CIRIS

CITY INVENTORY REPORTING AND INFORMATION SYSTEM

User Guide

A user guide for the City Inventory Reporting and Information System (CIRIS); an Excel-based tool for managing and reporting city greenhouse gas inventory data.

VERSION 1.2

Document History

Please note this guide (version 1.2) is written specifically for the use of CIRIS v2.4, available to download at no cost from the C40 Climate Action Planning Resource Centre: resourcecentre.c40.org/resources/reporting-ghg-emissions-inventories

Future updates to the guide, including planned updates and those triggered by revision to CIRIS, will be logged in the table below.

User Guide version	CIRIS version	Date of release	Revision description
1.0	2.0	7 April 2017	-
1.1	2.0 2.1	17 August 2017	Minor text amendments and addition of Calculators section
1.2	2.4	12 May 2020	Addition of information required to ensure alignment of CIRIS and this guide with the Global Covenant of Mayors Common Reporting Framework (GCoM CRF)

Contact

For any comments or questions relating to CIRIS or this User Guide, please contact measurement@c40.org.

Contents

CIRIS User Guide overview

This guide aims to assist users of the City Inventory Reporting and Information System (CIRIS); an Excel-based tool for managing and reporting city greenhouse gas inventory data. Based on the Global Protocol for Community-scale Greenhouse Gas Emission Inventories (GPC) standard, the tool facilitates transparent calculation and reporting of emissions for all sectors.

CIRIS itself contains basic instructions on how the tool can be used; this guide provides more detailed guidance and worked examples to support users to understand how to navigate CIRIS, the data and information requirements, and the outputs. It provides guidance for completing each of the sections of the CIRIS tool. This includes information on:

- The structure and function of CIRIS
- The purpose and background to each section
- The information requirements for each section and how to use each sheet
- Descriptions of sheets and why the information is needed
- Key terms and references to the relevant GPC section for further information
- Common challenges and recommendations
- Examples of best practice reporting and detailed worked examples

CIRIS and this guide should be used in conjunction with the GPC, available at resourcecentre.c40.org/resources and http://ghgprotocol.org

A GPC compliant inventory meets the requirements of the Common Reporting Framework (CRF) of the Global Covenant of Mayors for Climate and Energy (GCoM). The CRF can be accessed here: https://www.globalcovenantofmayors.org/our-initiatives/data4cities/common-global-reporting-framework/

Box 1: Shall, Should and May Terminology

The GPC uses precise language to indicate which provisions of the standard are requirements, which are recommendations, and which are permissible or allowable options that cities may choose to follow. In the same way, CRF defines three levels of reporting:

- Level 1 – Mandatory requirements: the term "shall" is used to indicate what is required in order for a GHG inventory to be in compliance with the minimum set of requirements that a GCoM city has to meet. The same term is used throughout GPC to indicate what is required in order for a GHG inventory to be in compliance with the standard.
- Level 2 – Recommendations: the term "should" is used to indicate what is considered good practice and therefore GCoM cities are strongly advised to follow these recommendations whenever possible, but they are not a requirement. The same term is used throughout GPC to indicate a recommendation but not a requirement.
- Level 3 – Additional options: refer to options that are acceptable under the initiative and that a local government can decide to follow. These options are introduced by the term "may", in the same way that GPC uses to indicate an option that is permissible or allowable.

The GPC is currently being updated to provide more guidance to support reporting alignment with the CRF. CIRIS and this guide has been adapted slightly to support reporting alignment with the CRF. For further information on reporting requirements terminology, see **Box 1.**

User Guide outline

The guide is structured as follows:

The Introduction section provides an overview of the components of CIRIS, the GPC, including definitions and reporting framework, notation keys, global warming potentials and conversion factors.

Part 1 covers the *Set-Up* tab, addressing each of the GPC requirements and the input of essential information for CIRIS functionality and compliant reporting. This includes emission factors, data sources and city information.

Part 2 covers the *Inventory* tab, including an overview of common functions and requirements, as well as sector-specific guidance for each of the sector sheets.

Part 3 covers the *Results* tab, providing an overview of the reporting and analysis functions, as well as how to use and interpret the reports produced.

Part 4 will cover the *Calculators* that are embedded within CIRIS, to support reporting of Waste sector and Fugitive emissions.

Throughout the guide are worked examples, showing correct reporting of information in each sheet. **Buenos Aires is used as the example city; however, the information has been altered for presentation within this guidance and therefore the figures included are for illustrative purposes.**

How to use CIRIS

This section of the guide describes the common functionality and layout which is seen throughout CIRIS.

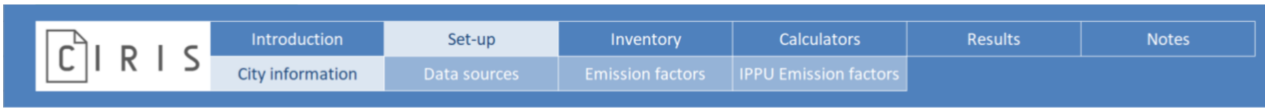
Navigation

When CIRIS is opened, users are greeted with a ’Welcome’ front page. To enter into the tool, simply click the “Click here to begin” button.

Each sheet of CIRIS is topped with a navigation bar, as below; this contains all the titles for each tab, and sheet within each tab. Throughout the guide, ‘tabs’ refer to the first row of headings (*Introduction, Set-up, Inventory,* etc.), ‘sheet’ refers to the second row of headings (e.g. in *Set-up* these are *City information, Data sources, Emission factors,* etc.).

The tab and sheet which is currently open is highlighted in a lighter shade of blue; in the example below, the *City information* sheet is open, which is found in the *Set-up* tab. Use the navigation bar to go to a desired tab and sheet.

Tip: Macros will need to be enabled for CIRIS to work with full functionality. If there are problems enabling macros, CIRIS can be used by navigating to each sheet using the Excel tabs along the bottom, shown in the image below.



Structure

Table 1 below summarises the CIRIS tabs and the sheets contained within them. The sections of the guide provide more detail and explanation on the contents and purpose of each tab and sheet. **Table 1** can be used to navigate through this guide; simply press ‘ctrl’ and click on the relevant tab or sheet title to jump to the relevant section of the guide.

Table 1: Summary of tabs and sheets in CIRIS

Tab	Sheets
Introduction	User Guide
	GPC
	Notation keys
	GWPs
	Conversion Factors
Set-up	City Information
	Data sources
	Emission factors
	IPPU Emission factors
Inventory	Stationary
	Transportation
	Waste
	IPPU

Tab	Sheets
	AFOLU
	Other scope 3
Calculators	Fugitive gas calculator
	Solid waste disposal calculator
	Biological treatment calculator
	Incineration and Open Burning calculator
	Wastewater
Results	Summary
	Graphs
	Overview
	Analysis
	Net emissions
	GCoM - CRF
Notes tab	Sheet 1 to 6

Cell colour-coding

Throughout CIRIS, there is consistent colour-coding of cells to indicate user input, calculation, tool, and relevant GPC requirements.

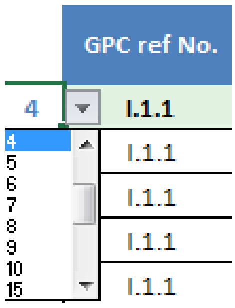
- White cells should be completed by the user, with city-specific information; this might be by entering activity data, selecting an emission factor, or simply stating the GPC reference number for a row of data in one of the inventory tabs.
- Grey cells contain pre-populated equations which automatically calculate results. These cells should not be overwritten or altered.
- Alongside many of the grey cells, there is space to override the default information in the grey cells; this should be used if information is known that is more relevant and/or city-specific than default values/assumptions. These optional override cells are shown with an orange header, as in the below example, taken from the *Stationary* sheet under the *Inventory* tab.

Activity data		Activity data unit converter		
Amount	Unit	EF unit	Default	Override
129,572,539	kWh	TJ	3.60E-06	

- Throughout the *Inventory* tabs, the GPC sub-sector titles are colour-coded to indicate whether they are required by BASIC or BASIC+ GPC inventories.
  - 'Light green' cells indicate sources required for BASIC reporting under the GPC
  - The 'light green' cells plus the 'light blue' cells are required for BASIC+ reporting
  - The 'light purple' cells are required for a territorial total but not for BASIC/ BASIC+ reporting
  - The 'light orange' cells are sources included in Other Scope 3.

BASIC reporting	BASIC+ reporting	Territorial emissions	Other Scope 3 emissions

Common table structure and function



- Each table in CIRIS is designed to only display a row for data if it is required. Users must specify the number of rows they wish to display in order to add their data.
- Alongside these tables is the word 'Add'. Clicking on this will bring up a drop down list of numbers. These numbers indicate the number of rows which are visible in the given table. To increase or reduce the number of visible rows in a table, simply select the desired number from the drop-down list. See the adjacent example for an illustration.
- For inventory sources which are either not estimated, or not occurring, set the drop-down list to 'Add'; this will show no rows for the particular source.
- In order for formulas within CIRIS to function properly, do not insert or delete rows manually. If a row of data that has been entered is no longer needed, simply remove the data entry and leave the row as empty or fill with other data.

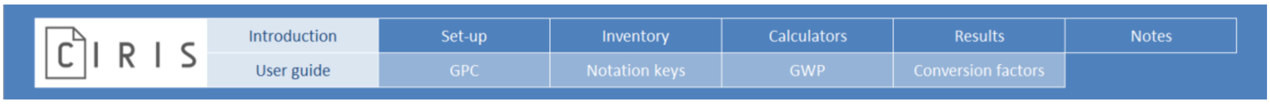
Software requirements and settings

CIRIS is designed to be compatible with the *Excel 2010* and all later versions. If an older version of Excel is being used, then a simplified version 'light' of CIRIS is available to download from: www.c40.org/programmes/ciris. The simplified version does not contain macros.

CIRIS is set to *Automatic* calculation mode by default. However, if CIRIS does not return results after data has been inputted, it is recommended that users check the calculation setting of Excel and ensure it is set to *Automatic* mode. Below is a quick guide on how to do so:

- For users of Excel 2013 or older versions, click on the *File* tab in the Excel toolbar, click *Options*, and then click the *Formulas* category, and select *Automatic*.
- For users of later versions of Excel including Mac versions, click on the *Formulas* tab in the toolbar, click *Calculation Options* (or *Settings* in some Excel versions), and select *Automatic* (or *Calculate Automatically* in some versions of Excel).

Introduction Tab



The *Introduction* tab contains information that is important to understanding the CIRIS tool, inventory reporting and the Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC). It is essential reading for all users who have not compiled an inventory before. Users should not edit or report anything in the Introduction tab.

The Introduction tab consists of five sheets, which are briefly described in **Table 2**. All five are explained in more detail below.

Table 2: Sheets in *Introduction* tab

Sheets	Description
User guide	Directory featuring a brief introduction to each tab, describing what the user is required to do at each stage.
GPC	Brief overview of the GPC, its purpose, structure and some definitions of the sectors and sub-sectors used.
Notation keys	Explanation of why it's necessary to use notation keys, when to use them and how.
GWP	A table of global warming potential (GWP) values for reported greenhouse gases.
Conversion factors	Conversion factors for commonly used units for energy, mass, volume and distance.

