Gibraltar City Inventory 2021

A City-Level Greenhouse Gas Emissions Inventory for Gibraltar

Report for HM Government of Gibraltar

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Executive summary

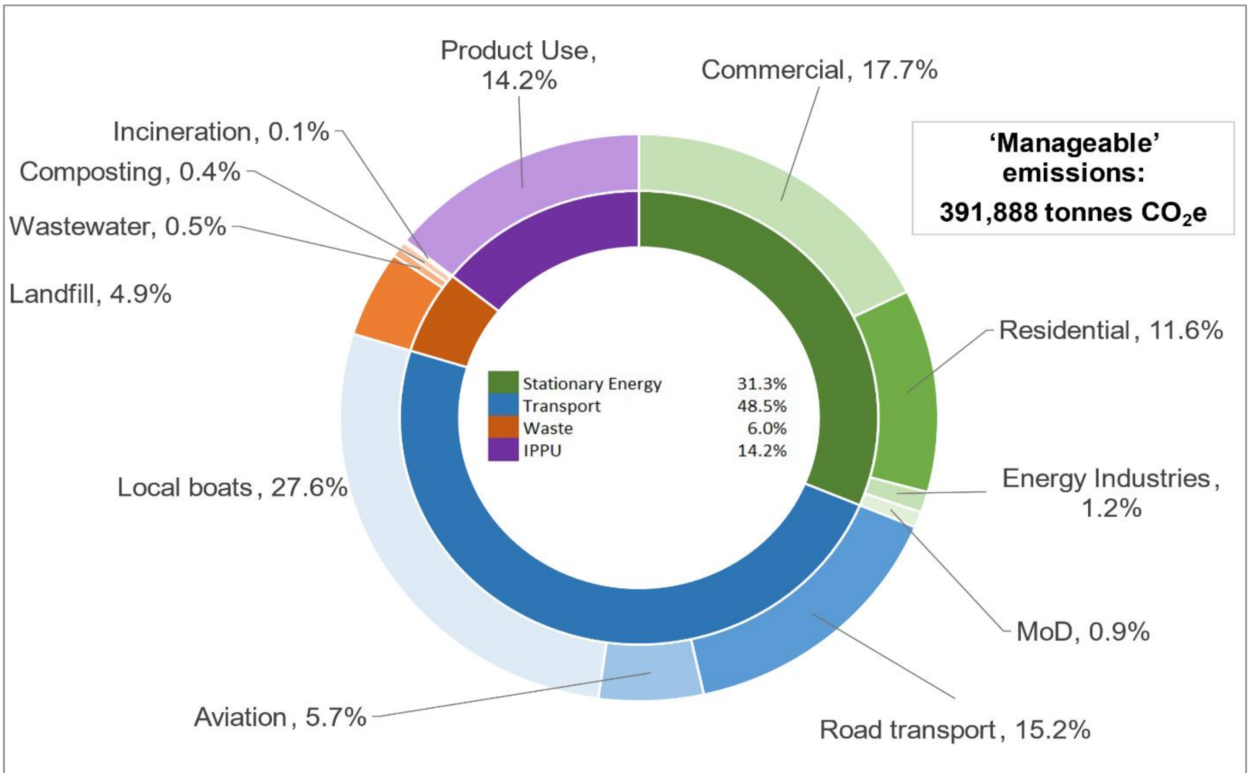
Gibraltar is committed to tackling climate change by reducing greenhouse gas (GHG) emissions. The Climate Change Act 2019[1] adopts ambitious climate targets to achieve net zero emissions by 2045, with a 2030 interim target of reducing emissions by 42% compared with 1990 emissions. To track progress towards these emission reduction targets, a GHG inventory is reported each year. This report covers the most recent inventory year, 2021. It includes 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), 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. Most cities report a BASIC inventory. Gibraltar's manageable emissions profile goes beyond a BASIC inventory, including additional emission sources such as transboundary road transport. Emissions associated with bunkering activity, international shipping and non-Gibraltarian use of road fuels are not included. Gibraltar's manageable emissions for 2021 are shown in **Figure i**.

Figure i: Gibraltar's 2021 manageable emissions



[1] https://www.gibraltarlaws.gov.gi/legislations/climate-change-act-2019-4688/download

Stationary energy and transport are the largest emitting sectors, accounting for 31.3% and 48.5% of manageable emissions respectively. Transport emissions are dominated by local boats (27.6% of manageable emissions) and road transport (15.2% of manageable emissions). Stationary energy emissions are largely from commercial users. Waste and IPPU are smaller, at 6% and 14.2% of manageable emissions respectively. As of the 2020 inventory, local boats make a more significant contribution to emissions; this is due to an improvement in the data used to calculate emissions from this source. As is inventory best practice, previous years' inventories have been revised in line with this change in data source to allow for a consistent time-series. Going forward, a key improvement will be to obtain data to allow the disaggregation of emissions from local boats into those attributable to Gibraltar and those which are not attributable to Gibraltar; as such, the contribution of local boats may change in future years.

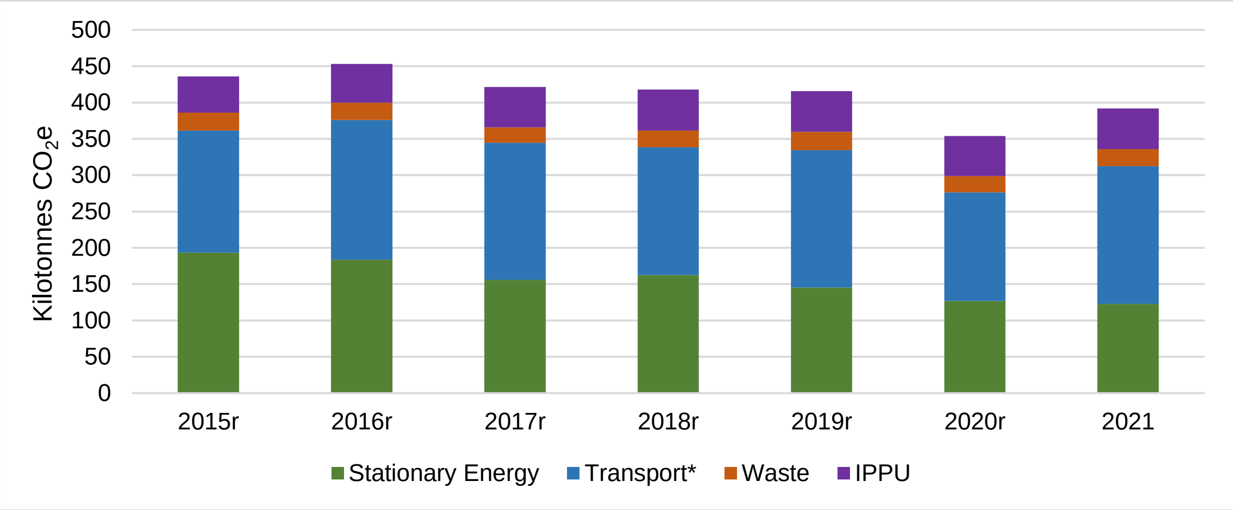
Scope 2 indirect emissions from electricity consumption are the second largest source of emissions in Gibraltar (after scope 1 transport emissions, and excluding scope 3 transport emissions), due to the reliance on electricity for all energy needs and generation technology. Prior to 2019, diesel/gas oil (with high carbon intensity) was the only fuel used to generate electricity, meaning the emissions per kilowatt hour (kWh) of electricity were considerably higher than, for example, the UK. However, in 2019, North Mole Power Station began using natural gas to generate electricity; natural gas has a lower carbon intensity than diesel/gas oil, which has caused a reduction in emissions from electricity consumption.

Figure ii shows Gibraltar's emissions from 2015 to 2021. For the 2021 inventory, Gibraltar's total manageable emissions have decreased by 10% since 2015r[2], but increased by 11% since 2020r; this is a result of the following:

- ↓ Emissions from electricity generation have decreased by 3% since 2020, and by 37% since 2015. This due to the introduction of natural gas (rather than gas oil only) as a fuel for North Mole Power Station. The amount of electricity produced/consumed has remained fairly static.
- ↑ Emissions from road transport in Gibraltar have increased by 9% since 2020 due to more fuel being consumed by vehicles in Gibraltar. Note that 2020 transport emissions were anomalously low due to the travel effects of the COVID-19 pandemic. Since 2015, road transport emissions have decreased by 23%.
- ↑ Emissions from aviation increased by 55% since 2020 as a result of increased flights. Note that 2020 aviation emissions were anomalously low due to the travel effects of the COVID-19 pandemic. Since 2015, aviation emissions have decreased by 26%.
- ↑ Emissions from waste increased by 5% since 2020, but have decreased by 4% since 2015. This is due to fluctuations in total waste arisings sent to landfill.
- ↑ Emissions from IPPU increased by 1% since 2020, and by 12% since 2015. This follows trends in UK data that is used as a proxy for Gibraltar's emissions from product use.

[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 2015-2020 inventories have therefore been revised, referred to as '20XXr'. More details on the revisions are found in the main body of the report.

Figure ii: Gibraltar's manageable emissions for 2015r-2020r and 2021 (*Transport emissions excluding scope 3 shipping)



This report provides additional context to Gibraltar’s GHG inventory, as well as details on the methods used to estimate emissions from each source, a further breakdown of results, descriptions of timeseries trends and recalculations, and a summary of suggested future improvements.

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.

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Appendices

1 Introduction

Box 1-1: Net zero definition

Net zero means achieving a balance between GHG emissions and removals from the atmosphere. In the context of Gibraltar, this means reducing emissions to 100% below 1990 levels.

The need for urgent action to reduce harmful greenhouse gas (GHG) emissions has never been clearer. At the COP26 climate conference, held in Scotland in 2021, almost 200 countries agreed to the Glasgow Climate Pact which aims to limit global temperature increase to 1.5°C above pre-industrial levels. Beyond 1.5°C of warming, we risk dramatic and irreversible changes to the global climate. The Pact recognises that meeting the 1.5°C goal requires reducing global GHG emissions to net zero by the middle of the century. Gibraltar's target to reach net zero emissions (see **Box 1-1**) by 2045 is in line with this.

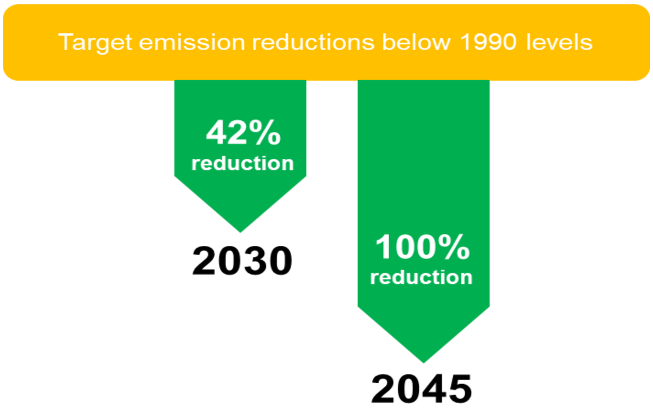
Effective and committed governance at the national level will be key to achieving global net zero emissions by the middle of the century; however, it is at the sub-national level where real gains in climate change mitigation will be made. The Intergovernmental Panel on Climate Change's (IPPC) Special 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, through undertaking a GHG inventory. Gibraltar has been reporting a GHG inventory, following the Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC) (section 1.2), since 2015.

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 last years' inventory, and also identifies a number of improvements where recalculations of the 2015-2020 inventories have 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 (section 1.1) and understand progress towards net zero.

1.1 Gibraltar's climate commitments

Figure 1-1 Climate Change Act targets



HM Government of Gibraltar (HMGoG) have been active in addressing the concerns of climate change and committing to reducing harmful GHG emissions. In 2019, Gibraltar Parliament unanimously declared a climate emergency. Following this, HMGoG published the Climate Change Act and, in 2021, published the Climate Change Strategy[3]. The Climate Change Act adopts ambitious climate targets to reach net zero emissions by 2045, with a 2030 interim target of reducing emissions by 42% compared with 1990 emissions (**Figure 1-1**). 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.

[3] https://www.gibraltar.gov.gi/uploads/environment/20211124-Climate_Change_Strategy_Final.pdf

Gibraltar has also been a signatory to the Global Covenant of Mayors for Climate and Energy (GCoM) since 2015. 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 12,500 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 1-2.**

Figure 1-2: GCoM commitment requirements

Source: Adapted from Compact of Mayors material

1.2 The Global Protocol for Community-Scale GHG Emission Inventories (GPC)

For more detailed technical information on the GPC, please see the GPC Guidebook or Chapter 2 of the 2015-2019 inventory reports[4].

1.2.1 Overview

The GPC was launched in 2014 to offer a globally accepted robust and clear framework that builds on existing methodologies for calculating and reporting city-scale GHG emissions, allowing for consistent and comparable reporting between cities. 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. Gibraltar's community-scale GHG inventory has been compiled following the GPC guidelines.

