Gibraltar City Inventory 2018

A City-Level Greenhouse Gas Emissions Inventory for Gibraltar

Report for HM Government of Gibraltar

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Executive summary

Cities and communities present a significant opportunity in the management of global greenhouse gas (GHG) emissions; this has been increasingly recognised internationally and locally as organisations and initiatives increasingly champion city and community action, recognising that these places are often a focus of energy and resource consumption, create significant demands for mobility, and generate large quantities of waste. Globally, the focus is increasingly shifting towards enhancing the accounting and management of emissions at the city scale, and scaling up efforts to accurately monitor, report and verify activities as the basis for developing robust and evidence-based plans for action.

Since the landmark Paris Agreement in 2015, the emphasis is moving from making promises to taking action and tracking that 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 and communities like Gibraltar, with significant autonomy in key areas, have significant potential for leadership in demonstrating local level climate action.

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. Previous emissions data captured and reported through the UK Greenhouse Gas Inventory (GHGI) for Gibraltar did not give a complete picture of Gibraltar's GHG impact and mitigation activities, as 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). As 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 such as electricity end use, the Gibraltar Emissions Inventory Programme was established to compile a detailed bottom-up inventory of community GHG emissions for Gibraltar annually from 2015.

This report covers the most recent inventory year, 2018. It considers emissions from all sources, including stationary combustion (both power generation and end consumption by sub-sector); mobile combustion (by road, marine, and shipping); waste disposal and wastewater; and industrial process and product use (IPPU) emissions. It follows the internationally approved standard from the Greenhouse Gas Protocol: the Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC) (Greenhouse Gas Protocol, 2014), and is reported using internationally approved tools.

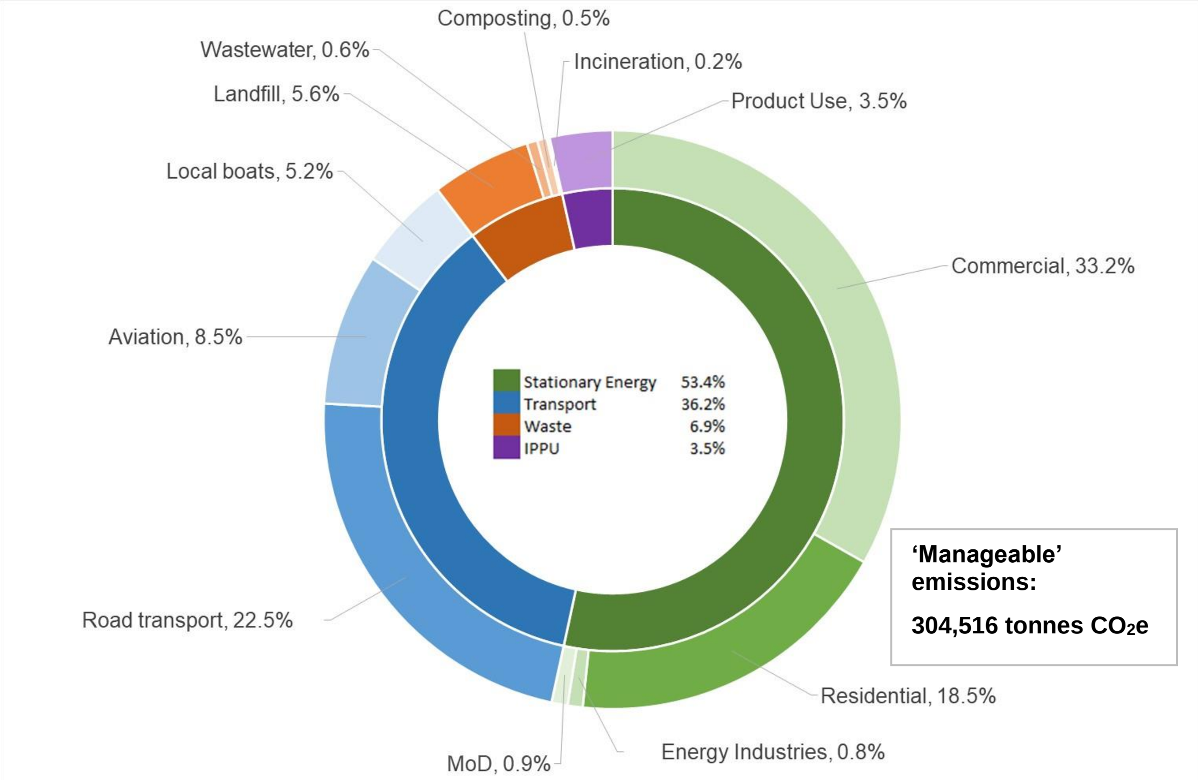
Emissions are calculated for the seven Kyoto GHGs, reported as carbon dioxide equivalent (CO_2e) and are categorised by 'scope', to distinguish where emissions physically occur:

- Scope 1 emissions are directly emitted in boundary (direct emissions)
- Scope 2 emissions are indirectly emitted from in-boundary consumption of electricity (Indirect emissions)
- Scope 3 emissions are indirect and out of boundary emissions (Other direct 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 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**.

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 bunker fuels accounting for 84% of total emissions when all are combined.

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



The results for BASIC+ excluding transboundary (international) shipping present a picture much more aligned to those expected for a community, with stationary energy dominating, accounting for 53% of emissions. This is particularly the case in Gibraltar given that electricity generation is still predominantly produced using higher-carbon (diesel) fuel. Transportation also contributes just over one third of emissions, with 22.5% from road transport sources, 8.5% from aviation, and 5.2% from local boats. Waste and IPPU are smaller, at 6.9% and 3.5 % respectively.

Scope 2 indirect 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 diesel 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 0.71kg CO_2e/kWh in Gibraltar in 2018, compared with the UK 2018 grid factor of 0.28 kg CO_2e/kWh[1].

When comparing emissions with other global cities, per capita BASIC-level emissions are used (excluding any scope 3 emissions). For Gibraltar this equates to 6.9 tonnes CO_2e per person. This compares to a UK average of 5.3 tonnes per person in 2017, with the lowest city emitting 3 tonnes per person[2].

When compiling the inventory for the latest year for Gibraltar, any improvements in data, methods or understanding are assessed and, where appropriate, are also applied to previous year's inventories to enhance accuracy and consistency across the time series. The 2015, 2016 and 2017 inventories have therefore been revised, referred to as '2015r', '2016r' and '2017r'. More details on the revisions are found in the main report.

The main findings from the 2018 inventory are summarised as follows:

Gibraltar's total manageable emissions have decreased by 5% since 2015r but have increased by 4% since 2017r; this is a result of the following:

- ↓ By 2018, emissions from electricity generation have decreased by 16% compared to 2015r. This is despite an increase in emissions from electricity generation (a 4% increase) since 2017r. The decrease since 2015 is due to less fuel being used to generate a unit of electricity, implying

[1] https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2017
[2] https://www.centreforcities.org/reader/cities-outlook-2020/city-monitor/#table-16-co2-emissions-per-capita

improvements in efficiency at Gibraltar's electricity power stations. Electricity consumption by residents and activity in Gibraltar remained fairly consistent between 2015 and 2018.

- ↓ Emissions from IPPU have decreased by 8% between 2015r and 2018; this follows trends in UK data that is used as a proxy for Gibraltar's emissions from product use (e.g. air conditioning and refrigeration).
- ↓ Emissions from aviation are around 9% lower in 2018 than 2015r, and 33% lower than in 2017r, likely due to a decreased number of flights to London Gatwick, London Heathrow and Manchester.
- ↓ Emissions from Waste are around 6% lower in 2018 than 2015r due to a reduction in total waste arisings sent to landfill (and composting). However, an increase in total waste produced between 2017r and 2018 saw emissions rise by 7%.
- ↑ Emissions from road transport in Gibraltar have increased by 18% due to more fuel being consumed by vehicles in Gibraltar.

An emissions inventory is an ongoing tool for understanding and reporting emissions, for tracking changes in total emissions over time, 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 GHG emissions, and some areas that are already demonstrating a reduction.

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, could be further prioritised. Road transport makes up 22.5% of emissions, which is significant given the small size of the territory and the potential for policy 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. Shipping activity remains a large source of emissions; and one that will likely increasingly dominate the inventory even after excluding those emissions considered outside of scope.

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. A inventory's effectiveness in being able to track the impact of GHG emission reduction policies is reliant on emission estimates being based upon high-quality, locally-specific, disaggregated data that reflect changes that have been caused by the policies. Improving the accuracy of the inventory will better support decision making and targeted climate policy making, potentially bring co-benefits for other strategic areas though enhanced data capture and management on key activities, and underpin the continued update of robust emission pathways modelling, supporting tracking of progress over time.

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Appendices

1 Introduction

Cities and communities present a significant opportunity in the reduction of global greenhouse gas (GHG) emissions; this has been increasingly recognised internationally and locally as organisations and initiatives increasingly champion city and community action, recognising that these places are often a focus of energy and resource consumption, create significant demands for mobility, and generate large quantities of waste. Globally, the focus is shifting towards enhancing the accounting and management of emissions at the city/community scale, and scaling up efforts to accurately monitor, report and verify activities as the basis for developing robust and evidence-based plans for action.

Since the landmark Paris Agreement in 2015, the emphasis is moving from making promises to taking action and tracking that 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 Intergovernmental Panel on Climate Change's (IPPC) Special Report on Global Warming of 1.5°C (SR1.5) identifies cities and urban areas as one of four critical global systems that can accelerate and upscale climate action. Communities like Gibraltar, with significant autonomy in key areas, have significant potential for leadership in demonstrating local level climate action.

The first step in managing 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 2014, cities lacked 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. 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, having also reported an inventory for 2015, 2016 and 2017. Gibraltar is therefore part of a fast-growing number of urban communities establishing processes to report such data regularly. 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. Previous inventories should also be revised in line with updated methodologies or available data, to ensure an ongoing process of improvement and consistency and accuracy across the time series. This report therefore provides an update to the 2017 inventory (reported in 2019) for the year 2018, and identifies a number of improvements where recalculations of the 2015, 2016 and 2017 inventories have also been undertaken. This will also allow Gibraltar to continue showing best practice in city GHG inventories, successfully take part and report under initiatives such as the Global Covenant of Mayors for Climate and Energy, formerly known as the Compact of Mayors (see **Section 2**), and understand progress towards goals outlined in Gibraltar's Climate Change Act and other programmes. Furthermore, this inventory programme will provide the evidence base to enable the undertaking of projections of emissions under different scenarios, including business-as-usual, planned policies and more ambitious actions.

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

This report and the accompanying GHG inventory data is part of Gibraltar's Emissions Inventory Programme (GibEmit), which in turn is part of the wider Gibraltar Air Quality and Climate programme, managed and delivered by Ricardo Energy & Environment.

1.1 Gibraltar's climate commitments

HM Government of Gibraltar (HMGoG) have been active in addressing the concerns of climate change and committing to reducing harmful GHG emissions. In October 2015, Gibraltar became a signatory of the Compact of Mayors, a global coalition of mayors and city officials pledging to reduce local GHGs, enhance resilience to climate change and track their progress transparently. As of January 2017, the Compact of Mayors merged with the EU's Covenant of Mayors to create the Global Covenant of Mayors for Climate and Energy (GCoM). GCoM brings together the world's two primary initiatives of cities and local governments – to advance city-level transition to a low emission and climate resilient economy, and to demonstrate the global impact of local action. Gibraltar is now one of over 10,500 cities and local governments who have committed to GCoM.

Under GCoM, Gibraltar have committed to regularly reporting a GHG Inventory, assessing climate risks and vulnerabilities, defining ambitious climate mitigation, resilience and energy targets, and creating a full climate action plan outlining how targets will be delivered, and monitoring progress over time, as depicted in **Figure 1-1**.

Figure 1-1: GCoM commitment requirements

Source: Adapted from Compact of Mayors material

It is important to note that as part of the merger, a common standard for city and local government GHG emissions inventory reporting for the GCoM, known as the 'Common Reporting Framework[4]' (CRF), has been developed. More information on the CRF is presented in **Section 2.8**.

[4] https://www.globalcovenantofmayors.org/our-initiatives/data4cities/common-global-reporting-framework/

As well as being a signatory to GCoM, in 2019, Gibraltar Parliament unanimously declared a climate emergency. Following this, HMGoG published the Climate Change Act and will also release the Climate Change Strategy. The Climate Change Act adopts ambitious climate targets to reduce emissions by 100% by 2045 when compared with emissions in 1990, with a 2030 interim target of reducing emissions by 42% compared with 1990 emissions (Figure 1-2). The Climate Change Strategy gives a high-level roadmap to meeting Gibraltar's emission reduction targets. To ensure HMGoG make continual progress towards long-term climate targets and successful action is taken, progress targets have also been set.

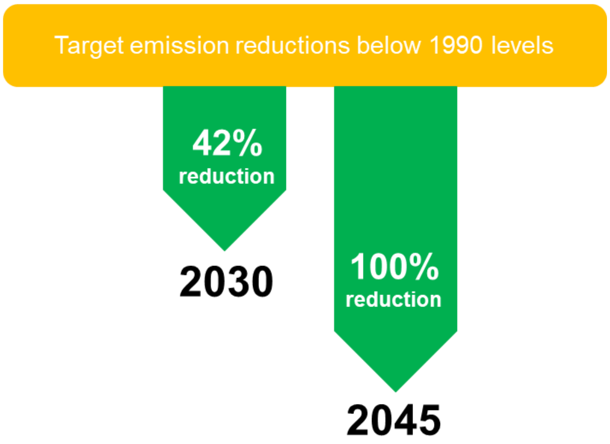


Figure 1-2 Climate Change Act targets

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 the inclusion of emission sources and GHGs, how emissions sources are defined and categorised, and how transboundary emissions are treated. This inconsistency made comparisons between cities difficult; raised questions around data quality; and limited the ability to aggregate local, subnational and national government GHG emissions data. It was recognised that, to allow for more credible reporting, meaningful benchmarking and aggregation of climate data, greater consistency in GHG accounting was 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 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 Gibraltar; hence the 2018 inventory presented in this report.

