Gibraltar City Inventory 2015

A City-Level Greenhouse Gas Emissions Inventory for Gibraltar

Report for HM Government of Gibraltar

ED 61636 | Issue Number 2 | Date 01/06/2017

Customer:

Catherine Walsh, Department of the Environment, HM Government of Gibraltar

Customer reference:

ED61636

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01 June 2017

Ricardo Energy & Environment reference:

Ref: ED61636- Issue Number 2

Executive summary

Cities are a large problem and a significant opportunity in the management of global greenhouse gas (GHG) emissions. Globally, the focus has increasingly shifted towards accounting and management of emissions at the city scale. Organisations such as the International Council for Local Environmental Initiatives (ICLEI), C40 Cities, the World Bank, CDP (formerly the Carbon Disclosure Project), United Nations Environment Programme (UNEP), World Resources Institute (WRI), and carbon*n* Cities Climate Registry are all championing the city scale as a key area on which to focus GHG accounting and mitigation activities.

At the 21st Conference of the Parties (the COP) in Paris in 2015, almost 200 countries came together and collectively committed to limiting global temperatures to 'well below' 2 degrees and avoiding the worsening effects of climate change. At the same time, more than 360 cities from all continents and regions across the globe announced that the collective impact of their commitments will deliver over half of the world's potential urban emissions reductions by 2020. Since Paris, the focus has transferred from making promises to taking action. Effective and committed governance at the national level will be key to achieving the Paris Agreement, however it is at the sub-national level where real gains in climate change mitigation will be made.

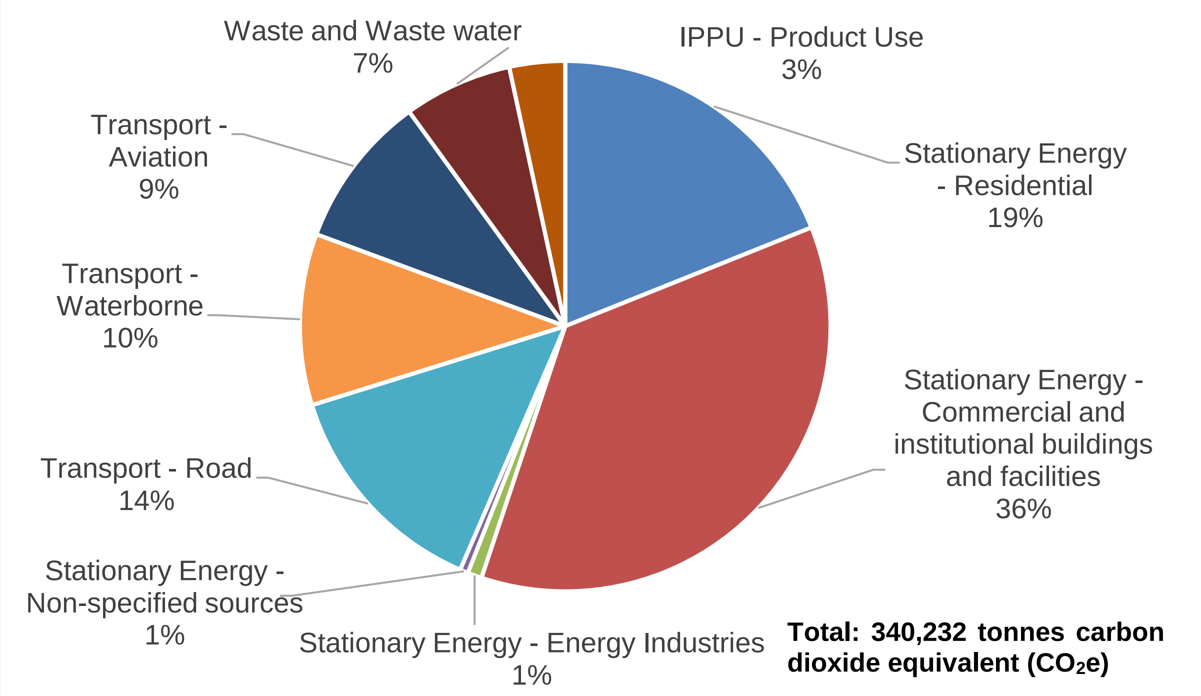
The first step in managing Greenhouse Gas (GHG) emissions effectively at the city (or community) scale and making informed decisions to contribute to global mitigation efforts, is to have a good understanding of these emissions – the major sources, activities and relative contributions of different activities. Existing emissions data captured and reported through the UK Greenhouse Gas Inventory (GHGI) for Gibraltar do not give a complete picture of Gibraltar's GHG impact and mitigation activities. Its primary purpose is to monitor and report emissions produced on a territorial basis and is compiled following the Intergovernmental Panel on Climate Change (IPCC) 2006 guidelines to meet the UK's reporting commitments under the United Nations Framework Convention on Climate Change (UNFCCC). It is not the most useful approach or format for estimating and reporting emissions for Gibraltar because it does not take account of activities outside of the geographic boundary or disaggregate information to a spatial resolution that is useful locally to enable targeted policy action, for instance electricity use.

The Gibraltar City Inventory Programme will compile a detailed bottom-up inventory of GHGs for Gibraltar annually. This report covers the most recent inventory year, 2015. It considers emissions from all sources, including stationary combustion by end user (power generation and consumption); mobile combustion (by road, marine, and shipping); waste disposal and wastewater; and industrial process and product use (IPPU) emissions. It follows the Greenhouse Gas Protocol's Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC) (Greenhouse Gas Protocol, 2014) and is reported using internationally approved tools.

Emissions are calculated for the seven Kyoto GHGs, reported as carbon dioxide equivalent (CO_2e) and are categorised by 'scope'. Scope 1 emissions are directly emitted in boundary; scope 2 emissions are indirect from in-boundary consumption of electricity; scope 3 emissions are indirect and out of boundary emissions.

There are various levels of reporting, and this inventory also distinguishes between these different accounting approaches. The GPC has two reporting levels, known as BASIC and BASIC+, the latter including a greater number of sources, in particular some Scope 3 indirect emission sources. It is recommended that cities aim to report BASIC+ emissions. Transboundary transport emissions are included under BASIC+ reporting, and this includes water-borne navigation. However, in the case of Gibraltar, much of this is international shipping (non-bunkering), and is excluded from the BASIC+ results presented in this report due to its very large impact on overall totals, and the lack of potential local influence. This sub-set can therefore be considered Gibraltar's 'manageable emissions'. This is shown in **Figure i**.

Figure i: BASIC+ emissions attributable to Gibraltar (under the GPC's BASIC+ reporting, excluding transboundary international shipping)



Sources that are deemed to be 'outside of scopes' (i.e. they are reported for information, but are not deemed to be within the influence or responsibility of Gibraltar – such as bunker fuel) would dominate emissions overall if included in emission totals, with other scope 3 emissions accounting for 84% of emissions when all are combined.

The results for BASIC+ excluding transboundary maritime navigation are much more aligned to those expected for a city, with stationary energy dominating, accounting for 56% of emissions. This is particularly the case in Gibraltar given the relative carbon inefficiency of electricity generation. Transportation also contributes about one third of emissions, with 14% from road transport sources. Waste and IPPU are smaller, at 7% and 3% respectively. When comparing emissions with other global cities, however per capita BASIC-level emissions are used. For Gibraltar this equates to almost 8 tonnes per person.

Scope 2 emissions from electricity consumption are the largest source of emissions in Gibraltar, due to the reliance on electricity for all energy needs and generation technology. Because gas oil is used to generate electricity, the emissions per kilowatt hour (kWh) are considerably higher than, for example, the UK. The implied emission factor based on fuel consumption in power stations and total output is 0.857kg/kWh in Gibraltar, compared with the UK grid factor of 0.462kg/kWh[1].

The main findings from the 2015 inventory are summarised as follows:

- In comparison to the 2013 inventory, the emissions from Gibraltar are largely unchanged for scope 1. As in 2013, the scope 1 emissions are dominated by the transport sector. There has been a 9.5% increase in total, although road transport emissions have declined slightly due to less gasoline consumption. The main driver of change however, has been increases in estimates of diesel consumption after the use of more detailed, disaggregated fuel import data.
- IPPU emissions remain a significant source of scope 1 emissions (accounting for 12%), and have also increased by 1kt CO_2e in comparison to 2013. Emissions in this sector are estimated using population as a proxy, and therefore population growth within Gibraltar will have somewhat influenced the calculated increase in scope 1 emissions. Improved data has also been used to calculate IPPU emissions in Gibraltar.
- Between 2013 and 2015, total scope 2 emissions (from the consumption of electricity) have declined by almost 20kt CO_2e. A reduction in consumed gas oil used for electricity generation and an improvement of the implied emission factor cause a decline in emissions from residential, and commercial, industrial, and government buildings and facilities.

[1] https://www.gov.uk/government/collections/government-conversion-factors-for-company-reporting

- Waterborne navigation emissions have declined significantly between 2013 and 2015 due to a methodology change within the calculation of emissions from shipping; the definition of shipping attributable to Gibraltar on the basis of the recorded ‘purpose of call’ has undergone significant changes, and as a result, the reported emissions from scope 3 are much lower in 2015.
- Waste emissions have declined by over 30% between 2013 and 2015; however, this is largely due to improved assumptions in calculating emissions from waste.

An emissions inventory is an ongoing tool for understanding and reporting emissions, and allows the identification of major sources and priority areas for mitigation. It can be seen from the results presented above that there are some areas where mitigation efforts could be focussed in order to reduce greenhouse gas emissions.

Stationary energy, as the highest contributor to overall manageable emissions, should be given priority. In particular, the commercial and institutional sub-sector, as the highest end user category. Road transport is not one of the larger sources, but is significant given the small size of the territory and the potential for interventions to reduce vehicle use. Finally, individual industries that are high-energy users, such as water supply, should be identified and ways to reduce energy consumption investigated.

This inventory has been compiled using the best available data and methods, however there remains potential for improvement, and future inventories should seek to build on the work undertaken here, and improve the accuracy, reliability, and coverage of data.

Table of contents

Appendices

1 Introduction

Cities are a large problem and a significant opportunity in the management of global greenhouse gas (GHG) emissions. The 2008 World Energy Outlook estimated that cities accounted for over 70% of global GHG emissions[2], yet they also offer unique mitigation opportunities, due to the concentration of people and activities in a geographically small area. Globally, the focus has increasingly shifted towards accounting and management of emissions at the city scale. Organisations such as the International Council for Local Environmental Initiatives (ICLEI), C40 Cities, the World Bank, CDP (formerly the Carbon Disclosure Project), United Nations Environment Programme (UNEP), World Resources Institute (WRI), and carbon*n* Cities Climate Registry are all championing the city scale as a key area on which to focus GHG accounting and mitigation activities.

At the 21st Conference of the Parties (the COP) in Paris in 2015, almost 200 countries came together and collectively committed to limiting global temperatures to 'well below' 2 degrees and avoiding the worsening effects of climate change. At the same time, more than 360 cities from all continents and regions across the globe announced that the collective impact of their commitments will deliver over half of the world's potential urban emissions reductions by 2020. Since Paris, the focus has transferred from making promises to taking action. Effective and committed governance at the national level will be key to achieving the Paris Agreement; however, it is at the sub-national level where real gains in climate change mitigation will be made.

The first step in managing greenhouse gas (GHG) emissions effectively at the city (or community) scale and making informed decisions to contribute to global mitigation efforts, is to have a good understanding of these emissions – the major sources, activities and relative contributions of different activities. However, until recently, one of the overwhelming problems was the lack of a common methodology for GHG accounting at the city scale. To overcome this problem, the Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC) was launched in December 2014. The GPC offers cities, communities and local governments a robust, transparent and globally-accepted framework to consistently identify, calculate and report on city GHGs. It is methodologically consistent with national territory-based approaches to emissions accounting, but also provides the flexibility to account for emissions in ways that more accurately reflect local circumstances.

The 2013 city-level GHG inventory for Gibraltar[3], prepared by Ricardo, was consistent with the draft version of the GPC standard available at the time. The 2013 inventory quantified emissions from stationary combustion by end user (power generation and consumption), mobile combustion (by road, marine and shipping), waste disposal and recycling, water supply, industrial emissions and indirect emissions associated with Gibraltar's supply chain (for instance, imports of food, construction materials and other goods). Gibraltar was one of the first communities to report a fully compliant GPC inventory, and the 2013 Gibraltar inventory was used as a case-study of best-practice in the final publication of the GPC, in meetings and with the World Bank and UNHABITAT, and in work with a number of global mega-cities (including Rio de Janeiro, Amman and Buenos Aires) on best practice in city GHG inventories. Gibraltar remains one of the leaders in community GHG reporting and is part of a fast growing number of urban communities reporting such data. It is significant that Gibraltar has committed to reporting this data on an annual basis, to maintain its position as a leader in this field.

A key part of following the GPC guidelines is to update the inventory on a regular basis, ideally annually, as it is intended to be a 'live' tool for reporting, mitigating and tracking GHG emissions. This report provides an update to the 2013 inventory for the reporting year 2015; as above, this will also allow Gibraltar to continue showing best practice in city GHG inventories, successfully take part and report under initiatives such as the Compact of Mayors (see **Section 1.1**), and understand progress towards goals and inform the Climate Change Act and other programmes. This report and the accompanying GHG inventory data is part of Gibraltar's Emissions Inventory Programme (GibEmit), as part of the wider Gibraltar Air Quality and Climate programme.

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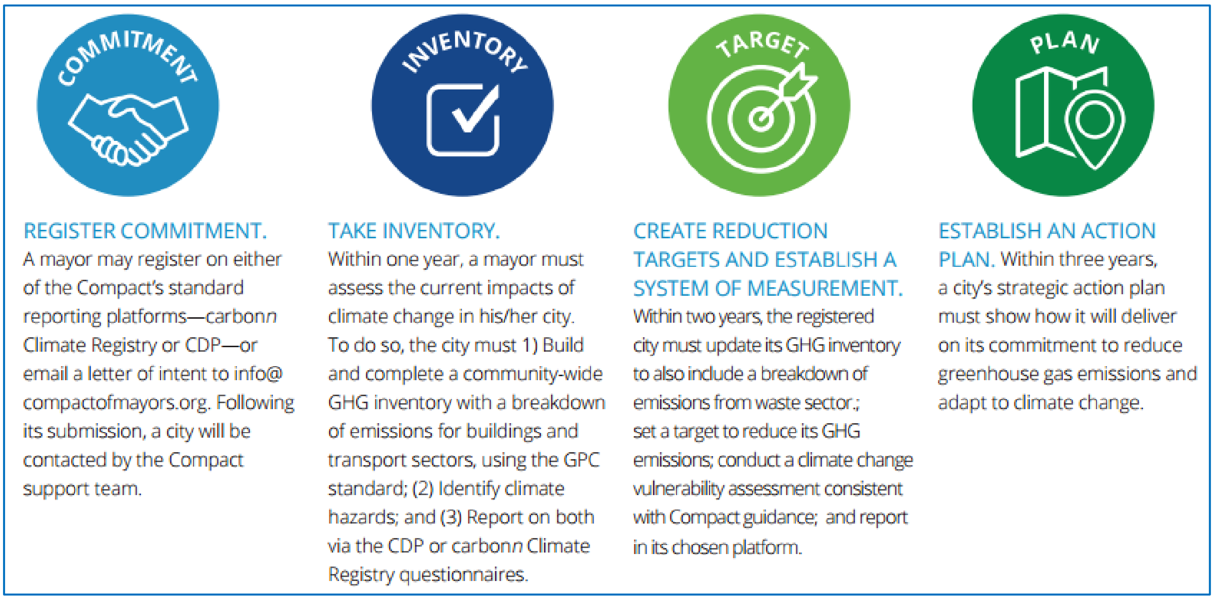
[2] www.worldenergyoutlook.org/media/weowebsite/2008-1994/weo2008.pdf
[3] https://www.gibraltar.gov.gi/new/sites/default/files/HMGoG_Documents/20150301-A_City-Level_Greenhouse_Gas_Inventory_for_Gibraltar_2013.pdf

1.1 The Compact of Mayors

The GPC has been adopted by the Compact of Mayors[4], a global coalition of mayors and city officials pledging to reduce local GHGs, enhance resilience to climate change and track their progress transparently. The Compact collects the significant climate action data that cities are already reporting in a single, transparent platform. It therefore represents the greatest opportunity to bring attention to, and quantify, city action. Gibraltar is one of over 600 cities and communities who have committed to the Compact of Mayors, and as such, are required to undertake a GPC-compliant inventory and vulnerability assessment, set a target, and establish an action plan to reduce emissions and establish a climate change adaptation strategy (see **Figure 1-1**).

Figure 1-1: Compact of Mayors commitment requirements



Source:https://data.bloomberglp.com/mayors/sites/14/2015/07/Compact-of-Mayors-Full-Guide_July2015.pdf

[4] https://www.compactofmayors.org/

2 The Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC)

2.1 Overview

In the past, inventory methods that cities have used have varied in what emission sources and GHGs are included, how emissions sources are defined and categorised, and how transboundary emissions are treated. This inconsistency makes comparisons between cities difficult; raises questions around data quality; and limits the ability to aggregate local, subnational and national government GHG emissions data. It has been recognised that, to allow for more credible reporting, meaningful benchmarking and aggregation of climate data, greater consistency in GHG accounting is required. As noted in the **Introduction**, the GPC was launched in 2014 to address these issues and to offer a globally accepted robust and clear framework that builds on existing methodologies for calculating and reporting city-scale GHG emissions

Gibraltar's community-scale GHG inventory has been compiled following the GPC guidelines.

2.2 Difference from national emissions reporting

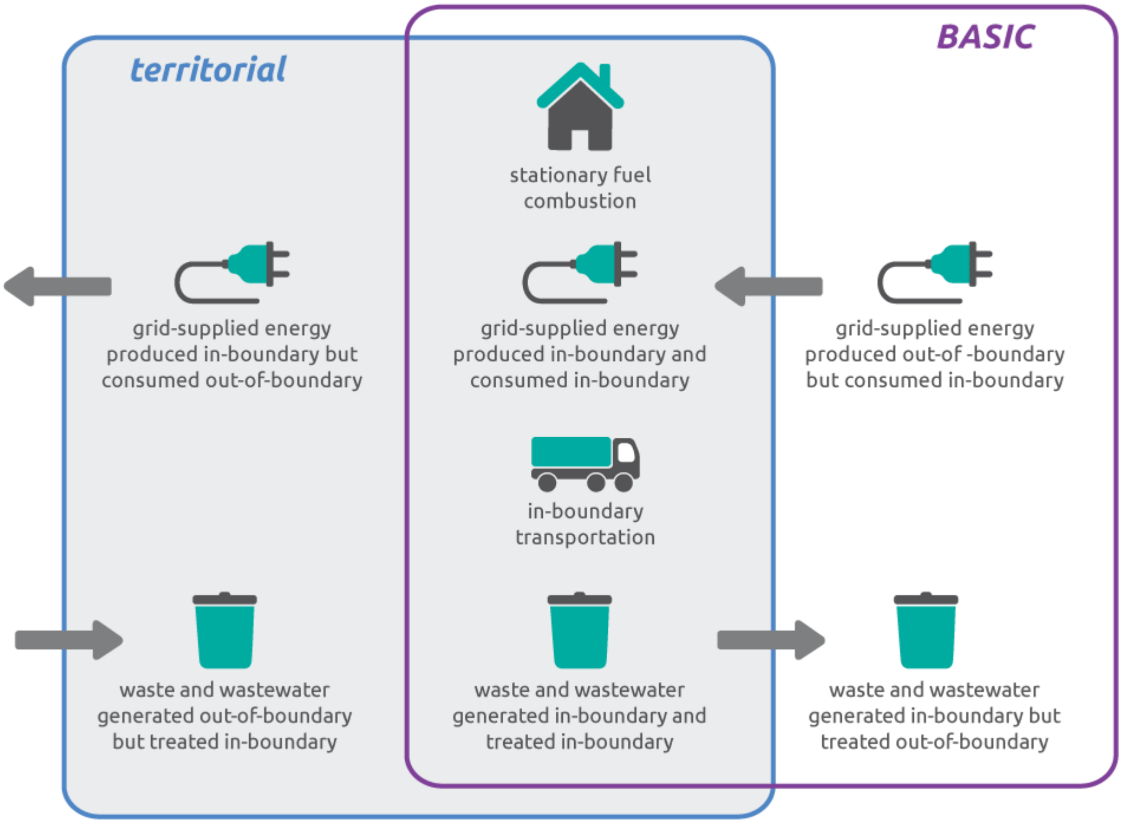
The GPC differs from national reporting methodologies (as required for reporting to the United Nations Framework Convention on Climate Change (UNFCCC)) in several fundamental ways, which reflect the unique circumstances of cities. Although adhering to basic principles of good practice in inventory compilation and reporting, the sources and sectors, and their categorisation are quite different. City-level emission inventories are not primarily focused on emissions from within the geographic boundary, as in a national inventory, but with emissions attributable to activities within the city. Therefore, a city-level inventory includes emissions that occur geographically outside the city (such as out of boundary waste disposal and transboundary transport). The focus on emission 'responsibility' also means that activities occurring in or near the city that are not the responsibility of the city can be excluded to give a more accurate picture of the city's impact; this is particularly significant for Gibraltar. Accounting for emissions on a territorial basis led to reports in summer 2012, based on data from the US Energy Information Administration, claiming that Gibraltar had the highest per capita carbon footprint in the world[5]; this was largely due to the volumes of bunker fuel sold to large marine cargo vessels[6] compared with a small population. This presents a distorted view of GHG emission sources under local control in Gibraltar. An alternative city 'activity-based' approach to measure and report community-scale GHG emissions was needed for Gibrlatar; hence Gibraltar's 2013 community-scale GHG inventory and the 2015 inventory presented in this report.

Figure 2-1 shows, in simple terms, the difference in accounting approaches.

This 'responsibility' is broadly identified by means of 'scopes'. Scopes 1 and 2 are those sources occurring as a result of activities within the city boundary by and within the city. Scope 3 sources are those occurring, usually outside of the city boundary, as a consequence of activities. There is more detail on this in **Section 2.3**.