User Guide

The *User guide* sheet is a directory for the CIRIS tool, listing the tabs and offering a brief explanation of what is required in each section and what the purpose of the sections are. The structure of this guide follows the structure of CIRIS as set out on the *User guide* sheet.

1. Set-up	To start with, users are asked to define the inventory boundary and provide supporting background information, such as population and land area. This helps to provide context and allows for meaningful benchmarking. This section should also be used to record all data sources and emission factors to be used in the inventory.
2. Inventory	The next step is to record activity data. Using the emission factors defined in the Set-up, emissions are calculated according to the GPC reporting framework. Stationary energy, Transportation and Waste must be completed for a BASIC inventory. IPPU and AFOLU are additional required for a BASIC+ inventory. To accommodate limitations in data availability and differences in emission sources between cities.
3. Calculators	CIRIS includes five calculators to help cities estimate emissions for: fugitive losses from gas distribution, solid waste landfill, biological treatment of waste, waste incineration and wastewater. The calculations are based on IPPC Guidance and use IPCC default factors. These should only be used if no other data is available or otherwise to compare results estimated using another methodology.

4. Results	This section presents your city's GHG emissions in a number of different ways - city-wide and broken down by (sub-) sector - based on the activity data and emission factors submitted, and enables you the compare your city's current GHG emissions against any historical inventories. It also gives you the option to record emission credits to estimate your city's net emissions. Note, the latter is for information only and cannot be used to report a GPC inventory.
5. Notes	As a user works through the guide or through the CIRIS tool itself, they may wish to take notes. This section provides room to record important points of guidance to consider, components of the CIRIS tool that a user may wish to find guidance for or whatever else may come to mind.

At the bottom of the *User guide* sheet, there is contact information for asking any questions regarding CIRIS; these are:

- C40 cities: measurement@c40.org
- ICLEI cities: your regional ICLEI office
- Cities reporting to CDP: cities@cdp.net
- GCoM: info@globalcovenantofmayors.org

These contacts should also be used for questions regarding this guide.

GPC

The *GPC* sheet gives a basic introduction to the Global Protocol for Community-Scale Greenhouse Gas Emission Inventories. The sheet is broken down into three sections that are briefly described in **Table 3**.

Table 3: Sections of GPC sheet

Section		Description	GPC Reference
The Global Protocol For Community-Scale Greenhouse Gas Emission Inventories (GPC)		Brief introduction to what the rationale behind the creation of the GPC was and what its uses are. These include the basic goal of helping a city build an inventory but also the role a GPC compliant inventory can play in setting targets, tracking performance and coordinating with other cities as well as other partners at the sub-national and national level.	Chapter 1 contains further information on the background of the GPC
GPC Reporting Framework	Overview	Overview of the reporting requirements of the GPC. The GPC does not prescribe particular methodologies for calculations however it offers a framework to report through that emphasises transparency and consistent organisation across inventories. This organisation is delineated primarily by scope and by sector.	Chapter 4 is focused on the GPC reporting requirements
	Scopes	A system that groups emitting activities by whether they occur inside the city boundary or outside. This helps to avoid double counting.	Chapter 3 section 5, and Chapter 4 section 1, give further information on GPC inventory scopes
	Sectors and Sub-sectors	A system that breaks emitting activities down by the consumptive behaviour.	Table 3.1 presents the GPC sectors and sub-sectors. Further information is available in the sector-specific chapters in part II of the GPC.
Sector Definitions		A brief explanation of each sector and sub-sector.	Chapter 5 gives an overview of calculating GHG emissions Chapter 6 - Stationary Energy Chapter 7 - Transportation Chapter 8 - Waste Chapter 9 - IPPU Chapter 10 - AFOLU

Notation Keys

Data availability and the presence/relevance of emission sources (which differ between cities) are common challenges faced when compiling an inventory. The GPC describes a set of notation keys that can be used to clearly communicate these situations and provide a basis for transparent explanation as to why data are missing.

More information on Notation Keys can be found in GPC section 2.2.

The notation keys are listed in **Table 4**; this table is taken from the *Notation keys* sheet under the *Introduction* tab.

Table 4: Notation keys

Notation key		Description and examples
Not occurring	NO	An activity or process does not occur or exist within the city.
	Example	I.7.1 does not occur. No coal-related activities within the city boundary.
		II.2.2 does not occur. Number of electric vehicles is negligible compared to total vehicle fleet (0.01% of vehicle sales in 2014 were electric).
Included elsewhere	IE	GHG emissions for this activity are estimated and presented in another category of the inventory. That category shall be noted in the explanation.
	Example	II.5.1 is reported in II.1.1. Fuel sales approach does not allow for disaggregation.
		III.1.3 is reported in III.1.1. It is not possible to disaggregate waste generated outside the city and inside the city that are disposed in the landfill site within the city boundary.
Not estimated	NE	Emissions occur but have not been estimated or reported; justification for exclusion shall be noted in the explanation
	Example	III.4.3 has not been estimated. Activity not required for BASIC inventory.
		V.1 has not been estimated. No livestock data available.
Confidential	C	GHG emissions which could lead to the disclosure of confidential information and can therefore not be reported.
	Example	Activity data for IV.1 is confidential. Data cannot be aggregated to provide confidentiality.
		II.5.1 is confidential. Military base within city boundary.

The *Notation Keys* tab provides an explanation of each key in turn, explaining how it might be used and providing examples to aid decision making. There is also a flow-chart that a user can follow to determine whether a notation key is appropriate and if so, which is appropriate.

GWPs

This sheet contains a list of Global Warming Potential (GWP) values for greenhouse gases that might be reported in a GPC compliant inventory. A fixed amount of one greenhouse gas emitted to the atmosphere will have a greater or lesser warming impact on the planet than another, different, greenhouse gas; this varying impact is known as its global

See Table 5.2 in the GPC for a list of GWPs for common GHGs.

warming potential. A GWP value is used to convert quantities of different greenhouse gases to a shared unit (carbon dioxide equivalent, CO_2e) that can then be directly compared.

The GPC requires that all emissions are reported in metric tonnes of CO_2e. CIRIS automatically calculates this based on the GWP values specified by the user in the *Emission Factors* sheet. More information on this is included in the *Emission factors sheet* within *Set-up Tab.*

There are several different sets of GWP values, derived from different 'Assessment Reports' published by the Intergovernmental Panel on Climate Change (IPCC). For example, the "4AR" values are taken from the 4th Assessment Report, published in 2007. Over time, these values change to reflect the latest understanding of the science of climate change.

The GPC requires that cities use the most recent GWP values when converting their emissions to CO_2e. Earlier versions are permissible to use where the city's inventory is required to be consistent with the National inventory, which may use an earlier set of GWP values. Few countries are reporting using 5AR values at present; most cities will find that 4AR GWP values are the most consistent and appropriate to select.

CIRIS automatically looks up the appropriate GWP values once the user specifies which they wish to use. For consistency, the same GWPs should be used throughout CIRIS. For example, if "4AR" is selected on the *City Information* sheet, then 4AR should also be selected on the *Emission factors* sheet (and emission factors should all be based on 4AR GWPs if reported as CO_2e). CIRIS then automatically calculates CO_2e values for each gas so no further user input or calculation is required. Users therefore do not need to look up GWPs or do conversions, unless the desired units are not listed.

Conversion Factors

Quantities of energy, mass, volume and distance can be measured using different units. Activity data and emission factors are also often provided in different units, requiring conversion. The *Conversion factors* sheet provides conversion factors, to convert a quantity in one unit into the same quantity in a different unit. Conversion factors are looked up by CIRIS to automatically convert the unit of emission factors and activity data once the units have been specified. There are two places this occurs:

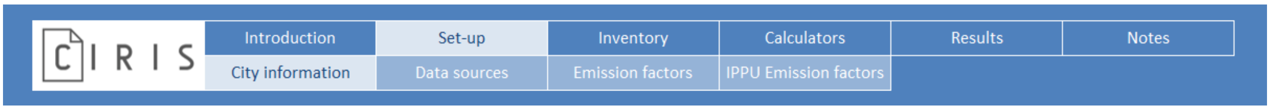
- To convert emission factors and results into a common unit of metric tonnes CO_2e. This requires no user input and is fully automatic
- To convert between units in the 'activity data unit converter' columns of the *Inventory* sheets. This should be used where the activity data and emission factor are in different units. For example, converting from activity data for natural gas in kWh, to the same amount in TJ, to be consistent with the available emission factor. This requires the user to specify the units of the activity data, and the emission factor. Where a conversion factor is available this conversion is automatic. Where it is not available, the user is prompted to provide this manually in the 'override' column. More information on the 'activity data unit converter' is available in **Table 14**.

Tables are provided which include conversions for:

- SI prefixes – e.g. giga tonnes (Gt) to mega tonnes (Mt)
- Energy – e.g. tera joules (TJ) to kilowatt hours (kWh)
- Mass – e.g. pounds (lb) to metric tonnes (t)
- Volume – e.g. cubic metres (m3) to litres (l)
- Distance – e.g. miles (m) to kilometres (km)

There is also a table with commonly used factors to convert from volumes of different fuels to units of energy, for example, m^3 of aviation gasoline to kWh of aviation gasoline. In addition, there is a table of factors to convert from mass of fuels to units of energy, for example, tonnes of bitumen to kWh of bitumen. Such conversion factors are often referred to as calorific values, which are dependent on the chemical composition of fuels and therefore may vary across regions. Users are recommended to source calorific values from energy suppliers or align with their national GHG inventory reports. If such information is not available, the general conversion factors given in CIRIS can also be used.

Part 1: Set-up Tab



The *Set-up* tab collates the background information needed to report a GPC-compliant inventory. Such information is collected for many reasons including for quality assurance/quality control (QA/QC), to enable transparent review of inventories, to allow benchmarking against other cities and between years, and to simplify the process of compiling an inventory and support the undertaking of calculations.

The *Set-up* tab consists of four sheets, which are briefly described in **Table 5**.

Table 5: Sheets in the Set-up Tab

Sheets	Description
City Information	Collects information on the boundary used for the inventory and other key information about the city
Data sources	Collects information regarding the sources of data used in the inventory
Emission factors	Used to document all emission factors used in the calculation of GHG emissions
IPPU Emission factors	

City Information sheet

The *City information* sheet collects information on the **boundary** used for the inventory. The inventory boundary is designed to provide a city with a comprehensive understanding of where emissions are coming from as well as an indication of where it can take action or influence change to reduce emissions.

The *City information* sheet is accessed via the *Set-Up* tab of CIRIS. The *City information* sheet is comprised of three sections, as presented in **Table 6**.

Table 6: *City Information* sheet sections

Section	Description
A. Inventory boundary	**What?** The inventory boundary identifies the geographic area, and time span covered by the GHG inventory. Other information is also collected such as population and GDP within the city boundary. **Why?** This information is key to ensuring that the city has a comprehensive understanding of what the inventory is showing, to allow for consistency between years and to enable the city to benchmark against other similar cities.
B. Map of city boundary	**What?** A map that clearly shows the geographic boundary of the city. **Why?** The same boundary shall be maintained for consistent inventory comparison over time. Changes in boundary may trigger base year inventory recalculation.
C. Inventory information	**What?** The inventory information identifies the desired reporting level that the city has chosen; BASIC (**Figure 4**) or BASIC+ (**Figure 5**). The gases, which global warming potentials (GWPs) are used, the overall methodology and any relevant regulations are also documented here.