[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 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**.

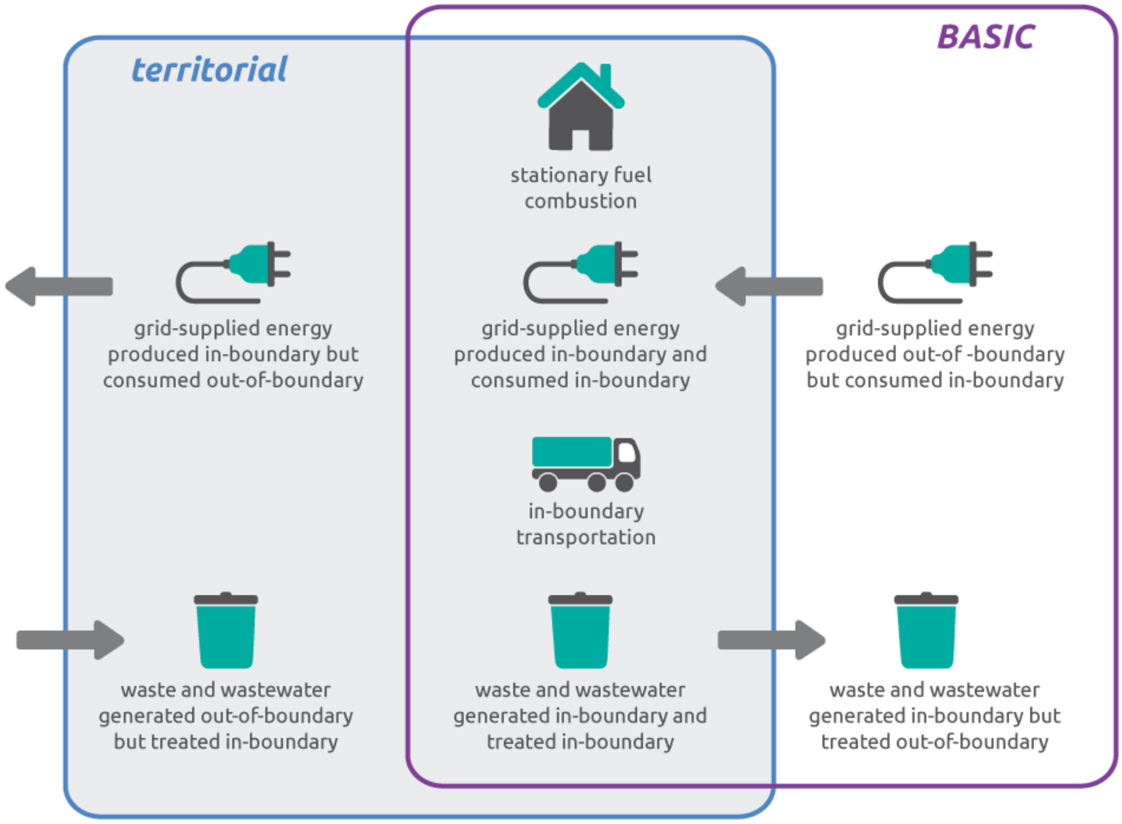


Figure 2-1: Comparison between territorial accounting approach and GPC

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**.

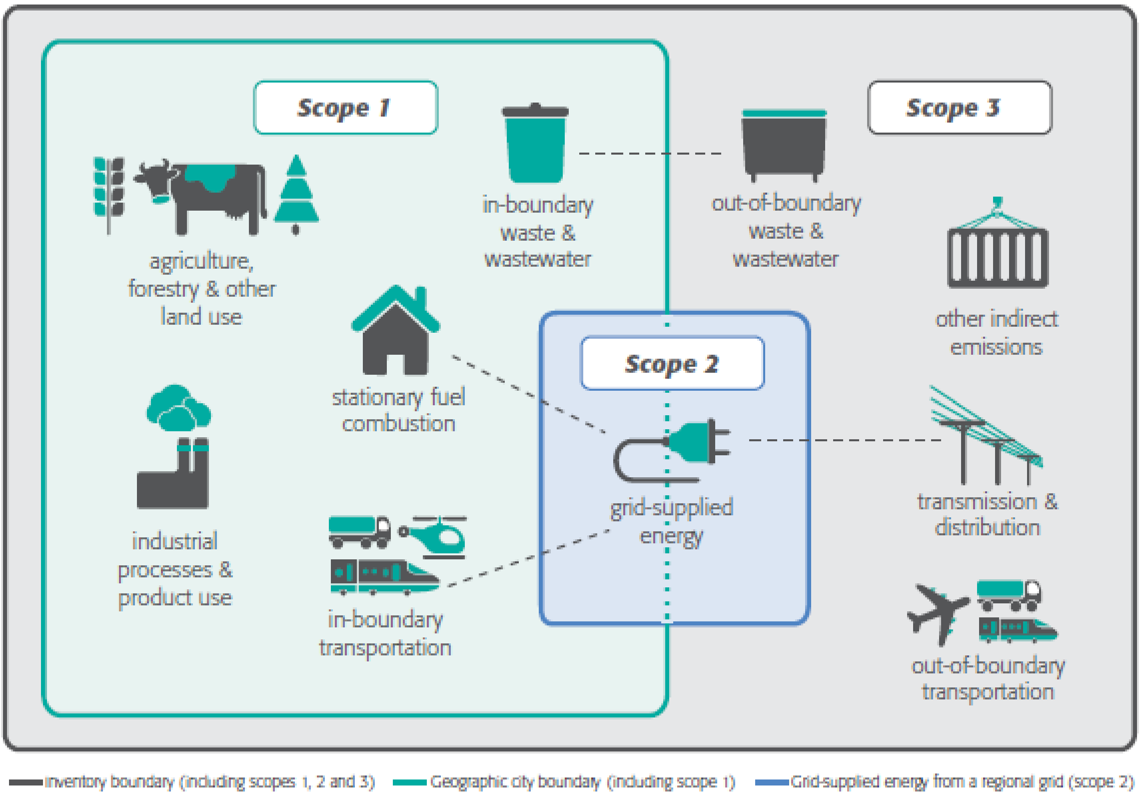


Figure 2-2: Sources and scopes of a city GHG inventory

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.

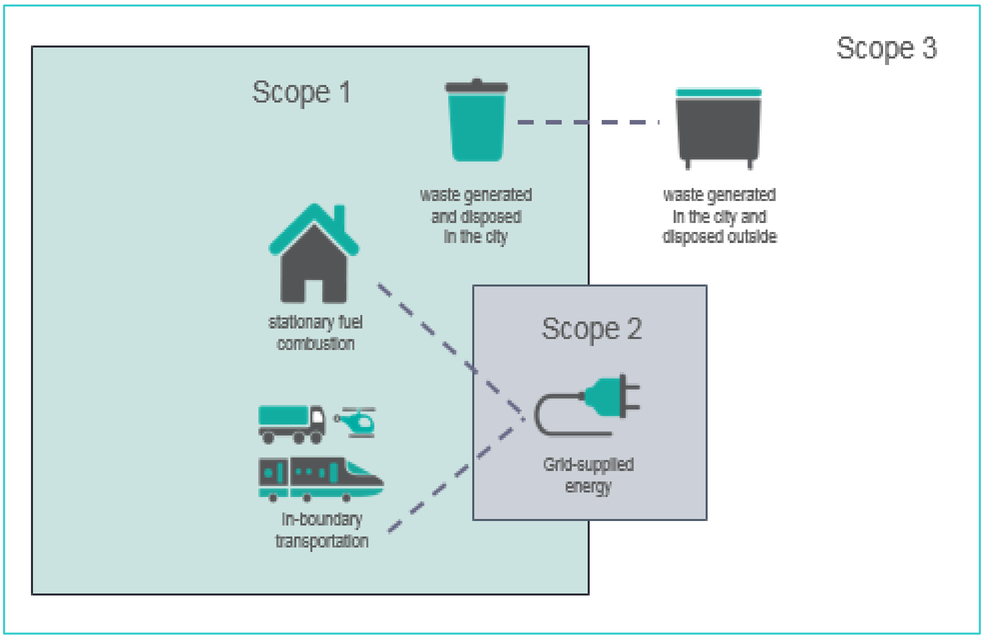


Figure 2-3: GPC reporting level - BASIC sources

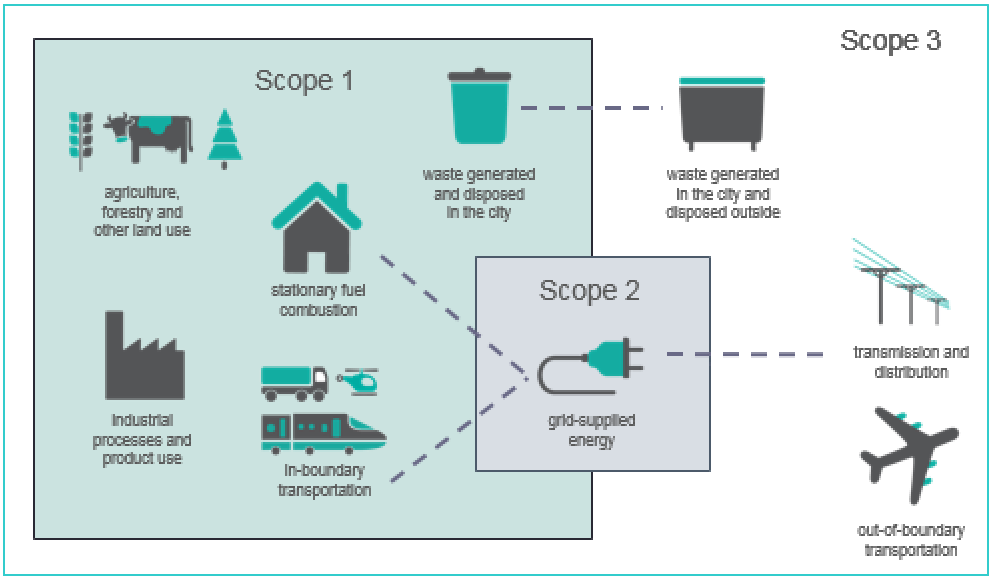


Figure 2-4: GPC reporting level – BASIC+ sources

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'. This is only permitted for scope 3 sources and IPPU and AFOLU sectors, reported under BASIC+ and therefore considered 'optional'.

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.

2.8 New reporting framework

As mentioned, GCoM have recently released a common standard for city and local government GHG emissions inventory reporting for the GCoM, known as the 'Common Reporting Framework[7]' (CRF). The CRF ensures a common approach for cities to monitor their performance against their individual action plans and targets while simultaneously creating a mechanism to transparently track the contributions and impacts of cities and local governments within the framework of the Paris Agreement. It helps track the invaluable contributions of all subnational actors, allow for comparison between

[7] https://www.globalcovenantofmayors.org/our-initiatives/data4cities/common-global-reporting-framework/

jurisdictions and increase the potential for financing opportunities at the local, regional, and global levels. This common standard has emerged from a need to harmonise the GPC reporting undertaken under the Compact of Mayors, and the alternative accounting approaches promoted by the Covenant of Mayors. Whilst very similar, there are some slight differences and GCoM has sought to harmonise these through the CRF. The principles and requirements of the CRF are largely the same as the GPC, with amendments confined to nomenclature of categories and mandatory versus optional requirements. As Gibraltar reports one of the most complete GHG inventories of any community, the changes in reporting do not require any additional effort with regards to inclusion of sources, gases etc., nor affect the reporting of the 'manageable' emissions as per this report.

The main differences between the GPC and CRF that affect how Gibraltar's emissions will be reported are outlined below. Please note, these changes affect how emissions are reported and not the emissions themselves.

- Under the CRF, emissions are reported as '**direct' and 'indirect**' emissions to distinguish where they physically occur, rather than using scopes as in the GPC. Under the CRF, emissions are categorised as:
  - **Direct emissions** (GPC Scope 1) due to fuel combustion in the buildings, equipment/facilities and transportation sectors within the city boundary. These emissions physically occur inside the city boundary.
  - **Other direct emissions** (GPC Scope 3) that are not related to fuel combustion, including: fugitive emissions from disposal and treatment of waste (including wastewater) generated within the city boundary, which may occur inside or outside the city boundary, and; fugitive emissions from natural gas distribution systems (such as equipment or pipeline leaks).
  - **Indirect emissions** (GPC Scope 2) due to consumption of grid-supplied energy (electricity, heat or cold) within the geographic boundary. Depending on where energy is generated, these emissions may physically occur inside or outside the city boundary.
- **Energy Industries** (GPC Sub-sector I.4.4) has been split into types of generation to enable reporting of how electricity is generated and the type of facilities generating electricity
- **Non-specified sources** (GPC Sub-sector I.6) have been removed and emissions are to be reported in one of the other sub-sectors

For the purposes of this report and Gibraltar's city inventory programme, emissions are still reported using the GPC. Appendix 1 reports Gibraltar's emissions following the CRF, as reported to CDP as part of Gibraltar's GCoM commitment. As mentioned, changes to reporting from following the CRF only affect how emissions are reported, and not the emissions themselves.