[5] www.theguardian.com/environment/2012/jul/16/gibraltar-carbon-emissions-distorted-table
[6] Bunker fuels refer to the storage and sale of fuels – typically gas oil and fuel oil – at national boundaries, in this case the trade of shipping fuels at the Port of Gibraltar.

Figure 2-1: Comparison between territorial accounting approach and GPC



Source: GPC v2.0 p.22

For Gibraltar, several key sources of emissions fall into the 'outside of scopes' category for a city inventory. These would be reported in a national inventory. Following an 'activity-based' approach which accounts for emissions that Gibraltar is 'responsible' for means that those sources that fall 'outside of scope' can be reported as such, and therefore excluded from inventory totals as a source beyond the responsibility of the community. Such sources for Gibraltar include bunker fuel sales and exported fuel in vehicles. Although methodologically more challenging to estimate (see methodology details below), it is important to attempt to differentiate between fuel used locally and that immediately exported by the many vehicles that cross the border to take advantage of cheaper fuel prices in Gibraltar.

2.3 Scopes and Sources

The GPC classifies emissions into six main sectors:

I. Stationary energy
II. Transportation
III. Waste
IV. Industrial processes and product use (*IPPU*)
V. Agriculture, forestry, and other land use (*AFOLU*)
VI. Other Scope 3 - Any other emissions occurring outside the geographic boundary as a result of city activities.

Emissions from these sectors are then sub-divided into sub-sectors and may be further divided into sub-categories. **Table 2-1** lists the GPC sectors and sub-sectors.

Table 2-1: GPC sectors and sub-sectors

Sector	Sub-sector
I. Stationary energy 	I.1 Residential buildings
	I.2 Commercial and institutional buildings and facilities
	I.3 Manufacturing industries and construction
	I.4 Energy industries
	I.5 Agriculture, forestry, and fishing activities
	I.6 Non-specified sources
	I.7 Fugitive emissions from coal
	I.8 Fugitive emissions from oil and natural gas systems
II. Transportation 	II.1 On-road
	II.2 Railways
	II.3 Waterborne navigation
	II.4 Aviation
	II.5 Off-road
III. Waste 	III.1 Solid waste disposal
	III.2 Biological treatment of waste
	III.3 Incineration and open burning
	III.4 Wastewater treatment and storage
IV. IPPU 	IV. 1 Industrial processes
	IV.2 Product use
V. AFOLU 	V.1 Livestock
	V.2 Land
	V.3 Aggregate sources
VI. Other Scope 3	VI.1 Other scope 3

Source: GPC

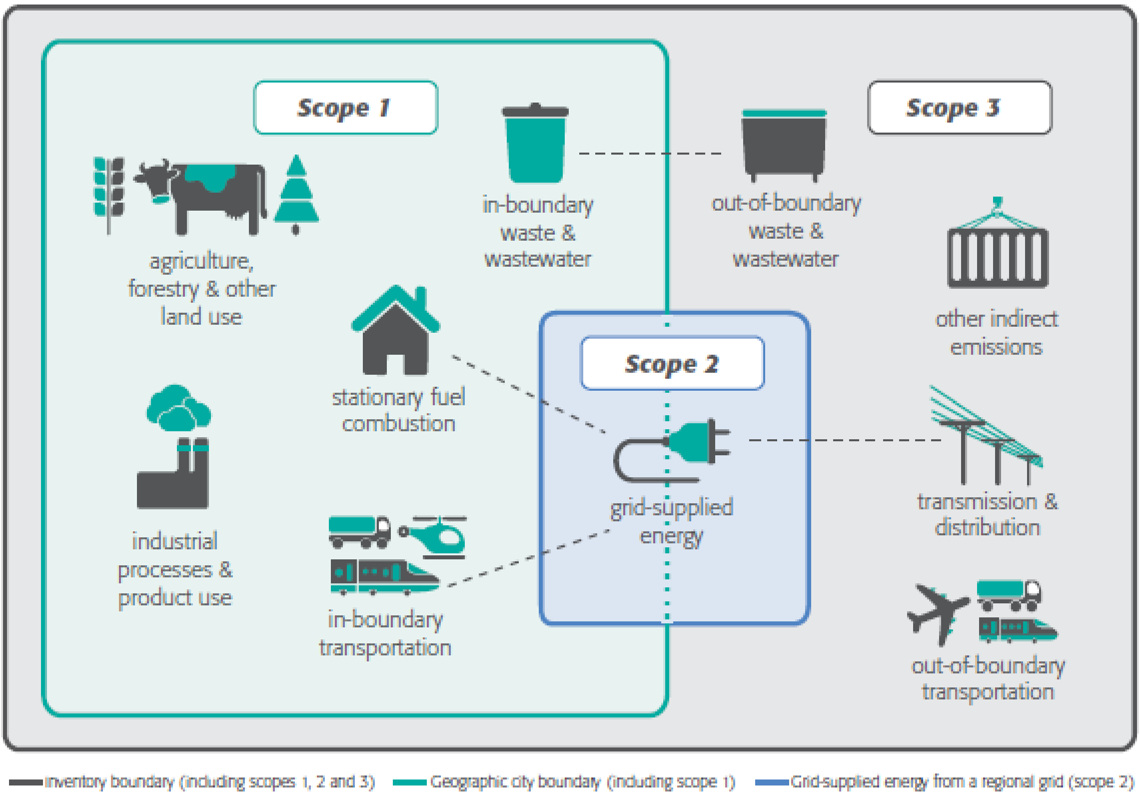
Activities taking place within a city can generate GHG emissions that occur inside the city boundary as well as outside the city boundary. To distinguish between these, the GPC groups emissions into three categories based on where they occur: scope 1, scope 2 or scope 3 emissions (**Table 2-2**).

Table 2-2: GPC inventory scopes

Scope	Definition	Example
Scope 1	GHG emissions from sources located within the city boundary.	• Fuel consumed within the city boundary • Waste generated and disposed of within the boundary
Scope 2	GHG emissions occurring as a consequence of the use of grid-supplied electricity, heat, steam and/or cooling within the city boundary.	• Industrial consumption of grid-supplied electricity • Residential consumption of grid-supplied heat
Scope 3	All other GHG emissions that occur outside the city boundary as a result of activities taking place within the city boundary.	• Waste generated in the city but disposed in a landfill outside of the city • Transmission and distribution losses from grid-supplied electricity

Sources and scopes of a GPC inventory are summarised in **Figure 2-2**.

Figure 2-2: Sources and scopes of a city GHG inventory



Source: GPC

2.4 Reporting levels

The GPC offers cities two levels of reporting demonstrating different levels of completeness, known as BASIC (**Figure 2-3**) and BASIC+ (**Figure 2-4**). The BASIC level covers emission sources that occur in almost all cities (Stationary Energy, in-boundary Transportation, and emissions from in-boundary generated Waste, including waste disposed outside the boundary). The BASIC+ level has a more comprehensive coverage of emissions sources (BASIC sources plus IPPU, AFOLU, transboundary transportation, and energy transmission and distribution losses) and reflects more challenging data collection and calculation procedures.

Gibraltar is reporting a BASIC+ inventory.

Figure 2-3: GPC reporting level - BASIC sources

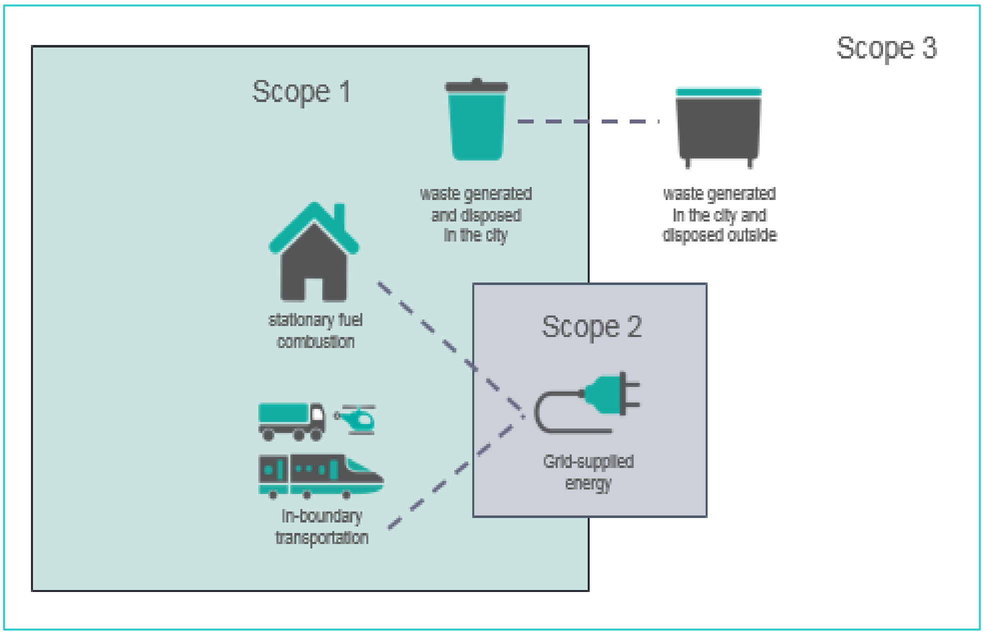
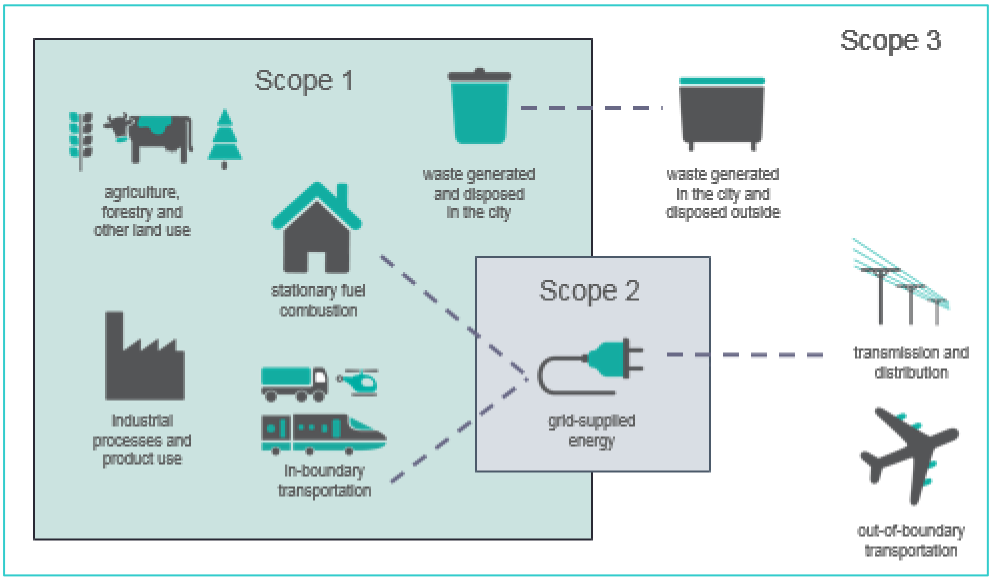


Figure 2-4: GPC reporting level – BASIC+ sources



2.5 Accounting and reporting principles

Any inventory should include quality assurance/quality control (QA/QC) activities. The five key principles enshrined in the Intergovernmental Panel on Climate Change (IPCC) reporting guidelines, **transparency**, **consistency**, **comparability**, **completeness** and **accuracy** (TCCCA) should be adhered to in compiling inventory data and reports. The GPC also has five principles, although 'comparability' has been replaced with **relevance** and a more city-specific definition (see **Box 2-1**).

Box 2-1: GPC Principles of inventory compilation

1. **Relevance**: The reported GHG emissions shall appropriately reflect emissions occurring as a result of activities and consumption patterns of the city. The inventory will also serve the decision-making needs of the city, taking into consideration relevant local, subnational, and national regulations. The principle of relevance applies when selecting data sources, and determining and prioritizing data collection improvements.

2. **Completeness**: Cities shall account for all required emissions sources within the inventory boundary. Any exclusion of emission sources shall be justified and clearly explained. Notation keys shall be used when an emission source is excluded, and/or not occurring.

3. **Consistency**: Emissions calculations shall be consistent in approach, boundary, and methodology. Using consistent methodologies for calculating GHG emissions enables meaningful documentation of emission changes over time, trend analysis, and comparisons between cities. Calculating emissions should follow the methodological approaches provided by the GPC. Any deviation from the preferred methodologies shall be disclosed and justified.

4. **Transparency**: Activity data, emission sources, emission factors, and accounting methodologies require adequate documentation and disclosure to enable verification. The information should be sufficient to allow individuals outside of the inventory process to use the same source data and derive the same results. All exclusions shall be clearly identified, disclosed and justified.

5. **Accuracy**: The calculation of GHG emissions shall not systematically overstate or understate actual GHG emissions. Accuracy should be sufficient enough to give decision makers and the public reasonable assurance of the integrity of the reported information. Uncertainties in the quantification process shall be reduced to the extent that it is possible and practical.

Source: Section 2.1 of the GPC

2.6 Data quality and notation keys

Data collection is an integral part of developing and updating a GHG inventory. Data will likely come from a variety of sources and will vary in quality, format and completeness. In many cases, data will also need to be adapted for the purposes of the assessment. The GPC and the IPCC recognise these challenges and set out good practice data collection principles.

Not all data will be perfect, and there will be gaps, assumptions and limitations with data that are available. To recognise, accommodate and report these limitations, the GPC requires the use of notation keys (see **Table 2-3**). The GPC also requires that when notation keys are used, an accompanying explanation to justify the use of the notation key is also provided; this is to increase transparency and completeness. When collecting emissions data, it is important to establish first whether a source exists, and then the data availability and quality.

- If the source does not exist, 'NO' is used to indicate it is 'not occurring'. For example, in Gibraltar, there is no rail transport and no agriculture.
- If the activity does occur in the city, and data are available, then the emissions should be estimated. However, if the data are also included in another emissions source category or cannot be disaggregated, the notation key 'IE' would be used to indicate 'included elsewhere' and avoid double counting. The category in which they are included should be identified. For example, in Gibraltar emissions from water are included under stationary energy as the only emissions attributable to water are from the consumption of electricity.
- If the data are not available and, therefore, the emissions are not estimated, the notation key 'NE' would be used to indicate 'not estimated'.

Table 2-3: Use of notation keys

Notation key	Definition	Explanation
NO	Not occurring	An activity or process does not occur or exist within the city.
IE	Included elsewhere	GHG emissions for this activity are estimated and presented in another category of the inventory. That category should be noted in the explanation.
NE	Not estimated	Emissions occur but have not been estimated or reported; justification for exclusion should be noted.
C	Confidential	GHG emissions which could lead to the disclosure of confidential information and can therefore not be reported.

Source: Table 2.1 of the GPC

The GPC also requires a qualitative assessment of data quality to be reported; this involves using expert judgement to assign a rating of high (H), medium (M) or low (L) quality to the both the activity data and emission factors used in emission calculations (see **Table 2-4**).

Table 2-4: Data quality assessment

Data Quality	Activity data	Emission factor
High (H)	Detailed activity data	Specific emission factors
Medium (M)	Modelled activity data using robust assumptions	More general emission factors
Low (L)	Highly-modelled or uncertain activity data	Default emission factors

Source: Table 5.3 of the GPC

2.7 Accuracy

Most major emission sources within the Gibraltar inventory ultimately fall under electricity consumption (relevant to most Stationary Energy sub-sectors) or fuel consumption (such as road and marine sub-sectors), for which accurate totals are available from the power stations and import statistics, respectively. Therefore, these data sources act as the high level 'fuel balance' that is allocated across different sources from available activity data. This ensures that there is a high level of reliability in the total emission figures and double-counting is avoided. Any uncertainty is then associated with the activity data and allocation methods across different end users. Accuracy here is important for policy purposes, but less important for understanding the total amount of GHGs emitted.

3 Assessment boundaries

This section sets out the reporting boundaries and requirements of the inventory.

3.1 Geographic boundary

The inventory is defined geographically by the territorial boundary of Gibraltar, as shown in **Figure 3-1**.

Figure 3-1: Map of Gibraltar

Source: http://www.geoportal.gov.gi/webviewer/

3.2 Temporal scale

This inventory covers all atmospheric emissions during calendar year 2015. Where 2015 data were not available, the most recent year's data have been used and the timescale noted accordingly. In particular, these are:

- Population: 2014 figure extrapolated to 2015 following recent trend (2015 not yet available)
- Gross domestic product (GDP): 2014 figure extrapolated to 2015 following recent trend (2015 not yet available)

3.3 Greenhouse gases reported

As per the GPC, Gibraltar accounts for emissions of the seven gases currently required for most national GHG inventory reporting under the Kyoto Protocol: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulfur hexafluoride (SF_6), and nitrogen trifluoride (NF_3). Nitrogen trifluoride was not one of the six gases originally mandated under the Kyoto Protocol, but was added for the second compliance period (starting 2012). The gases required by the GPC are the same seven gases currently required for most national GHG inventory reporting. CO_2 from biogenic sources are reported separately and not included in inventory totals.

The International System of Units (SI units) is used for measuring and reporting activity data, and all GHG emissions data are reported as metric tonnes of CO_2 equivalents (CO_2e). CO_2e accounts for the global warming potential (GWP) when measuring and comparing GHG emissions from different gases. Individual GHGs are converted into CO_2e by multiplying by the 100-year GWP coefficients given in the 2006 Intergovernmental Panel on Climate Change (IPCC) Guidelines (see **Table 3-1**). These are taken from the IPCC.

Gibraltar is using the 4th Assessment Report GWP values, consistent with the UK national GHG inventory and international best practice.

Box 3-1: Biogenic CO_2

Biogenic emissions are those that result from the combustion of biomass materials that naturally sequester CO_2, including materials used to make biofuels (e.g. crops, vegetable oils, or animal fats). For the purposes of national level GHG inventories, land-use activities are recorded as both sinks and sources of CO_2 emissions. Reporting emissions from combusting these biogenic fuels would result in double counting on a national level. The GPC also records land-use changes, and combusted biofuels may be linked to land-use changes in its own inventory, or other cities' inventories.

Source: Box 4.2 of the GPC

Table 3-1: Global warming potentials (GWP) used in calculations, adapted from IPCC 2006 Guidelines.

Industrial designation or common name	Chemical formula	Lifetime (years)	Radiative efficiency (W m^{-2} ppb^{-1})	Global warming potential for given time horizon (100 years)
Carbon dioxide	CO_2		$1.4x10^{-5}$	1
Methane	CH_4	12	$3.7x10^{-4}$	25
Nitrous oxide	N_2O	114	$3.03x10^{-3}$	298

3.4 Sources and scopes

Table 3-2 indicates the sources included in the inventory under each emission scope, and **Figure 3-2** shows this is diagrammatic format.

Table 3-2: Sources included in the inventory under each emission scope

Scope	Definition

Scope 1	All GHG emissions from sources located **within the boundary** of the city:
	• Stationary fuel combustion.
	• Direct IPPU emissions[7]
	• Electricity generation (information item only).
	• Mobile fuel combustion:
	  – Road vehicles in-boundary.
	  – Marine vessels in-boundary.
	  – Aircraft in-boundary[8].
	  – Rail in-boundary[8] .
	• Waste disposal.
	• AFOLU[8].

Scope 2	All GHG emissions occurring **as a consequence** of the use of grid-supplied **electricity**, heating and/or cooling within the city boundary: • Industrial electricity consumption[8]. • Commercial/other non-domestic electricity consumption. • Electricity consumption for key users (for example, water[9]).

Scope 3	All other GHG emissions that occur **outside the city boundary** as a result of activities within the city's boundary:
	• Mobile fuel combustion:
	  – Road vehicles transboundary.
	  – Marine vessels transboundary.
	  – Aircraft transboundary.
	  – Rail transboundary[8].
	• Waste disposal and wastewater treatment.

Outside of scopes (reported under 'VI. Other Scope 3')	Sources that occur in or within the vicinity of Gibraltar, but which occur indirectly as a result of activities outside the control or influence of the community. These sources are reported as information items and not included in the overall emission total: • Export of road transport fuels. • Marine fuel bunkering.

[7] Industrial Process emissions are not occurring in Gibraltar. Product Use emissions are reported however.
[8] Not occurring in Gibraltar
[9] In Gibraltar, water emissions are included under Scope 2 as emissions are solely those associated with electricity consumption for desalination plant and pumping. No mains water is imported.

Figure 3-2: Gibraltar's emission sources by scope

4 Calculation methodologies by emission source

4.1 Stationary energy

Stationary energy is a significant part of any inventory. This is generally divided into two categories – emissions from stationary combustion of fuel, and emissions from generation and consumption of grid supplied electricity. Stationary energy sources appear in all reporting scopes as shown in **Box 4-1**.

Box 4-1: Stationary energy sources

Scope 1: Emissions from in-boundary emissions from fuel combustion and fugitive emissions.

- Combustion of fuels in buildings and industry.
- Conversion of primary energy sources in refineries and power plants (including production of electricity used by the power plant).
- Fossil resource and exploration within the city boundary.
- Fugitive emissions from fuel systems.

Scope 2: Emissions from the consumption of grid-supplied electricity, steam, heating and cooling.

Scope 3: Other out-of-boundary emissions.

- Transmission and distribution losses of electricity
- Steam, heating and cooling (not occurring in Gibraltar).

4.1.1 Energy industries: electricity generation

Electricity is the major energy source for Gibraltar and is the only energy industry present. Gibraltar is self-sufficient in electricity and operates as a ‘closed system’ (that is, there are no imports or exports from neighbouring regions). This allows for a very accurate calculation of the electricity-related emissions for Gibraltar.

4.1.1.1 Summary of methods

Electricity production includes two categories, which should add up to total emissions from fuel combusted for energy generation:

1. Electricity generation sold and distributed: this comprises emissions from all fuel use for electricity generation from main activity producers.
2. Auxiliary energy use on the site of energy production facilities.

The process of estimating emissions from electricity generation is shown in **Figure 4-1**.