Section	Description
	Why? This information is key to ensuring that the city has a comprehensive understanding of what the inventory includes and covers, and makes clear to external audiences what and how the inventory is being reported.
D. Inventory compiler	**What?** This section documents when the inventory was compiled, by who and their contact details. **Why?** This information is important to preserve institutional memory and to enhance record keeping practices.

To complete the *City information* sheet, the user will need to have agreed the scope of the inventory – such as the geographic boundary and inventory year, sources that will and will not be included – and have identified appropriate methodologies and relevant regulations, and have access to general information about the city, consistent with the defined boundary.

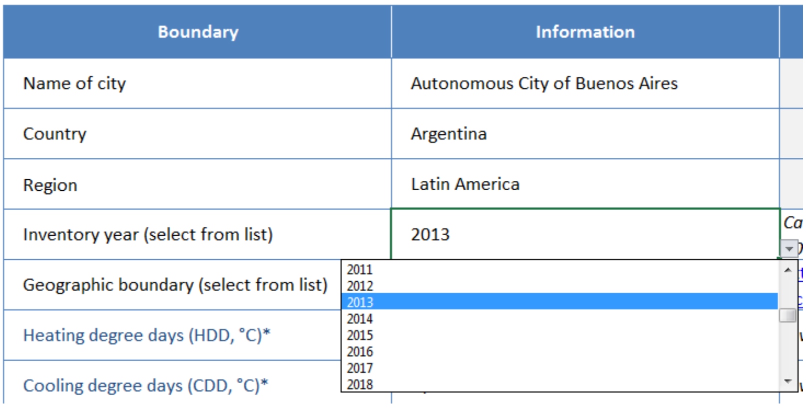
This may require consultation with data providers, political authorities or other stakeholders, in order to determine the most relevant and practical boundary based on, for example, planned use of the inventory, available information and other city priorities.

How to use this sheet

A. Inventory Boundary

- In the 'Information' columns, add the relevant information for the category stated in the 'Boundary' column.
- For some cells, information can be selected from drop-down menus in the 'Information' column (**Figure 1**).
- Ensure all information is consistent with the defined year and scale of your inventory.
- 'Reference(s)' columns should be completed with a relevant reference e.g. a link to a web page containing resident population, or the source of the stated data.
- *Optional Information* – information in blue font, including type of economy and climate, are optional but are good to report for additional transparency and comparability.

Figure 1: Example from *City Information* sheet: drop-down menu



Boundary	Information
Name of city	Autonomous City of Buenos Aires
Country	Argentina
Region	Latin America
Inventory year (select from list)	2013
Geographic boundary (select from list)	
Heating degree days (HDD, °C)*	
Cooling degree days (CDD, °C)*	

B. Map of city boundary

Include a map of the city boundary in the box given in this section to aid transparency (**Figure 2**). To do so, click on the *Insert* tab in the toolbar of Excel, and select *Picture from File* (The map needs to be saved as an image on your local computer first). The map should correspond to the boundary specified in section A above.

Figure 2: Map of the City of Sydney

There is no right or wrong boundary definition. Cities should select the most appropriate boundary to meet their needs. Sydney chose their CBD but other cities choose the urban area, greater metropolitan area or city region.

C. Inventory Information and D. Compiler Information

These tables should be completed in the same way as described for the two tables above. Users must select which greenhouse gases are included in the inventory; for further information on this, see **Box 2.**

Box 2: Greenhouse gases included in a GPC inventory

Under both the GPC and the CRF, local governments **shall** account for emissions of the following gases: carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O), as a minimum requirement. For a BASIC+ compliant GPC inventory, cities shall also account for emissions of the following greenhouse gasses: hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulfur hexafluoride (SF_6), and nitrogen trifluoride (NF_3). Nitrogen trifluoride was not one of the six gases originally mandated under the Kyoto Protocol, but was added for the second compliance period (starting 2012).

Under the GPC, CO_2 emissions from the combustion of materials of biogenic origin should be reported to show they have been accounted for but not included in the emissions totals. Reporting of CO_2(b) is optional using the CRF (see **Box 4**).

Key terms

Table 7 presents key terms to be understood in order to fill in the *City Information* sheet. A description of each key term is given, as well as a real-life example of how cities have fulfilled the requirements for each term.

Table 7: Key terms for *City Information* sheet

Item	Description	Examples in practice
Inventory year	The continuous 12-month period that the inventory covers.	Amman wanted to report the most recent inventory possible and their city reporting cycle was the calendar year, therefore they specified their inventory as the 2014 calendar year. Sydney reports their GHG data on the Australian financial year, July-June.
Geographic boundary	Description of the geographic boundary that identifies the spatial dimensions of the inventory's assessment boundary.	Melbourne reported emissions from the Central Business District administrative area, as this was the administrative boundary.
Heating degree days (HDD, °C), Cooling degree days (CDD, °C)	A measurement developed, using outside air temperature, to measure the demand for energy needed to heat or cool a building. Used to estimate weather-adjusted inventory-year energy use data. This is an optional field.	Miami, Florida, recorded 500 heating degree days for the heating season, whereas New York City recorded 5,050. A house in Miami therefore requires around one tenth of the energy required to heat a house in New York City. This is a useful metric for comparing or scaling energy consumption data.
GPC reporting level	BASIC (**Figure 4**) or BASIC+ (**Figure 5**) should be selected. See **Box 3** for more information on the GPC reporting levels.	Most cities have reported a BASIC inventory; BASIC should be stated unless all BASIC+ sources that are occurring have been included. Paris reported a BASIC inventory, although were able to additionally report some BASIC+ activities. Mexico City reported all IPPU and AFOLU emissions within the boundary, so were able to state their inventory was BASIC+.
Global Warming Potential (GWP)	Used to convert GHGs into CO_2e. GWPs from the latest IPCC Assessment Report should be used.	Tokyo updated the calculations in their most recent inventory to use the 4th Assessment Report, from the 2nd Assessment Report used in their 2012 inventory.

To understand the GPC reporting levels (See **Box 3**), it is also essential to understand the scopes of GPC reporting. Activities taking place within a city can generate GHG emissions that occur inside the city boundary as well as outside the city boundary. To distinguish between these, the GPC groups emissions into three categories based on where they occur: scope 1, scope 2 or scope 3 emissions. The CRF uses different terms to defines emissions, but these can be linked back to the GPC scopes (**Table 8**).

Table 8: GPC inventory scopes and CRF definitions

CRF definitions	Scope	Definition	Example

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

Common challenges and recommendations

Common challenge

It can often be challenging to find accurate, complete and transparent information describing a city, with references, for the inventory year, boundary and other characterises. This can be because the inventory area does not correspond to political or statistical boundaries which limits 'official' data, or because data that exists is old or judged to be less accurate or representative.

Recommendations

- Prioritise those sources of information that are used by other teams for policy-making purposes. Options include: scaling most recent census data is a commonly used approach
- Information can often be found on the websites or in publications/legislation from city governments, national statistic offices, national treasuries, and other relevant institutions
- If data is unavailable from these sources, look to high quality external sources such as universities, research institutes, scientific and technical articles published (peer-reviewed) or sector experts/ stakeholder organisations
- International sources can also be used. For example, for GDP data see
    - Lloyds http://www.lloyds.com/cityriskindex/locations
    - Brookings https://www.brookings.edu/research/global-metro-monitor/
    - OECD https://data.oecd.org/

Whichever approach is used, ensure that any data reported has a reference, to allow for easy updating and to enhance transparency. Also ensure that requests to data providers clearly specify the geographic boundary and inventory year to ensure they align.

Worked example

Figure 3 shows a thorough and complete city information sheet compiled by the city of Buenos Aires. The inventory contains a number of positive features:

- Description, map and source of map all provided, and are all consistent

- Conversion to USD explained

Consistent temporal boundary: 2013 is used throughout; this is important to ensure results are consistent and comparable. The GPC requires the temporal boundary to be a continuous 12-month period

Figure 3: Extract from Buenos Aires' inventory (consistent temporal boundary shown in red)

Boundary	Information	Reference(s)
Name of city	Autonomous City of Buenos Aires	
Country	Argentina	
Region	Latin America	
Inventory year (select from list)	2013	*Calendar year: 1st of January 2013 to 31st of December 2013.*
Geographic boundary (select from list)	City / Municipality	http://www.buenosaires.gob.ar/agenciaambiental/cambioclimatico/english-information-available-here/ghgs-
Heating degree days (HDD, °C)*	N/A	*Inventory is not weather corrected*
Cooling degree days (CDD, °C)*	N/A	*Inventory is not weather corrected*
Land area (km2) within city boundary	202.04	General direction of legislative documentation (CEDOM)
Resident population within city boundary*	3,079,071	Year 2013 projection by the Treasury Secretariat of Buenos Aires City Governement.
GDP (US$) of economic activity within city boundary*	79,384,000,000	Treasury Secretariat converted to US Dollar based on exchange currency price in january 2014 = $6,52
Type of economy (select from list)	Services	Treasury Secretariat - Statistics and Census General Direction (Anual report 2013)
Climate (select from list)	Temperate, hot summer	http://people.eng.unimelb.edu.au/mpeel/koppen.html
Other information	3,389,350 commuters	The City doubles its population daily because of more than 3 million people entering the City for work, study and administrative process. Source: Estudio de Cohesión Social en la Región Metropolitana de Buenos Aires 2014. http://www.buenosaires.gob.ar/gobierno/estudio-de-cohesion-social-en-la-region-metropolitana-de-buenos-aires-2014

* Should correspond to inventory year

Map of city boundary

Box 3: GPC Reporting levels

The below figures describe the sources and scopes which should be included under the two GPC reporting levels; BASIC and BASIC+.