1.2.2 Difference from national emissions reporting

The GPC differs from national reporting methodologies (as required for reporting to the United Nations Framework Convention on Climate Change (UNFCCC)) in several fundamental ways, which reflect the unique circumstances of cities. 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

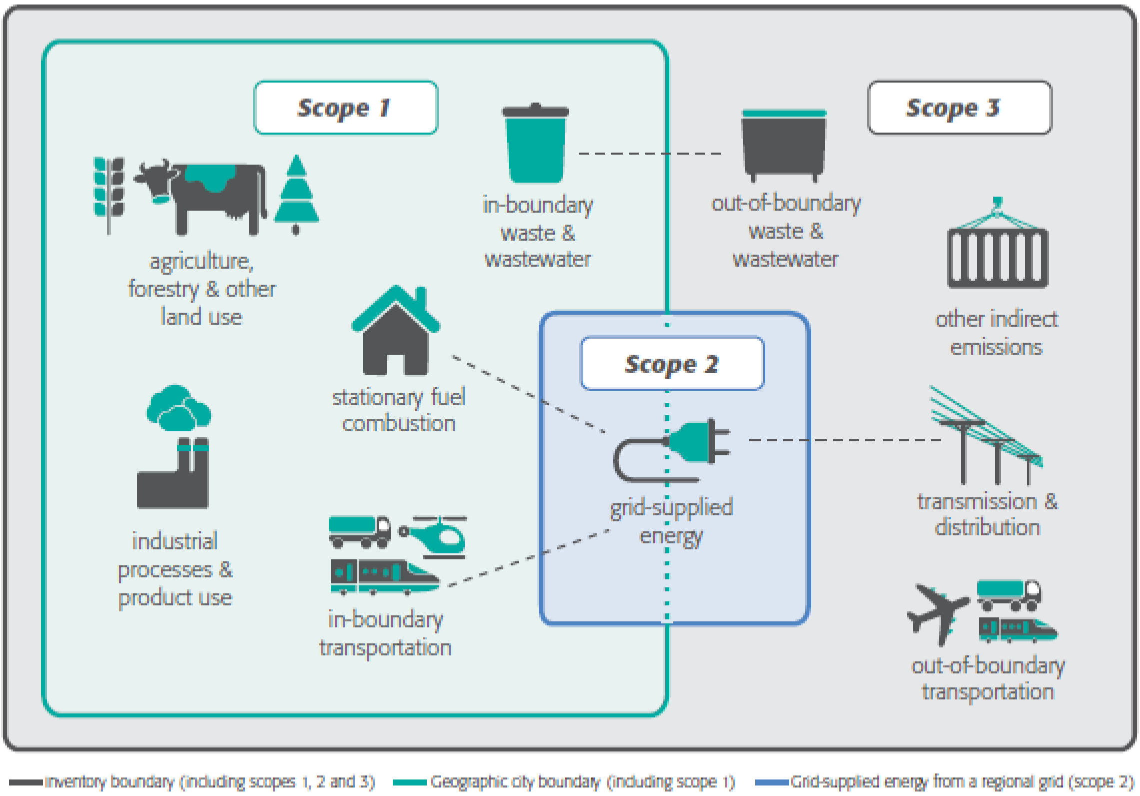
[4] Previous inventory reports are available here: https://www.gibraltarairquality.gi/climate-change/our-emissions

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. This is the approach followed in this inventory report.

1.2.3 Reporting levels and scopes

'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. Scope 3 sources are those occurring, usually outside of the city boundary, as a consequence of activities by and within the city boundary.

Figure 1-3: Sources and scopes of a city GHG inventory



Source: GPC

The GPC offers cities two levels of reporting demonstrating different levels of completeness, known as BASIC and BASIC+. 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.

Most cities report a BASIC inventory. Gibraltar's manageable emissions profile goes beyond a BASIC inventory, including additional emission sources such as transboundary road transport. Emissions associated with bunkering activity, international shipping and non-Gibraltarian use of road fuels are not included (see **Table 1-1**).

[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.

Table 1-1: Inventory scopes and reporting levels

Emission sources in grey font do not occur in Gibraltar

Scope	Definition	BASIC	BASIC+	Manageable emissions
Scope 1 (direct emissions)	**GHG emissions from sources located within the city boundary.**	Emissions from in-boundary fuel combustion Emissions from in-boundary production of energy used in auxiliary operations In-boundary fugitive emissions Emissions from in-boundary transport Emissions from waste and wastewater generated and treated within the city	Additionally: In-boundary emissions from industrial processes In-boundary emissions from product use *In-boundary emissions from livestock* *In-boundary emissions from land* *In-boundary emissions from other agriculture*	Same as BASIC+
Scope 2 (indirect emissions)	**GHG emissions occurring as a consequence of the use of grid-supplied electricity, heat, steam and/or cooling within the city boundary.**	Emissions from consumption of grid-supplied energy	Same as BASIC	Same as BASIC/+
Scope 3 (other direct emissions)	**All other GHG emissions that occur outside the city boundary as a result of activities taking place within the city boundary.**	Emissions from waste and wastewater generated within but treated outside of the city	Additionally: Transmission and distribution losses from grid-supplied energy Emissions from transboundary journeys	Same as BASIC+, minus scope 3 waterborne navigation
Outside of scopes	Sources deemed outside of scopes include: • Electricity generation* • International bunkers • Vehicle fuel exports	Not included	Not included	Not included

* Reported for information only. Electricity emissions are allocated to the end-user.

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 exported road transport fuels and emissions associated with international shipping and bunkering activities. Although methodologically more challenging to estimate, 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.

1.2.4 Data quality and notation keys

Not all inventory 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 (**Table 1-2**).

Table 1-2: 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 1-3**).

Table 1-3: Data quality assessment

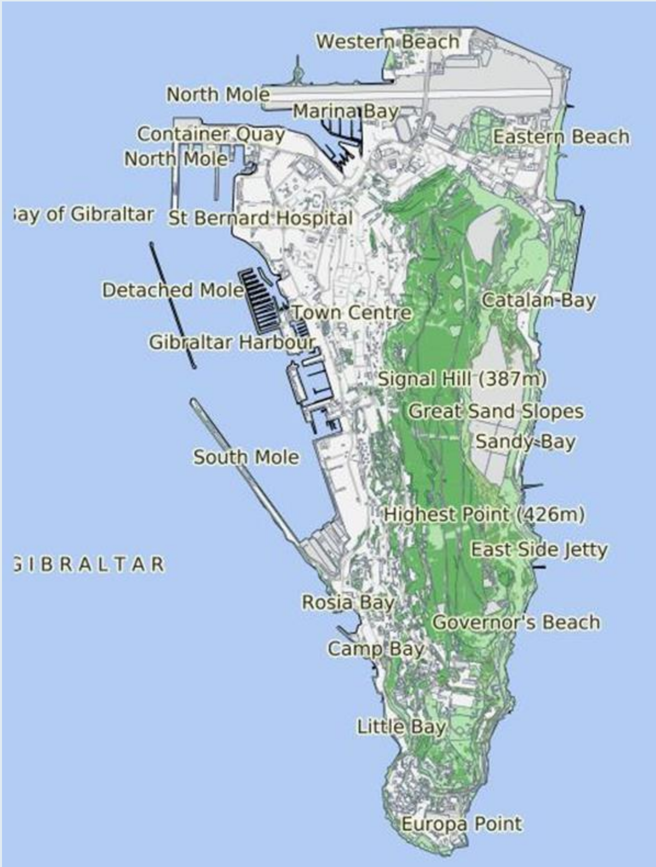
Data Quality	Activity data	Emission factor
High (H)	Detailed activity data	Specific emission factors
Medium (M)	Modelled activity data using robust assumptions	More general emission factors
Low (L)	Highly-modelled or uncertain activity data	Default emission factors

Source: Table 5.3 of the GPC

2 Assessment boundaries

Table 2-1 sets out the reporting boundaries and requirements of the inventory. For more detailed information on assessment boundaries, see Section 3 of the 2015-2019 inventory reports[7].

Table 2-1: Summary of Gibraltar's GHG inventory assessment boundaries

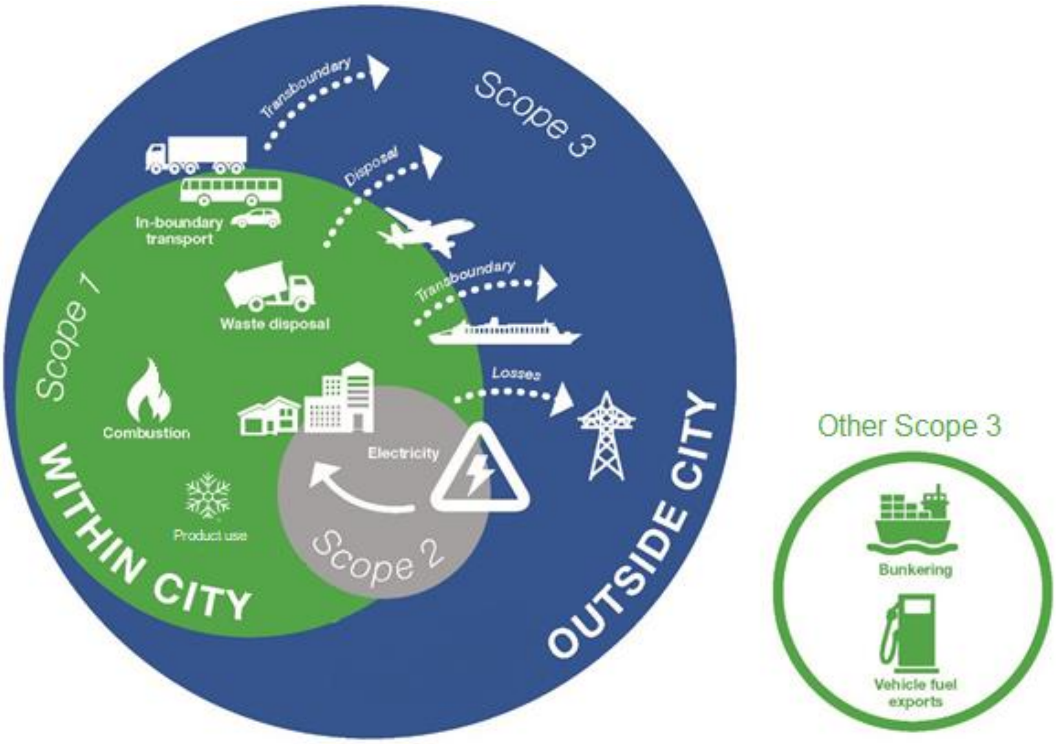
<table>
<tr><th>Boundary type</th><th>Details</th></tr>
<tr><td>Geographic</td><td>Territorial boundary of Gibraltar


Source: https://www.geoportal.gov.gi/index.php/maps/map-viewer-embedded</td></tr>
<tr><td>Temporal</td><td>The inventory presented here covers the calendar year 2021</td></tr>
<tr><td>Greenhouse gases reported</td><td>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).

Global Warming Potentials (GWPs) for these gases are taken from the IPCC 2006 Guidelines.</td></tr>
<tr><td>Reporting level</td><td>Gibraltar reports a BASIC+ inventory. Some sources deemed beyond Gibraltar’s control are excluded from reported totals, resulting in a subset of emissions named manageable emissions. See Table 1-1 and Figure 2-1 more details on manageable emissions.</td></tr>
</table>

[7] Previous inventory reports are available here: https://www.gibraltarairquality.gi/climate-change/our-emissions

Figure 2-1: Gibraltar's emission sources by scope



3 Methodology

3.1 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 3-1**.

Box 3-1: 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).

3.1.1 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.

3.1.1.1 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 3-1.**

Figure 3-1: 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.

3.1.1.2 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 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), apart from North Mole Power Station which began using natural gas (as well as gas oil) in 2019. Emission factors for fuels are taken from the UK National Atmospheric Emissions Inventory (NAEI) (2021 data) and are shown in **Table 3-1**.

Table 3-1: Emission factors for power station fuels (from UK NAEI 2021)

Fuel	Pollutant	Unit	Emission factor
Gas oil	Carbon	kt/Mt fuel consumed	870
	Methane (CH_4)	kt/Mt fuel consumed	0.13
	Nitrous oxide (N_2O)	kt/Mt fuel consumed	0.03
Natural gas	Carbon	kt/TJ fuel consumed	0.02
	Methane (CH_4)	kt/TJ fuel consumed	0.000001
	Nitrous oxide (N_2O)	kt/TJ fuel consumed	0.0000001

3.1.1.3 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 and natural gas have been used (**Table 3-1)**. 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 3-2**). 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 3-2: Implied emission factors for Gibraltar's power generation for 2021 (natural gas and gas oil combined)

Pollutant	Unit	IEF	IEF (CO_2e)
Carbon	kt/GWh	0.1474	0.5405
CH_4	kt/GWh	0.0000	0.0003
N_2O	kt/GWh	0.0000	0.0006
Total	**kt/GWh**	**0.1474**	**0.5414**

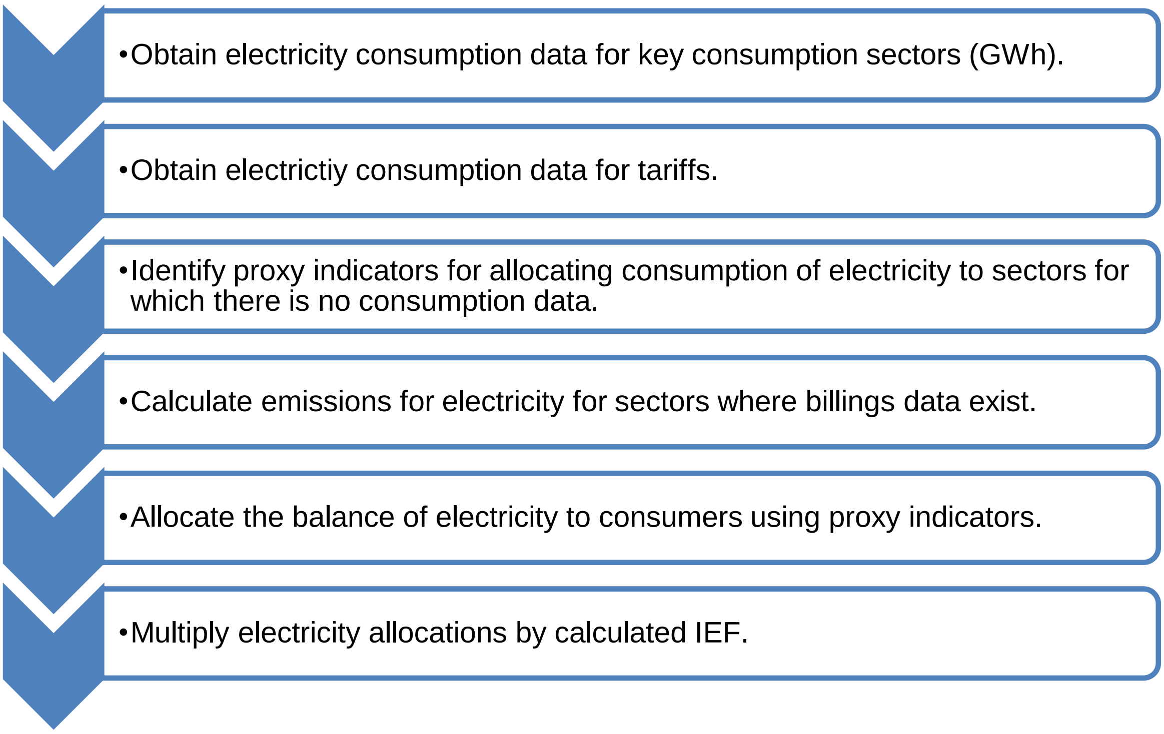
3.1.2 Allocating emissions based on electricity consumption

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.