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 2018. Where 2018 data were not available, the most recent year's data have been used and the timescale noted accordingly. In particular, these are:

- Population: 2016 figure extrapolated to 2018 following recent trend (2018 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.

Under the CRF, reporting biogenic CO_2 is now optional.

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 (direct emissions)	All GHG emissions from sources located **within the boundary** of the city: • Stationary fuel combustion. • Direct IPPU emissions[8] • Electricity generation (information item only). • Mobile fuel combustion: – Road vehicles in-boundary. – Marine vessels in-boundary. – Aircraft in-boundary[9]. – Rail in-boundary[9] . • Waste disposal. • AFOLU[9].
Scope 2 (indirect emissions)	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[9]. • Commercial/other non-domestic electricity consumption. • Electricity consumption for key users (for example, water[10]).
Scope 3 (Other direct emissions)	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[9]. • Waste disposal and wastewater treatment.
Outside of scopes (reported under 'VI. Other Scope 3') (Other direct emissions)	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.

[8] Industrial Process emissions are not occurring in Gibraltar. Product Use emissions are reported however.
[9] Not occurring in Gibraltar
[10] 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;
- North Mole Turbines, or temporary generators;
- OESCO power station; and,
- GMES power station.

All power stations use gas oil / diesel (either marine or automotive gas oil). Emission factors for fuels are taken from the UK National Atmospheric Emissions Inventory (NAEI) (2018 data) and are shown in **Table 4-1**.

Table 4-1: Emission factors for power station gas oil fuel (from UK NAEI 2018)

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 (**Table 4-1)**. 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 for 2018

Pollutant	Unit	IEF	IEF factor (CO_2e)
Carbon	kt/GWh	0.19420	0.7121
CH_4	kt/GWh	0.00003	0.0007
N_2O	kt/GWh	0.00001	0.0017
Total	**kt/GWh**		**0.7145**

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 4-2**.

Figure 4-2: Summary of the process of calculating emissions

- Obtain electricity consumption data for key consumption sectors (GWh).
- Obtain electrictiy consumption data for tariffs.
- Identify proxy indicators for allocating consumption of electricity to sectors for which there is no consumption data.
- Calculate emissions for electricity for sectors where billings data exist.
- Allocate the balance of electricity to consumers using proxy indicators.
- Multiply electricity allocations by calculated IEF.

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, the hospital, the airport and for water provision.
- Proxy data on employment by sector from the 2018 Employment Survey Report[11] (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); hospital and airport consumption, Ministry of Defence consumption 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 from the the 2017 Employment Survey Report, 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.

[11] https://www.gibraltar.gov.gi/uploads/statistics/2019/Reports/Employment%20Survey%20Report%202018.pdf

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	2018 employment	% of total
Shipbuilding	235	1%
Other Manufacture	237	1%
Electricity and Water Supply	260	1%
Construction	4,062	14%
Wholesale and Retail Trade	3,560	12%
Hotels and Restaurants	2,122	7%
Transport and Communication	1,848	6%
Financial Intermediation	2,273	8%
Real Estate and Business Activities	3,976	13%
Public Administration and Defence	2,256	8%
Education	1,238	4%
Health and Social Work	2,876	10%
Other Services	5,052	17%
Total	**29,995**	**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, hotels and the hospital. Fuel import data provided by HM Customs in 2015 has been used to estimate emissions from this source. In the absence of new data for the 2016, 2017 and 2018 inventories, we have assumed that the same fuel consumption occurred for 2016, 2017 and 2018 as 2015; this is an appropriate assumption as significant annual trends for this source are not expected. 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 2018 emission factor for LPG.

It is also understood that the hospital, airport and some hotels have fuel combustion capacity (such as diesel and gas oil used for back-up generators and LPG for cooking and patio heaters). New data was collected for the 2016, 2017 and 2018 inventories from a number of hotels and the hospital to reflect this activity and subtracted from the import statistics to avoid double counting. For the 2017 and 2018 inventories, new data was also collected for the airport where fuel is consumed for back-up generation and for powering the aviation training simulator. When new data is identified, revisions are made to previous year's inventories to ensure completeness, assuming trends in usage have been unchanged.

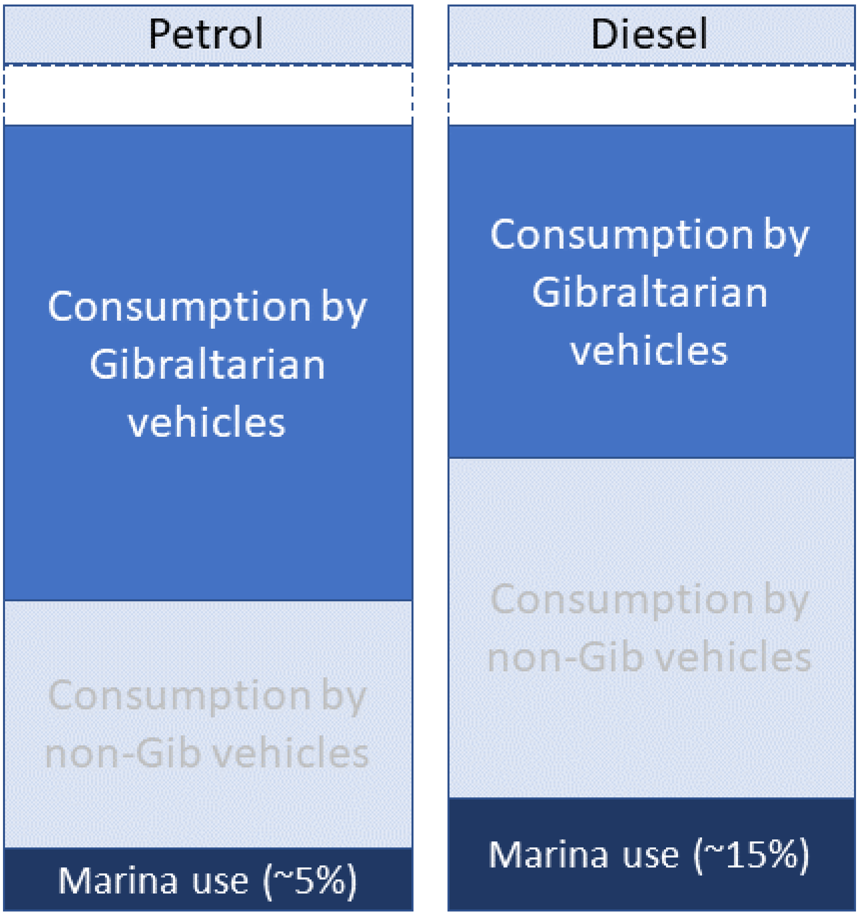
There is no stationary fuel combustion in households as all energy requirements are met through electricity, so this source is not occurring (NO).

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 4-3: End-use of imported fuel by sector, for petrol and automotive diesel assumed by the inventory



4.2.1 Road Transport

Road transport emissions have been calculated from Gibraltar's fuel import statistics for 2018. This effectively provides an 'energy balance' for total road transport fuel consumption. Imported fuel data is provided by the Port Authority of Gibraltar and is reallocated to different road vehicle types through a series of assumptions, further discussed below.

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 4-4 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 4-4: Road transport method summary

- Process the raw licensing statistics provided by the Government 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 HMGoG 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.

Licensing statistics for all years, except 2017, were made available and, as such, the fleet composition is interpolated between 2016 and 2018.

Fuel import data for 2018 provides a high-level total energy consumption to allocate by transport mode. Prior to use in this inventory, the fuel import statistics required 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 2018 is shown in **Table 4-5.**

Table 4-5: Gibraltar total road transport fuel use for 2018

Year	Fuel	Thousands of litres
2018	Motor spirits	15,426
2018	Automotive Gas Oil	33,923

Surveys of fuel stations carried out by the Department of the Environment in 2013, and then later in 2017, provide a snapshot of fuel use by vehicle type (commercial, private (assumed car) and motorcycle), the fuel type, and whether the vehicle is registered to Gibraltar or elsewhere (most typically Spain). Results from these surveys are combined and averaged to generate an estimate of fleet composition. This is because the results between the two surveys differed significantly, far beyond the extent that might be expected at typical fleet turnover rates, and so interpolating results between 2013 and 2017 would be misleading and likely highly inaccurate. Instead, the use of the 2017 results in the inventory is considered an expansion of the sample size and therefore, its representativeness to Gibraltar's fleet population. Some key differences are shown in **Box 4-2** below.

In addition, given the updated forecourt survey and differences identified, the road transport emissions for the 2015 inventory were revised following this new methodology and assumptions.

Box 4-2: Key differences between fuel station forecourt survey years and assumptions made

Key differences between the forecourt surveys were:

- The 2017 survey does not appear to count motorbikes for the majority of the dataset. To overcome this, it was assumed that the same proportion of motorcycles filled up between 2014 and 2017 and assumed that all two-wheelers were recorded as private vehicles in 2017 to offset this.

- There appears to be major shifts between 2014 and 2017 in the proportion of private vehicles originating from Gibraltar and from outside Gibraltar. After the correction to motorcycles, the 2017 % of private petrol vehicles from outside Gibraltar drops from 32% to 4%. This seems unlikely and is likely a reflection of the small sample size.

- There is a concurrent increase in the % of private petrol vehicles from Gibraltar from 34% to 62%.

- Diesel commercial vehicles registered to Gibraltar increased from 12% to 24%.

There is no obvious reason why the fleet composition of Gibraltar would have shifted significantly between 2014 and 2017, so using an interpolated time-series would be inaccurate and misleading as it would suggest a genuine trend. Therefore, we have used an average of the two surveys, suggesting that we do not think the fleet composition will have changed between these years (and hence 2015 and 2016 inventories).

Data were also available for fuel consumption for 2018 for the two major bus companies based in Gibraltar. In the 2015 inventory, data was ascertained for several other transport modes, including Government of Gibraltar vehicles, customs vehicles and fuel consumption from both major bus companies.

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 to the road transport sector by vehicle and fuel type.

It was assumed that fuel import data, by motor spirit (petrol) and automotive gas oil (diesel) for 2018, included fuel use, but excluded use in private marine vessels. This is because marina fuel is tax exempt and so would not be included in import records. In the 2016 inventory submission (submitted in 2018), it was assumed that diesel and petrol consumption in small marina craft, such as speedboats and dingy craft, equated to 30% and 10% of imports of these fuels respectively. However, after conversations with the Gibraltar Port Authority[12], these assumptions are felt to overestimate marina fuel use. As a result, at least until more comprehensive data is made available for the inventory, a revised assumption of 15% and 5% for diesel and petrol marina use is made.

Time-series analysis of import statistics to Gibraltar since 2003 suggest that marina consumption is additional to the total imports for road transport use. From 2008-2012 it is believed that import statistics include both road transport and marine uses and so estimates of total private vessel consumption can be calculated using the offset to the import trends over this period. Therefore, for the inventory we now approximate that in addition to the 15% assumption for diesel oil, the amount of petrol consumed by these smaller vessels equates to 5% of total imports.

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

Fuel type	Net fuel imports (thousands of litres)	Use by private marine vessels (thousands of litres)	Total use (thousands of litres)
Motor spirit	15,426	803	16,228
Automotive gas oil	33,923	5,233	39,157

Data was provided by Gibraltar's two principle bus companies which allowed for the estimation of fuel consumption directly from this vehicle type. For one of these companies, only 2015 and 2018 data is available, between these two years, a linear interpolation has been applied. In the case of 2015, the company could only provide data on annual fuel costs and so assumptions were made on the price paid for fuel to estimate fuel consumption. In addition, CO_2 emissions from urea consumption in Euro 6 buses was included in the inventory for the first time.

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. Vehicle licensing data was 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: Average fleet composition as indicated by the 2013 and 2017 forecourt surveys

<table>
<tr><th>Fuel</th><th>Gibraltarian/non-Gibraltarian</th><th>Vehicle type</th><th>Average fleet composition by fuel type (%)</th></tr>
<tr><td rowspan="2">Diesel</td><td rowspan="2">Gibraltarian</td><td>Private vehicle</td><td>29%</td></tr>
<tr><td>Commercial vehicle</td><td>18%</td></tr>
</table>

[12] Personal communication with John Ghio, Deputy Captain of Port, March 2019

Fuel	Gibraltarian/non -Gibraltarian	Vehicle type	Average fleet composition by fuel type (%)
		Motorcycle[13]	0%
	Non-Gibraltarian	Private vehicle	48%
		Commercial vehicle	3%
		Motorcycle[13]	2%
Petrol	Gibraltarian	Private vehicle	48%
		Commercial vehicle	8%
		Motorcycle	10%
	Non-Gibraltarian	Private vehicle	18%
		Commercial vehicle	1%
		Motorcycle	16%

4.2.1.4 Determining emissions

Carbon emissions factors are derived using COPERT fuel consumption factors and weighted using the detailed fleet composition information as suggested by active vehicles listed in Gibraltar's licensing statistics, based on vehicle type, fuel used, weight class, European emission standard and, if applicable, catalyst type. As discussed in **Section 4.2.1.2**, licensing statistics for 2018 were available for the 2020 compilation cycle and so the activity was obtained by determining the share of activity by vehicle type and euro standard. The emission factors then derived from the fuel consumption factors are the same as those used in the UK NAEI road transport projection models (using carbon contents provided by the United Kingdom Petroleum Industry Association, UKPIA).

