy sector for the estimation of emissions from fuel combustion.

3.2 FUEL COMBUSTION (CRF 1.A)

3.2.1 COMPARISON OF THE SECTORAL APPROACH WITH THE REFERENCE APPROACH

The Reference Approach is a top-down methodological approach to calculate CO_2 emissions. The main data sources are the oil balance reports compiled by the Malta Resources Authority for the period 2010 – 2014 and Enemalta's sales figures as reported in its annual reports for the period 1990 – 2009. During the latter time period, Enemalta was the sole importer and wholesaler of petroleum products in the inland market.

The Reference Approach serves as a comparison to the Sectoral Approach, wherein emission estimations for individual categories are calculated using a bottom-up approach based on activity statistics (mostly fuel consumption) obtained from the various economic sectors, industrial processes and end-users included in each sub-category.

Table 3-1 compares the Reference Approach and the Sectoral Approach for the year 2014. In principle, the total figures obtained under the Reference Approach can be compared with the total of Sector 1A. The consumption of liquid fuels (excluding international bunkers) as estimated using the Reference Approach differs by -3.72% from the Sectoral Approach which leads to a discrepancy of -4.62% in the total CO_2 emissions.

Table 3-1 Comparison of Reference Approach and Sectoral Approach for 2014

FUEL TYPES	REFERENCE APPROACH		SECTORAL APPROACH		DIFFERENCE	
	Apparent energy consumption	CO_2 emissions	Energy consumption	CO_2 emissions	Energy consumption	CO_2 emissions
	(PJ)	(Gg)	(PJ)	(Gg)	(%)	(%)
Liquid fuels (excluding international bunkers)	31.50	2369.35	32.67	2478.83	-3.72%	-4.62%
Solid fuels (excluding international bunkers)	NE	NO,NA,NE	NO,NA,IE	NO,NA,IE	NO,NA,NE,IE	NO,NA,NE,IE
Gaseous fuels	0.01202	0.76	0.01198	0.76	0.38%	0.33%
Other fossil fuels	NE	NA	NO,NA,IE	NO,NA,IE	NO,NA,NE,IE	NO,NA,IE
Peat	NO	NO	NO,IE	NO,IE	NO,IE	NO,IE
Total	**31.51**	**2370.11**	**32.68**	**2479.59**	**-3.72%**	**-4.62%**

3.2.2 International Bunker fuels

Emissions estimated for International Bunker activities are considered as 'Memo Items' and are not taken into account when speaking in terms of 'national' emissions of greenhouse gases. These memo items refer to fuels used for marine bunkering and for aviation purposes that are combusted outside the Maltese territorial waters or airspace, respectively.

The fuels used for international marine bunkering are fuel oil and gasoil, with the former making up the greater share of the total fuels used for this purpose (84% in 2014) within this sector. The fuel used for international aviation is jet kerosene (also known as jet A1 or aviation turbine fuel).

Activity data categorised between national navigation and international marine bunkers was provided by the Malta Resources Authority. As further detailed in Annex 3, an extensive exercise was carried out by this Authority to improve the methodology to identify those fuels that are used within Maltese territorial waters and those used outside Malta's territory. Furthermore, this improved methodological approach was applied to previous years (1990-2009) in order to streamline the whole time series.

Emissions from international marine bunkering have been estimated using a Tier 1 approach. IPCC 2006 default emission factors have been used for estimating CO_2, CH_4 and N_2O emissions and for calorific values. The EMEP/EEA 2013 Guidelines are used for indirect emissions. For SO_2 emissions, the sulphur content for marine fuels is obtained from the Regulation Unit within the Malta Resources Authority. This data is obtained through the sampling of fuels under reporting obligations of Directive 99/32/EC. The emission factors used are shown in Table 3-2.

Table 3-2 Emission Factors for category International Marine Bunkering

Fuel Type	CO_2 (kg/TJ)	CH_4 (kg/TJ)	N_2O (kg/TJ)	NOx (kg/TJ)	CO (kg/TJ)	NMVOC (kg/TJ)	SO_2 (%S)
Gas Oil	74,100	7.0	2.0	1,825.58	172.09	65.12	0.06
Fuel Oil	77,400	7.0	2.0	1,962.87	183.17	66.83	2.12
Petrol	69,300	7.0	2.0	212.90	12,954.85	4,097.07	0.000565

Estimated emissions for international maritime and aviation bunkers are presented in Figure 3-2 while a comparison of memo items with 'non' memo items i.e. those emissions that have been generated within national territory is presented in Figure 3-3. The 'non'-memo items have been divided between those sectors falling within the ETS, namely electricity generation and those falling within the 'Effort Sharing Decision', comprising of all other sectors including transport, manufacturing industries and commercial/institutional sectors.

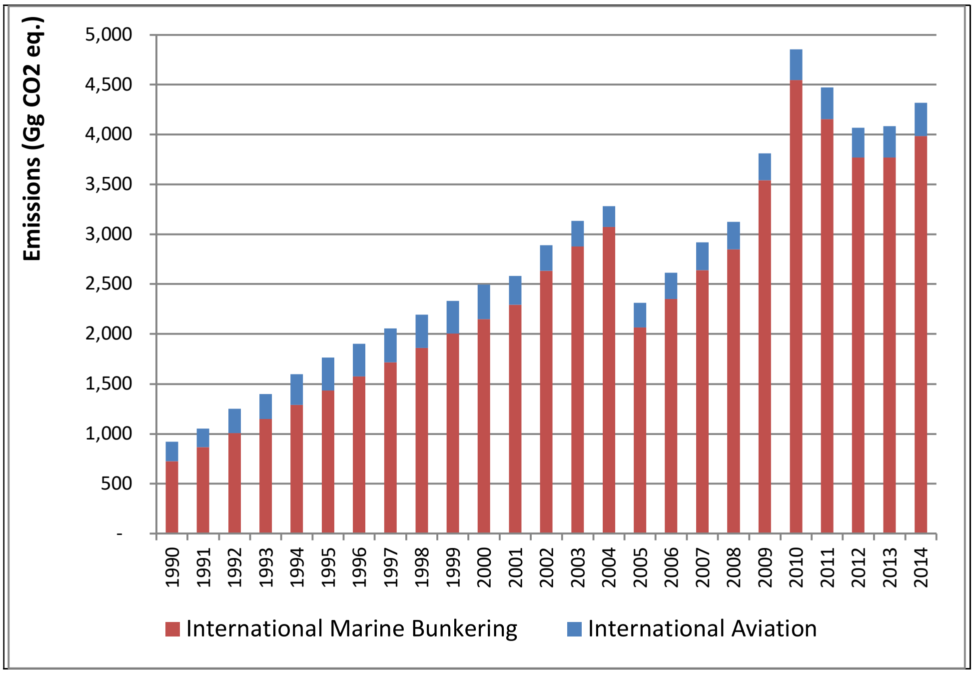

Figure 3-2 Emissions for categories International Aviation and International Marine Bunkers

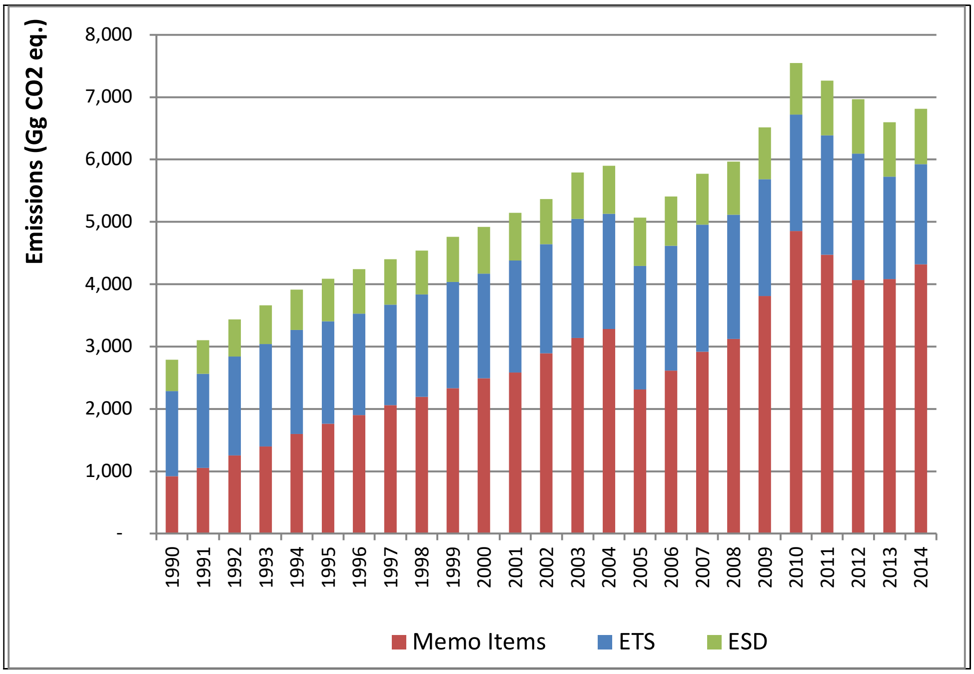

Figure 3-3 Emissions falling under Memo Items, ETS and ESD

3.2.3 FEEDSTOCKS AND NON-ENERGY USE OF FUELS

Activity data on feedstocks and non-energy use of fuels has, to-date, not been collected. Efforts are being made to improve on this specific area in order to include it in the methodological approach described in section 3.2.5.2 and to thus be able to estimate emissions (if any) in this particular category.

3.2.4 ENERGY INDUSTRIES (CRF SUB-CATEGORY 1A1a)

3.2.4.1 Category Description

This section is limited to emission calculations for the Public Electricity Generation sub-category (1A1a), since sub-categories Petroleum Refining (1A1b) and Manufacture of Solid Fuels and Other Energy Industries (1A1c) do not occur in Malta.

Subcategory 1A1a incorporates two point sources, namely the two electricity generation plants (Marsa Power Station and Delimara Power Station) that are currently run on fuel oil and gasoil. The former power station was decommissioned in 2015. It should be noted that until 1995, bituminous coal was also used for electricity generation in one of these plants.

Estimated greenhouse gas emissions show a good correlation with fuel consumption trends, in particular the trend for utilisation of fuel oil, as shown in Figure 3-4 and Figure 3-5.

Comparing CO_2 emissions with electricity generation shows two main trends over the period covered by this inventory, namely; a strong positive correlation between electricity generation and emissions (see Figure 3-6); and a gradual decrease in the rate of emissions per unit generated until 2004 with a reversal of this trend for the subsequent years up until 2012 (see Figure 3-7). The following two years (2013 and 2014) saw a marked improvement in generation efficiency and hence lower emissions per GWh generated.

In this submission there is additionally the inclusion of emissions from flue gas treatment: desulphurisation and deNO$_x$ using bicarbonate and urea. Moreover, emissions of CO_2 from CHPs operated in the waste management industry have also been included. These CO_2 emissions from the latter industry are considered biogenic.

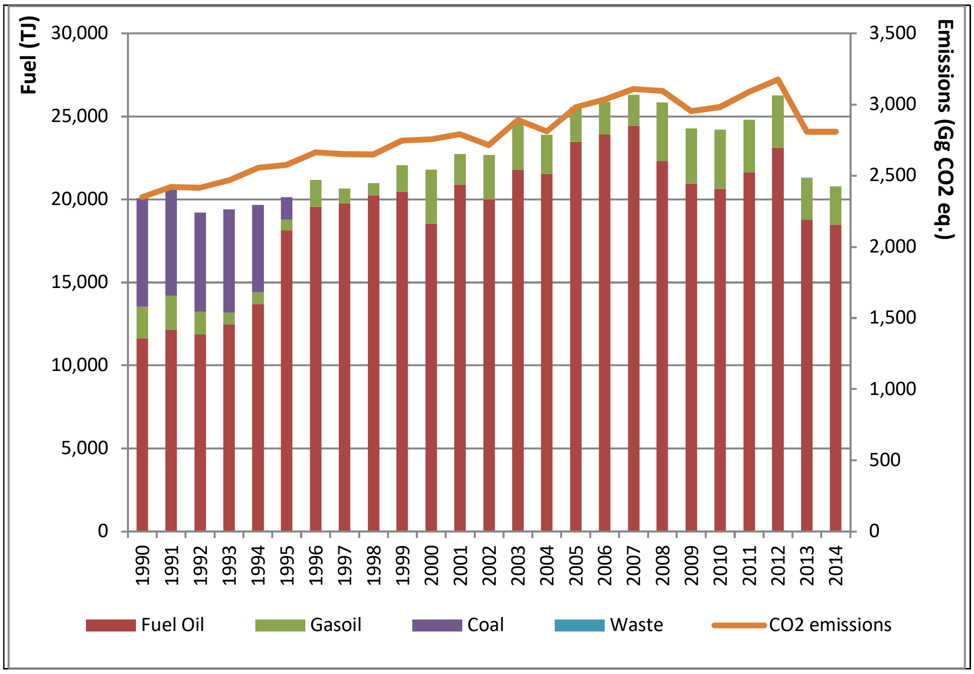

Figure 3-4 Time series of Emissions and Fuel Consumption for the category Energy Industries

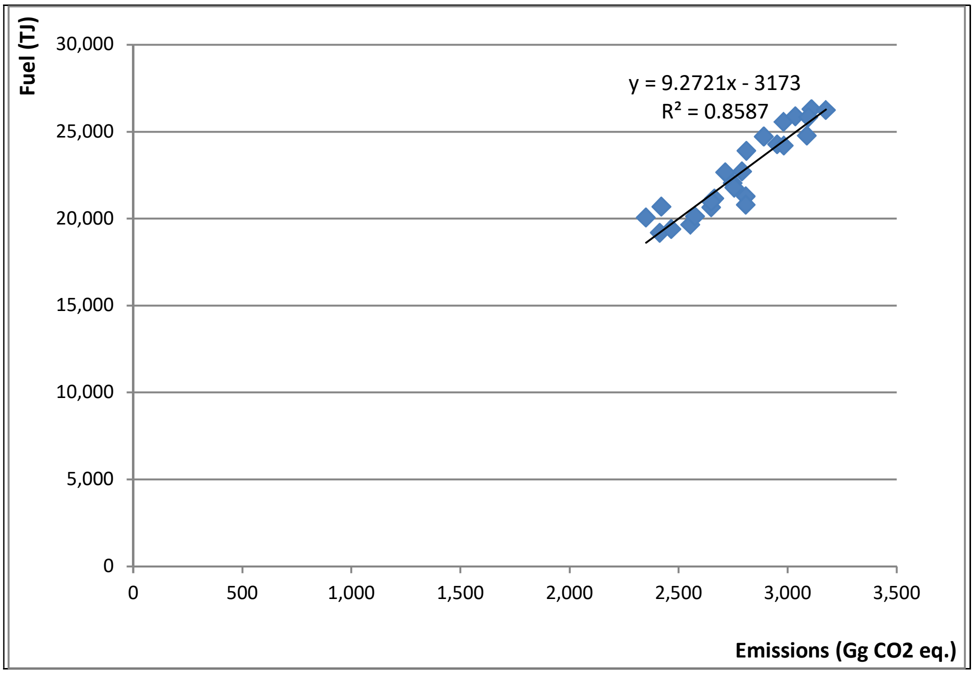

Figure 3-5 Correlation between emissions and fuel consumption for the category Energy Industries

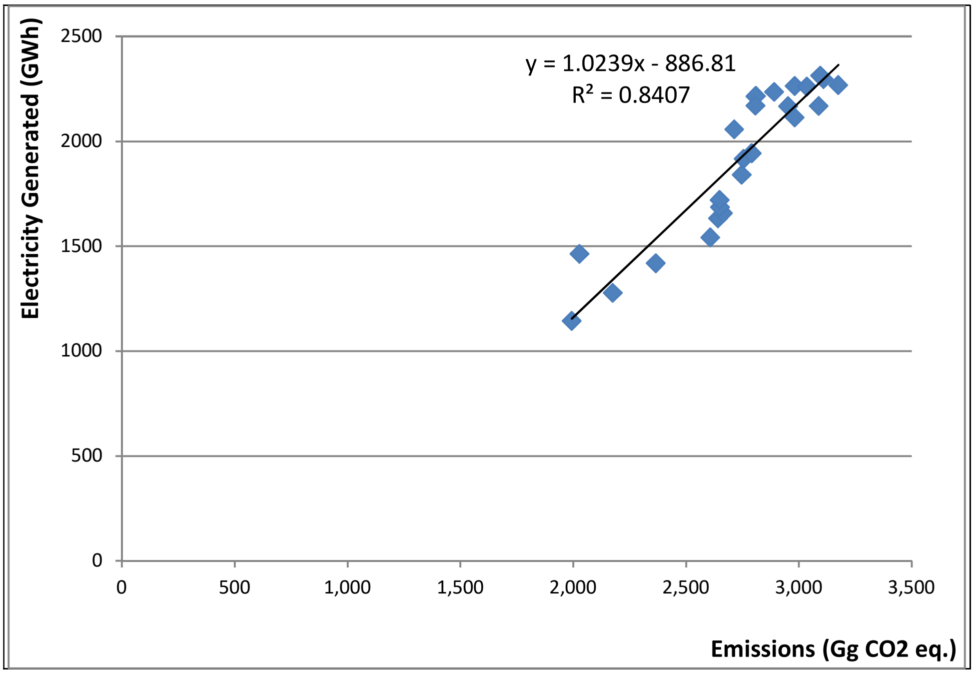

Figure 3-6 Correlation between emissions and electricity generation for the category Energy Industries

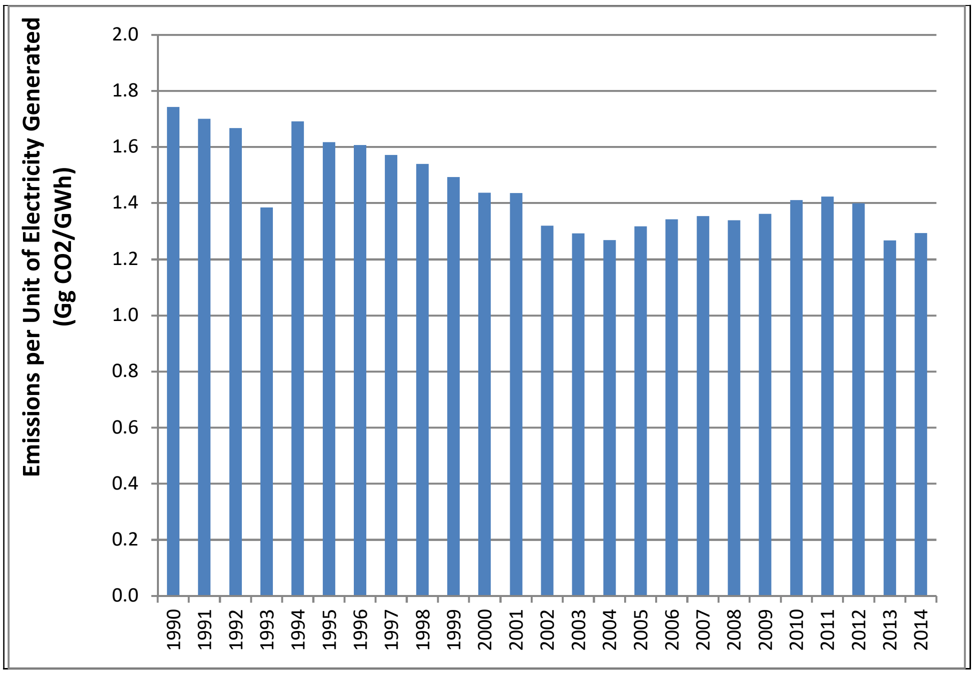

Figure 3-7 Emissions per Unit of Electricity Generated

3.2.4.2 Methodological Issues

Emissions for the sub-category Public Electricity and Heat Production have been calculated using data on the fuels used in the municipal thermal power stations as provided by the Regulator for Energy and Water Services (REWS).

The calculation of emissions for the years until 2008 is carried out using a country-specific calorific value for each of the fuels used in each power station and an oxidation factor of 1 in accordance with the 2006 IPCC Guidelines. For the years 2009 onwards, the calorific values and oxidation factor identified in the verified emission reports submitted pursuant to Directive 2003/87/EC have been used for estimating greenhouse gas inventory emissions.

The default emission factors for N_2O and CH_4 stated in the IPCC 2006 Guidelines and the calorific values calculated as explained above were used for the whole time-series. IPCC 1996 emission factors were used for NO_X, CO and NMVOC. The percentage sulphur content was taken from data provided by Enemalta for 2013.

The emission factors used for emission estimation under this sub-category are shown in Table 3-3.

Table 3-3 Factors for category Energy Industries

Fuel Type	C (tC/TJ)	CH_4 (kg/TJ)	N_2O (kg/TJ)	NOx (kg/TJ)	CO (kg/TJ)	NMVOC (kg/TJ)
Gas Oil	20.2	3.0	0.6	200.0	15.0	5.0
Fuel Oil	21.1	3.0	0.6	200.0	15.0	5.0

3.2.4.3 Uncertainties and time-series consistency

As stated below, time-series consistency was improved due to the use of data obtained from REWS and which was, in turn, compiled from one data source throughout the period 1990-2014, namely Enemalta Corporation.

3.2.4.4 Category-specific QA/QC and verification

Not applicable.

3.2.4.5 Category-specific recalculations

Activity data for the source category 'Energy Industries' was obtained from the REWS for the time period 1990 – 2014 in order to have a consistent data series and one data source. This has, however, resulted in recalculations when compared to the data submitted in previous inventories, due to the differences in the activity data itself. Additionally updates of emission factors used also affected the gross level of emissions, as shown in Table 3-4.

Table 3-4 Recalculation of direct emissions for category Energy Industries

Year	Emissions (Gg CO_2 eq.) as reported in the 2015 inventory report	Emissions (Gg CO_2 eq.) as reported in the 2016 inventory report	Percentage change in reported emissions (%)	Emissions (Gg CO_2 eq.) as reported in the 2015 inventory report	Emissions (Gg CO_2 eq.) as reported in the 2016 inventory report	Percentage change in reported emissions (%)	Emissions (Gg CO_2 eq.) as reported in the 2015 inventory report	Emissions (Gg CO_2 eq.) as reported in the 2016 inventory report	Percentage change in reported emissions (%)
	CO_2	CO_2		CH_4	CH_4		N_2O	N_2O	
1990	1367.03	1361.28	-0.42%	0.89	0.88	-0.76%	4.65	4.64	-0.24%
1991	1511.60	1506.93	-0.31%	1.03	1.03	-0.45%	4.98	4.97	-0.22%
1992	1596.46	1582.55	-0.87%	1.15	1.14	-1.22%	5.06	5.02	-0.67%
1993	1571.82	1637.46	4.18%	1.11	1.16	4.28%	5.06	5.27	4.05%
1994	1668.76	1661.03	-0.46%	1.27	1.26	-0.63%	5.06	5.04	-0.37%
1995	1605.78	1640.15	2.14%	1.47	1.50	2.37%	4.02	4.10	2.06%
1996	1633.08	1618.78	-0.88%	1.59	1.57	-0.92%	3.79	3.75	-0.92%
1997	1625.27	1610.39	-0.92%	1.58	1.56	-0.96%	3.76	3.73	-0.96%
1998	1639.82	1637.74	-0.13%	1.59	1.59	-0.13%	3.79	3.79	-0.13%
1999	1703.09	1696.66	-0.38%	1.66	1.65	-0.42%	3.95	3.94	-0.42%
2000	1687.84	1673.94	-0.82%	1.65	1.63	-0.86%	3.92	3.89	-0.86%
2001	1808.38	1792.83	-0.86%	1.76	1.74	-0.90%	4.20	4.16	-0.90%
2002	1824.44	1745.32	-4.34%	1.78	1.70	-4.37%	4.24	4.05	-4.37%
2003	2000.37	1904.34	-4.80%	1.95	1.85	-4.85%	4.65	4.42	-4.85%
2004	1951.16	1841.66	-5.61%	1.90	1.79	-5.65%	4.53	4.27	-5.65%
2005	1989.43	1971.94	-0.88%	1.94	1.92	-0.92%	4.61	4.57	-0.92%
2006	2004.19	1996.90	-0.36%	1.95	1.94	-0.40%	4.65	4.63	-0.40%
2007	2046.35	2029.39	-0.83%	1.99	1.97	-0.87%	4.74	4.70	-0.87%
2008	2003.34	1987.56	-0.79%	1.95	1.94	-0.83%	4.66	4.62	-0.83%
2009	1911.17	1867.73	-2.27%	1.86	1.82	-2.29%	4.44	4.34	-2.29%
2010	1887.46	1862.27	-1.33%	1.84	1.82	-1.36%	4.39	4.33	-1.36%
2011	1931.48	1907.62	-1.24%	1.88	1.86	-1.27%	4.49	4.43	-1.27%

2012	2052.50	2021.18	-1.53%	2.00	1.97	-1.46%	4.76	4.69	-1.46%
2013	1697.21	1638.13	-3.48%	1.62	1.60	-1.54%	3.86	3.80	-1.54%

3.2.4.6 Category-specific planned improvements

Not applicable.

3.2.5 Manufacturing Industries and Construction (CRF sub-category 1A2)

3.2.5.1 Category Description

This category comprises emissions from fuel combustion in the manufacturing industries and construction. The fuel types used in this sector are petrol, diesel, gas oil, fuel oil, liquefied petroleum gas (LPG), propane, kerosene and biodiesel. Biodiesel was first used in this sector in 2003 and is still being used to-date.

3.2.5.2 Methodological Issues

Fuel data for the source category 'Manufacturing Industries and Construction' was, up until 2009, provided by the Petroleum Division of Enemalta Corporation, which for many years was the sole importer of fuels used in industry. Following the liberalisation of the inland fuel market and the entry of new operators into the market, the Malta Resources Authority implemented a reporting system to collect, collate, audit and report fuel-related data to the National Statistics Office; this role has now been taken over by the Regulator for Energy and Water Services (REWS). This led to an overhaul of the activity data used for inventory purposes.

Furthermore, in recognition of the need to have a better picture of fuel use in Malta, the Malta Resources Authority, in conjunction with the National Statistics Office, carried out a detailed survey on the types of fuels used, and for which purpose(s), by the economic sectors over 2010 - 2013. The results of the survey distinguished the fuel usage for each NACE Section. Following the completion of the survey, the Malta Resources Authority carried out a statistical normalization exercise whereby the survey results were 'back-casted' over the period 1990-2009. Further details on the survey and back-casting exercise are provided in Annex 3 of this report.

In the case of 2014, the average of the survey results for the period 2010-2013 was used to estimate the fuel use for each NACE Section. This methodology will be applied for the years 2015 and 2016. However, it is expected that a second survey on the fuel used in the economic sectors will be carried in 2017 and covering the period 2014-2016. Thus, the data for the period 2014-2016 will be revised accordingly.

The results obtained from these studies and methodological approach represent the main data source for the estimation of emissions for all the fuel combustion source categories (excluding for electricity generation since this category uses a Tier 3 approach) for the purposes of this Inventory.

The calorific values for all fuel types were aligned with those used by the National Statistics Office[15] (as opposed to using the default factors of the IPCC 2006 Guidelines). In the case of biodiesel, the calorific

[15] NSO News Release 106/2015

value used to convert the mass of fuel into the required energy equivalent is in accordance with Subsidiary Legislation 423.28[16] to convert weight of fuel into energy equivalent.

The default emission factors for direct emissions provided in the IPCC 2006 Guidelines have been used for the whole time-series. The emission factors for indirect emissions were based on the EMEP/EEA 2013 Guidelines. For the years 2010 to 2013, the percentage sulphur content of the fuels consumed has been obtained from the Malta Resources Authority. The emission factors used are shown in Table 3-5.

Table 3-5 Emission factors and oxidation factor for category Manufacturing Industry and Construction

Fuel Type	CO_2 (kg/TJ)	CH_4 (kg/TJ)	N_2O (kg/TJ)	NOx (kg/TJ)	CO (kg/TJ)	NMVOC (kg/TJ)	NCV (TJ/KT)
LPG / Propane	63,100	1.0	0.1	150	29	23	46
Fuel Oil	77,400	3.0	0.6	74	66	25	40
Kerosene	71,500	3.0	0.6	513	66	25	43.8
Automotive Diesel	74,100	3.0	0.6	513	66	25	43
Gas Oil	74,100	3.0	0.6	513	66	25	43
Biodiesel	70,800	1.0	0.6	91	57	30	37

All the emissions of the manufacturing and construction industries have been reported in the CRF under 1AA 2F 'all industry' since a sub-division of end-user fuel consumption according to NACE codes was not possible for all fuels in this sector.

3.2.5.3 Uncertainties and time-series consistency

Uncertainty in the activity data and time-series consistency were greatly ameliorated as a direct result of the implementation of the methodological approach described in sub-section 3.2.5.2.

3.2.5.4 Category-specific QA/QC and verification

Not applicable.

3.2.5.5 Source Specific Recalculations

Recalculations were performed for emissions of direct greenhouse gases in the category Manufacturing Industries and Construction due to a revised methodology (including back-casting), as detailed in sub-section 3.2.5.2, and shown in Table 3-6.

[16] Subsidiary Legislation 423.28 (Legal Notice 278 of 2007) Petroleum for the Inland (Wholesale) Fuel Market, Bottling of LPG and Primary Storage Facilities Regulations.

Table 3-6 Recalculations of direct emissions for category Manufacturing Industry and Construction

Year	Emissions (Gg CO_2 eq.) as reported in the 2015 inventory report	Emissions (Gg CO_2 eq.) as reported in the 2016 inventory report	Percentage change in reported emissions (%)	Emissions (Gg CO_2 eq.) as reported in the 2015 inventory report	Emissions (Gg CO_2 eq.) as reported in the 2016 inventory report	Percentage change in reported emissions (%)	Emissions (Gg CO_2 eq.) as reported in the 2015 inventory report	Emissions (Gg CO_2 eq.) as reported in the 2016 inventory report	Percentage change in reported emissions (%)
	CO_2	CO_2		CH_4	CH_4		N_2O	N_2O	
1990	59.29	22.67	-62	0.0585	0.0218	-63	0.1376	0.0486	-65
1991	62.44	24.45	-61	0.0615	0.0236	-62	0.1446	0.0526	-64
1992	58.99	29.52	-50	0.0579	0.0285	-51	0.1358	0.0640	-53
1993	58.18	30.78	-47	0.0570	0.0299	-48	0.1338	0.0671	-50
1994	57.45	31.88	-45	0.0564	0.0310	-45	0.1325	0.0698	-47
1995	59.98	36.27	-40	0.0592	0.0354	-40	0.1391	0.0800	-43
1996	62.48	36.51	-42	0.0616	0.0357	-42	0.1447	0.0805	-44
1997	57.34	37.25	-35	0.0563	0.0365	-35	0.1320	0.0823	-38
1998	41.27	35.87	-13	0.0392	0.0349	-11	0.0913	0.0783	-14
1999	54.49	36.29	-33	0.0529	0.0354	-33	0.1239	0.0793	-36
2000	57.36	36.29	-37	0.0556	0.0356	-36	0.1303	0.0794	-39
2001	49.26	36.78	-25	0.0474	0.0364	-23	0.1107	0.0808	-27

2002	46.66	36.97	-21	0.0448	0.0361	-19	0.1043	0.0809	-22
2003	48.02	40.80	-15	0.0461	0.0400	-13	0.1074	0.0897	-16
2004	59.14	42.18	-29	0.0575	0.0414	-28	0.1346	0.0935	-30
2005	50.94	35.17	-31	0.0502	0.0348	-31	0.1187	0.0767	-35
2006	47.30	36.44	-23	0.0480	0.0356	-26	0.1133	0.0785	-31
2007	51.80	37.27	-28	0.0514	0.0365	-29	0.1212	0.0804	-34
2008	48.42	38.88	-20	0.0482	0.0378	-22	0.1137	0.0835	-27
2009	40.73	33.93	-17	0.0399	0.0331	-17	0.0940	0.0720	-23
2010	46.13	24.14	-48	0.0452	0.0240	-47	0.1065	0.0504	-53
2011	71.97	36.83	-49	0.0713	0.0358	-50	0.1688	0.0794	-53
2012	72.79	38.49	-47	0.0709	0.0371	-48	0.1676	0.0826	-51
2013	67.80	35.33	-48	0.0660	0.0014	-98	0.1558	0.0752	-52

3.2.6 Transport (CRF sub-category 1A3)

This category covers transport activities within Malta's national territory, thus including road transport, domestic aviation, national navigation and other relevant transport modes (where applicable), where direct emissions from such modes occur. International aviation and maritime emissions (so-called 'Memo Items') are not included under this category.

3.2.6.1 Transport - Civil Aviation (1A3a)

3.2.6.1.1 Category Description

This source category covers emissions in respect of flights that depart from and arrive at aerodromes within the Malta's territory. Aviation turbine fuel (Jet Kerosene) and aviation gasoline are used in domestic aviation.

3.2.6.1.2 Methodological Issues

Activity data for the civil aviation was previously provided by the Malta Resources Authority from the relevant Aviation Fuel Suppliers, however to be consistent throughout the different source categories, the same methodological approach described in sub-section 3.2.5.2 was applied to civil aviation.

Emission factors are based on the 2009 EMEP/EEA air pollutant emission inventory guidebook, Section 1.A.3.a tables 3.3 (Jet A1) and 3.4 (Aviation Gasoline). For the purposes of this report, all aviation turbine fuel emissions are calculated using emission factors of Domestic Cruise (Average fleet).

3.2.6.1.3 Uncertainties and time-series consistency

Uncertainty in the activity data and time-series consistency were greatly ameliorated as a direct result of the implementation of the methodological approach described in sub-section 3.2.5.2.

3.2.6.1.4 Category-specific QA/QC and verification

Data for emissions in this sector are also available from European sources such as Eurocontrol. Eurocontrol collects data from flight planning and route charging, and in agreement with the EU provided this data for comparison. Malta, because of the small scope, the limited number of aerodromes covered and an expectedly relative high proportion of short internal flights not covered by Eurocontrol, uses this data provided only as a comparative to the fuel used data.

3.2.6.1.5 Source Specific Recalculations

Recalculations were performed for emissions of direct greenhouse gases in the category Civil Aviation due to the revised methodology (including back-casting) detailed in sub-section 3.2.5.2.

3.2.6.1.6 Category-specific planned improvements

Not applicable.

3.2.6.2 Transport - Road Transport (1A3b)

3.2.6.2.1 Category Description

The transport sector in Malta is dominated by emissions from sub-category Road Transport (see Figure 3-8), with CO_2 being the gas that accounts for the bulk of overall GHG emissions for this sub-category. Road transport is also identified as a key source, for 1990 and 2014, in respect of CO_2 emissions.

Specifically to road transport, the share of the market between petrol and diesel in 2014 was 42% and 54% respectively, 2.7% share of biodiesel(B100 & blended portion) and <1% share for LPG (autogas). Most of the biodiesel is sold 'pre-blended' with diesel following the implementation of the substitution obligation for importers/wholesalers of diesel (EN590) and petrol (EN228) in 2010. The substitution obligation for 2014 requires a minimum of 4.5% of the total energy content of the petroleum placed on the market. This figure is projected to increase to 5.5% in 2015, to 6.5% in 2016 until it reaches the 10% RES target[17] by 2020. The trends in emissions follow closely the distribution of market shares for each fuel type as illustrated in Figure 3-9.

[17] As required by Directive 2009/28/EC on the promotion of the use of energy from renewable sources

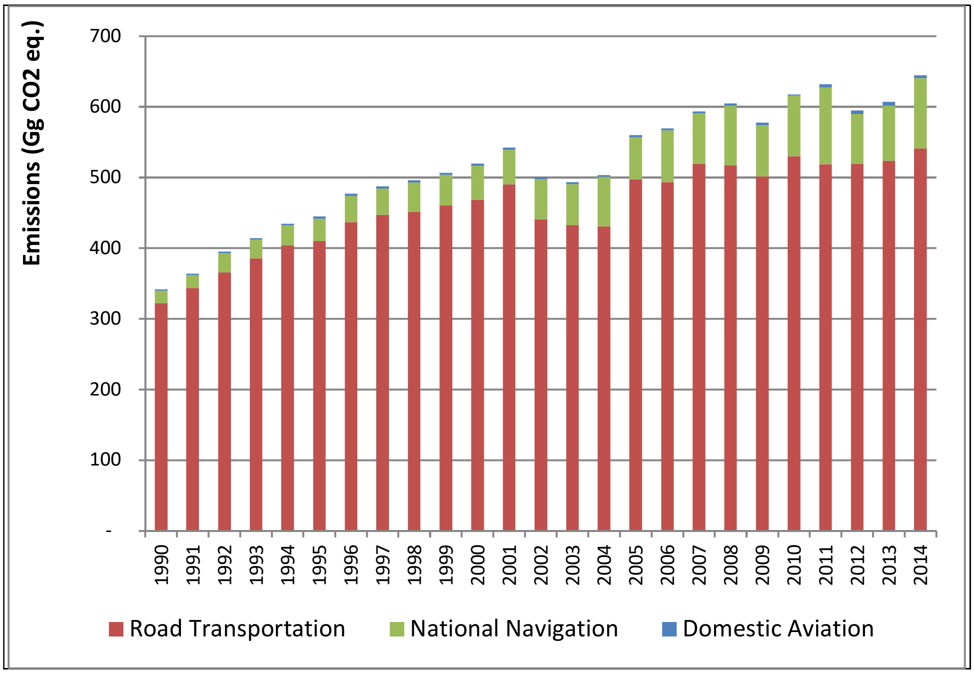

Figure 3-8 Emission trends in category Transport, by sub-category

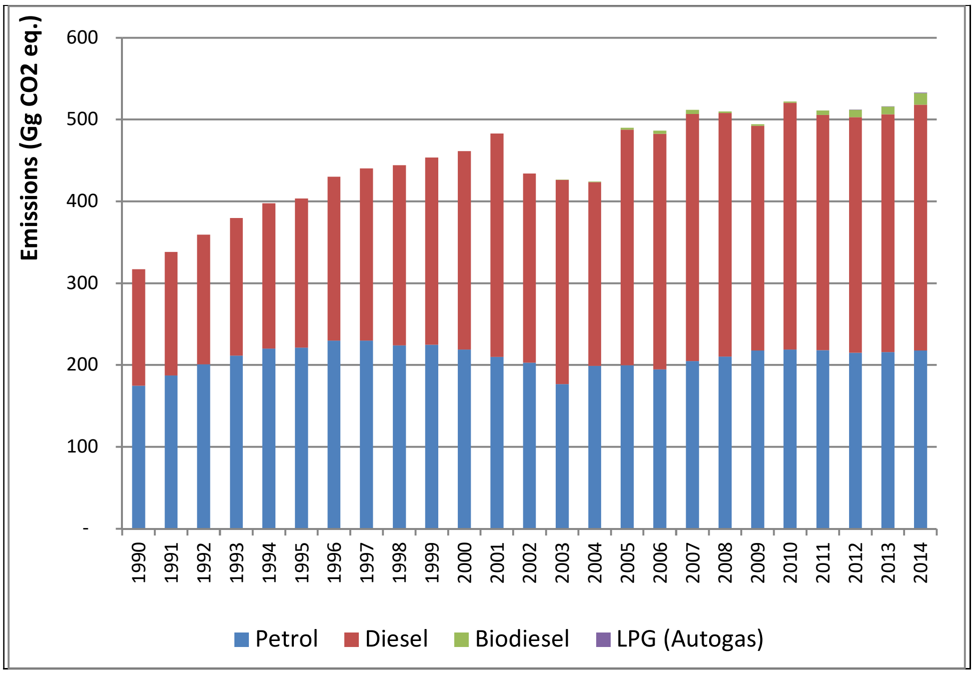

Figure 3-9 Emission trends in category Road Transport, by fuel type

3.2.6.2.2 Methodological Issues

3.2.6.2.2.1 Methodological Issues: Activity data

Activity data for road transport was previously provided by the Petroleum Division of Enemalta Corporation, however to be consistent throughout the different source categories, the same methodological approach described in sub-section 3.2.5.2 was applied to estimate the fuels used for road transport.

Tier 1 approach has been used to calculate GHG emissions for the 1990-2014 period using IPCC 2006 emission factors. The emission factors used in respect of greenhouse gas emissions from road transport are listed in Table 3-7.