Figure 4-1: Process of estimating emissions from electricity generation

- Obtain annual fuel consumption data for each power generation plant for specified time period.
- Obtain electricity output data (generation) for specified time period. The difference between fuel consumed at power plants and the output is assumed to be use of power at power stations
- Obtain total electricity billings data for specified period of time.
- Multiply total fuel consumption for electricity generation by emission factor for fuel type to obtain total emissions from generation.
- Divide total electricity generated by total emissions from fuel use to obtain implied emission factor (IEF).
- Multiply total electricity billings by implied emission factor to obtain total emissions from consumption.

4.1.1.2 Raw data

Raw data were obtained from the Gibraltar Electricity Authority (GEA) and consisted of electricity output, fuel use, fuel type and time period of reporting.

Gibraltar's power stations are:

- Waterport power station (since partially burned down, but operational in inventory year 2015);
- North Mole Turbines, or temporary generators;
- OESCO power station; and,
- GMES power station.

All power stations use gas oil (either marine or automotive gas oil). Emission factors for fuels are taken from the UK National Atmospheric Emissions Inventory (NAEI) (2015 data) and are shown in **Table 4-1**.

Table 4-1: Emission factors for power station gas oil fuel (from UK NAEI)

Pollutant	Unit	Emission factor
Carbon	kt/Mt fuel consumed	870
Methane (CH_4)	kt/Mt fuel consumed	0.13
Nitrous oxide (N_2O)	kt/Mt fuel consumed	0.026

4.1.1.3 Determining emissions

To calculate emissions from electricity generation, total annual fuel use at the power stations by type is summed and multiplied by the relevant emission factor for each pollutant; the UK NAEI emission factors for gas oil has been used. This figure is then multiplied by the pollutant's global warming potential (GWP) (or 44/12 to convert from carbon to CO_2) to give total carbon dioxide equivalent (CO_2e) emissions in tonnes. This gives the total emissions from generation. As emissions here are calculated from consumption of a known quantity and type of fuel, and not from other activity data, it is possible to aggregate emissions.

To disaggregate emissions on an end-user basis, based on electricity consumption, an implied emission factor (IEF) calculated from known activity data is required. To calculate the IEF, total emissions associated with the fuel consumed to produce the electricity is divided across the total production of electricity to estimate emissions per unit. This then givens an estimate of the emissions for each unit consumed, in kt CO_2e per gigawatt hour (GWh) (as shown in **Table 4-2**). This IEF can then be multiplied by total electricity consumed (billings data) to give emissions from energy consumed by end-users.

The difference between electricity produced by the power stations and the electricity supplied to the Gibraltar electricity network is assigned to use of their own power at the power station sites.

The difference between the amount of electricity supplied to the Gibraltar electricity network and the amount of electricity that is billed for by AquaGib is assumed to be the transmission and distribution losses across the network.

Table 4-2: Implied emission factors for Gibraltar's power generation

Pollutant	Unit	IEF	IEF factor (CO_2e)
Carbon	kt/GWh	0.23306	0.8546
CH_4	kt/GWh	0.00003	0.0009
N_2O	kt/GWh	0.00001	0.0020
Total	**kt/GWh**		**0.8574**

Figure 4-2: Turbines at North Mole

Figure 4-3: New skid-mounted generators at North Mole (2014)

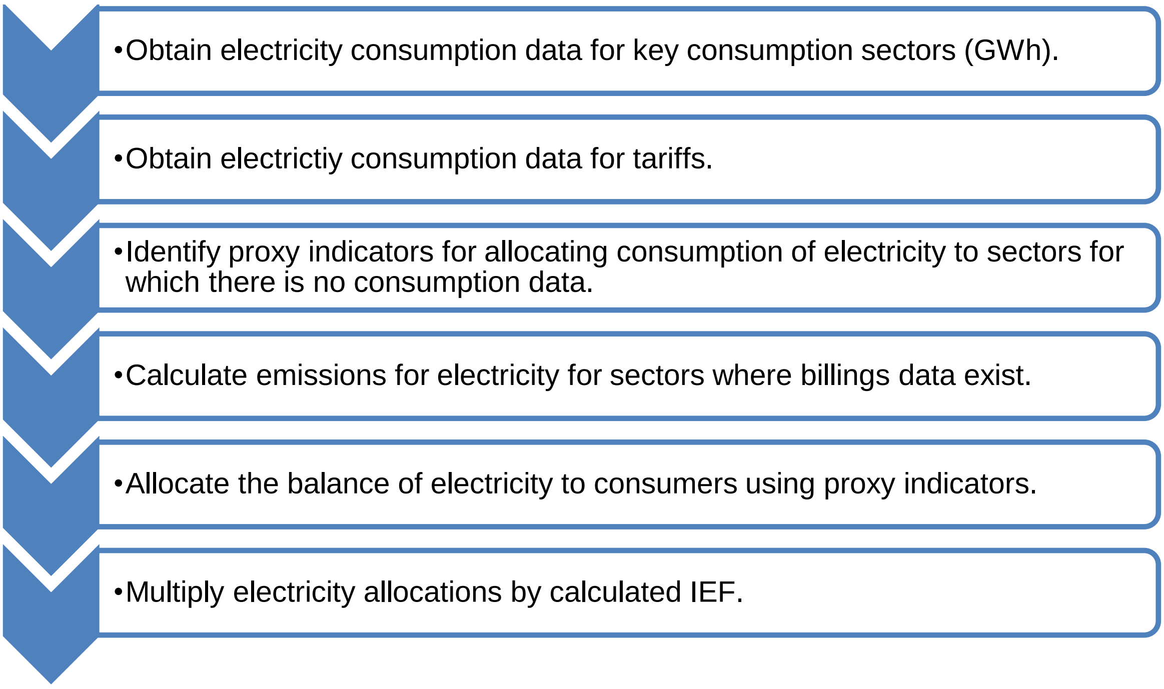
4.1.2 Allocating emissions based on electricity consumption

Allocation of emissions from electricity generation to the end user uses data on total electricity consumption in Gibraltar and the IEF calculated for generation as the basis for calculations. Gibraltar is unusual in that all electricity consumed is also generated within the boundary. Therefore, total emissions data are allocated across different sectors.

4.1.2.1 Overview

A summary of the process is illustrated in **Figure 4-4**.

Figure 4-4: Summary of the process of calculating emissions



4.1.2.2 Raw data

A number of data sources were used in compiling estimates of emissions from electricity consumption. These were:

- GWh billings by tariff supplied by AquaGib (see **Table 4-3**).
- Electricity consumption data for key sectors, including hotels and the hospital
- Proxy data on employment by sector from the 2014 Abstract of Statistics (Table 8.02 Number of Employee Jobs by Industry, October 2014), see **Table 4-4**. This shows proportion of employees by sector and allocation of industries to tariffs.

4.1.2.3 Determining activity

Electricity consumption data need to be allocated to end users through known consumption or an allocation based on a proxy indicator. Known consumption for sectors include domestic (residential) consumers (from AquaGib tariff data); hotel billings data (obtained directly from hotels); and AquaGib water electricity billings. Known billings were subtracted from total billings data.

Remaining billings data are then allocated to sectors based on employment numbers, and this employment data was used as a multiplier to billings data within tariff categories as shown in **Table 4-4**.

As mentioned, transmission and distribution losses are assumed to be the difference between the electricity that is supplied and the electricity that is billed. This is allocated to GPC sub-sectors based on the share of billed electricity consumption of each respective sub-sector.

The difference between electricity produced by the power stations and the electricity supplied to the Gibraltar electricity network is assigned to use of their own power at the power station sites.

Table 4-3: AquaGib electricity tariffs

Tariff number	Tariff name	Description	GPC sub-sector allocation
1	Lighting	Tariff for public lighting only	I.2.2
2	Power	Tariff for power only – examples include temporary sockets	I.2.2

3	Domestic	Residential properties only	I.1.2
4	Commercial	Majority of public sector and commercial premises (e.g. hospital)	I.2.2
5	Industrial maximum demand	Energy-intensive users, in particular bakeries, super markets, hotels	I.2.2
6A	Off-peak	Power during off-peak hours only	I.2.2
6B	Off-peak	Power during off-peak hours only	I.2.2
9	MOD Offices and Residential	Power used in MOD offices and residences	I.6.2

Table 4-4: Employment numbers by industrial/commercial sector, used as proxy data for electricity allocation

Industry	2014 employment	% of total
Shipbuilding	223	1%
Other Manufacture	223	1%
Electricity and Water Supply	290	1%
Construction	3017	12%
Wholesale and Retail Trade	3245	13%
Hotels and Restaurants	1534	6%
Transport and Communication	1381	6%
Financial Intermediation	2051	8%
Real Estate and Business Activities	2876	12%
Public Administration and Defence	2239	9%
Education	1039	4%
Health and Social Work	2161	9%
Other Services	4143	17%
Total	**24422**	**100%**

4.1.2.4 Determining emissions

Emissions are calculated by multiplying the GWh assigned to each end-user sector as above, by the IEF for each pollutant and its GWP, to give a value of CO_2 e by end-user sector.

4.1.3 Other stationary fuel combustion

Scope 1 emissions from combustion of fuels in power stations in Gibraltar are covered above.

There is believed to be a small amount of stationary fuel combustion, in the form of bottled gas, assumed to be used in restaurants. Fuel import data provided by HM Customs has been used to estimate emissions from this source. The import statistics refer to ‘Petroleum gases and others gaseous hydrocarbons’; this is assumed to be LPG. Activity data is multiplied by the Defra Conversion Factors 2015 emission factor for LPG.

It is also understood that some hotels have solid or liquid fuel (such as gas oil or fuel oil) combustion capacity (such as back-up generators). However, no data were available for this study. Therefore, this source is NE.

The Gibraltar Health Authority (GHA) maintains underground supplies of liquid fuel for standby generators in case of power cuts. However, no data were available for this study, therefore this source is NE.

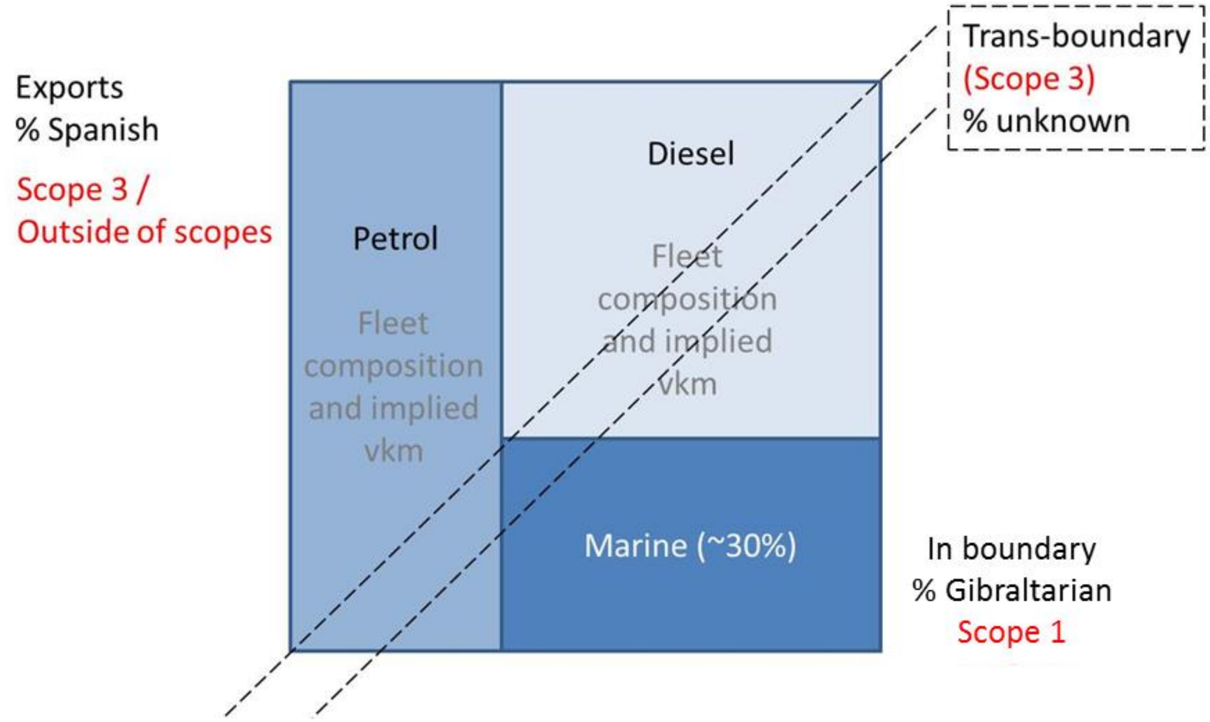
There is no stationary fuel combustion in households as all energy requirements are met through electricity, so this source is not occurring (NO).

There is no fossil resource or exploration in Gibraltar, so this source is NO.

4.2 Transportation

The transport sector covers a wide range of emission sources, including road, rail (not present in Gibraltar), air and water, and consists of in-boundary and transboundary sources. In the case of Gibraltar, some transport sources (exported road and marine bunker fuels) are also estimated, but excluded from totals.

Figure 4-5: Process of estimating emissions from electricity generation



4.2.1 Road Transport

Road transport emissions have been calculated from Gibraltar's fuel import statistics for 2015. This effectively provides an 'energy balance' for total road transport fuel consumption. As a result, the emissions total can be calculated very accurately by allocating to Gibraltar the proportion of fuel remaining when exports have been subtracted. A proportion of this imported fuel also goes to private marine use. The allocation of this is discussed in **Section 4.2.2**. Although there is uncertainty in allocation, the overall fuel total and, therefore, emissions, particularly for CO_2, remains accurate.

Road transport emissions from fuel used by Gibraltarian vehicles are assigned to Scope 1.

Road transport emissions from fuel used by non-Gibraltarian vehicles are assigned to outside of scopes.

There is no way of differentiating transboundary transport (Scope 3).

4.2.1.1 Overview

Figure 4-6 gives a brief overview of how estimates of emissions due to road transport have been made. A more detailed explanation is given in the following sections.

For the highest emitting sources, Gibraltar-specific data have been sought and used. In some cases, for less significant sources, emission factors have been taken from the UK inventory. Generally speaking, these assumptions are based on factors that are unlikely to vary much between Gibraltar and the UK or the impact of any significant differences would be small.

Figure 4-6: Road transport method summary

- Process the raw licensing statistics provided by the Govornment of Gibraltar and produce a fleet composition, split by vehicle type, fuel used, euro standard and weight class.
- Extract emission factors for each of the above kinds of vehicle (on a per km basis).
- Use the fleet composition and emission factors to produce fleet weighted emission factors.
- Normalise fuel station count data for private, commercial and motorcycle; petrol and diesel; and Gibraltarian/non-Gibraltarian.
- Remove known fuel consumption from net fuel imports, for example for consumption as reported by bus companies. Emissions from these sources are fuel consumption multiplied by fleet weighted emission factor.
- Allocate remaining total fuel imports by vehicle class based on normalised vehicle counts, removing emissions from known sources, such as from reported bus fuel consumption
- Divide total fuel consumption by fleet weighted emission factor to generate implied vehicle kilometre (vkm) data.
- Multiply vkm data by polluant emission factors.

4.2.1.2 Raw data

The licensing statistics provided by the Government of Gibraltar give a number of key pieces of information, allowing the nature of the road transport situation in Gibraltar to be determined. Particular data used were:

- The type of vehicle:
  - This allowed a decision on what kind of vehicle the record corresponded to and, in some cases, allowed a decision to be made about the fuel or weight class.

- Registration date:
  - This helped determine when vehicles were likely to have been manufactured and, hence, what European emission standard they will have been required to meet.
- The fuel type (that is, petrol or diesel vehicles).
- Cylinder capacity:
  - This was used to help determine the weight classes of the vehicles.
- The model and make:
  - Used to spot-check some assumptions and to correct other details (such as vehicle type) when found to be inaccurate.

Fuel import and export data for 2015 provided a high-level energy balance to allocate by mode and sector. Prior to use in this inventory, the data required some cleaning since the recorded mass and volume often implied an infeasible fuel density, suggesting that inconsistent units were used by importers when recording this data. Further details on the allocation of fuel use to the road transport sector are found in **Section 4.2.1.3**. Fuel consumption allocated to road transport in 2015 is shown in **Table 4-5.**

Table 4-5: Gibraltar total road transport fuel use for 2015

Year	Fuel	Thousands of litres
2015	Motor spirits	11,715
2015	Automotive Gas Oil	29,839

In addition, surveys of fuel stations carried out by the Department of the Environment over a 17-day period (for approximately a 1-hour period at each of four stations) captured the vehicle type (commercial, private (assumed car) and motorcycle), the fuel type and the licence plate, which was used to determine if the vehicle was Gibraltarian or other (mostly Spanish).

Data was also available for fuel consumption from a number of transport modes, including Government of Gibraltar vehicles, customs vehicles, and fuel consumption from two major bus companies operating within Gibraltar.

4.2.1.3 Determining activity

Road transport emissions are most accurately estimated from fuel consumption when the carbon content, and thus CO_2 emitted when combusted, is accurately known (although other pollutants are more greatly affected by the method of combustion). There are reliable data from the fuel import statistics for this. However, for a local-scale inventory, an understanding of how these emissions are allocated across modes by activity is more useful for informing policy. In this inventory, the fuel import data have been allocated by vehicle and fuel type.

It was assumed that fuel import data, by motor spirit (petrol) and automotive gas oil (diesel) for 2015, included gas oil use for private marine boats. Therefore, this marine fuel needs to be removed from the import data totals for allocation to the marine sector. It was assumed that 30% of automotive gas oil imports was used for marine vessels[10].

[10] Anecdotal evidence from the Department of the Environment (2013)

Table 4-6 - Fuel import data scaled and allocated for marine and road use

Fuel type	Net fuel imports (kt)	Removal of marine/military use (kt)	Road transport use (kt)	Marine use (kt)
Motor spirit	8.6	0	8.6	0
Automotive gas oil	37.1	11.1	26.0	11.1

Data was provided by Gibraltar's two principle bus companies which allowed for the estimation of fuel consumption directly from this vehicle type. In this case, one company could only provide data on annual fuel costs and so assumptions were made on the price paid for fuel in order to estimate fuel consumption.

In the absence of vehicle activity data (e.g. mileage by mode) to assign fuels to vehicle classes, vehicle fleet data were used to calculate activity data (vkm travelled) by category.

Using the fleet data described above, it was possible to build a basic fleet composition. Some further processing of these data was done to provide further disaggregation (for example, the types of catalysts used in heavy duty vehicles) of the fleet and to fill perceived gaps/errors in the Gibraltar licensing statistics. This processing was done with the aid of the Gibraltar Abstract of Statistics and the UK NAEI estimates.

Fuel station survey data were then processed and normalised to give a frequency of vehicle type (shown in **Table 4-7**) and, therefore, a fuel-use split. These fuel-use splits were then applied to total fuel use by type (as above), to give fuel use in kt by vehicle type – Gibraltarian and non-Gibraltarian.

Due to the lack of specific activity data for journey types (in-boundary and transboundary, and Gibraltarian and non-Gibraltarian vehicles) all fuel use by Gibraltarian vehicles was assigned as in-boundary. All fuel use by non-Gibraltarian vehicles was assigned to out of boundary with no explicit transboundary proportion (although some of the in-boundary fuel may be transboundary by Gibraltarians crossing the frontier).

Table 4-7: Fuel Station Survey data

Vehicle type	Fuel	Gibraltarian /non-Gibraltarian	Normalised vehicle frequencies by filling station			
			CEPSA (1)	PETROIL (2)	GIB OIL (3)	PETROIL (4)
Private vehicle	Diesel	Gibraltarian	17	33	71	20
Commercial vehicle	Diesel	Gibraltarian	7	13	28	19
Private vehicle	Petrol	Gibraltarian	20	87	146	72
Commercial vehicle	Petrol	Gibraltarian	6	18	25	19
Motorcycle	Petrol	Gibraltarian	9	32	0	57
Private vehicle	Diesel	Non-Gibraltarian	197	76	54	8
Commercial vehicle	Diesel	Non-Gibraltarian	16	5	10	2

Vehicle type	Fuel	Gibraltarian /non-Gibraltarian	Normalised vehicle frequencies by filling station			
			CEPSA (1)	PETROIL (2)	GIB OIL (3)	PETROIL (4)
Private vehicle	Petrol	Non-Gibraltarian	187	92	56	13
Commercial vehicle	Petrol	Non-Gibraltarian	8	1	2	0
Motorcycle	Petrol	Non-Gibraltarian	78	76	0	17
Scaling factors			1.26	1.36	1.75	1.56

4.2.1.4 Determining emissions

The emission factors used for Gibraltar are the same as those used in the UK NAEI road transport projections models (Transport Research Laboratory (TRL) emission factors for fuel consumption, N_2O and CH_4; and the United Kingdom Petroleum Industry Association (UKPIA) for carbon content of fuel). It has been assumed that all traffic in Gibraltar is urban and that any traffic attributed to Gibraltar, but done by vehicles registered outside (for example, people who travel into Gibraltar from Spain) will have a similar fleet composition and driving pattern as that of Gibraltarians.

Because the UK NAEI calculates carbon from fuel combustion on a mass of fuel basis, a fuel consumption factor is used to convert the carbon emission factor from a fuel mass-based factor to a journey distance-based factor.

Using the fleet composition, a very large set of emission factors (for each vehicle type, fuel, weight class, and European emission standard and catalyst type) can be reduced down to a handful of fleet-weighted emission factors for each vehicle type, as shown in **Table 4-8.**

Emissions are then calculated for each pollutant by multiplying the implied vkm travelled (shown in

Table 4-9**)** by the fleet weighted emission factors.

Emissions from non-Gibraltarian vehicles are accounted for under 'Other Scope 3' and are therefore not included in BASIC or BASIC+ inventory totals.