3.1.2.1 Summary of methods

A summary of the process is illustrated in **Figure 3-2**.

Figure 3-2: Summary of the process of calculating emissions



3.1.2.2 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 3-3**).
- Electricity consumption data for key sectors, including hotels, the hospital (please note, 2018 data was used for the 2019-2021 inventories), the airport and for water provision.
- Proxy data on employment by sector from the 2021 Employment Survey Report[8] (see **Table 3-4)**. This shows proportion of employees by sector and allocation of industries to tariffs.

3.1.2.3 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 2018 Employment Survey Report, and this employment data was used as a multiplier to billings data within tariff categories as shown in **Table 3-3.**

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.

[8] https://www.gibraltar.gov.gi/uploads/statistics/2021/Reports%202021/Employment%20Survey%20Report%202021.pdf

Table 3-3: 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 3-4: Employment numbers by industrial/commercial sector, used as proxy data for electricity allocation.

Industry	2021 employment	% of total
Ship-building	286	1%
Other Manufacture	189	1%
Electricity and Water Supply	274	1%
Construction	3,578	12%
Wholesale and Retail Trade	3,627	12%
Hotels and Restaurants	1,788	6%
Transport and Communication	1,816	6%
Financial Intermediation	2,208	7%
Real Estate and Business Activities	3,737	13%
Public Administration and Defence	2,368	8%
Education	1,426	5%
Health and Social Work	3,439	12%
Other Services	4,780	16%
Total	**29,516**	**100%**

3.1.2.4 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.

3.1.3 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 2016-2021 inventories, we have assumed that the same fuel consumption occurred for 2016-2021 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 latest Defra Conversion Factors 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). Fuel consumption data was collected for the 2016-2020 inventories from a number of hotels and the hospital to reflect this activity and subtracted from the import statistics to avoid double counting. For this inventory (2021), updated hotel data was available, but updated hospital data was not (meaning 2018 data was carried forward for 2019-2021). For the 2017 inventory onwards, data has also been collected for the airport where fuel is consumed for back-up generation and for powering the aviation training simulator.

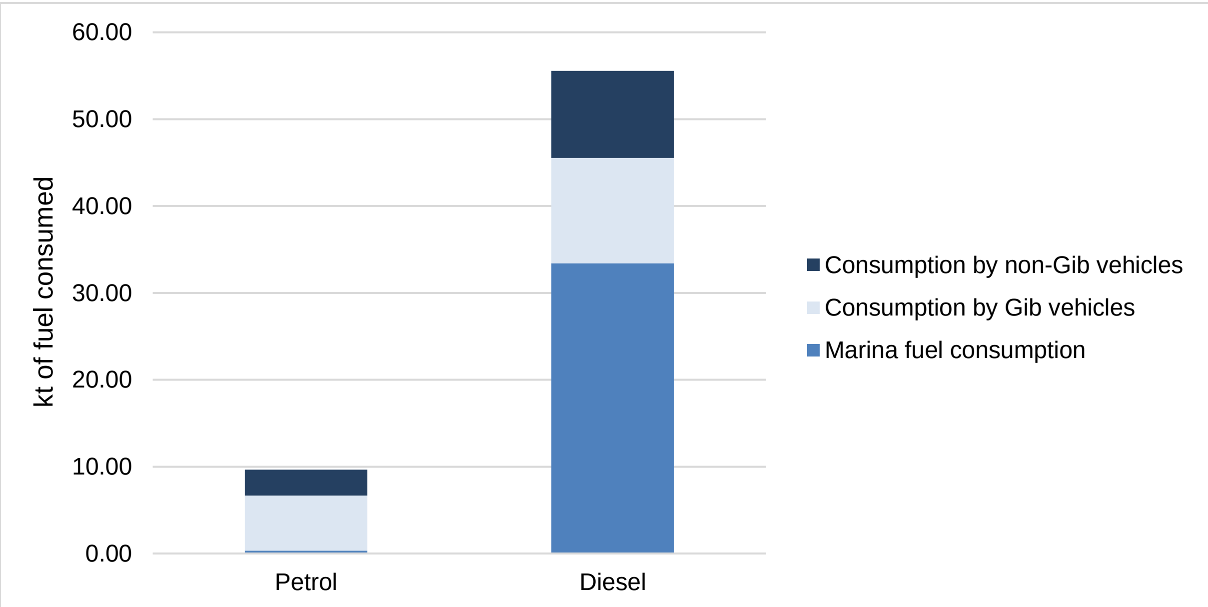
There is no stationary fuel combustion in households as all energy requirements are met through electricity, so this source is not occurring (NO).

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

3.2 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 transport fuels, and emissions associated with international shipping and bunkering activities) are also estimated but excluded from totals. **Figure 3-3** shows the end-use of imported fuels by sector (please note, this does not include bunker fuel sold).

Figure 3-3: End-use of imported fuel by sector, for petrol and automotive diesel assumed by the inventory in 2021



3.2.1 Road Transport

Road transport emissions have been calculated from Gibraltar's fuel import statistics for 2021. This effectively provides an 'energy balance' for total road transport fuel consumption. Imported fuel data is provided by Customs 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. An improvement since the 2020 inventory (and applied to the recalculated 2015-2019 inventories) is that we now know the volume of fuel sold at the marina. This gives a much-improved estimate of emissions associated with the use of local boats compared to previous estimates.

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.

We have not identified a suitable method for determining transboundary transport (Scope 3).

3.2.1.1 Summary of methods

Figure 3-4 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, 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 3-4: 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 or in the marina. 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.

3.2.1.2 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 data extracted by GoG in March 2023, and fleet compositions for inventory years were determined based off of the 'Date of registration' in Gibraltar.

Fuel import data for 2021 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 3.2.1.3**.

Surveys of fuel stations carried out by the Department of the Environment in 2014, 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 2014 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 3-2** below.

Box 3-2: 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 2021 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.

3.2.1.3 Determining activity

Fuel consumption allocated to road transport in 2021 is shown in Table 3-5.

For the 2021 inventory, a new set of fuel data was provided by HM Customs which were based on duty paid or refunded. This new dataset was anticipated to be a more accurate representation of the actual fuel consumption by road vehicles and marine vessels, compared to the previous method that was based on fuel commodity transactions.

Nonetheless, there were significant features in the new dataset when compared to the previous one that were not fully understood in time for this inventory update. Further investigation is required before we can have confidence in how to best utilise these data to generate an accurate, time-series consistent estimate of the fuel balance for Gibraltar.

Also, COVID-19 pandemic and related policies and restrictions had very different impacts on the activities of in-boundary and transboundary vehicles, the method used in previous years to extrapolate fuel consumed beyond 2019 by Gibraltarian and non-Gibraltarian vehicles was not able to reflect the unusual situation during the pandemic.

Consequently, for 2020 and 2021, fuel data was extrapolated from the 2015-2019 data. Given the significant impact of the pandemic on transport activities during 2020 and 2021, proxy datasets from the UK were used to account for the expected trends. The following proxy datasets were used:

- Fuel consumption by UK diesel/petrol car on urban roads was used as a proxy for Gibraltarian diesel/petrol private vehicle;
- Fuel consumption by UK diesel/petrol car on motorway was used as a proxy for non-Gibraltarian diesel/petrol private vehicle;
- Fuel consumption by UK diesel LGVs and HGVs (combined) on urban roads was used as a proxy for Gibraltarian diesel commercial vehicle;
- Fuel consumption by UK diesel LGVs and HGVs (combined) on motorways was used as a proxy for non-Gibraltarian diesel commercial vehicle;
- Fuel consumption by UK petrol LGVs on urban roads was used as a proxy for Gibraltarian petrol commercial vehicle;
- Fuel consumption by UK petrol LGVs on motorways was used as a proxy for non-Gibraltarian petrol commercial vehicle;
- Fuel consumption by UK petrol motorcycle on urban roads was used as a proxy for Gibraltarian petrol motorcycle;
- Fuel consumption by UK petrol motorcycle on motorways was used as a proxy for non-Gibraltarian petrol motorcycle;

Table 3-5: Gibraltar total road transport fuel use for 2021

Fuel	Thousands of litres
Motor spirits	12,638
Automotive Gas Oil	26,418

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.

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 3-6**) 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 3-6: Average fleet composition as indicated by the 2014 and 2017 forecourt surveys

Fuel	Gibraltarian/non-Gibraltarian	Vehicle type	Average fleet composition by fuel type (%)
Diesel	Gibraltarian	Private vehicle	29%
		Commercial vehicle	18%
		Motorcycle[9]	0%
	Non-Gibraltarian	Private vehicle	48%

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

Fuel	Gibraltarian/non-Gibraltarian	Vehicle type	Average fleet composition by fuel type (%)
		Commercial vehicle	3%
		Motorcycle[9]	2%
Petrol	Gibraltarian	Private vehicle	48%
		Commercial vehicle	8%
		Motorcycle	10%
	Non-Gibraltarian	Private vehicle	18%
		Commercial vehicle	1%
		Motorcycle	16%

Data was provided by Gibraltar's two principal bus companies which allowed for the estimation of fuel consumption directly from this vehicle type. For one of these companies, 2016 and 2017 data was not available – a linear interpolation using 2015 and 2018 data has therefore 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 are also included.

3.2.1.4 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, licensing statistics for 2021 were made available 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 3-8) 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 3-7: Fleet-weighted emission factors for 2021

Vehicle type	Weighted emission factor (g/km)		
	CO_2	CH_4	N_2O
Petrol cars	160	0.025	0.012
Diesel cars	217	0.001	0.016
Petrol LGVs*	240	0.021	0.013
Diesel LGVs	217	0.001	0.018
HGV **	108	0.050	0.023
Bus	703	0.031	0.031
Motorcycles	90	0.082	0.002

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

Table 3-8: Calculated fleet-weighted fuel consumption and vkm for 2021

Gibraltarian / non-Gibraltarian	Vehicle type	Fuel type	Fuel consumption (g/km)	Total calculated fuel consumption (kt)	Implied mvkm* travelled
Gibraltarian	Private vehicle	Petrol	50.93	4.43	87.00
Gibraltarian	Commercial vehicle	Petrol	75.56	0.79	10.47
Gibraltarian	Motorcycle	Petrol	28.49	1.12	39.25
Gibraltarian	Private vehicle	Diesel	68.73	6.63	96.50
Gibraltarian	Commercial vehicle	Diesel	66.42	5.21	78.42
Gibraltarian	Bus	Diesel	222.76	0.27	1.21
Non-Gibraltarian	Private vehicle	Petrol	50.93	1.66	32.60
Non-Gibraltarian	Commercial vehicle	Petrol	75.56	0.07	0.92
Non-Gibraltarian	Motorcycle	Petrol	28.49	1.25	44.03
Non-Gibraltarian	Private vehicle	Diesel	68.73	9.08	132.08
Non-Gibraltarian	Commercial vehicle	Diesel	66.42	0.95	14.28

*million vehicle kilometres

3.2.2 Marine – private boats

Emissions from private boats are calculated by fuel sales data for the marina, provided by GibOil, multiplied by an emission factor. The 2020 inventory cycle was the first for which fuel sales data for the marina specifically have been available. Previously, an assumption on the proportion of imported fuel was used for waterborne navigation was applied to fuel import statistics – this was estimated at 15% and 5% of total demand for gas oil and petrol respectively, based on historic fuel import statistics from 2008 to 2012. This assumption is no longer used, as activity data for the marina has been available in the form of marina fuel sales data since last years' inventory cycle. Previous inventories (2015r-2019r) were revised using this new data/methodology. Emissions have been estimated using the emission factors for marine gas oil and petrol as used within the UK NAEI.

The raw dataset was provided by GibOil, and provides information on fuel sales at the marina specifically (**Figure 3-3**).

A key improvement is to disaggregate marina fuel sales data, to allow for separate reporting of emissions attributed to Gibraltarian and non-Gibraltarian resident activity.

3.2.3 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 activities, and non-bunkering activities (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

For the 2020 and 2021 inventories, shipping data normally used were not available in time for this inventory update, so these data were extrapolated from 2015-2019 data. Globally, transport activities were significantly impacted in 2020 and 2021 due to the pandemic. To account for this, a series of proxy data sets were used to take account for this trend. The following proxy datasets with a strong correlation, and a justification for a causal link, were used:

- UK ferry fuel use, which correlates with Gibraltar passenger vessels;
- UK chemical tanker vessel fuel use, which correlates with Gibraltar liquid bulk vessels;
- UK general cargo vessel fuel use, which correlates with Gibraltar dry bulk vessels;
- UK Ro-Ro vessel fuel use, which correlates with Gibraltar other cargo vessels; and,
- UK tug fuel use, which correlates with Gibraltar support vessels.

The final weighted proxy had an overall correlation of 56% with historic estimates for Gibraltar vessels.