Table 3-7 Fuel based emission factors used to estimate emissions of greenhouse gases for category Road Transport

Fuel	CO_2 kg/TJ	CH_4 kg/TJ	N_2O kg/TJ
Diesel	74,100	3.9	3.9
Petrol	69,300	33.0	3.2
Biodiesel	70,800	3.0	0.6

3.2.6.2.2.2 Methodological Issues: Emissions Data for the years 2000-2009

For the years 2000 to 2009, emissions of NO_x, SO_2 and NMVOC have been calculated using the 2006 EMEP/CORINAIR Guidebook, applying a basic Tier 3 methodology. A model was developed to calculate emissions by vehicle class based on distance travelled per class and grams of fuel/km.

The annual fuel use for a vehicle in each EU Legislation class was obtained by multiplying the estimated vehicle km/year data (see Table 3-8) by the grams of fuel/km (see Table 3-9**Error! Reference source not found.**) for different vehicle technology types grouped according to Euro emission standard classes. However, the disaggregation of fuel use by the specific vehicle category i.e. categories 1A3bi [Cars], 1A3bii [Light duty trucks], 1A3biii [Heavy duty trucks and buses] and 1A3iv [Motorcycles], was not possible for the time being due to issues with vehicle fleet data for the period 1990 – 2009 and their non-inclusion in the COPERT model. Therefore, for reporting purposes, the annual fuel use for these categories was included under category 1A3bi [Cars].

Table 3-8 Estimated data for vehicle km/year by vehicle type

Vehicle Type	Estimated vehicle-km per year
Cars (petrol)	10,989
Cars (DERV)	12,698
Vans (petrol)	11,423
Vans (DERV)	25,480
Rigid lorries	39,150
Articulated lorries	39,150
Coaches and buses	25,052
minibuses	38,148
Mopeds	2,000
Motorcycles	4,000

Table 3-9 Fuel consumption factors for vehicle types grouped by EU legislation class

Vehicle Type	Vehicle EU Legislation Class	Grams fuel used / km
Petrol cars	pre ECE	96
	ECE 15.00	81
	ECE 15.01	81
	ECE 15.02	79
	ECE 15.03	79
	ECE 15.04	71
	EURO I	70
	EURO II	68
	EURO III	64
	EURO IV	57
	EURO V	47
Diesel car	Pre-Euro I	68
	EURO I	66
	EURO II	65
	EURO III	58
	EURO IV	53
	EURO V	49
Petrol LGV	Pre-Euro I	73
	Euro I	92
	Euro II	94
	Euro III	90
	Euro IV (~2005)	83
Diesel LGV	Pre-Euro I	94
	Euro I	94
	Euro II	94
	Euro III	86
	Euro IV (~2005)	81
Rigid HGV	Pre-1988	232
	88/77/EEC	229
	Euro I	301
	Euro II	281
	Euro III	281
	Euro IV (~2005)	272
	Euro V	264
Articulated HGV	Pre-1988	232
	88/77/EEC	229
	Euro I	301
	Euro II	281

	Euro III	281
	Euro IV (~2005)	272
	Euro V	264
Bus	Pre-1988	186
	88/77/EEC	181
	Euro I	201
	Euro II	200
	Euro III	200
	Euro IV (~2005)	194
	Euro V	188
Minibus petrol	Pre-Euro I	73
	Euro I	92
	Euro II	94
	Euro III	90
	Euro IV (~2005)	83
Minibus diesel	Pre-Euro I	94
	Euro I	94
	Euro II	94
	Euro III	86
	Euro IV (~2005)	81
Mopeds	Pre-Euro1	25
	97/24/EC	25
Motorcycles	Pre-Euro1	30
	97/24/EC	26

The composition of the vehicle fleet is obtained from the National Statistics Office using the vehicle numbers of each vehicle type in each class. The annual fuel use for automotive purposes has been used to disaggregate the annual fuel use by all the vehicles in each vehicle class. To ensure consistency with actual fuel sales, a recalibration procedure is used. The emission factors shown in Table 3-10 were then used to estimate NO_x and NMVOC emissions.

The total SO_2 emissions for petrol and diesel used in road transport for each inventory year were obtained by working out the weighted averages based on percentage sulphur in different fuel batches. The amount of fuel and percentage sulphur in each batch was obtained from fuel sampled by the Licensing and Enforcement Unit of the Malta Resources Authority. This was then used to calculate the SO_2 emissions depending on the amount of fuel used by each vehicle type in each different vehicle class.

Table 3-10 Emission factors for Road Transport NOx and NMVOC

Vehicle Type	Vehicle EC Legislation Class	NO_x (t NO_x/t of fuel)	NMVOC (t NMVOC/t of fuel)
Petrol cars	pre ECE	0.0235	0.0250
	ECE 15.00	0.0270	0.0224
	ECE 15.01	0.0270	0.0224
	ECE 15.02	0.0245	0.0241
	ECE 15.03	0.0263	0.0241
	ECE 15.04	0.0246	0.0212
	EURO I	0.0039	0.0008
	EURO II	0.0036	0.0006
	EURO III	0.0019	0.0004
	EURO IV	0.0012	0.0003
	EURO V	0.0012	0.0003
Diesel car	Pre-Euro I	0.0097	0.0023
	EURO I	0.0085	0.0012
	EURO II	0.0090	0.0010
	EURO III	0.0100	0.0008
	EURO IV	0.0070	0.0000
	EURO V	0.0070	0.0000
Petrol LGV	Pre-Euro I	0.0209	0.0184
	Euro I	0.0039	0.0007
	Euro II	0.0034	0.0004
	Euro III	0.0018	0.0002
	Euro IV (~2005)	0.0006	0.0002
Diesel LGV	Pre-Euro I	0.0140	0.0030
	Euro I	0.0109	0.0013
	Euro II	0.0103	0.0013
	Euro III	0.0084	0.0011
	Euro IV (~2005)	0.0065	0.0003
Rigid HGV	Pre-1988	0.0562	0.0144
	88/77/EEC	0.0250	0.0071
	Euro I	0.0317	0.0026
	Euro II	0.0271	0.0021
	Euro III	0.0186	0.0014
	Euro IV (~2005)	0.0179	0.0005
	Euro V	0.0103	0.0001
Articulated HGV	Pre-1988	0.0526	0.0093
	88/77/EEC	0.0430	0.0037
	Euro I	0.0582	0.0045
	Euro II	0.0434	0.0040

	Euro III	0.0299	0.0028
	Euro IV (~2005)	0.0186	0.0000
	Euro V	0.0107	0.0005
Bus	Pre-1988	0.0419	0.0182
	88/77/EEC	0.0353	0.0046
	Euro I	0.0343	0.0041
	Euro II	0.0339	0.0033
	Euro III	0.0234	0.0023
	Euro IV (~2005)	0.0178	0.0000
	Euro V	0.0107	0.0001
Petrol minibus	Pre-Euro I	0.0209	0.0184
	Euro I	0.0039	0.0007
	Euro II	0.0034	0.0004
	Euro III	0.0018	0.0002
	Euro IV (~2005)	0.0006	0.0002
Diesel minibus	Pre-Euro I	0.0140	0.0030
	Euro I	0.0109	0.0013
	Euro II	0.0103	0.0013
	Euro III	0.0084	0.0011
	Euro IV (~2005)	0.0065	0.0003
Mopeds	Pre-Euro1	0.0012	0.4834
	97/24/EC	0.0009	0.2417
Motorcycles	Pre-Euro1	0.0055	0.0571
	97/24/EC	0.0084	0.0276

3.2.6.2.2.3 Methodological Issues: Implementation of the COPERT model

Following recommendations made during inventory peer reviews of previous inventory submissions, it has been decided to start implementing a Tier 3 approach based on the 2013 EMEP/CORINAIR Guidebook.

The COPERT 4 model, published by the EEA and Emisia SA, estimates exhaust emissions for: passenger cars (1A3bi), light goods vehicles (1A3bii), heavy duty vehicles including buses and coaches (1A3biii), and motorcycles (1A3biv). A Tier 2 methodology has been used for calculating evaporative emissions (1A3bv) from petrol vehicles. Emission factors for the latest year (2013) have been obtained from diverse sources related to COPERT 4 i.e. EMEP/EEA Emission Inventory Guidebook and Emisia SA datasets and other EFs used in previous years.

Traffic activity data was carried forward from the data used in previous years. Total fuel sales for petrol, diesel, biodiesel and autogas for road transport were obtained from the Malta Resources Authority using the methodological approach described in sub-section 3.2.5.2. Other key figures used in the estimation of emissions that are fed in the COPERT 4 are provided in Table 3-11.

Table 3-11 Key figures used in respect of greenhouse gas emissions from road transport for 2014

Vehicle Class	Fuel Type	Vehicle Population	Mileage km/yr	Total Kms Driven Km (Million)	Fuel Consumption TJ
Passenger Cars	Petrol	177,266	8,792	1,559	3,294
Passenger Cars	Diesel	81,135	14,162	1,149	1,807
Passenger Cars	LPG	436	15,563	7	14
Light Commercial Vehicles	Petrol	1,269	6,425	8	29
Light Commercial Vehicles	Diesel	30,064	11,243	338	806
Heavy Duty Trucks	Diesel	14,769	14,412	213	1,080
Buses	Diesel	1,529	65,188	100	352
Mopeds & Motorcycles	Petrol	17,225	2,681	46	47

It is pertinent to note that in respect of this submission, the COPERT model has been used for the determination of relevant emissions for 2010 onwards only.

- ***Fuel consumption factors for petrol and diesel vehicles***

Emissions of CO2 reported under category Road Transport are computed from the amounts of petrol, diesel, autogas and biofuel provided under road transport in the national oil balance.

The CH_4 and N_2O emissions from road traffic are estimated in the COPERT 4 model, which estimates emissions of CH_4 and N_2O on the basis of distance travelled using a detailed bottom-up approach (Tier 3) that accounts for factors including fuel type, fuel consumption, engine capacity, driving speed and a range of applicable technological emission controls that may be applied on the basis of the age of the vehicle. The same model is also used to calculate indirect GHG emissions (excluding SO_2).

The estimation of CO_2 and SO_2 emissions is based on fuel consumption of petrol and automotive diesel, with the carbon content (by mass) of the fuel and the sulphur content of the fuel serving as additional calculation parameters for the two gases respectively. For SO_2, sulphur content values used reflect the highest permissible limits.

Emissions of CO_2 and SO_2 can be broken down by vehicle type based on the estimated fuel consumption factors and traffic data in a manner similar to the traffic-based emissions described below for other pollutants.

3.2.6.2.3 Uncertainties and time-series consistency

In absolute terms, and when compared to other countries, Malta has a relatively small vehicle fleet and data on the composition of this fleet is relatively robust. It is thus assumed that the level of uncertainty is comparable with that of countries with similar data accuracy and therefore the uncertainty level was taken to be equivalent to that quoted in Kouridis *et al* (2010) based on good vehicle statistics with fuel correction as shown in Table 3-12.

Table 3-12 Uncertainty levels for emissions using COPERT 4

	CO_2	CH_4	N_2O	CO	NOx	NMVOC	SO_2
Uncertainty (%)	4	34	26	19	10	12	4

3.2.6.2.4 Category-specific QA/QC and verification

Quality of fleet data is ensured through the use of NSO reviewed data for fleet numbers and characteristics, which is periodically published and communicated to Eurostat.

3.2.6.2.5 Source Specific Recalculations

No recalculations were required.

3.2.6.2.6 Category-specific planned improvements

For road transport, further refinement of the COPERT input data is being sought. For next year's submission Malta will be considering whether to introduce year specific values for temperature and relative humidity, thus calculating the Beta values on an annual basis. This estimation needs to be considered in view of the overall effect it should have on the accuracy of the estimates.

3.2.6.3 Transport - Railways (1A3c)

This source sub-category does not occur in Malta.

3.2.6.4 Transport - National (Water borne) Navigation (1A3d)

3.2.6.4.1 Category Description

Fuels used for national navigation are gasoil, fuel oil and petrol (used mainly in jet skis). Data for national navigation was obtained from the Malta Resources Authority, which in turn, is obtained from Transport Malta. The latter entity collects data on bunker fuel sales directly from the operators. The types of vessels which are accounted for in the national navigation sector include pleasure cruisers, small yachts, pilot boats, tug boats, supply vessels and ferries. A detailed list is provided in Annex 3 of this report.

3.2.6.4.2 Methodological Issues

The methodological approach described in Annex 3 was applied to the activity data pertaining to national navigation in order to remain consistent throughout the different source categories.

Data on fuels used by fishing vessels was previously reported under the category 'National Navigation' but it has now been included under category 'Agriculture, Forestry & Fisheries' in accordance with Good Practice Guidelines.

Emissions from national navigation have been estimated using a Tier 1 approach. IPCC 2006 default emission factors have been used for estimating CO_2, CH_4 and N_2O emissions and for calorific values. The EMEP/EEA 2013 Guidelines are used for indirect emissions.

For SO_2 emissions, the sulphur content for marine fuels is obtained from the MRA Regulation Unit. This data is obtained through the sampling of fuels under reporting obligations of Directive 99/32/EC. The emission factors used are shown in Table 3-13.

Table 3-13 Emission Factors for category National Navigation excluding Fishing Vessels

Fuel Type	CO_2 (kg/TJ)	CH_4 (kg/TJ)	N_2O (kg/TJ)	NOx (kg/TJ)	CO (kg/TJ)	NMVOC (kg/TJ)	SO_2 (%S)
Gas Oil	74,100	7.0	2.0	1,825.58	172.09	65.12	0.06
Petrol	69,300	7.0	2.0	212.90	12,954.85	4,097.07	0.000565
Residual Oil	77,400	7.0	2.0	1,962.87	183.17	66.83	2.12

3.2.6.4.3 Uncertainties and time-series consistency

Uncertainty in the activity data and time-series consistency were greatly ameliorated as a direct result of the implementation of the methodological approach described in sub-section 3.2.5.2 and in Annex 3 and including the extensive exercise carried out by the Malta Resources Authority and Transport Malta to update the methodology used to identify, and subsequently classify, those vessel types that are likely to use fuels within territorial waters, and thus falling under the definition of 'national navigation'.

3.2.6.4.4 Category-specific QA/QC and verification

Not applicable.

3.2.6.4.5 Source Specific Recalculation

Recalculations were performed for emissions of direct greenhouse gases in the category National Navigation due to a revised methodology (including back-casting) as detailed in sub-section 3.2.5.2.

3.2.6.4.6 Category-specific planned improvements

Not applicable.

3.2.6.5 Transport - Other Transportation (1A3e)

Data for specific fuel consumption by major users of diesel for airport ground support equipment (2011 only) and port machinery (2005-2011) was available and was forwarded to Malta Resources Authority. Emissions for this sector have been estimated using a Tier 1 approach for estimating CO_2 emissions using default factors and IPCC 1996 default emission factors for CH_4, N_2O and the indirect gases. The emission factors used are shown in Table 3-14. Data for 2012 to 2014 was not available and the activity was assumed as remaining at a level equivalent to 2011 activity.

Table 3-14 Emission Factors used in category Other Transportation

Fuel Type	C (tC/TJ)	CH_4 (kg/TJ)	N_2O (kg/TJ)	NOx (kg/TJ)	CO (kg/TJ)	NMVOC (kg/TJ)	NCV (kg/TJ)
Diesel	20.2	5	0.6	1200	1000	200	0.354

3.2.7 Other Sectors (CRF sub-category 1A4)

3.2.7.1 Category description

Source category 1A4 comprises emissions from fuel combustion in the categories Commercial/Institutional (1A4a), Residential (1A4b) and Agriculture/Forestry/Fisheries (1A4c).

The fuels used in the commercial/institutional sector (excluding fuels used for automotive purposes which are shown under Road Transport (1A3b) are diesel, biodiesel, gasoil, fuel oil, kerosene and propane. Up until 2004, kerosene was quite prominently used but this has gradually declined following a marked increase in excise duty levied on this product.

Fuels used in the residential sector are LPG, gasoil and kerosene. LPG also makes up the greater bulk of fuel consumption within the residential sector (excluding fuels used for automotive purposes which are shown under Road Transport (1A3b). This fuel type is used for heating and cooking purposes while gasoil is used for heating purposes and small generators. Fuels used in the Agriculture/Forestry/Fisheries sector are petrol, diesel, biodiesel and propane.

3.2.7.2 Methodological Issues

Activity data for this source category was previously obtained from the Petroleum Division of Enemalta Corporation. However, from 2010 onwards, the data was obtained from the Malta Resources Authority, which is compiling the oil balance reports and reporting them to the National Statistics Office. The sectoral breakdown of fuel consumption follows the methodological approach described in sub-section 3.2.5.2 and Annex 3, with the exception of the residential sector.

Activity data pertaining to the residential sector is collated from a number of sources including the Customs Department on gasoil used for heating purposes and the Malta Resources Authority on the LPG used for cooking and heating purposes. A number of different methodologies were also adopted depending on the fuel type or the purpose for which the particular fuel is used e.g. kerosene for lighting/heating purposes.

Activity data related to fuels used for fishing purposes under the sub-category Agriculture/Forestry/Fisheries was obtained from the Fishing and Farming Regulation and Control Department within the Ministry for Sustainable Development, the Environment and Climate Change, which is responsible for managing fuel subsidies for fishing vessels and from source data provided by Transport Malta as detailed in Annex 3.

Table 3-15 illustrates the emission factors used for each fuel. The default emission factors and calorific values provided in the IPCC 2006 Guidelines have been used for the whole time-series. The other emission factors have been based on the EMEP/EEA 2013 Guidelines. The percentage sulphur content has been obtained from the Malta Resources Authority.

The emissions for solid fuels, gaseous fuels and other fuels in the CRF tables have been changed to 'NO' (Not Occurring) since the burning of solid fuels, gaseous fuels and other fuels does not occur in the Commercial/Institutional and Agriculture/Forestry/Fisheries categories.

Table 3-15 Emission factors for categories Residential and Agriculture/Forestry/Fisheries

Fuel Type	CO_2 (kg/TJ)	CH_4 (kg/TJ)	N_2O (kg/TJ)	NOx (kg/TJ)	CO (kg/TJ)	NMVOC (kg/TJ)
Agriculture Automotive Diesel	74,100	10	0.6	815.0	254.4	78.3
Fisheries Diesel Oil	74,100	10	0.6	1,825.6	172.1	65.1
Gasoil	74,100	10	0.6	513.0	66.0	25.0
Petrol	69,300	10	0.6	212.2	12,954.9	4097.1
Fuel oil	77,400	10	0.6	513	66	25
Kerosene	71,500	10	0.6	513	66	25

3.2.7.3 Uncertainties and time-series consistency

Uncertainty in the activity data and time-series consistency were greatly ameliorated as a direct result of the implementation of the methodological approach described in sub-section 3.2.5.2.

For the residential sector, it is expected that data sources or methodologies will be collated in order to have a more accurate picture on the fuels used (and for what purposes) in this sector. This approach will also streamline the timeseries, if a back-casting exercise is carried out.

3.2.7.4 Category-specific QA/QC and verification

Not applicable.

3.2.7.5 Source Specific Recalculations

Table 3-16 presents the recalculation carried out for the categories consisting of 'Other Sectors', namely the Commercial/Institutional, Residential and Agriculture/Forestry/Fisheries sectors.

Table 3-16 Recalculations for category 'Other Sectors'

Year	Emissions (Gg CO_2 eq.) as reported in the 2015 inventory report	Emissions (Gg CO_2 eq.) as reported in the 2016 inventory report	Percentage change in reported emissions (%)	Emissions (Gg CO_2 eq.) as reported in the 2015 inventory report	Emissions (Gg CO_2 eq.) as reported in the 2016 inventory report	Percentage change in reported emissions (%)	Emissions (Gg CO_2 eq.) as reported in the 2015 inventory report	Emissions (Gg CO_2 eq.) as reported in the 2016 inventory report	Percentage change in reported emissions (%)
	CO_2	CO_2		CH_4	CH_4		N_2O	N_2O	
1990	96.16	136.16	42	0.27	0.40	46	0.1585	0.2516	59
1991	103.75	147.89	43	0.29	0.44	49	0.1681	0.2789	66
1992	102.85	170.34	66	0.29	0.50	77	0.1610	0.3283	104
1993	103.28	172.97	67	0.29	0.52	80	0.1604	0.3404	112
1994	101.43	178.42	76	0.28	0.53	89	0.1593	0.3571	124
1995	107.83	195.65	81	0.30	0.59	94	0.1755	0.4010	129
1996	107.76	201.03	87	0.30	0.61	101	0.1737	0.4154	139
1997	99.32	200.88	102	0.27	0.61	122	0.1535	0.4184	173
1998	97.54	173.60	78	0.27	0.51	93	0.1461	0.3512	140
1999	102.50	184.69	80	0.28	0.55	94	0.1576	0.3772	139
2000	105.37	190.37	81	0.29	0.57	94	0.1652	0.3941	139
2001	88.81	185.20	109	0.24	0.55	132	0.1274	0.3881	205
2002	90.75	187.68	107	0.24	0.56	129	0.1318	0.3981	202
2003	91.13	207.10	127	0.24	0.62	156	0.1282	0.4422	245
2004	106.99	223.80	109	0.30	0.68	131	0.1650	0.5002	203
2005	109.31	178.34	63	0.29	0.53	81	0.1513	0.3744	148
2006	100.69	183.56	82	0.26	0.53	102	0.1335	0.3781	183
2007	109.80	184.22	68	0.29	0.53	82	0.1546	0.3828	148
2008	117.54	200.52	71	0.31	0.58	86	0.1645	0.4288	161
2009	130.33	213.86	64	0.35	0.62	76	0.1898	0.4439	134
2010	125.10	185.37	48	0.34	0.53	56	0.1855	0.3915	111
2011	106.38	211.32	99	0.28	0.62	122	0.1405	0.4419	214
2012	140.41	234.22	67	0.39	0.69	79	0.2162	0.5037	133
2013	134.07	225.43	68	0.37	0.66	82	0.2016	0.4989	147

3.3 FUGITIVE EMISSIONS FROM SOLID FUELS AND OIL AND NATURAL GAS AND OTHER EMISSIONS FROM ENERGY PRODUCTION (CRF CATEGORY 1B)

3.3.1 CATEGORY DESCRIPTION

Malta has no fuel refining/abstraction processes of fuels and thus limited possibilities for fugitive emissions except for those related to the retailing of gasoline, which is considered as a source of NMVOCs. The trend in this particular emission source is shown inFigure 3-10.

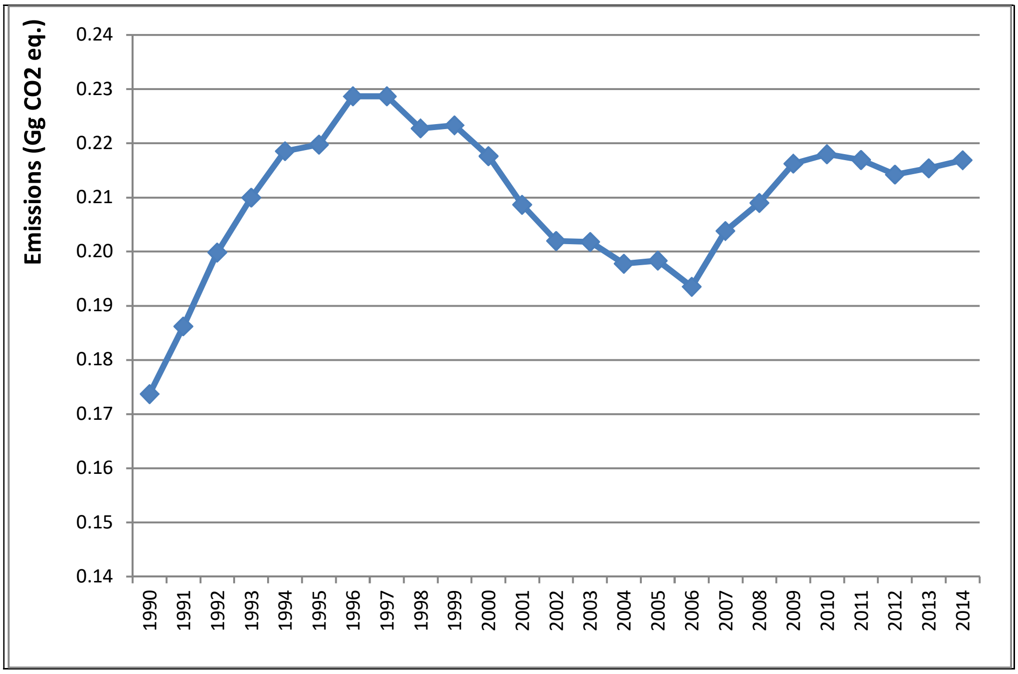

Figure 3-10 Trend in Fugitive Emission for category Transport

3.3.1.1 Methodological Issues

Activity data for this source category was previously obtained from the Petroleum Division of Enemalta Corporation. However, from 2010 onwards, the data was obtained from the Malta Resources Authority, which is compiling the oil balance reports and reporting them to the National Statistics Office. The methodological approach described in sub-section 3.2.5.2 and in Annex 3, has also been applied to this emission source given that emissions from this sector are related to the total volume of gasoline distributed for consumption throughout the retail network. Thus the total amount of gasoline reported within the retail sectors has been used and an emission factor of $0.022 Gg/10^3 m^3$ is considered. The emission factor is sourced from table 4.2.4 of Volume 2 of the 2006 IPCC Guidelines.

3.3.1.2 Uncertainties and time-series consistency

Uncertainty in the activity data and time-series consistency were greatly ameliorated as a direct result of the implementation of the methodological approach described in sub-section 3.2.5.2.

3.3.1.3 Category-specific QA/QC and verification

Not applicable.

3.3.1.4 Category-specific recalculations

Table 3-17 presents the recalculations carried out for Fugitive Emissions following a change in methodology as described in sub-section 3.2.5.2.

Table 3-17 Recalculations for Fugitive Emissions

Year	Emissions (Gg) as reported in the 2015 inventory report	Emissions (Gg) as reported in the 2016 inventory report	Percentage change in reported emissions (%)
	NMVOC	NMVOC	
1990	0.18	0.17	-2
1991	0.19	0.19	-2
1992	0.20	0.20	-1
1993	0.21	0.21	-1
1994	0.22	0.22	0
1995	0.22	0.22	-2
1996	0.23	0.23	0
1997	0.23	0.23	-1
1998	0.23	0.22	-2
1999	0.23	0.22	-1
2000	0.22	0.22	1
2001	0.21	0.21	2
2002	0.20	0.20	1
2003	0.20	0.18	-11
2004	0.20	0.20	1
2005	0.20	0.20	0
2006	0.20	0.19	-3
2007	0.21	0.20	-2
2008	0.21	0.21	0
2009	0.22	0.22	-1
2010	0.22	0.22	-2
2011	0.22	0.22	-1
2012	0.21	0.21	0
2013	0.22	0.22	0

3.3.1.5 Category-specific planned improvements

Not applicable.

3.4 CO_2 TRANSPORT AND STORAGE (CRF CATEGORY 1C)

3.4.1 CATEGORY DESCRIPTION

This category does not occur in Malta.

3.4.2 METHODOLOGICAL ISSUES

Not applicable.

3.4.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Not applicable.

3.4.4 CATEGORY-SPECIFIC QA/QC AND VERIFICATION

Not applicable.

3.4.5 CATEGORY-SPECIFIC RECALCULATIONS

Not applicable.

3.4.6 CATEGORY-SPECIFIC PLANNED IMPROVEMENTS

Not applicable.

Chapter 4. INDUSTRIAL PROCESSES AND OTHER PRODUCT USE (CRF SECTOR 2)

4.1 OVERVIEW OF SECTOR

Following the implementation of the 2006 IPCC Guidelines (IPCC, 2006) the sector previously known as '*Solvent and Other Product Use*' has been merged with the sector previously named '*Industrial Processes*', giving rise to the current '*Industrial Processes and Product Use*' sector (IPPU). This merger was based on the fact that for most sub-sector importation and production, data needed is common to both sectors.

Emissions within this sector comprise direct and indirect greenhouse gas emissions arising from various industrial activities. In Malta the most relevant sub-sectors comprise the use of fluorinated fluids. When assessing contributions by gas within this sector, in terms of carbon dioxide equivalent, the fluorinated gases contribute to almost 100% of the direct GHG emissions in this sector, especially due to their high global warming potentials. Figure 4-1 shows direct GHG emissions in this sector increasing continuously over the whole time series. Emissions of other GHGs in this sector are relatively marginal. A preliminary analysis of the industrial sectors in Malta shows the relative low presence of industrial production of significant GHG source. In the current situation the vast part of emissions arise from use of products (especially refrigerants and other F-gases) rather than from production processes. In reality a good number of production sub-sectors are considered not operational.

The emissions contribution from the industrial processes sector to the total national GHG emissions in Malta amounted to 7.95% in 2014.

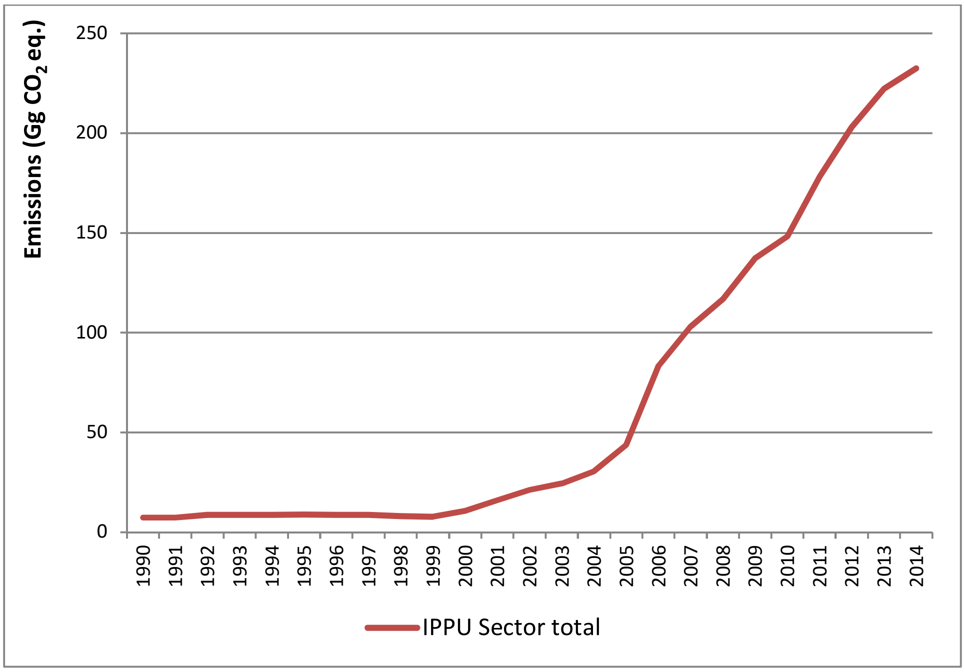

Figure 4-1 Direct GHG emissions for sector Industrial Processes and Product Use

Figure 4-2 illustrates trends in the indirect greenhouse gas emissions of NMVOC resulting from the sub-categories Road Paving with Asphalt (2A6) and Food and Drink (2D2). The relatively high NMVOC emissions for the years 1995 to 1998, when compared to the other years in the time series can be explained by the fact that there was a relatively high bread production in these years, as recorded by the National Statistics Office, leading to higher NMVOC emissions for those years.

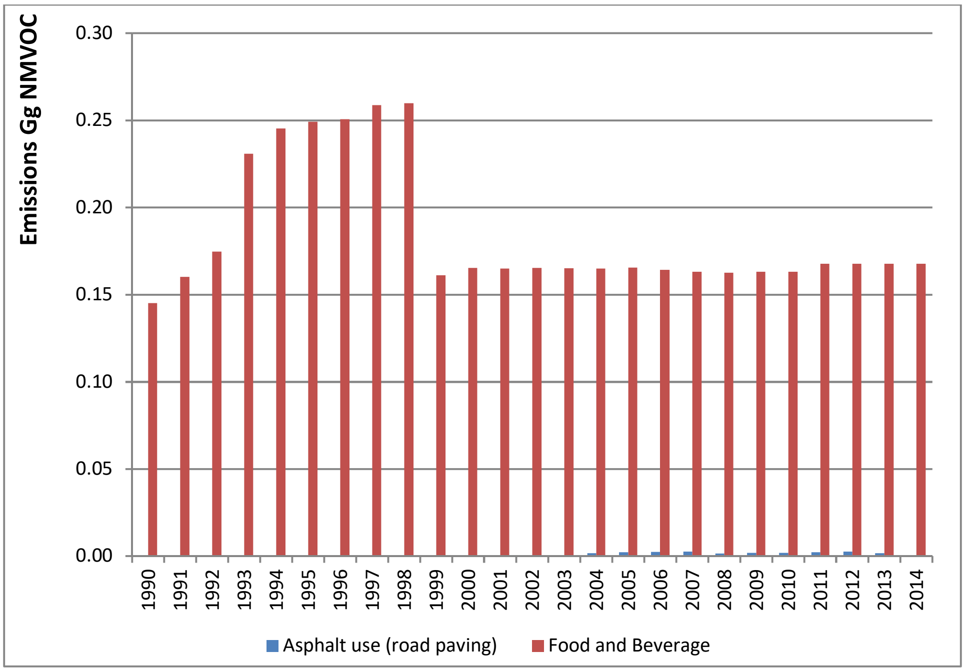

Figure 4-2 Indirect GHG emissions for sector Industrial Processes and Product Use

4.2 MINERAL PRODUCTS (CRF CATEGORY 2A)

4.2.1 MINERAL PRODUCTS - CEMENT PRODUCTION (2A1)

4.2.1.1 Category Description

This sector does not occur in Malta.

4.2.1.2 Methodological Issues

Not applicable.

4.2.1.3 Uncertainties and time-series consistency

Not applicable.

4.2.1.4 Category-specific QA/QC and verification

Not applicable.

4.2.1.5 Category-specific recalculations
Not applicable.

4.2.1.6 Category-specific planned improvements
Not applicable.

4.2.2 Mineral Products - Lime Production (2A2)

4.2.2.1 Category Description
Lime production (Quick Lime) was commonplace in Malta in the past. The lime produced was of the high calcium type. In more recent years, lime production activities no longer take place and any lime used in Malta is imported. Where applicable, activity data (quantity of lime produced) used for the estimation of emissions from this source category was compiled by Gauci (Gauci, 2000) from data provided by the then National Office of Statistics (now the National Statistics Office).

Emissions have been reported for the years 1990 till 1994, but since at the time two lime production plants were operational, the quantities of lime produced were not possible to obtain from the operators due to confidentiality rules and perceived market sensitivity data. Hence emissions for these years have been projected backwards from data available at a later stage. CO_2 emissions from this activity during the period 1995-1998 have also been reported.

4.2.2.2 Methodological Issues
The 2006 IPCC Guidelines provide two default emission factors. The Lime produced in Malta can be classified as high Calcium lime, thus an emission factor of 0.75 ton CO_2 per ton lime produced is used.

Production data for the period 1990-1994 was obtained by back extrapolation of actual production figures reported between 1995 and 1997.

4.2.2.3 Category-specific QA/QC and verification
Not applicable.

4.2.2.4 Source Specific Recalculations
No recalculations were required.

4.2.2.5 Uncertainty and time series consistency
The main issue with time series consistency in this sector has been described in the Category Description. Uncertainty is estimated at 8% for activity data and 2% for the emission factor.

4.2.2.6 Category Specific planned improvements
No planned improvements in this specific category.

4.2.3 Mineral Products - Glass production (2A3)

4.2.3.1 Category Description

This sector does not occur in Malta.

4.2.3.2 Methodological Issues

Not applicable.

4.2.3.3 Uncertainties and time-series consistency

Not applicable.

4.2.3.4 Category-specific QA/QC and verification

Not applicable.

4.2.3.5 Category-specific recalculations

Not applicable.

4.2.3.6 Category-specific planned improvements

Not applicable.

4.2.4 Mineral Products - Other uses of Carbonates (2A4)

4.2.4.1 Category Description

The use of Soda ash (sodium carbonate) as a raw material was identified in a large number of industries but more commonly in soap and detergent manufacture and for water treatment. Soda ash is neither mined nor produced in Malta but imported. Part of the import is used in acid neutralisation (desulphurisation) in power plants and waste incinerators. These emissions are accounted for under the specific sectors.

4.2.4.2 Methodological Issues

Data on mass of soda ash imports by year for the whole time series were obtained from the National Statistics Office. On heating, Na_2CO_3 dissociates releasing one mole of CO_2 per mole of Na_2CO_3 heated. Via a simple stoichiometric calculation the emission factor is determined as 415kg CO_2 emitted per tonne Na_2CO_3 used.

4.2.4.3 Category-specific QA/QC and verification

Not applicable.

4.2.4.4 Source Specific Recalculations

Due to an update in activity data for the year 2013 the emissions from this sector required a recalculation. Table 4-1 below illustrates the change:

Table 4-1 Recalculations for category Other uses of Carbonates

Year	Emissions (Gg CO2 eq.) as reported in the 2015 inventory report	Total Emissions (Gg CO2 eq.) as reported in the 2016 inventory report	Percentage change in reported emissions (%)
1990	0.182	0.182	0.00
1991	0.247	0.247	0.00
1992	0.020	0.020	0.00
1993	0.026	0.026	0.00
1994	0.301	0.301	0.00
1995	0.193	0.193	0.00
1996	0.206	0.206	0.00
1997	0.287	0.287	0.00
1998	0.322	0.322	0.00
1999	0.275	0.275	0.00
2000	0.213	0.213	0.00
2001	0.201	0.201	0.00
2002	0.198	0.198	0.00
2003	0.129	0.129	0.00
2004	0.182	0.182	0.00
2005	0.057	0.057	0.00
2006	0.179	0.179	0.00
2007	0.067	0.067	0.00
2008	0.046	0.046	0.00
2009	0.056	0.056	0.00
2010	0.053	0.053	0.00
2011	0.029	0.029	0.00
2012	0.079	0.079	0.00
2013	0.079	0.059	-25.78

4.2.4.5 Uncertainty and time series consistency

Activity data uncertainty is relatively low since imported carbonates mass is well documented in trade statistics, thus an uncertainty of 2% is assumed. On the contrary, the emission factor has a relatively high uncertainty due to the fact that the fate of carbonates not destined to desulphurisation is unknown; thus the assumption that all the carbonates imported are used in processes that release CO_2 may not be accurate. This is why a higher value of the emission factor uncertainty range (5%) is applied for this.

4.2.4.6 Category Specific planned improvements

No improvements are planned for this category.

4.3 CHEMICAL INDUSTRY (CRF CATEGORY 2B)

4.3.1 CATEGORY DESCRIPTION

The category 2B covers a wide variety of chemical production sub-categories for which, however, Malta does not have any activity. The category is thus considered as not occurring in Malta. In cases of chemical industry subsectors, where a chemical (e.g. urea) is imported for use in other sectors, the emissions from such use are included in the respective sector's estimations.

4.3.2 METHODOLOGICAL ISSUES

Not applicable.

4.3.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Not applicable.

4.3.4 CATEGORY-SPECIFIC QA/QC AND VERIFICATION

Not applicable.

4.3.5 CATEGORY-SPECIFIC RECALCULATIONS

Not applicable.

4.3.6 CATEGORY-SPECIFIC PLANNED IMPROVEMENTS

Not applicable.

4.4 METAL INDUSTRY (CRF CATEGORY 2C)

4.4.1 CATEGORY DESCRIPTION

The category 2C covers a wide variety of metal and alloy production activities, none of which, however, occurs in Malta. The category is thus considered as not occurring in Malta.

4.4.2 METHODOLOGICAL ISSUES

Not applicable.

4.4.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Not applicable.

4.4.4 Category-specific QA/QC and verification

Not applicable.

4.4.5 Category-specific recalculations

Not applicable.

4.4.6 Category-specific planned improvements

Not applicable.

4.5 NON-ENERGY PRODUCTS FROM FUEL AND SOLVENT USE (CRF CATEGORY 2D)

4.5.1 Non-Energy Products from Fuel and Solvent Use - Lubricant Use (2D1)

4.5.1.1 Category Description

Lubricants can be generally subdivided into two major groups by their physical characteristics, liquid oils (motor and industrial oils) and more viscous greases. The main function of lubricants is to minimise friction between moving surfaces; as lubricants are exposed to relatively high temperatures, oxidisation occurs which results in certain GHG emissions. This oxidisation is not considered as an energy use and thus the emissions from these lubricants are reported in this sector. Emissions from Lube oil used in 2-stroke engines are not included in the estimate.