Figure 4: GPC reporting level - BASIC sources

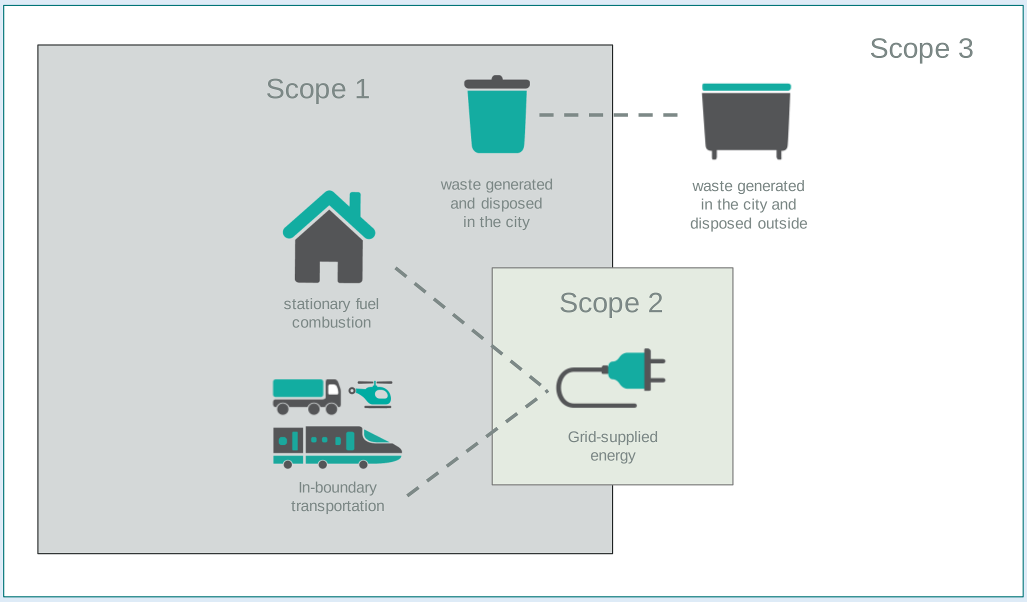
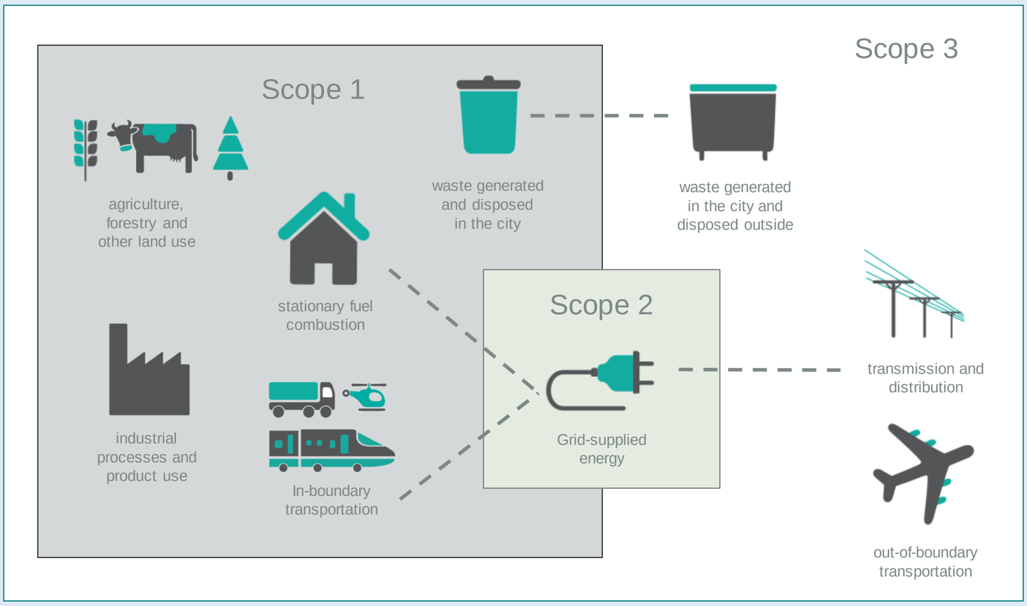


Figure 5: GPC reporting level - BASIC+ sources



Emissions can also be reported on a **territorial** basis. As policy makers and national authorities might seek to aggregate several sub-national emission inventories to create a national-level system, a mechanism has been included to facilitate this and it is known as "territorial" accounting. Only scope 1 emissions are aggregated from cities without overlapping geographic boundaries to build this aggregate result without double-counting any emissions sources. For more information on territorial accounting, see Figure 4.1 in the GPC.

Data sources sheet

The *Data sources* sheet records **where data used in the inventory have come from**, as well as relevant information associated with the data. The GPC stipulates that data sources should be documented. This aims to ensure that the inventory is transparent, and that users and future inventory compilers understand where the data have come from.

> "All data sources used and assumptions made when estimating GHG emissions, whether through scaling, extrapolation, or models, will need to be referenced to ensure full transparency" (GPC, p.52)

The *Data sources* sheet is comprised of a table which is used to record all the data sources used to compile the inventory. References provided in the "Name of source" column may be used to select the relevant data sources later, in the emission factors and sector sheets.

How to use this sheet

Users need to populate the data source table, using the fields described in **Table 9**.

Most fields allow the user to type in free-text. Some fields require the user to select from a drop-down list (e.g. period, frequency, scale). The number of rows needed can be specified using the drop-down list to the left of the table: see Common table structure and function in this guide.

Data can be gathered from a variety of sources, including government departments and statistics agencies, a country's national GHG inventory report, universities and research institutes, scientific and technical articles in environmental books, journals and reports, and sector experts/stakeholder organizations. In general, it is preferable to use local and national data over international data, and data from publicly-available, peer-reviewed and reputable sources, often available through government publications.

Key terms

Descriptions of key terms used in this sheet are presented in **Table 9**.

Table 9: Information needed to populate the data sources table

Column title	Description	Example
Data	Give the data a short description. This helps to identify what information is being taken from the data source listed.	"Electricity Emission factors"
Name of source	The name of the source from which the data comes from, such as the report, website, statistical report. This will be used to identify the data source in other sheets of CIRIS.	"National emissions factor database"
Provider	This should state where the data comes from. For example, the department or organisation who supplies the data.	"Ministry of the Environment"
Latest year	Select the year which the data covers.	"2014"
Period	Identify the length of time that the data covers; this is most likely to be calendar or financial year. If other, ensure this is specified.	"Calendar year"
Frequency	Indicate how often the information is updated. This is useful when reporting future inventories.	"Annual"
Scale	Document whether the data refers to local, metro, regional, national, international or another scale. If other, ensure this is specified.	"National"

Column title	Description	Example
	This is important because it affects the Quality Assessment, e.g. internationally-sourced activity data is considered to be low quality.	
Link	Provide a link to where the information can be found online. This helps to ensure users and future compilers are able to find, check and update the information in future.	“www.ipcc-nggip.iges.or.jp/EFDB/main.php”

Common challenges and recommendations

Common challenge

It can often be challenging to report all the supporting information on the data sources used in the inventory in full. The source, references, a description of the source or emission factor, year and scale (local, national, international) are sometimes hard to find if data is from unpublished sources or found online. It is important for transparency purposes that as much information is completed as possible, so that both external audiences and future inventory teams can easily trace information.

Recommendations

- Complete as much as possible, but prioritise the columns for *Data, Name of Source, Provider and Year*
- Use consistent naming approaches and avoid acronyms, e.g. ‘Ministry of Industry’ not MOI.
- If a source is not in the public domain, use ‘unpublished’ or ‘not available’ in the ‘link’ column rather than leaving blank
- If a data set or does not have a year clearly defined, trace the source, website, or look in the text for any information that may allow a guess at the year of publication. E.g. if data is shown annually to 2012, the source may be 2013
- Note any data that is confidential, even if it is not possible to report the source. For example, stating “confidential data on industrial energy consumption” under ‘Data’ and “Confidential” under source/provider as required

Worked example

Figure 6 gives an example of how the *Data sources* sheet should be completed.

Figure 6: Data sources sheet worked example

Give a very **brief description** of what the data source is.

Document the **provider** of the data.

Select the period that the data source covers – calendar year, financial year, or other (e.g. N/A if default emission factors). Ideally, the period will match the reporting period of the inventory.

Document the scale of the data. Is it an international default, data from the national inventory, or local consumption data?

Data	Name of source	Provider	Latest year	Period	Frequency	Scale	Link
EXAMPLE: Emission factors	*National emissions factor database*	*Ministry of the Environment*	*2014*	*Calendar year*	*Annual*	*National*	*www.ipcc-nggip.iges.or.jp/EFDB/main.php*
Natural gas stationary consumption	Natural gas operational data - Distribution	ENARGAS	2006	Calendar year	Monthly	Local	http://www.enargas.gov.ar/DatosOper/Indice.php
Fuel emission factors	2006 IPCC Guidelines for National Greenhouse Gas Inventories	IPCC	2006	NA	As required	International	http://www.ipcc-nggip.iges.or.jp/public/2006gl/
Fuel consumption in the transport sector	Transport Fuel Sales	Secretariat of Energy	2015	Calendar year	Annual	Local	http://www.energia.gov.ar/contenidos/verpagina.php?idpagina
CNG sold for transportation in the city	Annual statistics Report	Treasury Secretariat - GCBA	2014	Calendar year	Annual	Local	http://www.buenosaires.gob.ar/areas/hacienda/sis_estadistico

Name the data source – this name will be selected from a drop-down list in the 'source' columns in the *Emission factors* and the inventory sheets.

Document the latest year of the data source. For additional information (e.g. population) and activity data, you should aim for this to be the same as the inventory year.

- Default emission factors (e.g. from the IPCC) are not year-specific so will likely be from the 2006 IPCC guidelines.
- Some emission factors, such as electricity factors, are year-specific. Ideally, these factors will be for the same year as the inventory year.

Document how frequently the data is available (e.g. monthly, quarterly, annual).

If possible, **insert a web link** of where the data can be accessed.

Emission factors sheet

The *Emission factors* sheet is used to record the **emission factors** used to estimate the emissions for the inventory. Disclosing all information associated with emission factors improves transparency and allows emission factors to be verified.

How to use this sheet

All fields in the *Emission factors* table should be filled in. Columns labelled ‘type’, ‘GWP’, ‘Units’, ‘Data quality’, ‘Year’, ‘Scale’, and ‘Source’ require the user to select an appropriate answer from the drop-down lists. Columns which are highlighted grey (for example, tCO_2e, $CH_4\_tCO_2e$, $N_2O\_tCO_2e$) are auto-populated by CIRIS. The text in the 'Reference' column is used in the sector sheets (through drop-down lists) to identify the relevant emission factors.

Key terms

Emission factors convert activity data into a mass of GHG emissions. Emission factors should be relevant to the inventory boundary, specific to the activity being measured, and sourced from credible government, industry, or academic sources. If no local, regional, or country-specific sources are available, cities should use IPCC default factors or data from the CIRIS Emission Factor Database, or other standard values from international bodies that reflect national circumstances.

E.g. tonnes of CO_2 released per kilometre travelled or the ratio of CH_4 emissions produced to amount of waste landfilled.

Descriptions of the key terms within the *Emission factors* sheet are presented in **Table 10**.

Table 10: Information needed to populate the *Emission factors* sheet

Column title	Description
Fuel type or activity	Document the type of fuel or the activity
Unique Identifier	Provide a sensible reference for the emission factors that will be used to identify the relevant emission factors in the sector sheets.
Type	Select either “GHG” or “CO_2e” (CO_2 equivalent). • Select GHG if the emission factor converts activity data to an amount of a particular gas, not taking into account the GWP of the gas • Select CO_2e if the emission factor has already multiplied the quantity of gas emitted by a GWP in order to convert it into a common unit This is required because if the factor is identified as a GHG factor, CIRIS will automatically convert to a CO_2e factor using the specified GWP. Note that most default emission factors such as those provided by the IPCC are GHG factors, but some, such as the UK Defra emission factors, are already converted to CO_2e.
GWP	Global warming potential (GWP) allows for the conversion of different GHGs (e.g. CH_4 and N_2O) to CO_2e. Individual GHGs should be converted into CO_2e by multiplying by the 100-year GWP coefficients in the latest version of the IPCC Guidelines or the version used by the country’s national inventory body. The relevant GWP is selected in this column. This should be consistent throughout the inventory.
Units	Select the appropriate units for the emission factor. For example, *kilograms* of GHG per *litre* of fuel.