Emission factors for methane and nitrous oxide are also the same as those used in the UK NAEI road transport projection models and are derived from the Transport Research Laboratory (TRL) emission factors for fuel consumption. 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	0.033	0.012
Diesel cars	189	0.002	0.016
Petrol LGVs*	279	0.026	0.013
Diesel LGVs	226	0.003	0.015
HGV **	599	0.067	0.020
Bus	698	0.084	0.022
Motorcycles	78	0.085	0.002

[13] Diesel motorcycles are reallocated to petrol in the final calculations as they are considered rare and are probably errors in the survey results.

*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	5.23	89.18
Gibraltarian	Commercial vehicle	Petrol	89.0	0.89	10.00
Gibraltarian	Motorcycle	Petrol	25.0	1.13	45.35
Gibraltarian	Private vehicle	Diesel	59.7	8.32	139.40
Gibraltarian	Commercial vehicle	Diesel	78.9	5.34	67.68
Gibraltarian	Bus	Diesel	220.4	0.32	1.43
Non-Gibraltarian	Private vehicle	Petrol	57.4	1.95	33.27
Non-Gibraltarian	Commercial vehicle	Petrol	89.0	0.07	0.82
Non-Gibraltarian	Motorcycle	Petrol	25.0	2.11	84.39
Non-Gibraltarian	Private vehicle	Diesel	59.7	13.85	231.99
Non-Gibraltarian	Commercial vehicle	Diesel	78.9	0.92	11.67

*million vehicle kilometres

4.2.2 Marine – private boats

As noted above, a proportion of gas oil and petrol included in the fuel import data is used by private boats. This has been estimated at 15% and 5% of total demand for gas oil and petrol respectively in 2018, based on historic fuel import statistics from 2008 to 2012. Emissions have been estimated using the emission factors for marine gas oil and petrol as used within the UK NAEI. As activity data in this sector are not available, there is no way of allocating to specific activities within the private marine sector.

Figure 4-5: There are a large number of private boats in Gibraltar, but no bottom-up activity data are available on their fuel use and the characteristics of the resident fleet

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 that 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 4-6 gives a brief overview of how estimates of emissions due to shipping have been made. A more detailed explanation is given below.

Figure 4-6 – 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 of 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; these 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. A weighted, ship-type specific average distance is derived to estimate more representative vessel journey lengths. 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 methodology. The origin and destination are those reported on the ship manifests.
  - The method is weighted according to the frequency at which boats visit various ports (and also applied to the 2015 revised inventory). In addition, averages for each of the ship types considered is calculated separately so that more characteristics distances are calculated. This causes a reduction in implied average journey distance since the majority of boats leaving the port visit nearby ports and therefore onward journeys are significantly shorter than the average previously estimated.
- 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[14] 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.

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

Table 4-10 – Ship classification based on the EMEP/EEA Guidebook 2016[14]

Ship types	
Liquid bulk ships	Dry bulk carriers
Container	General cargo
Ro Ro Cargo	Passenger
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**
To Supply Bunkers	Bunkers
Arrested	Hold Inspection
Repairs	Slops Discharge
STS With Mother Ship (Bunker Barges only)	Crew Change
Laid Up	Underwater Cleaning
Waiting Orders	Medical Assistance
Gibraltar/Tangiers Ferry	Spares
Owners Change	Stores
Cruise Call	Charts
Stationed	Lub-Oil
STS	Provisions
Containers Loading/Unloading	Surveyor/Technician Transfer
Cargo Loading/Unloading	Underwater Inspection
Yacht Delivery	Cargo Sampling
Rocks Unloading/Loading	Change of Schedule
MOD Movement	Class Survey
Yacht Loading/Unloading	Bunker Survey
Eastern Anchorage - Awaiting Berth/Supply	Debunkers
Ship Sanitation Certificates	Pratique Note
Vehicle Loading/Unloading	Water Receive
Sail Training Ship Visit	Port Clearance Note
Eastern Anchorage - Awaiting STS	Shelter
Publicity Event	Compass Adjusting
Cancelled operation	Deliver Fenders
Dredging Works	STS Equipment Return
Sea Trials	PSC Inspection
STS | Aegean	Underwater Survey
Waste Discharge	Tender/Service

Purpose of call	
In-scope	**Out-of-scope**
	PSC Mandatory Expanded Inspection
	Yacht Visit
	Detention
	Towing
	Under Tow
	Garbage Discharge
	Load Line Certificate
	Fuel Discharge
	Mid-Harbour Marina Berthing
	Radio Repairs
	Gyro Repairs
	Fenders Discharge

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

$$\text{Fuel use (t)} = \frac{\text{Distance travelled(km)} * \text{Power}^{15}\ \text{(kW)} * \text{Fuel use factor(t/kWh)}}{\text{Average speed (km/hour)}}$$

[15] Main engine power

Figure 4-7: Bunkering ships

Table 4-12: Tier 2 emissions factors for shipping from the EMEP/EEA air pollutant emission inventory guidebook 2016[14] (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 (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 (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 (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	4,523	5,316	2,552	2,552	217.1	255.2	10.4	12.2
Dry bulk carriers	18,038	17,315	3,926	3,926	593.2	569.4	6.4	6.1
Container	192	261	130	130	15.3	20.8	0.2	0.3
General Cargo	2,197	2,943	907	907	43.5	58.3	6.5	8.7
Ro Ro Cargo	40	106	35	35	1.1	2.9	0.2	0.6
Passenger	265	275	335	335	13.0	13.5	2.3	2.4
Fishing	0	27	3	3	0.0	0.0	0.0	0.2
Other	1,837	2,173	909	909	24.5	29.0	21.7	25.7
Tug	50	348	323	323	0.1	0.5	1.0	6.7
Total	**27,143**	**28,764**	**9,120**	**9,120**	**907.9**	**949.6**	**48.6**	**62.8**

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	227	549	1014	1014	10.9	26.3	0.5	1.3
Dry bulk carriers	204	282	85	85	6.7	9.3	0.1	0.1
Container	31	46	34	34	2.5	3.7	0.0	0.0
General Cargo	76	91	41	41	1.5	1.8	0.2	0.3
Ro Ro Cargo	2	2	5	5	0.0	0.0	0.0	0.0
Passenger	244	241	320	320	12.0	11.8	2.1	2.1
Fishing	-	-	-	-	-	-	-	-
Other	29	71	36	36	0.4	0.9	0.3	0.8
Tug	30	318	301	301	0.0	0.5	0.6	6.1
Total	**843**	**1,600**	**1,836**	**1,836**	**34.1**	**54.4**	**3.9**	**10.7**

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	3,114	0.06	0.15
Gas oil	3,206	0.03	0.14

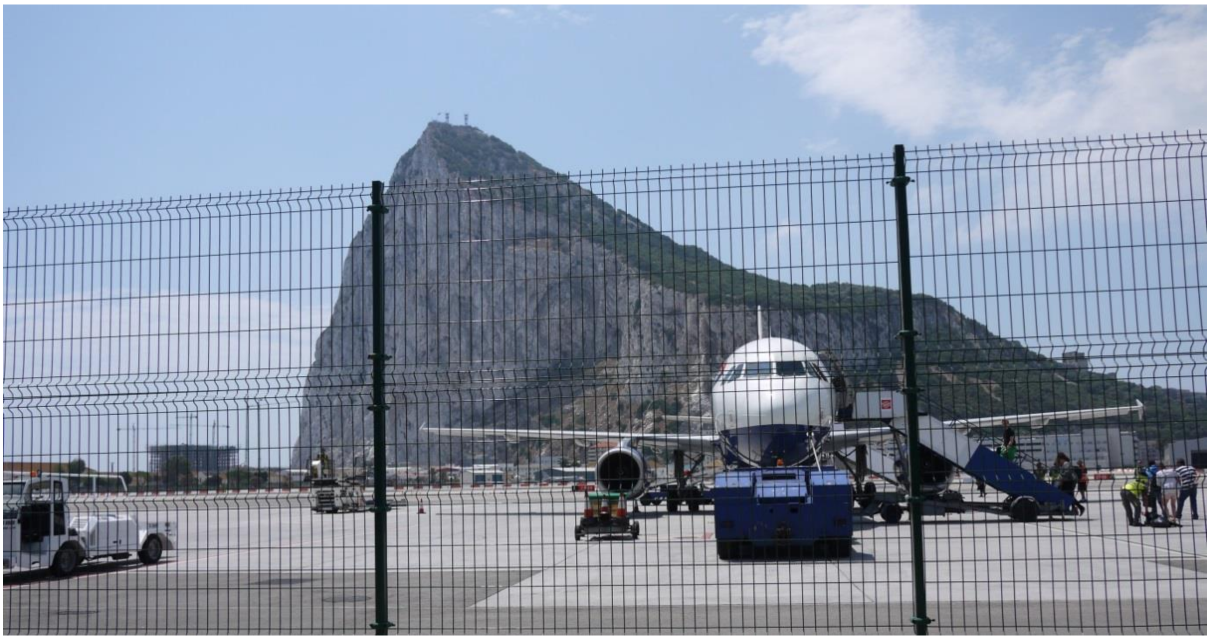
Only emissions from ship departures are included in the inventory as per GPC guidelines. Emissions from activities that are not attributable to Gibraltar (i.e. those that have been deemed 'out of scope' due to the purpose of their call, as shown in Table 4-11) are reported in 'Other Scope 3' and are 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 4-8**). 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.

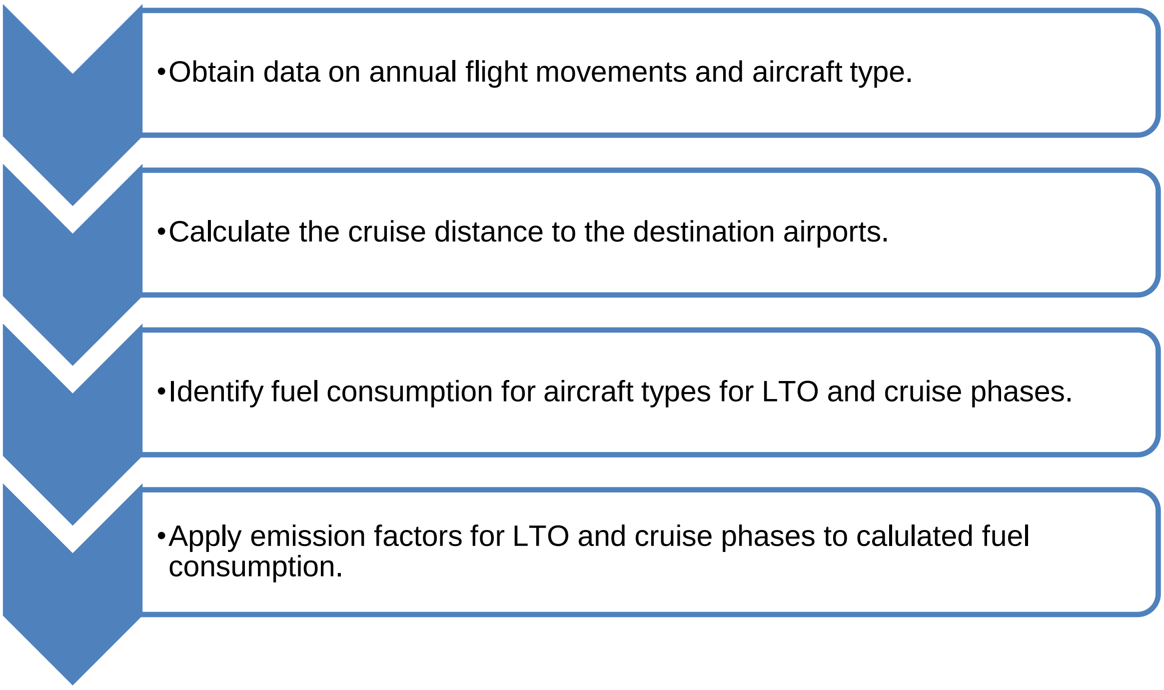
Figure 4-8: Gibraltar's International Airport



4.2.4.1 Overview

Figure 4-9 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 4-9: 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 2018 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 2018 were: Birmingham, Bristol, East Midlands, 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 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 consumption for an Airbus A319, Airbus A320 and an ATR 72 from the EMEP/EEA air pollutant emission inventory guidebook 2013 aviation annex[16] 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

[16] 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

Fuel (kg)	Phase of flight	Standard flight distances (nm)				(1nm = 1.852 km)		
		125	250	500	750	1,000	1,500	2,000
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	

The 2016 EMEP/EEA air pollutant emission inventory guidebook provides a spreadsheet tool to calculate fuel consumptions and emissions during the LTO cycle. This tool includes airport specific taxiing times by year. The latest year available for Gibraltar is 2015, which gave taxi-out and taxi-in times of 605 s and 204 s, respectively. These times, along with the aircraft fleet mix, have been used to calculate LTO emissions for 2018.

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	1,447	103
Total fuel consumption	Kt	8.6	0.04
Of which cruise	Kt	7.7	0.02
Total fuel consumption	TJ	378	1.66
Of which cruise	TJ	338	1.00

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

Phase of flight	Pollutant	Unit	Emission factor
Cruise	Carbon	kt/TJ fuel	0.0194847
Cruise	CH_4	kt/TJ fuel	Zero
Cruise	N_2O	kt/TJ fuel	0.000002
LTO	Carbon	kt/LTO	0.00006217
LTO	CH_4	kt/LTO	0.0000002
LTO	N_2O	kt/LTO	0.00000001

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 2018:

- 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.