4.5.1.2 Methodological issues

Due to unavailability of segregated data on lubricant use, total importation data is used to calculate emissions from use. The assumption is that lubricants imported in year x are used in the same year and emissions are attributed in whole to the same year. This data could only be readily available for the years 2004 onwards, thus a gap-filling exercise was carried out to estimate activity in the sector prior to 2004. This was done by back extrapolation of net emissions from the sector. Extrapolation of emissions was preferred to extrapolation of importation data. Since default emissions factors are being used in the present calculation, back extrapolation of activity data was considered to be unnecessary.

The calculation used is based on a tier 1 approach as specified in the 2006 IPCC Guidelines. The mass of lubricant imports is converted into energy equivalent assuming 0.0402 TJ/ton of lubricant as specified in the IPCC 2006 Guidelines Volume 2 (Energy). Default values for the parameters Oxidised During Use (ODU) and carbon content are used to calculate the relative emission factor.

4.5.1.3 Category-specific QA/QC and verification

Not applicable.

4.5.1.4 Source Specific Recalculations

No recalculations were required.

4.5.1.5 Uncertainty and time series consistency

The consistency of the time series is ensured by the back extrapolation exercise carried out, which based on expert judgement provides a conservative estimate since the growth in GDP over the years back extrapolated was far higher than the rate of increase which resulted.

To date lubricants and waxes are not included in the national energy balance calculation, thus this introduces a further factor of uncertainty in the activity data used. An uncertainty factor of 10% is used for activity data in this sub-sector. The emission factor used is based on the tier 1 approach specified in the 2006 IPCC Guidelines which also suggests that uncertainty could be as high as 50%. In view of this the emission factor uncertainty is estimated at 50%.

4.5.1.6 Category Specific planned improvements

Following the inclusion of this sector and identification of a data source, an additional data source or proxy is currently being identified to be used as a proxy. Moreover, there is currently no mention of this category in the country's energy balance, which also needs to be examined.

4.5.2 Non-Energy Products from Fuel and Solvent Use - Paraffin Wax use (2D2)

4.5.2.1 Category Description

Paraffin is a product of crude oil fractioning, and is commonly used in the production of candles, surfactants, paper coatings and polish. In Malta, since no petroleum refining occurs, all paraffin is imported, possibly transformed and largely used locally. The main source of emission from paraffin comes from its combustion in the form of candles, tapers etc. This is particularly relevant in the Maltese context due to the use of candles in religious and other popular practices. Most other uses do not emit GHGs.

4.5.2.2 Methodological issues

Activity data for this sector is obtained from importation data collected by the National Statistics Office. Data for mass of imported material is reported under specific CN codes specific to the nature of the product being imported. For paraffin wax codes 3406 0000 and 2712 20(00-99) are included[18]. This data could only be readily available for the years 2004 onwards, thus a gap-filling exercise was carried out to estimate activity in the sector prior to 2004. This was done through the back extrapolation of net emissions from the sector. Extrapolation of emissions was preferred to extrapolation of importation data. Since default emission factors are being used in the present calculation, the back extrapolation of activity data was considered to be unnecessary.

The activity data noted above is elaborated using the Tier 1 methodology and emission factors specified in the 2006 IPCC Guidelines. Default ODU and carbon content values are used to calculate emission factors for this sector. The net emission factor used is 14.6667tCO_2/TJ paraffin imported.

4.5.2.3 Category-specific QA/QC and verification

Not applicable.

[18] IntraStat Combined Nomenclature 2013

4.5.2.4 Source Specific Recalculations

No recalculations were required.

4.5.2.5 Uncertainty and time series consistency

The consistency of the time series is ensured by the back extrapolation exercise carried out, which on the basis of expert judgement provides a conservative estimate.

To date waxes and wanes are not included in the national energy balance calculation, thus this introduces a further factor of uncertainty in the activity data used. An uncertainty factor of 10% is used for activity data in this sub-sector. The emission factor used is based on the tier 1 approach specified in the 2006 IPCC Guidelines which also suggests that uncertainty could be as high as 50%. In view of this the emission factor uncertainty is estimated at 50%.

4.5.2.6 Category Specific planned improvements

Following the inclusion of this sector and identification of a data source, an additional data source or proxy is currently being identified to be used as a proxy. Moreover, there is currently no mention of this category in the country's energy balance, which also needs to be examined.

4.5.3 Non-Energy Products from Fuel and Solvent Use - Solvent use (2D3)

4.5.3.1 Category Description

Estimated non-methane volatile organic compound emissions from the use of organic solvents and solvent-containing products are reported under this category. Solvents and related compounds include chemical cleaning substances used in dry cleaning, printing activities, metal degreasing and a variety of other industrial applications as well as household uses. All of these activities and applications make use of chemicals that contain significant amounts of NMVOCs. Emissions are produced through evaporation of the volatile chemicals when these products are exposed to air. There is a gradual increase in NMVOCs emissions over the inventory time series.

4.5.3.2 Methodological issues

The EMEP/EEA (2013) Guidebook provides two methodologies that can be used to estimate NMVOC emissions:

- Estimating the amount of (pure) solvents consumed;
- Estimating the amount of solvent containing products consumed (taking account of their solvent content).

The first method based on a mass balance per solvent is being used in this inventory process, where the sum of all solvent mass balances equals the NMVOC emission due to solvent use. The following equation was assumed for each inventory year in Malta:

Solvent Import Quantities = Solvent Consumption Quantities = NMVOC Emissions

The list of volatile chemical compounds has been used as a reference list for volatile chemicals that may be imported annually in Malta. This list of chemicals was then double-checked with the National Statistics

Office. The yearly Solvent Import quantities were provided by the International Trade Unit within the National Statistics Office.

4.5.3.3 Category-specific QA/QC and verification

Not applicable.

4.5.3.4 Source Specific Recalculations

No recalculations were required.

4.5.3.5 Uncertainty and time series consistency

In terms of time series consistency, importation data provides time consistency but due to the variety of products falling under the different codes and the relatively different behaviour of each, the level of uncertainty is rather high.

4.5.3.6 Category Specific planned improvements

No planned improvements in this specific category.

4.5.4 Non-Energy Products from Fuel and Solvent Use - Other (2D4)

4.5.4.1 Road Paving with Asphalt

4.5.4.1.1 Category Description

Asphalt road surfacing is composed of compacted aggregate and an asphalt binder. In this inventory submission, CO_2 and NMVOC emissions from both the production phase and the application phase of asphalt to road surfaces have been reported.

For the years 1995 to 2003, the quantity of asphalt used was derived from data of asphalt imports. This data was compiled under the 1st inventory estimation carried under the scope of the First National Communication (Gauci, 2000). Relevant data for the years prior to 1995 was not available however. For the years 2004 and onwards, the activity data has been provided by Transport Malta.

4.5.4.1.2 Methodological Issues

Emissions of NMVOC for road surface (16g NMVOC per Mg asphalt produced and applied to the road surface) is used. In this inventory submission, the emission factor for both the production phase and the application phase of the asphalt to road surfaces, were applied to the Maltese activity data. The emission factor was obtained from EMEP/CORINAIR 2013 emission inventory guidebook. Malta is additionally reporting an estimate of CO_2 emissions, using the methodology provided in the 2009 Portuguese GHG Inventory Report. The Portuguese asphalt methodology assumes that solvents in asphalt products are 100% composed of NMVOC. The emitted NMVOC from the asphalt processes have on average 85% carbon content, which is the normal carbon content for medium linear simple hydrocarbons. Through multiplication, one can therefore estimate the resulting CO_2 emissions:

$$\text{Emissions (Gg } CO_2) = \text{Emissions (Gg NMVOC)} * 0.85 * (44/12)$$

It is also essential to note that even though the 2006 IPCC Guidelines specify that significant emissions of CO can occur from this activity, no adequate emission factor was identified, thus no CO emissions are estimated for this activity.

4.5.4.1.3 Category-specific QA/QC and verification

Not applicable.

4.5.4.1.4 Source Specific Recalculations

No recalculations were required. Nonetheless, due to mistakenly being excluded from the previous CFR submission, a recalculation in table 8 of the CRF is shown for this subsector.

4.5.4.1.5 Uncertainty and time series consistency

The data collected covers all public road works carried out in the geographical scope of the inventory, though private asphalt use is not included in the estimate. It is assumed that this use is limited and accounts for a marginal part of this sub-sector. Uncertainty of activity data is considered to be of 10% in line with the 2006 IPCC Guidelines, whereas EF uncertainty is assumed at 100%. This high emission factor does not affect significantly the overall uncertainty of the inventory due to the small extent of the emissions in this sub-sector.

4.5.4.1.6 Category Specific planned improvements

Not applicable.

4.6 ELECTRONICS INDUSTRY (CRF CATEGORY 2E)

4.6.1 Category Description

Advanced electronics production technologies use fluorinated compounds due to their chemical and physical characteristics. The industry makes use of both gaseous forms and liquid forms of fluorinated compounds.

The local electronics industry is relatively limited in scope, most of the processes that have been identified as emissive are not carried out locally. Local manufacturing of electronics as defined in the 2006 IPCC Guidelines generally does not occur in Malta. There is only one production plant, which falls within the scope of this sector, in the semi-conductor manufacturing sub-sector. This plant though performs only the final stages of semiconductor manufacture. It reported the use of HFC 23 and HFE 499sl as cleaning agents.

4.6.2 Methodological issues

Due to the very limited use of gases in this sector and the fact that there is only one plant in which such activities occur, activity data was directly obtained from the plant operator. The operator in question (a multinational electronics firm) compiles a GHG inventory compliant to ISO 14064. Consumption (activity) data has been extracted from this inventory. Due to the nature of the process an EF of 1 is used, thus assuming that all fluid consumed is actually emitted.

This methodology differs from what is outlined in the IPCC 2006 Guidelines. The Guidelines' Tier 2 method requires specific plant data to calculate consumption; however this data is not available. Since it is not obligatory to report HFE499sl, this is not included in the CRF submission.

4.6.3 Category-specific QA/QC and verification

The data provider for this sector provides ISO 14064 verified inventories for calculation of emissions in this sector. The verification process is considered sufficient QC for the data submitted.

4.6.4 Source Specific Recalculations

No recalculations were required.

4.6.5 Uncertainty and time series consistency

The availability of verified data in this sector, through ISO 14064 inventories, makes the uncertainty of activity data rather low, and assumed to be 2%. Since the data submitted is actual consumption data and considering the type of process, the emission factor uncertainty is also low.

4.6.6 Category Specific planned improvements

No planned improvements in this specific category.

4.7 PRODUCT USES AS OZONE DEPLETING SUBSTANCES (ODS) SUBSTITUTES (CRF CATEGORY 2F)

Current areas of application for the products in subject include refrigeration and air conditioning equipment, foam blowing applications, fire extinguishers and metered-dose inhalers. Figure 4-3 presents a pictorial overview of emissions of these gases from various applications over the whole time series covered by this report.

For recent inventory submissions, an effort was made to improve the reporting of emissions from the consumption of halocarbons and sulphur hexafluoride. A data gathering exercise was carried out in 2011/2012, in addition to another survey done in 2009 where importation and consumption quantities of fluorinated gases for the most recent years was collected. Information on the processes taking place locally, as well as details on the gases being used was also gathered. More detailed information on the outcome of this improvement process is presented in the following source category discussions.

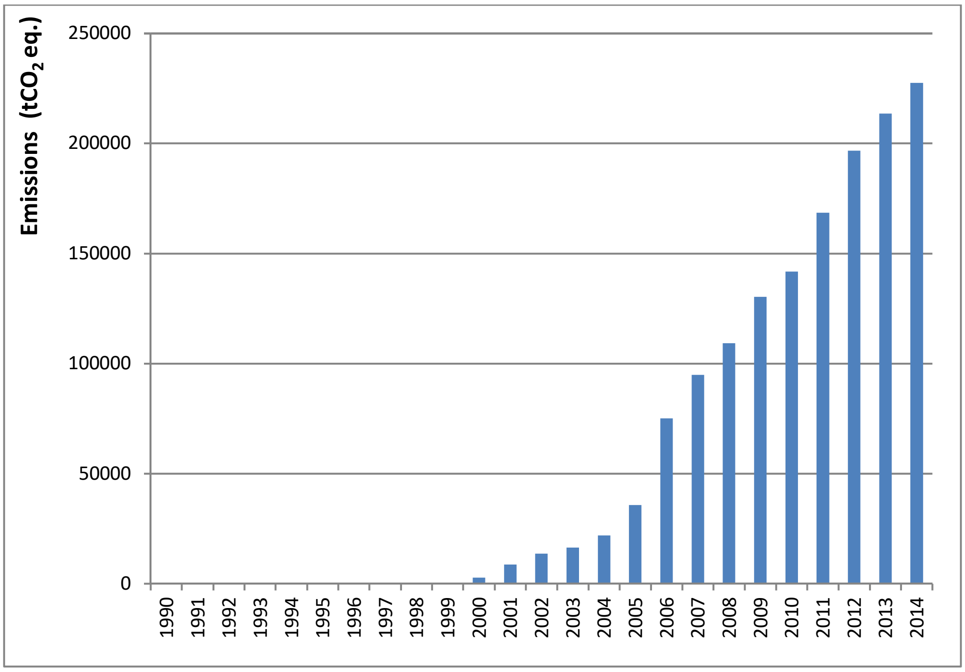

Figure 4-3 Actual emissions from category Refrigeration and Air-Conditioning

4.7.1 Product Uses as ODS Substitutes - Refrigeration and Air-conditioning (2F1)

4.7.1.1 Stationary refrigeration

4.7.1.1.1 Category Description

As in most European countries, the local market for domestic refrigeration appliances has reached saturation since many years (Abela 2012). It is estimated that about 182,000 appliances exist in ca. 139,000 households in Malta. Based on a replacement rate of 6% of the existing stock, about 11,000 domestic refrigeration and freezing equipment units are imported annually. An emission factor approach is used for emission estimates from the domestic refrigeration sub-category.

Imports of appliances containing R134a are estimated to have started in 1994 (as in most European countries) and increased gradually for some years. Previously all units were running on R12 which is an ozone depleting substance and has been subject to substitution by R134a. It is estimated that new units containing R12 were no longer imported from 2001 onwards.

Most Central European manufacturers of domestic appliances had converted their production lines to hydrocarbons (R600a) by the late 1990s, and manufacturers in Southern Europe have been following since. Therefore, it is assumed that imports containing hydrocarbons as refrigerants started in 2000 at a low rate of 10% and have increased from then onwards to a stable rate of 90% since 2008.

Commercial refrigeration today accounts for large parts of the F-gas demand, with R404A being one of the main refrigerants imported to Malta. This refrigerant blend is mainly used in supermarket installations (centralised systems) but also other types of small commercial refrigeration equipment. Commercial refrigeration systems are very diverse as they are usually customised to meet specific requirements (e.g. concerning the temperature ranges for different products) and built on site. The same applies to industrial refrigeration equipment which includes a large range of equipment types to cater for the needs of various industries. As no equipment register or statistical information on commercial and industrial refrigeration systems are available in Malta, the approach chosen for emission estimates relies on import data of HFC bulk substances which are partly used for first fill and refill of commercial and industrial refrigeration systems.

While in other European countries alternative commercial refrigeration technologies relying on natural refrigerants such as CO_2 as a refrigerant and hydrocarbons are gradually being introduced to the market, this development has not started in Malta yet.

4.7.1.1.2 Methodological issues

For domestic refrigeration the average charge size of 0.2 kg indicated by Abela (2012) is used as well as an estimated average lifetime of 15 years (CasaInginiera, 2012). No detailed information on the disposal of domestic appliances is available. CasaInginiera (2012) assumes that no recovery procedures are in place for scrapped equipment which, however, has not been confirmed by the national authorities. A disposal emission rate of 90% is assumed (recovery < 10%).

For commercial refrigeration the method chosen is a top-down approach: imported quantities of different refrigerants as reported by gas suppliers are used as the starting point for estimates. Refrigerants fully attributed to the commercial refrigeration subcategory (including transport refrigeration and industrial refrigeration) are R404A, R417A, R422A, R422D and R507A.

The situation is different for R134a, which is mainly used in mobile air conditioning devices but also to some extent in stationary (and transport) refrigeration applications. Thus, quantities used in the mobile air conditioning subcategory are calculated first (see relevant subcategory) and the remaining quantities are attributed to the commercial refrigeration subcategory.

The quantities of the refrigerants attributed to the commercial refrigeration sub-category imported annually are used both for first fill of new equipment and refill of existing equipment.

The amounts of refrigerants (mainly R134a, some R404A) needed annually for servicing of mobile air conditioning and transport refrigeration are deducted from the total imports of R134a and R404A. It is assumed that due to the relatively high temperatures in Malta mobile air conditioning and mobile refrigeration systems are being serviced regularly and that emitted refrigerants are refilled without major delay. Hence the calculated emissions for mobile AC and mobile refrigeration equal the quantities refilled in the same year.

The remaining refrigerant quantities of R134a, R404A, R417A, R422A, R422D and R507A, are attributed to the commercial refrigeration sub-category (including industrial refrigeration).

The chosen methodology for estimation of emissions in this sub-sector is similar to the one used for domestic refrigeration with a sub-sector specific emission factor of 10% from current year and banked gases used. The 20% includes both operation and disposal emissions in the sector, in view of the fact that disposal emissions for such larger systems are usually small due to recollection of gas.

4.7.1.1.3 Category-specific QA/QC and verification

Not applicable.

4.7.1.1.4 Source Specific Recalculations

Recalculations under this subsector will be described at the end of section 4.7.1.6.

4.7.1.2 Stationary Air-conditioning

4.7.1.2.1 Category Description

The Maltese stationary air conditioning market cannot yet be considered a mature market (CasaInginiera, 2012) but it is growing steadily.

The equipment types used include room air conditioners mainly imported from Asia, and chillers, mainly imported from Southern and Western Europe. Manufacturing emissions hardly occur but emissions during topping-up (mostly of pre-charged equipment) on installation do occur. These emissions are accounted for within lifetime emissions.

According to Maltese industry experts, the refrigerants R407C and R410A are the only HFC-refrigerants used in stationary air conditioning systems apart from R22 in older systems. The latter however is an Ozone Depleting Substance (ODS) and thus not subject to emission reporting. Hence the quantities of R407C and R410A imported for servicing are fully attributed to the stationary air conditioning category. These refrigerants entered the Maltese market only after its accession to the EU in 2005, given that R22 was used previously. Thus, HFC emissions from this sub-category started occurring only from 2005 onwards.

4.7.1.2.2 Methodological issues

For stationary air-conditioning systems a Tier 2 methodology has been preferred mainly due to the general dissemination of equipment across all sectors including domestic and commercial, mainly composed of smaller equipment.

The method chosen is a top-down approach: Imported quantities of different refrigerants as reported by gas suppliers are used as the starting point for estimates. Refrigerants fully attributed to the stationary air conditioning subcategory are R407C, R410A, R427A and R428A.

The quantities of the refrigerants attributed to the stationary air conditioning sub-category imported annually are used both for first fill of new equipment and refill of existing equipment.

Just as for commercial refrigeration, a bank of gases is built up through yearly imports of gases assigned to this sub-sector. An EF of 7% annual loss from the bank has been assigned to this sector which includes installation operation and disposal emissions.

4.7.1.2.3 Category-specific QA/QC and verification

Not applicable.

4.7.1.2.4 Source Specific Recalculations

Recalculations under this subsector will be described at the end of section 4.7.1.6.

4.7.1.3 Transport Refrigeration

4.7.1.3.1 Category Description

Transport refrigeration comprises vehicle and self-powered refrigeration units used in commercial vehicles. The biggest source within transport refrigeration is the local movement of perishable (frozen or refrigerated) goods in Malta. This includes transport from port or producer to distributor and from distributor to commercial premises. The sector also includes emissions from the use of refrigerated trailers. Contrary to air-conditioning systems, it is estimated that the dominant refrigerant used in the transport refrigeration sector is R-404A and not R-134a.

4.7.1.3.2 Methodological issues

Emission estimates for transport refrigeration are also based on an emission factor approach. A European study (RPA, 2005; p.12) estimated that there were 1,000 refrigerated vans, 600 refrigerated trucks and 300 refrigerated trailers in Malta in 2004. On the basis of information provided by the local transport authority, the total net number of refrigerated vans and trucks is assumed to have not varied between 2000 and 2012. It is therefore valid to use the same total of 1,900 refrigerated vans, trucks and trailers for the time series. Since most vehicles are imported from the UK, the same average charge of 3.9 kg for mobile refrigeration is used as reported in the UK NIR (2013).

Both R404A and R134a are used in transport refrigeration today and the split of the two refrigerants can be assumed to be 90% of R404A and 10% of R134a (expert estimate[19]). However, it is also assumed that R134a was the only refrigerant used in transport refrigeration in the period 2000-2004. R404A units were introduced in 2004 and emissions in that year only arose from the newly imported units. Refill of these units is assumed to have taken place in 2005 when imports of bulk quantities of R404A were first reported. The current number of refrigerated vans, trucks and trailers is not available from vehicle registration data or model reported.

Manufacturing emissions do not occur in Malta since no vehicle production takes place. A rate of 15% for operation emissions is used based on the fact that mainly short-distance transportation is carried out and the assumption that servicing and repair take place regularly. However, a European study (Schwarz et al. 2011) suggests higher emission rates of up to 25%.

Disposal emissions will only take place from 2016 onwards due to the introduction of HFC-refrigerants in 2001 and their estimated lifetime of 16 years.

4.7.1.3.3 Category-specific QA/QC and verification

Not applicable.

4.7.1.3.4 Source Specific Recalculations

Recalculations under this subsector will be described at the end of section 4.7.1.6.

[19] Stakeholder consultation: Sébastien Lemoine, company “Carrier”, 5 November 2013.

4.7.1.4 Mobile Refrigeration

4.7.1.4.1 Category Description

Emissions from mobile air conditioning today account for large shares of F-gas emissions in all European countries. Most vehicles imported in recent years are equipped with air-conditioning. In view of the local weather patterns it is also expected that air-conditioning in vehicles is regularly maintained in running order.

4.7.1.4.2 Methodological issues

As the refrigerant R134a is the main refrigerant used in mobile air conditioning of road vehicles and vehicle registration data for passenger cars, minibuses, buses, trucks are available, it was decided that emission estimates will follow an emission-factor approach.

For emission estimates from mobile air conditioning in ships, the approach chosen relies on data of bulk imports by a ship repair company.

- **Road vehicles**

The method used for emission estimates is based on vehicle registration data for passenger cars, minibuses, buses, coaches and trucks.

Relative to the country's size, the size of the car fleet of Malta is significant, at around 250,000 licensed passenger cars in 2013 (>570 cars per 1,000 inhabitants; EU average ca. 480). However, it is assumed that a proportion of these cars are not used on a daily basis. Both new and second-hand vehicles are being imported, mainly from the UK and Japan (due to left hand driving systems as in Malta). Export of end-of-life vehicles or second hand cars is negligible.

The lifetimes of all types of vehicles in Malta are comparably high since it is a country heavily depending on imports. Local experts in the business of mobile AC servicing[20] estimated that the currently used refrigerant R134a, introduced in new cars in 2000[21], has been the only refrigerant for car air conditioning since 2005 both in new and in second hand cars.

Due to the phase-out of the ozone depleting refrigerant R12 and the accession of Malta to the EU in 2004, R12 was no longer available from then onwards.

Concerning new refrigerants, local gas suppliers contacted during the stakeholder consultation[22] confirmed that no imports of HFC-1234yf have taken place so far since no vehicles with AC systems running on this new refrigerant have been imported.

A time series of the vehicle fleet in Malta (passenger cars, vans, trucks, buses) and an estimated number of air-conditioned vehicles has been used for emission estimates.

The percentage of air-conditioned vehicles of 54% in 2012 is the same as in a model by Emisia[23] on the vehicle fleet used also for other categories of the Maltese greenhouse gas inventory. The current AC quota of new cars is assumed to be about 90%. There is no data on the number of new cars available therefore

[20] References: Companies "V.Spiteri", "Tecnoplus".
[21] This finding is somewhat contradictory to the situation in most other European countries as the European carmakers were not producing cars with air conditioning systems containing R12 from 1995 onwards. However, second hand cars running on R-12 might have been imported well beyond 2000.
[22] Reference: John Catania, Multigas.
[23] EMISIA SA. Antoni Tritsi 21, GR 57 001, Thessaloniki, Greece.

it is calculated as the stock divided by the average lifetime plus the increase in stock compared to the year before. It is calculated that the AC quota of new cars in the year 2000 was about 50%, which is rather low compared to other European markets (e.g. Germany: 90% in 2000).

Lifetime: 16 years for all types of road vehicles (cars, trucks and buses) which range at the upper end of the span of 9 to 16 years provided in the 2006 IPCC Guidelines (table 7.9, p. 7.52).

As for passenger cars, the average charge is estimated to be 0.8 kg, which is also the default value given in the IPCC Good Practice Guidelines and well within the range of 0.5 to 1.5 kg provided by the 2006 IPCC Guidelines. The value is somewhat higher than in other European countries but takes into account the relatively long average lifetime of vehicles in Malta. As for buses and coaches, the average charge is 12 kg and for mobile air conditioning in trucks, a charge of 0.9 kg is assumed.

- **Ships**

Two ship repair facilities exist in Malta: Palumbo Ship Repair (since 2010; formerly Malta Shipyards/ Dry-docks) and Cassar Ship Repair. In addition, Palumbo Malta Superyachts Ltd is a major local provider of general servicing and refitting services for yachts.

During the stakeholder consultation, it was found that additional quantities of refrigerants had been imported by one of the ship repair companies (Palumbo Ship Repair). These quantities are used for the refill of refrigeration and air conditioning systems of yachts and small Maltese ships and not sold on the Maltese market.

The other ship repair company (Cassar Ship Repair) usually sub-contracts repair work of air conditioning and refrigeration systems of ships to Maltese service companies. Refrigerant quantities used are hence accounted for within the commercial refrigeration or stationary air conditioning sub-category of 2F1 and cannot be separated.

Large sea-going ships that are registered under Malta's flag, but are operated by foreign owners, and coming to Maltese ports, usually bring along their own refrigerant supplies which is mostly not purchased in Malta due to comparably high prices. Thus the ship's own refrigerant supply is used for servicing and repair needs. Emissions from ships which occur in areas beyond national jurisdiction are not accounted for in the national inventory.

Imports of bulk HFC quantities by one ship repair company amount to 120 kg of R410A (50% HFC-32; 50% HFC-125) and 80 kg of R134a annually since 2010. These quantities account for emissions from certain air conditioning systems on small national ships operating in Maltese waters and thus equal operation emissions from these ships in the respective years.

Before 2010, the ship repair facility was state-owned (Malta Shipyards/Drydocks) and substantially larger. No information on the historic time series before 2010 is available. However, based on the information for bulk imports reported by companies and expert input, it is estimated that the same level of F-gas emissions occurred since 2005 (first year of import of R410A). Prior to 2005, only R22 was used in refrigeration and air conditioning systems on ships.

4.7.1.4.3 Category-specific QA/QC and verification

Not applicable.

4.7.1.4.4 Source Specific Recalculations

Recalculations under this sub-sector will be described at the end of section 4.7.1.6.

4.7.1.5 Category-specific QA/QC and verification

Not applicable.

4.7.1.6 Source Specific Recalculations

Following a major methodological shift in the previous submission, some further fine tuning of the methodology was carried out in this submission. The recalculation affected only the stationary domestic refrigeration sector.

Table 4-2 Recalculations for category Refrigeration and Air-Conditioning

Year	Emissions (Gg CO_2 eq.) as reported in the 2015 inventory report	Total Emissions (Gg CO_2 eq.) as reported in the 2016 inventory report	Percentage change in reported emissions (%)
1990	NO	NO	NA
1991	NO	NO	NA
1992	NO	NO	NA
1993	NO	NO	NA
1994	0.001	0.001	0.00
1995	0.002	0.002	-0.15
1996	0.003	0.003	-0.30
1997	0.005	0.005	-0.36
1998	0.008	0.008	-0.41
1999	0.011	0.011	-0.47
2000	2.065	2.065	0.00
2001	8.011	8.011	0.00
2002	12.954	12.953	0.00
2003	15.621	15.621	0.00
2004	20.549	20.548	0.00
2005	35.230	35.229	0.00
2006	72.708	72.707	0.00
2007	85.247	85.247	0.00
2008	101.001	101.000	0.00
2009	121.608	121.894	0.24
2010	137.714	138.000	0.21
2011	156.874	157.159	0.18
2012	192.417	192.687	0.14
2013	209.488	210.046	0.27

4.7.1.7 Uncertainty and time series consistency

It is implied that due to the nature of this sector, it is expected that efforts are made to reduce uncertainty of estimation to a minimum. The current methodology provides better certainty than the previously used Tier 1 methodology since it disaggregates uses of the diverse gases and provides for sub-sector specific emission factors. The relative completeness of the data collected (for bulk imports) and the characterisation of the Market through studies further reduces the uncertainty in this sector. A key source of uncertainty is still the distribution of the different gases across the sectors, since it is mostly based on a one-time study and not an annual recurrent exercise.

EF uncertainty originates mainly from the use of emission factors that are either default emission factors or based on general Europe-wide data, which may not completely represent the Maltese situation. However, it is still considered as good practice to use such emission factors in the absence of Country specific emission factors.

4.7.1.8 Category Specific planned improvements

No planned improvements in this specific category.

4.7.2 PRODUCT USES AS ODS SUBSTITUTES - FOAM BLOWING AGENTS (2F2)

4.7.2.1 Category Description

HFCs are commonly being used in the foam blowing industry, mainly as replacements for CFCs and HCFCs. The distinction in types of foam between open-cell and closed-cell relates to the way in which the blowing agent is lost from the product. For open-cell foam, emissions of fluorinated gases used as blowing agents are likely to occur during the manufacturing process and shortly thereafter. Open-celled foams are used for applications such as household furniture cushioning, mattresses and moulded products.

In closed-cell foam, only minimum emissions occur during the manufacturing phase. Emissions therefore extend into the in-use phase, with often the majority of emissions not occurring until end-of-life. Closed-cell foams are primarily used for insulating applications where the gaseous thermal conductivity of the chosen blowing agent is used to contribute to the insulating performance of the product throughout its lifetime.

In the present inventory compilation, local businesses involved in foam preparation and use were identified. The types of fluorinated gases used and the applications carried out were noted. Emissions for HFC-227ea and HFC 365mfc, which is typically used as a flame retardant in the foam applications, have been reported. In 2010 no emissions were reported thus this sector is reported as NO.

4.7.2.2 Methodological issues

Estimating emissions for the two different types of foam requires a different methodological approach. Activity data for this category was collected by contacting all foam sector businesses registered with the Malta Resources Authority, a list is of which is available at http://www.mra.org.mt, as part of a government-run rebate scheme for the promotion of insulation in households. The rate of response was rather limited; however, it is assumed that the vast majority of the local foam blowing market is covered by the data actually gathered.

Closed-cell foams, due to their characteristics, cannot be accounted for using a simple methodology similar to the one used for open-cell foams. Thus, a Gamlen-based model for estimating emissions started being used in recent years for inventory purposes for the activities: blown foam and imported foam. The method is based on the mass of foam blown in a year and assumes that 1% of the mass of the foam is in fact blowing agent. The model also assumes that the lifetime of the product is 15yrs and that a constant 4.5% emission of blowing agent occurs in each year of its lifetime and that the remaining 32.5% of blowing agent is emitted in the year of destruction.

Imported closed-cell foams are also accounted for in this submission. The method of calculation is identical to the one used for locally blown closed-cell foams but omitting first year emissions as it is assumed that this emission will mainly take place at the point of production or during transit, nevertheless before entering the geographical scope of this inventory.

4.7.2.3 Category-specific QA/QC and verification

Not applicable.

4.7.2.4 Source Specific Recalculations

Due to incomplete inclusion of all sources in the previous CRF tables and inconsistencies in previous CRF software a recalculation was due in this sector and is summarised in Table 4-3.

4.7.2.1 Uncertainty and time series consistency

The inclusion of imported foams in addition to locally blown foams improved the completeness of the current inventory compilation. As specified in the 2006 IPCC Guidelines, there is significant uncertainty in the estimations of activity and emissions in this sector. This is especially relevant to such source categories in countries where consumption is very limited.

4.7.2.2 Category Specific planned improvements

No planned improvements in this specific category.

Table 4-3 Recalculation in sector 2F2 Foam blowing

Year	Emissions (Gg CO_2 eq.) as reported in the 2015 inventory report t CO_2 eq	Total Emissions (Gg CO_2 eq.) as reported in the 2016 inventory report t CO_2 eq	Percentage change in reported emissions %
1990	NE	NE	0.00
1991	NE	NE	0.00
1992	NE	NE	0.00
1993	NE	NE	0.00
1994	NE	NE	0.00
1995	NE	NE	0.00
1996	NE	NE	0.00
1997	NE	NE	0.00
1998	NE	NE	0.00
1999	NE	NE	0.00
2000	664.046	1654.453	149.15
2001	702.767	1682.131	139.36
2002	741.762	1709.556	130.47
2003	774.813	1730.513	123.35
2004	1083.342	2536.425	134.13
2005	597.275	1130.189	89.22
2006	2382.389	1857.614	-22.03
2007	8093.109	4994.386	-38.29
2008	8211.479	4915.888	-40.13
2009	6344.756	6596.192	3.96
2010	1854.067	1820.093	-1.83
2011	8605.331	4602.168	-46.52
2012	1598.136	1638.775	2.54
2013	1194.494	2011.708	68.41
2014	NA	1648.345	N/A

4.7.3 Product Uses as ODS Substitutes - Fire Protection (2F3)

4.7.3.1 Category Description

Nowadays fire protection (fire suppression) equipment using HFCs and/or PFCs is being used as partial replacement for halons. While actual emissions from the fire protection sub-sector are expected to be quite small, the use of such gases is growing, resulting in an accumulating bank of future potential emissions.

4.7.3.2 Methodological issues
The use of HFC-227ea has been identified in such applications. Local enterprises providing fire protection services were asked to indicate the use (if any) of fluorinated gases in fire protection systems.

It has been difficult to identify all the establishments that have fire protection systems containing HFC-227ea installed on their premises. In the past, where this was possible, the annual releases of HFC-227ea during fire incidents or accidental leakages were reported by the establishments, with annual activity data since the year 2004 being provided. For the present inventory submission, the data collection focus was on firms offering fire extinguishing equipment servicing in an effort to enhance coverage of HFC-227ea use.

4.7.3.3 Category-specific QA/QC and verification
Not applicable.

4.7.3.4 Source Specific Recalculations
No recalculations were required.

4.7.3.5 Uncertainty and time series consistency
Activity data uncertainty in this sector is relatively low due to the possibility of extensive coverage of the small sector given that only two service providers carrying out such services were identified. Thus coverage was guaranteed through information gathered from both service providers.

4.7.3.6 Category Specific planned improvements
No planned improvements in this specific category.

4.7.4 Product Uses as ODS Substitutes - Aerosols and Metered Dose Inhalers (2F4)

4.7.4.1 Category Description
Most aerosol packages contain hydrocarbons as propellants albeit in a small fraction of the total content. HFCs and PFCs may be used as propellants or solvents. Through the use of aerosol products, 100% of the propellant or solvent chemicals in such products are emitted.

Local potential importers were identified through communication with the Medicines Authority, It was established that Metered-Dose Inhalers (MDIs) containing the medical fluorinated propellant Norfluorane (HFC-134a) have been imported since the year 2004. In general, today only a few technical aerosol products contain HFCs and relate mainly to technical sprays used for the manufacture and/ or the repair of electrical and electronic equipment where only non-flammable substances (such as HFCs) may be used. No other uses of aerosols have been identified.

4.7.4.2 Methodological issues
The local importers have provided activity data on the annual quantities of imported inhalers containing Norfluorane. The charge of propellant per inhaler type was also provided. In some instances, where the actual charge of propellant was not identified, the default value of 10g Norfluorane per inhaler was

applied. Emissions from the use of MDIs were assumed to take place during the actual importation year. The emissions of HFCs from use are proportional to the amount of HFC containing MDIs imported and their relative charge. A significant increase in importation numbers was observed. It is also noted that the average charge per unit imported increased from 10.8g/unit to 12.4g/unit between 2009 and 2011.

4.7.4.3 Category-specific QA/QC and verification
Not applicable.

4.7.4.4 Source Specific Recalculations
No recalculations were required.

4.7.4.5 Uncertainty and time series consistency
Production and imports of medicinal products is controlled through the Medicines Authority, though data on propellants used may not be always readily available. The main uncertainty in this field is the uncertainty with respect to propellant charge per unit and the fate of residual charge after use of the product or its expiry.

4.7.4.6 Category Specific planned improvements
Currently efforts are being focused on creating an alternative approach, which could be based on the prevalence of asthma amongst the Maltese population and the methods of treatment (i.e. type of inhalative therapy) (Schwarz, et al., 2011). This methodology could serve as a quality assurance mechanism. Only two types of HFCs are used in MDIs: HFC-134a and HFC-227ea (only one manufacturer worldwide). The typical charge contained in each product (10 ml) ranges at 12 grams of HFC-134a and at 14 grams of HFC-227ea (reference for example: 2012 NIR Germany, p. 351: “0.15 g per 10 ml inhaler”).

4.8 OTHER PRODUCT MANUFACTURE AND USE (CRF CATEGORY 2G)

4.8.1 OTHER PRODUCT MANUFACTURE AND USE - ELECTRICAL EQUIPMENT (2G1)

4.8.1.1 Category Description
SF_6 has unique properties that allow the optimised operation of electrical switchgear and electricity networks. Electrical equipment based on SF_6 technology is used in the generation, transmission and distribution of electricity. SF_6 is also used in medical radiotherapy linear accelerators. While SF_6 possesses a unique combination of properties ideal for its uses, it has a potent greenhouse effect and despite great research efforts, to date no equivalent alternative gas has been identified.

Enemalta Corporation is identified as the main local user and emitter of SF_6 gas from switchgear equipment (emitting around 99% of the total estimated in 2014). Such switchgear equipment is found in the two local power generation plants operated by this organisation (Delimara and Marsa Power Stations, the latter currently on cold standby) and in the Electricity Distribution Network (substations and distribution centres).

Other users of SF_6-containing equipment include two hospitals (Sir Paul Boffa Hospital and Mater Dei Hospital) as well as a number of private establishments.

4.8.1.2 Methodological issues

In the year 2008, as part of this inventory process, industrial establishments and institutions that have SF_6-containing equipment in operation were identified. Through contacts with these organisations, data on the quantities of SF_6 gas contained in equipment by type (closed or sealed switchgear, linear accelerator), as well as information on installation dates, maintenance procedures and leakage rates per equipment type, were made available. The leakage rates as provided by the manufacturers of the respective equipment have been used to estimate emissions. It has been noted that during maintenance work, contaminated SF_6 is evacuated, collected in cylinders and shipped abroad for purification.

Where entities operating equipment containing SF_6 have not reported changes to equipment, that equipment is considered as still being in operation under constant operating conditions, with the level of emissions being assumed to be at a constant rate. In the case of any equipment that has been identified as being in operation but for which the respective operator has not provided estimates of emissions, IPCC 2006 Guidelines default emission factors have been used.