Table 4-8: Fleet-weighted emission factors

Vehicle type	Weighted emission factor (g/km)		
	CO_2	CH_4	N_2O
Petrol cars	180	0.034	0.013
Diesel cars	166	0.002	0.015
Petrol LGVs*	293	0.028	0.014
Diesel LGVs	230	0.004	0.014
HGV	543	0.064	0.014
Bus	712	0.090	0.021
Motorcycles	78	0.087	0.002

*Light goods vehicle (LGV) ** Heavy goods vehicle (HGV)

Table 4-9: Calculated fleet-weighted fuel consumption and vkm

Gibraltarian/ non-Gibraltarian	Vehicle type	Fuel type	Fuel consumption (g/km)	Total calculated fuel consumption (kt)	Implied mvkm* travelled
Gibraltarian	Private vehicle	Petrol	57.4	2.95	51
Gibraltarian	Commercial vehicle	Petrol	93.6	0.61	6
Gibraltarian	Motorcycle	Petrol	24.8	0.90	36
Gibraltarian	Private vehicle	Diesel	52.5	6.52	124
Gibraltarian	Commercial vehicle	Diesel	80.6	3.09	38
Non-Gibraltarian	Private vehicle	Petrol	57.4	2.77	48
Non-Gibraltarian	Commercial vehicle	Petrol	93.6	0.09	1
Non-Gibraltarian	Motorcycle	Petrol	24.8	1.69	68
Non-Gibraltarian	Private vehicle	Diesel	52.5	13.47	256
Non-Gibraltarian	Commercial vehicle	Diesel	80.6	1.40	17

*million vehicle kilometres

4.2.2 Marine – private boats

As noted above, a proportion of gas oil included in the fuel import data is used by private boats. This has been estimated at 30% of total demand in 2013[11]. Emissions have been estimated using the emission factors for marine gas oil. As activity data in this sector are not available, there is no way of allocating to specific activities within the private marine sector.

[11] From the Department of the Environment, Government of Gibraltar

Figure 4-7: There are a large number of private boats in Gibraltar, but no activity data are available

4.2.3 Shipping

Shipping generates a large proportion of Gibraltar's emissions in the national inventory because of the considerable amount of bunkering activity and the fact the Gibraltar is a large international port near a major shipping lane. In this inventory, shipping is divided into two main categories: bunkering, and non-bunkering (that is, ships that call at Gibraltar with a purpose other than just obtaining fuel).

Shipping emissions from non-bunkering traffic are assigned to scope 3.

Shipping emissions from bunkering traffic are assigned to outside of scopes

4.2.3.1 Overview

Figure 4-8 gives a brief overview of how estimates of emissions due to shipping have been made. A more detailed explanation is given below.

Figure 4-8 – Process of estimating emissions from shipping

- Extract raw data (port arrivals and departures) from the Gibraltar Port Statistics.
- Assign journeys as in-scope or out-of-scope on the basis of the reported purpose of call
- Assign distances travelled to/from Gibraltar based on ship manifests
- Assign vessel classes of the shipping traffic.
- Determine the fuel use per km for each vessel class.
- Calculate total fuel use by vessels to/from Gibraltar.
- Use NAEI emission factors to determine the total emissions due to the total fuel used.

4.2.3.2 Raw data

The raw dataset was provided by the Gibraltar Port Authority and provides information on the shipping movements of all vessels that ‘interface’ with Gibraltar, including details on ship-type, gross tonnage, last port, and next port destination. However, a number of vessels included within this dataset carry out off port limit calls, and do not enter Gibraltar waters, which are excluded from the dataset on the basis of additional information provided by the Port Authority. The key pieces of information used in the subsequent inventory calculations are;

- A distance (km) travelled to/from Gibraltar.
  - This is calculated using http://ports.com/sea-route to estimate the distance in nautical miles and converted to km. The activity for ships travelling both to and from Gibraltar has been calculated, but only one direction (departing) should be included in Gibraltar’s emissions total as per the GPC. The origin and destination are those reported on the ship manifests.
- Ship class
  - The given ship type was assigned to one of the below groups of ship, allowing the use of Tables 3-4 and 3-7 in the EMEP/EEA air pollutant emission inventory guidebook 2016[12] Section 1.A.3.d Navigation. (See **Table 4-10**) is within or outside the scope of the inventory
  - Guidance from the Port Authority was used to determine which ships should be included within the inventory, and which were involved with either bunkering, or off port limit calls. **Table 4-11** illustrates the allocation on the basis of the registered purpose of call within the dataset.

Table 4-10 – Ship classification based on the EMEP/EEA Guidebook 2016[12]

Ship types	
Liquid bulk ships	Dry bulk carriers
Container	General cargo
Ro Ro Cargo	Passenger

[12] www.eea.europa.eu/publications/emep-eea-guidebook-2016

Ship types	
Fishing	Tug
Other	

Table 4-11 – Definition of in-scope and out-of-scope shipping activity on the basis of stated purpose of call

Purpose of call	
In-scope	**Out-of-scope**
Arrested	Bunkers
Awaiting Berth/Supply	Change of Schedule
Cargo Loading/Unloading	Charts
Containers Loading/Unloading	Class Survey
Cruise Call	Compass Adjusting
Gibraltar/Tangiers Ferry	Crew Change
Laid Up	Debunkers
MOD Movement	Deliver Fenders
Owners Change	Detention
Repairs	Garbage Discharge
Rocks Unloading/Loading	Hold Inspection
Stationed	Load Line Certificate
Ship-to-ship Transfer	Lub-Oil
To Supply Bunkers	Medical Assistance
Waiting Orders	Port Clearance Note
Yacht Delivery	Pratique Note
Yacht Loading/Unloading	Provisions
	PSC Inspection
	Shelter
	Slops Discharge
	Spares
	Stores
	Ship-to-ship Equipment Return
	Surveyor/Technician Transfer
	Tender/Service
	Towing
	Under Tow
	Underwater Cleaning
	Underwater Inspection
	Underwater Survey
	Water Receive

Purpose of call	
In-scope	**Out-of-scope**
	Yacht Visit

4.2.3.3 Determining activity

The key activity data of interest are the mass of fuel used, as this is the activity for which emissions factors are available within the UK NAEI. After processing the raw data from the port statistics, the activity dataset is in km. To convert this to a fuel use, it is possible to use the following to calculate fuel use using Equation 4-1.

- Fuel use per unit energy given in Table 3-4 of the shipping chapter of the EMEP/EEA air pollutant emission inventory guidebook 2016 (shown here in **Table 4-12**).
- The engine type weightings provided in Table 3-7 of the guidebook (shown here in **Table 4-13**).
- The main engine power in table 3-6 of the guidebook (shown here in **Table 4-14**).
- The average speeds in table 3-14 of the guidebook (shown here in **Table 4-15**).

Bunker fuel sales data also was supplied. However, the data did not closely correlate to the reported fuel import/export data also provided and was considered to be less robust, so was not used in the shipping inventory calculations.

Equation 4-1: Calculation for shipping emissions

$$\text{Fuel use (t)} = \frac{\text{Distance travelled(km)} * \text{Power}^{13}\text{ (kW)} * \text{Fuel use factor(t/kWh)}}{\text{Average speed (km/hour)}}$$

Figure 4-9: Bunkering ships

[13] Main engine power

Table 4-12: Tier 2 emissions factors for shipping from the EMEP/EEA air pollutant emission inventory guidebook 2016[12] (appears as Table 3-4 in guidebook)

Tier 2 default emission factors							
Engine type	**Fuel type**	**NO_x 2000** (kg/tonne)	**NO_x 2005** (kg/tonne)	**NO_x 2010** (kg/tonne)	**TSP - PM_{10}** (kg/tonne)	**$PM_{2.5}$** (kg/tonne)	**Specific fuel consumption** (g fuel/kWh)
Gas turbine	BFO	20.0	19.3	18.6	0.3	0.3	305
	MDO/MGO	19.7	19.0	18.3	0.0	0.0	290
High-speed diesel	BFO	59.6	57.7	55.6	3.8	3.4	213
	MDO/MGO	59.1	57.1	55.1	1.5	1.3	203
Medium-speed diesel	BFO	65.7	63.4	61.3	3.8	3.4	213
	MDO/MGO	65.0	63.1	60.6	1.5	1.3	203
Slow-speed diesel	BFO	92.8	89.7	86.5	8.7	7.8	195
	MDO/MGO	91.9	88.6	86.5	1.6	1.5	185
Steam turbine	BFO	6.9	6.6	6.4	2.6	2.4	305
	MDO/MGO	6.9	6.6	6.4	1.0	0.9	290

Source: Entec (2002), Entec (2007), emission factors calculated in kg/tonne of fuel using specific fuel consumption.

BFO –Bunker Fuel Oil, MDO –Marine Diesel Oil, MGO –Marine Gas Oil
BC fraction of PM (f-BC); BFO: 0.12, MDO/MGO: 0.31. Source: for further information see Appendix A

Table 4-13: Engine type weightings from the EMEP/EEA air pollutant emission inventory guidebook 2016[12] (appears as Table 3-7 in guidebook)

Ship category	SSD MDO /MGO	SSD BFO	MSD MDO /MGO	MSD BFO	HSD MDO /MGO	HSD BFO	GT MDO /MGO	GT BFO	ST MDO /MGO	ST BFO
Liquid bulk ships	0.87	74.08	3.17	20.47	0.52	0.75	0.00	0.14	0.00	0.00
Dry bulk carriers	0.37	91.63	0.63	7.29	0.06	0.02	0.00	0.00	0.00	0.00
Container	1.23	92.98	0.11	5.56	0.03	0.09	0.00	0.00	0.00	0.00
General cargo	0.36	44.59	8.48	41.71	4.30	0.45	0.00	0.10	0.00	0.00
Ro Ro Cargo	0.17	20.09	9.86	59.82	5.57	2.23	2.27	0.00	0.00	0.00
Passenger	0.00	3.81	5.68	76.98	3.68	1.76	4.79	3.29	0.00	0.02
Fishing	0.00	0.00	84.42	3.82	11.76	0.00	0.00	0.00	0.00	0.00
Others	0.48	30.14	29.54	19.63	16.67	2.96	0.38	0.20	0.00	0.00
Tugs	0.00	0.00	39.99	6.14	52.80	0.78	0.28	0.00	0.00	0.00

SSD - Slow Speed Diesel, MSD – Medium Speed Diesel, HSD - High Speed Diesel, GT – Gas Turbine,
ST – Steam Turbine; MDO –Marine Diesel Oil, MGO –Marine Gas Oil, BFO –Bunker Fuel Oil

Source: Trozzi, 2010

Table 4-14: Main engine power from EMEP/EEA air pollutant emission inventory guidebook 2016[12] (appears as Table 3-6 in guidebook)

Ship category	Main engine power (kW)	
	1997 fleet	2010 fleet
Liquid bulk ships	6.695	6.543
Dry bulk carriers	8.032	4.397
Container	22.929	14.871
General cargo	2.657	2.555
Ro Ro Cargo	7.898	4.194
Passenger	3.885	10.196
Fishing	837	734
Other	2.778	2.469
Tug	2.059	2.033

Table 4-15: Average speeds from the EMEP/EEA air pollutant emission inventory guidebook 2016[12] (appears as Table 3-14 in guidebook)

Ship Type	Ave.Cruise Speed (km/h)	Manoeuvring time (hours)	Hotelling time (hours)
Liquid bulk ships	26	1.0	38
Dry bulk carriers	26	1.0	52
Container	36	1.0	14
General Cargo	23	1.0	39
Ro-Ro Cargo	27	1.0	15
Passenger	39	0.8	14
Fishing	25	0.7	60
Other	20	1.0	27

Source: Elaboration from Entec (2002)

These calculations allow the generation of the following activity data shown in **Table 4-16** and **Table 4-17.**

Non-bunkering can be subtracted from the total to give the total for bunkering and off-port calls.

Table 4-16: Activity data for all traffic

All traffic	Total distance travelled ('000 km)		Number of journeys		Fuel-oil consumption (kt)		Gas-oil consumption (kt)	
	To Gibraltar	From Gibraltar	To Gibraltar	From Gibraltar	To Gibraltar	From Gibraltar	To Gibraltar	From Gibraltar
Liquid bulk ships	5,982	8,868	2,612	2,612	287.1	425.6	13.7	20.3
Dry bulk carriers	17,012	17,835	3,769	3,769	559.5	586.6	6.0	6.3
Container	435	558	158	158	34.8	44.6	0.5	0.6
General Cargo	3,819	4,700	1,045	1,045	75.7	93.1	11.3	13.9
Ro Ro Cargo	97	102	28	28	2.6	2.7	0.6	0.6
Passenger	311	326	349	349	15.2	16.0	2.7	2.8
Fishing	12	15	3	3	0.0	0.0	0.1	0.1
Other	1,522	1,623	512	512	20.3	21.7	18.0	19.2
Tug	167	230	58	58	0.3	0.3	3.2	4.4
Total	**29,358**	**34,257**	**8,534**	**8,534**	**995.5**	**1,190.6**	**56.0**	**68.2**

Table 4-17: Activity data for non-bunkering and in-port traffic only

Non-bunkering port traffic only	Total distance travelled ('000 km)		Number of journeys		Fuel-oil consumption (kt)		Gas-oil consumption (kt)	
	To Gibraltar	From Gibraltar	To Gibraltar	From Gibraltar	To Gibraltar	From Gibraltar	To Gibraltar	From Gibraltar
Liquid bulk ships	330	1,510	956	956	15.8	72.5	0.8	3.5
Dry bulk carriers	157	269	158	158	5.2	8.9	0.1	0.1
Container	58	76	45	45	4.7	6.0	0.1	0.1
General Cargo	111	246	62	62	2.2	4.9	0.3	0.7
Ro Ro Cargo	7	10	6	6	0.2	0.3	0.0	0.1
Passenger	246	285	332	332	12.1	14.0	2.1	2.5
Fishing	-	-	0	0	-	-	-	-
Other	55	104	29	29	0.7	1.4	0.7	1.2
Tug	8	71	19	19	0.0	0.1	0.2	1.4
Total	**974**	**2,571**	**1,607**	**1,607**	**40.9**	**108.0**	**4.2**	**9.5**

4.2.3.4 Determining emissions

With the fuel use activity data, for both gas oil (marine diesel oil) and fuel oil (bunkers fuel oil), NAEI emission factors for the use of gas oil and fuel oil in shipping were applied to calculate emissions from the relevant pollutants, shown in **Table 4-18.**

Table 4-18: Emission factors used for the shipping inventory

Fuel type	Emission factors (kt/Mt fuel)		
	CO_2	CH_4	N_2O
Fuel oil	3,223	0.05	0.08
Gas oil	3,190	0.05	0.08

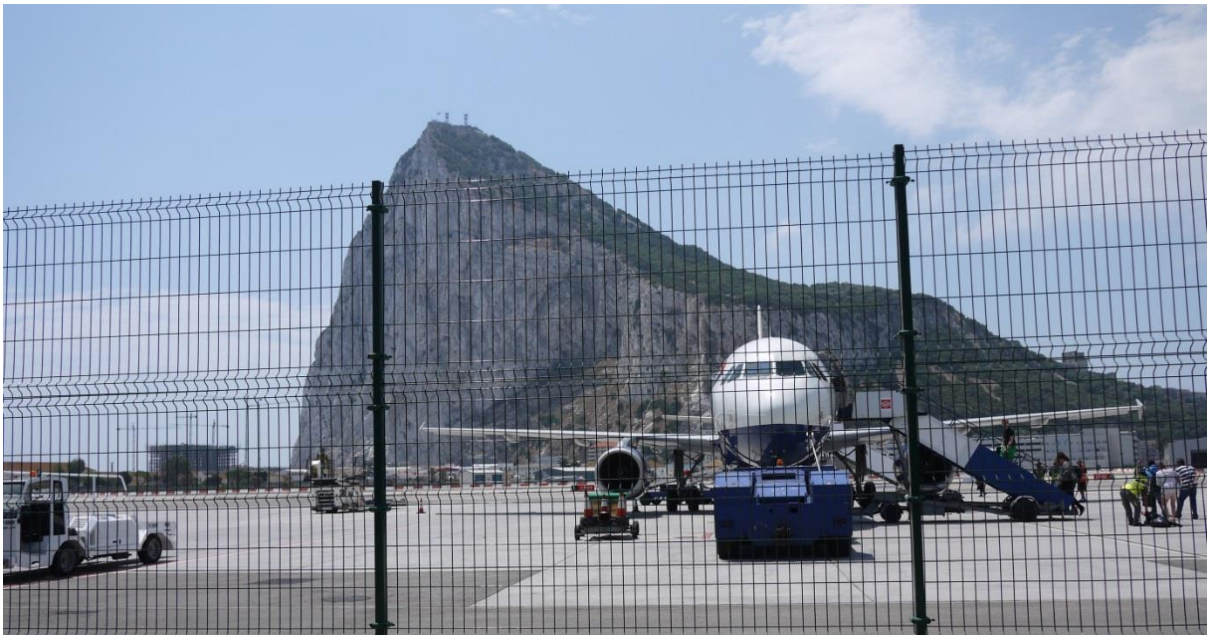
Only emissions from ship departures are included in the inventory as per GPC guidelines. Emissions from activities that are not attributable to Gibraltar (i.e. those that have been deemed 'out of scope' due to the purpose of their call, as shown in Table 4-11) are reported in 'Other Scope 3' and are therefore not included in BASIC or BASIC+ inventory totals.

4.2.4 Aviation

Aviation emissions from the cruise phase and LTO are allocated to scope 3 (transboundary).

Gibraltar is served by its own airport located within its boundary (**Figure 4-10**). There is also a nearby airport at Malaga, which is sometimes used when flights are diverted or as an alternative to flying directly into Gibraltar. However, no information is available for Malaga airport so Gibraltar Airport only is included here. Emissions are estimated for the 'landing/take-off cycle' (LTO) and cruise phases of flights. Only departing aircraft are included in the inventory as per GPC guidance.

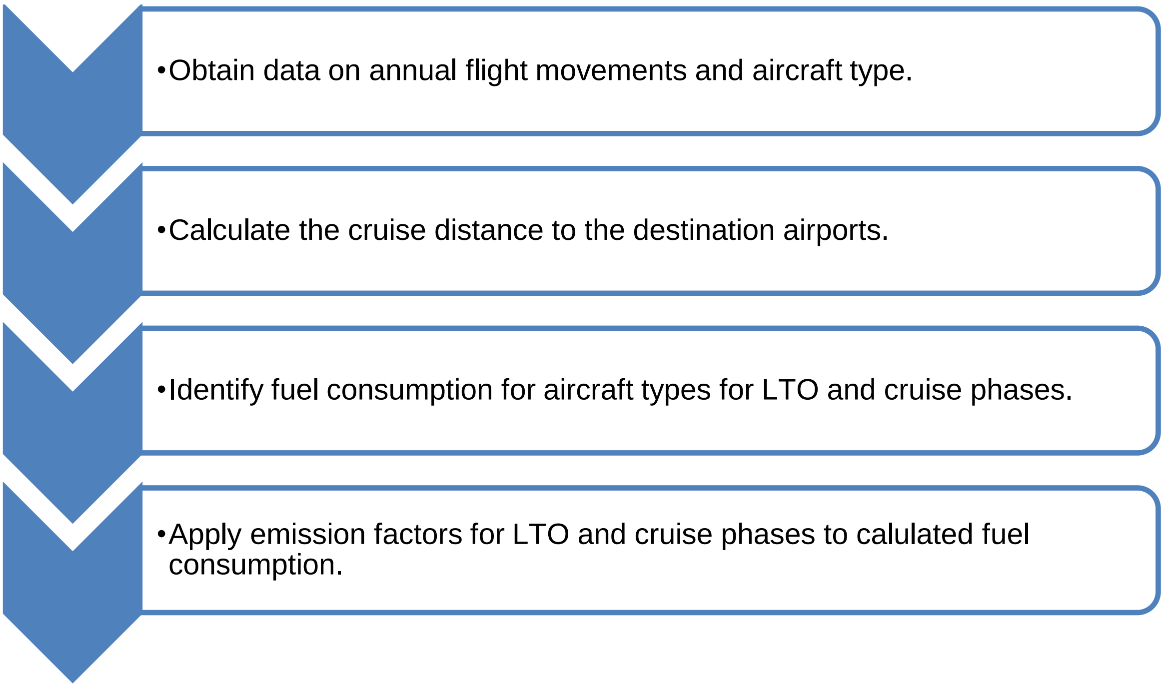
Figure 4-10: Gibraltar's International Airport



4.2.4.1 Overview

Figure 4-11 gives a brief overview of how estimates of emissions due to aviation have been made; a more detailed explanation is given in the following sections.

Figure 4-11: Aviation methodology flow diagram



4.2.4.2 Raw data

The raw data for estimating emissions have come from the International Civil Aviation Organization (ICAO) via the Department for Transport (DfT). The data provide a detailed log of all the journeys between Gibraltar and UK and non-UK airports.

4.2.4.3 Determining activity

The aircraft that operated between Gibraltar and the UK in 2015 were the Airbus A320 and A319. A smaller turboprop aircraft, the ATR 72, operated on flights between Gibraltar and Tangiers in Morocco. The UK airports that operated flights to and from Gibraltar in 2015 were: Birmingham, Bristol, Gatwick, Heathrow, Luton and Manchester.

Flight distances are calculated from great circle distances between airport pairs uplifted by 9.5% to allow for aircraft flying non-direct routes, in accordance with IPCC guidance. Cruise and LTO emission factors (based on fuel consumption) are selected from the EMEP/EEA air pollutant emission inventory guidebook 2013 by interpolating between the standard flight distances presented.

Fuel consumptions for an Airbus A319, Airbus A320 and an ATR 72 from the EMEP/EEA air pollutant emission inventory guidebook 2013 aviation annex[14] are shown in **Table 4-19**.