We also explored the potential to use global datasets, which we thought should have fairly good correlation with Gibraltar trends, but found that all of the global proxy datasets considered had a negative correlation with Gibraltar trends. As we did not find a strong positive correlation with these international datasets, we could not justify using them as proxies, and instead used the UK proxy datasets detailed above.

3.2.3.1 Summary of methods

Figure 3-5 gives a brief overview of how estimates of emissions due to shipping have been made. A more detailed explanation is given below.

Figure 3-5 – Process of estimating emissions from shipping (2015-2019)

- 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.

3.2.3.2 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[10] Section 1.A.3.d Navigation. (See **Table 3-9**) 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 3-10** illustrates the allocation on the basis of the registered purpose of call within the dataset.

Table 3-9 – Ship classification based on the EMEP/EEA Guidebook 2016[10]

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

Table 3-10 – Definition of in-scope and out-of-scope shipping activity on the basis of stated purpose of call

Purpose of call	
In-scope (included in BASIC+ inventory)	**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

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

Purpose of call	
In-scope (included in BASIC+ inventory)	**Out-of-scope**
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
	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

3.2.3.3 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 3-1.

Factors from the shipping chapter of the EMEP/EEA air pollutant emission inventory guidebook 2016[11] are used to calculate emissions, specifically:

- Fuel use per unit energy given in Table 3-4 of the guidebook,
- The engine type weightings provided in Table 3-7 of the guidebook,
- The main engine power in table 3-6 of the guidebook, and

[11] https://www.eea.europa.eu/publications/emep-eea-guidebook-2016

- The average speeds in table 3-14 of the guidebook.

Equation 3-1: Calculation for shipping emissions

$$\text{Fuel use (t)} = \frac{\text{Distance travelled(km)} * \text{Power}^{12}\ \text{(kW)} * \text{Fuel use factor(t/kWh)}}{\text{Average speed (km/hour)}}$$

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.

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

[12] Main engine power

3.2.3.4 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 3-11.**

Table 3-11: 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 3-10**) are reported in ‘Other Scope 3’ and are therefore not included in BASIC or BASIC+ inventory totals. Emissions from ‘in scope’ shipping are included in BASIC+ inventory totals, but are **not included in Gibraltar’s manageable emission profile.**

3.2.4 Aviation

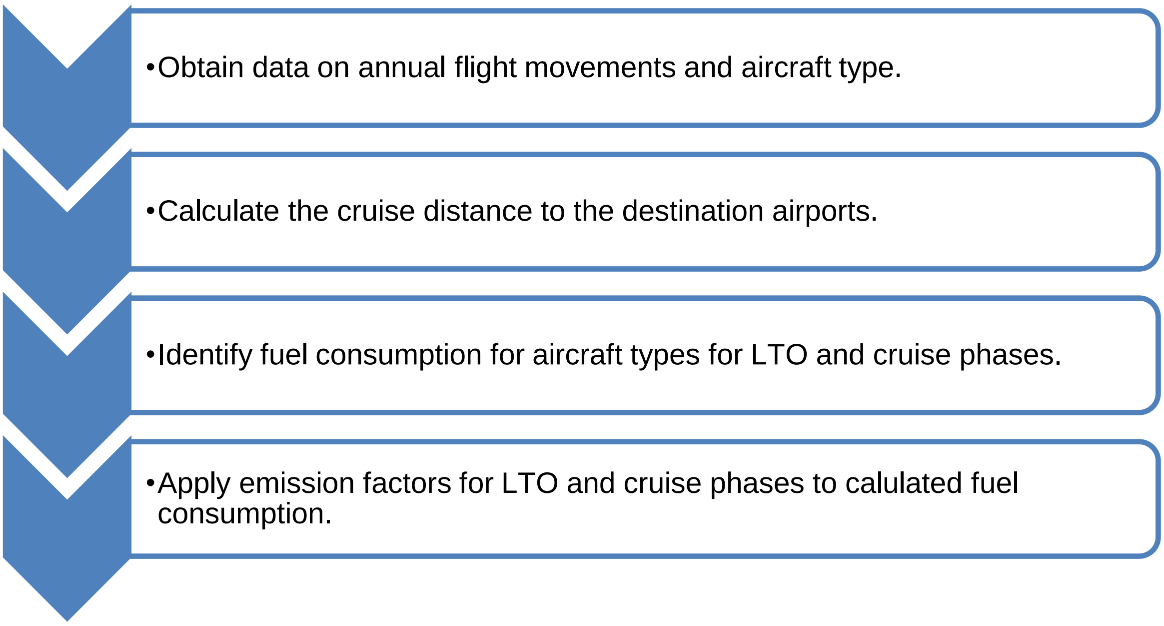
Gibraltar is served by its own airport located within its boundary. There is also a nearby airport at Malaga, which is sometimes used when flights are diverted or as an alternative to flying directly into Gibraltar. However, no information is available for Malaga airport so Gibraltar Airport only is 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.

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

3.2.4.1 Summary of methods

Figure 3-6 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 3-6: Aviation methodology flow diagram



3.2.4.2 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.

3.2.4.3 Determining activity

The aircraft that operated between Gibraltar and the UK in 2021 were the Airbus A320, A320-neo, A321, 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 2021 were Bristol, Gatwick, Heathrow, Luton, Edinburgh 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 2019 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 2019 aviation annex[13] are shown in **Table 3-12**. In line with manufacturers data, the fuel consumption for an Airbus A320-neo is assumed to be 15% lower than the Airbus A320.

Table 3-12: Illustrative dataset from the EMEP/EEA air pollutant emission inventory guidebook 2019

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	890.4	1587.5	2833.3	3874.1	4863.0	7134.1	9481.2
	LTO	688.8	688.8	688.8	688.8	688.8	688.8	688.8
	Total	1579.2	1579.2	1579.2	1579.2	1579.2	1579.2	1579.2
A320	Climb/cruise/descent	919.1	1634.8	2934.3	4112.7	5260.6	7755.7	10470.7
	LTO	816.2	816.2	816.2	816.2	816.2	816.2	816.2
	Total	1735.2	2451.0	3750.5	4928.9	6076.8	8571.8	11286.9
A321	Climb/cruise/descent	1125.7	2015.6	3626.9	5117.1	6570.2	9708.3	13061.1
	LTO	1034.6	1034.6	1034.6	1034.6	1034.6	1034.6	1034.6
	Total	2160.3	3050.2	4661.4	6151.7	7604.8	10742.8	14095.7
AT72	Climb/cruise/descent	385.1	634.7	1178.5	1754.7	2329.2		
	LTO	242.8	242.8	242.8	242.8	242.8		
	Total	627.9	877.5	1421.2	1997.5	2572.0		

The 2019 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

[13] https://www.eea.europa.eu/publications/emep-eea-guidebook-2019/part-b-sectoral-guidance-chapters/1-energy/1-a-combustion/1-a-3-a-aviation-1-annex5-LTO/view

times of 605 s and 204 s, respectively. These times, along with the aircraft fleet mix, have been used to calculate LTO emissions for 2021.

3.2.4.4 Determining emissions

The calculation for emissions is shown in **Equation 3-2**.

Equation 3-2: 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 3-12**. These were then summed to give the values in **Table 3-13**.

The emission factors in **Table 3-14** 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 3-13: Total annual fuel consumption by aircraft

Phase of flight	Unit	Domestic (UK)	International (non-UK)
LTOs	Number	1170	1
Total fuel consumption	Kt	7.01	<0.01
Of which cruise	Kt	6.24	<0.01
Total fuel consumption	TJ	307.69	<0.01
Of which cruise	TJ	274.15	<0.01

Table 3-14: Emission factors for aircraft phases by pollutant

Phase of flight	Pollutant	Unit	Emission factor
Cruise	Carbon	kt/TJ fuel	0.0195
Cruise	CH_4	kt/TJ fuel	Zero
Cruise	N_2O	kt/TJ fuel	0.000002
LTO	Carbon	kt/TJ fuel	0.0195
LTO	CH_4	kt/LTO	0.00000016
LTO	N_2O	kt/TJ fuel	0.000002

3.3 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 2021:

- 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.

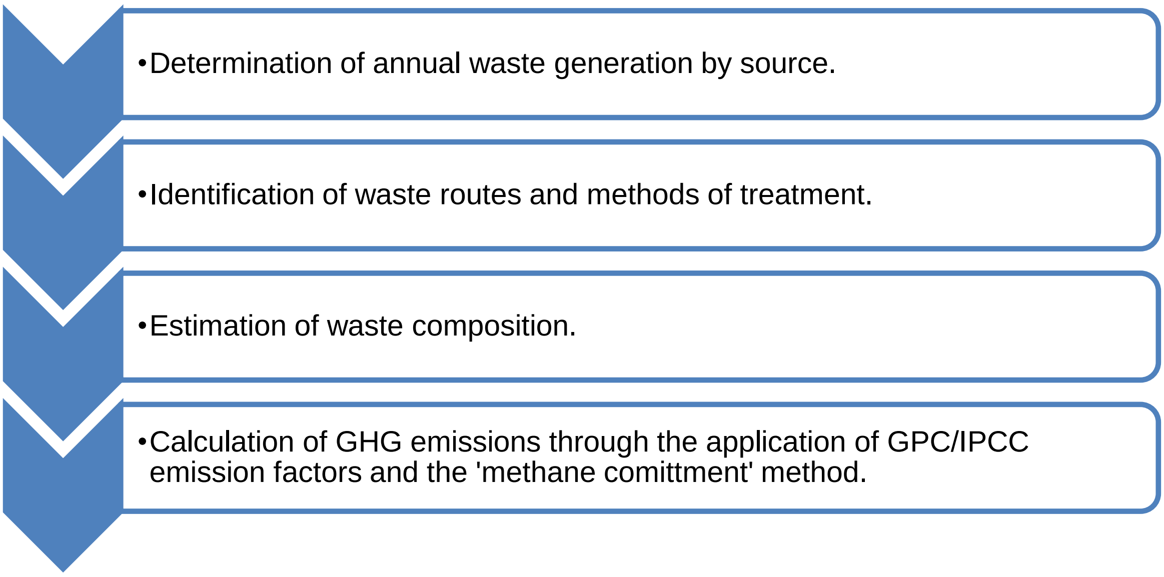
Emissions from incineration in Gibraltar are scope 1.

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

3.3.1 Summary of methods

Figure 3-7 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 3-7: Waste methodology flow diagram



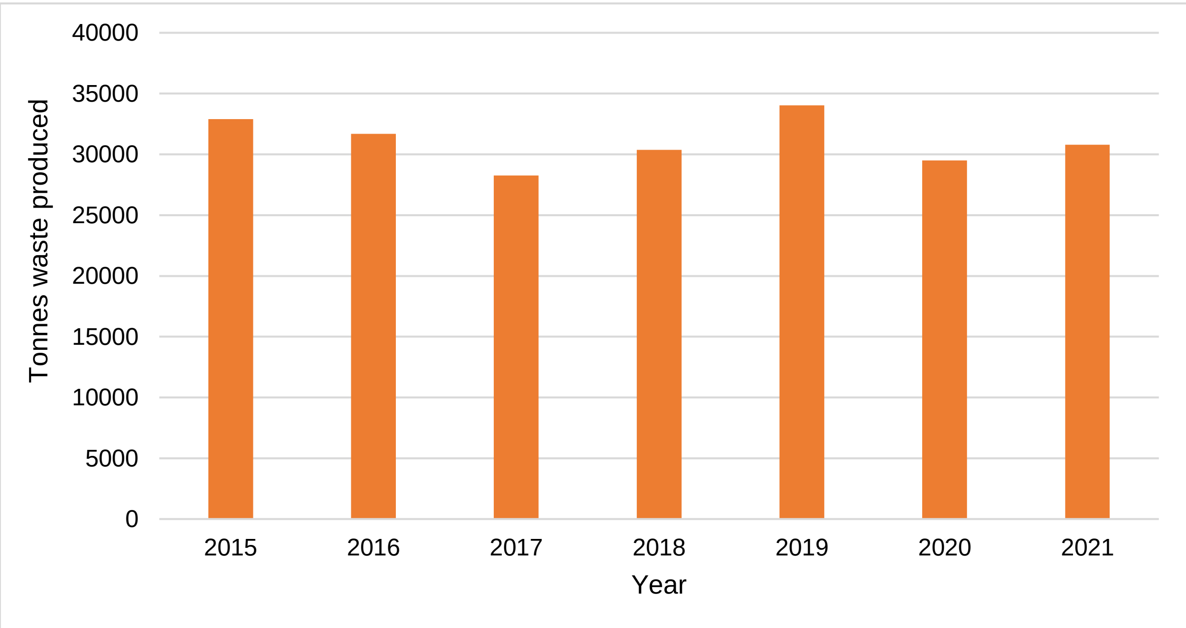
3.3.2 Raw data

3.3.2.1 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 **Figure 3-8.**

Figure 3-8: MSW arisings in Gibraltar from 2015 to 2021



3.3.2.2 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 2021 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.

3.3.3 Determining activity

3.3.3.1 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 3-15.**

Table 3-15: 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	

3.3.4 Determining emissions

3.3.4.1 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. 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.

3.3.4.2 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 and emission factors for composting given in the GPC; these are detailed in **Table 3-16.** It is assumed that waste is treated whilst wet, as we have no information on whether waste is dried before being treated.

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

Table 3-16: 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

3.3.4.3 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. The emission factors are provided in **Table 3-17**.

Table 3-17: Clinical waste incineration emission factors

GHG	Emission factor	Unit
Carbon	240	kt/mt waste incinerated
CH_4	0.02	kt/mt waste incinerated
N_2O	0.03	kt/mt waste incinerated

3.3.5 Wastewater

Wastewater in Gibraltar is pumped out to sea with no treatment. HM Government of Gibraltar had previously 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. Unfortunately, this had to be cancelled due to one of the partners in the joint venture going into liquidation. Given the change in circumstances and subsequent impacts on the procurement process, the view was taken that a new procurement process was required. As such, an Expression of Interest was published in September 2022 and closed on the 28th November 2022. Government is currently assessing the technical submissions and will seek to make a decision shortly.