Column title		Description
Convert to tonnes		This column automatically converts to tonnes using the pre-populated conversion factor in this cell
Emission factor	CO_2	Amount of CO_2 produced (depending on units of emission factor) per unit of activity
	tCO_2e	Tonnes of CO_2 produced per unit of activity • Amount of CO_2 is converted to tonnes using conversion factor from 'convert to tonnes' column
	CH_4	Amount of CH_4 produced (depending on units of emission factor) per unit of activity
	CH_4_tCO_2e	Tonnes of CH_4 as CO_2e produced per unit of activity • If the emission factor 'type' is GHG, the amount of CH_4 is converted to CO_2e using GWP selected from 'GWP' column • Amount of CH_4 as CO_2e converted to tonnes using conversion factor from 'convert to tonnes' column
	N_2O	Amount of N_2O produced (depending on units of emission factor) per unit of activity
	N_2O_tCO_2e	Tonnes of N_2O as CO_2e produced per unit of activity • If the emission factor 'type' is GHG, the amount of N_2O is converted to CO_2e using GWP selected from 'GWP' column • Amount of N_2O as CO_2e converted to tonnes using conversion factor from 'convert to tonnes' column
	Total CO_2e	Total CO_2e produced per unit of activity – should include CH_4 and N_2O emissions, as well as CO_2. If the user has already entered these three gases individually, the total CO_2e does not need to be manually entered.
	tCO_2e	Total tonnes of CO_2 produced per unit of activity
	CO_2(b)	Emissions from the combustion of biogenic CO_2 must be reported separately from fossil CO_2, and not included in overall GHG emissions. See Box 4 on biogenic CO_2.
	tCO_2(b)	Tonnes of CO_2(b) produced per unit of activity. See Box 4 on biogenic CO_2.
Data quality		The GPC requires cities to provide an assessment of data quality for all emission factors used in the estimation of emissions, following a high-medium-low rating. Emission factors are regarded as: • *High (H)* if they are city-specific • *Medium (M)* if they are more general (e.g. country-specific) • *Low (L)* if they are default factors (e.g. IPCC emission factors)
Year		Select the temporal boundary of the emission factor (which year the emission factor relates to)
Scale		Select the physical boundary of the emission factor (whether it is city-specific estimation or covers a regional, national or supranational grid)
Description		Short summary of the emission factor, including what is covers and any relevant features, e.g. "average grid emission factor for Australia".
Source		Select the emission factor source from the drop-down menu; the drop-down menu is linked to the 'Name of source' column in the Data Sources tab.

Common challenges and recommendations

The main challenge is around transparency and the ability to complete all relevant information associated with the emission factors being used.

Common challenge 1

The source, reference, description, year and scale (local, national, international) of emission factors might be difficult to complete.

Recommendations

- Complete as much as possible! Prioritise the key information, such as source naming and units. Ensure all this information is documented appropriately wherever possible, and refer back to the source of the information if unsure
- If the source is not reliable, consider alternative sources such as the Emission Factor Database

Common challenge 2

The GWPs used in reported emission factors might not be known, e.g. where emission factors are already provided as CO_2e, or the emission factors are not specified as CO_2e or GHG.

Recommendations

- Where possible, use emission factors from widely-recognised and reputable sources to allow verification of the emission factors
- Consult guidance related to any tools or data sources used to determine which GWPs were used in the calculation and the scope of the factors. Send an enquiry if still unclear
- If emission factors are provided by data suppliers such as industries or energy companies, ensure that information is also requested on the GWPs used if they are provided as CO_2e
- Compare emission factors with those form sources such as the IPCC (GHG factors) and calculate backwards to work out the GWP

Common challenge 3

Emission factors provided might not compatible with the GPC, i.e. they do not provide all gases separately, or are 'lifecycle' emission factors.

Recommendations

- Total CO_2e factors can be used if there are no other suitable emission factors available, but it is encouraged in future inventories to report emission factors by individual gas
- Consulting the source of lifecycle emission factors to identify the components in the calculation process. See if any can be removed, e.g. separating transportation elements from waste emission factors. If this is not possible then use of alternative emission factors is recommended

Common challenge 4

Only CO_2 factors might have been provided, CH_4 and N_2O are missing.

Recommendations

- Consult data providers for the 'missing' local or national emission factors for activities. This might be national inventory compilers, or local energy companies
- Default emission factors can be obtained from the CIRIS Emission Factor Database (EFD)
- Country-specific electricity emission factors can be obtained from IEA data, available for many countries at www.emissionfactors.com

Box 4: Biogenic CO_2

Biogenic emissions are those that result from the combustion of biomass materials that naturally sequester CO_2, including materials used to make biofuels (e.g. crops, vegetable oils, or animal fats). For the purposes of national level GHG inventories, land-use activities are recorded as both sinks and sources of CO_2 emissions. Reporting emissions from combusting these biogenic fuels would result in double counting on a national level. The GPC also records land-use changes, and combusted biofuels may be linked to land-use changes in its own inventory, or other cities' inventories (Box 4.2 of the GPC).

Worked example

Figure 7 gives an example of the *Emission factors* sheet.

Figure 7: Worked example from Emission factors sheet. The table is split for display purposes.

Input the fuel type or activity to which the emission factor refers

Choose a reference for the emission factor – this will be used later in the tool to identify the factor out of a list so must therefore be sufficiently unique to make it simply to identify.

Select whether the factor type is CO_2 equivalent (CO_2e) or greenhouse gas (GHG). Choosing CO_2e means the emissions require no further conversion. GHG on the other hand must be transformed to CO_2e.

Select the units that the source data is recorded in. This ensures that any conversion will be accurate.

	Fuel type or activity	Unique identifier	Type	GWP	Units	Convert to tonnes
40	*EXAMPLE: Natural gas*	*EF_Natural gas*	*CO2e*	*5AR*	*kg / kWh*	*0.001*
	Residential Diesel Oil	EF_Residential_diesel_oil	GHG	4AR	kg / TJ	0.001
	Residential LPG	EF_Residential_LPG	GHG	4AR	kg / TJ	0.001
	Residential Kerosene	EF_Residential_kerosene	GHG	4AR	kg / TJ	0.001
	Electricity	EF_Electricity	CO2e	4AR	kg / kWh	0.001
	Commercial Diesel Oil	EF_Commercial_diesel_oil	GHG	4AR	kg / TOE	0.001
	Commercial LPG	EF_Commercial_LPG	GHG	4AR	kg / TOE	0.001
	Commercial Kerosene	EF_Commercial_Kerosene	GHG	4AR	kg / TOE	0.001
	MSW Emissions	EF_MSW	GHG	4AR	t / t	1

Cities should select the Assessment Report from which they extracted the Global Warming Potentials (GWP) they used, to ensure conversion to CO_2 is consistent in CIRIS.

This cell is auto-populated and simply shows what conversion is necessary to get the source data into tonnes. Kg here, for example, must be multiplied by 0.001.

These values are for biogenic CO_2 emissions. This is CO_2 emitted from the combustion of material that when grown naturally sequesters CO_2, to avoid double counting nationally or between other cities, these values are therefore not included in the totals.

White cells here are for entering the specific emission values for the various GHGs.

Fuel type or activity		Emission factor									
		CO_2	tCO2e	CH_4	CH4_tCO2e	N_2O	N2O_tCO2e	Total CO_2e	tCO2e	CO_2(b)	tCO_2(b)
EXAMPLE: Natural gas		*0.4822*	*0.0004822*	*0.003*	0.000003	*0.0029*	0.000003	*0.4881*	*0.000488*	*0.09644*	*0.00009644*
Residential Diesel Oil		74100.0000	74.10	10	0.25	0.6	0.18				
Residential LPG		63100	63.10	5	0.13	0.1	0.03				
Residential Kerosene		71900	71.90	10	0.25	0.6	0.18				
Electricity		0.78879576	0.00	0.000686047	0.00	0.001577667	0.00				
Commercial Diesel Oil		3102.418795	3.10	0.0251208	0.00	0.0251208	0.01				
Commercial LPG		2641.870796	2.64	0.20934	0.01	0.0041868	0.00				
Commercial Kerosene		3010.309195	3.01	0.418679999	0.01	0.0251208	0.01				
MSW Emissions		0	0.00	0.000813348	0.02	0	0.00			0.009150161	0.009150161

Grey cells here are auto-populated; they show the CO_2 equivalent values for inputted non-CO_2 gases.

Provide a description of the data quality: High (H), Medium (M), or Low (L)

Choose which year the emission factor applies to.

Briefly describe the emission factor, what it covers and any important information not already explicit – e.g. the methane content for the municipal solid waste emissions.

Data quality	Year	Scale	Description	Source
H	*2014*	*National*	*Emission factor for grid-supplied natural gas*	*National emissions factor database*
L	2006	International	International default for Residential sector - Gas/Diesel Oil	IPCC 2006 Guidelines
L	2006	International	International default for Residential sector - Liquified Petroleum Gas	IPCC 2006 Guidelines
L	2006	International	International default for Residential sector - Other Kerosene	IPCC 2006 Guidelines
M	2012	National	Calculated Implied Emission Factor for Supply from IEA Energy Balance data and Electricity Generation Statistics	IPCC 2006 Guidelines
L	2006	International	International default for Commercial sector - Gas/Diesel Oil	IPCC 2006 Guidelines
L	2006	International	International default for Commercial sector - Liquified Petroleum Gas	IPCC 2006 Guidelines
L	2006	International	International default for Commercial sector - Other Kerosene	IPCC 2006 Guidelines
M	2006	Local	Calculated implied emission factor per tonne MSW from Methane Commitment Method, with known methane content of gas 55%, waste composition (2010 study) and methane capture from the site at 1200m3/hr. No approach for estimating N2O using this methodology. CO2(b) assumed to be equivalent to 45% of remining gas emitted	GAM waste treatment department document

Select which scale the emission factor covers: Local, Metro, Regional, National or International.

Sources have been selected from the drop-down list, which is linked to the *Data sources* sheet.

IPPU Emission factors sheet

The *IPPU Emission factors* sheet is used to document emission factors used to calculate F-gas emissions for IPPU activities; this is necessary for a fully-compliant BASIC+ GPC inventory. Emission factors used to calculate emissions in the *IPPU* sheet should be entered in the *IPPU Emission factors* sheet, rather than the *Emission factors* sheet.

How to use this sheet

This sheet is filled out in the same way as the *Emission factors* sheet. The only difference is that there are more gases to consider.

Key terms

Table 11 gives an overview of some terms, additional to those covered in the *Emission factors* section, which need to be understood in order to complete this sheet.

Table 11: Key terms used in *IPPU Emission factors* sheet

<table>
<tr><th>Term</th><th>Description</th><th>Example</th></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td>F-gases</td><td>The gases listed in this sheet are fluorinated gases, or F-gases. F-gases are a group of man-made gases used in a range of industrial applications. They are often used as substitutes for ozone depleting substances.</td><td>Tokyo reported total emissions of all F-gases which included HFCs from refrigerators, air conditioning, foam materials, aerosols, and fire extinguishing, and SF_6 from voltage inverters.</td></tr>
<tr><td>HFCs</td><td>GHGs beginning with HFC are known as hydrofluorocarbons (e.g. HFC-41).</td><td rowspan="2">Bogotá reported HFCs and PFCs from the use of substitutes for ozone depleting substances for refrigeration and air conditioning</td></tr>
<tr><td>PFCs</td><td>CF_4 and C_2F_5 are the PFCs, or perfluorocarbon gases listed in the CIRIS tool.</td></tr>
<tr><td>SF_6</td><td>Sulfur hexafluoride is an F-gas</td><td rowspan="2">SF_6 and NF_3 are less common than other F-gases and are most frequently emitted by fluorochemical production, magnesium production, and in the production of electronic equipment.</td></tr>
<tr><td>NF_3</td><td>Nitrogen trifluoride is an F-gas</td></tr>
</table>

Common challenges and recommendations

Common challenge

A common problem for BASIC+ activities is sourcing the relevant emission factors. If an activity is occurring in the city, then identifying an appropriate emission factor to report it is important.