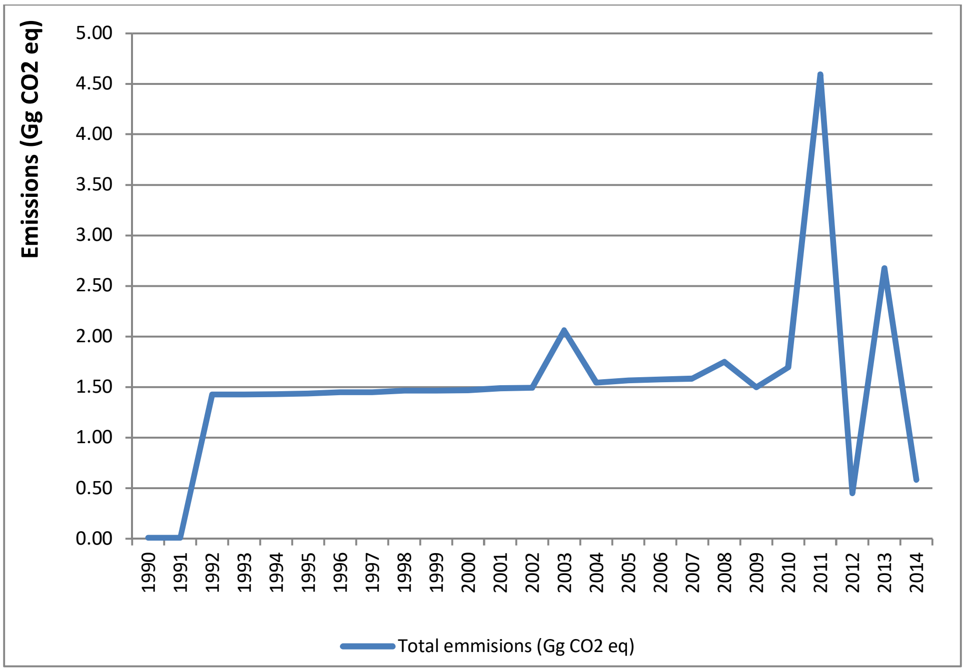

Figure 4-4 SF_6 Emissions from category Electrical Equipment

Figure 4-4 presents the sulphur hexafluoride emissions in carbon dioxide equivalents over the inventory time series. The emissions in the years 1990 and 1991 are minimal due to the very limited extent to which equipment containing SF_6 was used at the time (mainly in the electricity distribution network). The commissioning of new equipment, by current and new (including private industry as from around the year 2000) operators as well as extensions to existing systems explains the subsequent significant increase, compared to 1990 and 1991.

The spike in emissions reported for the year 2003 resulted from an incident at one of the establishments operating such equipment during which SF_6 was released from switchgear equipment in a substation badly damaged by a storm. The much more significant spike in emissions reported for 2011 is the consequence of a leak detected in a local power plant which could not be immediately repaired, with the operator having to continuously maintain the charging of gas into the leaking system until the leak was eventually closed.

4.8.1.3 Category-specific QA/QC and verification

Not Applicable.

4.8.1.4 Source Specific Recalculations

No recalculations were required.

4.8.1.5 Uncertainty and time series consistency

The data collection for the major emitter in this sector (electricity generation and distribution) is collected by the operator of the grid and due to this it has very low uncertainty. It is assumed that 5% activity data uncertainty and 2% EF uncertainty is sufficient.

4.8.1.6 Category Specific planned improvements

No planned improvements in this specific category.

4.8.2 Other Product Manufacture and Use - SF_6 and PFC from other Product Uses (Medical) (2G2)

4.8.2.1 Category Description

HFCs, PFCs and SF_6 represent a large choice of gases whose properties make them attractive for a variety of niche applications which for inventory purposes are aggregated. Recently, as part of the data gathering exercise on the use of fluorinated gases in Malta, it has been determined that very small quantities of SF_6 and PFC-218 (perfluoropropane) are used during hospital operations. Emissions of such gases are being reported for the years 2007 to 2013.

4.8.2.2 Methodological issues

Activity data for this sector was collected via communication with all other known local users of these gases; all the users reported use of small amounts in the medical sector.

4.8.2.3 Category-specific QA/QC and verification

Not applicable.

4.8.2.4 Source Specific Recalculations

No recalculations were required.

4.8.2.5 Uncertainty and time series consistency

Uncertainty in this sector is mainly attributable to the small quantities and very specific applications in which such fluids are used. The possibility of incomplete coverage is present though the scale of this incompleteness is presumably small enough not to affect significantly the end result. Activity data uncertainty is assumed at 100%, whereas emission factor uncertainty is assumed at 5%.

4.8.2.6 Category Specific planned improvements

No planned improvements in this specific category.

4.8.3 Other Product Manufacture and Use - N_2O from Product Use (2G3)

4.8.3.1 Category Description

In Malta, medical grade nitrous oxide is used for anaesthetic, analgesic use and veterinary use.

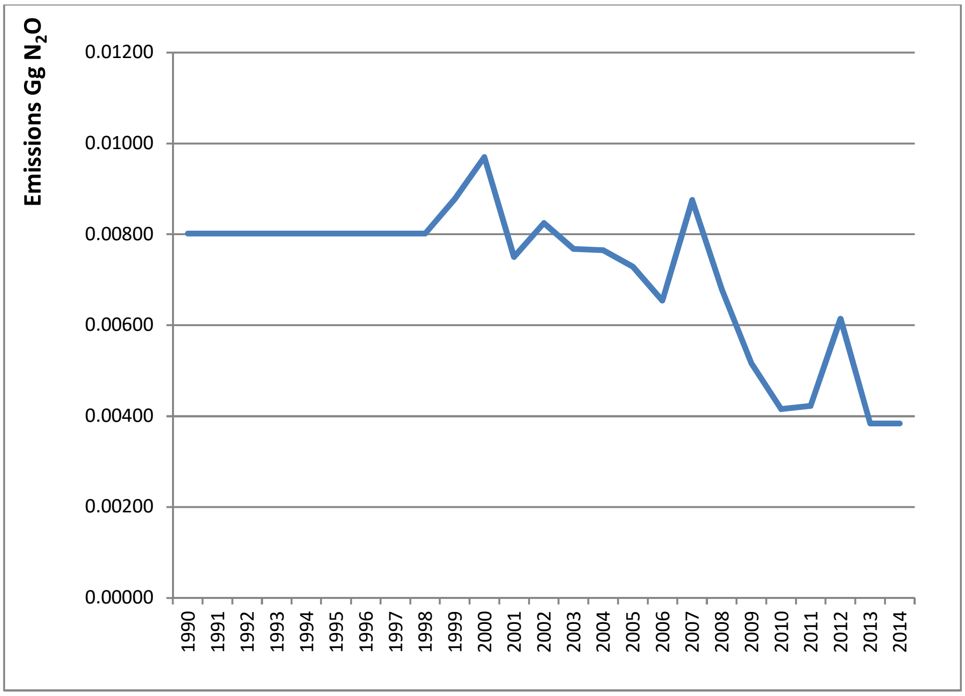

Figure 4-5 Nitrous Oxide emissions from anaesthetic use

Figure 4-5 shows the variations in N_2O emissions that result from the consumption of medical grade N_2O during medical applications in Malta. The emissions figure being reported for the years 1990 to 1998 (0.008 Gg N_2O per year) is the calculated average of the actual consumption of N_2O during the years 1999 till 2007. A downward trend in the consumption of N_2O for this scope is observed from 2008 onwards, linked to a decrease in the use of Antenox in dental and other surgical applications.

4.8.3.2 Methodological Issues

The use of medical grade nitrous oxide in public and private hospitals and other small clinics operating in Malta has been investigated through communication with these institutions in 2008. A comparative analysis of the information provided by these institutions and the available imports data of medical grade nitrous oxide in Malta shows that the institutions were only able to provide reliable and complete information for the most recent years, whereas the complete imports statistics are available as from 1999 onwards. This inventory process therefore uses the imports data of medical grade nitrous oxide rather than relying solely on the information provided by the institutions.

The methodology as available in the IPCC 2006 Guidelines as been followed, with an emission factor of 1.0 made applicable to the activity data, since it can be assumed that all of the administered nitrous oxide is returned to the atmosphere. It is also assumed that the quantity of medical grade nitrous oxide imported is all consumed during the same importation year. Since actual imports data for the years 1990 to 1998 are unavailable, the average import figure for the years 1999 to 2007 has been applied to the years 1990 till 1998.

4.8.3.3 Category-specific QA/QC and verification

Not applicable.

4.8.3.4 Source Specific Recalculations

No recalculations were required.

4.8.3.5 Uncertainty and time series consistency

Data collection coverage in this sector is complete, since only one manufacturer of medical grade N_2O exists in Malta. Thus it is assumed that activity data uncertainty in this sector only pertains to the instrumental uncertainty of the bottling plant, which is assumed at 3%. The emission factor uncertainty is presumably very low, as described in the IPCC 2006 Guidelines, it can be assumed that all gas inhaled is eventually exhaled, thus an arbitrary 1% EF uncertainty is used.

4.8.3.6 Category Specific planned improvements

No planned improvements in this specific category.

4.8.4 Other Product Manufacture and Use - Other (2G4)

Not applicable.

4.9 OTHER (CRF CATEGORY 2H)

4.9.1 Other - Pulp and Paper Industry (2H1)

The sector 2H1 covers activities in the pulp and paper industry that do not happen within the geographical scope of this report. Thus the sector as a whole is considered as not occurring in Malta.

4.9.2 OTHER - FOOD AND BEVERAGE INDUSTRY (2H2)

4.9.2.1 Category Description

Various processes related to the production of food and drink products give rise to emissions of NMVOCs. For this inventory, this source category includes emissions from the local production of wine and beer.

Bread production involves a fermentation reaction where ethanol (a NMVOC) is released. These emissions are included in this inventory.

4.9.2.2 Methodological Issues

The quantities of wine produced in Malta from the year 2000 onwards were available from Eurostat. Beer production does take place in Malta; however, no activity data for inventory compilation purposes was available prior to 2011 due to commercial confidentiality concerns in the light of the existence of two competing local breweries. In 2011 an agreement was reached with the NSO to overcome the confidentiality issues through the reporting of aggregated emissions data for the two sub-categories. However, at the time of compiling this report, no activity data had yet been provided on beer production for 2012, 2013 and 2014.

Default IPCC 2006 emission factors for red wine (0.08 kg NMVOC per hectolitre beverage) and white wine (0.035 kg NMVOC per hectolitre beverage) and beer (0.035 kg NMVOC per hectolitre beverage) have been used.

Data on bread production has not always been readily available for inventory purposes. Until 1998, bread production figures were provided by NSO. Since 1999, changes in data collection approaches by NSO (mainly the collection of production figures in monetary terms) makes it difficult to estimate the actual quantity of bread produced due to the nature of the bread production industry. This has led to a potential gap in activity data availability. This gap has been resolved to a certain extent through assistance provided by the Maltese Bakers' Cooperative.

Default IPCC 2006 Guidelines emissions factor for white bread (4.5kg NMVOC per tonne of bread produced) and sponge bread (8kg NMVOC per tonne of bread produced) have been used.

4.9.2.3 Category-specific QA/QC and verification

Not applicable.

4.9.2.4 Source Specific Recalculations

No recalculations were required.

4.9.2.5 Uncertainty and time series consistency

The lack of availability of bottom up data in this sector, perceived market sensitivities and a relatively limited number of market players impose uncertainty in the data collection process and adequacy issues with regards to the data provided. There is poor opportunity to quality control the data supplied, thus a relatively high uncertainty is present in this sector. The aggregated nature of the data provided also impinges on the emission factor uncertainty.

4.9.2.6 Category Specific planned improvements

Not applicable.

4.9.3 OTHER - OTHER (2H3)

4.9.3.1 Ethyne production

4.9.3.1.1 Category Description

No facility for Carbide Production (2B4) exists in Malta. Calcium carbide (CaC_2) is however imported mainly for the production of ethyne. This report considers emissions from this use.

4.9.3.1.2 Methodological Issues

CO_2 emissions from ethyne combustion:

$$CaC_2 + 2H_2O \longrightarrow \underset{\text{ethyne}}{C_2H_2} + Ca(OH)_2$$

$$2C_2H_2 + 5O_2 \longrightarrow 2H_2O + 4CO_2$$

1.375 tonnes of CO_2 are emitted when one tonne of calcium carbide is used to produce ethyne. This is the emission factor used for the purposes of estimating emissions from ethyne combustion.

Import figures of calcium carbide for the period 1990 to 2014 were calculated from data available at the National Statistics Office. It has been assumed that the calcium carbide imported in Malta is 100% utilised for ethyne production.

4.9.3.1.3 Category-specific QA/QC and verification

Not applicable.

4.9.3.1.4 Source Specific Recalculations

No recalculations were required.

4.9.3.1.5 Uncertainty and time series consistency

Imports of raw carbide for production of ethyne are well documented. Thus the uncertainty in this sector is in line with the levels of uncertainty of other import products. Production efficiency is the main component of uncertainty in the emission factor used.

4.9.3.1.6 Category Specific planned improvements

No planned improvements in this specific category.

Chapter 5. AGRICULTURE (CRF SECTOR 3)

5.1 OVERVIEW OF SECTOR

In this chapter information on the estimation of greenhouse gas (GHG) emissions from the sector Agriculture is given. Emissions are estimated for source categories Enteric Fermentation (3A), Manure Management (3B) and Agriculture Soils (3D). The source categories Rice Cultivation (3C), Prescribed Burning of Savannas (3E) and Liming (3G) do not take place in Malta. No emissions have been included under the source category Other Sources (3J). Source categories Field Burning of Agricultural residues (3F), Urea Application (3H) and Other Carbon-containing Fertilizers (3I) have not been estimated. Gases estimated and reported are methane (CH_4) and nitrous oxide (N_2O). The characterization of the agriculture sector in Malta is based on figures taken from the Census of Agriculture, the Farm Structure Survey, the Cattle Survey, the Pig Census, the Sheep and Goats Survey and the Agriculture and Fisheries publications.

Figure 5-1 shows the emissions in carbon dioxide equivalents from the Agriculture sector for the years 1990 till 2014. The Agriculture sector in Malta contributes around 2.76% of the total national GHG emissions. Greenhouse gas emissions mainly result from Enteric Fermentation (43.7%) and also from Manure Management (22.9%) and Agricultural Soils (33.5%). Total emissions decreased by 1.09 Gg CO_2 eq. between 2013 and 2014.

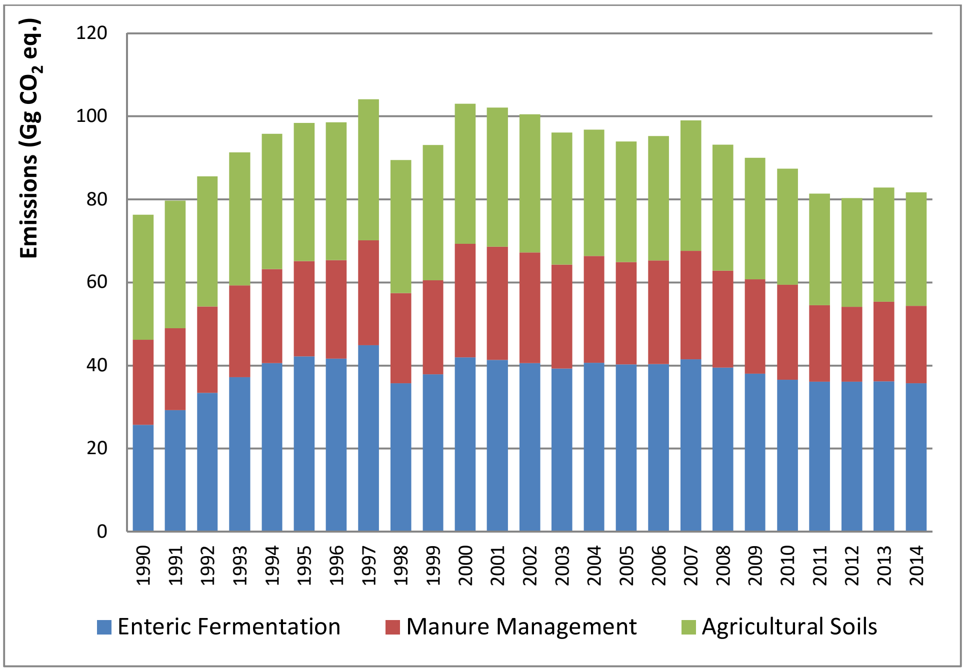

Figure 5-1 Total emissions for the sector Agriculture from 1990 to 2014

5.2 ENTERIC FERMENTATION (CRF CATEGORY 3A)

5.2.1 CATEGORY DESCRIPTION

Domestic livestock rearing leads to CH_4 emissions from enteric fermentation, the gas being a by-product of the digestive process in herbivores by which carbohydrates are broken down by micro-organisms into simple molecules for absorption into the blood stream. Both ruminant animals (e.g. cattle, sheep) and some non-ruminant animals (e.g. pigs, horses) produce CH_4, although ruminants are the largest source. The amount of CH_4 that is released depends upon the type, age and weight of the animal and the quantity and quality of the feed consumed.

Emissions from wild animals and pets do not fall within the scope of national GHG inventories. In Malta, as reported in the National Rural Development Strategy 2007-2013, the two most important livestock types reared for meat production are swine and poultry (broiler production) while cows are generally reared for milk, with beef production being a by-product of this activity.

In 2014, total CH_4 emissions from this source category were 35.70 Gg CO_2 eq.

5.2.2 METHODOLOGICAL ISSUES

Livestock categories for which emissions are estimated are dairy cows, other cattle, sheep, goats, horses, swine, poultry and rabbits. Annual average animal numbers have been used to calculate methane emissions from enteric fermentation. The time-series of figures are a combination of data from a past GHG inventory compilation and data from the National Statistics Office. The activity data (animal numbers) is presented in Table 5-1.

Data from an unpublished agricultural census is available for 1991. Prior to that year, the last agricultural census was carried out in 1983. The inventory referred to above provides figures collected by the Department of Veterinary Services for the years 1984 to 2001. These figures are partially complete, and where data is available this has been used to fill the gaps in the time series. The remaining gaps in the time series were filled by interpolating between available numbers, and extrapolating using the same annual difference up to 1990. The interpolated and extrapolated figures are shown in italics in Table 5-1.

Livestock characterisation has been applied to the cattle and sheep categories applying Tier 2 category and default values. A simplified Tier 2 method has been applied for the feed intake estimate.

Table 5-1 Annual animal numbers

	Livestock type and animal numbers							
Year	Total cows	Dairy Cows	Sheep	Goats	Horses	Swine	Poultry	Rabbits
1990	*10352*	*4315*	*7428*	*5993*	*953*	61607	*1508521*	*26609*
1991	12891	*5373*	7480	5147	*944*	53549	1513713	29213
1992	*15431*	*6432*	*7280*	*4408*	*935*	54794	*1518905*	*31817*
1993	*17970*	*7490*	*7080*	*3669*	*926*	57748	*1524096*	*34421*
1994	*20510*	*8549*	*6145*	*3600*	*917*	55726	*1529288*	*37025*
1995	23049	*9607*	6749	3647	*908*	52578	*1534479*	*39629*
1996	21894	*9126*	7354	3694	*899*	58027	*1539671*	*42234*
1997	24197	*10086*	7958	3741	*889*	62460	*1544863*	*44838*
1998	15486	*6455*	8563	3789	*880*	56887	*1550054*	*47442*
1999	16902	*7045*	9167	3836	*871*	59229	*1555246*	*50046*
2000	19380	8796	9772	3883	*862*	80074	*1560437*	*52650*
2001	18417	8332	10376	3930	853	81841	1565629	*55254*
2002	18770	8033	12253	5163	*953*	78303	1529100	*57858*
2003	17940	7607	14861	5374	*1053*	73067	1381544	*60462*
2004	19408	7835	14131	5635	*1153*	76853	*1216779*	*63066*
2005	19742	7832	14641	6273	*1253*	73025	1052013	*65670*
2006	19233	7494	12172	5828	*1354*	73683	*1138140*	*68275*
2007	19442	7545	12315	6227	*1454*	76900	1224267	*70879*
2008	17777	7247	12843	6361	*1554*	65511	*1139608*	*73483*
2009	16264	6931	12889	5983	*1654*	65918	*1054950*	*76087*
2010	14954	6362	12379	5110	1754	70583	970291	78691
2011	15074	6308	11887	4938	*1854*	46287	*885632*	*81295*
2012	15593	6320	11697	4847	*1954*	45209	*800974*	*83899*
2013	15220	6333	10930	4598	2054	49451	918426	86503
2014	14883	6502	10526	4627	2054	47465	918426	86503

5.2.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Where animal numbers are obtained through surveys and censuses, there is a high degree of certainty. Wherever livestock categories had to be interpolated or extrapolated, this leads to greater uncertainty in the figures. There is however no further possibility of confirming these numbers against real data.

5.2.4 CATEGORY-SPECIFIC QA/QC AND VERIFICATION

Not applicable.

5.2.5 CATEGORY-SPECIFIC RECALCULATIONS

A study on improving greenhouse gas emission estimates from agriculture had been commissioned to improve the overall quality of the data and assumptions feeding into the estimation of emissions. [Sammut, S. 2015. Estimation of greenhouse gas emissions from agricultural activities for Malta's inventory.] Following this study, a number of changes have been made to the agriculture sector.

A livestock characterisation has been carried out on the sheep population, whereby this population is characterised by the subcategories growing lambs, mature ewes, and other mature sheep.

A number of factors in the livestock characterisation of cattle have been also amended following this study. The effect of these recalculations is shown in Table 5-2.

Table 5-2 Recalculations for the category Enteric Fermentation

Year	Enteric Fermentation (Gg CO_2 eq.) as reported in the previous inventory report	Enteric Fermentation (Gg CO_2 eq.) as reported in this inventory report	Percentage change in reported emissions (%)
1990	21.60	25.73	19.13
1991	25.56	29.28	14.59
1992	30.09	33.42	11.05
1993	34.35	37.17	8.21
1994	38.43	40.60	5.64
1995	42.43	42.20	-0.55
1996	41.09	41.72	1.53
1997	44.22	44.89	1.51
1998	34.73	35.76	2.98
1999	36.37	37.91	4.23
2000	39.83	42.02	5.51
2001	38.84	41.30	6.34
2002	39.20	40.61	3.59
2003	37.88	39.31	3.78
2004	39.10	40.67	4.02
2005	39.15	40.29	2.89
2006	38.42	40.35	5.05
2007	38.81	41.53	6.99
2008	36.92	39.50	7.00
2009	35.17	38.00	8.07
2010	34.28	36.62	6.83
2011	33.23	36.18	8.88
2012	33.88	36.13	6.64
2013	32.97	36.23	9.89

5.2.6 CATEGORY-SPECIFIC PLANNED IMPROVEMENTS

A livestock characterisation has been implemented for cattle and sheep. A number of other changes have been made following the commissioned study referred to in section 5.2.5 above. No further improvements are envisaged.

5.3 MANURE MANAGEMENT (CRF CATEGORY 3B)

5.3.1 CATEGORY DESCRIPTION

This category reports emissions of methane from animal manures as well as emissions from their manures arising during its storage. Domestic livestock rearing leads to both CH_4 and N_2O emissions from manure management. CH_4 from the management of animal manure occurs as the result of its decomposition under anaerobic conditions. These conditions often occur when a large number of animals are managed in a confined area (e.g. dairy farms, swine and poultry farms). N_2O emissions from manure management vary significantly between the types of manure management systems used (e.g. solid or liquid). When manure is stored or treated as liquid in a pond or tank it tends to decompose anaerobically and produce a significant quantity of methane. When manure is handled as a solid or when it is deposited on pastures, it tends to decompose aerobically and little or no methane is produced. Hence the system of manure management used affects emission rates. Figure 5-2 shows the methane and nitrous oxide emissions from manure management in CO_2 equivalents.

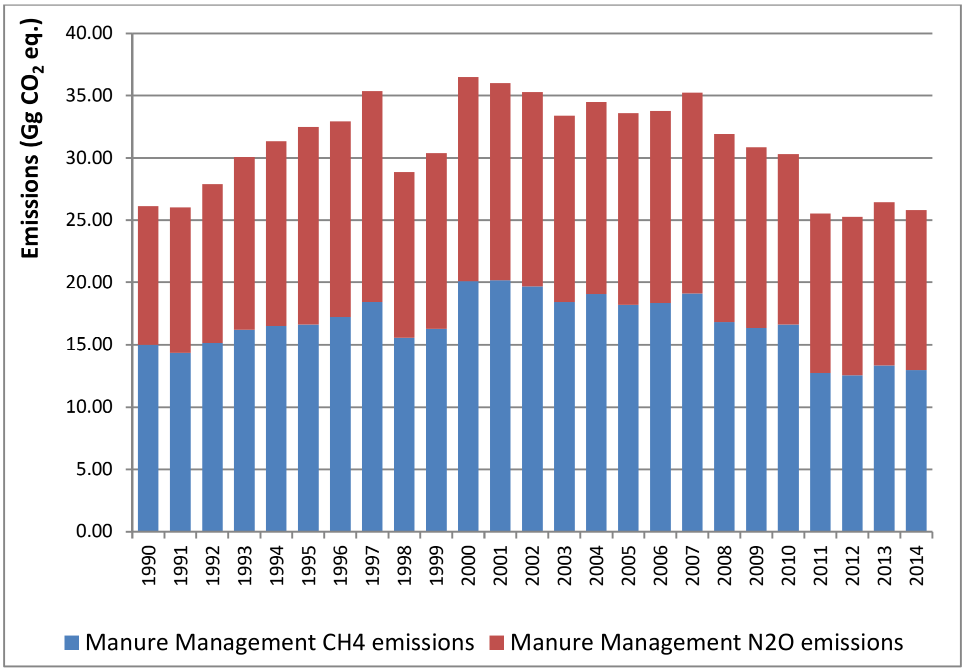

Figure 5-2 Methane and nitrous oxide emissions from category Manure Management

5.3.2 METHODOLOGICAL ISSUES

5.3.2.1 Methane Emissions from Manure Management

To estimate methane emissions from livestock manure, livestock population data by animal category, in combination with default emission factors have been used. Table 5-3 shows the methane emission factors used.

Table 5-3 Annual average methane emission factors from manure management, by animal type

Animal	Emission Factor used ($kg\ CH_4$ / head / year)	Source of Emission Factor
Sheep	0.28	IPCC, 2006
Goats	0.20	IPCC, 2006
Horses	2.34	IPCC, 2006
Rabbits	0.08	IPCC, 2006

Methane emissions from cattle, swine and poultry were estimated using a Tier 2 methodology applying country-specific values for manure produced per animal per day, volatile solids and dry matter.

5.3.2.2 Direct Nitrous Oxide Emissions from Manure Management

This section includes the estimate details for direct N_2O emissions during the storage and treatment of manure before it is applied to agricultural land. Direct N_2O emissions occur via combined nitrification and denitrification of nitrogen contained in the manure. A Tier 2 method, with country-specific nitrogen excretion rates for poultry and swine was applied.

The nitrogen excretion rates used for poultry are presented in Table 5-4 below. For broilers, the mid-point of the quoted range was used for emission estimation.

Table 5-4 Nitrogen excretion rates for poultry [Sustech**]**

Animal Category	Nitrogen Excretion Rates
Poultry – Broilers	0.35 – 0.82 kg N / place
Poultry – Layers	0.87 kg N / place

Nitrogen excretion rates for swine classes are based on expert judgement following a study carried out and are shown in Table 5-5 below.

Table 5-5 Nitrogen excretion rates for swine

Animal Category	Nitrogen Excretion Rates
Piglets < 20kg	2.1 kg N / head / year
Young piglets 20 – 50 kg	7.0 kg N / head / year
Fattening pigs > 51 kg	15.1 kg N / head / year
Breeding sows	29.4 kg N / head / year
Gilts	20.1 kg N / head / year
Breeding boars	42.0 kg N / head / year

Default emission factors for direct N_2O emissions from manure management, from Table 10.21 of the IPCC 2006 guidelines were applied to the quantities of kg N generated annually by livestock categories. The emission factors used are presented in Table 5-6 below.

Table 5-6 Default emission factors for direct N_2O emissions from manure management

Animal Category	Default Emission Factor (kg N_2O-N/kg N excreted)	Management System
Cattle	0.0125	Solid storage; dry lot
Swine	0.002	Pit storage
Poultry	0.001	Poultry manure without litter
Sheep	0.01	Deep bedding
Goats	0.01	Deep bedding
Horses	0.005	Solid storage
Rabbits	0.001	Poultry manure without litter

5.3.2.3 Indirect Nitrous Oxide Emissions from Manure Management

A significant proportion of the total nitrogen excreted by the animals in managed systems is lost prior to final application of the manure to the soils. In order to estimate the amount of animal manure nitrogen that is directly applied to the soils, it was necessary to reduce the total amount of nitrogen excreted by the animals but lost as volatilisation.

Default values for nitrogen loss due to volatilisation of NH_3 and NO_x from manure management, from Table 10.22 of the IPCC 2006 guidelines were applied to the quantities of kg N excreted annually by livestock categories. The emission factors used are presented in Table 5-7 below.

Table 5-7 Default emission factors for nitrogen loss due to volatilisation from manure management

Animal Category	Default Emission Factor (Fraction)	Management System
Cattle – Dairy	0.25	Solid storage; dry lot
Cattle – Other Cattle	0.375	Solid storage; dry lot
Swine	0.48	Liquid/slurry
Poultry - layers	0.55	Poultry without litter
Poultry - broilers	0.40	Poultry with litter
Sheep	0.25	Deep bedding
Goats	0.25	Deep bedding
Horses	0.12	Solid storage
Rabbits	0.55	Poultry without litter

The resultant activity data on the manure quantities (kg N) was multiplied with the default emission factor to estimate indirect N_2O-N emissions from manure management (0.01 kg N_2O-N per kg N), as available in Table 11.3 of the IPCC 2006 guidelines.

5.3.3 Uncertainties and Time-Series Consistency

More certainty is required on the treatment applied to animal manure for each livestock type, and to what percentage of manure each treatment applies.

5.3.4 Category-Specific QA/QC and Verification

Not applicable.

5.3.5 CATEGORY-SPECIFIC RECALCULATIONS

The source category has been completely revised following the study previously mentioned. Default methane emission factors from manure management were revised to reflect the 2006 Guidelines. A Tier 2 methodology was applied to methane emissions from cattle, swine and poultry.

Nitrous oxide emissions from swine manure management were revised to apply a Tier 2 methodology. Default emission factors for direct emissions from manure management were applied to all livestock categories and reflect the manure management system. The effects of these changes are shown in Table 5-8.

Table 5-8 Recalculations for category Manure Management

Year	Manure Management (Gg CO2 eq.) as reported in the previous inventory report	Manure Management (Gg CO2 eq.) as reported in this inventory report	Percentage change in reported emissions (%)
1990	31.19	26.12	-16.24
1991	31.32	26.04	-16.87
1992	33.99	27.89	-17.94
1993	37.13	30.07	-19.02
1994	38.92	31.32	-19.52
1995	40.39	32.50	-19.52
1996	40.83	32.93	-19.36
1997	44.15	35.38	-19.86
1998	34.78	28.89	-16.92
1999	36.70	30.38	-17.22
2000	45.25	36.51	-19.31
2001	44.71	36.00	-19.50
2002	43.58	35.30	-18.99
2003	40.86	33.41	-18.23
2004	42.46	34.49	-18.78
2005	41.06	33.61	-18.15
2006	40.98	33.77	-17.61
2007	42.36	35.26	-16.78
2008	37.79	31.93	-15.50
2009	36.50	30.85	-15.47
2010	36.13	30.30	-16.13
2011	29.48	25.52	-13.43
2012	29.44	25.29	-14.10
2013	30.31	26.42	-12.84

5.3.6 CATEGORY-SPECIFIC PLANNED IMPROVEMENTS

No immediate improvements planned.

5.4 RICE CULTIVATION (CRF CATEGORY 3C)

5.4.1 Category Description

This category does not occur.

5.4.2 Methodological Issues

Not applicable.

5.4.3 Uncertainties and time-series consistency

Not applicable.

5.4.4 Category-specific QA/QC and verification

Not applicable.

5.4.5 Category-specific recalculations

Not applicable.

5.4.6 Category-specific planned improvements

Not applicable.

5.5 AGRICULTURAL SOILS (CRF CATEGORY 3D)

5.5.1 Category Description

5.5.1.1 Source Category 3Da – Direct Soil Emissions

This section includes direct nitrous oxide emissions through an increase in available nitrogen. The following sources are included in the estimates:

- application of synthetic nitrogen fertilisers (F_{SN});
- application of organic nitrogen as fertiliser (animal manure) (F_{ON});
- nitrogen input from crop residues (F_{CR}).

5.5.1.2 Source Category 3Db – Indirect Soil Emissions

Indirect pathways involve nitrogen that is removed in agricultural soils or animal waste management systems via volatilisation, leaching or runoff.

Current activity data used to calculate indirect N_2O emissions include commercial synthetic fertiliser consumption, livestock and poultry populations.

5.5.2 METHODOLOGICAL ISSUES

5.5.2.1 Synthetic Fertiliser Nitrogen Applied to Soils

There are two possible sources to establish the input of nitrogen from synthetic fertilisers on managed soils for the estimation of both direct and indirect N_2O emissions. One is using data on the consumption of fertilisers on a national level, derived from importation/trade data, and the other is using nitrogen application rates on the basis of fertiliser use data for different crops, aggregated on a national level. In fact, the source for the latter rates is the NSO study on the gross nitrogen balance for Malta conducted in 2007 and published in 2008 [NSO. 2008. Gross Nitrogen Balance for Malta, 2007]. The average nitrogen rate per hectare derived from the import data is approximately 50 kg N/ha; while the same rate on the basis of application data is approximately 60 kg N/ha. Taking into consideration the values obtained from the two data sources, it was recommended to use an average rate of 55.5 kg N/ha throughout the time series [Sammut, S].

5.5.2.2 Manure Applied to Soils

When calculating the total manure nitrogen available for application to managed soils, the same principles were applied in selecting the most appropriate default values for total nitrogen loss from manure systems on the basis of an understanding of the type of manure management system in use. In some cases, e.g. cattle, and similar to previous situations, average values of different fractions were used to represent a mix of situations where the actual proportions of management systems are not known.

In assigning a value to the amount of nitrogen from bedding, data from literature supplied in IPCC 2006 was used in combination with an understanding of how much and when such bedding is in use. It is known that in most cases, the use of straw bedding is limited in order to reduce costs.

For the estimation of emissions under this category, the assumption is made that only a small fraction of pig slurry is applied to soils. Unofficial sources state that it is customary for almost all pig slurry to be flushed into the sewerage system, which means that in effect any emissions from the slurry are taken into account at the sewage treatment plant. Therefore in order to avoid double counting of emissions – as applied on land and as treated in the sewage treatment plant – it is assumed that 10% of total pig slurry is applied to soils. This percentage is also considered adequate to allow for cases where slurry is applied onto fields in the vicinity of the farms [Sammut, S].

Default values for total nitrogen loss due from manure management, derived from Table 10.23 of the IPCC 2006 guidelines, were applied to the quantities of kg N excreted annually by livestock categories. The emission factors used are presented in Table 5-9 below.

Table 5-9 Default emission factors for total nitrogen loss from manure management

Animal Category	Default Emission Factor (Fraction)	Management System
Cattle	0.40	Solid storage; dry lot
Swine	0.365	Liquid/slurry; pit storage
Poultry - layers	0.55	Poultry without litter
Poultry - broilers	0.50	Poultry with litter
Sheep	0.35	Deep bedding
Goats	0.35	Deep bedding
Horses	0.15	Solid storage
Rabbits	0.55	Poultry without litter

5.5.2.3 Nitrogen in crop residues

Calculations of the amount of N available from crop residues were based on the information in Table 11.2 for the main crops under the categories listed: 1. Non-N fixing grain crops, 2. N-fixing grains and pulses, 3. Root and tuber crops, 4. N-fixing forage crops and 5. Other forages / perennial grasses. In practice this includes wheat, barley, beans, chickpeas, sulla, peas, potato, carrots and other vetch. These crops constitute a significant share of the total utilised agricultural area, standing at 55% in 2010.

Effort was made to obtain data on the area under each crop considered, for the years in between census years, however, this was not successful. Thus, the area under each crop for these years was derived by interpolating data from Census (notwithstanding the issues with the 1991 Census, in the absence of a better reference base, data from this source was still used).

The approximate yield (in terms of weight of dry matter per hectare) for each of the main crops considered was obtained from different sources, using national data wherever possible. Country-specific data on crop yields was in fact obtained for wheat, barley and sulla [Vella, S., 1997] and for potato [Vella, S., 2003].

5.5.2.4 Indirect emissions through atmospheric deposition

Calculation of N volatilisation in forms of NH_3 and NO_x from nitrogen applied to soils is based on multiplication of the amount of nitrogen applied by a fraction of volatilised nitrogen.

Activity data and methodology used are the same as those used above. The fraction of nitrogen volatilised from organic manure applied ($Frac_{GASM}$) was taken as 0.20 and the fraction of nitrogen volatilised from synthetic fertiliser application ($Frac_{GASF}$) was taken as 0.10 from Table 11.3 of the 2006 IPCC Guidelines. The indirect N_2O emissions from volatilisation of N are estimated by multiplying the resulting figures with EF_4 taken to be 0.010 from the same table.

5.5.2.5 Indirect emissions through leaching / runoff

Another issue is the leaching, and runoff from land, of nitrogen which originates from synthetic and organic fertiliser additions, crop residues, and mineralisation of N associated with loss of soil C in mineral and drained/managed organic soils through land-use change or management practices. Urine and dung deposition from grazing does not occur in Malta. Some of the inorganic N on or in the soil, mainly in the NO_3^- form, may bypass biological retention mechanisms in the soil/vegetation system by transport in overland water flow (runoff) and/or flow through soil macropores or pipe drains. The nitrification and denitrification processes transform some of the NH_4^+ and NO_3^- to N_2O. This may take place in the groundwater lying under the land to which N has been applied, in riparian zones receiving drain or runoff water, or in the ditches into which the land drainage water flows (IPCC Guidelines 2006). Total N applied to soil through mineral fertilisers and manure is multiplied by $Frac_{LEACH-(H)}$ from Table 11.3 of the 2006 IPCC Guidelines with a value of 0.30 and multiplied by EF_5 0.0075 also from the same table. Conversion to N_2O is achieved by multiplying by 44/28.

5.5.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Uncertainties in this source category are associated with uncertainties of the fractions of manure management systems applied to animal waste. There is also uncertainty regarding the figures for fertilisers brought into Malta from other countries and the actual use of these fertilisers. This has been partially addressed through the estimation of nitrogen applied through the utilised agricultural area and rate of application.

5.5.4 CATEGORY-SPECIFIC QA/QC AND VERIFICATION

Not applicable.

5.5.5 CATEGORY-SPECIFIC RECALCULATIONS

Nitrous oxide emissions from swine manure management were revised to apply a Tier 2 methodology. Default emission factors for direct emissions from manure management were applied to all livestock categories and reflect the manure management system. Changes have been applied in the estimation of inorganic nitrogen applied through synthetic fertilisers. Nitrogen inputs through crop residues have been evaluated through areas of production and yield. The effect of these changes is shown in Table 5-10.

Table 5-10 Recalculations for category Agricultural Soils

Year	Agricultural Soils (Gg CO_2 eq.) as reported in the previous inventory report	Agricultural Soils (Gg CO_2 eq.) as reported in this inventory report	Percentage change in reported emissions (%)
1990	20.28	30.15	48.72
1991	21.14	30.71	45.25
1992	22.78	31.33	37.56
1993	23.50	31.96	35.96
1994	24.47	32.56	33.08
1995	31.11	33.29	7.01
1996	27.22	33.23	22.10
1997	29.81	33.95	13.89
1998	29.78	32.11	7.83
1999	25.93	32.62	25.78
2000	28.92	33.73	16.64
2001	25.93	33.45	29.02
2002	25.84	33.19	28.48
2003	22.92	31.72	38.39
2004	24.56	30.42	23.84
2005	24.04	29.00	20.62
2006	25.81	29.96	16.08
2007	24.52	31.43	28.18
2008	22.58	30.39	34.60
2009	21.32	29.36	37.74
2010	20.69	27.97	35.14
2011	20.36	26.95	32.35
2012	19.94	26.13	31.02
2013	20.02	27.47	37.20

5.5.6 Category-specific planned improvements

Better data on manure management systems is required in order to better allocate manure management systems. More information is required on fertiliser import statistics and end-use of the fertilisers in order to allow for accurate accounting. Data on areas under crops is required in order to better estimate emissions from crop residues.

5.6 PRESCRIBED BURNING OF SAVANNAS (CRF CATEGORY 3E)

5.6.1 Category Description

This category does not occur in Malta.

5.6.2 Methodological Issues

Not applicable.