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

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

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

The equations for calculating emissions from wastewater are given in the GPC.

3.4 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.

3.4.1 Summary of methods

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.

3.4.2 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[14], 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.

3.4.3 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. For the 2019-2021 inventories, 2018 hospital data has been used due to data availability.

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. Estimates of air conditioning use are based on assumptions on the proportion of homes with air conditioning installed in Malaga.

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

3.4.4 Estimating emissions

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

Estimates of air conditioning use are based on assumptions on the proportion of homes with air conditioning installed in Malaga.

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[15]. The split of HFCs is calculated using UK NAEI assumption that 96% of MDIs are formulated with HFC-134a and 4% are formulated with HFC-227ea.

3.5 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'.

[15] 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

3.6 Accuracy

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

3.7 Assumptions

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 3-18** 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 3-18 - Summary of assumptions and impact on inventory totals

Emission or data source	Assumption	Possible impact	Improvement
Population data	2016 population figure is used as more recent values not available	It is unlikely that using 2016 population data will have had a large impact on emission sources but it will be important to update to the correct year when available	Use up-to-date population data. An updated Census was undertaken in 2022 so new data should be available for future inventories.
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, 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	It is likely that the allocation of emissions has low accuracy. The	A short-term improvement would be to conduct fuel

Emission or data source	Assumption	Possible impact	Improvement
	data based on the vehicle fleet. Information on vehicle movements was is now available, but a longer timeseries is required before this data is used. It was therefore assumed that all fuel sold to Gibraltarian vehicles was used in-boundary and all non-Gibraltarian out of boundary.	implied vehicle kilometres (vkm) are for Gibraltarian vehicles and are higher than would be expected for a region of this size. Therefore, it is likely this is an over estimate of in-boundary emissions. It is probable that some proportion of the Gibraltarian fuel sales should be allocated to transboundary emissions, but it is not possible to distinguish. The lack of vehicle activity data also makes it difficult to account for off-road vehicles and public transport. Furthermore, the survey used to allocate fuel to Gibraltarian and non-Gibraltarian vehicles was conducted during daytime hours; it is likely that this causes an underestimate of non-Gibraltarian fuel sales as, anecdotally, Spanish vehicles refuel during the evening and night when queues at the Frontier are at their shortest. We also do not estimate the amount of fuel bought by Gibraltarians while outside of Gibraltar, which will lead to a small underestimate.	forecourt surveys again, but spanning a 24 hour period, not just daytime hours. 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 on annual distance travelled by vehicle types is improving, as this data is now collected via the MOT process. As the timeseries of data grows, this data will be explored for inclusion in the inventory calculations. 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	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	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

Emission or data source	Assumption	Possible impact	Improvement
	evidently linked to very small planes, for which we had limited emissions and fuel consumption estimates	omission of the 'unscheduled' flights will lead to a small under estimate	indication of the fuel use on outgoing journeys. This would also remove the possible under estimate due to the omission of unscheduled flights
Shipping activity data	Activity data for ships were estimated through calculations of distance travelled to and from other ports. This provided an indicator of fuel consumption per journey. Note updated data was not available for 2020 or 2021.	It is possible that the ship classes and average fuel consumptions taken form the EMEP/EEA air pollutant emission inventory guidebook 2016 do not accurately match the ships visiting Gibraltar. However, it is likely that any impact here is small	The estimations in this sector are now based on a large amount of reliable and accurate data. Accuracy could be further improved through use of ship specific fuel consumption and emission rates, technologies etc. to replace use of EMEP/EEA defaults. Up to date data is required for this sector.
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.
Wastewater 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	The new method of calculating waste emissions (presented in **Appendix 2**) uses updated assumptions from the waste facility in Spain on the amount of waste

Emission or data source	Assumption	Possible impact	Improvement
	is based on waste collection data, rather than final processing in Spain.	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	recycled/composted; these assumptions give a more accurate reflection of the amounts of Gibraltar's waste that ends up recycled/composted.

3.8 Quality assurance

The quality assurance (QA) and quality control (QC) processes undertaken as part of the inventory compilation process are detailed in **Appendix 6.**

4 Results

This section sets out the results of the Gibraltar city GHG inventory. **Table 4-1** gives an overview of 2021 emissions by different reporting level. 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, transmission and distribution losses and IPPU. Manageable emissions include all BASIC+ emissions, but exclude transboundary (scope 3) emissions from shipping. Total emissions include sources 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 activities).

Table 4-1 – Emissions by sector and reporting level

Reporting level	BASIC	BASIC+	Manageable emissions	Total emissions (BASIC+ and other scope 3)
Sector	**Emissions (tCO_2e)**			
Stationary Energy	106,777	122,676	122,676	122,676
Transportation	167,813	421,299	189,978	421,299
Waste	23,405	23,405	23,405	23,405
IPPU		55,830	55,830	55,830
Other Scope 3				2,225,633
TOTAL	***297,995***	***623,210***	***391,888***	***2,848,843***

4.1 2021 manageable emissions

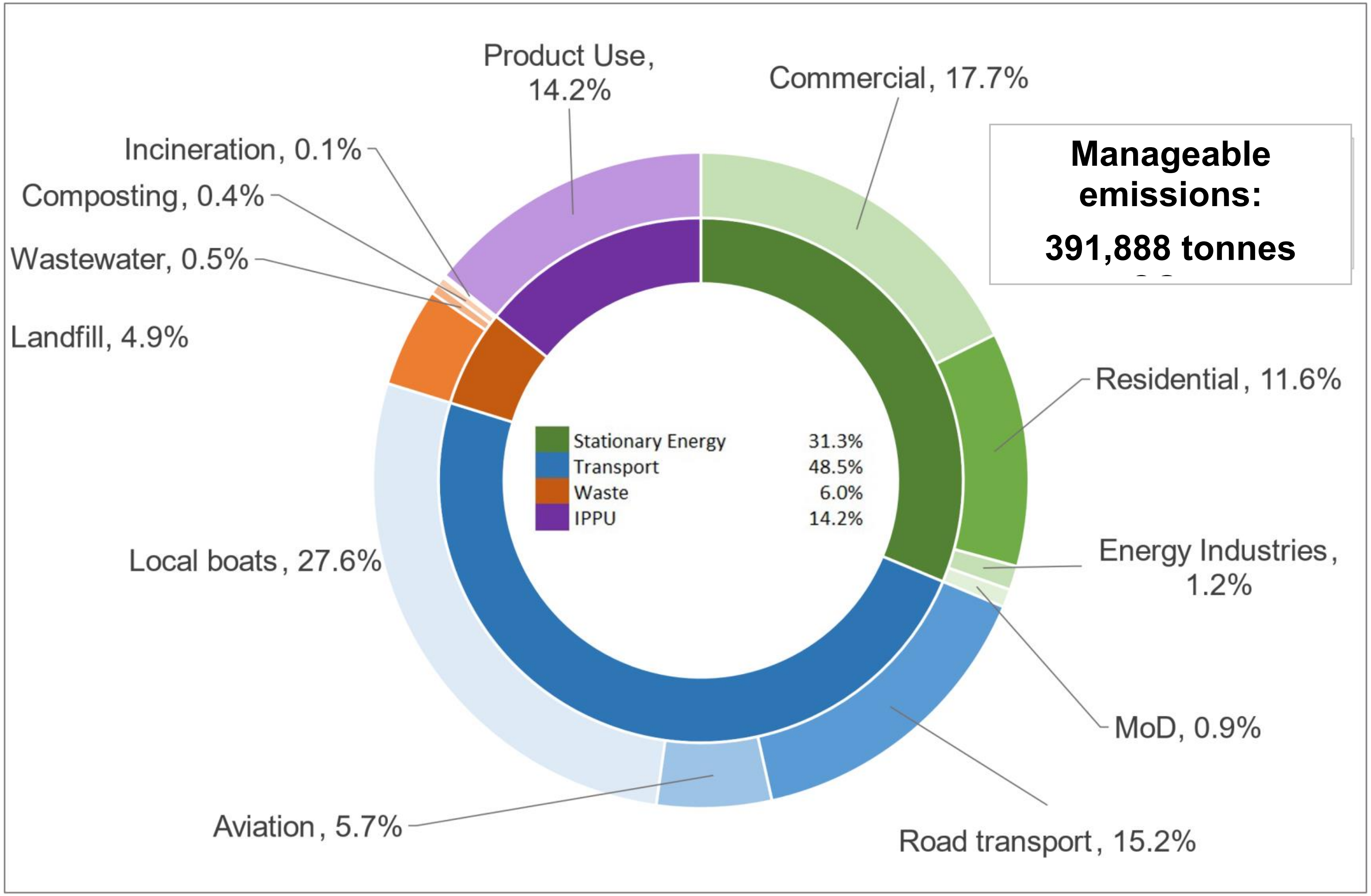
The recommended reporting approach for city-level emissions under the GPC is BASIC+, therefore excluding emissions from bunkering activity. Transboundary transport emissions are included under BASIC+ reporting however, and this includes a large proportion of waterborne navigation emissions. This presents 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 emissions presented in **Figure 4-1**. Private marine emissions are retained. This subset, therefore, may be considered **Gibraltar's manageable emissions**.

Gibraltar's manageable emissions profile is more aligned to that expected for a city (than when scope 3 waterborne navigation and other sources are included). Transport dominates, accounting for 48.5% of emissions (quite high for a small city) – 15.2% of this is attributable to road transport and 5.7% comes from aviation, while a significant proportion (27.6%) is attributable to local boats. Stationary energy contributes slightly less than transport, at 31.3%. Contributions from waste and IPPU sectors are smaller, contributing 6.0% and 14.2% respectively.

Gibraltar's per capita emissions are 8.2 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[16].

[16] https://www.c40.org/research/open_data/5

Figure 4-1 – Gibraltar's manageable emissions for 2021



4.2 2021 Total emissions for Gibraltar

Total emissions for Gibraltar, from all calculated sources are presented in **Table 4-2** and **Figure 4-2**.

Overall, the largest contributor of emissions to the Gibraltar city inventory is ‘Other scope 3’ accounting for 86.3% of total emissions. ‘Other scope 3’ is dominated by marine bunkering activities (76.6% of total emissions), with a small contribution from non-Gibraltarian road transport emissions (1.5% of total emissions). International shipping is responsible for 8.1% of total emissions in 2021.

Stationary energy is responsible for 4.3% of total emissions, waste 0.8%, and industrial processes and product use (IPPU), 2.0%. Transport emissions from in-scope sources comprise 6.7% of total emissions, a significant proportion of which are attributable to waterborne transport.

As **Table 4-2** illustrates, Scope 1 emissions are largely dominated by waterborne navigation and road transport, 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 and natural gas are 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.

Figure 4-2 – Gibraltar's total emissions (including ALL sources) by source category for 2021.

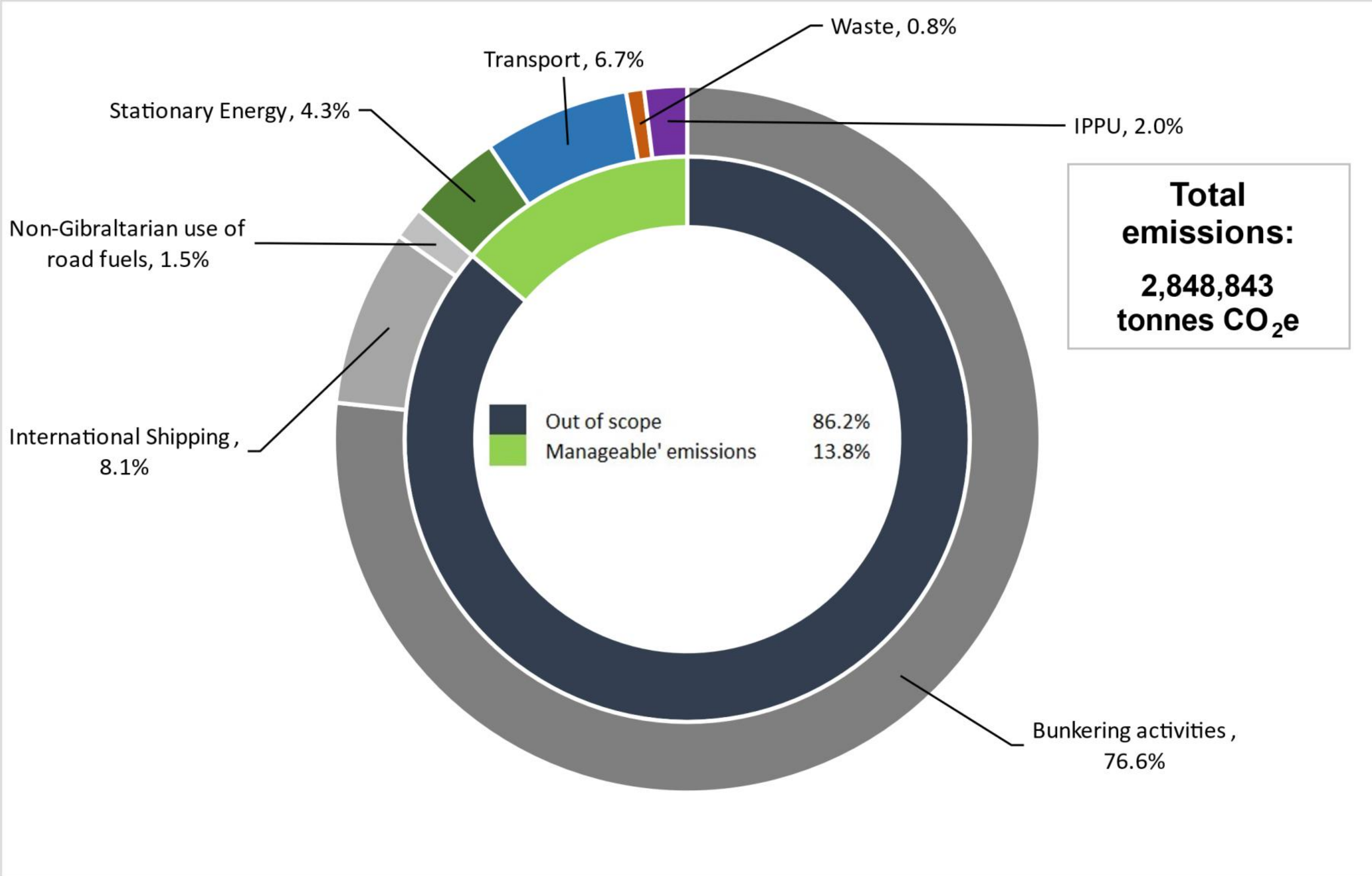


Table 4-2 – Total emissions for Gibraltar in 2021 by source.