Recommendations

- Check with the industry in question to see if they have an emission factor for the plant/facility/process. They may have had to report this information to national government or other bodies
- The IPCC Guidelines contain a large number of default emission factors for many processes and products
- Consulting national inventory compilers and national inventory reports can be helpful
- If the activity cannot be reported using activity data and an emission factor then simply report the emissions data directly in CIRIS

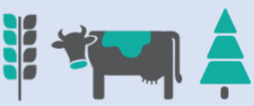
Worked example

Refer to **Figure 7** for how to complete an E*mission factors* sheet.

Part 2: Inventory Tab

The *Inventory* tab contains sheets for estimating emissions from each sector: Stationary energy, Transportation, Waste, Industrial processes and product use (IPPU), Agriculture, forestry and other land use (AFOLU), and Scope 3 emissions. **Table 12** contains more information on each sector and examples of emission sources.

Table 12: Sector sheets

Sheet	Description	Examples of sources
Stationary energy 	Used to record activity and emissions data for **stationary energy sources**. Stationary energy sources are one of the largest contributors to a city's GHG emissions. These emissions come from direct fuel combustion in buildings and industries, indirect use of grid-supplied electricity or heat, as well as fugitive emissions released in the process of generating, delivering, and consuming energy.	• Coal used for domestic heating • Bottled gas used for domestic cooking • Grid-supplied electricity • Natural gas use by sub-sector • Energy Generation • Electricity Transmission & Distribution losses
Transportation 	Used to record activity and emissions data for **transportation** sources. Transportation sources are another large contributor to a city's GHG emissions. Transportation covers all journeys by road, rail, water and air, including inter-city and international travel. GHG emissions are produced directly by the combustion of fuel or indirectly by the use of grid-supplied electricity.	• Gasoline used by cars • Diesel used by commercial vehicles • Km travelled per passenger by aeroplane • Grid-supplied electricity used by a metro rail system
Waste 	Used to record activity and emissions data for **waste** sources; this includes solid waste and wastewater. Waste can be disposed of and/or treated at facilities inside or outside of the city boundary. Waste disposal and treatment produces GHG emissions through aerobic or anaerobic decomposition, or incineration.	• Municipal solid waste disposed at managed landfill sites • Wastewater treatment • Industrial waste incineration • Waste sent to composting plants
IPPU 	Used to record activity and emissions data from non-energy related **industrial activities** that occur within the city boundary, and **products used** with the city boundary. Scope 3 emissions of IPPU are not yet covered in GPC's assessment boundary.	• Blast furnace emissions in the iron and steel industry • Use of air conditioning units • Use of electronics containing F-gases
AFOLU 	Used to record activity and emissions data from **agriculture, forestry** and **other land use**. This covers GHG emissions from activities including land-use changes that	• Forest management • Amenity land management (e.g. golf courses) • Livestock farming

Sheet	Description	Examples of sources
	alter the composition of the soil, methane produced in the digestive processes of livestock, and nutrient management for agricultural purposes. Scope 3 emissions of AFOLU are not yet covered in GPC's assessment boundary.	• Manure management • Use of fertilisers • Crop production
Other Scope 3 	Used to record activity and emissions data for **any other emissions** occurring outside the geographic boundary as a result of city activities. Measuring these emissions allows cities to take a more holistic approach to tackling climate change by assessing the GHG impact of all city activities, particularly emissions embodied in the supply chain of goods and services used by city residents.	• Supply chain emissions from city resident's consumption of food and drink • Supply chain emissions from construction • Any other emissions attributable to the city, but not occurring within the city boundary

Inventory tab instructions

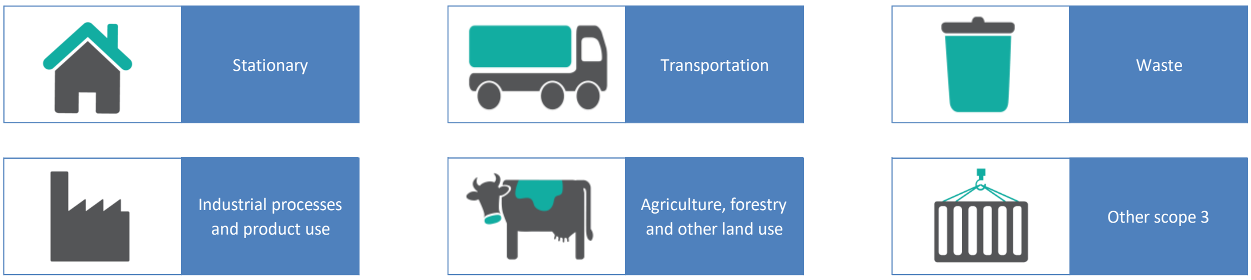
The first inventory tab page contains instructions on how to use the inventory sheets to estimate emissions (**Table 13**). For more information on how to complete these steps, see **Table 14** and the sheet-specific sections of this document.

Table 13: Inventory tab instructions

1.	Choose a sector. *Stationary*, *Transportation* and *Waste* must be completed for a BASIC inventory. *IPPU* and *AFOLU* are additional required for a BASIC+ inventory. Select a sector from the main menu at the top of the page, by selecting the graphic on the *Inventory* tab (**Figure 8: Inventory sectors**) or by selecting the relevant sheet from the worksheet tabs at the bottom of the page.
2.	Each sector is broken down by sub-sector and scope, using the GPC referencing system. Grey cells contain formulas; please do not modify the grey cells.
3.	Select the number of rows you will need from the drop-down list under 'Add'. You will need to do this for each emission category (sub-sector / scope).
4.	For each sub-sector, select an activity from the drop-down list e.g. natural gas. If your activity does not appear in the drop-down list, please enter this is in yourself.
5.	For the Stationary sector you will also need to select a sub-category; for Transportation the boundary system methodology; and for the Waste sector the type of waste.
6.	If data are not available for an emission category (sub-sector/scope), notation keys should be used. Select the appropriate notation key from the drop-down list (see Reporting requirements, key terms).
7.	Next, enter the activity data in the 'Activity data' column, including the amount and the units. If the units are different to the denominator of the emission factor used, use the activity data unit converter function to convert to the appropriate unit.
8.	To use the activity data unit converter, select the unit you wish to convert your activity data into. Alternatively, you can enter your own conversion factor in the override column.
9.	Select the greenhouse gases included in your calculations from the drop-down list.
10.	Select an emission factor from the drop-down list. These are the ones that have been defined in the *Emission factors* sheets. They are shown here in tonnes of CO_2e.

11.	Alternatively, if you do not have an emission factor for a specific activity, you may enter emissions data directly; to do so, select the ✓ in the 'Emissions data' column and then manually fill out the 'GHGs (metric tonnes CO_2e)' columns. Make sure this is reported in metric tonnes of CO_2e.
12.	The oxidation factor for combustion has been set to 1. This appears in the Oxidation factor column when you enter data. Use the override column to input a different value.
13.	CIRIS then calculates emissions based on the data submitted, in metric tonnes of CO_2e.
14.	Assess the quality of your activity data in the Data quality column. Choose from high, medium or low. You can provide an optional explanation in the final column.
15.	You must also provide a clear description of the methodologies you have used, and explanation for using notation keys.
16.	Finally, select a data source from the drop-down list which lists all the references you defined in the *Data sources* sheet.
17.	Repeat the above process for all emission sources in your city.
18.	Your estimated emissions can be found in the Results section.

Figure 8: Inventory sectors



Reporting requirements, key terms and how to use this sheet

There are a number of key terms and reporting requirements to be aware of to complete the sheets in the inventory tab; these are presented and explained in **Table 14**. Instructions on how to complete the sheets are also given.

Table 14: Reporting requirements and key terms for Inventory tab sheets

Column headings/ key terms	Description	Example	Reporting Requirement	Further information
GPC ref No.	A reference number for identifying the sector, sub-sector and (usually) the scope.	**I.1.1** indicates emissions from: **I** – *Stationary energy* **1** – *Residential buildings* **1** – *Emissions from fuel combustion within the city boundary (scope 1)*	• CIRIS is pre-populated with the GPC ref No. • Emissions should be estimated for all BASIC sources	List of GPC reference numbers relative to IPCC in GPC: *Table A.3 Comparison of emissions sources categories*
Scope	Activities taking place within a city can generate emissions that occur inside the city boundary as well as outside the city boundary. To distinguish between these, the GPC groups emissions into three categories based on where they occur: **Scope 1:** All GHG emissions from sources located within the city boundary **Scope 2:** All GHG emissions from the use of grid-supplied electricity, steam, heating and/or cooling within the city boundary **Scope 3:** All other GHG emissions that occur outside the city boundary as a result of activities within the city boundary	See ***Table*** 8	• Emissions from all scope 1 and 2 sources must be reported • Only scope 3 waste (disposed out of boundary) is required for BASIC	Full explanation of scopes in GPC: *Table 3.2 Scopes definitions for city inventories*

Column headings/ key terms		Description	Example	Reporting Requirement	Further information
GHG Emissions source	*Sub-category*[1]	Select the particular IPCC sub-category from any options provided to more specifically indicate the sources of emissions. When there are no alternatives to select, the sub-category will be auto populated, e.g. for I.1 Residential Buildings – the sub-category Residential (1.A.4.b) is automatically populated. See Table 2.1 - Stationary Combustion - Vol. 2 Energy - 2006 IPCC Guidelines	I.4 Energy Industries sub-categories: • Electricity generation (1.A.1.a.i) • Combined heat and power generation (1.A.1.a.ii) • Heat plants (1.A.1.a.iii) • Petroleum refining (1.A.1.b) • Manufacture of solid fuels (1.A.1.c.i) • Other energy industries (1.A.1.c.ii)	Select a sub-category from the drop down list	
	Method[2]	Select the method used to estimate emissions from transportation sources. There are four methods outlined in the GPC: 1. **Fuel sales:** the volume of fuel purchased within the city 2. **Induced activity:** in-boundary trips and 50% of transboundary trips that originate or terminate within the city boundary	**Paris** chose to use the fuel sales approach for estimating emissions from electric railways, the city-induced activity approach for emissions from freight rail (allocation 50% of all freight rail entering and leaving Paris), and the geographic approach when estimating emissions from road transport sources	Users must select a method from the drop-down list	Full explanation in GPC: *Figure 7.2 Boundary types and scopes allocation*

[1] Only applicable for I. Stationary sheet
[2] Only applicable for II. Transportation sheet

Column headings/ key terms		Description	Example	Reporting Requirement	Further information
		3. **Geographic:** all on-road travel occurring within the geographic boundary 4. **Resident activity:** a measurement of the transport activities of city residents			
	Treatment activity[3]	The treatment activity that is applied to the waste. This varies depending on the type of waste that is being disposed of. For III.1 Solid Waste Disposal, the two different accounting methodologies for landfill sites are also included: Methane commitment (MC) and first order of decay (FOD).	III.1 Solid Waste Disposal: • Landfill sites – Methane Commitment • Landfill sites – First order decay • Other managed waste disposal site(s) • Unmanaged waste disposal sites • Uncategorised waste disposal sites	Users must select a treatment activity from the drop-down list	Full explanation of different accounting methods for landfill sites and more information on waste treatment in GPC: *Section 8.3: Calculating emissions from solid waste disposal*
	Type of waste[4]	Select the type of waste that is being treated. The CIRIS tool deals with the following waste types: 1. All waste 2. Municipal solid waste 3. Sludge 4. Industrial waste	• **London** reported emissions for 'all waste' types as the waste model aggregated data from all waste types • **Madrid** reported emissions from municipal solid waste and organic waste	Users must Select a waste type from the drop-down list	

[3] Only applicable for III. Waste sheet
[4] Ibid.