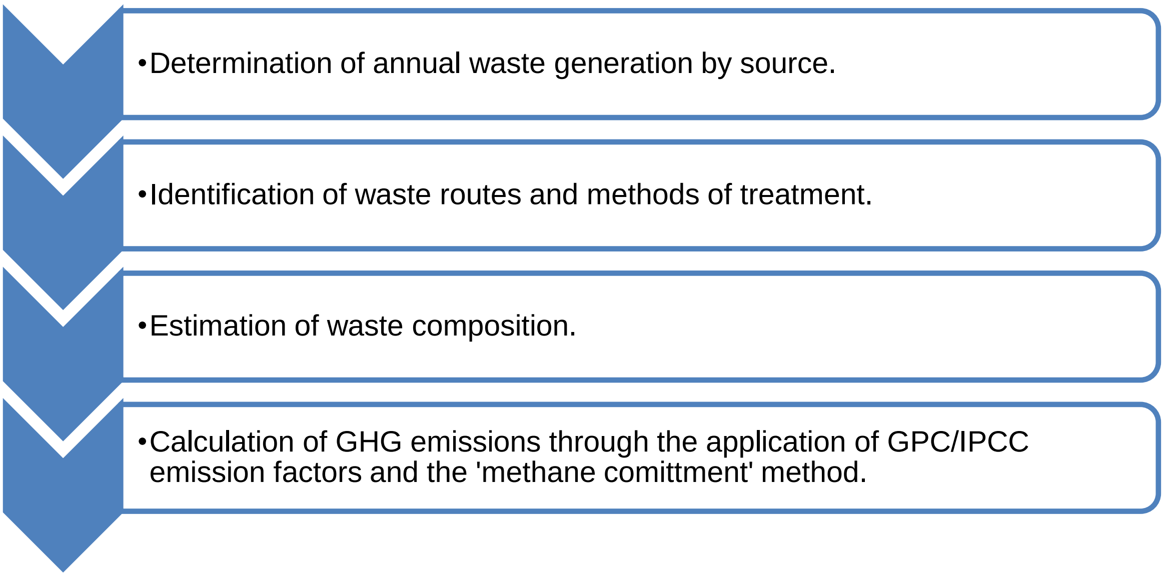
Emissions from incineration in Gibraltar are scope 1.

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

4.3.1 Summary

Figure 4-10 gives a brief overview of how waste emissions have been estimated, with a more detailed explanation provided in the following sections. A revised calculation using improved assumptions for future inventory compilation can be found in **Appendix 2.**

Figure 4-10: 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 2018

Month	Household (tonnes)	Refuse (tonnes)	Total (tonnes)
January 2018	1,026	1,455	2,481
February 2018	1,083	1,256	2,338
March 2018	824	1,467	2,291
April 2018	1,248	1,412	2,660
May 2018	1,281	1,459	2,740
June 2018	1,197	1,279	2,476
July 2018	1,191	1,262	2,452
August 2018	1,447	758	2,206
September 2018	1,137	1,422	2,559
October 2018	1,535	1,393	2,928
November 2018	1,706	1,485	3,191
December 2018	887	1,152	2,039
Total	**14,562**	**15,799**	**30,362**

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 2018 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	**Average waste composition**	**Assumed treatment route**
	Weight (%)	
Paper & Cardboard	25.1	Recycled
Dense Plastics	7.0	Recycled
Plastic Film	6.1	Landfill
Organics	30.7	Composted
Metals	3.4	Recycled
Glass	4.9	Recycled
Composites	2.2	Landfill
Special Municipal waste	3.0	Landfill
Textiles	3.2	Recycled
Fines	0.5	Landfill
Unclassified Combustibles	12.4	Landfill
Unclassified Incombustibles	0.9	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 4-11**). 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 0.246 tonnes C/tonne waste.

Figure 4-11: GPC equations for calculating emissions from landfill

Equation 8.3 Methane commitment estimate for solid waste sent to landfill

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

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 4-12**) 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. This year a revised emission factor for N_2O from composting has been applied from the IPCC 2006 Guidelines Waste Chapter update.

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	0.24g per kg of wet waste treated

Figure 4-12: GPC equation for calculating emissions from biological treatment of waste

Equation 8.5 Direct emissions from biologically treated solid waste

$$CH_4\ Emissions = (\Sigma_i (m_i \times F\_CH4_i) \times 10^{-3} - R)$$

$$N_2O\ Emissions = (\Sigma_i (m_i \times EF\_N2O_i) \times 10^{-3})$$

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 2016. The emission factors are provided in **Table 4-25**.

Table 4-25: Clinical waste incineration emission factors

GHG	Emission factor	Unit
CH_4	240	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, the Government of Gibraltar has awarded an Advanced Works Contract to the joint venture between NWG Commercial Services Limited [Northumbrian Water] and Modern Water to design, construct, operate and maintain a wastewater treatment facility in Gibraltar. This is planned to be operational soon.

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 below.

Figure 4-13: 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_i	=	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

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

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[17], 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 2018.

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**.

[17] 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
Electrical Insulation	non-fuel combustion	GDP
Precision cleaning	non-fuel combustion	GDP

*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[18]. 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.

Emissions from the use of electrical insulation and precision cleaning were added for the 2017 and 2018 inventories. Recalculations have also been made to add these emissions to the 2015 and 2016 inventories.

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'.

[18] 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) termed the 'manageable emissions', excluding international transboundary shipping.

5.1 Summary

Total emissions for Gibraltar in 2018 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 – 2018 emissions disaggregated by scope and by reporting level (BASIC and BASIC+)

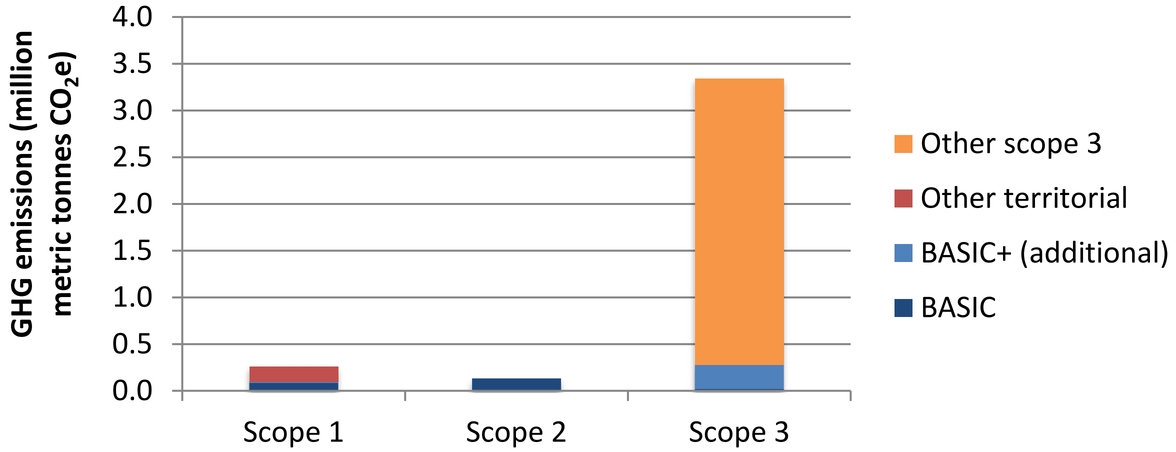


Table 5-1 - Classification of emission categories by scope and reporting level. Note, these are cumulative, and higher reporting levels include those sources in lower levels

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 fugitive emissions	In-boundary emissions from industrial processes In-boundary emissions from product use In-boundary emissions from livestock In-boundary emissions from land	

Scope	BASIC	BASIC+	Outside of scopes
	Emissions from in-boundary transport Emissions from waste and wastewater generated and treated within the city	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 2018 (under the GPC's BASIC+ reporting, excluding transboundary waterborne navigation and other scope 3)

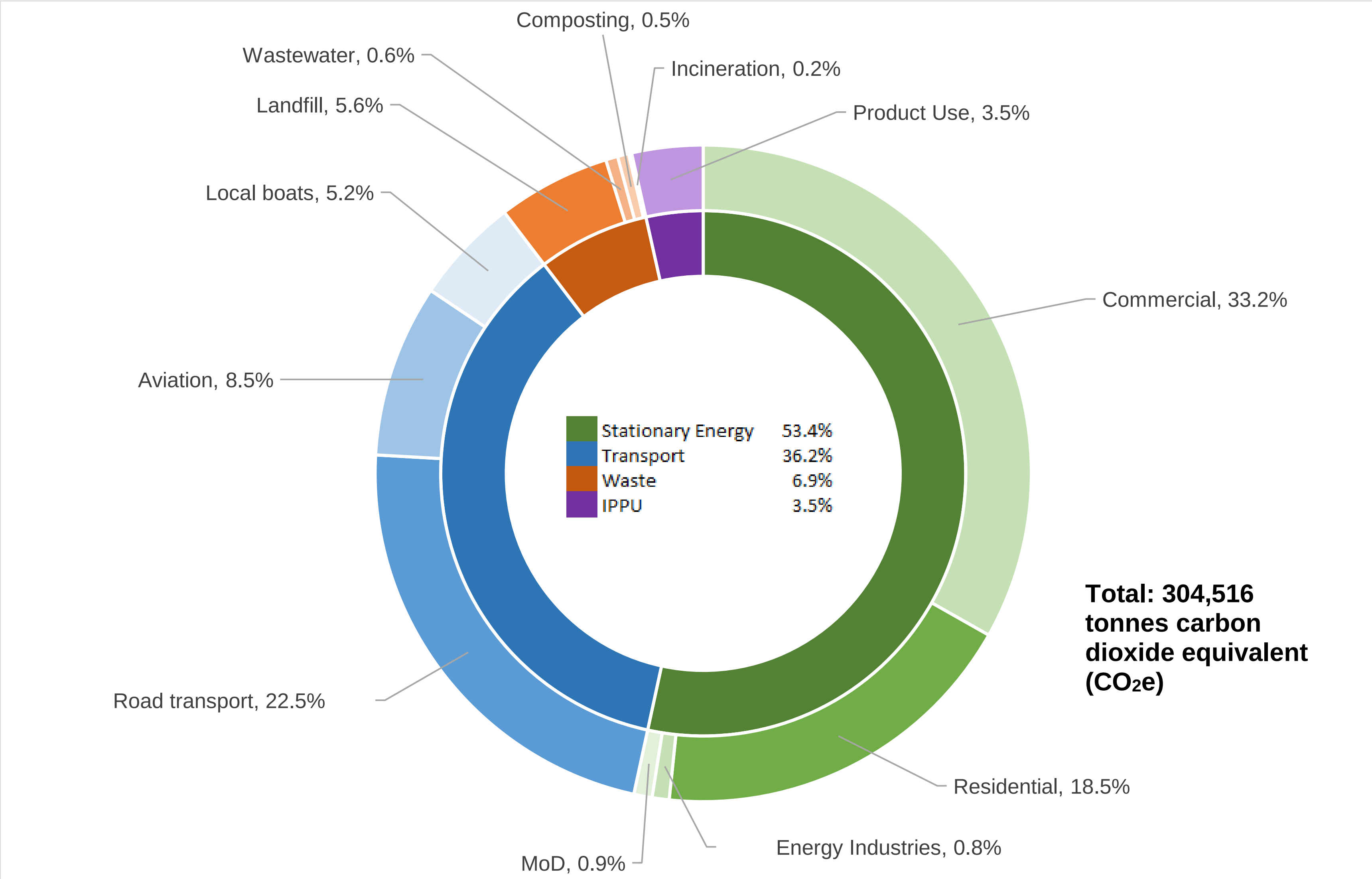


Figure 5-3 – Gibraltar's total emissions (including excluded sources) by source category for 2018.

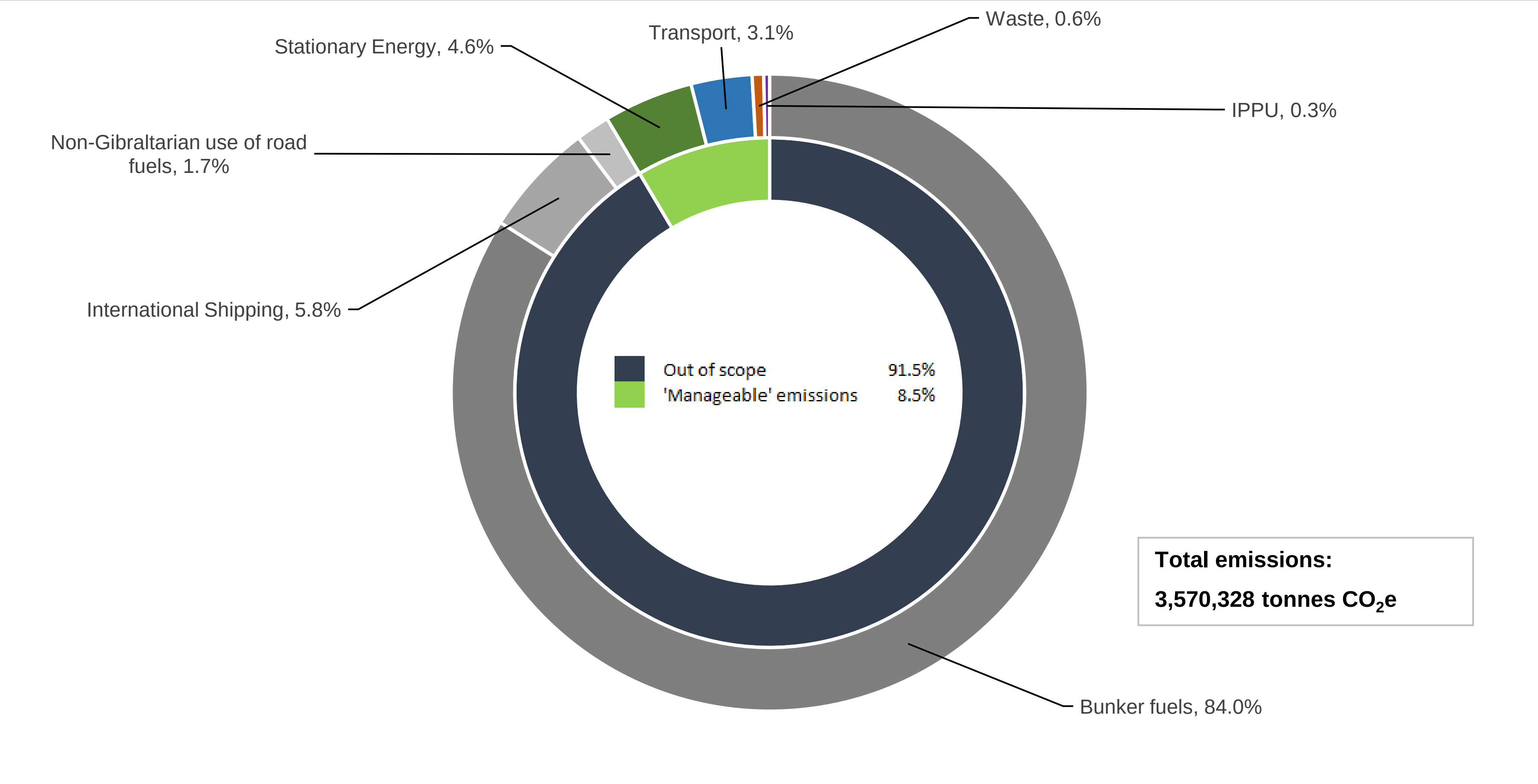


Table 5-2 – Total emissions for Gibraltar in 2018 by source.