5.6.3 Uncertainties and time-series consistency

Not applicable.

5.6.4 Category-specific QA/QC and verification

Not applicable.

5.6.5 Category-specific recalculations

Not applicable.

5.6.6 Category-specific planned improvements

Not applicable.

5.7 FIELD BURNING OF AGRICULTURAL RESIDUES (CRF CATEGORY 3F)

5.7.1 Category Description

In accordance to Standard B2 of the first set of national Good Agricultural and Environmental Conditions (GAEC) adopted for Malta (Rural Development Programme for Malta 2007 – 2013, Rural Development Department Ministry for Sustainable Development, the Environment and Climate

Change, April 2013), stubble and vegetable residue should not be burnt in the field, except by order of the local Plant Health authorities in case of the presence of harmful pests and diseases. In view of this condition, there is no need to consider emissions arising from the burning of crop residues on the fields. [Sammut, S.]

5.7.2 Methodological Issues

Not applicable.

5.7.3 Uncertainties and time-series consistency

Not applicable.

5.7.4 Category-specific QA/QC and verification

Not applicable.

5.7.5 Category-specific recalculations

Not applicable.

5.7.6 Category-specific planned improvements

Not applicable.

5.8 LIMING (CRF CATEGORY 3G)

5.8.1 Category Description

This category does not occur.

5.8.2 Methodological Issues

Not applicable.

5.8.3 Uncertainties and time-series consistency
Not applicable.

5.8.4 Category-specific QA/QC and verification
Not applicable.

5.8.5 Category-specific recalculations
Not applicable.

5.8.6 Category-specific planned improvements
Not applicable.

5.9 UREA APPLICATION (CRF CATEGORY 3H)

5.9.1 Category Description
This category has not been estimated.

5.9.2 Methodological Issues
Not applicable.

5.9.3 Uncertainties and time-series consistency
Not applicable.

5.9.4 Category-specific QA/QC and verification
Not applicable.

5.9.5 Category-specific recalculations
Not applicable.

5.9.6 Category-specific planned improvements
Not applicable.

5.10 OTHER CARBON-CONTAINING FERTILISERS (CRF CATEGORY 3I)

5.10.1 Category Description
This category has not been estimated.

5.10.2 Methodological Issues
Not applicable.

5.10.3 Uncertainties and time-series consistency
Not applicable.

5.10.4 Category-specific QA/QC and verification
Not applicable.

5.10.5 Category-specific recalculations
Not applicable.

5.10.6 Category-specific planned improvements
Not applicable.

5.11 OTHERS (CRF CATEGORY 3J)

5.11.1 Category Description
Not applicable.

5.11.2 Methodological Issues
Not applicable.

5.11.3 Uncertainties and time-series consistency
Not applicable.

5.11.4 Category-specific QA/QC and verification
Not applicable.

5.11.5 Category-specific recalculations
Not applicable.

5.11.6 Category-specific planned improvements
Not applicable.

Chapter 6. Land use, land-use change and forestry (CRF sector 4)

6.1 Overview of sector

This sector can contribute both to emissions (from sources) and removals of CO_2 (through sinks). Overall, the sector accounted for -2.70 Gg of CO_2 removals in 2014. The 2003 IPCC GPG for the sector Land Use, Land-Use Change and Forestry (LULUCF) has been applied for all the categories of this sector. Data used from national statistics and the Corine Land Cover 1990, 2000, 2006 and 2012.

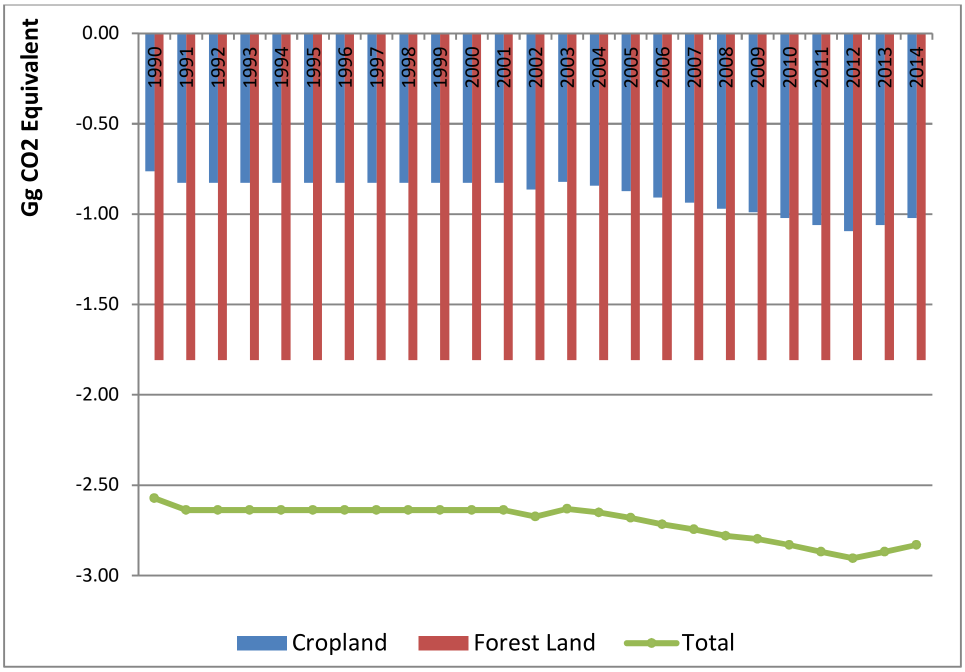

Figure 6-1 CO_2 removals for sector LULUCF and categories Forest Land and Cropland

Figure 6-1 shows the trend for carbon dioxide removals by vegetation in the LULUCF sector for Malta. A mean figure of -2.7Gg CO_2 has been estimated to be sequestered annually by Maltese vegetation during the time series 1990 to 2014. In this inventory, carbon dioxide removals from above-ground biomass are being reported for the categories Forest Land (4A) and Cropland (4B). Grassland (4C), Wetlands (4D) and Settlements (4E) are reported as zero, as the increase in biomass is equal to biomass loss.

This year, improvement in this sector is to continue, working with last year's project carried out with the University of Malta (please refer to the 2015 national inventory submission for more information). Through the project, the importance of proper characterization, quantification and monitoring of land cover, land use and their changes was shown. It is evident, from interviews with various stakeholders, that the information currently available on land use at a national scale is incomplete, and access to it is difficult due to fragmented data sources, potentially leading to inaccuracies. This study has confirmed the need for more effort to be put into consolidating and combining data sets and enhancing quality. The need for a Working Group specifically for the sector where experts can meet, discuss issues and decide on the way forward to a more reliable inventory for LULUCF, has been identified.

For this year's submission, the emissions and removals were calculated using spreadsheets specifically made to manually insert the values. This is due to the CRF Reporter system having issues resulting in discrepancies in values, thus affecting the final removal values. Moreover, rounding up of decimal places in the CRF system represents an additional source of discrepancies in results.

6.2 LAND-USE DEFINITIONS AND THE CLASSIFICATION SYSTEMS USED AND THEIR CORRESPONDENCE TO THE LAND USE, LAND-USE CHANGE AND FORESTRY CATEGORIES

The definitions established and used for this reporting are thus.

- **Forest Land** is defined as an area with minimum area of land of 1 hectare, tree crown cover more than 30% and trees minimum height more than 5 meters.
- **Cropland** is defined as arable and tillage land, and agro-forestry systems where vegetation falls below the thresholds used for forestry land categories. Cropland includes all annual and perennial crops as well as temporary fallow land (i.e., land set at rest for one or several years before being cultivated again). Annual crops may include cereals, oils seeds, vegetables, root crops and forages. Perennial crops can include trees and shrubs, in combination with herbaceous crops (e.g. agroforestry) or as orchards, vineyards and plantations such as cocoa, coffee, tea, oil palm, coconut, rubber trees, and bananas, except where these lands meet the criteria for categorisation as forest land. Arable land which is normally used for cultivation of annual crops but which is temporarily used for forage crops or grazing as part of an annual crop-pasture rotation is included under cropland.
- **Grassland** is defined as areas with highly biodiverse grassland:
  - habitats as listed in Annex I of Council Directive 92/43/EEC;
  - habitats of significant importance for animal and plant species of Union interest listed in Annex II and IV of Directive 92/43/EEC;
  - habitats of significant importance for wild bird species listed in Annex I of Directive 2009/147/EC. Highly biodiverse grassland in the European Union is not limited to the geographic ranges referred to under Article 3 of Directive 92/43/EEC. Other grassland might fulfill the criteria for highly biodiverse grassland set out in Article 1 of the same Directive. "
- **Wetland** is defined the same as for the RAMSAR Convention, Article 1.1 and Article 2.1:
  - Article 1.1 states:

"For the purpose of this Convention wetlands are areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres."

- Article 2.1 provides that wetlands:

"[…] *may incorporate riparian and coastal zones adjacent to the wetlands, and islands or bodies of marine water deeper than six metres at low tide lying within the wetlands".*

6.3 INFORMATION ON APPROACHES USED FOR REPRESENTING LAND AREAS AND ON LAND-USE DATABASES USED FOR THE INVENTORY PREPARATION

Approaches 2 and 3 of the LULUCF Good Practice Guidelines were used for the identification of land use areas. Data for the elaboration of land-use transition matrices was obtained from Corine Land Cover (1990, 2000, 2006 and 2012), with additional data relating to Cropland from the National Statistics Office, the latter providing more recent data for the Cropland sub-category. Corine land Cover data was obtained from the local competent authority (MEPA) responsible for the Corine Land Cover rather that the EEA directly. The latest Corine Land Cover report available for the purpose of this submission was 2012 Corine Land Cover.

6.3.1 THE LAND USE TRANSITION MATRIX

In accordance with feedback from past inventory reviews, a land use matrix was created to represent, in a consistent quantified manner, land-use conversions (see Table 6-1). The matrices allow the determination of areas of land-use transition, separately from each initial and final land use (i.e. forest land, grassland and so on). Annual values for areas in transition from one type of land use to another have been derived by a hierarchy of basic assumptions with expert judgement of land-use changes in Malta. Land-use change matrices for each year of the period 1990-2013 have been assembled based on time series of national land use statistics for Forest lands, Croplands, Grasslands, Wetland and Settlement areas.

For the category Wetlands, no occurrences of land-use transition to or from wetlands have been determined. It is to note that most wetlands in Malta are considered as being natural reserves in accordance with Legal Notice 311 of 2006 as amended (Flora, Fauna and Natural Habitats Protection Regulations) and Legal Notice 194 of 2004 (Water Policy Framework Regulations).

Areas of land use and land-use change are compiled from the various sources. Areas of Forest Land, Grassland, Wetland and Settlement come from the Corine Land Cover 1990, 2000 and 2006. Land areas related to Cropland were sourced from the National Statistics Office.

Table 6-1 Land-use change matrices for the years 1990-2013 (figures in hectares)

	Year 1990-1991										
	TO	Coniferous forest	Mixed forest	Woody crops	Annual crops	Maquia	Other GL	WL	SL	OL	Total end 1990
FROM	Coniferous forest	67									67
	Mixed forest		143								143
	Woody crops			917							917
	Annual crops				8594						8594
	Maquia					4951			8		4958

	Other GL						7774		15		7789
	WL							38	1		39
	SL								8602		8602
	OL								7	419	426
	Total end 1991	67	143	917	8594	4951	7774	38	8633	419	31535

	YEAR 1991-1992										
FROM	To	Coniferous forest	Mixed forest	Woody crops	Annual crops	Maquia	Other GL	WL	SL	OL	Total end 1991
	Coniferous forest	67									67
	Mixed forest		143								143
	Woody crops			917							917
	Annual crops				8594						8594
	Maquia					4943			8		4951
	Other GL						7758		15		7774
	WL							36	1		38
	SL								8633		8633
	OL								7	412	419
	Total end 1992	67	143	917	8594	4943	7758	36	8664	412	31535

	YEAR 1992-1993										
FROM	To	Coniferous forest	Mixed forest	Woody crops	Annual crops	Maquia	Other GL	WL	SL	OL	Total end 1992
	Coniferous forest	67									67
	Mixed forest		143								143
	Woody crops			917							917
	Annual crops				8594						8594
	Maquia					4935			8		4943
	Other GL						7743		15		7758
	WL							35	1		36
	SL								8664		8664
	OL								7	405	412
	Total end 1993	67	143	917	8594	4935	7743	35	8696	405	31535

	YEAR 1993-1994										
FROM	To	Coniferous forest	Mixed forest	Woody crops	Annual crops	Maquia	Other GL	WL	SL	OL	Total end 1993
	Coniferous forest	67									67
	Mixed forest		143								143
	Woody crops			917							917
	Annual crops				8594						8594
	Maquia					4928			8		4935
	Other GL						7728		15		7743

	WL							34	1		35
	SL								8696		8696
	OL								7	399	405
	Total end 1994	67	143	917	8594	4928	7728	34	8727	399	31535

	YEAR 1994-1995										
FROM	To	Coniferous forest	Mixed forest	Woody crops	Annual crops	Maquia	Other GL	WL	SL	OL	Total end 1994
	Coniferous forest	67									67
	Mixed forest		143								143
	Woody crops			917							917
	Annual crops				8594						8594
	Maquia					4920			8		4928
	Other GL						7712		15		7728
	WL							32	1		34
	SL								8727		8727
	OL								7	392	399
	Total end 1995	67	143	917	8594	4920	7712	32	8758	392	31535

	YEAR 1995-1996										
FROM	To	Coniferous forest	Mixed forest	Woody crops	Annual crops	Maquia	Other GL	WL	SL	OL	Total end 1995
	Coniferous forest	67									67
	Mixed forest		143								143
	Woody crops			917							917
	Annual crops				8594						8594
	Maquia					4913			8		4920
	Other GL						7697		15		7712
	WL							31	1		32
	SL								8758		8758
	OL								7	385	392
	Total end 1996	67	143	917	8594	4913	7697	31	8789	385	31535

	YEAR 1996-1997										
FROM	To	Coniferous forest	Mixed forest	Woody crops	Annual crops	Maquia	Other GL	WL	SL	OL	Total end 1996
	Coniferous forest	67									67
	Mixed forest		143								143
	Woody crops			917							917
	Annual crops				8594						8594
	Maquia					4905			8		4913
	Other GL						7681		15		7697

	WL							29	1		31
	SL								8789		8789
	OL								7	379	385
	Total end 1997	67	143	917	8594	4905	7681	29	8820	379	31535

	Year 1997-1998										
	TO	Coniferous forest	Mixed forest	Woody crops	Annual crops	Maquia	Other GL	WL	SL	OL	Total end 1997
FROM	Coniferous forest	67									67
	Mixed forest		143								143
	Woody crops			917							917
	Annual crops				8594						8594
	Maquia					4898			8		4905
	Other GL						7666		15		7681
	WL							28	1		29
	SL								8820		8820
	OL								7	372	379
	Total end 1998	67	143	917	8594	4951	7774	38	8851	372	31535

	Year 1998-1999										
	TO	Coniferous forest	Mixed forest	Woody crops	Annual crops	Maquia	Other GL	WL	SL	OL	Total end 1998
FROM	Coniferous forest	67									67
	Mixed forest		143								143
	Woody crops			917							917
	Annual crops				8594						8594
	Maquia					4951			8		4898
	Other GL						7651		15		7666
	WL							27	1		28
	SL								8851		8851
	OL								7	365	372
	Total end 1999	67	143	917	8594	4951	7651	27	8882	365	31535

	Year 1999-2000										
	To	Coniferous forest	Mixed forest	Woody crops	Annual crops	Maquia	Other GL	WL	SL	OL	Total end 1999
FROM	Coniferous forest	67									67
	Mixed forest		143								143
	Woody crops			917							917
	Annual crops				8594						8594
	Maquia					4883			8		4890
	Other GL						7635		15		7651

	WL							25	1		27
	SL								8882		8882
	OL								7	358	365
	Total end 2000	67	143	917	8594	4883	7635	25	8913	358	31535

	YEAR 2000-2001										
	To	Coniferous forest	Mixed forest	Woody crops	Annual crops	Maquia	Other GL	WL	SL	OL	Total end 2000
FROM	Coniferous forest	67									67
	Mixed forest		143								143
	Woody crops			917							917
	Annual crops				8594						8594
	Maquia					4883					4883
	Other GL			33	161	14	7410		12	5	7635
	WL							25			25
	SL								8913		8913
	OL									358	358
	Total end 2001	67	143	951	8755	4897	7410	25	8925	363	31535

	YEAR 2001-2002										
	To	Coniferous forest	Mixed forest	Woody crops	Annual crops	Maquia	Other GL	WL	SL	OL	Total end 2001
FROM	Coniferous forest	67									67
	Mixed forest		143								143
	Woody crops			951							951
	Annual crops				8755						8755
	Maquia					4897					4897
	Other GL			33	161	14	7185		12	5	7410
	WL							25			25
	SL								8925		8925
	OL									363	363
	Total end 2002	67	143	984	8915	4911	7185	25	8937	368	31535

	YEAR 2002-2003										
	To	Coniferous forest	Mixed forest	Woody crops	Annual crops	Maquia	Other GL	WL	SL	OL	Total end 2002
FROM	Coniferous forest	67									67
	Mixed forest		143								143
	Woody crops			984							984
	Annual crops				8915						8915
	Maquia					4911					4911
	Other GL			33	161	14	6960		12	5	7185

	WL							25			25
	SL								8937		8937
	OL									368	368
	Total end 2003	67	143	1017	9076	4926	6960	25	8949	372	31535

	YEAR 2003-2004										
	TO	Coniferous forest	Mixed forest	Woody crops	Annual crops	Maquia	Other GL	WL	SL	OL	Total end 2003
FROM	Coniferous forest	67									67
	Mixed forest		143								143
	Woody crops			1017							1017
	Annual crops				9076						9076
	Maquia					4926					4926
	Other GL			33	161	14	6735		12	5	6960
	WL							25			25
	SL								8949		8949
	OL									372	372
	Total end 2004	67	143	1051	9237	4940	6735	25	8960	377	31535

	YEAR 2004-2005										
	To	Coniferous forest	Mixed forest	Woody crops	Annual crops	Maquia	Other GL	WL	SL	OL	Total end 2004
FROM	Coniferous forest	67									67
	Mixed forest		143								143
	Woody crops			1051							1051
	Annual crops				9237						9237
	Maquia					4940					4940
	Other GL			33	161	14	6510		12	5	6735
	WL							25			25
	SL								8960		8960
	OL									377	377
	Total end 2005	67	143	1084	9398	4955	6510	25	8972	382	31535

	YEAR 2005-2006										
	To	Coniferous forest	Mixed forest	Woody crops	Annual crops	Maquia	Other GL	WL	SL	OL	Total end 2005
FROM	Coniferous forest	67									67
	Mixed forest		143								143
	Woody crops			1084							1084
	Annual crops				9398						9398
	Maquia					4955					4955
	Other GL			33	161	14	6285		12	5	6510

	WL							25			25
	SL								8972		8972
	OL									382	382
	Total end 2006	67	143	1118	9559	4969	6285	25	8984	386	31535

	Year 2006-2007										
	TO	Coniferous forest	Mixed forest	Woody crops	Annual crops	Maquia	Other GL	WL	SL	OL	Total end 2006
	Coniferous forest	67									67
	Mixed forest		143								143
	Woody crops			1118							1118
FROM	Annual crops				9559						9559
	Maquia					4969					4969
	Other GL			21	124	3	6132		5	0	6285
	WL							25			25
	SL								8984		8984
	OL									386	386
	Total end 2007	67	143	1139	9682	4972	6132	25	8989	386	31535

	Year 2007-2008										
	To	Coniferous forest	Mixed forest	Woody crops	Annual crops	Maquia	Other GL	WL	SL	OL	Total end 2007
	Coniferous forest	67									67
	Mixed forest		143								143
	Woody crops			1139							1139
FROM	Annual crops				9682						9682
	Maquia					4972					4972
	Other GL			21	124	3	5980		5	0	6132
	WL							25			25
	SL								8989		8989
	OL									386	386
	Total end 2008	67	143	1159	9806	4974	5980	25	8994	386	31535

	YEAR 2008-2009										
	To	Coniferous forest	Mixed forest	Woody crops	Annual crops	Maquia	Other GL	WL	SL	OL	Total end 2008
	Coniferous forest	67									67
FROM	Mixed forest		143								143
	Woody crops			1159							1159
	Annual crops				9806						9806
	Maquia					4974					4974
	Other GL			21	124	3	5828		5	0	5980

	WL							25			25
	SL								8994		8994
	OL									386	386
	Total end 2009	67	143	1180	9930	4977	5828	25	8999	386	31535

	YEAR 2009-2010										
	To	Coniferous forest	Mixed forest	Woody crops	Annual crops	Maquia	Other GL	WL	SL	OL	Total end 2009
	Coniferous forest	67									67
	Mixed forest		143								143
	Woody crops			1180							1180
FROM	Annual crops				9930						9930
	Maquia					4977					4977
	Other GL			21	124	3	5675		5	0	5828
	WL							25			25
	SL								8999		8999
	OL									386	386
	Total end 2010	67	143	1201	10054	4979	5675	25	9004	387	31535

	YEAR 2010-2011										
	To	Coniferous forest	Mixed forest	Woody crops	Annual crops	Maquia	Other GL	WL	SL	OL	Total end 2010
	Coniferous forest	67									67
	Mixed forest		143								143
	Woody crops			1201							1201
FROM	Annual crops				10054						10054
	Maquia					4979					4979
	Other GL			21	124	3	5523		5	0	5675
	WL							25			25
	SL								9004		9004
	OL									387	387
	Total end 2011	67	143	1222	10177	4982	5523	25	9009	387	31535

	YEAR 2011-2012										
	To	Coniferous forest	Mixed forest	Woody crops	Annual crops	Maquia	Other GL	WL	SL	OL	Total end 2011
	Coniferous forest	67									67
FROM	Mixed forest		143								143
	Woody crops			1222							1222
	Annual crops				10177						10177
	Maquia					4982					4982
	Other GL			21	124	3	5371		5	0	5523

	WL							25			25
	SL								9009		9009
	OL									387	387
	Total end 2012	67	143	1243	10301	4985	5371	25	9014	387	31535

	YEAR 2012-2013										
	To	Coniferous forest	Mixed forest	Woody crops	Annual crops	Maquia	Other GL	WL	SL	OL	Total end 2012
FROM	Coniferous forest	67									67
	Mixed forest		143								143
	Woody crops			1243							1243
	Annual crops				10301						10301
	Maquia					4985					4985
	Other GL			21	124	3	5218		5	0	5371
	WL							25			25
	SL								9014		9014
	OL									387	387
	Total end 2013	67	143	1264	10425	4987	5218	25	9019	387	31535

	YEAR 2013-2014										
	To	Coniferous forest	Mixed forest	Woody crops	Annual crops	Maquia	Other GL	WL	SL	OL	Total end 2013
FROM	Coniferous forest	67									67
	Mixed forest		143								143
	Woody crops			1264							1264
	Annual crops				10425						10425
	Maquia					4987					4987
	Other GL			21	124	3	5066		5	0	5218
	WL							25			25
	SL								9019		9019
	OL									387	387
	Total end 2014	67	143	1285	10549	4990	5066	25	9024	387	31535

6.4 FOREST LAND (CRF CATEGORY 4A)

6.4.1 FOREST LAND - FOREST LAND REMAINING FOREST LAND (4.A.1)

6.4.1.1 Category Description

Under this category, reported removals are limited to sub-category Forest Land remaining Forest Land. CO_2 emissions from living biomass, dead organic matter and soils, were calculated using a Tier 1 method. It is to note that in accordance with such a method, the net change of CO_2 for dead organic matter is equal to zero as it is assumed that the average transfer rate of CO_2 into the dead wood pool is equal to the transfer rate out of the dead wood pool. This assumption also applies for soils.

The Forest Land category includes carbon dioxide removals from above ground biomass from woodland and mixed forest. No harvest or logging industries exist in Malta. Woodland is protected under Maltese legislation, namely Legal Notice 12 of 2001 'Trees and Woodland (Protection) Regulations'. The evergreen woodland is dominated by evergreen tree species such as oak (*Quercus ilex*) and Aleppo pine (*Pinus halepensis*); however very few old oak trees still exist. The land area for sub-category Forest Land remaining Forest Land is taken from the 2012 Corine Land Cover data.

The largest areas are Mizieb and Buskett area. None of these woodland areas are utilized for logging (MRRA 2009). Both areas are under a management plan under the responsibility of MEPA. Buskett Woodland is a result of afforestation that started during the Knights of St. John's period who used the area for hunting activities. Today a large part of Buskett Woodland is semi-natural woodland. There are still some areas that are managed particularly the citrus groves from the alcove to the picnic area. The land management at Il-Buskett is particularly unique for a Special Area of Conservation in Malta. It is one of a handful of sites that are actively managed by the Government. Certain parts of the woodland are under direct management of the ELC consortium through a Private-Public Partnership agreement with the Government of Malta while the Directorate for Parks, Afforestation and Countryside Restoration (PARKS) within the Ministry for Sustainable Development, the Environment and Climate Change is responsible for the woodland. There are a number of plans to rehabilitate the area. Specific interest is ensuring that forested areas are safeguarded, enhanced and positively promoted (MRRA, 2009).

Mizieb area is also part of the Natura 2000 network but is largely privately owned. The site is mainly managed by the area's landowners who use the area for its agricultural value. A number of landowners have received funding in order to conserve the area. Some invasive alien species have been removed and replaced by the Sandarac Gum tree (MEPA 2015). The Miżieb Special Area of Conservation incorporates a plateau that has been weathered to give a karstic landscape bounded by a steep scarp that indents to form the headwaters of two small valleys which flow into Wied il-Miżieb. The southern half of the site is located below the coralline plateau and consists of a mixture of used and abandoned agricultural land.

6.4.1.2 Methodological Issues

Area coverage data was obtained from the Corine Land Cover 2006 which was made available by MEPA. The methodologies used are those available in the IPCC Good Practice Guidelines (IPCC, 2003). The removal factors utilised are default values.

Equations 3.2.4 and 3.2.5 A of the Good Practice Guidelines have been used to estimate CO_2 emissions from Coniferous Wooded Land and from Mixed Forest:

EQUATION 3.2.4
ANNUAL INCREASE IN CARBON STOCKS DUE TO BIOMASS INCREMENT IN FOREST LAND REMAINING FOREST LAND

$$\Delta C_{FF_G} = \sum_{ij} (A_{ij} \bullet G_{TOTAL_{ij}}) \bullet CF$$

ΔC_{FF_G} = annual increase in carbon stocks due to biomass increment in forest land remaining forest land by forest type and climatic zone, tonnes C yr^{-1}

A_{ij} = area of forest land remaining forest land, by forest type (i = 1 to n) and climatic zone (j = 1 to m), ha

$G_{TOTAL_{ij}}$ = average annual increment rate in total biomass in units of dry matter, by forest type (i = 1 to n) and climatic zone (j = 1 to m), tonnes d.m. ha^{-1} yr^{-1}

CF = carbon fraction of dry matter (default = 0.5), tonnes C (tonne d.m.)$^{-1}$

EQUATION 3.2.5
AVERAGE ANNUAL INCREMENT IN BIOMASS

$G_{TOTAL} = G_W \bullet (1 + R)$	(A)	In case aboveground biomass increment (dry matter) data are used directly. Otherwise G_W is estimated using equation B or its equivalent
$G_W = I_V \bullet D \bullet BEF_1$	(B)	In case net volume increment data are used to estimate G_W.

G_{TOTAL} = average annual biomass increment above and belowground, tonnes d.m. ha^{-1} yr^{-1}

G_W = average annual aboveground biomass increment, tonnes d.m. ha^{-1} yr^{-1}; Tables 3A.1.5 and 3A.1.6

R = root-to-shoot ratio appropriate to increments, dimensionless; Table 3A.1.8

I_V =average annual net increment in volume suitable for industrial processing, m^3 ha^{-1} yr^{-1}; Table 3A.1.7

D = basic wood density, tonnes d.m. m^{-3}; Table 3A.1.9

BEF_1 = biomass expansion factor for conversion of annual net increment (including bark) to aboveground tree biomass increment, dimensionless; Table 3A.1.10

For the calculation of dead wood, litter and mineral soils for sub-category Forest Land remaining Forest Land, Tier 1 was used. In the CRF tables this is indicated as zero. Soil organic is considered as Not Occurring (NO) for Malta. Organic soils are sparse or nonexistent in Malta. No long term data is available to assess whether organic matter in Maltese soils is in fact declining. Baseline data shows that 58% of soils have soil organic carbon content below the threshold of 2% (MEPA, 2006) (MEPA, 2010).

For the calculation of change in carbon stocks in dead wood, Equation 3.2.11 of the Good Practice Guidance, Option 1 was estimated.

EQUATION 3.2.11
ANNUAL CHANGE IN CARBON STOCKS IN DEAD WOOD IN FOREST LAND REMAINING FOREST LAND (OPTION 1)

$$\Delta C_{FF_{DW}} = [A \bullet (B_{into} - B_{out})] \bullet CF$$

Where:

$\Delta C_{FF\ DW}$ = Annual change in carbon stocks in dead wood in forest land remaining forest land, tonnes C yr^{-1}A = size of land (ha)B_{into}= average annual transfer into dead wood d.m $ha^{-1}yr^{-1}$

B_{out}= average annual transfer out of dead wood d.m $ha^{-1}yr^{-1}$

CF = carbon fraction of dry matter (default=0.5), tonnes C.

As regards litter, annual change in carbon stocks was calculated using the following equation:

EQUATION 3.2.13
ANNUAL CHANGE IN CARBON STOCKS IN LITTER IN FOREST LAND REMAINING FOREST LAND

$$\Delta C_{FF_{LT}} = \sum_{i,j} [(C_j - C_i) \bullet A_{ij}] / T_{ij}$$

where,

$$C_i = LT_{ref(i)} \bullet f_{man\ intensity(i)} \bullet f_{dist\ regime(i)}$$

Where:

$\Delta C_{FF_{LT}}$ = annual change in carbon stocks in litter, tonnes C yr^{-1}

C_i = stable litter stock, under previous state *i*, tonnes C ha^{-1}

C_j = stable litter stock, under current state *j*, tonnes C ha^{-1}

A_{ij} = forest area undergoing a transition from state *i* to *j*, ha

T_{ij} = time period of the transition from state *i* to state *j*, yr. The default is 20 years

$LT_{ref(i)}$ = the reference stock of litter under native, unmanaged forest, corresponding to state *i*, tonnes C ha^{-1}

$f_{man\ intensity(i)}$ = adjustment factor reflecting the effect of management intensity or practices on LT_{ref} in state *i*, dimensionless

$f_{dist\ regime(i)}$= adjustment factor reflecting a change in the disturbance regime with respect to LT_{ref} in state *i*, dimensionless

The default value for the 'time period of the transition from state' parameter is 20 yrs.

It was assumed that the average transfer rate into the litter pool is equal to the transfer rate out of the litter pool, so the net change is zero. This assumption means that the magnitude of the litter pool does not need to be quantified.

For mineral soils, the equation used for estimation of annual change in carbon stocks was the following:

EQUATION 3.2.14
ANNUAL CHANGE IN CARBON STOCKS IN MINERAL SOILS IN FOREST LAND REMAINING FOREST LAND

$$\Delta C_{FF_{MINERAL}} = \sum_{ij} [(SOC_j - SOC_i) \bullet A_{ij}] / T_{ij}$$

Where,

$$SOC_i = SOC_{ref} \bullet f_{forest\ type\ (i)} \bullet f_{man\ intensity\ (i)} \bullet f_{dist\ regime\ (i)}$$

Where:

$\Delta C_{FF_{Mineral}}$ = annual change in carbon stocks in mineral soils in forest land remaining forest land, tonnes C yr^{-1}

SOC_i = stable soil organic carbon stock, under previous state i, tonnes C ha^{-1}

SOC_j = stable soil organic carbon stock, under current state j, tonnes C ha^{-1}

A_{ij} = forest area undergoing a transition from state i to j, ha

T_{ij} = time period of the transition from SOC_i to SOC_j, yr. The default is 20 years.

SOC_{ref} = the reference carbon stock, under native, unmanaged forest on a given soil, tonnes C ha^{-1}

$f_{forest\ type\ (i)}$ = adjustment factor reflecting the effect of a change from the native forest to forest type in state i, dimensionless

$f_{man\ intensity\ (i)}$ = adjustment factor reflecting the effect of management intensity or practices on forest in state i, dimensionless

$f_{dist\ regime\ (i)}$ = adjustment factor reflecting the effect of a change in the disturbance regime to state i with respect to the native forest, dimensionless

The same as for the above, the default for 'time period of the transition from state' is 20 years. Under Tier 1 it is assumed that when forest land remains forest land the carbon stock in soil organic matter does not change regardless of changes in forest management types and disturbance regimes; in other words the carbon stock in mineral soils remains constant as long as the land remains forest.

As mentioned previously there is no production of harvested wood products in Malta; therefore this category is taken as not occurring in Malta. Data on wildfires is not available and emissions are thus indicated as Not Estimated (NE).

An issue was encountered when inserting the values in the CRF Reporter system for the category Forest Land remaining Forest Land. The area of perennial crops for the 'carbon stock change' in 'living biomass', 'dead organic matter' and 'soil' child nodes was inserted manually (0.20967848 kha); however the CRF considers the areas as an aggregate for each of the three nodes instead of a single area. As a result, the value for total area in Forest Land remaining Forest Land has tripled (0.62903544 kha), when in fact it is supposed to stay 0.20967848 kh.

6.4.1.3 Uncertainties and time-series consistency
Not applicable.

6.4.1.4 Category-specific QA/QC and verification
Not applicable.

6.4.1.5 Category-specific recalculations

No recalculations were required.

6.4.1.6 Category-specific planned improvements
Improvements are required in data which is still missing on the afforestation areas and addressing the difficulty of collection data relating to trees planted in parts of forested areas, an issue which has also been raised in the project with the University of Malta.

6.4.2 Forest Land - Land converted to forest land (4.A.2)

6.4.2.1 Category Description
This category has not occurred.

6.4.2.2 Methodological Issues
Not applicable.

6.4.2.3 Uncertainties and time-series consistency
Not applicable.

6.4.2.4 Category-specific QA/QC and verification
Not applicable.

6.4.2.5 Category-specific recalculations
Not applicable.

6.4.2.6 Category-specific planned improvements
Not applicable.

6.5 CROPLAND (CRF CATEGROY 4B)

6.5.1 CROPLAND - CROPLAND REMAINING CROPLAND (4.B.1)

6.5.1.1 Category Description

Under this category, CO_2 emissions from living biomass, dead organic matter and soils, from sub-category Cropland remaining Cropland and sub-category Land converted to Cropland have been reported. Removals are almost entirely due to sub-category Cropland remaining Cropland.

In Malta cropland can be split into three types:

i) Arable area which is cultivated under a system of crop rotation;

ii) Kitchen gardens that include small plots of cultivated land, in which most of the products are intended for consumption by the farmer;

iii) Land under permanent crops where the crop occupies the same land for a period of time, normally 5 years or more.

For inventory purposes, local cropland was split into two: annual crops and perennial woody crops.

The change in biomass is only estimated for perennial woody crops. Annual crops are harvested each year, for annual crops, increase in biomass stocks in a single year is assumed equal to biomass losses from harvest and mortality in the same year – thus there is no net accumulation of biomass carbon stocks (IPCC, 2003). Perennial woody vegetation (e.g. in orchards and vineyards) can store significant carbon in long lived biomass. In this inventory process, only the carbon dioxide removal from land under permanent crops has been estimated. Data is taken from the Agriculture and Fisheries 2013 statistics from the National Statistics Office. The total UAA amounted to 11,689 hectares. Agricultural holdings in Malta and Gozo are small, where 9,427 each had a UNAA of less than 1 hectare. Medium-sized agricultural holdings made up 22% of the total; such holdings comprise between one and five hectares, while 2.4% are considered large, each having a minimum of five hectares of UAA. Arable land accounted for 76.7% of the total UAA, while permanent crops and kitchen gardens made up the remaining 10.8% and 12.5% respectively.

According to the 'Rural Development Plan for Malta 2007-2013' (MRRA, 2009), the main perennial crops considered for this inventory are vines, being the most cultivated crop. Furthermore, limited resources did not allow for additional splits into other crops to be carried out. As is stated in the previous section soil organic matter level in Maltese soils is 2% which is considered to be low. The soils' suitability for agronomic purposes is limited by a number of factors, the most important of which include unfavourable soil chemical status as a result of alkalinity and the calcareous nature of the soils, shallow depth to bedrock, low soil organic matter, high soil stoniness, and unfavourable water regime as a result of an impermeable surface crust. Soils with a carbonate and bicarbonate content greater than 25% occupy approximately 91% of the total country area. Very shallow soils (<25cm) and shallow soils (> 25cm and < 50cm) occupy 58% of the country's area. 40% of soils are estimated to contain more than 15% coarse fragments.

Field Burning of Agriculture Residues estimates are not reported as the data available is not sufficient enough; this is therefore considered as Not Estimated (NE).

6.5.1.2 Methodological Issues

As discussed previously only changes in biomass from perennial woody crops are calculated. The methodology used was Method 2 of the IPCC Good Practice Guidance Equation 3.2.4 (the same equation used in section 6.4.1.2) for the annual increase in carbon stock due to biomass increment. The Joint Research Centre (JRC) provided data on dry matter for various tree species; this data relates to countries with conditions similar to Malta's. Vines being taken as being the most abundant crop in Malta, only values of dry matter relating to vineyards have been considered for the purposes of this submission. Malta considers the maturity age for wood crops is 26 years, at which age the carbon stock in these crops is 12 tC/ha. To fill in the data gaps for the years between 1964 and 1970, changes in areas for the period 1970 to 1980 was extrapolated back to 1964.

For Mineral soils Tier 1 method was applied; this results in a value of zero and therefore the annotation Not Estimated (NE) is included in the CRF.

Activity data on perennial crops coverage as available from the 1991 Agriculture Census (NSO, 1993) has been used for the years 1990 to 1998, whereas for the years 1999 onwards activity data on Perennial crops as published by the National Statistics Office has been used (NSO, 2015).

Liming of agricultural soils is not applicable to Malta as soils have large calcium carbonate content (MRAE, 2004). Maltese soil types are classified as Leptosols, Vertisols, Calcisols, Luvisols, Cambisols, Regosols or Arensols (data from the MALSIS database sourced through (MEPA, 2006)). Of these, Calcisols, which occupy approximately 27% of total country area, Luvizols and Leptosols are the most common groups. Calcisols are calcareous (lime-rich) soils with significant accumulation of secondary calcium carbonates, generally developed in dry areas. In Malta, soils are now relict soils because they have developed under different climatic conditions to those of the present age.

The Agriculture Census issued by NSO in 2012 shows that Cropland area size was 11689ha in 2012. This same value has been used for 2013. This same value has been used for 2014.

6.5.1.3 Uncertainties and time-series consistency

Not applicable

6.5.1.4 Category-specific QA/QC and verification

Not applicable

6.5.1.5 Category-specific recalculations

Recalculation has been carried out due to revision in the data on permanent crops. Data for the year 2008 till 2013 data from NSO was revised as shown below in table below.

Table 6-2 Recalculations for the Cropland remaining Cropland

Year	Permanent Crops (Gg CO_2 eq) as reported in the 2016 inventory report	Permanent Crops (Gg CO_2 eq) as reported in the 2015 inventory report	Percentage change in reported emissions (%)
1990	-0.76	-0.76	NA
1991	-0.83	-0.83	NA
1992	-0.83	-0.83	NA
1993	-0.83	-0.83	NA
1994	-0.83	-0.83	NA
1995	-0.83	-0.83	NA
1996	-0.83	-0.83	NA
1997	-0.83	-0.83	NA
1998	-0.83	-0.83	NA
1999	-0.83	-0.83	NA
2000	-0.83	-0.83	NA
2001	-0.83	-0.83	NA
2002	-0.87	-0.87	NA
2003	-0.82	-0.82	NA
2004	-0.84	-0.84	NA
2005	-0.87	-0.87	NA
2006	-0.91	-0.91	NA
2007	-0.94	-0.94	NA
2008	-0.97	-0.99	-2.06
2009	-0.99	-1.03	-3.88
2010	-1.02	-1.09	-6.42
2011	-1.06	-1.14	-7.54
2012	-1.10	-1.20	-8.33
2013	-1.06	-1.19	-10.92

6.5.1.6 Category-specific planned improvements

Investigation on management practices through time needs to be taken into consideration so soil organic carbon (SOC) can be calculated. At present it is equal to zero because till now the management practices were assumed as remaining the same through time. Another task will be that the perennial crops will be split into various crops and by using the Joint Research Centre (JRC) method data on emissions and removals will be more accurate.