Sector	Sub-sector	Total GHGs (metric tonnes CO_2e)			
		Scope 1	Scope 2	Scope 3	Total
Stationary Energy	Residential buildings	NO	39,111	6,182	45,293
	Commercial and institutional buildings and facilities	1,594	58,412	9,240	69,245
	Manufacturing industries and construction	NO	NO	NO	
	Energy industries	NO	4,638	IE	4,638
	Energy generation supplied to the grid	121,082			
	Agriculture, forestry and fishing activities	NO	NO	NO	
	Non-specified sources	NO	3,023	478	3,500
	Fugitive emissions from mining, processing, storage, and transportation of coal	NO			
	Fugitive emissions from oil and natural gas systems	NO			
	SUBTOTAL	**1,594**	**105,184**	**15,899**	**122,677**
Transport	On-road transportation	59,627	NO	IE	59,627
	Railways	NO	NO	NO	
	Waterborne navigation	108,186	NO	231,322	339,508
	Aviation	NO	NO	22,164	22,164
	Off-road transportation	IE	NO	IE	
	SUBTOTAL	**167,813**		**253,486**	**421,299**
Waste	Solid waste generated in the city	NO		19,263	19,263

Sector	Sub-sector	Total GHGs (metric tonnes CO_2e)			
		Scope 1	Scope 2	Scope 3	Total
	Biological waste generated in the city	NO		1,661	1,661
	Incinerated and burned waste generated in the city	381		155	536
	Wastewater generated in the city	NO		1,945	1,945
	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	**381**		**23,024**	**23,405**
Industrial Processes and Product Use	Emissions from industrial processes occurring in the city boundary	NO			
	Emissions from product use occurring within the city boundary	55,830			55,830
	SUBTOTAL	**55,830**			**55,830**
Other Scope 3	***SUBTOTAL***	0		2,225,633	2,225,633
TOTAL		**225,618**	**105,184**	**2,518,041**	**2,848,843**

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

Colour coding of Table 4.2

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

4.3 Timeseries trends

This section presents emission trends over Gibraltar's inventory time series (2015 to 2021). The 2021 inventory results are compared against the revised 2015-2020 (2015r-2020r), inventories. There are some differences between the original 2015-2020 inventories 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 2021 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 2021 inventory has not been compared to the 2013 inventory; the 2013 inventory was a 'pilot' using a draft 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 2015-2021 inventories due to a large number of method changes and an updated reporting approach using the now-finalised GPC.

With seven 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.

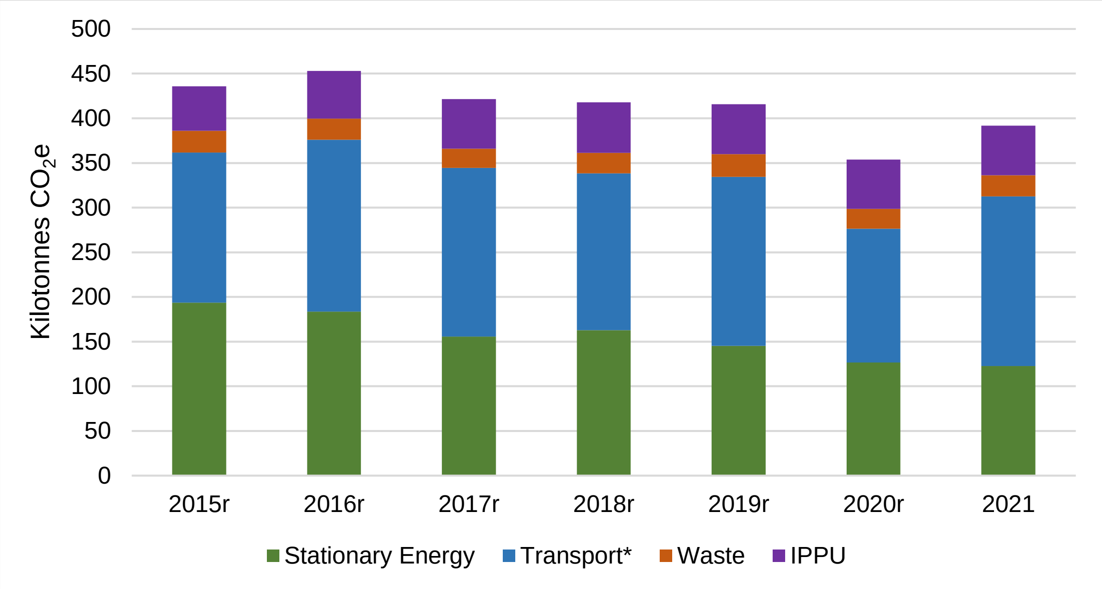
Emissions from the 2015r-2020r and 2021 inventories are presented, by sector, in **Table 4-3** and **Figure 4-3.**

More information on the specific reasons for changes between the 2015r and 2021 inventories is found in **Appendix 3.** Information on the revisions between the 2021 and 2020r inventories is given in **Appendix 4**.

Table 4-3 – Comparison between the 2015r-2020r and 2021 inventories by sector.

Reporting sector	Emissions (tCO_2e)						
	2015r	2016r	2017r	2018r	2019r	2020	2021
Stationary Energy	193,540	183,785	155,844	162,740	145,419	126,741	122,677
Transport (all)	356,955	464,294	450,390	381,571	438,540	376,065	421,299
Transport (excluding scope 3 shipping)	167,961	192,208	188,667	175,616	188,974	149,511	189,978
Waste	24,494	23,723	21,388	22,893	25,344	22,364	23,405
IPPU	49,963	53,323	55,640	56,609	56,079	55,219	55,830
Other Scope 3	3,095,506	3,243,896	3,342,666	3,067,166	2,415,489	2,177,375	2,225,633
Manageable emissions	**435,959**	**453,039**	**421,540**	**417,858**	**415,817**	**353,835**	**391,888**

Figure 4-3 - Gibraltar's manageable emissions for 2015 to 2021.



* Transport emissions excluding scope 3 shipping

4.3.1 Highlights

Gibraltar's manageable emissions have decreased by 10% since 2015r, but increased by 11% since 2020r; this is a result of the following:

- Emissions from electricity generation have decreased by 3% since 2020, and by 37% since 2015. This due to the introduction of natural gas (rather than gas oil only) as a fuel for North Mole Power Station. The amount of electricity produced/consumed has remained fairly static.
- Emissions from road transport in Gibraltar have increased by 9% since 2020 due to more fuel being consumed by vehicles in Gibraltar. Note that 2020 transport emissions were anomalously low due to the travel effects of the COVID-19 pandemic. Since 2015, road transport emissions have decreased by 23%.
- Emissions from aviation increased by 55% since 2020 as a result of increased flights. Note that 2020 aviation emissions were anomalously low due to the travel effects of the COVID-19 pandemic. Since 2015, aviation emissions have decreased by 26%.
- Emissions from waste increased by 5% since 2020, but have decreased by 4% since 2015. This is due to fluctuations in total waste arisings sent to landfill.
- Emissions from IPPU increased by 1% since 2020, and by 12% since 2015. This follows trends in UK data that is used as a proxy for Gibraltar's emissions from product use.

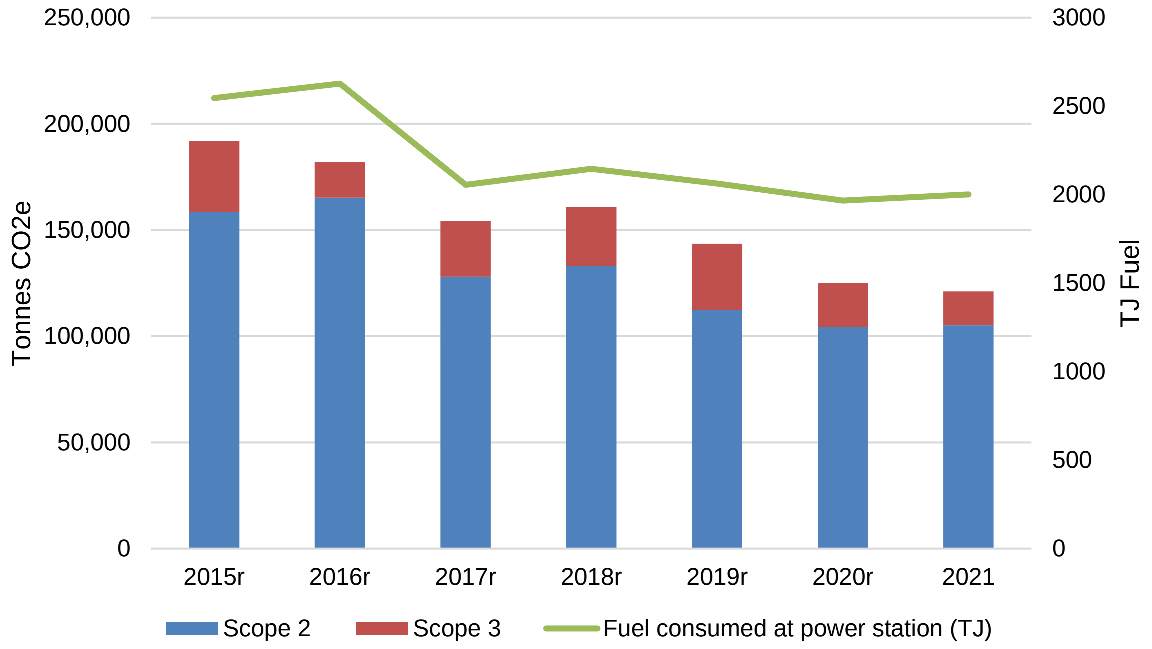
4.3.2 Stationary Energy

Electricity

Although not presented in the scope 1 totals (to avoid double counting), emissions from the generation of electricity have decreased by 3% since 2020r and by 37% since 2015r; this is due to the introduction of natural gas as a fuel at North Mole Power Station in 2019, replacing some of the gas oil (with a much higher carbon intensity than natural gas) used to generate electricity in previous years. It is important to note that some gas oil remains and that, even with the introduction of natural gas, power stations still run completely on fossil fuels.

Scope 2 emissions in Gibraltar are solely those from **electricity consumption** – between 2015r and 2021 total scope 2 emissions have shown a decrease of over 54 ktCO_2e (or -34%), and between 2020r and 2021 total scope 2 emissions show a decrease of 8 ktCO_2e (or -7%). This decrease in emissions is despite total electricity consumption being fairly stable, and is due to less fuel being used at the power stations to generate a unit of electricity and the introduction of natural gas as a fuel source for electricity generation (**Figure 4-4**).

Figure 4-4 - Gibraltar's emissions from electricity consumption/generation from 2015r-2021



The implied emission factor (IEF) for electricity is slightly lower in 2021 than in 2020r; this means that the emissions produced per unit of electricity generated at the power stations were lower in 2021 than 2020r. Between 2020r and 2021, the IEF decreases by 0.02kt CO_2e/GWh, which is largely due to the further replacement gas oil with natural gas (with a lower EF). Increased electricity generation efficiency may also contribute to the decreased IEF. This explains the decrease in emissions associated with electricity consumption over this period. **Table 4-4** below shows a comparison of the IEF between years.

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 4-4 – Implied emission factor (IEF) for 2015r-2020r and 2021.

	2015r	2016r	2017r	2018r	2019r	2020	2021	% Change	
								2015r - 2021	2020r - 2021
Implied Emission Factor (IEF) (kt CO_2e/GWh)	0.86	0.91	0.69	0.71	0.64	0.56	0.54	-37.0%	-3.5%

Fuel combustion

Emissions from stationary fuel combustion have decreased by 1% since 2015r and decreased by 0.04% since 2020r; this is due to small annual variations in the amount of diesel used for back-up electricity generation in the hospital, hotels, restaurants and the airport. There are also small changes in the Defra Conversion factors used for each year.

Box 4-1: Energy consumption for desalination of water

Due to a lack of natural water resources in Gibraltar, the city is reliant on water provided by the desalination of seawater. This process is energy intensive, accounting for between 5% and 6% of Gibraltar's total electricity consumption between 2015 and 2021. Energy consumption from desalination peaked in 2016 at 11,050,005 kWh – or 6.2% of total electricity consumption – but has decreased since, reaching a low of 4.7% (8,752,858 kWh) in 2021. This data is provided by AquaGib, and is summarised in Table 4-5 below.