Sector	Sub-sector	Total GHGs (metric tonnes CO_2e)			
		Scope 1	Scope 2	Scope 3	Total
Stationary Energy	Residential buildings	NO	46,290	9,908	56,198
	Commercial and institutional buildings and facilities	1,668	81,906	17,531	101,105
	Manufacturing industries and construction	NO	NO	NO	
	Energy industries	NO	2,555	IE	2,555
	Energy generation supplied to the grid	160,929			
	Agriculture, forestry and fishing activities	NO	NO	NO	
	Non-specified sources	NO	2,256	483	2,738
	Fugitive emissions from mining, processing, storage, and transportation of coal	NO			
	Fugitive emissions from oil and natural gas systems	NO			
	SUBTOTAL	1,423	128,044	26,273	155,740
Transport	On-road transportation	68,516	NO	IE	68,516
	Railways	NO	NO	NO	
	Waterborne navigation	15,935	NO	206,829	222,764
	Aviation	NO	NO	25,906	25,906
	Off-road transportation	IE	NO	IE	
	SUBTOTAL	**84,451**		**232,736**	**317,186**
Waste	Solid waste generated in the city	NO		16,952	16,952

Sector	Sub-sector	Total GHGs (metric tonnes CO_2e)			
		Scope 1	Scope 2	Scope 3	Total
	Biological waste generated in the city	NO		1,669	1,669
	Incinerated and burned waste generated in the city	317		142	459
	Wastewater generated in the city	NO		1,812	1,812
	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	**317**		**20,574**	**20,891**
Industrial Processes and Product Use	Emissions from industrial processes occurring in the city boundary	NO			
	Emissions from product use occurring within the city boundary	10,671			10,671
	SUBTOTAL	**10,671**			**10,671**
Other Scope 3	***SUBTOTAL***			3,058,982	3,058,982
TOTAL		**97,107**	**133,007**	**3,340,214**	**3,570,328**

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' accounting for 86% of emissions. 'Other scope 3' is dominated by marine bunkering (99%), with a small contribution (1%) from non-Gibraltarian road transport 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. Note that emissions from private boats are captured under Scope 1.

Stationary energy is responsible for 5% of total emissions, waste 0.6%, and industrial processes and product use (IPPU), 0.3%. Transport emissions from in-scope sources comprise 3.1% of total emissions, of which 70% 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 diesel is used to generate electricity, the emissions per kilowatt hour (kWh) are considerably higher than, for example, those in the UK.

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

Table 5-3 – Emissions by sector and reporting standard

Sector	BASIC	BASIC+	Manageable	BASIC+ and Scope 3
Stationary Energy	134,675	162,597	162,597	162,597
Transportation	84,451	317,186	110,357	317,186
Waste	20,891	20,891	20,891	20,891
IPPU		10,671	10,671	10,671
Other Scope 3				3,058,982
TOTAL	***240,017***	***511,346***	***304,516***	**3,570,328**

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) dwarf the BASIC and BASIC+ when considered, contributing to 84% of total emissions.

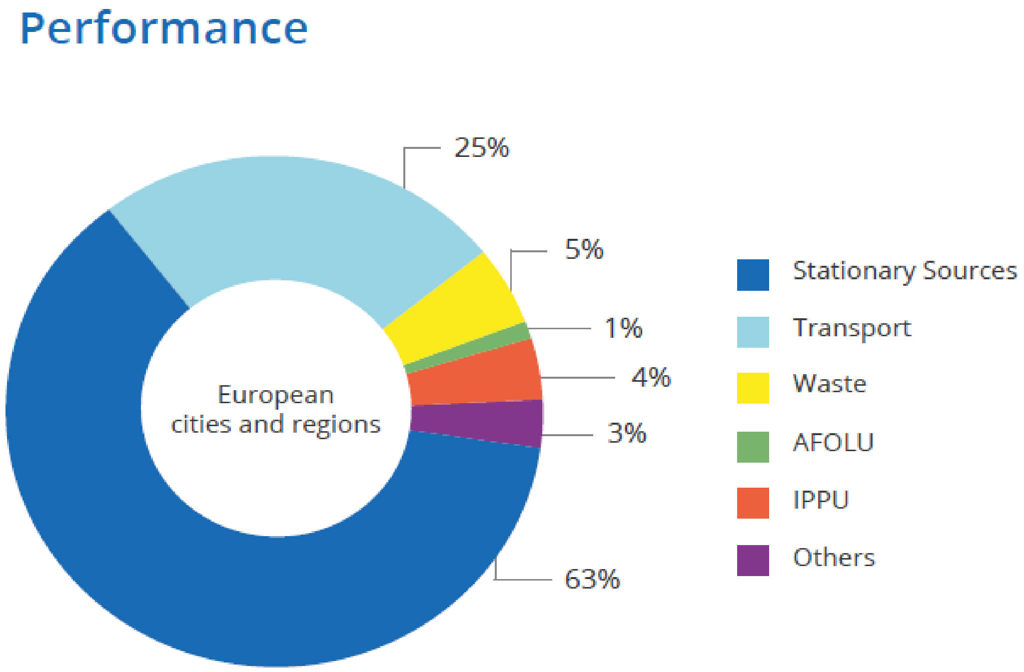
5.3 Total manageable emissions

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 a large proportion of waterborne navigation emissions. 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 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 53% of emissions. Transportation contributes 36%; 23.5% is attributable to road transport, 5% to waterborne navigation, and 8.5% to aviation. Contributions from waste and IPPU sectors are smaller, contributing 7% and 4% respectively.

Gibraltar's per capita emissions are 6.9 tCO_2e, based on the 'BASIC' emissions profile. This indicates that Gibraltar has slightly higher emissions per capita, compared with other cities and the UK average of 5.4 tonnes per person in 2018. 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. Cities with similar per capita emissions to Gibraltar include Boston and New Orleans[19].

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



5.4 Comparison with past inventories

This section aims to compare the 2018 inventory results against the revised 2017 (2017r), 2016 (2016r) and 2015 (2015r) inventory inventories. There are some differences between the original 2015 inventory[21], 2016 inventory[22], 2017 inventory[23] and the revised versions used as the comparison in this section; this is due to improvements in methodologies and activity data availability during the compilation of the 2018 inventory, which have been applied retrospectively to previous year's inventories for consistency and accuracy, following international best practice. Important recalculations are explained in **Appendix 3**. The 2018 inventory has not been compared to the 2013 inventory; the 2013 inventory was a 'pilot' using a pilot version of the GPC. For Gibraltar's city inventory programme, the 2015 inventory is the first official inventory. The 2013 inventory is also not directly comparable to the 2015-2018 inventories due to a large number of method changes and an updated reporting approach using the now-finalised GPC.

With four directly comparable inventories, observations can be made on changes to the time series; this section highlights key changes and aims to provide some insight and interpretation. As Gibraltar's inventory programme progresses, there will be a longer time series of inventories, allowing more confident commentary on annual emission trends.

[19] https://www.c40.org/research/open_data/5
[20] http://carbonn.org/fileadmin/user_upload/cCCR/ccr-digest-2014-2015/ccr-digest-2014-2015-online-final.pdf
[21] https://www.gibraltar.gov.gi/new/sites/default/files/HMGoG_Documents/20170601-Gibraltar_City_Inventory_Report_Published.pdf
[22] https://www.gibraltar.gov.gi/new/sites/default/files/HMGoG_Documents/2016-GibraltarCityInventory_Report_Final.pdf
[23] https://www.gibraltar.gov.gi/uploads/environment/GHG%20Inventory/2017-GibraltarCityInventory_Report_Final.pdf

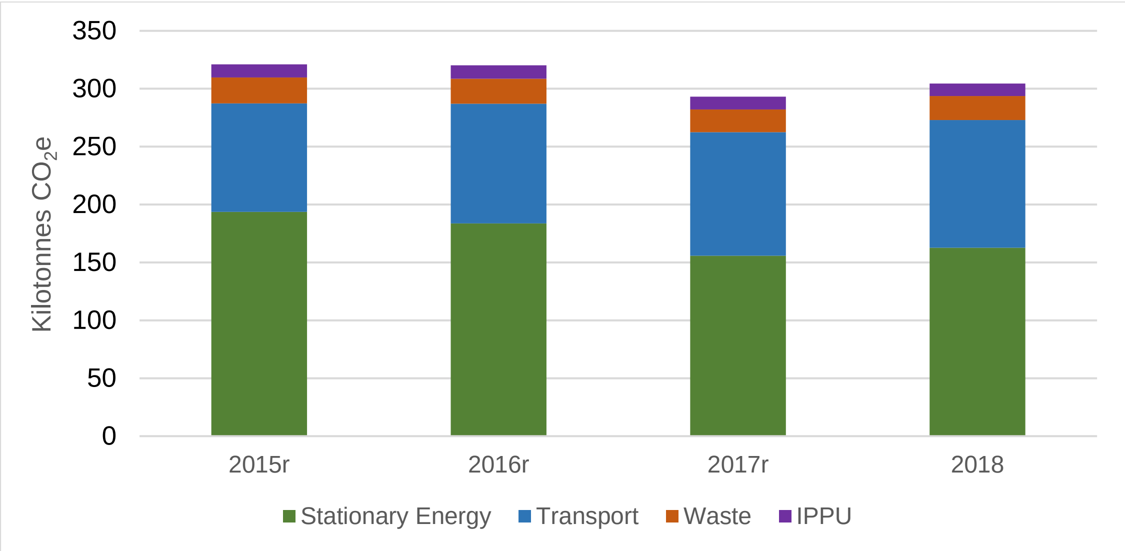
Emissions from the 2015r, 2016r, 2017r and 2018 inventories are presented, by sector, in **Table 5-4** and **Figure 5-5.**

More information on the specific reasons for changes between 2015r and 2018 inventories is found in **Appendix 3.** Information on the revisions between the 2018 and 2017r inventories is given in **Appendix 4**.