Table 4-19: Illustrative dataset from the EMEP/EEA air pollutant emission inventory guidebook 2013

Fuel (kg)	Phase of flight	Standard flight distances (nm) (1nm = 1.852 km)						
		125	250	500	750	1,000	1,500	2,000
A319	Climb/cruise/ descent	1074.6	1812.2	2819.8	3905.4	5013.8	7294.7	9513.4
	LTO	688.8	688.8	688.8	688.8	688.8	688.8	688.8
	Total	1763.4	2501.0	3508.7	4594.2	5702.6	7983.5	10202.2

[14] www.eea.europa.eu/publications/emep-eea-guidebook-2013/part-b-sectoral-guidance-chapters/1-energy/1-a-combustion/1-a-3-a-aviation-annex

A320	Climb/cruise/ descent	1062.6	1831.1	2949.3	4200.4	5439.0	7994.8	10464.9
	LTO	873.3	873.3	873.3	873.3	873.3	873.3	873.3
	Total	1935.8	2704.4	3822.6	5073.6	6312.3	8868.1	11338.2
AT72	Climb/cruise/ descent	723.5	1361.9	2652.5	3967.0	5276.0	8090.4	
	LTO	393.8	393.8	393.8	393.8	393.8	393.8	
	Total	1117.4	1755.7	3046.3	4360.9	5669.8	8484.2	

4.2.4.4 Determining emissions

The calculation for emissions is shown in **Equation 4-2.**

Equation 4-2: Equation for aviation emission estimation

$$Emissions = \sum (LTO\ fuel\ use * LTO\ EF), (Cruise\ fuel\ use * fuel\ EF)$$

LTO = Landing/take-off cycle

EF = Emission factor

To generate total fuel consumption, the total number of flights broken down by destination airport and aircraft type were multiplied by the emission factors, interpolated on distance, from **Table 4-19**. These were then summed to give the values **Table 4-20**.

The emission factors in **Table 4-21** were then used to calculate total emissions. The fuel use factors assume jet kerosene from Tables 3.6.4 and 3.6.5 of the 2006 IPCC Guidelines; Emission factors for methane for LTO cycle are taken from Table 3-5 in the EMEP/EEA air pollutant emission inventory guidebook 2013 for an Airbus A320: examples of aircraft types and emission factors for LTO cycles as well as fuel consumption per aircraft type, kg/LTO.

It is assumed that emissions from all aircraft departing Gibraltar Airport are allocated to Gibraltar. This is because, although there may be some use of the airport by non-Gibraltarian residents/visitors, these numbers are impossible to determine with any accuracy, it is assumed the majority of visitors arriving at Gibraltar Airport are likely to be resident or visiting.

LTO cycle emissions include emissions from both take-off at the departure airport and landing at the destination airport. However, for each departure from Gibraltar there is an associated arrival movement at Gibraltar that has emissions that are equivalent to the emissions from landing at the destination airport. Therefore counting all the LTO cycle emissions associated with departures from Gibraltar captures all the LTO cycle emissions at the airport. For cruise only the departure emissions are included in the inventory for Gibraltar.

Table 4-20: Total annual fuel consumption by aircraft

Phase of flight	Unit	Domestic (UK)	International (non-UK)
LTOs	Number	1,569	80
Total fuel consumption	Kt	10.00	0.05
Of which cruise	Kt	8.72	0.02
Total fuel consumption	TJ	439.07	2.41
Of which cruise	TJ	382.66	1.03

Table 4-21: Emission factors for aircraft phases by pollutant

Phase of flight	Pollutant	Unit	Emission factor
Cruise	Carbon	kt/TJ fuel	0.0195
Cruise	CH_4	kt/TJ fuel	Zero
Cruise	N_2O	kt/TJ fuel	0.000002
LTO	Carbon	kt/LTO	0.00070909
LTO	CH_4	kt/LTO	0.0000002
LTO	N_2O	kt/LTO	0.00000010

4.3 Waste

The waste profile of Gibraltar is unique due to the territory's location, restricted land area, high population density and absence of heavy industry. The majority of waste generated in Gibraltar is municipal, largely arising at households and commercial premises.

This report has applied the methodologies recommended under the GPC Guidelines for the estimation of GHG emissions from waste. Where possible, quantities of CO_2, CH_4 and N_2O have been estimated from the following sources based on activities during 2015:

- Solid waste disposal.
- Biological treatment of solid waste.
- Incineration.
- Wastewater.

Emissions from waste are allocated by scope to the location they are emitted.

Therefore, the treatment of biological waste, MSW and some incineration in Spain are allocated to scope 3.

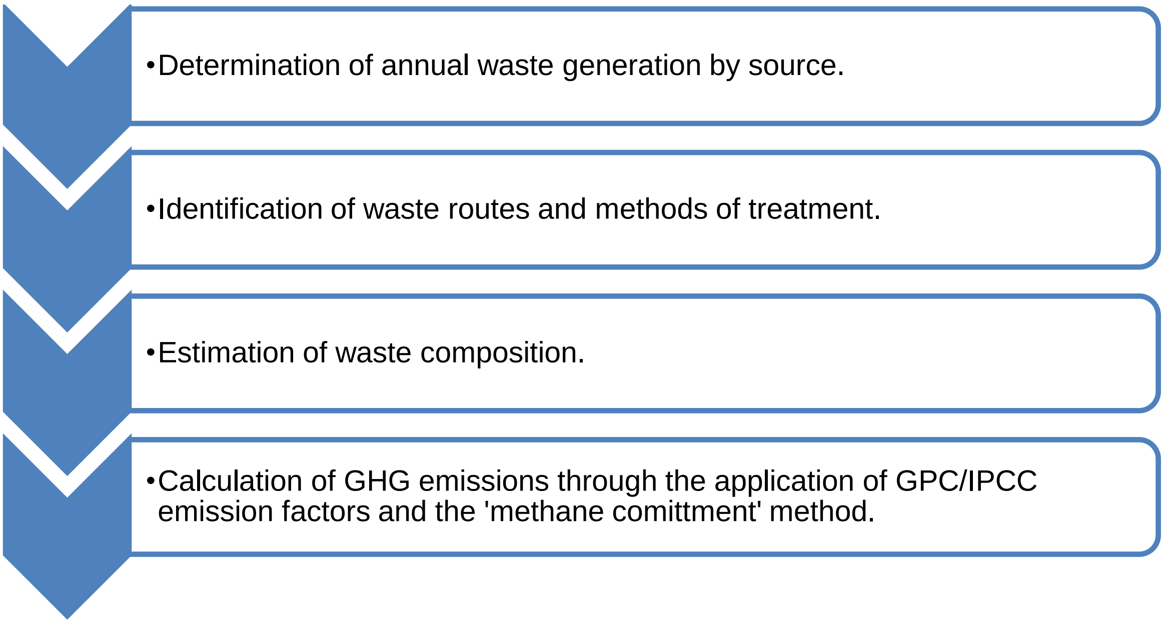
Emissions from incineration in Gibraltar are scope 1.

Emissions from wastewater are out of boundary so allocated to scope 3.

4.3.1 Summary

Figure 4-12 gives a brief overview of how waste emissions have been estimated, with a more detailed explanation provided in the following sections.

Figure 4-12: Waste methodology flow diagram



4.3.2 Raw data

4.3.2.1 Municipal solid waste

Municipal waste, generated at households, commercial premises and state-run facilities, such as schools and hospitals, is collected six days a week by a waste management contractor. This waste is then transported in bulk to the Complejo Medioambiental, Sur de Europa, in Los Barrios, Spain via a temporary waste transfer station in Gibraltar.

At Los Barrios, waste is manually and mechanically sorted to remove the recyclable fraction. Biological waste is also removed for composting and the remaining fraction is disposed of to landfill.

Data on the total quantity of MSW arisings by weight for Gibraltar have been provided by the Government of Gibraltar, as shown in **Table 4-22**.

Table 4-22: MSW arisings in Gibraltar in 2015

Month	Refuse (tonnes)	Households (tonnes)	Mattresses (tonnes)
January 2015	1,095	1,564	11
February 2015	1,197	1,344	6
March 2015	1,221	1,529	10
April 2015	1,070	1,433	8
May 2015	1,278	1,356	4
June 2015	1,964	1,513	6
July 2015	1,447	1,548	7
August 2015	1,108	1,327	10
September 2015	1,212	1,556	9
October 2015	1,338	1,513	10
November 2015	1,279	1,482	10

December 2015	1,001	1,436	7
Total	**15,211**	**17,599**	**97**

4.3.2.2 Clinical waste

Gibraltar's clinical waste is generated by a number of sources including dental and veterinary practices, and medical premises. In 2008, a new incinerator was commissioned in Gibraltar for the sole purpose of treating clinical waste. Although the incinerator has adequate capacity for the treatment of all clinical waste arisings within the boundary, maintenance issues will occasionally result in clinical waste being exported to an incinerator in Spain.

Details on the quantity of clinical waste incinerated within Gibraltar in 2015 are provided by the Gibraltar Health Authority. Volumes of clinical waste incinerated are based on average bin weight of 7.5Kg per 60 Litre bin of waste. The Government of Gibraltar provides information regarding the amount of clinical waste exported to Spain for incineration.

4.3.3 Determining activity

4.3.3.1 Composition of MSW

To determine the fraction of degradable organic carbon (DOC), the composition of MSW arisings have been estimated by applying the results of the 2014 Waste Characterisation Study to the total reported MSW detailed above. The study was completed by the Department of the Environment. It analysed MSW from three collection routes, in March and August 2014, in Gibraltar recording the waste type, weight and bulk density.

The waste categories have been grouped into three assumed treated groups; biological treatment (composted), landfill and recycled. A summary of the results and the treatment groups are provided in **Table 4-23.**

Table 4-23: Results of the 2014 Waste Characterisation Study and assumed treatment groups

Waste category	*Results of the 2014 Waste Characterisation Study (sum of the three collection routes)*	**Assumed treatment route**
	Weight (%)	
Paper & Cardboard	28.2	Recycled
Dense Plastics	7.8	Recycled
Plastic Film	6.7	Landfill
Organics	35.4	Composted
Metals	3.9	Recycled
Glass	5.6	Recycled
Composites	2.4	Landfill
Special Municipal waste	3.2	Landfill
Textiles	3.5	Recycled
Fines	0.6	Landfill
Unclassified Combustibles	1.0	Landfill
Unclassified Incombustibles	1.0	Landfill

WEEE	0.5	Recycled
Batteries	0.0	Recycled
Total	100	

4.3.4 Determining emissions

4.3.4.1 Solid waste disposal

Emissions of CH_4 from landfilling MSW have been calculated using the 'Methane Commitment' method. This allows emissions to be estimated based on the quantity of waste sent to landfill in a single year by adopting a mass balance approach. Prior to this, it was necessary to determine the 'methane generation potential' of the waste landfilled. The formulas for each are provided in formulas 8.1, 8.3 and 8.4 of the GPC, as below (**Figure 4-13**). A change was made to the DOC value to exclude waste categories that we assume are not landfilled (e.g. paper/card, food, etc.), and include waste categories that are landfilled (e.g. nappies). The DOC value used in the calculation is therefore 0.091 tonnes C/tonne waste.

Figure 4-13: GPC equations for calculating emissions from landfill

Equation 8.3 Methane commitment estimate for solid waste sent to landfill

$$CH_4 \text{ emissions} = MSW_x \times L_0 \times (1\text{-}f_{rec}) \times (1\text{-}OX)$$

Description			Value
CH_4 emissions	=	Total CH_4 emissions in metric tonnes	Computed
MSW_x	=	Mass of solid waste sent to landfill in inventory year, measured in metric tonnes	User input
L_0	=	Methane generation potential	Equation 8.4 Methane generation potential
f_{rec}	=	Fraction of methane recovered at the landfill (flared or energy recovery)	User input
OX	=	Oxidation factor	0.1 for well-managed landfills; 0 for unmanaged landfills

Source: Adapted from *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories*

Equation 8.4 Methane generation potential, L_0

$$L_0 = MCF \times DOC \times DOC_F \times F \times 16/12$$

Description			Value
L_0	=	Methane generation potential	Computed
MCF	=	Methane correction factor based on type of landfill site for the year of deposition (managed, unmanaged, etc., fraction)	Managed = 1.0 Unmanaged (≥5 m deep) = 0.8 Unmanaged (<5 m deep) = 0.4 Uncategorized = 0.6
DOC	=	Degradable organic carbon in year of deposition, fraction (tonnes C/tonnes waste)	Equation 8.1
DOC_F	=	Fraction of DOC that is ultimately degraded (reflects the fact that some organic carbon does not degrade)	Assumed equal to 0.6
F	=	Fraction of methane in landfill gas	Default range 0.4-0.6 (usually taken to be 0.5)
16/12	=	Stoichiometric ratio between methane and carbon	

Source: IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (2000)

Equation 8.1 Degradable organic carbon (DOC)[52]

$$DOC = (0.15 \times A) + (0.2 \times B) + (0.4 \times C) + (0.43 \times D) + (0.24 \times E) + (0.15 \times F)$$

A	=	Fraction of solid waste that is food
B	=	Fraction of solid waste that is garden waste and other plant debris
C	=	Fraction of solid waste that is paper
D	=	Fraction of solid waste that is wood
E	=	Fraction of solid waste that is textiles
F	=	Fraction of solid waste that is industrial waste

Source: GPC

4.3.4.2 Biological treatment

The emissions of CH_4 and N_2O from the biological treatment of waste have been calculated using equation 8.5 from the GPC guidelines (**Figure 4-14**) and emission factors for composting given in the GPC; these are detailed in **Table 4-24.** It is assumed that waste is treated whilst wet, as we have no information on whether waste is dried before being treated.

As the Los Barrios waste treatment facility only provides composting as a form of biological treatment, it has been assumed this is the sole method of biological treatment.

Table 4-24: Biological waste treatment emission factors

GHG	Emission factor
CH_4	4g per kg of wet waste treated
N_2O	0.3g per kg of wet waste treated

Figure 4-14: GPC equation for calculating emissions from biological treatment of waste

Equation 8.5 Direct emissions from biologically treated solid waste

$$\textbf{CH}_4\ \textbf{Emissions} = (\Sigma_i (m_i \times F\_CH4_i) \times 10^{-3} - R)$$

$$\textbf{N}_2\textbf{O Emissions} = (\Sigma_i (m_i \times EF\_N2O_i) \times 10^{-3})$$

Description			Value
CH_4 emissions	–	Total CH_4 emissions in tonnes	Computed
N_2O emissions	–	Total N_2O emissions in tonnes	Computed
m	–	Mass of organic waste treated by biological treatment type i, kg	User input
EF_ CH4	–	CH_4 emissions factor based upon treatment type, i	User input or default value from table 8.3 Biological treatment emission factor
EF_ N2O	–	N_2O emissions factor based upon treatment type, i	User input or default value User input or default value from table 8.3 Biological treatment emission factor
i	–	Treatment type: composting or anaerobic digestion	User input
R	–	Total tonnes of CH_4 recovered in the inventory year, if gas recovery system is in place	User input, measured at recovery point

Source: *2006 IPCC Guidelines for National Greenhouse Gas Inventories,* Volume 5, Chapter 4: Biological Treatment of Solid Waste

Source: GPC

4.3.4.3 Clinical waste incineration

The emission of CH_4 and N_2O from the incineration of clinical waste has been calculated using emission factors provided in the UK NAEI 2015. The emission factors are provided in **Table 4-25**.

Table 4-25: Clinical waste incineration emission factors

GHG	Emission factor	Unit
CH_4	228	kt/mt waste incinerated
N_2O	0.02	kt/mt waste incinerated
CO_2	0.03	kt/mt waste incinerated

4.3.5 Wastewater

Wastewater in Gibraltar is pumped out to sea with no treatment. However, Gibraltar has recently given preferred bidder status to a joint venture between Northumbrian Water Services and Modern Water Services. This will result in the construction of a water treatment facility that is expected to be operational in the coming years.

Emissions from pumping are reported under stationary combustion scope 2 emissions (consumption of electricity). Emissions from wastewater have been calculated by scaling UK data. These are:

- Biochemical oxygen demand (BOD) and nitrogen content on a per person per day basis.
- Tonnes of N_2O per million people.

The IPCC CH_4 conversion factor for wastewater to sea/lakes/rivers was used to estimate CH_4 – this is also given in the GPC. This is likely to overestimate emissions as it assumes anaerobic decomposition in stagnant water, and ocean decomposition is likely to be much less stagnant and, therefore, undergoes higher aerobic decomposition with lower associated emissions. N_2O emission assumptions do not account for denitrification in sewage treatment or alternative disposal methods (e.g. to land, incineration). It is assumed that all sewage is discharged in raw form to sea.

The equations for calculating emissions from wastewater are given in **Figure 4-15**.

Figure 4-15: GPC equations for calculating emissions from wastewater treatment

Equation 8.9 CH_4 generation from wastewater treatment

$$CH_4 \text{ emissions} = \sum_i [(TOW_i - S_i)\, EF_i - R_i] \times 10^{-3}$$

Description			Value
CH_4 emissions	=	Total CH_4 emissions in metric tonnes	Computed
TOW_i	=	Organic content in the wastewater **For domestic wastewater:** total organics in wastewater in inventory year, kg BOD/yr Note 1 **For industrial wastewater:** total organically degradable material in wastewater from industry i in inventory year, kg COD/yr	Equation 8.10
EF_i	=	Emission factor kg CH_4 per kg BOD or kg CH_4 per kg COD Note 2	Equation 8.10
S_i	=	Organic component removed as sludge in inventory year, kg COD/yr or kg BOD/yr	User input
R_i	=	Amount of CH_4 recovered in inventory year, kg CH_4/yr	User input
i	=	Type of wastewater **For domestic wastewater:** income group for each wastewater treatment and handling system **For industrial wastewater:** total organically degradable material in wastewater from industry i in inventory year, kg COD/yr	Equation 8.10

Note 1: Biochemical Oxygen Demand (BOD): The BOD concentration indicates only the amount of carbon that is aerobically biodegradable. The standard measurement for BOD is a 5-day test, denoted as BOD_5. The term "BOD" in this chapter refers to BOD_5.
Note 2: Chemical Oxygen Demand (COD): COD measures the total material available for chemical oxidation (both biodegradable and non-biodegradable).
Source: 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 5, chapter 6: Wastewater Treatment and Discharge

Equation 8.10 Organic content and emission factors in domestic wastewater[55]

$$TOW_i = P \times BOD \times I \times 365$$

$$EF_j = B_o \times MCF_j \times U_i \times T_{i,j}$$

Description			Value
TOW_i	=	For domestic wastewater: total organics in wastewater in inventory year, kg BOD/yr	Computed
P		City's population in inventory year (person)	User input[56]
BOD	=	City-specific per capita BOD in inventory year, g/person/day	User input
I	=	Correction factor for additional industrial BOD discharged into sewers	In the absence of expert judgment, a city may apply default value 1.25 for collected wastewater, and 1.00 for uncollected.[57]
EF_j	=	Emission factor for each treatment and handling system	Computed
B_o	=	Maximum CH_4 producing capacity	User input or default value: • 0.6 kg CH_4/kg BOD • 0.25 kg CH_4/kg COD
MCF_j	=	Methane correction factor (fraction)	User input[58]
U_i	=	Fraction of population in income group i in inventory year	User input[59]
$T_{i,j}$	=	Degree of utilization (ratio) of treatment/discharge pathway or system, j, for each income group fraction i in inventory year	

Source: 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 5, chapter 6: Wastewater Treatment and Discharge

Equation 8.11 Indirect N_2O emissions from wastewater effluent

$$N_2O \text{ emissions} = [(P \times Protein \times F_{NPR} \times F_{NON-CON} \times F_{IND-COM}) - N_{SLUDGE}] \times EF_{EFFLUENT} \times 44/28 \times 10^{-3}$$

Description			Value
N_2O emissions	=	Total N_2O emissions in tonnes	Computed
P	=	Total population served by the water treatment plant	User input
Protein	=	Annual per capita protein consumption, kg/person/yr	User input
$F_{NON-CON}$	=	Factor to adjust for non-consumed protein	1.1 for countries with no garbage disposals, 1.4 for countries with garbage disposals
F_{NPR}	=	Fraction of nitrogen in protein	0.16, kg N/kg protein
$F_{IND-COM}$	=	Factor for industrial and commercial co-discharged protein into the sewer system	1.25
N_{SLUDGE}	=	Nitrogen removed with sludge, kg N/yr	User input or default value: 0
$EF_{EFFLUENT}$	=	Emission factor for N_2O emissions from discharged to wastewater in kg N_2O-N per kg N_2O	0.005
44/ 28	=	The conversion of kg N_2O-N into kg N_2O	

Source: 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 5, chapter 6: Wastewater Treatment and Discharge

4.4 Industrial Processes and Product Use (IPPU)

The industrial processes and product use (IPPU) sector covers GHG emissions from a range of activities. The main emission sources are releases from industrial processes that chemically or physically transform materials (e.g. blast furnaces in the iron and steel industry, and ammonia and other chemical products manufactured from fossil fuels used as chemical feedstock). During these processes, many different GHGs, including CO_2, CH_4, N_2O, hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs) can be produced. Emissions also occur from the use of products such as solvents, aerosols and inhalers, and anaesthetics.

4.4.1 Summary

Industrial processes specifically covered by the GPC include:

- Production and use of mineral products.
- Production and use of chemicals.
- Production of metals.

None of these activities occur in Gibraltar, so this source is NO.

Product use in the GPC covers:

- Lubricants and paraffin waxes used in non-energy products.
- HFC gases used in electronics production.
- Fluorinated gases used as substitutes for ozone-depleting substances.

4.4.2 Separating IPPU GHG emissions and energy-related GHG emissions

Allocation of emissions from the use of fossil fuels between the stationary energy and IPPU sectors can be complex. The GPC follows IPCC Guidelines[15], which define 'fuel combustion' in an industrial process context as 'the intentional oxidation of material within an apparatus that is designed to provide heat or mechanical work to a process, or for use away from the apparatus.'

Therefore:

- If the fuels are combusted for energy use, the emission from fuel uses shall be counted under stationary energy.
- If the derived fuels are transferred for combustion in another source category, the emissions shall be reported under stationary energy.
- If combustion emissions from fuels are obtained directly or indirectly from the feedstock, those emissions shall be allocated to IPPU.
- If heat is released from a chemical reaction, the emissions from that chemical reaction shall be reported as an industrial process in IPPU.

In the case of Gibraltar, in the stationary combustion category all fuels are combusted for energy use so emissions are accounted for in this sector and not IPPU.

4.4.3 Determining activity

The industrial processes identified above are NO, so no data are available.