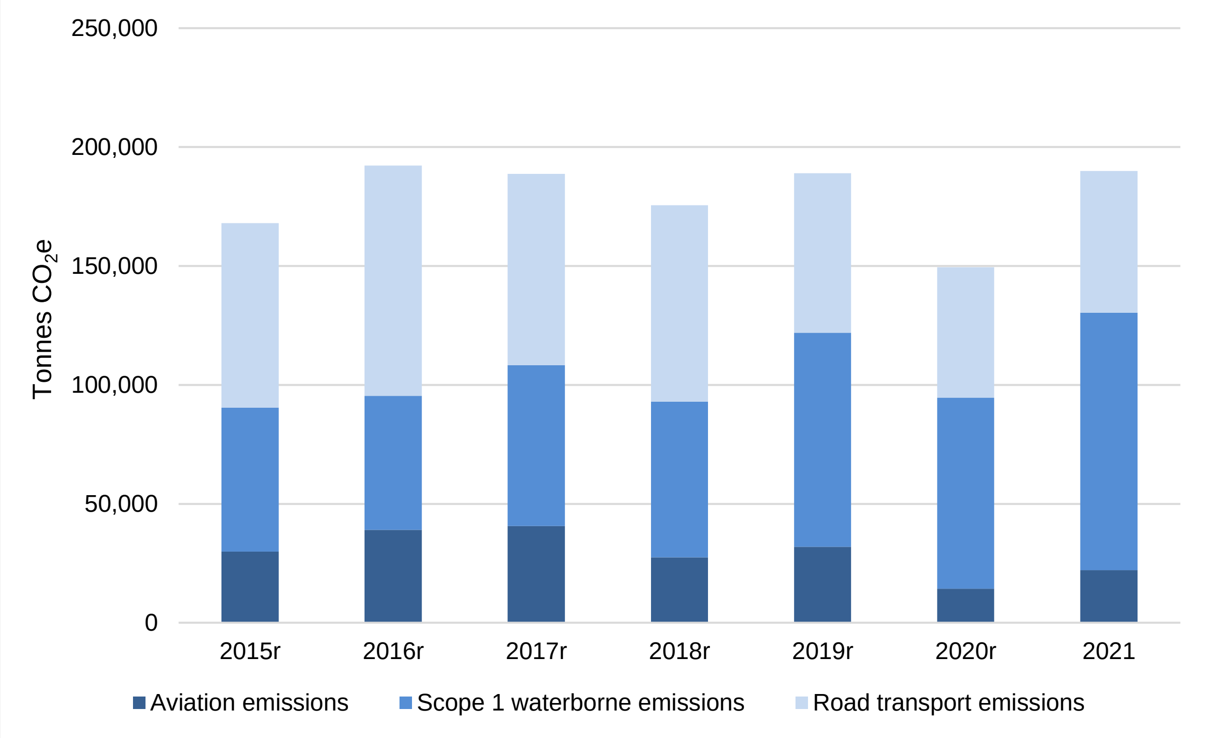
Table 4-5. Energy consumption from the desalination process

Year	2015	2016	2017	2018	2019	2020	2021
Energy Consumption from Desalination (kWh)	10,442,864	11,050,005	9,524,129	8,738,789	8,624,661	8,914,832	8,752,858
% of total consumption	5.8%	6.2%	5.3%	4.8%	5.1%	5.0%	4.7%

4.3.3 Transport

Transport emissions (excluding scope 3 shipping) have increased by 27% since 2020r, and by 13% since 2015r. The large annual decrease seen between 2019r and 2020r is largely a function of the COVID-19 pandemic, and the subsequent travel restrictions put in place. The 2021 inventory demonstrates a rebound from the anomalous 2020 emissions levels. Local boats (scope 1 waterborne emissions) now dominate transport – accounting for 57% of manageable transport emissions. However, there is no split between local boat emissions that should be attributed to Gibraltarian and non-Gibraltarian use; this is a key area for improvement going forward.

Figure 4-5: Gibraltar's transport emissions (excluding scope 3 shipping) for 2015r-2021.



Road Transport

Road transport emissions are only reported for Scope 1, with all fuel consumed by Gibraltarian vehicles reported in boundary[17]. A 9% increase in emissions from road transport is seen in between 2020r and 2021, as a result of more fuel being consumed by vehicles in Gibraltar. Over 2015r-2021, road transport emissions have decreased by 23%.

Waterborne navigation

Scope 1 emissions from this sector increased by 79% from 2015r and by 35% from 2020r in 2021, due to changes in the overall fuel imported and used in Gibraltar. Scope 3 emissions from this sector increased by 22% from 2015r, and by 2% from 2020r in 2021.

Aviation

Emissions from aviation are 55% higher in 2021 than 2020r, due to an increased number of flights operating in 2021 (although the number of flights in 2020 was significantly impacted by the COVID-19 pandemic, so can be considered anomalously low). Between 2015r and 2021, aviation emissions decreased by 26% overall.

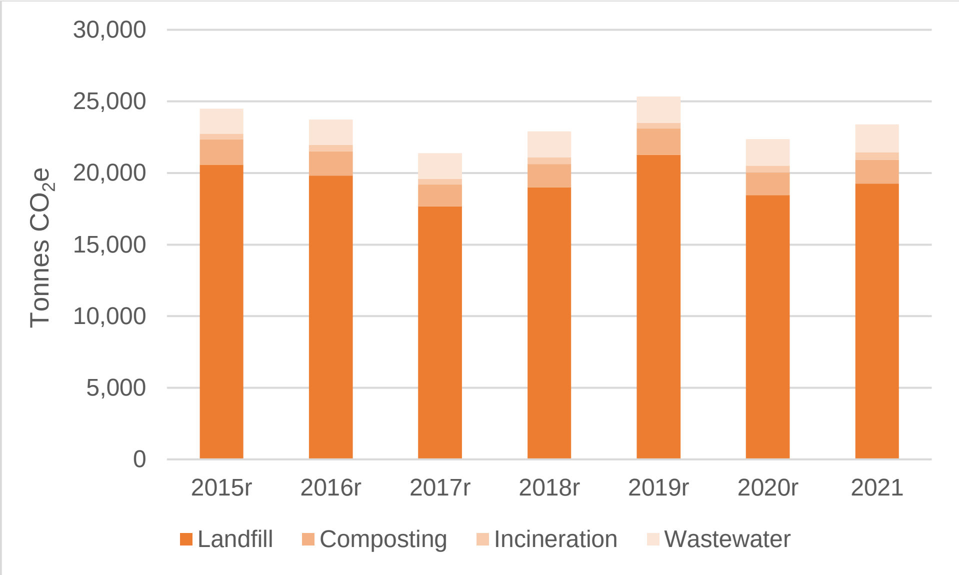
4.3.4 Waste

Total reported emissions from Waste have seen an increase of 5% in 2021 compared to 2020r, and a decrease of 4% in 2020 compared to 2015r. These changes are largely a function of shifts in emissions associated solid waste and biological waste, which both increased by 4% from 2020r and decreased by 6% since 2015r. Emissions from incinerated waste increased by 16% between 2020r and 2021, and by 36% between 2015r and 2021.

Wastewater emissions generated in the city have increased slightly (by 5%) between 2020r and 2021 as a result of population growth, as the methodology is a Tier 1 population-based approach.

[17] 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.

Figure 4-6: Gibraltar's waste emissions for 2015r-2021.



4.3.5 IPPU

There are still no Industrial Process emissions in Gibraltar, but Product Use emissions remain a significant source of scope 1 emissions. IPPU emissions have increased by 12% in 2021 in comparison to 2015r (and by 1% in comparison to 2020r). This follows the UK trend for products including aerosols, firefighting, foams, refrigeration and air-conditioning.

Since previous year inventories, there have been significant recalculations in the IPPU sector (applied through timeseries) due to adjusted assumptions for air conditioning, which is now based on data from Malaga (assuming ~50% of homes have air conditioning installed).

4.3.6 Other Scope 3

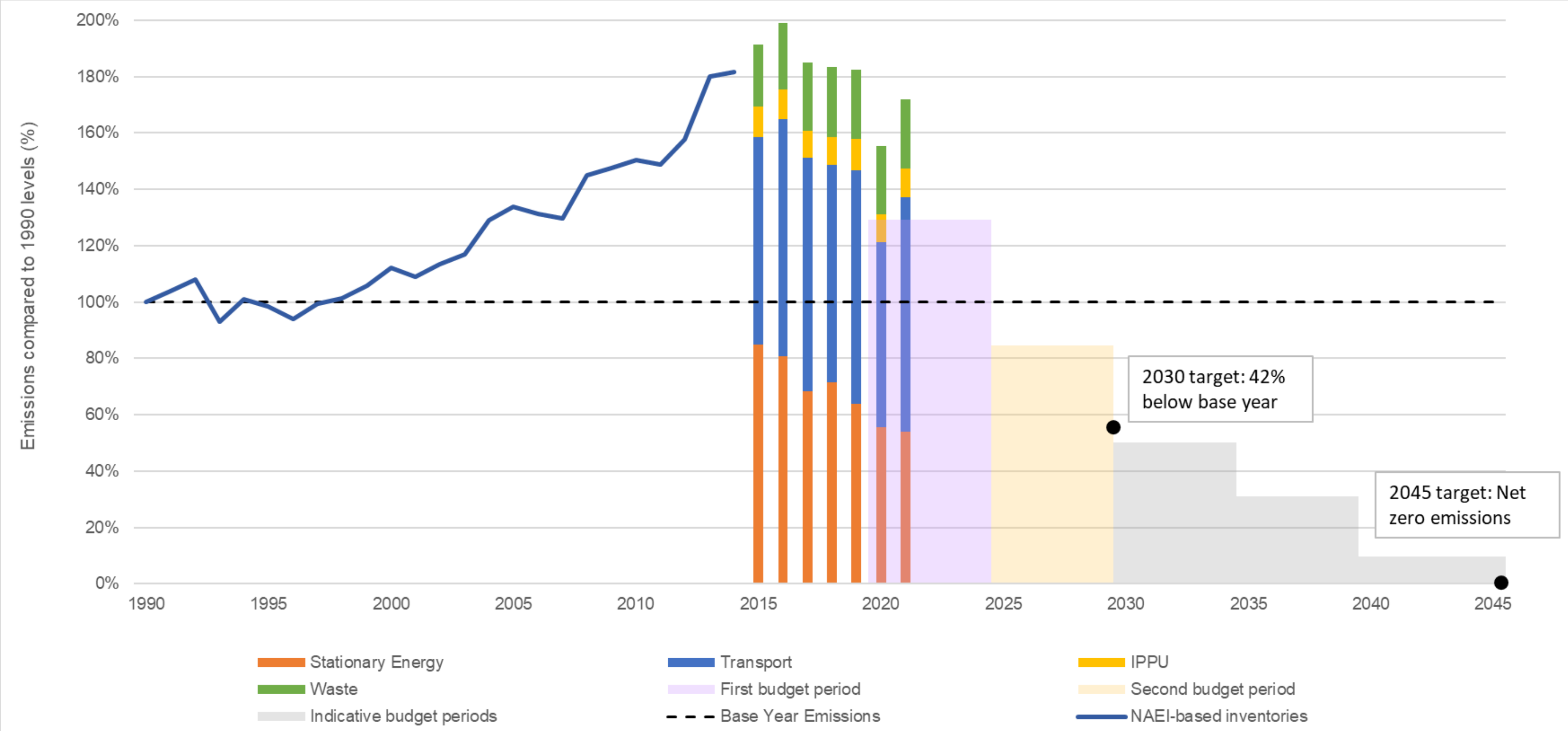
Other Scope 3 includes emissions from out-of-scope shipping traffic (e.g. bunkering) and out-of-scope fuel use by non-Gibraltarian vehicles. These emissions have decreased by 28% compared to the 2015r inventory, and increased by 2% compared to 2020r.

More information on the specific reasons for changes between the 2021 and previous inventories are given in **Appendix 3.**

5 Results within wider context

As detailed in Section 1.1, Gibraltar has a number of targets and commitments relating to GHG emissions and climate change. This includes the Climate Change Act (2019) targets to reduce emissions by 42% by 2030 (from a base year of 1990), and by 100% by 2045. To guide progress towards these targets, indicative carbon budgets have been developed – these carbon budgets show the average emissions that must be met over 5-year periods to keep Gibraltar on track to meet its targets. The inventory year presented in this report (2021) represents the second year if Gibraltar's first carbon budget period. While emissions have reduced this year compared to 2015, the graph shows emission reductions must be retained, and go further, over the first carbon budget period.

Figure 5-1: A summary of Gibraltar's historical GHG emissions, current GHG emissions, and indicative future carbon budgets (guiding the journey towards Gibraltar's emission reduction targets).



5.1 Reducing emissions in Gibraltar

The GHG inventory is an ongoing tool for understanding and reporting emissions, and allows the identification of major sources and priority areas for mitigation. With an understanding of the emission profile, Gibraltar's mitigation measures target the largest emitting sources, for example:

- For **transport** (the highest contributor to manageable emissions in 2021), aviation and private marine are difficult to influence. However, scope 1 marine transport and road transport, although relatively small compared to sources such as stationary energy, are significant given the small size of the territory. Gibraltar has a suite of measures designed to shift the road transport modal share (i.e., moving individuals away from more polluting modes of transport, towards non-motorised transport, such as cycling and walking, and public transport, such as buses) and switch from internal combustion engine vehicles to electric vehicles.
- **Stationary energy** (in this instance nearly entirely electricity production) is the second highest contributor to manageable emissions in 2021, and as such Gibraltar has measures specifically aimed at switching towards renewable energy sources, and improving the energy efficiency of the building stock.
- Gibraltar is tackling **waste** emissions through encouraging recycling.

Gibraltar's GHG inventory provides an effective way to track changes to GHG emissions over time, track progress against the various targets Gibraltar have committed to, and a basis for tracking progress against mitigation policies. 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.

Appendices

Appendix 1 – Common Reporting Framework (CRF) for 2021

GCoM have produced a common standard for city and local government GHG emissions inventory reporting for the GCoM, known as the 'Common Reporting Framework[18]' (CRF). While the body of this report reports emissions using the GPC (see section 1.2), this Appendix reports Gibraltar's emissions following the CRF, as reported to CDP as part of Gibraltar's GCoM commitment. Changes to reporting from following the CRF only affect how emissions are reported, and not the emissions themselves.

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

Table A-1 below presents Gibraltar's 2021 inventory in CRF format.