Column headings/ key terms		Description	Example	Reporting Requirement	Further information
		5. Other (this must be specified)			
	Industry[5]	The main industrial subsector that the source activity refers to, in other words the type of industry being reported.	For IV.1 Industrial Processes: • All industrial processes • Mineral • Chemical • Metal • Other	Users must select an industry from the drop-down list	
	Industrial process[6]	This is the particular industrial process being reported. For IV.1 Industrial Processes this will largely be choosing what is being produced, for IV.2 Product Use it is the application of a product.	For IV.1 Industrial Processes – Industry: Metal: • Iron and steel production (2.C.1) • Ferroalloy production (2.C.2) • Aluminium production (2.C.3) • Lead production (2.C.5) • Zinc production (2.C.6) • Other (2.C.7)	Users must select an industrial process from the drop-down list	
	Activity	This should specify the fuel type or activity that results in GHG emissions.	To report emissions from domestic LPG use, the fuel/activity stated will be ‘Liquefied petroleum gases (LPG)’	Users must select the activity from the drop-down list. Fuels or activities not listed can be added manually	

[5] Only applicable for IV. IPPU sheet
[6] Ibid.

Column headings/ key terms	Description	Example	Reporting Requirement	Further information
Description	This should provide a summary of the GHG emissions source and any clarifications required, explaining the activity or fuel use and any context needed.	E.g. “use of coal for domestic heating in non-gas connected areas of the city” E.g. “metro rail system – airport line”	Users must provide a brief description of the activity that is producing GHG emissions	
Notation keys	To ensure a complete and transparent inventory, notation keys are used so that exclusions can be clearly identified and justified. Notation keys help reviewers understand why no data is reported. Notation keys are: **Included Elsewhere (IE):** The category that the emissions *are* included in should be noted in the explanation. **Not Estimated (NE):** Justification for exclusion shall be noted in the explanation **Not Occurring (NO):** an activity or process does not occur or exist within the city **Confidential (C):** emissions which could lead to the disclosure of confidential information and can therefore not be reported.	London reported emissions from electric vehicles as **IE**; it was not possible to disaggregate these emissions from domestic/commercial energy use. Instead, emissions from this source were included in total electricity consumption reported under I.1.2 and I.2.2. Many cities currently report emissions from IPPU and AFOLU sources as **NE** as they are not a requirement of a BASIC inventory. Amman used **NO** for II.3 Waterborne Navigation and explained that there were no waterways in the city. **C** is most relevant to IPPU sector and for military sources	Users must select an appropriate notation key if there is no data reported, and include an explanation. Note: • NE must NOT be used for BASIC sources • NO can be used for very insignificant sources if clearly justified • If IE is used, a description of where the emissions are reported must be included	Full descriptions of all notation keys are given in the **Notation** Keys section of this guide.

Column headings/ key terms		Description	Example	Reporting Requirement	Further information
Activity data	Amount	The amount of fuel/activity that has produced emissions within the inventory boundary.	• 2,863,752 litres • 32,954,338 Kwh • 83,950 tonnes • 4,856,245 km	Amount of activity data (and unit) should be reported for each source of emissions	
	Units	The unit that the activity data is measured in.	• Litres (of diesel) • Kwh (of electricity) • Tonnes (of coal) • vkm (vehicle km travelled)	Activity data units must match the emission factor numerator	
Activity data unit converter		The activity data unit converter cells convert activity data into the same units as the emission factor. The activity data unit converter uses pre-populated conversion factors which will be auto-populated in the 'Default' column. This requires the following: • the Activity Data 'Unit' column must specified using the drop-down list • the 'EF Unit' column must specify the emission factor unit, corresponding to the emission factor to be used If the units required are not pre-populated, 'not available' will be displayed. The 'Override' column can then be manually populated to specify the unit converter.	• From GWh to KWh, the conversion factor will be 1000000. • From m3 to TJ, the factor will be 0.026. • From kg to Ml there is no built in conversion factor, so the factor 1000 is manually added into the override column.	Users should use the activity data unit converter to convert the activity data unit to match the unit of the emission factors	

Column headings/ key terms	Description	Example	Reporting Requirement	Further information
Gas(es)	The GHG emissions being reported for each activity.	A BASIC inventory shall report CO_2, CH_4 and N_2O for each activity in Stationary Energy and Transportation. Solid waste, Anaerobic digestion and Wastewater produce CH_4 and N_2O (plus biogenic CO_2). Incineration produces CO_2 (non-biogenic), CH_4 and N_2O. IPPU sources reported in a BASIC+ inventory will include additional gases, for example use of air conditioning produces F-Gas emissions so these should be specified	Users must select the emissions being reported for each activity from the drop-down list.	GHGs included in the GPC are explained in **Box 2.**
Emission factor	Emission factors convert activity data into a mass of GHG emissions. Select the appropriate emission factor from the drop-down list. This is linked to the 'Reference' column of the *Emission factors* sheet (and the *IPPU Emission factors* sheet if used). Once selected, the grey emission factor cells will populate using the relevant emission factors and will also specify the units.	• Tonnes of CO_2 released per kilometre travelled • Ratio of CH_4 emissions produced to amount of waste landfilled	Users should specify the emission factors used in the calculation, using the drop-down list (populated in the *Emission factors* sheet)	
Oxidation factor	Oxidation factors account for the amount of carbon that is actually	Quito used the country's national inventory to support	Optional, and not required for most users.	

Column headings/ key terms	Description	Example	Reporting Requirement	Further information
	oxidised when combustion occurs. The default oxidation factor is assumed to be 1, unless cities have more accurate information available. This is optional and is not a GPC requirement.	their GPC inventory, and the national inventory reported oxidation factors for each fuel. Quito therefore incorporated this into their emission calculations to improve accuracy and compatibility with their national inventory.		
Emissions data	If data has been supplied pre-calculated in tonnes CO_2e, this emissions data can be entered directly into CIRIS rather than using the activity data and emission factor calculation functionality. To do so, select the ✓ in the 'Emissions data' column. Note that it is good practice to still report activity data if available.	Paris reported emissions data from electric buses, metro, trams and Paris' RER (ground-level commuter train connecting suburbs of Paris to central Paris). The emissions data was obtained from Régie Autonome des Transports Parisiens (RATP) as emissions data, rather than calculated in CIRIS using activity data and emission factors.	Users should select the ✓ in the 'Emissions data' column if manually inputting emissions data	
GHGs (metric tonnes CO_2e)	If entering emissions data directly, manually fill out the 'GHGs (metric tonnes CO_2e)' columns, the titles of which are filled pink. If CIRIS has been used to calculate emissions using activity data selected emission factors, the grey 'GHGs (metric	**Buenos Aires** calculated solid waste emissions from landfill sites using the first order of decay method. As this calculation is complex, the resulting emissions were added manually to CIRIS.	• Cells in columns with pink column headings do not need to be completed if a user has entered activity data and emissions factors. • Users must ensure that manually added	

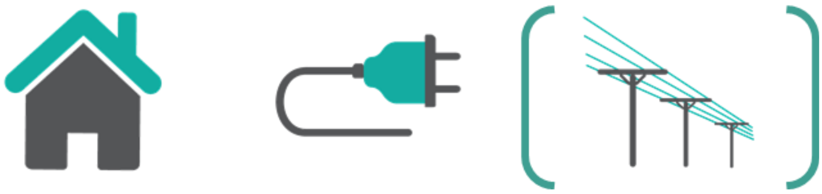
Column headings/ key terms	Description	Example	Reporting Requirement	Further information
	tonnes CO_2e)' cells will be auto-populated.		emissions data is reported in metric tonnes of CO_2e. • CIRIS automatically reports calculated emissions in metric tonnes	
Data quality (AD)	Use this column to record assessment of data quality for the activity data used in quantification of emissions (or for the emissions data directly entered if activity data are not specified). To do so, select from the drop-down list. **High (H)** generally includes detailed city-specific data **Medium (M)** generally includes national data **Low (L)** generally includes international or scaled data	**Gibraltar** reported activity data on end user fuel consumption as H as it was obtained from metered data contained in National Statistics. **Amman** reported national level electricity consumption activity data scaled by population, the data quality was therefore L.	Users must select H, M or L from the drop-down list in the 'Data Quality - AD' column for each source	
Description of method(s) used or explanation for using notation key(s)	This should contain a short summary of methodologies used to calculate emissions. Where emissions have not been reported and a notation key used, this should be explained here.	**London** described their Stationary Energy methodologies, as: "domestic combustion of gas, coal & oil is calculated by summing UK sub-national energy data for London boroughs and multiplying by UK average emission factor for fuel type"	Users should include a description of the methodology for each source estimated, including any assumptions, and/or a justification for the use of a notation key	

Column headings/ key terms	Description	Example	Reporting Requirement	Further information
Source	This column should be used to select the relevant data source used for the calculation. This should be selected from the drop-down list, which is populated in the *Data sources* sheet.	**Mexico City** obtained IPPU emissions data using information derived from Annual Operating Licenses reported to Mexico City's Secretary of the Environment. All details for the source were added to the *Data sources* sheet and the source name could then be selected for the activity.	Users should select the relevant data source from the drop-down list which is linked to the *Data sources* sheet in the Set-up tab	See *Data sources* sheet section in this guide
Data quality explanation (optional)	An explanation of the chosen data quality (H, M, L) is recommended to provide additional transparency and to help a reviewer to understand the chosen data quality	**Sydney** assessed metered data from gas utility companies to be high quality AD as it was city-specific and came from the gas utility company	An explanation of the data quality is optional, but recommended	

Stationary sheet

The *Stationary* sheet is used to record activity and emissions data for stationary energy sources. Stationary energy sources are one of the largest contributors to a city's GHG emissions. These emissions primarily come from fuel combustion. Consumption of grid-supplied electricity, steam, heating or cooling are also reported in this sector. In addition, fugitive emissions released in the process of generating, delivering, and consuming useful forms of energy (such as electricity or heat) are also included.

Figure 9: Stationary energy sources; stationary fuel consumption, grid-supplied electricity, and T&D



For a BASIC inventory, cities shall report all GHG emissions from Stationary energy sources and fugitive emissions in scope 1, and those from use of grid-supplied electricity, steam, heating, and cooling in scope 2.

For a BASIC+ inventory, cities shall report all BASIC sources and scope 3 GHG emissions associated with transmission and distribution (T&D) losses from grid-supplied electricity, steam, heating, and cooling.

Emissions from energy generation supplied to the grid shall be reported as part of total scope 1 emissions, but not included in BASIC/BASIC+ totals.

Fugitive emissions occur during the extraction, processing, storage and transport of fuel to the point of final use.