6.5.2 CROPLAND - LAND CONVERTED TO CROPLAND (4.B.2)

6.5.2.1 Category Description

Based on expert judgement, land converted to Cropland is taken as being converted from Grassland. The conversion is taken as starting from 2000/2001, assumed at 0.194kHa per annum.

6.5.2.2 Methodological Issues

The methodology used was the same as for the sub-category Cropland remaining Cropland. For CRF reporting purposes, this is notated as Included Elsewhere (IE).

6.5.2.3 Uncertainties and time-series consistency

Not applicable.

6.5.2.4 Category-specific QA/QC and verification

Not applicable.

6.5.2.5 Category-specific recalculations

Not applicable.

6.5.2.6 Category-specific planned improvements

Not applicable.

6.6 GRASSLAND (CRF CATEGORY 4C)

6.6.1 GRASSLAND - GRASSLAND REMAINING GRASSLAND (4.C.1)

6.6.1.1 Category Description

Grassland in Malta is an area of high biodiversity importance. It is protected under the Habitats Directive (Directive 92/43/ECC). As reported in the National Rural Development Strategy 2007-2013 (MRRA, 2012) the extensive permanent grass areas or pastures that are typical of most European countries are non-existent in Malta. Given the prevailing semi-arid climate, geology of the island, relatively shallow depth of soil and small agricultural land parcels, extensive permanent grass areas or pastures that is typical of most temperate European countries is nonexistent. The closest to such land is the *'xaghri',* characterised by a variety of low aromatic shrubs. Effectively, in the past grazing was practiced on such land, as well as on steppe, and this had resulted in the further degradation of 'xaghri' or maquis areas as well as abandoned fields. With the transition from extensive goat and sheep hers to cattle in the 1950s, following outbreaks of Maltese fever, grazing eventually diminished and is now rarely practised, whilst the dairy industry has become mostly reliant on forage harvested as the main cereal crop (MRRA, 2009.

On the basis of Legal Notice 321 of 2011 (Nitrates Action Programme Regulations, as amended) which requires that animals are housed under roofed structures at all times, grazing in Malta is considered as not taking place. Furthermore, the Trees and Woodland Protection Regulations (Legal Notice 12 of 2001) states that no person shall allow or attempt to allow animals to graze in any tree protection area or other protected area.

This category is split into other grassland and maquis. On the basis of expert judgement it was decided that maquis will be included in this category. The data of this category was derived from the Corine Land Cover 1996, 2000, 2006 and 2012 under the sclerophyllous vegetation and sparsely vegetated areas.

6.6.1.2 Methodological Issues

Tier 1 approach was used for the calculation for sub-category Grassland remaining Grassland due to limitations in the availability of data. It is assumed that the increase in biomass stocks in a single year is equal to biomass losses from mortality in that same year; hence, in the CRF, it is annotated as Not Occurring (NO) which for CRF purposes is equivalent to zero. There are no changes in management practices taking place. The change in area of category Grassland was assumed to be due to area converted to category Settlements and category Other Land.

There was no application of mineral and organic fertiliser, organic residues or biological nitrogen.

6.6.1.3 Uncertainties and time-series consistency

Not applicable.

6.6.1.4 Category-specific QA/QC and verification

Not applicable.

6.6.1.5 Category-specific recalculations

No recalculations were required.

6.6.1.6 Category-specific planned improvements

Not applicable.

6.6.2 Grassland - Land converted to Grassland (4.C.2)

6.6.2.1 Category Description

There was no land converted to Grassland.

6.6.2.2 Methodological Issues

Not applicable.

6.6.2.3 Uncertainties and time-series consistency

Not applicable.

6.6.2.4 Category-specific QA/QC and verification

Not applicable.

6.6.2.5 Category-specific recalculations

Not applicable.

6.6.2.6 Category-specific planned improvements

Not applicable

6.7 WETLANDS (CRF CATEGORY 4D)

6.7.1 WETLANDS - WETLANDS REMAINING WETLANDS (4.D.1)

6.7.1.1 Category Description

In the Maltese islands wetlands are mostly saline and therefore are not expected to have a large carbon pool. Wetlands in Malta are protected under various legislations. For the purpose of defining the wetlands, the Ramsar Convention was taken into consideration, with two sites, l-Għadira and is-Simar (Convention, 2014), being designated as such. MEPA is the lead nation agency responsible for designation, regulation and management of these protected areas. As from this year MEPA issued two management plans on these sites to conserve and improve the area. Both sites do not have any acquaculture, salt production, peat extraction, drainage or rewetting.

A number of activities exert pressure on the ecology of the site. The Għadira area is popular with tourists and experiences pressures from recreational activities as well as pressure from development including impacts from noise, trampling, habitat disturbance and habitat loss.

Overuse of fertilizers and pesticides from surrounding agricultural practices exerts pressure on the wetland from eutrophication and water pollution (MEPA, 2015).

6.7.1.2 Methodological Issues

Tier 1 was used due to data-availability limitations. The calculation for this category gives a value of 0, which was reported in the CRF.

6.7.1.3 Uncertainties and time-series consistency

Not applicable.

6.7.1.4 Category-specific QA/QC and verification

Not applicable.

6.7.1.5 Category-specific recalculations

Not applicable.

6.7.1.6 Category-specific planned improvements

The aim is to take into consideration data that is available in the management plan for this category.

6.7.2 Wetlands - Land converted to wetlands (4.D.2)

6.7.2.1 Category Description

Throughout the years there was no land converted to Wetland.

6.7.2.2 Methodological Issues

Not applicable.

6.7.2.3 Uncertainties and time-series consistency

Not applicable.

6.7.2.4 Category-specific QA/QC and verification

Not applicable.

6.7.2.5 Category-specific recalculations

Not applicable.

6.7.2.6 Category-specific planned improvements

Not applicable

6.8 SETTLEMENTS (CRF CATEGORY 4E)

6.8.1 Settlements - Settlements remaining settlements (4.E.1)

6.8.1.1 Category Description

Settlements are defined as all developed land, including transportation infrastructure and human settlements of any size. The land-use category Settlements includes all classes of urban tree formations, namely trees grown along roads and streets, in public and private gardens, and in cemeteries, airports, construction sites, dumpsites, industrial or commercial units, port areas and sport and leisure facilities.

6.8.1.2 Methodological Issues

A Tier 1 methodology has been used, which assumes that carbon stock in living biomass, dead organic matter and soil organic carbon is in equilibrium. This is based on advice given during reviews.

6.8.1.3 Uncertainties and time-series consistency

Not applicable.

6.8.1.4 Category-specific QA/QC and verification

Not applicable.

6.8.1.5 Category-specific recalculations

Not applicable.

6.8.1.6 Category-specific planned improvements

Not applicable.

6.8.2 Settlements - Land converted to Settlements (4.E.2)

6.8.2.1 Category Description

From the year 1990 till 1999 there was land converted to settlement from categories Grassland, Wetland and Other Land. As from the year 2000 land converted to settlement is coming from category Grassland. On expert judgement it was suggested that any category could change to Settlement.

6.8.2.2 Methodological Issues

In this sub category Tier 1 methodology has been used, which assumes that carbon stock in living biomass, DOM and SOC is in equilibrium. This is based on advice given during reviews.

6.8.2.3 Uncertainties and time-series consistency

Not applicable.

6.8.2.4 Category-specific QA/QC and verification

Not applicable.

6.8.2.5 Category-specific recalculations

Not applicable.

6.8.2.6 Category-specific planned improvements

Not applicable.

6.9 OTHER LAND (CRF CATEGORY 4F)

6.9.1 Other Land - Other land remaining other land (4.F.1)

6.9.1.1 Category Description

This section includes bare soil, rock, and all unmanaged land areas that do not fall into any of the other five categories. It allows the total sum of identified land areas to match the total national area. Change in carbon stocks and non-CO_2 emissions and removals are not considered, assuming that it is typically unmanaged. Mineral extraction sites in Malta are included under this land-use category. Only land area is reported in the CRF tables. As from the year 2000 there was an increase in area for category 'Other land' due to conversion from Grassland.

6.9.1.2 Methodological Issues

Not applicable.

6.9.1.3 Uncertainties and time-series consistency

Not applicable.

6.9.1.4 Category-specific QA/QC and verification

Not applicable.

6.9.1.5 Category-specific recalculations

Not applicable.

6.9.1.6 Category-specific planned improvements

Not applicable.

6.9.2 Other Land - Land converted to other land (4.F.2)

6.9.2.1 Category Description

This category has not been estimated.

6.9.2.2 Methodological Issues

Not applicable.

6.9.2.3 Uncertainties and time-series consistency

Not applicable.

6.9.2.4 Category-specific QA/QC and verification

Not applicable.

6.9.2.5 Category-specific recalculations

Not applicable.

6.9.2.6 Category-specific planned improvements

Not applicable

6.10 HARVESTED WOOD PRODUCTS (CRF CATEGORY 4G)

6.10.1 Category Description

This category does not occur in Malta. In the CRF it is reported as NO.

6.10.2 Methodological Issues

Not applicable.

6.10.3 Uncertainties and time-series consistency

Not applicable.

6.10.4 Category-specific QA/QC and verification

Not applicable.

6.10.5 Category-specific recalculations

Not applicable.

6.10.6 Category-specific planned improvements

Not applicable.

6.11 OTHER (CRF CATEGORY 4H)

6.11.1 Category Description

Not applicable.

6.11.2 Methodological Issues
Not applicable.

6.11.3 Uncertainties and time-series consistency
Not applicable.

6.11.4 Category-specific QA/QC and verification
Not applicable.

6.11.5 Category-specific recalculations
Not applicable.

6.11.6 Category-specific planned improvements
Not applicable

Chapter 7. WASTE (CRF SECTOR 5)

7.1 OVERVIEW OF SECTOR

In the waste sector, emissions generated from waste management practices over the period 1990 to 2013 are presented. Emission source categories include Solid Waste Disposal (5A), Biological treatment of Solid Waste (5B), Incineration and Open Burning of Waste (5C), and Wastewater Treatment and Discharge (5D).

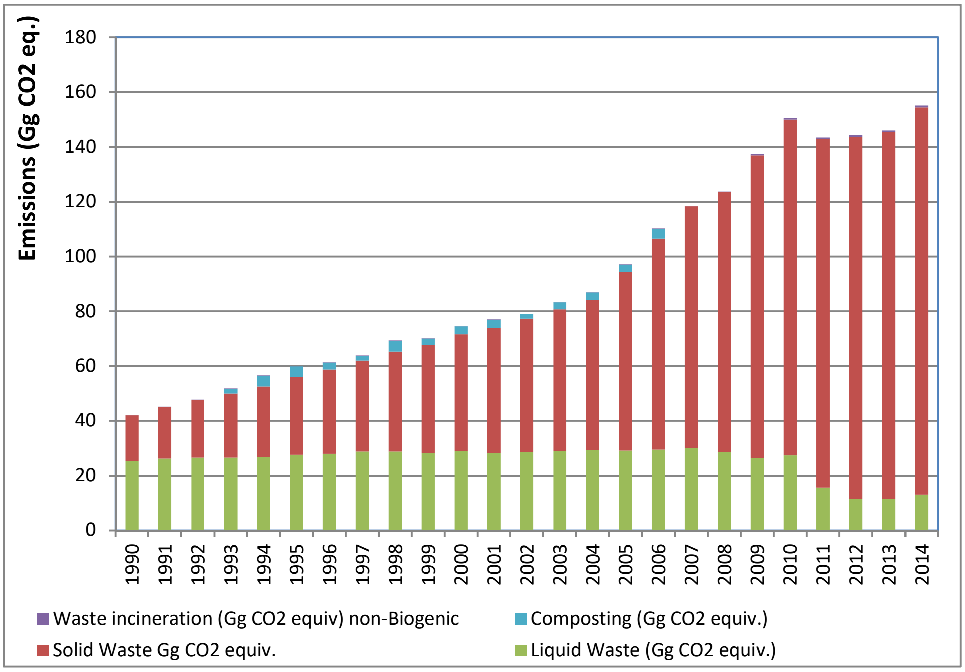

Figure 7-1 Total emissions for sector Waste

The waste sector contributes 5.28% to the total GHG emissions within this inventory, as estimated for 2014. Within the sector, emissions are mainly attributable to Solid Waste Disposal (SWD), specifically disposal on land. A relatively large proportion of emissions reported pertain to methane (CH_4) emitted from landfill operations.

The trend in this sector as presented in Figure 7-1 shows a growth of emissions from this sector throughout the period up to 2010. However, a drastic decrease in emissions is manifest in the years 2011-2013, mainly in sectors 5A and 5D (Solid Waste Disposal and Wastewater Management). The reasons behind this abrupt change of trends are further explained in detail in the sections discussing respective categories and can be summarised as the effect of the entry into operation of specific installations aimed at reducing emissions from these sectors.

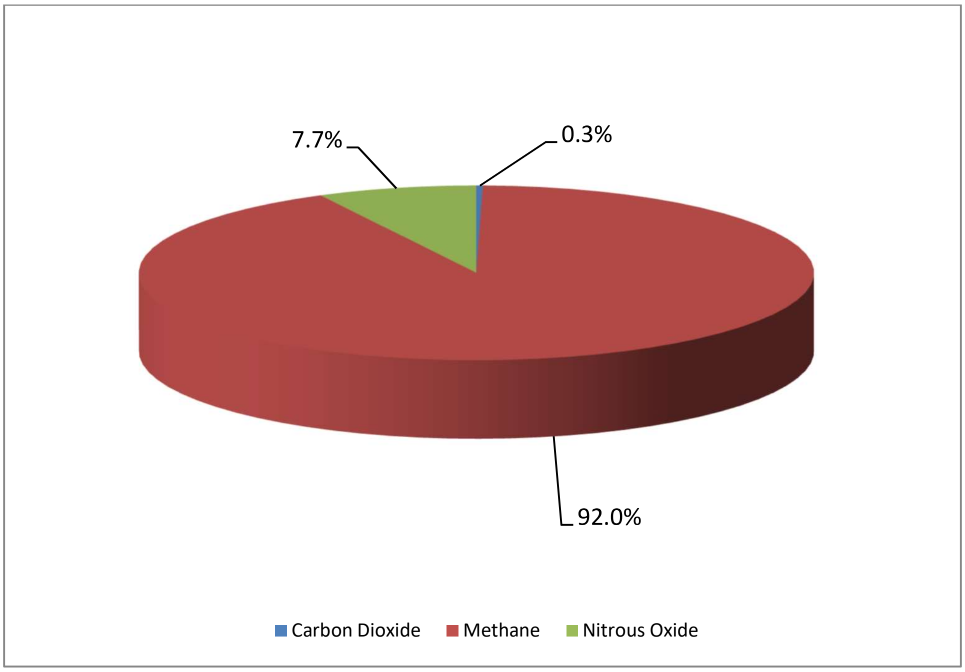

Figure 7-2 Share of emissions, by gas, for sector Waste (% share by gas, based on CO_2 equivalents)

Figure 7-2 shows the contribution in carbon dioxide equivalents of carbon dioxide, methane and nitrous oxide emissions in the latest inventory year. A large proportion is methane emissions resulting from SWD on land. Waste management practices are continuously being improved with newer technologies being planned and implemented mainly in the solid waste treatment sector, with an increased amount of organic fraction being directed to alternative processes (such as Bio-digestion), increased recycling and material recovery and aerobic treatment of liquid waste. The need to divert organics in general from solid waste disposal is the main reason behind such trends.

7.1.1 Waste generation trends

A general look to the local waste generation trends shows relative stability in the totals of waste disposed (excluding recycled waste). The amount of waste being deposited in landfills has stabilised following a sharp decrease in previous years. Wastewater generation volumes also show a very similar trend. Figure 7-3 below illustrates this scenario. Correlations between the activity and resulting emissions, also through a description of the measures implemented that affect this correlation are described in the specific sector's overview.

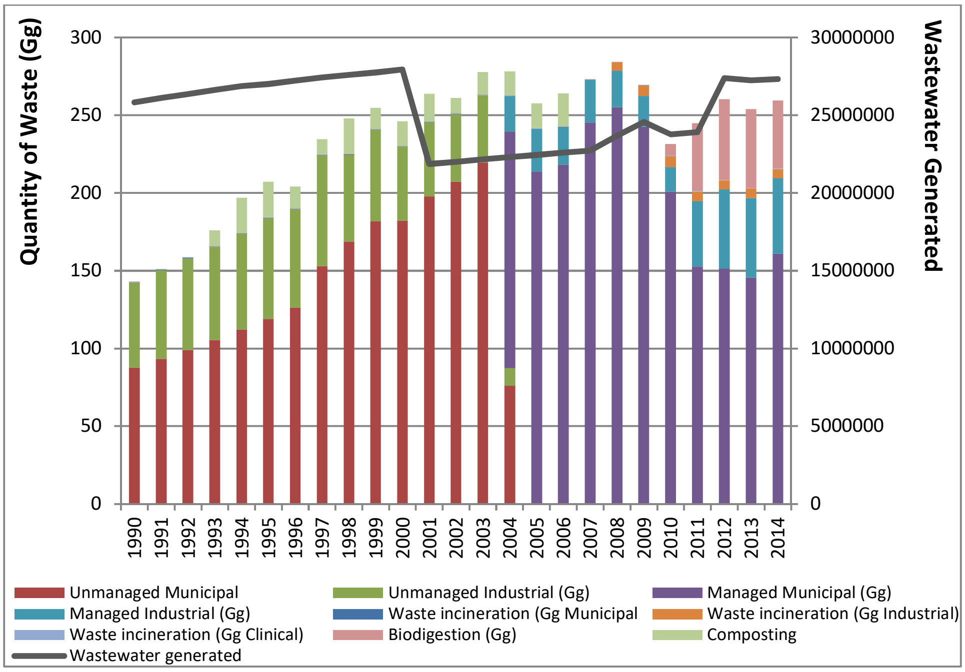

Figure 7-3 Waste disposal trends

7.2 SOLID WASTE DISPOSAL (CRF CATEGORY 5A)

7.2.1 Category Description

The disposal of solid waste in land-based Solid Waste Disposal sites leads to CH_4 emissions through anaerobic decomposition of organic matter in the waste. From 1990 to 1996, solid waste (both municipal and industrial) was deposited into one of three unmanaged landfills: 'Magħtab' and 'Wied Fulija' in Malta and 'Qortin' in Gozo. In 1997 waste stopped being deposited at Wied Fulija, all the waste generated between the years 1997 to 2004 was deposited at Magħtab and Qortin. Eventually, from 2004, waste deposition in unmanaged landfills was stopped, due to requirements under European Union law and all solid waste started to be deposited in the newly opened Ta' Żwejra managed landfill. The Għallis non-hazardous managed landfill also became operational in 2007. The Magħtab, Żwejra and Għallis landfills form part of the Magħtab complex and are geographically adjacent to each other and also share facilities including a Regenerative Treatment Oxidiser (RTO) and Combined Heat and Power (CHP) generation facilities. The Magħtab, Wied Fulija, Qortin, Żwejra and Għallis Landfills are under the responsibility of one operator, namely Wasteserv Malta Ltd. The Operator is a state owned company responsible for permitting, reporting on the closed sites and operation of the active sites. Sites operating post 2004 like Għallis and Ta' Żwejra have operated under an Integrated Pollution Prevention and Control (IPPC) permit.

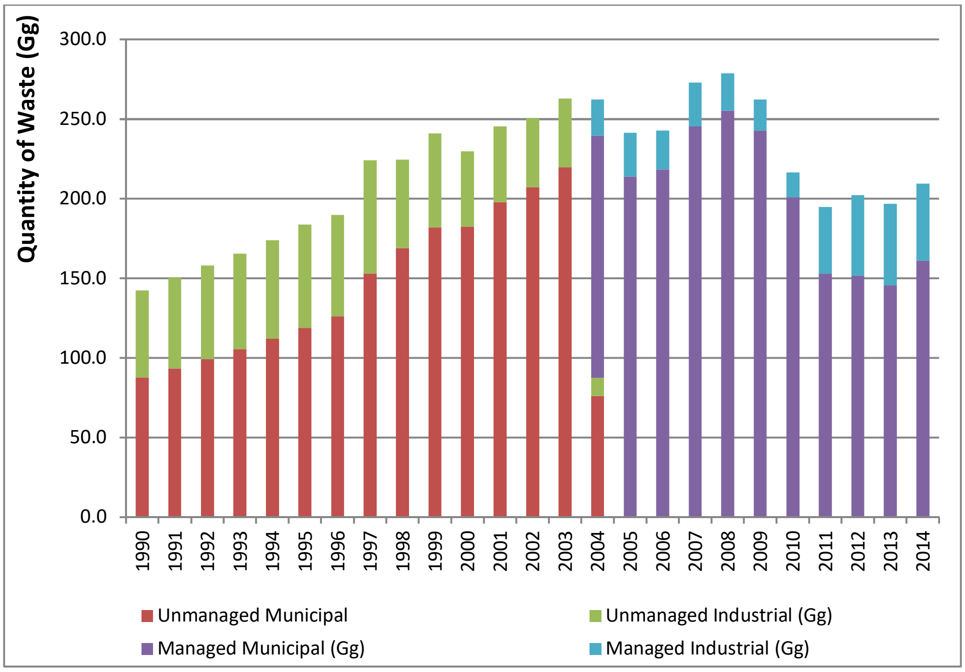

Figure 7-4 Amounts of waste deposited in SWD sites by SWD type

The RTO gas compound at the Magħtab environmental complex became operational in 2008, following this a CHP generation facility was also installed in the same area to generate energy from the landfill oxidised gases. Methane generated in the Magħtab landfill is directed to the RTO. Characteristically, gas from this landfill is too 'poor' in methane to be burned for energy purposes and actually requires the input of energy (through the RTO's electric heaters or gas boosting from the nearby managed landfills) for successful combustion.

Gases from other landfills in the complex are directed to the CHP for energy production purposes. The quantities of methane oxidised to carbon dioxide during operation at the RTO and CHP have been provided for each year of operation. In addition a smaller amount of CH_4 was oxidised to CO_2 via flaring at the Qortin Landfill.

In 2012 Wasteserv Malta Ltd scaled up the collection of gas from the Għallis landfill, through the closure of the first landfill cell, which increased drastically the amount of gas being oxidised on site. This was the main reason behind the greatly reduced emissions from the sector as from 2012. The savings from the reported annual methane emissions from the same landfills has thus been calculated. No significant gas extraction volumes have been reported for the other local landfills.

Prior to 1997 no weighing bridges were available at the Maltese landfills. Hence, the available solid waste statistics prior to 1997 may at best be considered as indicative. The quantities of industrial waste deposited in landfills decreased gradually over the years because of improved recycling practices. As shown in Figure 7-4 above a significant decrease in the amounts of municipal and industrial waste being landfilled is visible from 2009 onwards.

To fill in the gap in activity data between 1990 and 1997 a conservative back extrapolation exercise has been undertaken, using available data on GDP, population, waste/capita and waste/GDP. The data was back extrapolated to 1950 as indicated in the IPCC 2006 guidelines (IPCC, 2006) for the implementation of the Tier 2 First Order Decay Model. An explanation of the back extrapolation of activity data is presented in Annex 3.

7.2.2 Methodological Issues

A First Order Decay (FOD) spreadsheet model has been used to work out methane emissions from the solid waste category. This model method uses (IPCC, 2006) default parameters as well as country specific activity data. This method assumes that the degradable organic component in the waste decays slowly over the course of a few decades. The emissions are highest in the first few years after waste deposition, and then gradually decline as the degradable carbon in the waste is consumed by the bacteria responsible for the decay.

In this waste model, 1950 was chosen as the starting year for waste deposition into landfills.

The following parameters have been selected to represent Malta in the model:

- Region: Southern Europe;
- Climate: Dry Temperate;
- Starting Year for Waste Deposition: 1950;
- Delay Time for methane emissions to start being generated: 6 months;
- % waste going to SWDS = 100%;
- Methane Correction Factor (MCF):
  - unmanaged shallow landfill (1977 – 1987) = 0.4
  - unmanaged deep landfill (1988 – 2004) = 0.8
  - managed deep landfill (2004 onwards) = 1.0;
- Methane Generation Rate Constant (k):
  - for municipal waste = 0.09
  - for industrial waste = 0.08
  - for sewage sludge = 0.06;
- Fraction of Degradable Organic Component (DOC) in waste:
  - for municipal waste = 0.18
  - for industrial waste = 0.15
  - for sewage sludge = 0.05;
- Fraction of Carbon released as CH_4 = 0.5;
- Oxidation Factor (OX) (unmanaged) = 0.6;
- Oxidation Factor (OX) (managed)= 0;
- % content of paper in industrial waste = 14%;
- % content of wood in industrial waste = 5%.

It is notable that the OX factor for unmanaged waste deposition sites is set to a higher value than that stipulated in the guidelines. This modification is based on the findings of a study carried out on behalf of the operator following the installation of the RTO plant at Magħtab, which claimed that more than 50% of the landfill gas produced is actually treated by the RTO and 90% of the methane treated is actually destroyed (Scott Wilson, 2004) (Scott Wilson, 2010). Additionally the findings in the abovementioned study are in line with the findings in (Oonk, 2012), where the RTO collection efficiency varies between 45-75%.

Based on statistics for 2008 (Scott Wilson, 2010), where 0.619 Gg of methane were treated by the RTO, it is also noted that during surface monitoring for the study mentioned prior, a relatively low CH_4 content and a high CO_2 content of the deep-well emissions has been identified. These findings were submitted by MRA to Prof. Alfred Vella[24] of the University of Malta, following which an expert judgment was issued stating that:

- *Oxidation is evidently occurring at the sub-surface levels of the landfill which is more efficient than the biological oxidation process which occurs at the surface of the landfill. To account for this effect the OX factor has to account for oxidation other than simply surface oxidation.*
- *Estimates suggest an oxidation factor of 0.6 would be adequate and would near the true value.*

(Vella, 2013)

To date little or no evidence is available to reflect this same finding in managed landfills.

These findings were further corroborated by the Malta Resources Authority which commissioned a review of the study already finalised (Italiano, 2013). Conclusions from both studies are included in Annex 3.

Municipal waste composition data used in the FOD model was obtained from waste composition surveys carried out by the National Statistics Office (NSO, 2012). The results of the surveys are described in Annex 3.

The parameters described above were only used in managed waste data, since no indications of the municipal waste composition for unmanaged practices prior 2002 can be verified and also noting that unmanaged practices were discontinued from 2004 onwards.

In the current FOD model the landfilling of industrial waste and waste water sludge from aerobic treatment of waste is also included.

7.2.3 UNCERTAINTY AND TIME SERIES CONSISTENCY

Uncertainty is estimated using IPCC good practice guideline (IPCC, 2006). The main component of uncertainty is related to the emission factor and specifically to the use of default methane generation rate constant (k) as per IPCC 2006. It is understood that all activity (waste entering sites) is weighed at the gate. Uncertainty levels are presented in Table 7-1.

Table 7-1 Uncertainty levels for category Solid Waste Disposal

[24] Prof. Alfred J. Vella B.Sc.,M.Sc.,Ph.D.(Col.Sch.Mines.),CSci,CChem,FRSC, Professor and Pro Rector at the University of Malta.

Uncertainty issues for SWD	Managed	Unmanaged
% MSW sent to SWDS	5.00%	10.00%
Total uncertainty in waste composition	60.00%	200.00%
DOC Value	20.00%	20.00%
Percentage of DOC decomposed	20.00%	20.00%
MCF	10.00%	50.00%
Fraction of CH_4 generated at Landfill	5.00%	5.00%
OX factor	NA	50.00%
Half life	20.00%	20.00%
Totals	24.87%	76.10%

For Activity data an uncertainty of ±10% has been used.

Data collected spans back to 1997, prior to which, as previously explained, no weighbridges were used, thus no activity data was collected, international data on such a small economy scale, is in this case considered inadequate. This is why back extrapolation based on common drivers was preferred.

7.2.4 Category-specific QA/QC and verification

Category specific studies have been carried out by the Malta Resources Authority to ensure accuracy and consistency in this chapter. Data provided through the operator, Wasteserv Malta Ltd, is also provided under IPPC permitting and reporting and reviewed accordingly.

7.2.5 Category Specific Recalculations

Following updates in activity data provided the amounts of recovered methane from managed landfills required recalculation, thus net emissions (following subtraction of recovered methane) from the sector were revised accordingly. Table 7-2 illustrates this recalculation.

Table 7-2 Recalculation of CH_4 emissions from Managed Solid Waste Disposal on Land

Year	Total Emissions (Gg CO_2 eq.) as reported in the 2015 inventory report	Total Emissions (Gg CO_2 eq.) as reported in the 2016 inventory report	Percentage change in reported emissions (%)

1990	NO	NO	NO
1991	NO	NO	NO
1992	NO	NO	NO
1993	NO	NO	NO
1994	NO	NO	NO
1995	NO	NO	NO
1996	NO	NO	NO
1997	NO	NO	NO
1998	NO	NO	NO
1999	NO	NO	NO
2000	NO	NO	NO
2001	NO	NO	NO
2002	NO	NO	NO
2003	NO	NO	NO
2004	NO	NO	NO
2005	10.977	10.977	0.00
2006	25.492	25.492	0.00
2007	39.363	39.363	0.00
2008	54.415	54.415	0.00
2009	69.058	69.058	0.00
2010	81.815	81.815	0.00
2011	88.503	88.503	0.00
2012	23.463	95.693	307.85
2013	5.387	97.517	1710.08

7.2.6 Category Specific planned improvements

No current planned improvements.

7.3 BIOLOGICAL TREATMENT OF SOLID WASTE (CRF CATEGORY 5B)

7.3.1 Biological Treatment of Solid Waste - Composting

7.3.1.1 Category Description

The St. Antnin Solid Waste Treatment Plant started operating in 1993. Waste arriving at the plant was either mixed waste or waste separated at source. Mixed wastes were separated mechanically and the biodegradable fraction was composted. Some non-biodegradable materials such as metals and plastics were channelled into recycling, whilst the rejects from mechanical separation were landfilled.

The organic fraction was composted using the open window system with the product raw compost being refined and left in the open to mature. No abatement measures were ever installed at the St. Antnin Solid Waste Treatment Plant (personal communication, WasteServ Malta Ltd, October 2007). The composting plant stopped operating in early 2007 and it was replaced by a Mechanical biological anaerobic treatment plant, the activity of which is accounted for in 7.3.2. Between the decommissioning of this plant in 2007 and the commissioning of the new plant in 2010, no plant scale biological treatment of solid waste operated in Malta.

7.3.1.2 Methodological Issues

Data on biological solid waste treated at the St. Antnin Solid Waste Treatment Plant has been provided by WasteServ Malta Ltd for the operating years 1993 to 2006. Default IPCC 2006 Tier 1 emission factors are used for CH_4 (wet weight basis- 4g CH_4/kg waste composted) and N_2O (wet weight basis- 0.3g N_2O/kg waste composted) respectively.

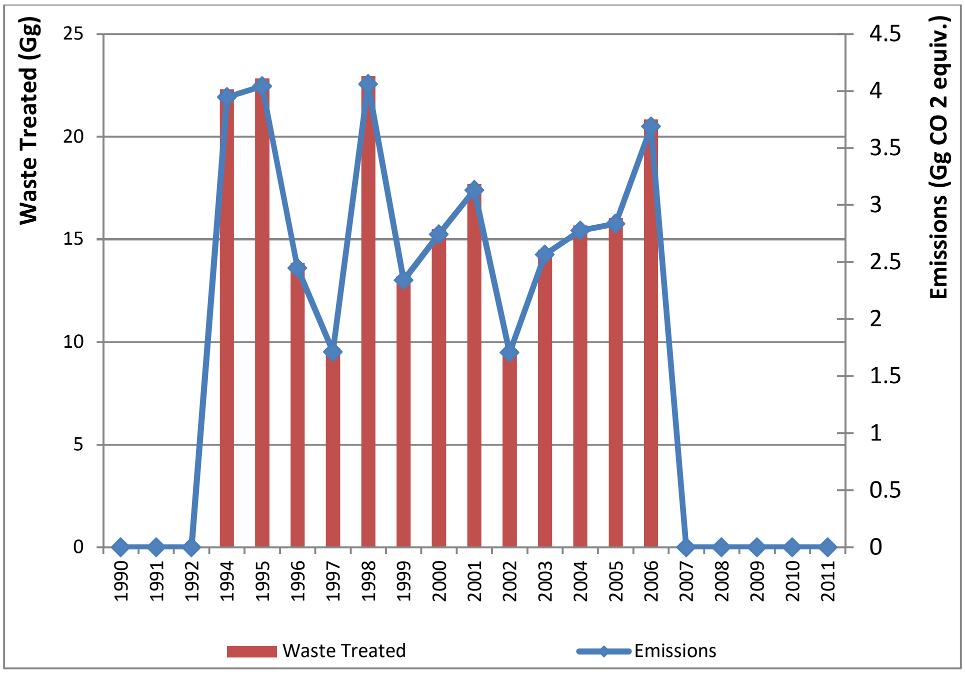

Figure 7-5 Waste treated and emissions from composting

Figure 7-5 shows the different quantities of waste composted during the period 1990 to 2011. The quantities of waste accepted at the St. Antnin plant decreased progressively during the mid 1990s and in 2002 once again in attempts to keep odour emissions within control. The resultant emissions from composting reflect the quantities of degradable municipal waste received at the compost plant.

7.3.1.3 Uncertainty and time series consistency

Not applicable.

7.3.1.4 Category-specific QA/QC and verification

Not applicable.

7.3.1.5 Category Specific Recalculations

No recalculations were required.

7.3.1.6 Category Specific planned improvements

No current planned improvements in this specific category.

7.3.2 Biological Treatment of Solid Waste - Anaerobic Biodigestion of Waste

7.3.2.1 Category Description

The process of Biodigestion expedites the process of decomposition of organic waste through controlled conditions (e.g. temperature moisture and pH) within a reaction vessel. In the conditions set methane is generated and contrary to landfilling it can easily be directed into a combustion system to be used for energy or else flared.

Since 2010 Malta has one plant operating this process (St. Antnin Waste treatment plant following upgrading). The operator of the plant (WasteServ Malta Ltd) is the same operator of the landfills. The plant consists of an MBT plant, which separates the biological fraction of waste from the remainder and this part is sent for anaerobic treatment. The remaining fractions are either recovered or treated elsewhere.

7.3.2.2 Methodological Issues

The calculation used is based on plant specific data supplied by the operator, the operator submits the amount of waste and amount of gas generated and flared (or used for energy) on a yearly basis. The net biogenic CO_2 emissions from flaring are calculated by multiplying the amount of CH_4 flared by 2.75. The proportion which is used for energy is transferred to the specific sub sector in the energy sector.

7.3.2.3 Uncertainty and time series consistency

The time series of this sector contains a number of gaps mainly due to inconsistent operation of biological plants in the country. Two main periods of no operation are identified: 1990-1993 and 2007-2010. No operation periods can be easily explained with the inexistence or unavailability of infrastructure due to the decommissioning and subsequent upgrades of the St Antnin plant.

In terms of uncertainty, specifically in recent inventory years for anaerobic biodigestion, the use of gas monitoring data decreases the uncertainty of emission (Activity Data (AD) x Emission Factor (EF)) to ±10%. This uncertainty can be fully attributed to AD, since the EF in direct measurement is equal to 1 with no uncertainty.

7.3.2.4 Category-specific QA/QC and verification

Not applicable.

7.3.2.5 Category Specific Recalculations

Following the publication of the 9th corrigenda of the 2006 IPCC guidelines and the inclusion of recovery in the tier 1 Emission factor for biological treatment of Solid waste, the sector had to be revised and recalculated. Table 7-3 illustrates the changes. Recalculation only affected the anaerobic Biodigestion of waste and had no effect on composting.

Table 7-3 Recalculation of CH_4 emissions from Biological Treatment of Solid Waste (Anaerobic Digestion of Waste)

Year	Total Emissions (Gg CO2 eq.) as reported in the 2015 inventory report	Total Emissions (Gg CO2 eq.) as reported in the 2016 inventory report	Percentage change in reported emissions (%)
1990	NO	NO	NO
1991	NO	NO	NO
1992	NO	NO	NO
1993	NO	NO	NO
1994	NO	NO	NO
1995	NO	NO	NO
1996	NO	NO	NO
1997	NO	NO	NO
1998	NO	NO	NO
1999	NO	NO	NO
2000	NO	NO	NO
2001	NO	NO	NO
2002	NO	NO	NO
2003	NO	NO	NO
2004	NO	NO	NO
2005	NO	NO	NO
2006	NO	NO	NO
2007	NO	NO	NO
2008	NO	NO	NO
2009	NA	NO	NO
2010	NA	0.153	N/A
2011	NA	0.876	N/A
2012	NA	1.041	N/A
2013	NA	1.013	N/A

7.3.2.6 Category Specific planned improvements

No current planned improvements in this specific category.

7.4 INCINERATION AND OPEN BURNING OF WASTE (CRF CATEGORY 5C)

7.4.1 Category Description

Waste incineration is defined as the combustion of solid and liquid waste in controlled facilities. In Malta, to date the emissions from Waste incineration are minimal (<5% of the total emissions in the Waste sector). This category includes emissions from municipal, clinical and industrial waste incineration, leading to carbon dioxide, methane and nitrous oxide emissions; as well as emissions of the indirect greenhouse gases: nitrogen oxides (NO_x), carbon monoxide (CO), non-methane volatile organic compounds (NMVOC) and sulphur dioxide (SO_2).

Between 1990 and 2007 no regulated/licensed facility existed for Waste incineration in Malta. The facilities in operation at the time were basic and without combustion control. As a precautionary measure their emissions are considered with open burning of Waste rather than as waste incineration. A major improvement took place in early 2008 with the commissioning of a Thermal Treatment Facility in line with the European Union incineration Directive[25]. This incinerator allowed for the decommissioning of old non-compliant local incinerators.

Figure 7-6 shows the emissions in CO_2 equivalents from the combustion of municipal, clinical and industrial waste. The major source of emissions until 2007 was combustion of clinical waste, whereas from 2008, industrial waste incineration has the highest share of emissions in this category. Municipal waste combustion is being reported for the years 1990 to 2003 and intermittently from 2008 onwards. The gap between the latter sets is due to the unavailability of such waste treatment facilities, thus this type of incineration was not-operational.

Figure 7-7 includes the indirect emissions from the combustion of municipal, clinical and industrial waste.

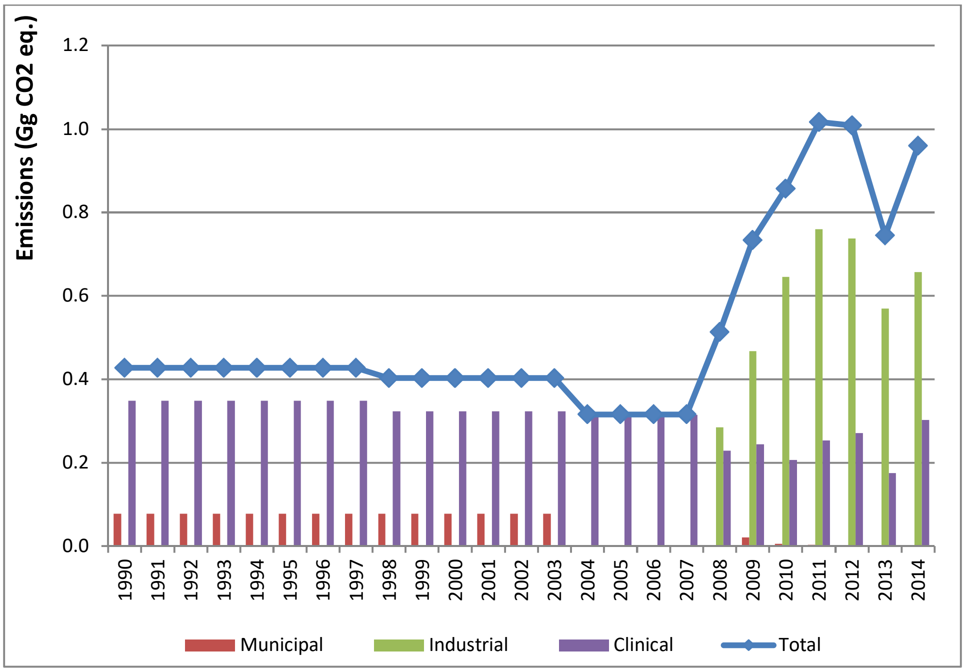

Figure 7-6 Direct GHG emissions from category Incineration

[25] Directive 2000/76/EC of the European Parliament and of the Council of 4 December 2000 on the incineration of waste.