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

Table A- 1: CRF Reporting for 2021

GHG Emissions Source (By Sector and Sub-sector)	Total GHGs (metric tonnes CO_2e)				Comments
	Direct	Indirect	Other Direct	Total	
STATIONARY ENERGY					
Residential buildings	NO	39,111	6,182	45,293	
Commercial buildings and facilities	1,594	58,411	9,240	69,245	
Institutional buildings and facilities	NO	3,023	478	3,500	Reported under 'I.6 Non-specified sources' in the GPC
Industrial buidlings and facitilites	NO	4,638	IE	4,638	Reported under 'I.4 Energy industries' in the GPC
Agriculture	NO	NO	NO		
Fugitive emissions	NO	NO	NO		
SUB-TOTAL	**1,594**	**105,183**	**15,899**	**122,676**	
TRANSPORTATION					
On-road	59,627	NO	IE	59,627	
Rail	NO	NO	NO		
Waterborne navigation	108,186	NO	231,322	339,508	
Aviation	NO	NO	22,164	22,164	
Off-road	IE	NO	IE		
SUB-TOTAL	**167,813**		**253,486**	**421,299**	
WASTE					
Solid waste disposal	NO	NO	19,263	19,263	
Biological treatment	NO	NO	1,661	1,661	
Incineration and open burning	381	NO	155	536	
Wastewater treatment and discharge	NO	NO	1,945	1,945	
SUB-TOTAL	**381**		**23,024**	**23,405**	
INDUSTRIAL PROCESSES and PRODUCT USES					
Industrial Process	NO	NO	NO		
Product Use	55,830	NO	NO	55,830	
SUB-TOTAL	**55,830**			**55,830**	
AGRICULTURE, FORESTRY and OTHER LAND USE					
Livestock	NO	NO	NO		
Land use	NO	NO	NO		
Other AFOLU	NO	NO	NO		
SUB-TOTAL					
TOTAL	**225,618**	**105,183**	**292,408**	**623,210**	
ENERGY GENERATION					
Electricity-only generation	121,082			121,082	
CHP generation	NO				
Heat/cold generation	NO				
Local renewable generation	NE				
SUB-TOTAL	**121,082**			**121,082**	

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 **Section 3.3.**

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 5-2**).

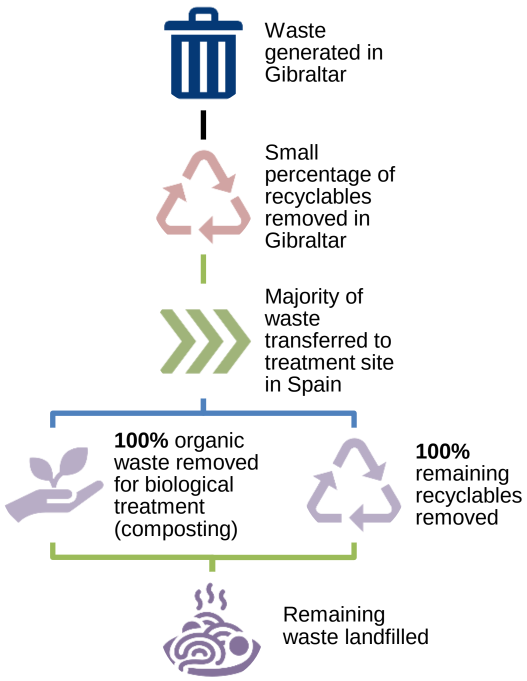


Figure 5-2 Old assumptions used to estimate emissions from MSW in Gibraltar

Suggestion for improvement

For recent inventories, we have included new improvements to the assumptions about recycling efficiency used to estimate emissions from MSW in Gibraltar. Where previously it was assumed that 100% of compostable/recyclable materials were composted/recycled, a 30% recycling efficiency for all recyclable/compostable materials is proposed. The 30% recovery figure comes from a personal communication from the reception facility at Los Barrios to Stephen Warr and is included in the Transfrontier Shipment of Waste (TFS) documents for municipal waste.

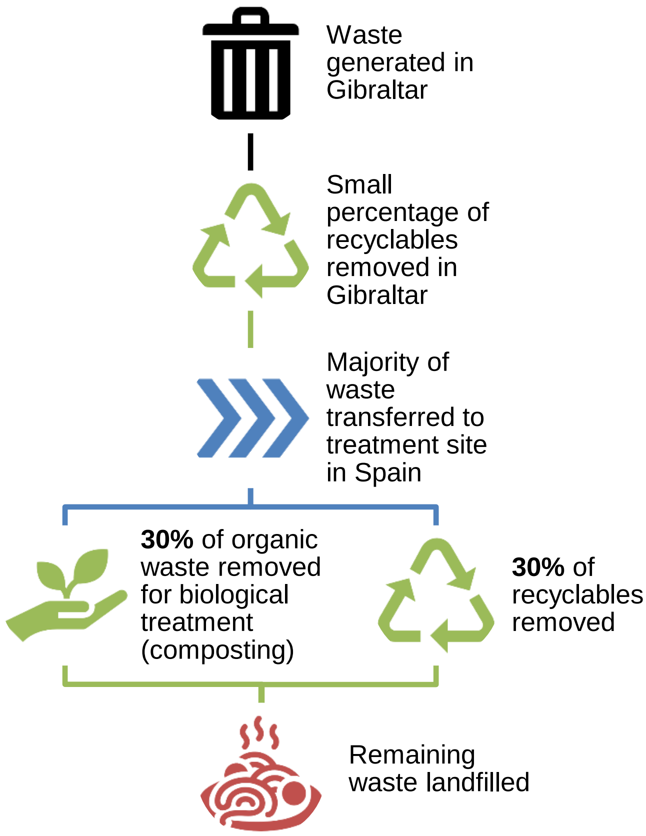


Figure 5-3 Revised assumptions used in this years' submission in future inventories to estimate emissions from MSW in Gibraltar

Proposed recalculations

Table A- 2 and **Table A- 3** below illustrate the difference in emissions from MSW when the new recycling efficiency assumptions are used. **Table A- 2** illustrates that emissions from biological treatment of waste are 70% lower under new assumptions (of 30% composting efficiency, compared to 100%).

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	2019	2020	2021
Absolute change in emissions	Tonnes CO_2e	-1,242	-1,196	-1,067	-1,146	-1,285	-1,114	-1,163
% change in emissions	%	-70%	-70%	-70%	-70%	-70%	-70%	-70%

When the new assumptions on waste sorting are taken into consideration for estimating landfill emissions, emissions increase dramatically across the inventory (**Table A- 3:** Recalculations) as we are assuming a much larger fraction of waste is being sent to landfill.

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

	Unit	2015	2016	2017	2018	2019	2020	2021
Absolute change in emissions	Tonnes CO_2e	27,049	23,383	18,161	20,966	25,242	20,909	23,036
% change in emissions	%	131%	118%	103%	110%	119%	113%	120%

When applying these changes and focusing on total waste sector emissions (including emissions from wastewater), 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	2019	2020	2021
Absolute change in emissions	Tonnes CO_2e	25,806	22,187	17,094	19,820	23,957	19,796	0
% change in emissions	%	116%	103%	88%	95%	104%	97%	0%

Appendix 3 – Detailed reasons for changes between 2021 and 2015r, and 2021 and 2020r

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 2021 and previous year inventories

Source	Change between current year (2021) base year (2015r)	Change between current year (2021) and previous year (2020r)	Reason
Stationary Energy			
Electricity generation	Decrease	Decrease	Emissions from electricity generation have decreased by 3% since 2020r (and by 37% since 2015r) - this is not driven by a decrease in electricity generation/consumption (which has remained fairly static) but is a function of the increased use of natural gas (replacing gas oil) at North Mole Power Station.
Scope 2 Electricity	Decrease	Increase	Scope 2 electricity emissions (electricity consumption) have shown a decrease of 34% between 2015r and 2021, and an increase of 1% between 2020r and 2021. These changes are partially a function of fluctuating fuel consumption at the power station, but are mostly due to the increased use of natural gas over gas oil at the power station.
Scope 3 Electricity	Decrease	Decrease	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 2019 (and considerably less than in 2017 and 2018 also). In 2020r, emissions from this source decreased significantly (by 33% from 2019r and by 38% from 2015r) bringing them almost in line with the 2016r anomaly (20.76 ktCO_2e in 2020r, compared to 16.91 ktCO_2e in 2016r). This decreasing trend continued in 2021, where a decrease of 23% from 2020r was seen. Scope 3 electricity emissions therefore reached an all-time low in 2021, of 15.90 ktCO_2e. This could be due to improvements in the way electricity is billed to consumers or due to actions to improve electricity losses across the network.
Transportation			

Source	Change between current year (2021) base year (2015r)	Change between current year (2021) and previous year (2020r)	Reason
Scope 1 On-road transportation	Decrease	Increase	Trends in road transport emissions are dictated principally by changes the fuel imported into Gibraltar. 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 influence emission trends, but these are much less important. Between 2020r and 2021, road transport emissions increased by 9% (despite an overall decrease of 23% being seen between 2015r and 2021). It is important to note though that the 2020 results for this sector were highly impacted by the lockdowns and travel restrictions under the COVID-19 pandemic, and so were considered anomalously low.
Scope 1 Waterborne navigation	Increase	Increase	Emissions trends from this source are now dictated by marina fuel sales. Between 2015r and 2021, a 22% increase in scope 1 waterborne navigation emissions is observed. Between 2020r and 2021, a 2% increase in emissions is observed.
Aviation	Decrease	Increase	Emissions from aviation are around 55% higher in 2021 than 2020r (but 26% lower than 2015r), due to significant increases in flight operations in 2021 compared to the previous year. However, drastically decreased flight operations during 2020 (a function of travel restrictions under the COVID-19 pandemic) mean results for this year were considered anomalously low. Over the whole time-series, aviation emission have fluctuated significantly.
Waste			
Landfill and Biological treatment of waste	Decrease	Increase	Total emissions from landfill and biological treatment of waste are around 4% higher in 2021 than 2020r, and 6% lower in 2021 compared to 2015r. These changes are driven by fluctuations in the total municipal solid waste generated in Gibraltar.
Incineration of waste	Increase	Increase	Overall, emissions from incineration of waste increased by 16% between 2020r and 2021 (with an increase of 36% seen between 2015r and 2021). Scope 1 emissions from waste are attributable to the incineration of clinical waste within Gibraltar – emissions from this activity have decreased by 0.4% since 2020r due to a tiny decrease in clinical waste arisings treated by incineration within the city boundary. Scope 3 emissions from incinerating waste outside of Gibraltar, however, have increased by 92% between 2020r and 2021, driving the increase seen in overall emissions from incineration of waste over this time.

Source	Change between current year (2021) base year (2015r)	Change between current year (2021) and previous year (2020r)	Reason
Wastewater	Increase	Increase	Wastewater emissions have increased in line with population growth. Between 2020r and 2021, an increase of 5% is seen. Between 2015r and 2021, an increase of 11% has been observed.
IPPU			
Product use	Increase	Increase	There are still no Industrial Process emissions in Gibraltar, but Product Use emissions remain a significant source of scope 1 emissions. IPPU emissions have increased by 12% in 2021 in comparison to 2015r (and 1% in comparison to 2020r). This is a small increase 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	Decrease	Increase	The decrease of 41% seen between scope 3 road transport emissions seen between 2015r and 2021 is driven by decreased fuel consumption for non-Gibraltarian vehicles over this time period. Between 2020r and 2021, however, an increase in emissions of 8% was seen from this source. The lockdowns and travel restrictions seen in 2020 as a result of the COVID-19 pandemic will have caused last years' results for this sector to be anomalously low, meaning the increase seen this year is essentially a rebound from this anomalous low.

Appendix 4 – Recalculations

This appendix covers the main recalculations made this year to the revised inventories for 2015-2020. Recalculations with a very small or insignificant impact (<1%) have not been covered.

Table A- 6: Recalculations to the 2015r-2020r inventories in this years' submission.

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	Change in tonnes of CO_2e to 2018r	Change in tonnes of CO_2e to 2019r	Change in tonnes of CO_2e to 2020r	Reason
Transport	II.1 – On-road transportation	-6.05	-26.10	-6.07	-11.16	+1.20	+22,227.88	+68.29% in 2020r, and negligible (<0.1%) for all other years. Major change in 2020 was due to fuel consumption data changed from using fuel sale data to using UK proxies to account for COVID trend. Small changes from 2015 to 2019 are due to updated GWPs.
IPPU	IV.2 – All product use	+39,398	+42,103	+44,172	+44,579	+45,106	+44,179	+402% in 2015r, +401% in 2016r, +411% in 2017r, +395% in 2018r, +441% in 2019r, +429% in 2020r. Due to major recalculations for air conditioning - updated assumptions were applied to the UK NAEI this year to reflect AC use in warmer climate. Data from Malaga on the proportion of homes with air conditioning has been used. Also a small change due to updated GWPs.
Waste	III.1 – Solid waste disposal	+2205	+2123	+1894	+2034	+2280	+1977	+12% for each year, due to using updated GWPs.

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	Change in tonnes of CO_2e to 2018r	Change in tonnes of CO_2e to 2019r	Change in tonnes of CO_2e to 2020r	Reason
Waste	III.1 – Biological treatment of waste	+41	+40	+35	+38	+43	+37	+2% for each year, due to using updated GWPs.

Appendix 5 – Data recommendations

Data collection

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 7**. 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.

Suggested improvements to data

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 2021 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 (although updated waste calculations in Appendix 2 take this into account)	Not applicable
Wastewater	Total volume of wastewater Biological content Treatment streams	Wastewater volume by sector	Population Average wastewater and biological content per person (from UK)

Industrial Processes and Product Use	Numbers of products by type (e.g., A/C units, refrigerators, vehicle A/C) Volumes of N_2O (hospital) (previous years' data used)	Numbers of products by end use sector	Population GDP

Appendix 5 – QAQC and verification

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.

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.

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.

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.

Appendix 7 – 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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