N_2O emissions from medical anaesthetics have been estimated using delivery information supplied by the hospital's medical gas supplier.

HFC emissions from metered dose inhalers (MDIs) have been estimated using information supplied by the Gibraltar Health Authority regarding the total number of MDIs prescribed in Gibraltar in 2015.

In product use, emissions of fluorinated gases (the so-called F-gases) have been estimated based on a scaling of UK data using an appropriate indicator. The source categories of these emissions and the indicators used are shown in **Table 4-26**.

[15] Box 1-1 from *2006 IPCC Guidelines for National Greenhouse Gas Inventories*, Volume 3 IPPU, Chapter 1 introduction.

Table 4-26: F-gas emission sources and activities

Source	Activity	Indicator
Aerosols - halocarbons	non-fuel combustion	Population
Firefighting	non-fuel combustion	GDP
Foams	non-fuel combustion	GDP
Commercial refrigeration	Refrigeration and air-conditioning - lifetime	GDP
Domestic refrigeration	Refrigeration and air-conditioning - lifetime	Population
Industrial refrigeration	Refrigeration and air-conditioning - lifetime	GDP
Mobile Air Conditioning	Refrigeration and air-conditioning - lifetime	Number of vehicles
Refrigerated Transport	Refrigeration and air-conditioning - lifetime	GDP
Stationary Air Conditioning	Refrigeration and air-conditioning - lifetime	Population

*Gross domestic product (GDP)

4.4.4 Estimating emissions

Emissions have been estimated by multiplying the factor for the UK by the associated indicator for Gibraltar (GDP, population, etc.).

Estimates of N_2O emissions from anaesthetics have been calculated using an emission factor of 1 as it is assumed that none of the administered N_2O is chemically changed by the body, and all is returned to the atmosphere, so therefore, it is reasonable to assume an emission factor of 1.0 (IPCC 2006 GL).

The emissions factor used is based on an assumption that each MDI contains 12g of HFC per MDI[16]. The split of HFCs us calculated using UK NAEI assumption that 96% of MDIs are formulated with HFC-134a and 4% are formulated with HFC-227ea.

4.5 Agriculture, Forestry, and Other Land Use (AFOLU)

Gibraltar has no notable agriculture, so this emission source has not been estimated, and is noted as 'NO'.

Gibraltar is also regarded as having no emissions from land use, land use change and forestry (LULUCF), so this emission source is also noted as 'NO'.

[16] Gluckman (2013). NAEI – Report on F-Gases. Report on Programme of Work on F-Gases, Financial Year 2013/14. Version 2, November 11th 2013. Report prepared by Ray Gluckman, SKM Enviros, Sinclair Knight Merz, New City Court, 20 St Thomas Street, London, SE1 9R, UK

5 Results

This section sets out the results of the Gibraltar city GHG inventory. As detailed in the methodology section above, this inventory considered all sources attributable to Gibraltar, following the methods published by the GPC guidelines.

The inclusion of different sources in the reported total varies by chosen reporting standard, and these sources also vary in their level of potential influence: Gibraltar has limited control over the emissions associated with water-borne navigation, for example, whereas power generation can be much more easily affected through local decision-making. Water-borne navigation emissions dominate the results, discussed below, and overshadow other sources for which Gibraltar has more influence. With this in mind, the results section presents the results both as a whole – total emissions for Gibraltar across all sources – and distinguishes between different reporting levels and sources, including presenting a sub-set of BASIC+ emissions (the recommended reporting level) excluding international transboundary shipping.

5.1 Summary

Total emissions for Gibraltar in 2015 by different reporting level are shown in **Figure 5-1.** Sources included within each reporting level are detailed in **Table 5-1** and summarised in **Table 5-2** below. Emissions included within each higher reporting level are cumulative from lower levels. It is current best practice for cities to report BASIC+ emissions wherever possible, and this chart represents emission sources as classified by the GPC.

Figure 5-1 – Emissions disaggregated by scope and by reporting level (BASIC and BASIC+)

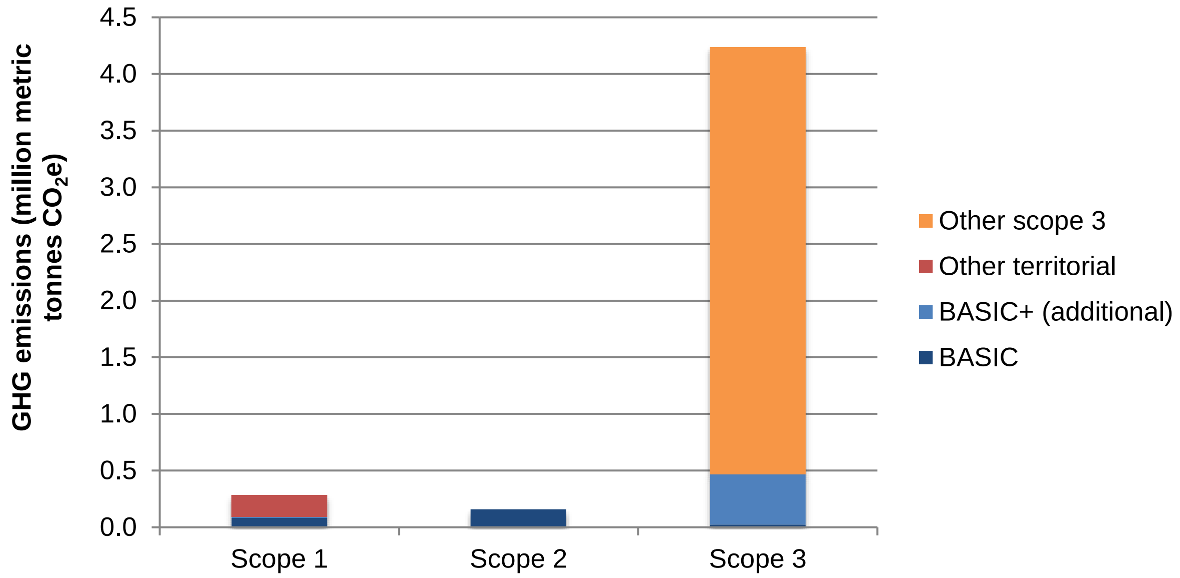


Table 5-1 - Classification of emission categories by scope and reporting level. Note, these are cumulative, and higher reporting levels include those sources in lower levels

Scope	BASIC	BASIC+	Outside of scopes
Scope 1	Emissions from in-boundary fuel combustion Emissions from in-boundary production of energy used in auxiliary operations	In-boundary emissions from industrial processes In-boundary emissions from product use In-boundary emissions from livestock	

Scope	BASIC	BASIC+	Outside of scopes
	In-boundary fugitive emissions Emissions from in-boundary transport Emissions from waste and wastewater generated and treated within the city	In-boundary emissions from land In-boundary emissions from other agriculture	
Scope 2	Emissions from consumption of grid-supplied energy		
Scope 3	Emissions from waste and wastewater generated within but treated outside of the city	Transmission and distribution losses from grid-supplied energy Emissions from transboundary journeys	
Outside of scopes			Electricity generation[1] International bunkers Vehicle fuel exports

[1] Reported for information only. Electricity emissions are allocated to the end-user.

Figure 5-2 – Gibraltar's manageable emissions by source category for 2015 (under the GPC's BASIC+ reporting, excluding transboundary waterborne navigation and other scope 3)

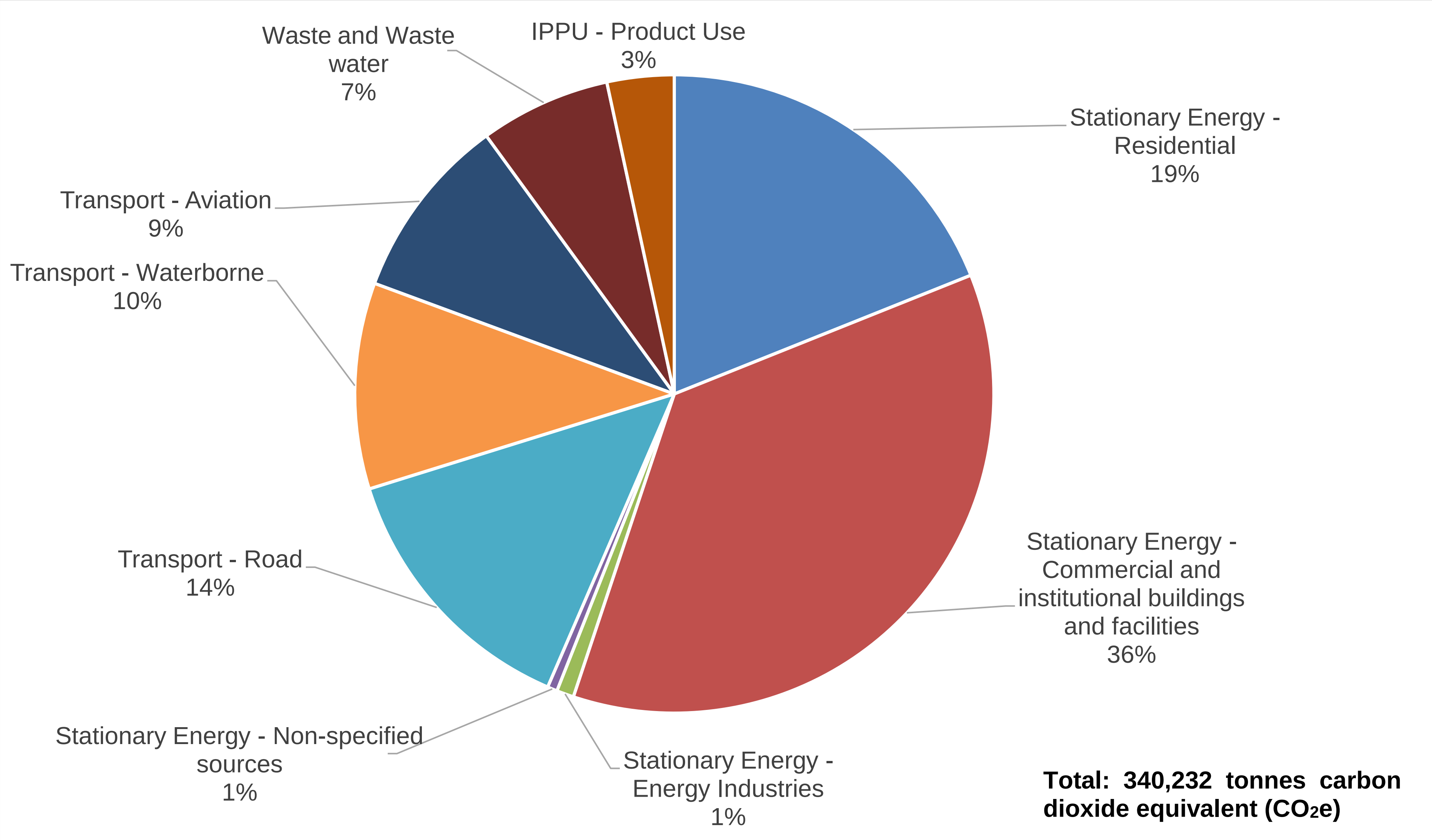
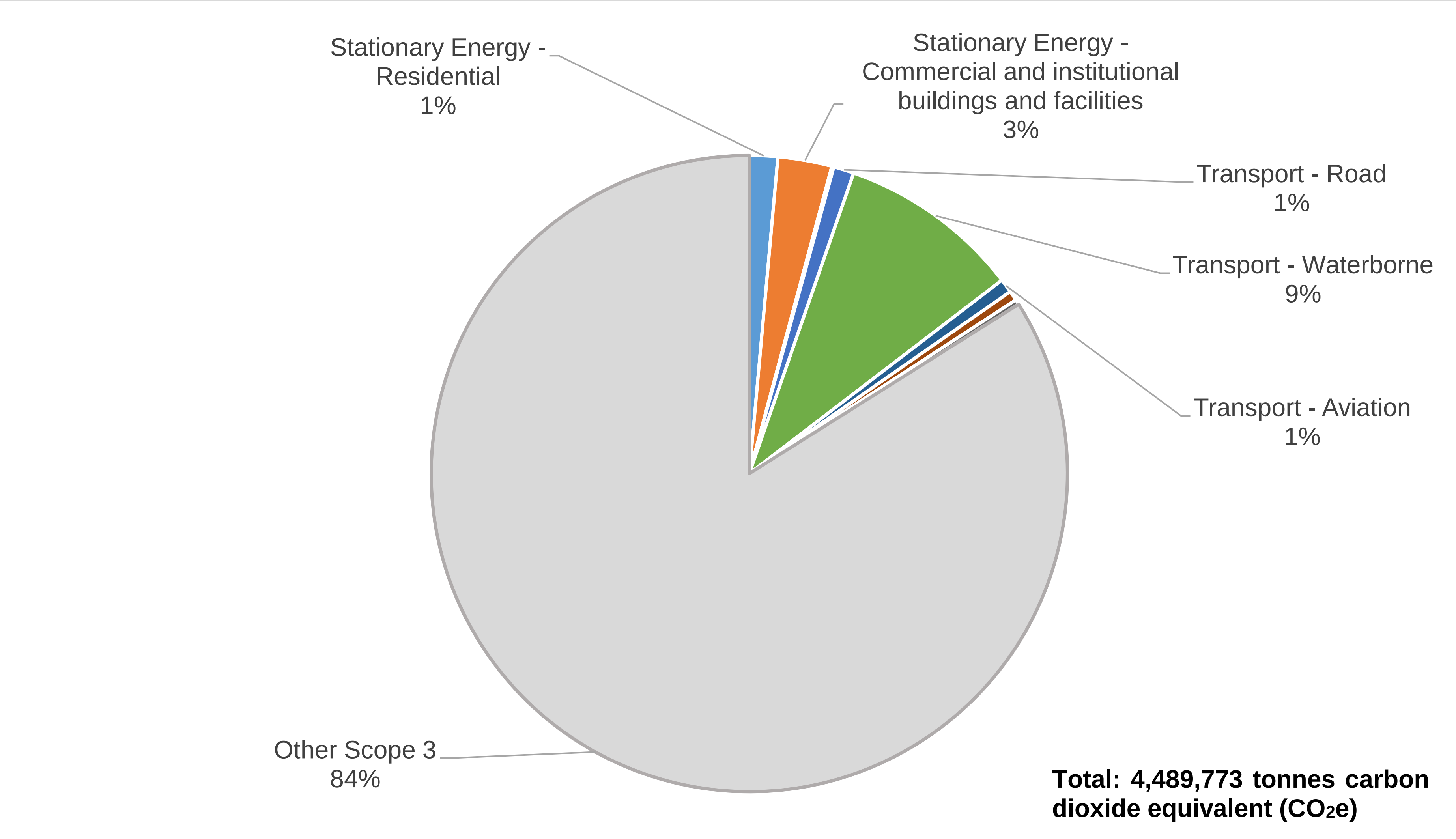


Figure 5-3 – Gibraltar's total emissions (including excluded sources) by source category for 2015[17].



[17] Data labels for stationary energy – energy industries, stationary energy – non-specified sources, waste and waste water, and IPPU – product use have been removed to aid legibility. All values from these sectors round to 0%

Table 5-2 – Total emissions for Gibraltar in 2015 by source.

Sector	Sub-sector	Total GHGs (metric tonnes CO_2e)			
		Scope 1	Scope 2	Scope 3	Total
Stationary Energy	Residential buildings	NO	51,954	12,463	64,417
	Commercial and institutional buildings and facilities	222	102,153	20,722	123,098
	Manufacturing industries and construction	NO	NO	NO	
	Energy industries	NO	2,964	IE	2,964
	Energy generation supplied to the grid	191,954			
	Agriculture, forestry and fishing activities	NO	NO	NO	
	Non-specified sources	NO	1,369	328	1,697
	Fugitive emissions from mining, processing, storage, and transportation of coal	NO			
	Fugitive emissions from oil and natural gas systems	NO			
	SUBTOTAL	**222**	**158,441**	**33,513**	**192,176**
Transport	On-road transportation	46,634	NO	IE	46,634
	Railways	NO	NO	NO	
	Waterborne navigation	35,533	NO	381,183	416,715
	Aviation	NO	NO	31,837	31,837
	Off-road transportation	IE	NO	IE	
	SUBTOTAL	**82,166**		**413,020**	**495,186**
Waste	Solid waste generated in the city	NO		18,319	18,319

Sector	Sub-sector	Total GHGs (metric tonnes CO_2e)			
		Scope 1	Scope 2	Scope 3	Total
	Biological waste generated in the city	NO		1,908	1,908
	Incinerated and burned waste generated in the city	259		117	377
	Wastewater generated in the city	NO		1,919	1,919
	Solid waste generated outside the city	NO			
	Biological waste generated outside the city	NO			
	Incinerated and burned waste generated outside city	NO			
	Wastewater generated outside the city	NO			
	SUBTOTAL	***259***		***22,264***	***22,523***
Industrial Processes and Product Use	Emissions from industrial processes occurring in the city boundary	NO			
	Emissions from product use occurring within the city boundary	11,529			11,529
	SUBTOTAL	**11,529**			**11,529**
Other Scope 3	***SUBTOTAL***			3,768,359	3,768,359
TOTAL		**94,176**	**158,441**	**4,237,155**	**4,489,773**

Note: Agriculture, Forestry, and Other Land Use emissions are not estimated within this inventory and are considered negligible

Colour coding of Table 5.2

(green)	BASIC sources
(blue)	BASIC+ sources
(purple)	Additional scope 1 sources required for territorial reporting
(peach)	Other scope 3 sources

5.2 Total emissions for Gibraltar

Total emissions for Gibraltar, from all calculated sources are presented in **Table 5-2** and **Figure 5-3** above.

Overall, the largest contributor of emissions to the Gibraltar city inventory is 'Other scope 3' including marine bunkering and non-Gibraltarian road transport emissions accounting for 84% of emissions. Transboundary transportation sources are included in BASIC+ reporting, but have been excluded from the chart in **Figure 5-2** to better represent emissions attributable to and influenced by the community. Emissions from private boats are captured under Scope 1.

Stationary energy is responsible for 4.3% of emissions, waste 0.5%, and industrial processes and product use (IPPU), 0.3%. Transport emissions from in-scope sources comprise 11% of total emissions, of which 84% are attributable to waterborne transport.

As **Table 5-2** illustrates, Scope 1 emissions are largely dominated by road transport fuel use, but there is also a noticeable contribution from hydrofluorocarbons (HFCs) from product use (such as air conditioning units).

Scope 2 emissions from electricity consumption are also large, due to the reliance on electricity for energy requirements and generation technologies. Because gas oil is used to generate electricity, the emissions per kilowatt hour (kWh) are considerably higher than, for example, those in the UK. The implied emission factor based on fuel consumption in power stations and total output in Gibraltar is 0.85kg CO_2e/kWh, compared to the UK grid factor of 0.41kg CO_2e/kWh[18].

Scope 3 emissions are largest overall across scopes, due primarily to shipping activities and bunkering.

Table 5-3 – Emissions by reporting standard

Sector	BASIC	BASIC+	BASIC+ and Scope 3
Stationary Energy	158,663	192,176	192,176
Transportation	82,166	495,186	495,186
Waste	22,523	22,523	22,523
IPPU		11,529	11,529
Other Scope 3			3,768,359
TOTAL	***263,352***	***721,414***	***4,489,773***

As **Table 5-3** illustrates, there is a large difference between the reported emissions between the GPC's BASIC and BASIC+ reporting levels. This is due to the inclusion of additional sources within BASIC+ which are significant within Gibraltar, namely transboundary (scope 3) emissions from shipping, and lesser contributions from aviation. Further inclusion of emissions that are deemed 'outside of scopes' (i.e. they are reported for information but are not deemed to be within the influence of responsibility of the city, such as bunkering fuels) dwarfs the BASIC and BASIC+ when considered, contributing to 84% of total emissions.

5.3 Total manageable emissions

The recommended reporting approach for city-level emissions under the GPC is BASIC+, therefore excluding emissions from combustion of bunkering fuels. Transboundary transport emissions are included under BASIC+ reporting however, and this includes waterborne navigation. This presents a particularly large source for Gibraltar, and is one that the community has little influence over. It also dominates the results, making it difficult to identify the impact of smaller, more manageable local sources. For this reason, waterborne navigation (scope 3, transboundary) has been excluded from the

[18] https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2016

total presented in **Figure 5-2**. Private marine emissions are retained. This subset, therefore, may be considered Gibraltar's 'manageable emissions'.

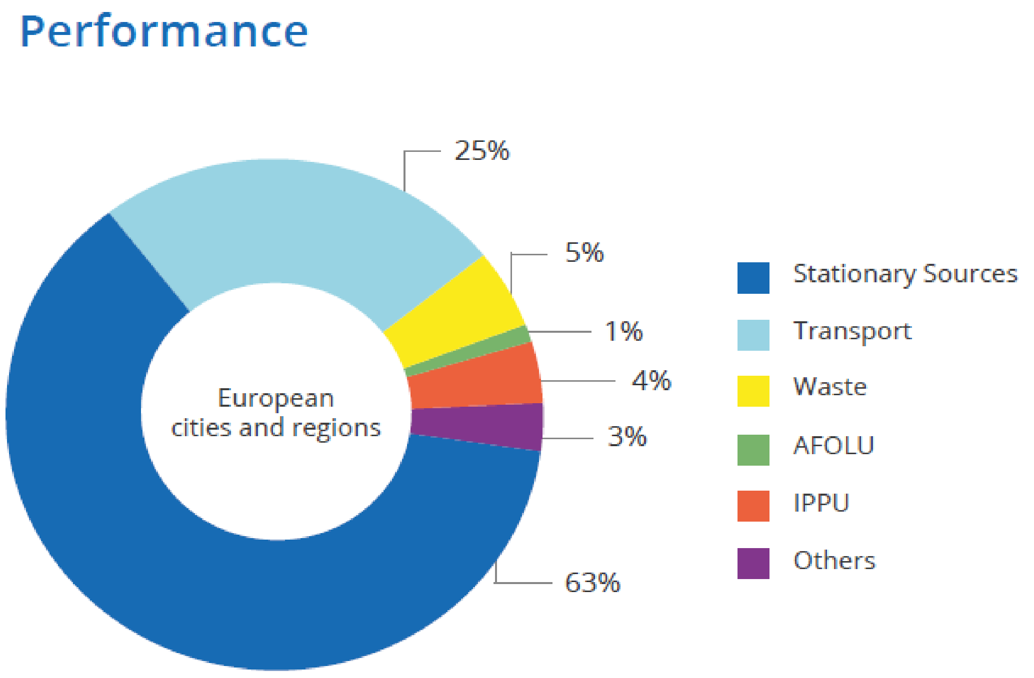
When these sources are removed, the inventory results are much more aligned to those expected for a city (see **Figure 5-4**), with stationary energy dominating, accounting for 56% of emissions. Transportation contributes 34%; 14% is attributable to road transport, 10% to waterborne navigation, and 9% to aviation. Contributions from waste and IPPU sectors is smaller, contributing 7% and 3% respectively.