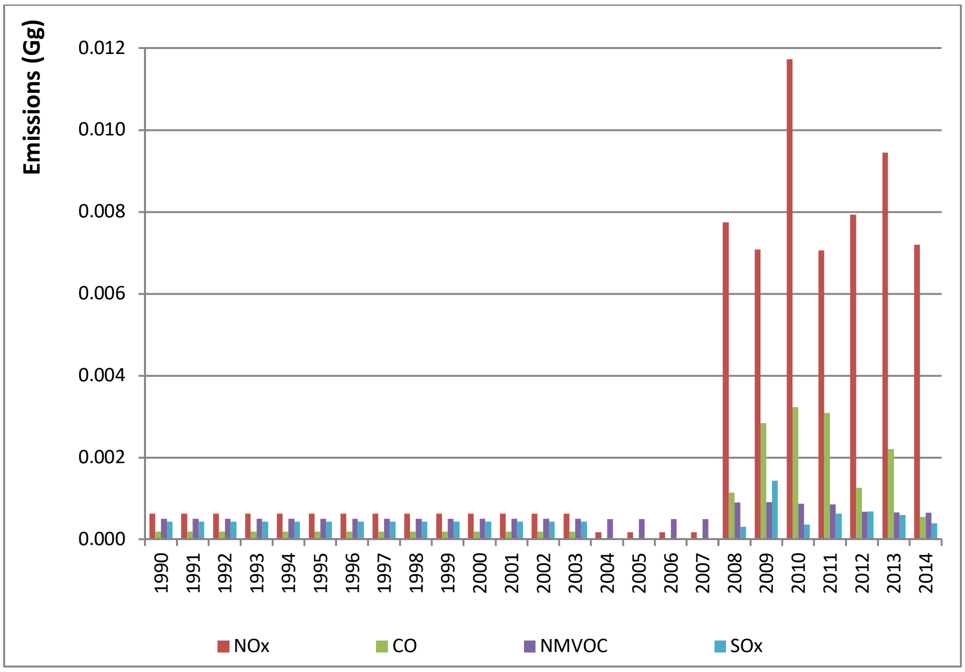

Figure 7-7 Indirect GHG emissions from category Incineration

7.4.2 METHODOLOGICAL ISSUES

7.4.2.1 Municipal Waste Incineration

Under this section the following points are to be considered:

- Shipboard kitchen waste reported under Municipal Waste Incineration was previously incinerated at the Malta Shipyards. Shipyard wastes (sediments or paints) were never incinerated.
- Municipal waste incineration is being reported for the years 1990 to 2003, when the incinerator at the Malta Shipyards was operational.
- On average 0.25Gg of waste, 85% of which is considered to be of biogenic origin, used to be incinerated at the shipyards. It is to be noted that the incinerator coped easily with one tonne of waste daily and had no abatement measures fitted.
- For the year 2008, emissions from the incineration of about 0.1tonnes (0.0001Gg) of paper and cardboard, at the Thermal Treatment Facility have been included.
- During 2004-2007, no plants incinerating MSW were operational.

CO_2 emissions from municipal waste incineration have been calculated using the default IPCC 2006 method, as presented in Table 17-11 for the year 1990. EFs for CH_4 and N_2O used in this section prior to 2007 were equivalent to EFs specified for open burning of Waste. This has been done in order to take due account of the lacking and unregulated infrastructure which was in place at the time. Details of EFs used can be found in Annex 3.

For practicality the plant specific deNO_x and desulphurisation emissions are calculated and included in municipal waste.

DeNO$_x$

In 2011 the Marsa Thermal treatment plant was upgraded with the installation of a deNO$_x$ facility which utilises Urea in liquid form (AdBlue or ISO 22241 compliant fluid) is used to reduce NO$_x$ emissions. During this process of de-noxification, CO_2 is released as a by-product. This emission is calculated by multiplying the amount of AdBlue use reported by an EF of 0.733 tCO_2/m^3 AdBlue.

Desulphurisation

Imported Sodium Bicarbonate is currently being used for desulphurisation. This process is only possible in modern plants, thus no desulphurisation occurred prior to 2008. The amount of bicarbonate consumed by year was obtained from the operator. An emission factor of 0.525t CO_2/t Na_2HCO_3 is used.

7.4.2.2 Clinical Waste Incineration

Two clinical waste incineration facilities existed in the Maltese Islands between 1990 and 2007. During this period, the St Luke's Hospital incinerator provided services for all public and private healthcare institutions on the island of Malta. From a clinical waste survey carried out in 2001 (personal communication, Ministry of Health, 2007) it was found that approximately 1 tonne of clinical waste was produced daily in Malta. In 2006, the St Luke's Hospital incinerator was processing, on average, approximately 910kg of clinical waste per day. No abatement measures were present at the St Luke's Hospital incinerator. The total clinical waste processed by the St Luke's Hospital incinerator in 2006 was estimated at approximately 330 tonnes per year (excluding Gozo).

A second clinical waste incinerator was also operating at the Gozo General Hospital. During the early 1990s, approximately 180kg of contaminated waste per day was incinerated at the Gozo Hospital. This quantity of waste amounts to an estimated 65.7 tonnes of waste incinerated annually. This figure of waste incineration at the Gozo General Hospital is being used for the inventory years 1990 to 1997. For the years 1998 till 2003 a figure of 37.6 tonnes waste incinerated per year as reported in the 1998 MEPA report is being used. For the years 2004 till 2007, a figure of 27.5 tonnes of waste incinerated as reported from waste audits (personal communication, Ministry of Health, 2007), carried out in 2004 is being used. For the year 2008, emissions from the incineration of about 0.26Gg clinical waste at the Thermal Treatment Facility have been reported.

CO_2 emissions from clinical waste incineration are calculated using the default IPCC 2006 method, as presented in Table 17-13 in Annex 3 for the year 1990.

7.4.2.3 Industrial Waste Incineration

Under this category, incineration of paper waste at a local industrial establishment is reported for the inventory years 1990 to 2007, 99% of which is considered as waste of biogenic origin. As indicated by the operator of this facility, the incinerator was more than three decades old and was of a self-burning configuration, that is, no other fuel was used during the burning process. During the years 1990 to 2007, about 0.066Gg of paper waste was incinerated annually (personal communication, private industry representatives, October 2007). Details of this private facility are not listed for reasons of data protection.

CO_2 incineration emissions are calculated using the default IPCC 2006 method, as presented in Table 17-14 in Annex 3 for the year 1990.

7.4.3 Uncertainty and time series consistency

Activity data uncertainty in the latest years is rather low due to the introduction of IPPC permitting and obligatory weighbridges at the entry of incineration plants. The same is not true for the earliest years of the time series. Due to the lack of available data conservative assumptions on activity are included in the calculation of emissions for the period 1990-2007.

In earlier years the EFs calculations for incineration include EFs from open burning due to the lacking infrastructure. However, following the introduction of IPPC regulated plants, much more reliable data on emissions has been provided from facilities which fit the definition of 'controlled facility' in the IPCC 2006 guidelines. Table 7-4 illustrates the quantified uncertainty for this sector.

Table 7-4 Uncertainties for category Waste Incineration

Parameter	CO_2	CH_4	N_2O
Emission factor uncertainty (%)	60.00	100.00	100.00
Activity data uncertainty (%)		10.00	

7.4.4 Category-specific QA/QC and verification

Not Applicable.

7.4.5 Category Specific Recalculations

No recalculations were required. Incomplete data was identified in previous CRF submissions and corrected in this submission.

7.4.6 Category Specific planned improvements

No current planned improvements in this specific category.

7.5 WASTEWATER TREATMENT AND DISCHARGE (CRF CATEGORY 5D)

7.5.1 Wastewater Treatment and Discharge - Domestic and Industrial (5D1, 5D2)

7.5.1.1 Category Description

Malta's sewerage infrastructure consists of two main geographically separate networks that collect both domestic and industrial wastewaters, as well as a portion of storm-water runoff. During the inventory years 1990 up to 2007, a single sewage treatment plant was in operation and catered for only a fraction of the total wastewater generated on the Maltese Islands. The collection treatment and discharge system has recently undergone major upgrades with the building of three new sewage treatment plants. Two of the plants came into operation in 2008, and this is reflected in an increase in the percentage of treated sewage in the years after 2008. The third and largest plant came in operation in late 2010 and was fully operational in 2011. This is reflected in the reduction of methane emissions in 2011 compared to other years. These infrastructural developments represent a near to 100% treatment of all wastewater generated, not considering exceptional events (accidental releases, overload due to storm runoff or plant breakdown), resulting in no emissions of methane and minimal emissions of nitrous oxide from this source category.

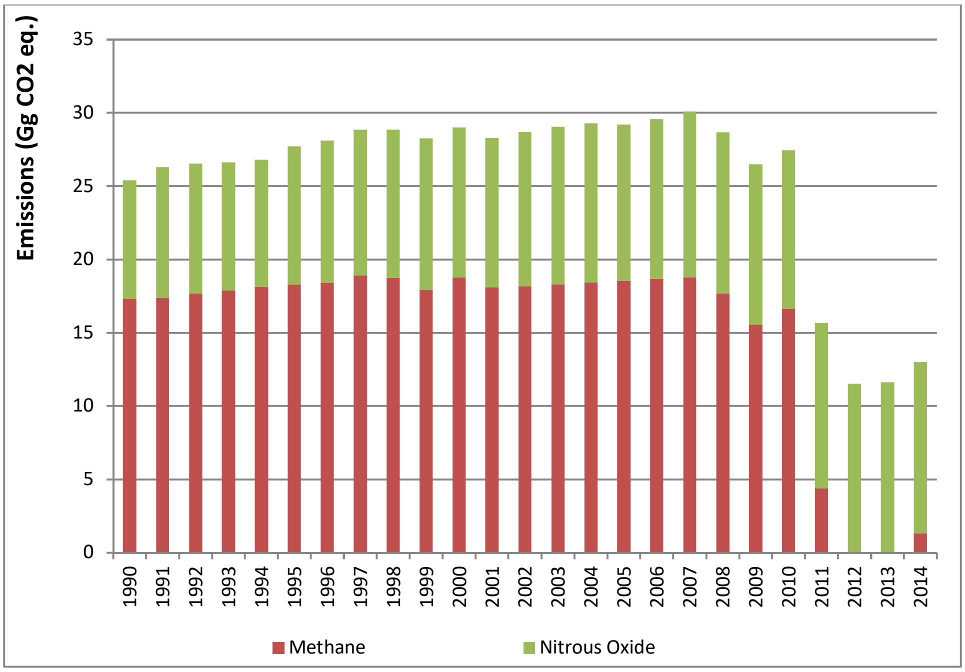

Figure 7-8 GHG emissions for category Wastewater Treatment

7.5.1.2 Methodological Issues

For the period 1990 to 2000, the sewage generation rate for the year 1992 in m^3/capita/year has been used to calculate the total volume of sewage generated annually. For the years 2001 to 2006, the average rate of sewage generation for 2005/2006 has been used to calculate the total volume of sewage generated annually. This is because no data specific to this period is available. For the years 2007 onwards, annual wastewater generation and treatment figures have been provided by the Water Services Corporation.

7.5.1.2.1 Methane emissions

Methane is released where anaerobic conditions prevail. An important factor is the amount of degradable organic component (DOC) in the wastewater, of which a quantitative measure can be taken through the Biological and Chemical oxygen demand of the wastewater (BOD, COD). This DOC in anaerobic conditions will generate methane emissions and the existence of these conditions is subject to the treatment methodology used. Estimates of the total BOD entering the system have been provided by the Wastewater system operator. This includes all BOD (domestic and Industrial) entering the Wastewater handling system. This data is available for 2012 and 2013. It is important to note that the average BOD/capita /year calculated from BOD data submitted is higher than the range of the default factor provided in Table 6.4 of the IPCC 2006 guidelines Volume 5. The average BOD/capita/year of the period 1990-2010 is back extrapolated as the average of the same between 2012 and 2013. An explanation for this could be that animal liquid waste is reportedly introduced in the wastewater handling system.

In Malta's case only two treatment methods are relevant: aerobic treatment in wastewater treatment plants and direct disposal at sea. Through the data collected it is possible to elucidate the amount of wastewater which was directed to both processes and thus the proportion of DOC going into the relevant process. Default emission factors as described in Table 6.3 of Volume 5 of the 2006 IPCC guidelines are used to calculate the emission from each process at this stage.

7.5.1.2.2 Nitrous Oxide emissions

N_2O emissions also occur due to anaerobic conditions during handling or disposal of Wastewater, where the nitrogenous molecules, mostly protein is broken down by specific microorganisms. Aerobic Treatment of wastewater reduces the amount of nitrogen available for formation of N_2O.

- **Direct N_2O emissions from WWT**

Wastewater treatment plants are a small but distinct source of N_2O, emanating from the nutrient removal mechanisms. Even though mainly aerobic, some anaerobic pockets do occur, creating N_2O emissions. Emissions are calculated using equation 6.9 found in Volume 5 of the 2006 IPCC guidelines, assuming, an EF_{PLANT} of 3.2g N_2O/person/year, and also including the default factor for Industrial and domestic co-disposal of wastewater (1.25).

- **Indirect N_2O emissions from Effluent**

Effluent disposed in waterways, in this case the sea, is a source of N_2O. The calculation of this emission is based on the nitrogen content of Wastewater, which in this case is inferred from protein consumption/capita. This data was obtained through the FAOSTAT database; which provides an annual figure for the years 1990-2011. For the remaining years (2012-2013) the 2011 estimate is used until updated data is available from FAOSTAT. Using the protein consumption data, assuming 16% of that mass is nitrogen and assuming an additional 40% for non-consumed protein and 25% for industrial domestic co-disposal, with no Nitrogen being retained as sludge, the Nitrogen Content of Effluent ($N_{EFFLUENT}$) is estimated. From this, N_{PLANT} (the amount of nitrogen resulting in direct emissions from WWT) is subtracted to obtain the net $N_{EFFLUENT}$. A default EF is used as highlighted in Table 6.11 of the 2006 IPCC guidelines is used and equation 6.7 of the same guidelines is used to calculate the N_2O emission.

7.5.1.3 Uncertainty and time series consistency

Uncertainty in both methane and nitrous oxide emissions are summarised in Table 7-5. It is clear that the biggest uncertainty is at EF level especially for N_2O emissions.

Table 7-5 Uncertainty estimates for category Wastewater Treatment

Uncertainty Source	Value (%)
Population	5.0
EF_j	10.0
BOD total	10.0
$T_{i,j}$	10.0
I	20.0
F_{NPR}	10.0
$EF_{Effluent}$	100.0
EF_{PLANTS}	200.0
Annual Protein Consumption	10.0
$F_{IND-COM}$	25.0
$F_{NON-CON}$	10.0
Total Uncertainties	
N_2O_{PLANT} uncertainty	100.9
$N_2O_{EFFLUENT}$ uncertainty	42.7
CH_4 uncertainty	17.5

7.5.1.4 Category-specific QA/QC and verification

Not applicable.

7.5.1.5 Category Specific Recalculations

No recalculations were required.

7.5.1.6 Category Specific planned improvements

No current planned improvements in this specific category.

7.6 BIOGENIC EMISSIONS FROM WASTE

7.6.1 Category Description

A number of waste management practices currently implemented give rise to CO_2 that can be classified as biogenic, thus not being accounted as emissions in the totals estimated for the country. This is mainly because of the changes in waste management practices and implementation of flaring in closed landfills.

7.6.2 Methodological Issues

The major contributors of biogenic CO_2 in the waste sector are the incineration of non-fossil fractions of waste and flaring of methane from landfill gas and, or, biological processes. Only the CO_2 portion of emissions from these processes can be considered biogenic, other gases (CH_4 and N_2O) are accounted for in the previous sections of the specific sectors. Figure 7-9 summarises the emissions of biogenic CO_2 from 1990.

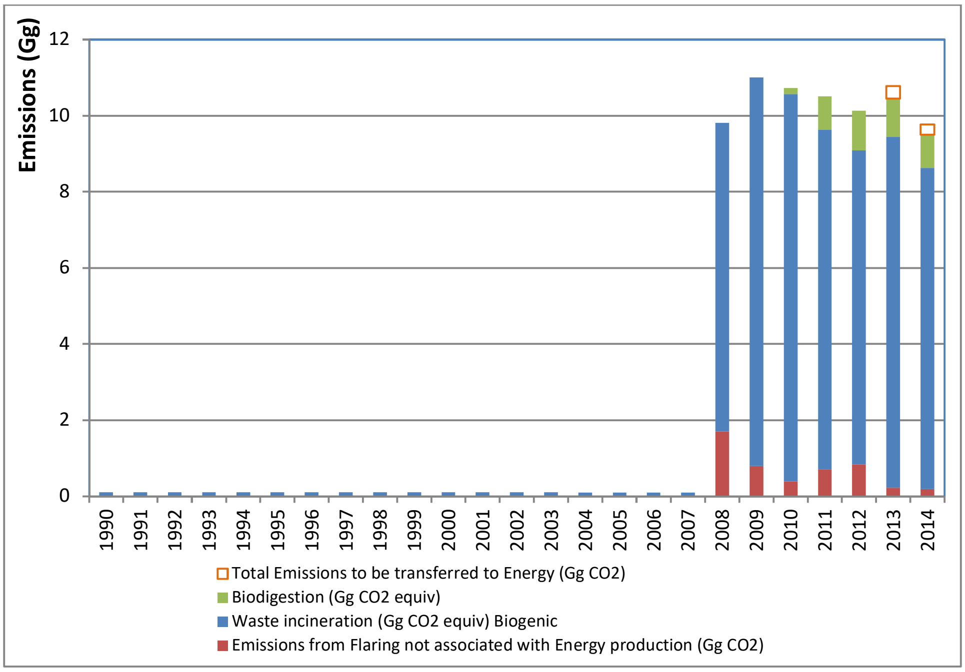

Figure 7-9 CO_2 emissions of biogenic origin from a number of waste processes

Between 1990 and 2006 the non-fossil fraction was assumed using the type of waste and obtained from tables 2.4 and table 2.5 of section 2.3 of the 2006 IPCC guidelines. From 2007 onwards the estimation was done using the distribution and types of waste actually incinerated.

7.6.3 Uncertainty and time series consistency

Uncertainty in this category was not estimated.

7.6.4 Category-specific QA/QC and verification

Not Applicable.

7.6.5 Category Specific Recalculations

No recalculations were required.

7.6.6 Category Specific planned improvements

No current planned improvements in this specific category.

Chapter 8. OTHER (CRF SECTOR 6)

No sources of emissions or sinks have been identified that do not fall under any of the sectors discussed in Chapters 3 to 7 above. To this effect, there is no further information to report under this chapter.

Chapter 9. INDIRECT CO_2 AND N_2O EMISSIONS

Information on indirect CO_2 and N_2O emissions may be found in the sectoral chapters where such emissions occur, namely the chapter relating to source sector Agriculture.

Chapter 10. RECALCULATIONS AND IMPROVEMENTS

Information on recalculations and improvements relating to specific categories is provided in the respective sections in chapters 3 to 9.

Chapter 11. KP-LULUCF Reporting

11.1 GENERAL INFORMATION

This chapter is refers to information related to KP-LULUCF reporting.

11.1.1 Definition of forest and any other criteria

Malta has identified the minimum values for the three relevant parameters. Thus, 'Forest' is defined as '*an area with minimum area of land of 1 hectare, tree crown cover more than 30% and trees minimum height more than 5 meters.*'

11.1.2 Elected activities under Article 3, paragraph 4 of the Kyoto Protocol

Malta confirms 'Forest Management' as the only activity under Article 3(4) of the Kyoto Protocol for inclusion in the accounting for the 2nd Commitment Period of the Kyoto Protocol.

11.2 LAND-RELATED INFORMATION

11.2.1 Spatial assessment used for determining the area of the units of land under Article 3, paragraph 3 of the Kyoto Protocol

The assessment made is the same one that is mentioned in the LULUCF sector chapter (refer to Chapter 6), where datasets are mainly acquired from the Corine Land Cover 2012.

11.2.2 Information on harvested wood products

Malta does not produce any harvested wood products; therefore this category does not occur in Malta.

11.2.3 Information related to natural disturbances

Malta will exclude emissions from natural disturbances.

11.3 INFORMATION RELATING TO ARTICLE 3, PARAGRAPH 4 OF THE KYOTO PROTOCOL

11.3.1 The forest management reference level

Malta is seeking a correction of the Forest Management Reference Level (FMRL) currently inscribed under the Kyoto Protocol.

The European Union report '*Submission of information on forest management reference level by the European Union as requested by Decision 2/CMP6: The Cancun Agreements: Land use, Land Use Change and Forestry*' published in 2011 defined (paragraph 4) the FMRL value for Malta at 0-0.049 Mt CO_2 equivalent/year, indicating that this was derived through extrapolation of historic data on greenhouse removals related to forest management.

Since the national greenhouse gas inventory submission of 2011, Malta has changed the methodology for estimating emissions and removals for the sector LULUCF. Unit that time the category '*Forestland remaining forestland' was taken to include coniferous forest, mixed forest and shrubland (maquis).*

Malta has now a national definition which states that a forest is defined as an area of minimum 1 hectare with a tree crown cover of more than 30% and minimum tree height of 5 meters. This has resulted in shrubland no longer being considered as part of the category 'Forestland', now being classified as part of the category 'Grassland'.

This methodological change leads to the sink value of -49Gg CO_2 equivalent as reported when using the previous methodology being reduced to a net removal for the category '*Forestland remaining forestland'* of -1.2Gg CO_2 equivalent. This means that for Malta, if a FMRL value of -49Gg CO_2 equivalent had to continue being applied, it would always start which a deficit of 47.8Gg CO_2 equivalent when accounting for national emissions under the Kyoto Protocol. Under such a situation Malta would have to surrender an additional amount of Assigned Amount Units equivalent to the deficit. The inconsistency created by the change in methodology used in the determination of the FMRL therefore needs to be addressed through a technical correction.

Chapter 12. Information on Accounting of Kyoto Units

Information relevant to this chapter will be presented in subsequent versions of the report, as may be applicable.

Chapter 13. Information on Changes in National System

An overview of the current system for the compilation of national GHG inventories and recent developments is provided in Chapter 1.

Chapter 14. Information on Changes in National Registry

This is not applicable to Malta because a Kyoto Protocol registry for Malta is not yet in place.

Chapter 15. INFORMATION ON MINIMISATION OF ADVERSE IMPACTS IN ACCORDANCE WITH ARTICLE 3, PARAGRAPH 14

Malta has no information to report on minimisation of adverse impacts.

Chapter 16. OTHER INFORMATION

No other information is being reported.

Chapter 17. ANNEXES

ANNEX 1. KEY CATEGORIES - DETAILED ASSESSMENT

Table 17-1 Key Category Level assessment (Base Year With LULUCF)

CRF Category Code	Category	Gas	Base Year Estimate	Absolute Value of Latest year estimate	Level assessment	Cumulative Level
1A1	Energy Industries (Liquid Fuels)	CO2	742.1552	1600.9000	37.1%	37.1%
1A1	Energy Industries (Solid Fuels)	CO2	619.1224	0.0000	30.9%	68.0%
1A3b	Road Transportation	CO2	315.7061	534.1166	15.8%	83.8%
1A4	Other Sectors	CO2	209.5065	136.1619	6.8%	90.6%
3D	Agricultural Soils	N2O	30.1558	27.3435	1.1%	91.7%
3A	Enteric Fermentation	CH4	25.7272	35.6993	1.3%	93.0%
1A2	Manufacturing Industries and Construction	CO2	22.6719	32.5866	1.1%	94.1%
5D	Wastewater Treatment and Discharge	CH4	17.3030	1.3137	0.9%	95.0%
1A3D	Domestic Navigation	CO2	17.1432	98.3731	0.9%	95.9%
5A	Solid Waste Disposal	CH4	16.5984	141.4023	0.8%	96.7%
3B	Manure Management	CH4	14.9698	12.9520	0.7%	97.4%
3B	Manure Management	N2O	11.1208	12.8684	0.6%	98.0%
5D	Wastewater Treatment and Discharge	N2O	8.1060	11.6977	0.4%	98.4%
1A1	Energy Industries	N2O	4.6427	3.7159	0.1%	98.5%
1A3b	Road Transportation	N2O	4.6171	9.9671	0.2%	98.7%
2D	Non-energy Products from Fuels and Solvent Use	CO2	3.6561	3.1204	0.2%	98.9%
2D	Other Product Manufacture and Use	N2O	2.3886	1.1443	0.1%	99.0%
1A3b	Road Transportation	CH4	2.2569	1.8364	0.1%	99.1%
1A3a	Domestic Aviation	CO2	2.0506	4.1081	0.1%	99.2%
2A	Lime Production	CO2	1.2540	0.0000	0.1%	99.3%
4A	Forest Land	CO2	-1.8040	-1.8040	0.1%	99.4%

Table 17-2 Key Category Level assessment (Base Year Without LULUCF)

CRF Category Code	Category	Gas	Base Year Estimate	Absolute Value of Latest year estimate	Level assesment	Cumulative Level
1A1	Energy Industries (Liquid Fuels)	CO2	742.1552	1600.9000	37.1%	37.1%
1A1	Energy Industries (Solid Fuels)	CO2	619.1224	0.0000	30.9%	68.0%
1A3b	Road Transportation	CO2	315.7061	534.1166	15.8%	83.8%
1A4	Other Sectors	CO2	209.5065	136.1619	6.8%	90.6%
3D	Agricultural Soils	N2O	30.1558	27.3435	1.1%	91.7%
3A	Enteric Fermentation	CH4	25.7272	35.6993	1.3%	93.0%
1A2	Manufacturing Industries and Construction	CO2	22.6719	32.5866	1.1%	94.1%
5D	Wastewater Treatment and Discharge	CH4	17.3030	1.3137	0.9%	95.0%
1A3D	Domestic Navigation	CO2	17.1432	98.3731	0.9%	95.9%
5A	Solid Waste Disposal	CH4	16.5984	141.4023	0.8%	96.7%
3B	Manure Management	CH4	14.9698	12.9520	0.7%	97.4%
3B	Manure Management	N2O	11.1208	12.8684	0.6%	98.0%
5D	Wastewater Treatment and Discharge	N2O	8.1060	11.6977	0.4%	98.4%
1A1	Energy Industries	N2O	4.6427	3.7159	0.1%	98.5%
1A3b	Road Transportation	N2O	4.6171	9.9671	0.2%	98.7%
2D	Non-energy Products from Fuels and Solvent Use	CO2	3.6561	3.1204	0.2%	98.9%
2D	Other Product Manufacture and Use	N2O	2.3886	1.1443	0.1%	99.0%
1A3b	Road Transportation	CH4	2.2569	1.8364	0.1%	99.1%
1A3a	Domestic Aviation	CO2	2.0506	4.1081	0.1%	99.2%
2A	Lime Production	CO2	1.2540	0.0000	0.1%	99.3%

Table 17-3 Key Category Level assessment (Latest Year With LULUCF)

CRF Category Code	Category	Gas	Latest Year Estimate	Absolute Value of Latest year estimate	Level assesment	Cumulative Level
1A1	Energy Industries	CO2	1600.9000	1600.9000	53.6%	53.6%
1A3b	Road Transportation	CO2	534.1166	534.1166	17.9%	71.5%
2F1	Refrigeration and Air conditioning	Aggregate F-gases	227.2933	227.2933	7.6%	79.1%
1A4	Other Sectors	CO2	209.5065	209.5065	7.0%	86.1%
5A	Solid Waste Disposal	CH4	141.4023	141.4023	4.7%	90.8%
1A3d	Domestic Navigation	CO2	98.3731	98.3731	3.3%	94.1%
3A	Enteric Fermentation	CH4	35.6993	35.6993	1.2%	95.3%
1A2	Manufacturing Industries and Construction	CO2	32.5866	32.5866	1.1%	96.4%
3D	Agricultural Soils	N2O	27.3435	27.3435	0.7%	97.1%
3B	Manure Management	CH4	12.9520	12.9520	0.4%	97.5%
3B	Manure Management	N2O	12.8684	12.8684	0.4%	97.9%
5D	Wastewater Treatment and Discharge	N2O	11.6977	11.6977	0.4%	98.3%
1A3b	Road Transportation	N2O	9.9671	9.9671	0.3%	98.6%
1A3a	Domestic Aviation	CO2	4.1081	4.1081	0.1%	98.7%
1A1	Energy Industries	N2O	3.7159	3.7159	0.1%	98.8%
2G	Non-energy Products from Fuels and Solvent Use	CO2	3.1204	3.1204	0.1%	98.9%
2F3	Fire Protection	Aggregate F-gases	2.7193	2.7193	0.1%	99.0%
1A3b	Road Transportation	CH4	1.8364	1.8364	0.1%	99.1%
2F4	Aerosols	Aggregate F-gases	1.7829	1.7829	0.1%	99.2%
2F2	Foam Blowing Agents	Aggregate F-gases	1.6483	1.6483	0.1%	99.3%
1A1	Energy Industries	CH4	1.5587	1.5587	0.1%	99.4%
4A	Forest Land	CO2	-1.8040	-1.8040	0.1%	99.5%

Table 17-4 Key Category Level assessment (Latest Year Without LULUCF)

CRF Category Code	Category	Gas	Latest Year Estimate	Absolute Value of Latest year estimate	Level assesment	Cumulative Level
1A1	Energy Industries	CO2	1600.9000	1600.9000	53.6%	53.6%
1A3b	Road Transportation	CO2	534.1166	534.1166	17.9%	71.5%
2F1	Refrigeration and Air conditioning	Aggregate F-gases	227.2933	227.2933	7.6%	79.1%
1A4	Other Sectors	CO2	209.5065	209.5065	7.0%	86.1%
5A	Solid Waste Disposal	CH4	141.4023	141.4023	4.7%	90.8%
1A3d	Domestic Navigation	CO2	98.3731	98.3731	3.3%	94.1%
3A	Enteric Fermentation	CH4	35.6993	35.6993	1.2%	95.3%
1A2	Manufacturing Industries and Construction	CO2	32.5866	32.5866	1.1%	96.4%
3D	Agricultural Soils	N2O	27.3435	27.3435	0.7%	97.1%
3B	Manure Management	CH4	12.9520	12.9520	0.4%	97.5%
3B	Manure Management	N2O	12.8684	12.8684	0.4%	97.9%
5D	Wastewater Treatment and Discharge	N2O	11.6977	11.6977	0.4%	98.3%
1A3b	Road Transportation	N2O	9.9671	9.9671	0.3%	98.6%
1A3a	Domestic Aviation	CO2	4.1081	4.1081	0.1%	98.7%
1A1	Energy Industries	N2O	3.7159	3.7159	0.1%	98.8%
2G	Non-energy Products from Fuels and Solvent Use	CO2	3.1204	3.1204	0.1%	98.9%
2F3	Fire Protection	Aggregate F-gases	2.7193	2.7193	0.1%	99.0%
1A3b	Road Transportation	CH4	1.8364	1.8364	0.1%	99.1%
2F4	Aerosols	Aggregate F-gases	1.7829	1.7829	0.1%	99.2%
2F2	Foam Blowing Agents	Aggregate F-gases	1.6483	1.6483	0.1%	99.3%
1A1	Energy Industries	CH4	1.5587	1.5587	0.1%	99.4%

Table 17-5 Key Category Trend assessment With LULUCF

CRF Category Code	Category	Gas	Base year Emissions ($GgCO_2eq$)	Latest year emissions ($GgCO_2eq$)	Trend	% Contribution to Trend	Cumulative total
1A1	Energy Industries	CO2	742.1552	1600.9000	0.247	47.2%	47.2%
2F1	Refrigeration and Air conditioning	Aggregate F-gases	0.0000	227.2933	0.113	21.6%	68.8%
5A	Solid Waste Disposal	CH4	16.5984	141.4023	0.058	11.1%	79.9%
1A3d	Domestic Navigation	CO2	17.1432	98.3731	0.036	6.9%	86.8%
1A3b	Road Transportation	CO2	315.7061	534.1166	0.032	6.1%	92.9%
5D	Wastewater Treatment and Discharge	CH4	17.3030	1.3137	0.012	2.3%	95.2%
3D	Agricultural Soils	N2O	30.1558	27.3435	0.006	1.1%	96.4%
3B	Manure Management	CH4	14.9698	12.9520	0.005	1.0%	97.3%
1A4	Other Sectors	CO2	209.5065	136.1619	0.003	0.6%	97.9%
1A3b	Road Transportation	N2O	4.6171	9.9671	0.002	0.4%	98.3%
3B	Manure Management	N2O	11.1208	12.8684	0.002	0.4%	98.7%
1F4	Aerosols	Aggregate F-gases	0.0000	1.7829	0.001	0.2%	98.9%
1F3	Fire Protection	Aggregate F-gases	0.0000	2.7193	0.001	0.2%	99.0%
1F2	Foam Blowing Agents	Aggregate F-gases	0.0000	1.6483	0.001	0.2%	99.2%
1A2	Manufacturing Industries and Construction	CO2	22.6719	32.5866	0.001	0.2%	99.4%
3A	Enteric Fermentation	CH4	25.7272	35.6993	0.001	0.2%	99.6%
2G	Non-energy Products from Fuels and Solvent Use	CO2	3.6561	3.1204	0.001	0.2%	99.8%

Table 17-6 Key Category Trend assessment Without LULUCF

CRF Category Code	Category	Gas	Base year Emissions ($GgCO_2eq$)	Latest year emissions ($GgCO_2eq$)	Trend	% Contribution to Trend	Cumulative total
1A1	Energy Industries	CO2	742.1552	1600.9000	0.247	47.2%	47.2%
2F1	Refrigeration and Air conditioning	Aggregate F-gases	0.0000	227.2933	0.113	21.6%	68.8%
5A	Solid Waste Disposal	CH4	16.5984	141.4023	0.058	11.1%	79.9%
1A3d	Domestic Navigation	CO2	17.1432	98.3731	0.036	6.9%	86.8%
1A3b	Road Transportation	CO2	315.7061	534.1166	0.032	6.1%	92.9%
5D	Wastewater Treatment and Discharge	CH4	17.3030	1.3137	0.012	2.3%	95.2%
3D	Agricultural Soils	N2O	30.1558	27.3435	0.006	1.1%	96.4%
3B	Manure Management	CH4	14.9698	12.9520	0.005	1.0%	97.3%
1A4	Other Sectors	CO2	209.5065	136.1619	0.003	0.6%	97.9%
1A3b	Road Transportation	N2O	4.6171	9.9671	0.002	0.4%	98.3%
3B	Manure Management	N2O	11.1208	12.8684	0.002	0.4%	98.7%
1F4	Aerosols	Aggregate F-gases	0.0000	1.7829	0.001	0.2%	98.9%
1F3	Fire Protection	Aggregate F-gases	0.0000	2.7193	0.001	0.2%	99.0%
1F2	Foam Blowing Agents	Aggregate F-gases	0.0000	1.6483	0.001	0.2%	99.2%
1A2	Manufacturing Industries and Construction	CO2	22.6719	32.5866	0.001	0.2%	99.4%
3A	Enteric Fermentation	CH4	25.7272	35.6993	0.001	0.2%	99.6%
2G	Non-energy Products from Fuels and Solvent Use	CO2	3.6561	3.1204	0.001	0.2%	99.8%

ANNEX 2. ASSESSMENT OF UNCERTAINTY

Table 17-7 Uncertainty assessment with LULUCF

IPCC Source Category		Gas	Base Year emissions 1990	Year t emissions 2013	Activity Data Uncertainty	Emission Factor Uncertainty	Combined Uncertainty	Contribution to Variance by Category in year T	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
			CO2 eq. (Gg)	CO2 eq. (Gg)	%	%	%		%	%	%	%	%
1A1ai	Energy Industries - Gas/Diesel Oil	CO2	27.42	171.75	1.00%	3.00%	3.16%	0.033	0.07%	0.09%	0.20%	0.12%	0.00%
1A1ai	Energy Industries - Residual Fuel Oil	CO2	714.74	1429.15	1.00%	3.00%	3.16%	2.274	0.18%	0.71%	0.54%	1.01%	0.01%
1A2	Manufacturing Industries and Construction	CO2	22.67	32.59	5.00%	12.00%	13.00%	0.020	0.00%	0.02%	-0.01%	0.12%	0.00%
1A3a i	Domestic Aviation	CO2	2.05	4.11	5.00%	10.00%	11.18%	0.000	0.00%	0.00%	0.01%	0.01%	0.00%
1A3b	Road Transportation	CO2	315.71	534.12	0.00%	4.00%	4.00%	0.508	0.03%	0.27%	0.12%	0.00%	0.00%
1A3d	Navigation	CO2	17.14	98.37	5.00%	30.00%	30.41%	0.996	0.04%	0.05%	1.09%	0.35%	0.01%
1A4a	Commercial Institutional	CO2	63.12	118.89	5.00%	12.00%	13.00%	0.266	0.01%	0.06%	0.15%	0.42%	0.00%
1A4b	Residential	CO2	70.02	74.16	5.00%	12.00%	13.00%	0.103	-0.02%	0.04%	-0.18%	0.26%	0.00%

1A4c	Agriculture/Forestry/Fisheries/Fish Farms	CO2	3.02	16.45	5.00%	12.00%	13.00%	0.005	0.01%	0.01%	0.07%	0.06%	0.00%
2A4	Other processes/uses of Carbonates	CO2	0.18	0.04	2.00%	0.00%	2.00%	0.000	0.00%	0.00%	0.00%	0.00%	0.00%
2D1	Lubricant use	CO2	3.15	2.85	10.00%	0.00%	10.00%	0.000	0.00%	0.00%	0.00%	0.02%	0.00%
2D2	Paraffin Wax use	CO2	0.51	0.27	10.00%	50.00%	50.99%	0.000	0.00%	0.00%	-0.01%	0.00%	0.00%
3B1	Forest Land	CO2	-1.80	-1.80	18.00%	0.00%	18.00%	0.000	0.00%	0.00%	0.00%	-0.02%	0.00%
3B2	Cropland	CO2	-0.77	-1.03	5.00%	0.00%	5.00%	0.000	0.00%	0.00%	0.00%	0.00%	0.00%
4C	Waste Incineration	CO2	0.37	0.79	10.00%	0.00%	10.00%	0.000	0.00%	0.00%	0.00%	0.01%	0.00%
1A1ai	Energy Industries - Gas/Diesel Oil	CH4	0.03	0.17	1.00%	60.00%	60.01%	0.000	0.00%	0.00%	0.00%	0.00%	0.00%
1A1ai	Energy Industries - Residual Fuel Oil	CH4	0.69	1.38	1.00%	0.00%	1.00%	0.000	0.00%	0.00%	0.00%	0.00%	0.00%
1A2	Manufacturing Industries and Construction	CH4	0.02	0.03	5.00%	0.00%	5.00%	0.000	0.00%	0.00%	0.00%	0.00%	0.00%
1A3a i	Domestic Aviation	CH4	0.01	0.01	5.00%	0.00%	5.00%	0.000	0.00%	0.00%	0.00%	0.00%	0.00%
1A3b	Road Transportation	CH4	2.26	1.84	0.00%	0.00%	0.00%	0.000	0.00%	0.00%	0.00%	0.00%	0.00%
1A3d	Navigation	CH4	0.04	0.23	5.00%	0.00%	5.00%	0.000	0.00%	0.00%	0.00%	0.00%	0.00%
1A4a	Commercial Institutional	CH4	0.20	0.38	5.00%	0.00%	5.00%	0.000	0.00%	0.00%	0.00%	0.00%	0.00%
1A4b	Residential	CH4	0.19	0.18	5.00%	0.00%	5.00%	0.000	0.00%	0.00%	0.00%	0.00%	0.00%