Table 5-4 – Comparison between the 2015r, 2016r, 2017r and 2018 inventories by sector

Reporting sector	Emissions (tCO_2e)			
	2015r	2016r	2017r	2018
Stationary Energy	193,567	183,811	155,868	162,597
Transportation (all[24])	283,694	376,519	369,492	317,186
Transportation (excluding scope 3 shipping)	93,795	103,234	106,709	110,357
Waste	22,249	21,561	19,460	20,891
IPPU	11,536	11,532	11,233	10,671
Other Scope 3[24]	3,077,657	3,207,139	3,324,843	3,058,982
Total Manageable emissions	**321,147**	**320,137**	**293,270**	**304,516**

Figure 5-5 - Gibraltar's 'manageable' emissions for 2015r, 2016r, 2017r and 2018



* Transport emissions excluding scope 3 shipping

[24] not included in Gibraltar's 'manageable' emissions

5.4.1 Summary of changes

Highlights

Gibraltar's total manageable emissions have decreased by 5% since 2015r but have increased by 4% since 2017r; this is a result of the following:

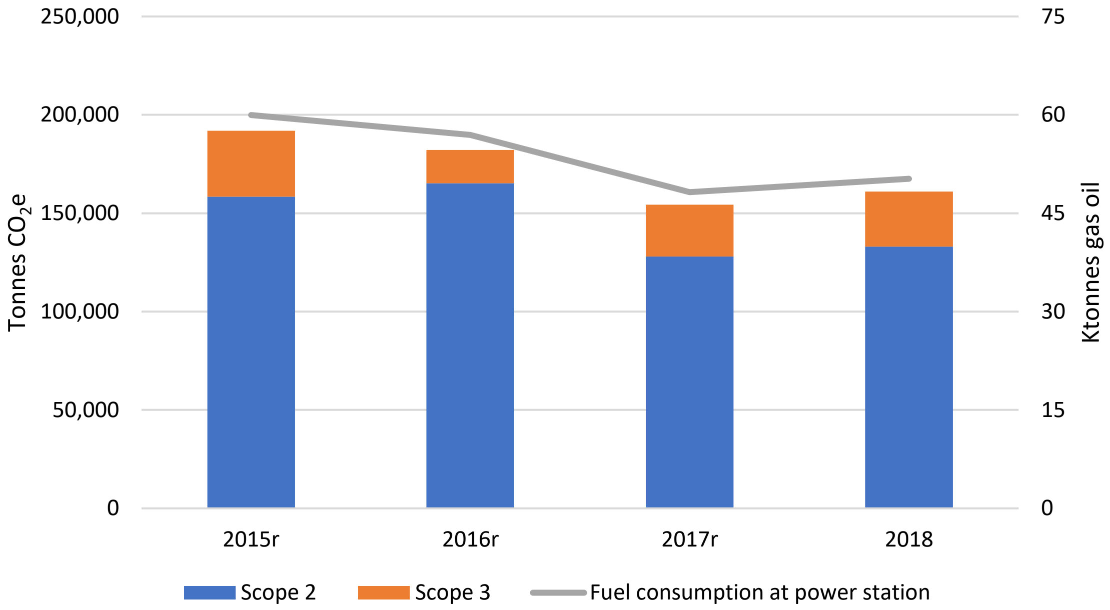
- ↓ By 2018, emissions from electricity generation have decreased by 16% compared to 2015r. This is despite an increase in emissions from electricity generation (a 4% increase) since 2017r. The decrease since 2015 is due to less fuel being used to generate a unit of electricity, implying improvements in efficiency at Gibraltar's electricity power stations. Electricity consumption by residents and activity in Gibraltar remained fairly consistent between 2015 and 2018.Emissions from IPPU have decreased by 8% between 2015r and 2018; this follows trends in UK data that is used as a proxy for Gibraltar's emissions from product use (e.g. air conditioning and refrigeration).
- ↓ Emissions from aviation are around 9% lower in 2018 than 2015r, and 33% lower than in 2017r, likely due to a decreased number of flights to London Gatwick, London Heathrow and Manchester.
- ↓ Emissions from Waste are around 6% lower in 2018 than 2015r due to a reduction in total waste arisings sent to landfill (and composting). However, an increase in total waste produced between 2017r and 2018 saw emissions rise by 7%.
- ↑ Emissions from road transport in Gibraltar have increased by 18% due to more fuel being consumed by vehicles in Gibraltar.

Stationary Energy – Electricity

Although not presented in the scope 1 totals (to avoid double counting), emissions from the generation of electricity have decreased by 16% since 2015r; this is due to considerably less fuel use for electricity generation at Gibraltar's power stations. However, emissions from electricity generation increased by 4% in 2018 since 2017r.

Scope 2 emissions in Gibraltar are solely those from **electricity consumption** and between 2015r and 2018, total scope 2 emissions have shown a decrease of over 30kt CO_2e or 16%. This decrease in emissions is despite total electricity consumption being fairly stable from 2015r to 2017, and is due to considerably less fuel being used at the power stations to generate a unit of electricity (**Figure 5-6**), and also how emissions from electricity are reported. However, electricity consumption increased by over 4% between 2017r and 2018.

Figure 5-6 - Gibraltar's emissions from electricity consumption/generation



The implied emission factor (IEF) for electricity is considerably lower in 2018 and 2017r than in 2016r; this means that less electricity was reported as generated per volume of fuel reported as consumed at the power stations in 2018 and 2017r than 2016r, implying that the efficiency of electricity generation has increased. Between 2017r and 2018, the IEF increases by 0.02kt CO2e/GWh, which might explain the increase in emissions associated with electricity consumption over this period. **Table 5-5** below shows a comparison of electricity data and the IEF between years.

Emissions from the generation of electricity are calculated on the basis of total fuel consumed in the power stations. There have been no significant changes to the methodology and assumptions used: all 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.

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 technologies change, 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.

Table 5-5 – Comparison of electricity consumption and production data, 2015r, 2016r, 2017r and 2018

	2015r	2016r	2017r	2018	% change	
					2015r - 2018	2017r - 2018
Kt fuel consumed	60.0	56.9	48.2	50.3	-16%	4%
GWh electricity produced	223.9	200.0	222.3	225.2	1%	1%

Implied Emission Factor (IEF) (kt CO_2e/GWh)	0.86	0.91	0.69	0.71	-17%	3%

Stationary Energy – Fuel combustion

Emissions from stationary fuel combustion have increased by 13% and 17% between 2018 and 2015r and 2017r respectively; this is due to slightly less diesel used for back-up electricity generation in the hospital and hotels. There are also small change in the Defra Conversion factors used for each year.

Road Transport

Road transport emission are only reported for Scope 1, with all fuel consumed by Gibraltarian vehicles reported in boundary[25]. Whilst recalculations of emissions for each particular fuel type are more significantly affected by this, overall emissions from the road transport sector have reduced by only 0.4% in each of 2015r, 2016r and 2017r. Since emissions from this sector are largely dictated by fuel import statistics received from HM Customs, an increase in petrol imports (14%) causes a small increase in emissions from road transport in 2018.

It should also be noted that there have been significant recalculations to the fuel consumed in the road transport sector. After consultation with HM Customs in March 2019, assumptions made to interpret raw import statistics were revisited. Harmonisation of customs declarations with EU standards over 2017 and 2018 are thought to have improved the reliability of import statistics, particularly for the importation of road-worthy diesel, which is thought to have confused with other forms of diesel, such as marine diesel, and gas oil. As a result, estimates for imported fuel, and therefore the fuel consumed on Gibraltar's road network, have been revised for both 2016 and 2015.

Waste

Total reported emissions from Waste have seen a reduction of 6% in 2018 compared to 2015r and an increase of 7% in 2018 compared to 2017r; this is due to decreases in the amount of waste that has been composted and sent to landfill. Emissions from the incineration of clinical waste have reduced slightly since 2015r.

Wastewater emissions generated in the city have increased slightly (by 1%) between 2017r and 2018 as a result of population growth, as the methodology is a Tier 1 population-based approach.

Waterborne navigation

Scope 1 emissions from waterborne (private boats) were an important recalculation in the 2017 submission. The most important factor in the recalculation was the revision to the assumptions about the fuel consumed by vessels included under Scope 1. Stakeholder discussions with the Gibraltar Port Authority in March 2019 revealed that the previous estimates of fuel use were overestimates. Previously, historic time-series analyses had suggested that diesel and petrol consumption amounted to about 30% and 10% of the imported fuel for a given year. However, following our discussions with the Gibraltar Port Authority, these assumptions were reduced to 15% and 5%. In future years, the inventory agency hopes to use more comprehensive fuel use data, such as statistics on the supply of automotive gas oil to vessels from refuelling activities which is now thought to exist in a usable format, but this assumption is kept at present as a conservative estimate of fuel use from this sector. In addition, these changes are influenced by the recalculations to total fuel imports described above. In the 2018 submission, total emissions from this sector have increased by 28% and 26% in 2015r and 2017r respectively, likely due increases in fuel imported into Gibraltar.

Scope 3 emissions from this sector increased by 9% and decreased by 21% compared to 2015r and 2017r respectively.

Aviation

Emissions from aviation are around 33% lower in 2018 than 2017r, likely due a decreased number of flights to London Gatwick, London Heathrow and Manchester. Between 2015r and 2018, aviation

[25] Consistent with GPC methodologies and best practice, where a robust method for splitting in-boundary and out of boundary emissions cannot be undertaken, fuel sales are reported under Scope 1. Sales to non-Gibraltarian vehicles is considered outside of Scope.

emissions have decreased by 9%, largely due to an increased number of flights to London Gatwick and Manchester.

Emissions from aviation may also be lower as a result of revised assumptions on the fuel consumption at different stages of a flight stage, aligning with the NAEI.

IPPU

There are still no Industrial Process emissions in Gibraltar, but Product Use emissions remain a significant source of scope 1 emissions (accounting for 11%). IPPU emissions have decreased by 8% in 2018 in comparison to 2015r. This is a small decrease in terms of total tonnes of CO_2e and follows the UK trend for products including aerosols, firefighting, foams, refrigeration and air-conditioning.

Other Scope 3

Other Scope 3 includes emissions from out-of-scope shipping traffic (e.g. bunkering) and out-of-scope fuel use by non-Gibraltarian vehicles. These emissions have increased by 1% and 4% compared to the 2015r and 2017r inventories respectively. Emissions from other scope 3 sources show minor recalculations, a result of the changes in fuel import statistics discussed above influencing the road transport element of this sector.

More information on the specific reasons for changes between the 2018 and previous inventories are given in **Appendix 3.**

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 nearly 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.

Gibraltar's GHG inventory provides an effective way to track changes to GHG emissions over time and a basis for tracking progress against mitigation policies. Gibraltar have been active in taking action on climate change, with the release of the Climate Change Act, the Climate Emergency Declaration and the Climate Change Strategy. Going forward, the GHG inventory will continue to be a key tool in tracking progress against the various targets Gibraltar have committed to. For the inventory to be as effective and useful as possible in reflecting emission reductions as a result of mitigation policy, efforts should continue in order to improve the data quality and accuracy used to calculate emissions.

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 5-6** 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 5-6 - Summary of assumptions and impact on inventory totals

Emission or data source	Assumption	Possible impact	Improvement
Proxy indicators	2016 values used as 2017/2018 values not available	It is unlikely that using 2016 values for proxy indicators (such as 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 Consider working with the Abstract of Statistics team to obtain official correct year figures in advance of publication in future cycles
Electricity allocation to end users	Electricity could only be allocated accurately for some users (domestic was based on tariffs and others were based on billings data) requiring allocation by proxy indicator	Ultimately, the total electricity emissions 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	Billings data for other key sectors (such as 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	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

Emission or data source	Assumption	Possible impact	Improvement
		it difficult to account for off-road vehicles and public transport. The fuel import data provides 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, which will lead to a small under estimate.	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 may also be 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 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 aviation 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	A proportion of gas oil and petrol included in the fuel import data is used by private boats. This has been estimated at 15% and 5% of total demand for gas oil and petrol respectively in 2018, based on discussions with Gibraltar Port Authority and historic time-series analyses of fuel imports.	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	It is possible that the ship classes and average fuel	The estimations in this sector are now based on a large amount of

Emission or data source	Assumption	Possible impact	Improvement
	travelled to and from other ports. This provided an indicator of fuel consumption per journey	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	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, we have used a weighted, ship-type specific average distance to estimate more representative vessel journey lengths. Previously, simple average journey lengths were applied.	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 using UK data and proxy indicators (population, GDP) (with the exception of N_2O for anaesthesia and MDIs which have been accurately estimated).	It is possible that the Gibraltarian case differs from the UK, particularly for air-conditioning units, which may be under estimated.	Latest year indicator data and Gibraltar-specific information on 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 2015 Waste Characterisation Study to the total reported MSW. Therefore, this assumption	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	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

Emission or data source	Assumption	Possible impact	Improvement
	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	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	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, it 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 will be requested during the winter. 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 6**. 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. Data supply agreements have been drafted, and are to be formally put in place, to ensure to consistent, timely and reliable supply of data for use in the inventory.

Appendix 5 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.

A number of recalculations have been made to the 2015, 2016 and 2017 inventories, based on data improvements realised through the 2018 inventory process; these are explained in **Appendix 4**.

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.
- Time series 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 6-1: Quality Checking

Sector	Reviewer(s)
Stationary Energy	Ellie Kilroy
Waste	Ellie Kilroy
Road transport	Peter Brown
Aviation	Ellie Kilroy
Shipping	John Watterson
IPPU	Ellie Kilroy

In addition, quality checks of the final reported data to ensure consistency with the GPC and complete and transparent reporting of the final results, and documentation of methods and results in this report are also carried out by the Knowledge Leadership and project management team.

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 – Common Reporting Framework (CRF) for 2018

Table A- 1: CRF Reporting for 2018

GHG Emissions Source (By Sector and Sub-sector)	Total GHGs (metric tonnes CO_2e)				Comments
	Direct	Other Direct	Indirect	Total	
STATIONARY ENERGY					
Residential buildings	NO	9,908	46,290	56,198	
Commercial buildings and facilities	1,668	17,531	81,906	101,105	
Institutional buildings and facilities	NO	483	2,256	2,738	Reported under 'I.6 Non-specified sources' in the GPC
Industrial buidlings and facitilites	NO	IE	2,555	2,555	Reported under 'I.4 Energy industries' in the GPC
Agriculture	NO	NO	NO		
Fugitive emissions	NO	NO	NO		
SUB-TOTAL	1,668	27,922	133,007	162,597	
TRANSPORTATION					
On-road	68,516	IE	NO	68,516	
Rail	NO	NO	NO		
Waterborne navigation	15,935	206,829	NO	222,764	
Aviation	NO	25,906	NO	25,906	
Off-road	IE	IE	NO		
SUB-TOTAL	84,451	232,736		317,186	
WASTE					
Solid waste disposal	NO	16,952	NO	16,952	
Biological treatment	NO	1,669	NO	1,669	
Incineration and open burning	NO	459	NO	459	
Wastewater treatment and discharge	NO	1,812	NO	1,812	
SUB-TOTAL		20,891		20,891	
INDUSTRIAL PROCESSES and PRODUCT USES					
Industrial Process	NO	NO	NO		
Product Use	NO	10,671	NO	10,671	
SUB-TOTAL		10,671		10,671	
AGRICULTURE, FORESTRY and OTHER LAND USE					
Livestock	NO	NO	NO		
Land use	NO	NO	NO		
Other AFOLU	NO	NO	NO		
SUB-TOTAL					
TOTAL	86,119	292,220	133,007	511,346	
ENERGY GENERATION					
Electricity-only generation	160,929			160,929	
CHP generation	NO				
Heat/cold generation	NO				
Local renewable generation	NE				
SUB-TOTAL	160,929			160,929	

Appendix 2 – Comparison of waste emissions using different assumptions

The current methodology undertaken to estimate emissions from municipal solid waste (MSW) disposal and the biological treatment of solid waste in Gibraltar contains a number of assumptions, as outlined in Chapter 4.3.