The values shown in **Table 5-4** are emission totals and corresponding per capita emissions for a selection of the smallest cities (by population) reporting emissions to the CDP[19]. These data are reported to have been compiled consistent with GPC methods (presumed to be 'BASIC'). However, the lack of supporting documentation that is publicly available means that this should be treated as indicative only. This indicates that Gibraltar has relatively high emissions per capita, compared with these reporting cities. However, it is important to acknowledge Gibraltar's small resident population, its unique geographical situation compared to most global cities, and the impacts and limitations this places upon emissions.

Table 5-4 - Indicative per capita GPC BASIC emissions for global cities reporting to the CDP.

City	Emissions (tCO_2e)	Population	Per capita emissions (tCO_2e)
Moita, Portugal	96,508	66,029	1.46
Leicester, UK	1,799,400	329,839	5.46
Reykjavik, Iceland	346,630	123,246	2.81
Lahti, Finland	685,460	118,885	5.77
Gibraltar	263,352	33,528	7.85

Figure 5-4 - Sectoral breakdown of latest community GHG emission inventories from Carbon*n* Cities Climate Registry (cCCR) report[20]



[19] Available from CDP Cities 2015, www.cdp.net
[20] http://carbonn.org/fileadmin/user_upload/cCCR/ccr-digest-2014-2015/ccr-digest-2014-2015-online-final.pdf

5.4 Comparison with 2013 inventory

This section aims to compare the 2015 inventory results against the 2013 inventory[21]; however, there are some minor differences between the original 2013 inventory as reported and the 2013 inventory we are comparing to in this section. This is due to changes that were made to the 2013 inventory after categorisation of emissions was clarified in the published version of the GPC.

This comparison is therefore based on the revised 2013 inventory, categorised according to the final published GPC and as submitted to CDP.

It should also be noted that because of a large number of method changes and an updated reporting approach using the now-finalised GPC, **the inventories are not directly comparable**.

Since the new data sources available for the 2015 inventory are not similarly available to allow for updates to the 2013 inventory, it is not possible to confidently identify and quantify specific changes in emissions due to methodological updates or genuine changes in activity. This section, however, highlights some of the key changes, whether due to activity data or method changes and seeks to provide some insight and interpretation. Future years will seek to ensure that the time series is revised where possible to allow such comparisons to be made.

Emissions from the 2013 and 2015 inventories are presented, by scope, in **Table 5-5**.

More information on the specific reasons for changes between the 2013 and 2015 inventories and a comparison of years by sector and sub-sector is found in **Appendix 1.**

Table 5-5 – Comparison between the 2013 and 2015 inventories by reporting level

Reporting scope	Emissions (tCO_2e) 2013	Emissions (tCO_2e) 2015
Scope 1	87,609	94,176
Scope 2	177,820	158,441
Scope 3 (not including 'VI. Other Scope 3' emissions)	942,233	468,797
Total emissions (including 'VI. Other Scope 3')	5,764,949	4,489,773

5.4.1 Summary of changes

Scope 1

In comparison with the 2013 inventory, the emissions from Gibraltar are largely unchanged for scope 1, with a small increase of 6.6kt CO2e, which is attributable to increased emissions in the transportation and IPPU sectors.

- **Transportation sector:** As in 2013, the scope 1 emissions are dominated by transportation emissions, which have increased by around 9.5% between 2013 and 2015. This change is considered to be due to increases in estimates of total diesel consumption after the use of more detailed, disaggregated fuel import data obtained via HM Customs, as described in **Section 4.2.11**. This more detailed dataset shows an increased overall quantity of transport fuel consumption but the underlying reasons for this increase – whether increased activity (i.e. higher fuel sales) or more accurate data – is not possible to determine.
- **Road transport:** In addition to changes in fuel import data, the modelling approach for road transport was revised slightly with regards to the allocation to Gibraltarian and non-Gibraltarian vehicles, i.e. in and out of scope. This has generated a slight reduction in overall reported road

[21] https://www.gibraltar.gov.gi/new/sites/default/files/HMGoG_Documents/20150301-A_City-Level_Greenhouse_Gas_Inventory_for_Gibraltar_2013.pdf

transport emissions in Scope 1 of 11% despite increased overall fuel imports. Some of this decrease may also be due to lower overall consumption of Gasoline (14% less than reported in 2013) in road transport but the differing datasets make it difficult to draw confident conclusions on these trends at present. To be consistent with previous years, all non-Gibraltarian fuel consumption is reported in 'Other Scope 3' as it is not possible to determine the proportion related to transboundary activity, but this may change in future years.

- **Waterborne navigation:** The fuel import data for 2015 showed considerably higher diesel/gas oil consumption than 2013, as mentioned above. As the waterborne navigation sector is calculated on the basis of a 30% allocation, this sub-sector has seen a substantial increase (64%) in reported emissions as the 30% share is based on a larger overall quantity.
- **IPPU**: There are still no Industrial Process emissions in Gibraltar, but Product Use emissions remain a significant source of scope 1 emissions (accounting for 12%), and have also increased by 1.2kt CO_2e in comparison to 2013. Emissions in this sector are estimated using population as a proxy, and therefore population growth within Gibraltar will have somewhat influenced the calculated increase in scope 1 emissions. Improved data has also been used to calculate IPPU emissions in Gibraltar; for example, activity data regarding MDIs and N_2O use has been provided by the Gibraltar Health Authority, rather than relying on scaling UK data.
- **Stationary Energy**: there has been a very minor increase (<1% of the total) in stationary energy scope 1 emissions due to the addition of some fuel consumption data for bottled gas that has been reported for the first time in 2015.

Scope 2

Scope 2 emissions in Gibraltar are solely those from **electricity consumption** and between 2013 and 2015, total scope 2 emissions have shown a decline of almost 20kt CO_2e or 11%. The decline in emissions is despite electricity consumption being 8% higher in 2015 than 2013.

- The implied emission factor (IEF) is lower in 2015 than in 2013: this means that more electricity was reported as generated per volume of fuel reported as consumed at the power stations in 2015 than 2013.
- Emissions from the generation of electricity are calculated on the basis of total fuel consumed in the power stations. Between the 2013 inventory and 2015 inventory there have been no significant changes to the methodology and assumptions used: both years have estimated emissions using the NAEI emission factor for Gas Oil in power stations, and follow a simple approach of multiplying the fuel use (and activity data) by this emission factor.
- In the 2013 inventory, the fuel use data was obtained via the NAEI with additional data and clarifications from the GEA and AquaGib. Data on total electricity production was obtained from the Gibraltar Abstract of Statistics. In the 2015 inventory, all data was supplied directly from the GEA and so we judge this to be higher quality.
- At present the inventory calculation process is not sensitive enough to see a change in the IEF given different generation technologies, where they are using the same fuel. This is because more detailed information on plant generation characteristics is required to estimate the non-CO_2 gases. The CO_2 emissions remain unchanged as the quantity of carbon is fixed for combusting a given amount of fuel. In addition, because the supply of electricity from multiple sources is treated as a 'Gibraltar grid', the fuel and electricity outputs are aggregated to generate the IEF that represents an average across all generation technologies. Typically, the IEF will change as the balance of fuel and combustion types changes, for example a large input of renewables would increase the overall level of supply but without increasing the overall consumption of fuel, therefore the IEF would decrease. Likewise switching from gas oil to natural gas. Small changes between use of fuels in different plants is less likely to show a large impact. It is important to note however, that the IEF is only an indicative number that allows for the disaggregation of electricity emissions across end users based on estimated consumption.
- We therefore tentatively conclude that the reduction in the emissions from electricity consumption may be due to a potentially under reported figure for electricity production in the 2013 inventory year. However, with only 2 years of data, it is not easy to draw firm conclusions. The data provided for the 2015 inventory appears to be of higher quality and future years' inventories will provide greater confidence in the trend. **Table 5-6** below shows a comparison of electricity data and IEF between years.

- In addition, higher quality data on tariffs, including more tariffs (such as MOD), plus direct metered data from hotels and other businesses have enabled a greater accuracy in the distribution of emissions. This includes the reported of MOD electricity under 'non-specified sources' for the first time.

Table 5-6 – Comparison of electricity consumption and production data, 2013 and 2015

	2013 inventory	2015 inventory	% change
Kt fuel consumed	55.54	59.97	8%
GWh electricity produced	189.2	223.86	18%
Implied Emission Factor (IEF) (kt CO_2e/GWh)	0.98	0.86	
Data source	NAEI and Gibraltar Abstract of Statistics	GEA supplied	

Scope 3

The major activities reported in Scope 3 are emissions from Waste disposal and transboundary transport, the main contributor of this being waterborne navigation.

- **Waterborne navigation:** Emissions from this source are 57% lower in the 2015 inventory compared to the 2013 inventory due to a methodology change within the calculation of emissions from shipping. As outlined in Section 4.2.3, the definition of shipping attributable to Gibraltar on the basis of the recorded 'purpose of call' has undergone significant update based on input from the Port of Gibraltar, and as a result, the reported emissions from scope 3 are much lower in 2015.
- **Waste:** Total reported emissions from Waste have also seen a reduction (over 30%) between 2013 and 2015 despite a 20% increase in total waste arisings; however, this is largely due to improved assumptions in calculating emissions from waste. Previously, an IPCC default value for the fraction of degradable organic carbon (DOC) found in the waste was used as there was little recent information and low confidence in the data on landfill waste composition and treatment. This default value included waste categories that are now assumed are not landfilled (e.g. paper/card, food, etc.) thanks to greater clarification on the treatment processes, specifically the diversion to composting. For the 2015 inventory therefore, the DOC value has been recalculated to only include waste categories that are present in Gibraltar's landfilled waste (i.e. largely non-organic components) which has led to a large decrease in the DOC value (from 0.45 tonnes C/tonne waste, to 0.091 tonnes C/tonne waste). This change to the DOC value explains the decrease in emissions, but not activity data (i.e. amount of waste sent to landfill. In addition, composted waste is now assumed to be wet (rather than assumed dry in 2013), based on expert advice. Emissions from incineration have also decreased by 88% between 2013 and 2015; this is due to a large decrease in the activity data for both in and out of boundary incineration.
- **T&D losses:** for the first time, transmission and distribution losses of electricity have been included in the inventory in Scope 3. This was assumed to be the difference between total production plus on-site consumption, and total billings.

Other Scope 3

In the 2015 inventory, 'Other Scope 3' includes emissions from out-of-scope shipping traffic (e.g. bunkering) and out-of-scope fuel use by non-Gibraltarian vehicles. In the 2013 inventory, 'Other scope 3' also included upstream fuel emissions and emissions from the supply chain, which have not been considered in the 2015 inventory. This is due to more clarity in the GPC guidance, the need to use the GPC above the PAS 2070 method, and the unavailability of data to update the supply chain emissions.

More information on the specific reasons for changes between the 2013 and 2015 inventories are given in **Appendix 1.**

5.5 Reducing emissions in Gibraltar

An emissions inventory is an ongoing tool for understanding and reporting emissions, and allows the identification of major sources and priority areas for mitigation. From the results presented it can be seen that there are some areas where efforts should be focussed. Recommendations are therefore as follows:

- Stationary energy (in this instance entirely electricity production) is the highest contributor to manageable emissions, and as such efforts should be focussed on both reducing consumption and decarbonising supply. A full assessment of both supply side mitigation options, and demand-side efficiency, should be undertaken.
- For transport, aviation and private marine are difficult to influence. However, scope 1 road transport, although relatively small compared to sources such as stationary energy, is significant given the small size of the territory. Road transport emissions would also be possible to influence through local policy measures. Gibraltar should therefore consider ways to reduce road transport, particularly car use.
- Proportionally, waste and IPPU emissions are aligned with the performance break-down in **Figure 5-4**, but in absolute terms, emissions from these sectors remain high. Gibraltar should therefore undertake research to identify methods to both reduce overall waste, increase recycling, and find alternative lower impact disposal methods.
- Individual industries that are high energy users should be identified and ways to reduce energy consumption investigated.

It is beyond the scope of this work to make detailed recommendations for mitigation measures beyond identifying the above major sources. However, it is recommended that should Gibraltar want to make significant improvements to its total emissions, a separate and detailed study of mitigation options and potential reductions in different sectors should be carried out.

5.6 Inventory accuracy

In compiling the Gibraltar City Inventory, there are a number of assumptions that have had to be made in the compilation and calculations that will have impacts on the accuracy of the data. The largest sources have been calculated with a high level of confidence, due to the presence of, for example, energy import statistics, detailed shipping records and the clearly bounded nature of activities (such as electricity generation). Some of the more minor assumptions relate to interpretation of data (such as units or fuel types where not consistent with the International System of Units (SI units), for instance). Most assumptions relate to methods of allocation within sectors, so the total inventory is associated with low uncertainty, but the sector allocations are more uncertain.

All assumptions have been documented in the relevant methodology section, but **Table 5-7** summarises some of the main assumptions and possible impacts on the data. A formal uncertainty analysis was not undertaken on the inventory as it was beyond the scope of this work.

Table 5-7 - Summary of assumptions and impact on inventory totals

Emission or data source	Assumption	Possible impact	Improvement
Proxy indicators	2014 values used as 2015 values not available	It is unlikely that using 2014 values for proxy indicators (such as gross domestic product (GDP) and population) will have had a large impact on emission sources but it will be important to update to the correct year when available	Latest year data for key indicators
Electricity allocation to end users	Electricity could only be allocated accurately for	Ultimately, the total electricity emissions	Billings data for other key sectors (such as

Emission or data source	Assumption	Possible impact	Improvement
	some users (domestic was based on tariffs and others were based on billings data) requiring allocation by proxy indicator	remain unchanged as this is an allocation issue. It is possible that some users have been over or under estimated and the emissions details possible for each end user is limited	public sector buildings, port, airport, retail) to allow better allocation It is anticipated that discussions and improvement work by GEA and AquaGib to refine and improve the tariffs and reporting by high users will improve the granularity of consumption data available in future years
Transport activity data	Transport emissions were calculated by generating implied fuel consumption data based on the vehicle fleet. Actual information on vehicle movements was not available, so it was not possible to establish the proportion of travel in-boundary and out of boundary. It was therefore assumed that all fuel sold to Gibraltarian vehicles was used in-boundary and all non-Gibraltarian out of boundary	It is likely that the allocation of emissions has low accuracy. The implied vehicle kilometres (vkm) are for Gibraltarian vehicles and are higher than would be expected for a region of this size. Therefore, it is likely this is an over estimate of in-boundary emissions. It is probable that some proportion of the Gibraltarian fuel sales should be allocated to transboundary emissions, but it is not possible to distinguish. The lack of vehicle activity data also makes it difficult to account for off-road vehicles and public transport. The fuel import data provide the overall fuel balance, but in the transport sector some of this is allocated to 'outside of scopes' as it is deemed to be 'exported' by non-Gibraltarian drivers. Therefore, the proportion of emissions from fuel imported that is allocated to Gibraltar is possibly over estimated. We also do not estimate the amount of fuel bought by Gibraltarians while outside of Gibraltar,	Data on household travel habits, in particular activity data to enable a better understanding of annual distance travelled by vehicle type (car/heavy goods vehicle (HGV)/light goods vehicle (LGV)/motorcycle, and private, commercial, public) would enable a better characterisation of vehicle emissions and improved allocation to end users. Understanding annual distance travelled by vehicle types can also be achieved through obtaining more detailed vehicle licensing data from the Department of Transport. By recording vehicle mileage during vehicle MOTs, high quality data on the annual distance travelled by each vehicle will be available. It is also possible to use ANPR technology, alongside the vehicle licensing information, to understand the split of vehicles travelling within and outside Gibraltar. This will give a far more accurate representation of the

Emission or data source	Assumption	Possible impact	Improvement
		which will lead to a small under estimate	split of in- and out-of-boundary journeys than is currently available.
Aviation activity data	Aviation was calculated on a bottom-up basis and was based on the number of flights, assumptions on the plane class and the expected distance flown. 'Unscheduled' flights were omitted as they were evidently linked to very small planes, for which we had limited emissions and fuel consumption estimates	There is some uncertainty on how much fuel would be used on journeys, the actual distance travelled and the validity of some of our assumptions. Additionally, the omission of the 'unscheduled' flights will lead to a small under estimate	Access to fuel sales in Gibraltar would enable verification of bottom-up calculated fuel use data. This would reduce uncertainty as fuel sold gives a strong indication of the fuel use on outgoing journeys. This would also remove the possible under estimate due to the omission of unscheduled flights
Private marine emissions	Due to a lack of data, it was assumed in the 2013 inventory that 30% of fuel oil imports were sold for private marine uses. The 30% assumption is broadly supported by trends in the data and has been retained for 2015. (Note that data had to be scaled up in 2013 to give a whole year when imports for marine fuels ceased part way through).	This assumption is supported by analysis of historical data trends. However, it is possible that this is not an accurate estimation of marine fuel use and is not sensitive to any trends in activity.	Activity data, such as fuel sales at marine filling stations, would improve calculations of this emission source significantly. Information on the movements of private marine boats would also improve estimations from this sub-sector.
Shipping activity data	Activity data for ships were estimated through calculations of distance travelled to and from other ports. This provided an indicator of fuel consumption per journey	It is possible that the ship classes and average fuel consumptions taken form the EMEP/EEA air pollutant emission inventory guidebook 2016 do not accurately match the ships visiting Gibraltar. However, it is likely that any impact here is small	The estimations in this sector are now based on a large amount of reliable and accurate data. Accuracy could be further improved through use of ship specific fuel consumption and emission rates, technologies etc. to replace use of EMEP/EEA defaults.
Shipping activity data	Where it wasn't clear which port was being referred to in the port statistics (around 25% of cases), we assumed it to be the average distance to the known ports	This increases the uncertainty in the distance travelled estimates and, hence, fuel consumption estimates	Complete, clear records of destination ports would reduce the need for assumptions to be applied
IPPU activity data	Little data existed on IPPU emissions for Gibraltar so these were estimated	It is possible that the Gibraltarian case differs from the UK, particularly	Latest year indicator data and Gibraltar-specific information on

Emission or data source	Assumption	Possible impact	Improvement
	using UK data and proxy indicators (population, GDP) (with the exception of N_20 for anaesthesia and MDIs which have been accurately estimated).	for air-conditioning units, which may be under estimated. Indicator data were also not up to date	relevant product use, e.g. numbers of air-conditioning units, solvent use, etc. Some of this information is available (e.g. the number of refrigerators imported into Gibraltar); however, information on the current stock of such products in Gibraltar is not currently available.
Waste water emission calculation	Emissions were calculated using a default emission factor for wastewater to sea, lakes and rivers	It is likely that this has resulted in an over estimate of CH_4 as sea water is less stagnant than lakes and inland waterways, so there will likely be less anaerobic decomposition	This is a very small inventory source. Improvements to estimates would require a level of work beyond the significance of the source
Waste composition data and disposal	The composition of municipal solid waste (MSW) arisings were estimated by applying the results of the 2014 Waste Characterisation Study to the total reported MSW. Therefore, this assumption is based on waste collection data, rather than final processing in Spain. In general, the waste sector has a lot of assumptions about composition and disposal/treatment methods	It is probable that the fraction of waste recycled has been over estimated and emissions are, therefore, an under estimate. There are also assumptions about waste treatment in Spain which could result in uncertainty of the estimates. Overall, this is one of the smaller sources, so is less of a priority. However, it is possible that should the recycled fraction be lower, the source would have a greater overall emission share	Data from final processing rather than composition of waste exported should be obtained to improve this estimate. This is one of the inventory emission sources where local activity and decisions can have a significant impact. Therefore, effort should be made to better characterise waste and understand disposal processes.

6 Recommendations

This chapter sets out a series of recommendations following the compilation of this city-level greenhouse gas (GHG) inventory for Gibraltar. These recommendations include:

- Improving inventory compilation and future year reporting.
- Quality assurance, quality control (QAQC) and verification.

6.1 Improving inventory compilation and future year reporting

Inventories are very much intended to be a 'live' reporting tool and, as such, should be subject to regular revision and improvement. There are two particular aspects that should be considered by Gibraltar for ongoing improvement of compilation and future reporting of the inventory. These are:

- Improved activity data collection and management, including sectoral allocations.
- Recalculations and tracking emissions over time.

6.1.1 Improved activity data collection and management

All inventories have scope for improvement of data collection and management. The collection of data is often the most time consuming and challenging aspect of the inventory, so adequate time needs to be dedicated to this stage. The challenge is often that third parties hold the information that is required or that it is not available at all. It is vital to clearly express the data required – units, scope, boundaries, time period, sources and activities. It should also be requested that each data source is provided with an explanatory note and a contact for any queries. Failure to do so often results in incomplete data, the wrong data and a lack of transparency of how the data was compiled. An inventory is only ever as good as the data that underpins it. With this in mind, it is important to acknowledge that whilst data quality can be maximised ot can never be ensured. In addition, new data, improved information or clarity of assumptions may be developed over time, leading to recalculations and changes.