1A4c	Agriculture/Forestry/Fisheries/Fish Farms	CH4	0.01	0.04	5.00%	0.00%	5.00%	0.000	0.00%	0.00%	0.00%	0.00%	0.00%
3A1a	Cattle (Enteric Fermentation)	CH4	16.04	26.27	5.00%	0.00%	5.00%	0.002	0.00%	0.01%	0.00%	0.09%	0.00%
3A1c	Sheep (Enteric Fermentation)	CH4	2.37	3.68	5.00%	0.00%	5.00%	0.000	0.00%	0.00%	0.00%	0.01%	0.00%
3A1d	Goats (Enteric Fermentation)	CH4	0.75	0.58	5.00%	0.00%	5.00%	0.000	0.00%	0.00%	0.00%	0.00%	0.00%
3A1f	Horses (Enteric Fermentation)	CH4	0.43	0.92	5.00%	0.00%	5.00%	0.000	0.00%	0.00%	0.00%	0.00%	0.00%
3A1h	Swine (Enteric Fermentation)	CH4	2.31	1.78	5.00%	0.00%	5.00%	0.000	0.00%	0.00%	0.00%	0.01%	0.00%
3A1i	Poultry (Enteric Fermentation)	CH4	3.77	2.30	5.00%	0.00%	5.00%	0.000	0.00%	0.00%	0.00%	0.01%	0.00%
3A1j	Others (Rabbits) (Enteric Fermentation)	CH4	0.05	0.17	5.00%	0.00%	5.00%	0.000	0.00%	0.00%	0.00%	0.00%	0.00%
3A2a	Cattle (Manure Management)	CH4	2.42	3.48	5.00%	0.00%	5.00%	0.000	0.00%	0.00%	0.00%	0.01%	0.00%
3A2c	Sheep (Manure Management)	CH4	0.05	0.07	5.00%	0.00%	5.00%	0.000	0.00%	0.00%	0.00%	0.00%	0.00%
3A2d	Goats (Manure Management)	CH4	0.03	0.02	5.00%	0.00%	5.00%	0.000	0.00%	0.00%	0.00%	0.00%	0.00%
3A2f	Horses (Manure Management)	CH4	0.06	0.12	5.00%	0.00%	5.00%	0.000	0.00%	0.00%	0.00%	0.00%	0.00%
3A2h	Swine (Manure Management)	CH4	9.50	7.34	5.00%	0.00%	5.00%	0.000	0.00%	0.00%	0.00%	0.03%	0.00%
3A2i	Poultry (Manure Management)	CH4	2.86	1.74	5.00%	0.00%	5.00%	0.000	0.00%	0.00%	0.00%	0.01%	0.00%

3A2j	Others (Rabbits) (Manure Management)	CH4	0.05	0.17	5.00%	0.00%	5.00%	0.000	0.00%	0.00%	0.00%	0.00%	0.00%
4A1	Managed Waste Disposal on Land	CH4	0.00	106.92	10.00%	0.00%	10.00%	0.127	0.05%	0.05%	0.00%	0.75%	0.01%
4A2	Unmanaged Waste Disposal on Land	CH4	16.60	34.49	10.00%	0.00%	10.00%	0.013	0.00%	0.02%	0.00%	0.24%	0.00%
4B	Biological Treatment of Solid Waste	CH4	0.00	0.88	10.00%	0.00%	10.00%	0.000	0.00%	0.00%	0.00%	0.01%	0.00%
4D	Domestic and Commercial Wastewater	CH4	17.30	13.14	10.00%	0.00%	10.00%	0.002	-0.01%	0.01%	0.00%	0.09%	0.00%
1A1ai	Energy Industries - Gas/Diesel Oil	N2O	1.65	3.30	1.00%	0.00%	1.00%	0.000	0.00%	0.00%	0.00%	0.00%	0.00%
1A1ai	Energy Industries - Residual Fuel Oil	N2O	0.07	0.41	1.00%	0.00%	1.00%	0.000	0.00%	0.00%	0.00%	0.00%	0.00%
1A2	Manufacturing Industries and Construction	N2O	0.05	0.07	5.00%	0.00%	5.00%	0.000	0.00%	0.00%	0.00%	0.00%	0.00%
1A3a i	Domestic Aviation	N2O	0.01	0.01	5.00%	0.00%	5.00%	0.000	0.00%	0.00%	0.00%	0.00%	0.00%
1A3b	Road Transportation	N2O	4.62	9.84	0.00%	0.00%	0.00%	0.000	0.00%	0.00%	0.00%	0.00%	0.00%
1A3d	Navigation	N2O	0.14	0.78	5.00%	0.00%	5.00%	0.000	0.00%	0.00%	0.00%	0.00%	0.00%
1A4a	Commercial Institutional	N2O	0.14	0.26	5.00%	0.00%	5.00%	0.000	0.00%	0.00%	0.00%	0.00%	0.00%
1A4b	Residential	N2O	0.10	0.08	5.00%	0.00%	5.00%	0.000	0.00%	0.00%	0.00%	0.00%	0.00%

1A4c	Agriculture/Forestry/Fisheries/Fish Farms	N2O	0.01	0.11	5.00%	0.00%	5.00%	0.000	0.00%	0.00%	0.00%	0.00%	0.00%
2G3	Use of N2O for Product uses	N2O	2.39	1.14	3.00%	0.00%	3.00%	0.000	0.00%	0.00%	0.00%	0.00%	0.00%
3A2	Direct emissions (Manure (management)	N2O	11.12	12.87	5.00%	0.00%	5.00%	0.000	0.00%	0.01%	0.00%	0.05%	0.00%
3C4	Direct N2O from Managed Soils	N2O	21.92	20.03	5.00%	0.00%	5.00%	0.001	-0.01%	0.01%	0.00%	0.07%	0.00%
3C5	Indirect N2O from Managed Soils	N2O	8.24	7.32	5.00%	0.00%	5.00%	0.000	0.00%	0.00%	0.00%	0.03%	0.00%
3C6	Indirect N2O from Manure Management	N2O	5.43	5.74	5.00%	0.00%	5.00%	0.000	0.00%	0.00%	0.00%	0.02%	0.00%
4C	Waste Incineration	N2O	0.02	0.17	10.00%	0.00%	10.00%	0.000	0.00%	0.00%	0.00%	0.00%	0.00%
4D	Domestic and Commercial Wastewater	N2O	8.11	11.70	10.00%	0.00%	10.00%	0.002	0.00%	0.01%	0.00%	0.08%	0.00%
2E	Electronics Industry	HFCs	0.00	0.34	2.00%	0.00%	2.00%	0.000	0.00%	0.00%	0.00%	0.00%	0.00%
2F1	Refrigeration and Air Conditioning	HFCs	0.00	227.29	10.00%	0.00%	10.00%	0.575	0.11%	0.11%	0.00%	1.60%	0.03%
2F2	Foam Blowing Agents	HFCs	0.00	1.65	50.00%	0.00%	50.00%	0.001	0.00%	0.00%	0.00%	0.06%	0.00%
2F3	Fire Protection	HFCs	0.00	2.72	5.00%	0.00%	5.00%	0.000	0.00%	0.00%	0.00%	0.01%	0.00%
2F4	Aerosols and Solvents (MDIs)	HFCs	0.00	1.78	30.00%	0.00%	30.00%	0.000	0.00%	0.00%	0.00%	0.04%	0.00%

2G1	Electrical Equipment	SF6	0.00	0.58	5.00%	0.00%	5.00%	0.000	0.00%	0.00%	0.00%	0.00%	0.00%
Total emissions	All GHGs		2003.06	2997.25				4.930					0.08%
						Percentage uncertainty in Total inventory		2.220			Trend Uncertainty		2.86%

Table 17-8 Uncertainty assessment without LULUCF

IPCC Source Category		Gas	Base Year emissions 1990	Year t emissions 2013	Activity Data Uncertainty	Emission Factor Uncertainty	Combined Uncertainty	Contribution to Variance by Category in year T	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
			CO2 eq. (Gg)	CO2 eq. (Gg)	%	%	%		%	%	%	%	%
1A1ai	Energy Industries - Gas/Diesel Oil	CO2	27.42	171.75	1.00%	3.00%	3.16%	0.033	0.07%	0.09%	0.20%	0.12%	0.00%
1A1ai	Energy Industries - Residual Fuel Oil	CO2	714.74	1429.15	1.00%	3.00%	3.16%	2.269	0.18%	0.71%	0.54%	1.01%	0.01%
1A2	Manufacturing Industries and Construction	CO2	619.12	0.00	1.00%	3.00%	3.16%	0.000	-0.46%	0.00%	-1.38%	0.00%	0.02%
1A3a i	Domestic Aviation	CO2	22.67	32.59	5.00%	12.00%	13.00%	0.020	0.00%	0.02%	-0.01%	0.11%	0.00%
1A3b	Road Transportation	CO2	2.05	4.11	5.00%	10.00%	11.18%	0.000	0.00%	0.00%	0.01%	0.01%	0.00%
1A3d	Navigation	CO2	315.71	534.12	0.00%	4.00%	4.00%	0.507	0.03%	0.27%	0.12%	0.00%	0.00%
1A4a	Commercial Institutional	CO2	17.14	98.37	5.00%	30.00%	30.41%	0.995	0.04%	0.05%	1.09%	0.35%	0.01%
1A4b	Residential	CO2	63.12	118.89	5.00%	12.00%	13.00%	0.265	0.01%	0.06%	0.15%	0.42%	0.00%
1A4c	Agriculture/Forestry/Fisheries/Fish Farms	CO2	70.02	74.16	5.00%	12.00%	13.00%	0.103	-0.02%	0.04%	-0.18%	0.26%	0.00%

2A4	Other processes/uses of Carbonates	CO2	3.02	16.45	5.00%	12.00%	13.00%	0.005	0.01%	0.01%	0.07%	0.06%	0.00%
2D1	Lubricant use	CO2	1.25	0.00	8.00%	0.00%	8.00%	0.000	0.00%	0.00%	0.00%	0.00%	0.00%
2D2	Paraffin Wax use	CO2	0.00	0.00	0.00%	2.00%	2.00%	0.000	0.00%	0.00%	0.00%	0.00%	0.00%
4C	Waste Incineration	CO2	0.18	0.04	2.00%	0.00%	2.00%	0.000	0.00%	0.00%	0.00%	0.00%	0.00%
1A1ai	Energy Industries - Gas/Diesel Oil	CH4	0.03	0.17	1.00%	60.00%	60.01%	0.000	0.00%	0.00%	0.00%	0.00%	0.00%
1A1ai	Energy Industries - Residual Fuel Oil	CH4	0.69	1.38	1.00%	0.00%	1.00%	0.000	0.00%	0.00%	0.00%	0.00%	0.00%
1A2	Manufacturing Industries and Construction	CH4	0.16	0.00	1.00%	0.00%	1.00%	0.000	0.00%	0.00%	0.00%	0.00%	0.00%
1A3a i	Domestic Aviation	CH4	0.02	0.03	5.00%	0.00%	5.00%	0.000	0.00%	0.00%	0.00%	0.00%	0.00%
1A3b	Road Transportation	CH4	0.01	0.01	5.00%	0.00%	5.00%	0.000	0.00%	0.00%	0.00%	0.00%	0.00%
1A3d	Navigation	CH4	0.04	0.23	5.00%	0.00%	5.00%	0.000	0.00%	0.00%	0.00%	0.00%	0.00%
1A4a	Commercial Institutional	CH4	0.20	0.38	5.00%	0.00%	5.00%	0.000	0.00%	0.00%	0.00%	0.00%	0.00%
1A4b	Residential	CH4	0.19	0.18	5.00%	0.00%	5.00%	0.000	0.00%	0.00%	0.00%	0.00%	0.00%
1A4c	Agriculture/Forestry/Fisheries/Fish Farms	CH4	0.01	0.04	5.00%	0.00%	5.00%	0.000	0.00%	0.00%	0.00%	0.00%	0.00%
3A1a	Cattle (Enteric Fermentation)	CH4	16.04	26.27	5.00%	0.00%	5.00%	0.002	0.00%	0.01%	0.00%	0.09%	0.00%

3A1c	Sheep (Enteric Fermentation)	CH4	0.00	0.00	5.00%	0.00%	5.00%	0.000	0.00%	0.00%	0.00%	0.00%	0.00%
3A1d	Goats (Enteric Fermentation)	CH4	2.37	3.68	5.00%	0.00%	5.00%	0.000	0.00%	0.00%	0.00%	0.01%	0.00%
3A1f	Horses (Enteric Fermentation)	CH4	0.75	0.58	5.00%	0.00%	5.00%	0.000	0.00%	0.00%	0.00%	0.00%	0.00%
3A1h	Swine (Enteric Fermentation)	CH4	0.00	0.00	5.00%	0.00%	5.00%	0.000	0.00%	0.00%	0.00%	0.00%	0.00%
3A1i	Poultry (Enteric Fermentation)	CH4	0.43	0.92	5.00%	0.00%	5.00%	0.000	0.00%	0.00%	0.00%	0.00%	0.00%
3A1j	Others (Rabbits) (Enteric Fermentation)	CH4	0.00	0.00	5.00%	0.00%	5.00%	0.000	0.00%	0.00%	0.00%	0.00%	0.00%
3A2a	Cattle (Manure Management)	CH4	2.31	1.78	5.00%	0.00%	5.00%	0.000	0.00%	0.00%	0.00%	0.01%	0.00%
3A2c	Sheep (Manure Management)	CH4	3.77	2.30	5.00%	0.00%	5.00%	0.000	0.00%	0.00%	0.00%	0.01%	0.00%
3A2d	Goats (Manure Management)	CH4	0.05	0.17	5.00%	0.00%	5.00%	0.000	0.00%	0.00%	0.00%	0.00%	0.00%
3A2f	Horses (Manure Management)	CH4	2.42	3.48	5.00%	0.00%	5.00%	0.000	0.00%	0.00%	0.00%	0.01%	0.00%
3A2h	Swine (Manure Management)	CH4	0.00	0.00	5.00%	0.00%	5.00%	0.000	0.00%	0.00%	0.00%	0.00%	0.00%
3A2i	Poultry (Manure Management)	CH4	0.05	0.07	5.00%	0.00%	5.00%	0.000	0.00%	0.00%	0.00%	0.00%	0.00%
3A2j	Others (Rabbits) (Manure Management)	CH4	0.03	0.02	5.00%	0.00%	5.00%	0.000	0.00%	0.00%	0.00%	0.00%	0.00%

4A1	Managed Waste Disposal on Land	CH4	0.00	0.00	5.00%	0.00%	5.00%	0.000	0.00%	0.00%	0.00%	0.00%	0.00%
4A2	Unmanaged Waste Disposal on Land	CH4	0.06	0.12	5.00%	0.00%	5.00%	0.000	0.00%	0.00%	0.00%	0.00%	0.00%
4B	Biological Treatment of Solid Waste	CH4	0.00	0.00	5.00%	0.00%	5.00%	0.000	0.00%	0.00%	0.00%	0.00%	0.00%
4D	Domestic and Commercial Wastewater	CH4	9.50	7.34	5.00%	0.00%	5.00%	0.000	0.00%	0.00%	0.00%	0.03%	0.00%
1A1ai	Energy Industries - Gas/Diesel Oil	N2O	1.65	3.30	1.00%	0.00%	1.00%	0.000	0.00%	0.00%	0.00%	0.00%	0.00%
1A1ai	Energy Industries - Residual Fuel Oil	N2O	0.07	0.41	1.00%	0.00%	1.00%	0.000	0.00%	0.00%	0.00%	0.00%	0.00%
1A2	Manufacturing Industries and Construction	N2O	2.93	0.00	1.00%	0.00%	1.00%	0.000	0.00%	0.00%	0.00%	0.00%	0.00%
1A3a i	Domestic Aviation	N2O	0.05	0.07	5.00%	0.00%	5.00%	0.000	0.00%	0.00%	0.00%	0.00%	0.00%
1A3b	Road Transportation	N2O	0.01	0.01	5.00%	0.00%	5.00%	0.000	0.00%	0.00%	0.00%	0.00%	0.00%
1A3d	Navigation	N2O	0.14	0.78	5.00%	0.00%	5.00%	0.000	0.00%	0.00%	0.00%	0.00%	0.00%
1A4a	Commercial Institutional	N2O	0.14	0.26	5.00%	0.00%	5.00%	0.000	0.00%	0.00%	0.00%	0.00%	0.00%
1A4b	Residential	N2O	0.10	0.08	5.00%	0.00%	5.00%	0.000	0.00%	0.00%	0.00%	0.00%	0.00%
1A4c	Agriculture/Forestry/Fisheries/Fish Farms	N2O	0.01	0.11	5.00%	0.00%	5.00%	0.000	0.00%	0.00%	0.00%	0.00%	0.00%

2G3	Use of N2O for Product uses	N2O	2.39	1.14	3.00%	0.00%	3.00%	0.000	0.00%	0.00%	0.00%	0.00%	0.00%
3A2	Direct emissions (Manure (management)	N2O	11.12	12.87	5.00%	0.00%	5.00%	0.000	0.00%	0.01%	0.00%	0.05%	0.00%
3C4	Direct N2O from Managed Soils	N2O	21.92	20.03	5.00%	0.00%	5.00%	0.001	-0.01%	0.01%	0.00%	0.07%	0.00%
3C5	Indirect N2O from Managed Soils	N2O	8.24	7.32	5.00%	0.00%	5.00%	0.000	0.00%	0.00%	0.00%	0.03%	0.00%
3C6	Indirect N2O from Manure Management	N2O	5.43	5.74	5.00%	0.00%	5.00%	0.000	0.00%	0.00%	0.00%	0.02%	0.00%
4C	Waste Incineration	N2O	0.02	0.17	10.00%	0.00%	10.00%	0.000	0.00%	0.00%	0.00%	0.00%	0.00%
4D	Domestic and Commercial Wastewater	N2O	8.11	11.70	10.00%	0.00%	10.00%	0.002	0.00%	0.01%	0.00%	0.08%	0.00%
2E	Electronics Industry	HFCs	0.00	0.34	2.00%	0.00%	2.00%	0.000	0.00%	0.00%	0.00%	0.00%	0.00%
2F1	Refrigeration and Air Conditioning	HFCs	0.00	227.29	10.00%	0.00%	10.00%	0.588	0.11%	0.11%	0.00%	1.60%	0.03%
2F2	Foam Blowing Agents	HFCs	0.00	1.65	50.00%	0.00%	50.00%	0.001	0.00%	0.00%	0.00%	0.06%	0.00%
2F3	Fire Protection	HFCs	0.00	2.72	5.00%	0.00%	5.00%	0.000	0.00%	0.00%	0.00%	0.01%	0.00%
2F4	Aerosols and Solvents (MDIs)	HFCs	0.00	1.78	30.00%	0.00%	30.00%	0.000	0.00%	0.00%	0.00%	0.04%	0.00%
2G1	Electrical Equipment	SF6	0.00	0.58	5.00%	0.00%	5.00%	0.000	0.00%	0.00%	0.00%	0.00%	0.00%

Total emissions	All GHGs		2005.63	3000.08				4.921					0.08%
						Percentage uncertainty in Total inventory		2.218%			Trend Uncertainty		2.853%

ANNEX 3. DETAILED METHODOLOGICAL DESCRIPTIONS FOR INDIVIDUAL SOURCE OR SINK CATEGORIES

This annex includes additional detailed information specific to individual sectors and categories discussed in chapters 3 to 8. The information presented under this annex should be read in conjunction with the respective sector or category discussions presented in chapters 3 to 8.

A-3-1 WASTE (CRF CATEGORY 5)

BACK EXTRAPOLATION OF ACTIVITY IN SOLID WASTE DISPOSAL SITES

As highlighted in the main text weighbridges for the accurate measurement of waste entering waste disposal sites on land became operational only in 1997. Data prior to this date is both scant and only indicative. Therefore, in order to ensure completeness and time series consistency, the values for deposited amounts were back extrapolated using reliable and validated available data. Due to the type of model being used for the estimation of emissions from such sites the back extrapolation was required for the period 1950-1997. The extrapolation is based on UN data on population and GDP as referred to in section 3.2.2 of the 2006 IPCC Guidelines Volume 5.

Data for population was obtained from the United Nations POPIN Database (http://www.un.org/popin/data.html). Waste generation trends were calculated extrapolating the waste generation rates (/capita) in recent years to previous periods. The waste generation rates calculated and the actual rates are summarised in Figure 17-1.

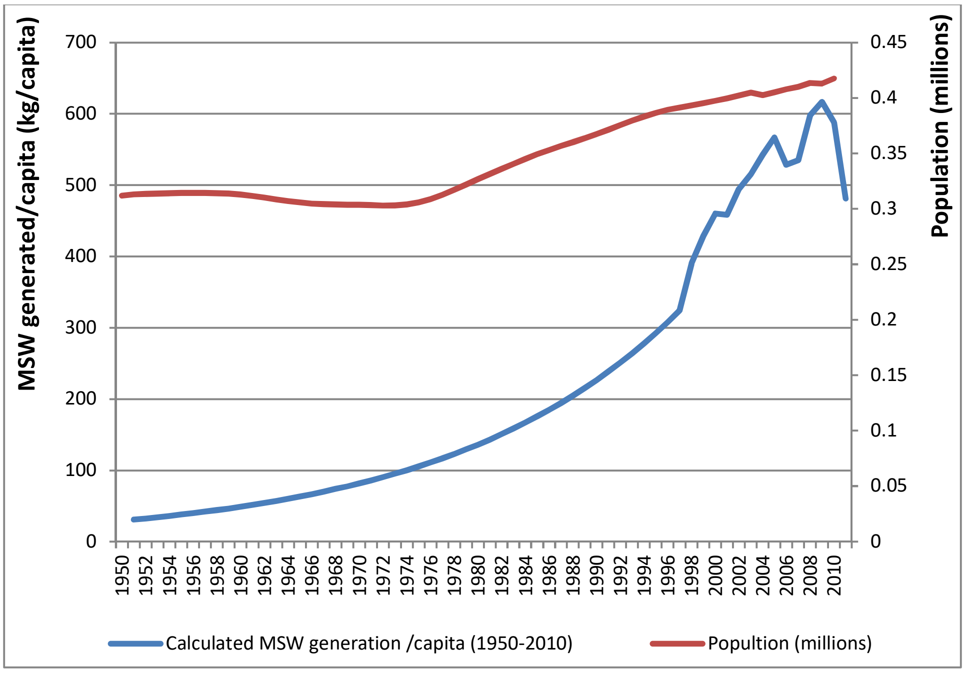

Figure 17-1 Trend of municipal solid waste generation/capita

Multiplying the population estimate by the generation rate, the actual estimate for MSW generation is obtained.

For industrial waste, GDP is more indicative of activity than population, thus GDP was used instead of population. Similarly to the above the trends in Waste generation/GDP were calculated and back extrapolated with GDP estimates used to calculate the industrial waste activity over the period 1950-1997 (later data was available from weighbridges).

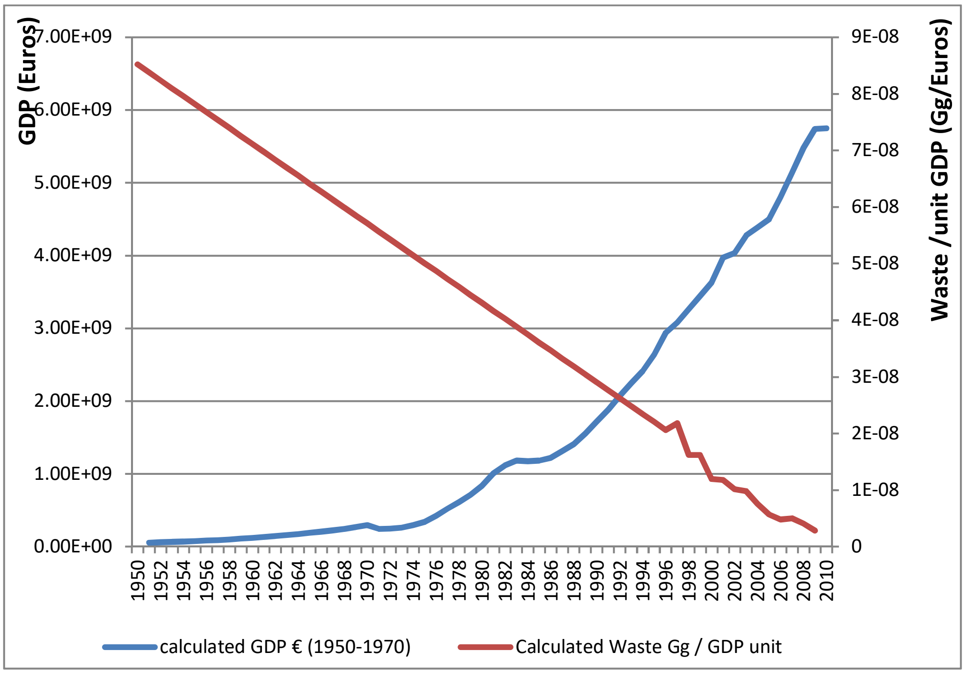

Figure 17-2 Trend of industrial waste/unit GDP for 1950-2010 compared to GDP

Following the combination of the two above mentioned calculations Figure 17-2 depicts the final activity amounts used in the FOD model.

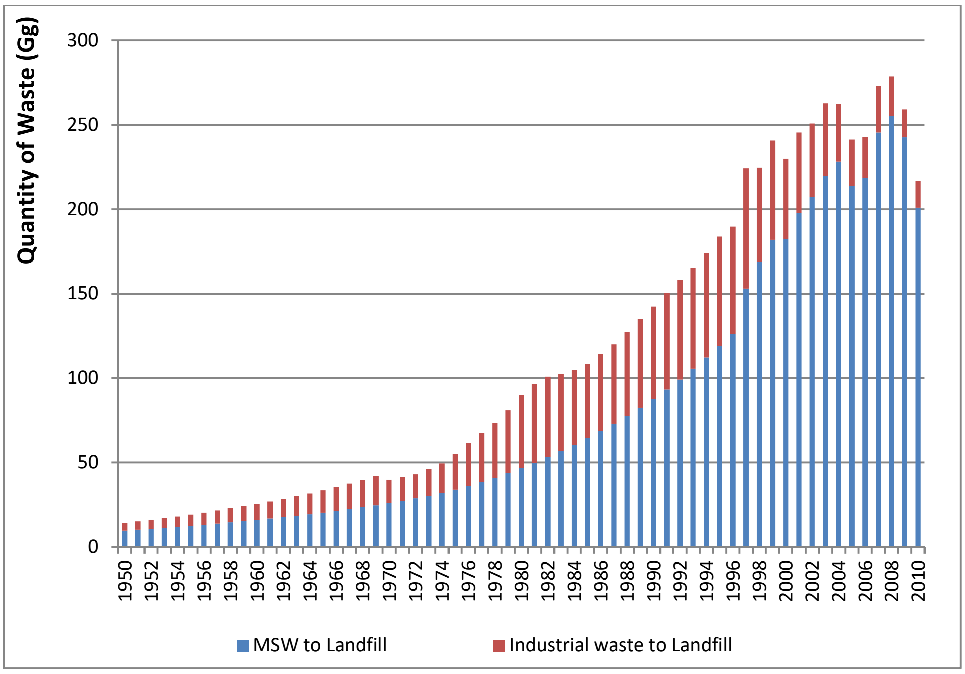

Figure 17-3 Waste deposited in landfills for 1950-2010

OXIDATION FACTOR STUDIES (CONCLUSIONS)

Professor Alfred J Vella BSc, MSc, PhD (Colo), C Sci, C Chem, FRSC 'Emissions of Methane from Magħtab Landfill: an opinion based on measurement data pertaining to the landfill and Scott Wilson's Report CT2586/2004' March 2013

"It is concluded that at the discontinued and unmanaged Magħtab landfill there are conditions, which conduce to significant sub-surface methane oxidation that result in destruction of the gas by processes that are more efficient than biological oxidation afforded by a soil or compost cap. Measurements of rates of volumes generated and composition of the landfill gases (especially in terms of methane and carbon dioxide content) suggest that, in applying the IPCC model for estimating methane emissions from the landfill, a value of 0.60 for the oxidation factor is employed, provided that conditions at the Magħtab landfill remain as were during 2009. This would likely provide a modelled value of methane emissions from the landfill that is nearer to the true value."

Dr. Francesco Italiano 'Review of the Vella report on Magħtab landfill GHG emissions' May 2014

"The report of Prof. Vella is based on the information available from the SI report and the conclusions are correct and I fully agree with them. The oxidation factor estimated in the VR is correct and in good agreement with other OXs estimated using different CH_4 flow-rates and concentrations. The estimated values show that the chemical oxidation processes occurring at shallow levels over the landfill (also demonstrated by the high-temperature areas), are able to decrease the amount of CH_4 released from the Magħtab landfill by a factor of about 2 to the respect of the methane produced."

MUNICIPAL SOLID WASTE COMPOSITION

Results extracted from waste composition surveys carried out in 2002 and 2011 used to calculate waste composition. Table 17-9 illustrates the results of the two reports mentioned above:

Table 17-9 Municipal solid waste composition results from NSO surveys in 2002 and 2011

	Waste composition shares (%)	
	2002	**2011**
Plastic	9.6	11.6
Paper + cardboard	12.7	17.6
Food Remains	59.6	52.1
Glass	4	5.5
Metal	3.7	3.7
Textile	3.4	2.3
Hazardous	2.8	0.5
Others	4.2	6.7

Data from these reports was used in the model as illustrated below in Table 17-10 below:

Table 17-10 Implementation of waste composition data in current FOD model

	Food	Garden	Paper	Wood	Textile	Nappies	Plastics other inert	Used in Model Years
2002	59.6	0	12.7	0	3.4	0	24.3	Prior to 2002
2011	52.1	0	17.6	0	2.3	0	28	2011 onwards
Average 2002/2011 data	55.85	0	15.15	0	2.85	0	26.15	2003-2010

INCINERATION EMISSION FACTORS

- ***Municipal Waste***

Table 17-11 Example calculation for CO_2 emissions of municipal waste from incineration

Year	A: Total Amount of municipal waste incinerated (wet weight) (Gg)	B: Dry Matter Content (fraction)	C: Fraction of Carbon in Dry Matter (fraction)	D: Fraction of fossil carbon in total carbon (fraction)	E: Oxidation Factor (fraction)	F: Conversion Factor	G: Emission Factor (Gg CO_2/ Gg waste) (B*C*D*E*F)	H: Emissions of CO_2 (Gg) (A*G)
1990	0.25	0.4	0.38	0.15	1	3.67	0.0836	0.0209

The following emission factors have been used to calculate CH_4 emissions: (6500g CH_4/tonne waste for 1990 to 2003; 0.2g CH_4/tonne waste for 2008) and N_2O emissions (221g N_2O/tonne waste for 1990 to 2003; 8g N_2O/tonne waste for 2008), as available in the IPCC 2006 guidelines.

The following emission factors have been used to calculate NO_x emissions (1.8 kg NO_x/Mg waste), CO emissions (0.7 kg CO/Mg waste), NMVOC emissions (0.02 kg NMVOC/Mg waste) and SO_2 emissions (1.7 kg SO_2/Mg waste, as available in EMEP/EEA. From 2008 onwards emission factors for, CO, NO_x and SO_2 were taken from plant specific data reported in the E-PRTR of the plant submitted to the Malta Environment and Planning Authority at the end of each year, and EF for NMVOC was extrapolated from the IPPC permit specific TOC emission limit (correcting for the CH_4 emissions), this assuming the plant operated to the limit for the whole number of hours of operation as reported in the E-PRTR report. Table 17-12 illustrates the emission factors used.

Table 17-12 Emission factors for indirect GHGs in incineration

Year	NO_x	CO	NMVOC	SO_2
2008	1.4277	0.2104	0.1661	0.0563
2009	1.0248	0.4107	0.1314	0.2080
2010	1.6690	0.4593	0.1241	0.0512
2011	1.1435	0.4998	0.1385	0.1014
2012	1.4002	0.2221	0.1185	0.1197
2013	1.5269	0.3554	0.1059	0.0969
2014	1.2442	0.0938	0.1127	0.0677

- ***Clinical Waste***

Table 17-13 Example of calculation for CO_2 emissions of clinical waste from incineration

Year	A: Total Amount of clinical waste incinerated (wet weight) (Gg)	B: Dry Matter Content (fraction)	C: Fraction of Carbon in Dry Matter (fraction)	D: Fraction of fossil carbon in total carbon (fraction)	E: Oxidation Factor (fraction)	F: Conversion Factor	G: Emission Factor (Gg CO_2/ Gg waste) (C*D*E*F)	H: Emissions of CO_2 (Gg) (A*G)
1990	1.99	NA	0.6	0.4	1	3.67	0.88	1.75

The following emission factors have been used to calculate CH_4 emissions (60kg CH_4/Gg waste for 1990 to 2007; 0.2kg CH_4/Gg waste for 2008) and N_2O emissions (100g N_2O/tonne waste), as available in the IPCC 2006 guidelines.

The following emission factors have been used to calculate NO_x emissions (2.3kg NO_x/Mg waste for 1990 to 2007), CO emissions (0.19 kg CO/Mg waste for 1990 to 2007), NMVOC emissions (0.7kg NMVOC/Mg waste for 1990 to 2007) and SO_2 emissions (0.54kg SO_2/Mg waste for 1990 to 2007), as available in EMEP/EEA [Ref tbc]. Following 2007 emissions factors listed in Table 17-12 were used.

- ***Industrial Waste***

Table 17-14 Example of calculation for CO_2 emissions of Industrial waste from incineration

Year	A: Total amount of waste incinerated (Gg waste)	B: Dry Matter Content (fraction)	C: Fraction of Carbon in Dry Matter (fraction)	D: Fraction of Fossil Carbon in Total Carbon (fraction)	E: Oxidation Factor (fraction)	F: Conversion Factor	G: Emission Factor for CO_2 emissions (Gg CO_2 / Gg Waste) (B*C*D*E*F)	H: Emissions (Gg CO_2) (A*G)
1990	0.066	0.9	0.46	0.01	1	3.67	0.015	0.001

The following emission factors have been used to calculate CH_4 emissions (60kg CH_4/Gg waste for 1990 to 2007; 0.2kg CH_4/Gg waste for 2008) and N_2O emissions (10g N_2O/tonne waste for 1990 to 2007; 100g N2O/tonne waste for 2008), as available in the IPCC 2006 guidelines.

The following emission factors have been used to calculate NO_x emissions (2.5kg NO_x/Mg waste for 1990 to 2007), CO emissions (0.13 kg CO/Mg waste for 1990 to 2007), NMVOC emissions (7.4kg NMVOC/Mg waste from 1990 - 2007) and SO_2 emissions (0.07kg SO_2/ Mg waste for 1990 to 2007), as available in EMEP/EEA . Following 2007, emission factors listed in Table 17-12 were used.

ANNEX 4. NATIONAL ENERGY BALANCE

The information provided below pertains to the National Oil Balance as elaborated by the National Statistics Office and submitted to Eurostat pursuant to Regulation 1099/2008 (EC).

The Annual National Oil Balance reports are the main data source for the estimation of the Reference Approach and the CO_2 emissions calculated there from. The monthly data on the fuel products released in the inland market is collected by the the Regulator for Energy and Water Services (formerly the Malta Resources Authority) from the operators that are regulated under Legal Notice 278 of 2007 'Petroleum for the Inland (Wholesale) Fuel Market Regulations, 2007' and Legal Notice 270 of 2010 'Bunkering (Authorisation) Regulations, 2010' and as enabled by Regulation 17 of Legal Notice 278 of 2007 and Regulation 15 of Legal Notice 270 of 2010 which oblige such operators to submit data in the form as requested by the relevant authorities. Subsequently, this information is provided to the National Statistics Office which compiles the required reports to be submitted to Eurostat pursuant to Regulation 1099/2008 (EC) on Energy Statistics.

The Annual National Oil Balance for 2014 (as at 30 October 2015) is provided in Table 17-15 below.

Table 17-15 National oil balance for Malta for 2014

OIL STATISTICS OF MALTA - ANNUAL 2014											
	Petrol	**Diesel**	**Biodiesel**	**Jet A1**	**Aviation Gasoline**	**Kerosene**	**Gasoil**	**Fuel Oil incl LCO**	**Liquified Petroleum Gas**	**Propane**	**Total**
	Metric tonnes										
Imports	77,579.92	106,036.14	4,094.77	108,083.51	36.44	-	280,385.71	1,542,706.83	22,465.61	767.26	**2,142,156.18**
Imports - Tickets held in Malta	-	-	-	-	-	-	20,000.00	140,000.00	-	-	**160,000.00**
Exports	-	-	-	-	-	-	700.61	1,439.00	-	-	**2,139.61**
Exports - Tickets held in Malta	-	-	-	-	-	-	24,700.00	180,000.00	-	-	**204,700.00**
International Marine Bunkering	-	482.66	-	-	-	-	185,215.36	1,071,043.72	-	-	**1,256,741.74**
Indigenous Production	-	-	1,156.86	-	-	-	-	-	-	-	**1,156.86**
Inter-Product Transfers:	(14.07)	(2,556.47)	3,924.35	454.05	4.60	(454.05)	997.65	(2,355.53)	(236.34)	236.34	**0.54**
Reductions	-	1,367.88	3,924.35	454.05	4.60	-	2,310.16	6,703.55	8.21	244.55	**15,017.34**
Additions	14.07	3,924.35	-	-	-	454.05	1,312.51	9,059.08	244.55	8.21	**15,016.80**
Intra-Installation Movements:	-	-	-	-	-	-	-	(0.07)	-	-	**(0.07)**
Reductions	-	62,189.11	-	291,681.84	4.60	-	19,111.00	120,074.05	-	-	**493,060.60**
Additions	-	62,189.11	-	291,681.84	4.60	-	19,111.00	120,074.12	-	-	**493,060.68**
Third-Party Product Transfers:	(323.20)	(876.25)	(310.60)	(3.18)	-	(45.54)	(1,615.02)	6,855.02	-	-	**3,681.22**
Sales	-	923.68	988.58	-	-	-	4,560.91	19,660.94	-	-	**26,134.10**
Purchases	323.20	1,799.93	1,299.18	3.18	-	45.54	6,175.93	12,805.92	-	-	**22,452.88**
Stock Change:	4,685.48	5,496.62	(8.05)	(1,072.57)	(2.40)	(7.45)	(4,172.75)	(43,674.43)	998.51	269.51	**(37,487.53)**
Total Closing Stock as at 31 December	9,729.22	20,183.09	-	9,698.16	9.07	36.01	42,476.91	136,487.74	2,955.57	427.01	**222,002.78**
Total Opening Stock as at 1 January	5,043.74	14,686.48	8.05	10,770.73	11.47	43.46	46,649.66	180,162.17	1,957.05	157.50	**259,490.31**
Returns to Petrochemical Industry	-	141.62	12.88	-	-	-	2,620.98	482.82	-	-	**3,258.31**
Product Gains/(Losses)	(208.94)	118.62	-	551.39	0.23	17.28	-	-	256.58	(1.00)	**734.15**
Gross Inland Consumption (Calculated)	73,022.78	103,466.57	1,633.05	109,256.59	34.47	524.31	91,938.88	468,916.31	21,960.01	260.41	**871,013.38**
Biodiesel (Blended):	-	(3,924.35)	3,924.35	-	-	-	-	-	-	-	**-**
Gross Inland Consumption (Adjusted)	73,022.78	99,542.22	5,557.40	109,256.59	34.47	524.31	91,938.88	468,916.31	21,960.01	260.41	**871,013.38**
Statistical Difference	0.04	0.14	0.46	(0.00)	(0.06)	0.50	(0.68)	0.30	0.03	-	**0.73**
	0.00	0.00	0.00	(0.00)	(0.00)	0.00	(0.00)	0.00	0.00	-	**(0.00)**
Gross Inland Consumption (Observed)	73,022.82	103,466.71	1,633.51	109,256.58	34.41	524.81	91,938.20	468,916.61	21,960.04	260.41	**871,014.11**