MSW 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. Some recyclables from this waste are sorted via coloured recycling bins in Gibraltar. Remaining 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.

A key assumption made in the current estimations of emissions is that all waste is perfectly sorted and separated once waste has been transported to Los Barrios, Spain. For example, all biological waste is composted, all recyclables are removed and all of the remaining waste is landfilled (Figure 28).

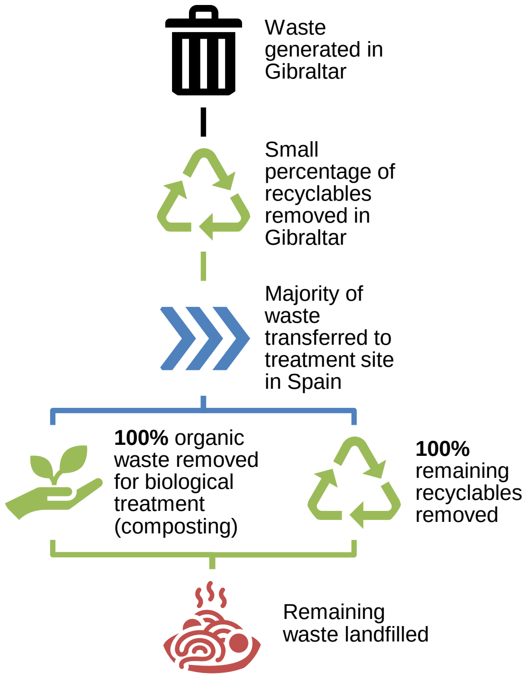


Figure 28 Current assumptions used to estimate emissions from MSW in Gibraltar

Suggestion for improvement

In 2013, the Government of Gibraltar instructed Ramboll to carry out a high-level assessment of available waste management and disposal scenarios in order to meet the ambition of EU recycling requirements of a 50% recycling target by 2020[26]. Scenario 1A was chosen in this study to best reflect the current waste disposal system for Los Barrios, which assumes a 20-30% sorting efficiency of residual waste into recyclables, a 50% sorting efficiency of organic waste which is composted for biogas, and a remaining fraction which is sent to landfill (Figure 29). Without more recent data, the assumptions outlined in this scenario are likely to better reflect the current situation of waste sorting than the assumptions used currently to calculate emissions from Gibraltar's waste.

[26] Ramboll (2013) 'Waste treatment options assessment'. Final Report for Government of Gibraltar. January 2013. p52. https://www.gibraltar.gov.gi/new/sites/default/files/Ramboll_Waste_Treatment_Options_Assessment.pdf

It is therefore recommended that updated assumptions are used in the calculation of emissions from waste in Gibraltar. The updated assumptions should reflect the assumed recycling rates taking place at the Los Barrios site in Spain. Obtaining more accurate information directly from the Los Barrios site for future inventory compilation is recommended.

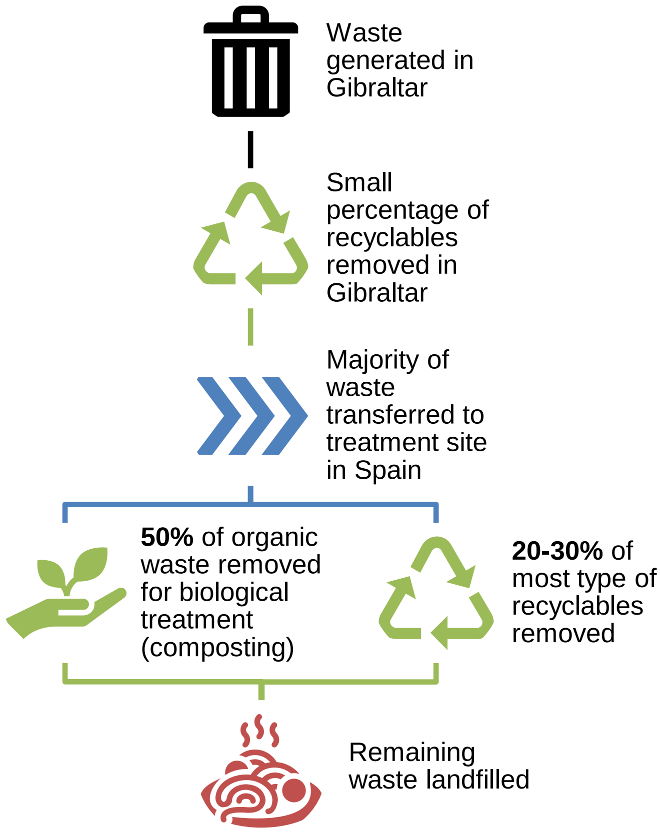


Figure 29 Revised assumptions that could be used in future inventories to estimate emissions from MSW in Gibraltar

Proposed recalculations

Table A- 2 and Table A- 3 below illustrate changes that would occur to emissions in Gibraltar's 2018 inventory if the new assumptions were adopted. Table A- 2: Recalculations between current and revised assumptions used to estimate emissions from biological treatment of Gibraltar's waste

illustrates that if Ramboll's assumptions on waste sorting for biological waste were taken into account, emissions would decrease across the 2018 inventory time series by ~50%.

Table A- 2: Recalculations between current and revised assumptions used to estimate emissions from biological treatment of Gibraltar's waste

	Unit	2015	2016	2017	2018
Absolute change in emissions	Tonnes CO_2e	-867	-834	-744	-869
% change in emissions	%	-50%	-50%	-50%	-52%

If Ramboll's assumptions on waste sorting were also taken into consideration for estimating landfill emissions, emissions would increase dramatically across the inventory (Table A- 3: Recalculations) as we would be assuming a much larger fraction of waste is being sent to landfill. This is due to an increase in emissions as all recyclables are currently assumed to be removed from the waste composition before being added to landfill. By reducing this assumption to only 20-30% of recyclables being removed from the waste compositions, emissions from landfill will in turn increase.

Table A- 3: Recalculations between current and revised assumptions used to estimate emissions from landfill of Gibraltar's waste

	Unit	2015	2016	2017	2018
Absolute change in emissions	Tonnes CO_2e	+28,842	+25,224	+19,922	+22,794
% change in emissions	%	+157%	+143%	+126%	+134%

When applying these changes and focusing on total waste sector emissions (including emissions from waste water), emission would increase overall, as shown in Table A- 4.

Table A- 4: Recalculations between total waste emissions using current and revised methodologies for estimating emissions from landfill and biological treatment

	Unit	2015	2016	2017	2018
Absolute change in emissions	Tonnes CO_2e	+27,975	+24,390	+19,178	+21,925
% change in emissions	%	+126%	+113%	+99%	+105%

Appendix 3 – Detailed reasons for changes between 2018 and 2015r, and 2018 and 2017r

Table A- 5 provides a summary of the reasons for changes in emissions in sub-sectors. Sub-sectors not included in this table did not show any significant change in emissions between years.

Table A- 5: Reasons for changes between 2018 and previous year inventories

Source	Change between current year (2018) base year (2015r)	Change between current year (2018) and previous year (2017r)	Reason
Stationary Energy			
Electricity generation	Decrease	Increase	Emissions from electricity generation have decreased by 16% since 2015r and increased by 4% since 2017r; this is due to less fuel being used to generate a unit of electricity, implying improvements in efficiency at Gibraltar's electricity power stations.
Scope 2 Electricity	Decrease	Increase	Scope 2 electricity emissions (electricity consumption) have decreased by over 30kt CO_2e, or 16%, since 2015r. This is due to less fuel being used to generate electricity, rather than electricity consumption itself reducing. In 2016r, more electricity was assigned to scope 2 electricity consumption compared to scope 3 transmission and distribution losses (as more electricity was 'billed' of the total supplied to the grid), which led an increase in overall scope 2 electricity emissions in 2016r. Less electricity was therefore considered as scope 3 transmission and distribution losses, or unbilled electricity in 2016r compared to 2015r and 2017. Since 2016, residential and commercial electricity use has increased, but electricity use by the 'power' tariff and by the MOD have decreased. In 2017r, electricity consumption increased by over 6kt or 4% compared with 2018.
Scope 3 Electricity	Decrease	Increase	The difference between the amount of electricity supplied to the Gibraltar electricity network and the amount of electricity that is billed for by AquaGib (reported under scope 2) is assumed to be the transmission and distribution losses across the network. In 2016, there was around half the amount of this 'unallocated' electricity reported than 2015 and 2017; this could be due to improvements in the way electricity is billed to consumers (with subsequent increases in scope 2, see above row) or due to actions to improve electricity

			losses across the network. The 2018 results are more consistent with the 2015 results, hence an increase between 2017r and 2018.
Transportation			
Scope 1 On-road transportation	Increase	Increase	Trends in road transport emissions are dictated principally by changes the fuel imported into Gibraltar. For example, an 8% increase in petrol imports is reflected in the emissions statistics from this particular fuel. To a lesser extent, changes in fleet composition, with greater penetration of Euro 6 vehicles which tend to be more fuel efficient and have differing methane and nitrous oxide factors cause emission trends, but these are much less important.
Scope 1 Waterborne navigation	Increase	Increase	Trends in Scope 1 waterborne emissions are dictated principally by changes the fuel imported into Gibraltar. For example, a 14% increase in petrol imports is reflected in the emissions statistics from this particular fuel.
Aviation	Decrease	Decrease	Emissions from aviation are around 9% lower in 2018 than 2015r, likely due to decreased number of flights to London Gatwick, London Heathrow and Manchester between 2015r and 2018. Between 2017r and 2018, aviation emissions have decreased by 33%, largely due to a decreased number of flights to London Gatwick and Manchester.
Waste			
Landfill and Biological treatment of waste	Decrease	Increase	Emissions from Waste are around 6% lower in 2018 than 2015r, and 7% higher in 2018 compared to 2017r; this is due to decreases in the amount of waste that has been composted and sent to landfill, but an increase between 2017 and 2018.
Incineration of waste	Increase	Increase	Scope 1 emissions from waste are attributable to the incineration of clinical waste within Gibraltar. Emissions from this activity have increased since 2015r due to an increase in clinical waste arisings treated by incineration. Scope 3 emissions from incinerating waste outside of Gibraltar have increased between 2017r and 2018.
Wastewater	Increase	Increase	Wastewater emissions have increased along with population growth.
IPPU			
Product use	Decrease	Decrease	There are still no Industrial Process emissions in Gibraltar, but Product Use emissions remain a significant source of scope 1 emissions (accounting for 11%). IPPU emissions have decreased by 8% in 2018 in comparison to 2015r. This is a small decrease in terms

			of total tonnes of CO_2e and follows the UK trend for products including aerosols, firefighting, foams, refrigeration and air-conditioning.
Other Scope 3			
Road Transport	Increase	Decrease	Revisions to assumptions made during cleaning and handling of raw fuel import statistics are responsible for small declines in the use of petrol and diesel on-road, both by non-Gibraltarian vehicles and Gibraltarian vehicles (the latter as a part of Scope 1)

Appendix 4 – Recalculations

This appendix covers the main recalculations between the 2020 submission and the 2018 revised inventories for 2015, 2016 and 2017. Recalculations with a very small or insignificant impact have not been covered.

Table A- 6: Recalculations between the 2020 submission and the 2018 revised inventories for 2015, 2016 and 2017

Sector	Sector/sub-sector	Change in tonnes of CO_2e to 2015r	Change in tonnes of CO_2e to 2016r	Change in tonnes of CO_2e to 2017r	Reason
I. Stationary energy	I.2 – Commercial and institutional buildings and facilities	128	104	128	Addition of airport fuel consumption data.
II. Transport	II.1 - Road Transport	202	200	213	Revisions to Gibraltar fuel consumption data.
II. Transport	II.3 Waterborne Navigation	20	23	22	Revisions to Gibraltar fuel consumption data.
II. Transport	II.4 Aviation	-16	-21	-21	These recalculations are as a result of revised assumptions on the fuel consumption at different stages of a flight (mainly taxing times), aligning with the NAEI.
IV. IPPU	IV.2 Product Use	-476	-657	-701	Recalculations across the time series for firefighting, precision cleaning and electrical insulation.

Sector	Sector/sub-sector	Change in tonnes of CO_2e to 2015r	Change in tonnes of CO_2e to 2016r	Change in tonnes of CO_2e to 2017r	Reason
VI. Other Scope 3	VI. Other Scope 3	135	158	196	See II.1 Road transport

Appendix 5 – Data recommendations

Table A- 7 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 2018 inventory.

Table A- 7: Data requirements and recommended improvements

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 Purpose for calling (bunkers/non-bunkers)	Fuel sold
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 - Further information on the waste treatment process in Spain	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 6 – Data collection template

Table A- 8 below is an extract from the data collection template that has been sent to data providers during the data collection process.

Table A- 8: Data collection template example

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.

Table A- 9: Quality control information

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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