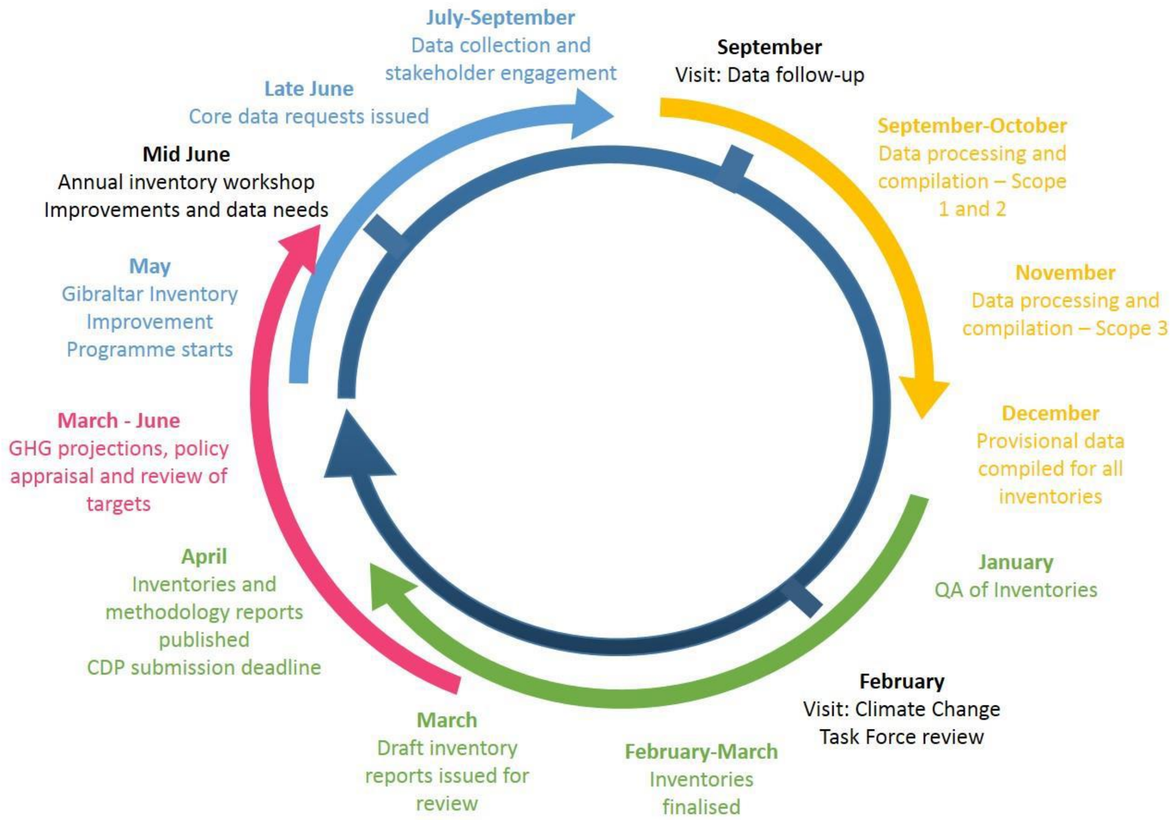
Under the Gibraltar inventory programme, a transparent and rigorous process of data requests, supply, processing and documentation has been implemented. Key to this has been the involvement of stakeholders and data suppliers, supporting the process of data identification, availability and transparency.

Currently and going forward, data required for Gibraltar's inventory is/will be requested during the summer (see **Figure 6-1** for the full inventory cycle). Data templates have been developed which are sent to data providers to encourage the provision of all the required data. The data templates provide space to enter the required data, as well as accompanying information (such as data quality, how the data was compiled, the period the data covers, etc) for QA/QC purposes. An example of a Gibraltar city inventory data template is given in **Appendix 3**. Data templates will be improved over time, working with data suppliers, to make the data collection process as efficient as possible.

Whilst the data templates aim to capture all relevant information, it should be acknowledged that these templates are not compulsory, and many suppliers will find it easier to provide data in other formats. Where this is the case, or supporting information is not clear or not provided, there are risks that data quality will be compromised. Efforts will therefore be made every year to engage data suppliers early and ensure that the principles of data quality can be maximised.

Currently, there are no formal agreements between the Government of Gibraltar and the data providers; this is something that could potentially be explored to ensure to consistent, timely and reliable supply of data for use in the inventory.

Figure 6-1: Gibraltar city inventory timeline



Appendix 2 sets out the minimum data requirements needed for estimation of emissions in each sector, and the data required for disaggregation and verification.

6.1.2 Recalculations and tracking emissions over time

It is important to track emissions over time to provide information on historical emissions trends, and the effects of policies and actions to reduce emissions at the city level.

As far as is possible, the time series should be calculated using the same methods, data sources and boundary definitions in all years to ensure consistency. Using different methods, data or applying different boundaries in a time series could introduce bias because the estimated emissions trend will reflect real changes in emissions or removals and the pattern of methodological refinements.

Significant changes may occur over time, which will alter the historical emissions profile, making meaningful comparisons over time difficult. To maintain consistency over time, historical emissions data from a base year inventory will have to be recalculated. This should also occur if methods change and data improve.

The GPC sets out examples of the kinds of significant changes a city might experience that should trigger a recalculation. These are set out below and examples given in **Table 6-1**.

Structural changes in the assessment boundary. This may be triggered by adjustment in a city's administrative boundary, or changes in inclusion or exclusion of activities within the city boundary. For example, a category previously regarded as insignificant has grown to the point where it should be included in the inventory. However, no emissions recalculations are needed for activities that either did not exist in the base year, or reflect a natural increase or decrease in city activities ('organic growth').

- For Gibraltar, it will be necessary to track land use activities, particularly land reclamation as an extension of the territory and the emission implications of greater land area over time. The treatment of sources such as international bunkering, shipping and road vehicle fuel export may also be possible areas for change to assessment boundary (inclusion/exclusion) over time. Sources that have not been estimated should also be considered for inclusion.

Changes in calculation methodology or improvements in data accuracy. A city might report the same sources of GHG emissions as in previous years, but measure or calculate them differently. Changes resulting in significant emission differences should be considered as recalculation triggers, but any changes that reflect real changes in emissions do not trigger a recalculation. Sometimes, the more accurate data input may not reasonably be applied to all past years, or new data points may not be available for past years. The city may then have to back cast these data points, or the change in data source may simply be acknowledged without recalculation. This acknowledgement should be made in the report each year to enhance transparency. Otherwise, new users of the report in the two or three years after the change may make incorrect assumptions about the city's performance.

- There is a likelihood that Gibraltarian activity data can be improved over time to give more accurate estimates. This is dealt with in more detail below and was discussed in **section 5.4**.
- Improvements have been made between the 2013 and 2015 inventories; however, no recalculations have been performed for the 2013 inventory as the available data did not allow recalculations for 2013.

Discovery of significant errors. A significant error or a number of cumulative errors that are collectively significant, should also be considered as a reason to recalculate emissions.

- QAQC procedures on this inventory should have minimised errors, but should an error have occurred, recalculations will be required.

Table 6-1: Examples of recalculation triggers, from Table 11.2 of GPC

Trigger	Example change	Recalculation needed	No recalculation needed
Changes in assessment boundary	A community is included in or set aside from a city's administrative boundary	X	
	Change in goal boundary from BASIC to BASIC+, or from six GHGs to seven GHGs	X	
	Shut down of a power plant		X
	Build of a new cement factory		X
Changes in calculation methodology or improvements in data accuracy	Change in calculation methodology for landfilled municipal solid waste (MSW) from *Mass Balance Method* to the *First Order Decay Method*	X	
	Adoption of more accurate local emission factors, instead of a national average for scope 2 emissions	X	
	Change in electricity emission factor due to energy efficiency improvement and growth of renewable energy utilisation		X
Discovery of significant errors	Discovery of mistake in unit conversion in formula used	X	

Whether recalculation is needed depends on the significance of the changes. The determination of a significant change may require taking into account the cumulative effect on base year emissions of a number of small changes.

No recalculations have been made to the 2013 inventory as any improved data that has been collected was not made available for 2015. As the GibEmit programme is to be a long-running programme of work, the need for recalculations and historical data will be built into the improvement programme. Recalculations will be considered in future inventory years if significantly improved data is collected, or if significantly different methods are adopted. Where a new data source is identified, data providers will be request to provide historical data where possible to enable this to occur.

6.2 QAQC and verification

6.2.1 Quality control

Quality control (QC) is a set of technical activities that measure and control the quality of the inventory as it is being developed. They are designed to:

- Provide routine and consistent checks to ensure data integrity, correctness and completeness.
- Identify and address errors and omissions.
- Document and archive inventory material and record all QC activities.

QC activities include accuracy checks on data acquisition and calculations, and the use of approved standardised procedures for emission calculations, measurements, estimating uncertainties, archiving information and reporting. Higher tier QC activities include technical reviews of source categories, activity and emission factor data, and methods.

A number of QC checks were undertaken in the compilation of the inventory; these included:

- Mass balance checks – fuel data 'used' versus fuel data 'supplied' for Gibraltar should balance.
- Implied Emission Factors (IEFs) – checks against UK GHG inventory to ensure the order of magnitude is what would be expected.
- Timeseries checks – checks against previous year to assess data accuracy and completeness.
- Spreadsheet functions – manual checks that formulae are working as expected.
- Consistent labelling, file revisions (e.g. dated file extensions).
- Documentation on spreadsheets, with details of calculation method, assumptions, emission factors and data quality.

6.2.2 Quality assurance

Quality assurance (QA) activities include a planned system of review procedures conducted by personnel not directly involved in the inventory compilation/development process. Reviews, preferably performed by independent third parties, should take place when an inventory is finalised following the implementation of QC procedures. Reviews verify that data quality objectives were met and that the inventory represents the best possible estimates of emissions – and sinks given the current state of scientific knowledge and data available.

Several QA reviews were undertaken by internal inventory experts for the calculations for each sector and of methodologies used across the inventory.

Table 6-2: Quality Checking

Sector	Reviewer(s)
Stationary Energy	Luke Jones and Peter Brown
Waste	Luke Jones
Road transport	Peter Brown
Aviation	Luke Jones
Shipping	Daniel Wakeling
IPPU	Sina Wartmann and Luke Jones

6.2.3 Verification

Verification can be used to increase credibility of publicly reported emissions information with external audiences and increase confidence in the data used to develop climate action plans, set GHG targets and track progress.

Verification involves an assessment of the completeness, accuracy and reliability of reported data. It seeks to determine if there are any material discrepancies between reported data and data generated from the proper application of the relevant standards and methodologies. It does this by making sure that the reporting requirements have been met, that the estimates are correct and that the data sourced are reliable.

No verification was carried out on this report or the underlying data, due a lack of defined verification processes and bodies to carry this out.

Appendices

Appendix 1 – Detailed reasons for changes between 2013 and 2015 inventories

GPC Ref. No / Scope	Change between 2013 and 2015 inventory	Reason
Stationary Energy		
All scope 2	Decrease	Total fuel consumption was 8% higher in the 2015 inventory than the 2013 inventory; however, emissions in 2015 are lower than in 2013 due to a reduction in the IEF (more electricity generated per volume of fuel consumed at the power station in 2015 than 2013). We tentatively conclude that this reduction may be due to a potentially under reported figure for production in the 2013 inventory year. However, with only 2 years data it is not easy to draw firm conclusions.
All scope 3	Increase	Emissions from the transmission and distribution losses of electricity were reported as 'IE' in 2013. In 2015, the difference between the amount of electricity supplied to the Gibraltar electricity network and the amount of electricity that is billed for by AquaGib is assumed to be the transmission and distribution losses across the network.
I.2.1	Increase	Inclusion of LPG use – assumed to be used in restaurants (activity data for this source was not available in for 2013).
I.6.2	Increase	Inclusion of electricity consumption at MOD sites (activity data for this source was not available in for 2013).
Transportation		
II.1.1	Decrease	More detailed, disaggregated fuel import data has been used to estimate emissions from this source. A net decrease is seen due to reduced consumption of petrol, despite an increase in diesel use. In addition, a small adjustment to the modelling approach for allocation of activity in and out of boundary was made.
II.3.1	Increase	More detailed, disaggregated fuel import data has been used to estimate emissions from this source. An increase in emissions is seen due to overall increased diesel consumption and retention of the 30% allocation.
II.3.3	Decrease	This large decrease is because the definition of shipping attributable to Gibraltar on the basis of the recorded 'purpose of call' has undergone significant changes, and as a result, the reported emissions from scope 3 are much lower in 2015.

II.4.3	Increase	There are flights to more destinations in 2015 than 2013. There is also a small increase attributable to a method change to include the whole LTO cycle in Gibraltar (previously 50%).
Waste		
III.1.2	Decrease	This is due to improved assumptions we were able to make in the 2015 inventory. Previously, an IPCC default value for the fraction of degradable organic carbon (DOC) found in the waste was used due to limited recent information and low confidence in the data on landfill waste composition and treatment. This default value included waste categories that are now assumed to not be landfilled (e.g. paper/card, food, etc.) thanks to greater clarification on the treatment processes, specifically the diversion to composting. For the 2015 inventory, the DOC value has therefore been recalculate to only include waste categories that are present in Gibraltar's landfilled waste (i.e. largely non-organic components) which has led to a large decrease in the DOC value (from 0.45 tonnes C/tonne waste, to 0.091 tonnes C/tonne waste). This change to the DOC value explains the decrease in emissions, but not activity data (i.e. amount of waste sent to landfill).
III.2.2	Decrease	Although activity data is higher (due to higher total waste and a larger proportion of waste being organic, indicated by the updated waste characterisation study), emissions from biological treatment have decreased; however, this is due to a change to the assumptions. Previously, it was assumed that waste being composted was dry; however, upon review during the compilation process, this assumption has been improved to assume that waste is wet when composted. This assumption is deemed to be more accurate/sensible as it is not known whether a process of drying occurs before waste is composted.
III.3.1	Decrease	This reduction is emissions is due to a large decrease in the activity data for both in and out of boundary incineration.
III.3.2	Decrease	
III.4.2	Increase	This calculation is based on population as a proxy, so an increase in population has led to an increase in emissions.
IPPU		
IV.2	Increase	Emissions in this sector are estimated using population as a proxy, and therefore population growth within Gibraltar will have somewhat influenced the calculated increase in scope 1 emissions. Improved data has also been used to calculate IPPU emissions in Gibraltar; for example, activity data regarding MDIs and N_2O use has been provided by the Gibraltar Health Authority, rather than relying on scaling UK data.
Other Scope 3		

VI.1	Decrease	Comparing 'Other scope 3' emissions between the two inventories is complex due to inclusion of different sources within this category. In the 2013 inventory, 'Other Scope 3' included additional emissions from the supply chain and upstream fuel emissions, which are not included in the 2015 inventory. Emissions from out-of-scope shipping traffic have increased due to the allocation of shipping attributable to Gibraltar on the basis of the recorded 'purpose of call' having undergone significant changes, and as a result, the reported emissions from other scope 3 are much higher in 2015 (and lower in II.3.3). Emissions from out-of-scope fuel use by non-Gibraltarian vehicles follow the same trends as explained under II.1.1.

The Table below depicts the magnitude of these changes in metric tonnes CO_2e and %, between the 2013 and 2015 inventories. Note that negative numbers reflect a reported reduction and positive numbers a reported increase.

Table A-1: comparison of changes between 2013-2015 by sector (excluding those not occurring)

GHG Emissions Source (By Sector and Sub-sector)	Change (metric tonnes CO_2e) 2013-2015				Change (%) 2013-2015			
	Scope 1	Scope 2	Scope 3	Total	Scope 1	Scope 2	Scope 3	Total
STATIONARY ENERGY								
Residential buildings	NO	-7,695	12,463	4,768	NO	-13%	NEW	8%
Commercial and institutional buildings and facilities	222	-10,559	20,722	10,385	NEW	-9%	NEW	9%
Energy industries	NO	-2,494	IE	-2,494	NO	-46%	IE	-46%
Energy generation supplied to the grid	*14,134*				*8%*			
Non-specified sources	NO	1,369	328	1,697	NO	NEW	NEW	NEW
Total (city induced framework only)	**222**	**-19,379**	**33,513**	**14,356**	**NEW**	**-11%**	**33513%**	**8%**
TRANSPORTATION								
On-road transportation	-6,771	NO	IE	-6,771	-13%	NO	IE	-13%
Waterborne navigation	13,891	NO	-501,798	-487,907	64%	NO	-57%	-54%
Aviation	NO	NO	3,002	3,002	NO	NO	10%	10%
Total (city induced framework only)	**7,120**	**NO**	**-498,796**	**-491,676**	**9%**	**NO**	**-55%**	**-50%**
WASTE								
Solid waste generated in the city	NO		-6,706	-6,706	NO		-27%	-27%
Biological waste generated in the city	NO		-950	-950	NO		-33%	-33%
Incinerated and burned waste generated in the city	-1,937		-699	-2,636	-88%		-86%	-88%
Wastewater generated in the city	NO		201	201	NO		12%	12%
Total (city induced framework only)	**-1,937**		**-8,153**	**-10,090**	**-88%**		**-27%**	**-31%**
INDUSTRIAL PROCESSES and PRODUCT USES								
Emissions from product use occurring within the city boundary	1,163			1,163	11%			11%
Total (city induced framework only)	**1,163**	**0**	**0**	**1,163**	**11%**			**11%**
AGRICULTURE, FORESTRY and OTHER LAND USE								
Total (city induced framework only)	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**

GHG Emissions Source (By Sector and Sub-sector)	Change (metric tonnes CO_2e) 2013-2015				Change (%) 2013-2015			
	Scope 1	Scope 2	Scope 3	Total	Scope 1	Scope 2	Scope 3	Total
OTHER SCOPE 3								
Other Scope 3			-788,930	-788,930			-17%	-17%
TOTAL								
(city induced framework only)	**6,567**	**-19,379**	**-1,262,365**	**-1,275,177**	**7%**	**-11%**	**-23%**	**-22%**

Appendix 2 – Data recommendations

The table below sets out the data requirements for each of the main sectors. It shows the minimum top-level data required for emission calculation, and the data required to enable a disaggregation of the data by end user and/or category. The Data for Verification column shows the data required to cross-check and verify the disaggregation of data.

Cells in grey indicate data that was not available for the Gibraltar 2015 inventory.

Sector	Minimum top level data	Data for disaggregation	Data for verification
Power	Fuel consumption for power (electricity) generation by fuel type - Gibraltar power station -	Electricity produced in Gibraltar (total) Electricity consumed by sector (e.g. residential, commercial, Government/public services, Industrial) - Billings by tariff or end-user - Meter readings	Total power (electricity) generation
Fuels/ combustion	Total fuel consumption by fuel type (non-electricity generation)	Fuel combustion locations End user sales / permits Total use by purpose (cooking stove, boiler etc.)	Not applicable
Transport (road)	Fuel import data by fuel type	Gibraltar vehicle licencing statistics End-user activity split : fuel use by vehicle type and purpose (including in and out of boundary – crossings of the Frontier) Fuel sold	Vehicle kilometre (vkm) data, by vehicle type and purpose
Marine (private)	Fuel import data	Fuel sold Fleet composition Fuel usage by marine use (boat type)	Not applicable
Shipping	Port activity - Number of ships - Types - Distance (origin/ destination)	Ship details (each) - Purpose - Class - Tonnage	Fuel sold

		Purpose for calling (bunkers/non-bunkers)	
Off-road	Fuel sold	Licencing statistics for off-road fleet Fleet composition Fuel use by vehicle type	Vehicle kilometre (vkm) data or hours of use
Aviation *(from CAA)*	Numbers of flights and destinations Distances flown (origin/destination)	Fleet data (aircraft types)	Fuel sold
Waste	Total tonnage of waste Disposal methods	Tonnes / type - Biological content - Waste treatment process	Not applicable
Wastewater	Total volume of wastewater Biological content Treatment streams	Wastewater volume by sector	Population Average wastewater and biological content per person
Industrial Processes and Product Use	Numbers of products by type (e.g. A/C units, refrigerators, vehicle A/C) (*some data available*) Volumes of N_2O (hospital)	Numbers of products by end use sector	Population GDP Average product use / number per person / GDP

Appendix 3 – Data collection template

The below is an extract from the data collection template that has been sent to data providers during the data collection process.

Data
Please use this template as a guide to the information required for the GibEMIT programme
Please do not feel contrained by the template - tables can be altered or replaced as best suits the information available - but the information requested below should all be provided if posible

Specify sector relevant to this data
Sector

Specify sub-sector(s) relevant to this data. Select additional sub-sectors in the next column if necessary
Sub-Sector(s)

Note: Data should correspond to the 2015 calendar year and the boundary of the Government of Gibraltar

GPC Ref	Activity	Description	Amount	Units	Time-period	Data Quality	Description of the data/methods	Source
Compiler input	*State the activity, site, end-user, fuel type, transport mode etc. e.g. "Residential Electricity consumption" "Buses"*	*If required, please provide further description of the data e.g. "total consumed electricity from all billings to residential electricity tarrifs within Gibraltar" "Total diesel consumption in buses on route 1"*	*State the data value e.g. if 10 litres, state 10*	*Specify the unit, e.g. litres, km, kWh*	*Specify whether the data is annual (and the year), monthly (and the month) etc.*	*If possible, please give an indicative assessment of the quality of the data (L,M,H) Note - H is directly measureed/recorded locally specific data, L is internatonal default or highly modelled*	*If relevant, please give provide a brief description of any methods used to derive the data*	*If relevant, please state the source of this data, place of publication etc.*

As well as collecting the actual activity data, additional information is also requested for quality control purposes; this information is presented below.

QC information required	Description of information required
Compiler	*Who compiled this data?*
Date created	*When was this data created/compiled?*
Source of data	*Where has this data come from?*
Data provided to	*Who has this data been provided for?*
Data purpose	*What has this data been provided for? Does this affect its use?*
Quality / Checking	*Has this data been checked by anyone? How has it been checked? Can you give an indication of the data quality?*
Data range / scope	*Time (e.g. date range)* *Geographic scope* *Installations/activities*
Notes/disclaimers	*Any other important information that the data recipient should be aware of? Are there missing years? Is this an estimate? Is this confidential?*

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