For most cities, the most common source within the city boundary is leakage from gas distribution (i.e. pipes).

How to use this sheet

The *Stationary* sheet should be filled in following the guidance and description of key terms given in **Table 14**. Users should enter their data and information into the relevant cells for each sector. The Stationary sheet is split into sub-sectors, following the GPC guidelines. These are explained in **Table 15**.

Table 15: Stationary energy sub-sectors

Sub-sector	Definition
I.1 Residential Buildings	All emissions from energy use in households
I.2 Commercial and Institutional Buildings and Facilities	All emissions from energy use in commercial buildings and facilities. All emissions from energy use in public buildings such as schools, hospitals, government offices, highway street lighting, and other public facilities, including waste treatment. The CRF recommends that emissions from commercial and institutional buildings should be reported separately. The sub-category column can be used to for this purpose.
I.3 Manufacturing Industries and construction	All emissions from energy use in industrial facilities and construction activities, except those included in energy industries sub-sector. This also includes combustion for the generation of electricity and heat for own use in these industries, and construction vehicles/plant machinery.

Sub-sector	Definition
I.4 Energy Industries	All emissions from energy production and energy use in energy industries. Examples of energy industries include primary fuel production, fuel processing and conversion, and energy production supplied to a grid.
I.4.4 Energy generation supplied to the grid	All emissions from the use of primary energy sources for the generation of grid–distributed energy (e.g. electricity, steam, heat and cooling). For example, emissions from combustion of natural gas at electricity generation power plants inside the city.
I.5 Agriculture, Forestry And Fishing Activities	All emissions from energy use in agriculture, forestry, and fishing activities (including farm machinery, fishing boats)
I.6 Non-Specified Sources	All remaining emissions from facilities producing or consuming energy not specified elsewhere. This is most commonly military sources
I.7 Fugitive emissions from Mining, Processing, Storage and Transportation Of Coal	Includes all intentional and unintentional emissions from the extraction, processing, storage and transport of coal in the city
I.8 Fugitive emissions from Oil and Natural Gas Systems	Fugitive emissions from all oil and natural gas activities occurring in the city. The primary sources of these emissions may include fugitive equipment leaks, evaporation losses, venting, flaring and accidental releases. Gas distribution is the most common source here.

Tip: It is good practice to further sub-divide sub-sectors if possible. The more disaggregation and detail provided for a city, the more useful and transparent the inventory will be, and the easier it will be to track trends and changes year-on-year. This is dependent on data availability, but even a small portion of the inventory further disaggregated can be useful for policy making.

For example, sub-sector I.2 Commercial and Institutional Buildings and Facilities could be disaggregated into different end users, such as:

Highways & roads Pedestrian Areas	Government Buildings Hospitals	Commercial Office Space Shopping Centers	Parking
Mass Transit	Docks	Navigation Aids	Fire & Police Protection
Water Supply	Waste Collection & Treatment	Public Recreation Areas Sports Centers	Religious Institutions

Things to note

When reporting stationary energy emissions, be aware of the following reporting rules:

All combustion of fuels for Energy is reported under Stationary Energy.

- Includes fuels used in industries for energy, and in waste processing

Some fuels are used in industrial processes for non-energy uses. These are reported in IV. IPPU sector. For example:

- Natural gas is used to produce fertilizer
- Petrochemicals are used to produce plastic

All energy generation to the grid within the city should be reported within the Territorial inventory in I.4.4.

- A grid is any energy (electricity/heating/cooling etc) distributed to, and used in, a geographically different location to the generation site (e.g. a national electricity grid, or a local power station supplying a community 'grid')

Energy generated from waste (e.g. incineration or landfill gas combustion) is reported under Energy Generation not the Waste sector

Vehicles and machinery that directly support sectors on-site are reported in the corresponding Stationary Energy sector not Off-road transportation

- Tractors and farm machinery used in agriculture are reported in I.5 Agriculture, Forestry and Fishing
- Plant vehicles used on construction sites and forklifts used in warehouses are reported in I.3 Manufacturing Industries and Construction

Calculating stationary energy emissions

Emissions from Stationary Energy sources are calculated by multiplying sub-sector specific fuel consumption (activity data) by the corresponding emission factors for each fuel, by gas (**Figure 10**). Typical activity data generally consists of some form of consumption data; this can be real consumption data, a representative sample of real consumption, or modelled energy consumption, which can include national per capita average consumption where there is limited data available. The appropriate emission factor should be selected either from the CIRIS Emission Factor Database or from a city or country-specific source, ensuring that the activity data and emission factor units are consistent with one another.

Figure 10: Calculating GHG emissions

GHG emissions =
Activity data × Emission factor

For specific information on activity data that can be used for calculation emissions for stationary fuel combustion, see **section 6.3** of the GPC.

Common challenges and recommendations

Common challenge 1

Often total fuel consumption data is available in the city. However, disaggregating this across the different sub-sectors ideally requires consumption data by each sub-sector. This breakdown by sub-sector is often not available.

Recommendations

- National Statistics sometimes provide total consumption by main sector – these proportions could be used to allocate total fuel across the sub-sectors
- Allocate consumption data to each sector using, for example, population or GDP. If national per capita consumption is known, this could be used to estimate total residential consumption, likewise national consumption by GDP in commercial and industrial sectors
- If no information is available, then expert judgement could be used through consultations with energy providers, energy industry engineers etc.

Common challenge 2

For a BASIC+ inventory, or just for the most complete reporting, it is good practice to report losses from transmission and distribution (T&D) of electricity as well as emissions associated with the end consumption. However, 'knowing where to start' with estimating this, and reporting losses correctly can be challenging.

Recommendations

- "Loss factors" represent the amount of additional electricity that is 'lost' through the process of transmission and distribution, and is normally expressed as a percentage
- It is best practice to apply the loss factor to the electricity activity data being reported for each sub-sector, e.g. if the loss factor is 6%, the T&D activity data will be 6% of the total consumption
- The emissions can then be estimated using the same electricity grid factor as used for the scope 2 emissions
- Loss factors are available internationally, from the IEA, and are included in the CIRIS emission factor database

Common challenge 3

If the city has gas distribution network then there will be fugitive emissions (of CH_4 and traces of CO_2) from leaks in pipes, but often these are difficult to estimate and overlooked.

Recommendations

- The IPCC 2006 Guidelines provide default emission factors for developed and developing countries, which can be used to estimate fugitive emissions from gas. The IPCC 2006 Guidelines provide multiple factors for venting, flaring, transmission, and distribution – for most cities, the distribution factors are the only ones relevant and can be applied to total consumption data for gas in the city
- CIRIS contains a calculator that supports easy reporting of fugitive emissions from gas if total consumption is known
- It is best practice to obtain locally specific information on average leakage rates from the network if possible, and use these in place of default factors

Common challenge 4

It can be confusing knowing where to report some activities related to ‘vehicles’, such as construction, agricultural tractors, or fishing boats. These are often incorrectly reported under Off-road (II.5) or Waterborne Navigation (II.3) in the case of fishing boats.

Recommendations

- The GPC recommends that these are reported under Stationary energy, under the industry they support – i.e. I.5 Agriculture, Forestry and Fishing, or I.3 Manufacturing Industries and Construction
- The key question to ask is: “does this activity provide *transportation* as its primary aim?” Where ‘vehicles’ are actually operating as equipment in a sub-sector, they are therefore reported under Stationary and not in Transportation

Worked example

Figure 11 gives an example of the *Stationary energy* sheet.

Figure 11: Worked example from the Stationary Energy sheet. The table is shown here in full, then further split below for display purposes.

I.1 RESIDENTIAL BUILDINGS

Enter activity data — Select an emission factor — OR — Enter emissions data

	GPC ref No.	Scope	GHG Emissions Source			Notation keys	Activity data		Activity data multiplier			Gas(es)	Emission factor	Emission factor					Oxidation factor		Emissions data	GHGs (metric tonnes CO₂e)					GHGs (metric tonnes CO₂e)					Data Quality	Description of method(s) used or explanation for using notation key(s)	Source	Data quality explanation (optional)
			Sub-category	Activity	Description		Amount	Units	Unit	Default	Override			Units	CO_2	CH_4	N_2O	Total tCO_2e	$CO_2(b)$	Default	Override		CO_2	CH_4	N_2O	Total tCO_2e	$CO_2(b)$	CO_2	CH_4	N_2O	Total tCO_2e	$CO_2(b)$	AD			
6	I.1.1	1	Emissions from fuel combustion within the city boundary																																	
	I.1.1	1	Residential (1.A.4.b)	Natural gas	Natural gas consumption by residential users reported by the national body for gas regulation		20254	TJ				CO2, CH4, N2O	EF_Natural Gas	tCO2e/kWh	0.0004822	0.000003	0.0000029	0.0004881	0.00009644	1		✓	1702872.992	758.8560574	904.5564204	1704536.405	0	0	0	0	0	0	H	Natural gas billed to residential sector (m3) multiplied by: NG density (t/m3, national data), NCV (TJ/t, IPCC 2006) and NG emission factors (t_GHG/TJ, IPCC 2006)	Natural gas operational data - Distribution	Scaled national data
	I.1.1	1	Residential (1.A.4.b)	Liquefied Petroleum Gas (LPG)	LPG consumption by residential users		369	TJ				CO2, CH4, N2O	EF_Residential_LPG	tCO2e/TJ	63.1	0.125	0.0298			1		✓	23253.76555	9.21306836	10.98196852	23273.96058	0	0	0	0	0	-	L	Estimated based on national consumption multiplied by a proxy based on the population within Buenos Aires city that utilises this fuel divided by the total population of the country (data from the National Institute of Statistics (INDEC) from the 2010 Census)	National energy balance	National energy balance
	I.1.1	1	Residential (1.A.4.b)	Kerosene	Kerosene consumption by residential users		0.054	TJ				CO2, CH4, N2O	EF_kerosene - stationary combustion	tCO2e/TJ	71.5	0.075	0.1788		0	1		✓	3.87101853	0.004060509	0.009680253	3.8847593	0	0	0	0	0	0	L	Estimated based on national consumption multiplied by a proxy based on the population within Buenos Aires city that utilises this fuel divided by the total population of the country (data from the National Institute of Statistics (INDEC) from the 2010 Census)	National energy balance	National energy balance
	I.1.1	1	Residential (1.A.4.b)	Charcoal	Charcoal consumption by residential users		0.087	TJ				CO2, CH4, N2O	EF_wood - stationary combustion	tCO2e/TJ	0	0.75	1.192		112	1		✓	0	0.436406946	0.104039416	0.540446361	9.77551558	0	0	0	0	0	L	Estimated based on national consumption multiplied by a proxy based on the population within Buenos Aires city that utilises this fuel divided by the total population of the country (data from the National Institute of Statistics (INDEC) from the 2010 Census)	National energy balance	National energy balance
	I.1.1	1	Residential (1.A.4.b)	Wood or wood waste	Wood consumption by residential users		0	TJ				CO2, CH4, N2O	EF_wood - stationary combustion	tCO2e/TJ	0	0.75	1.192		112	1		✓	0	0.006450709	0.010252327	0.016703036	0.96330589	0	0	0	0	0		Estimated based on national consumption multiplied by a proxy based on the population within Buenos Aires city that utilises this fuel divided by the total population of the country (data from the National Institute of Statistics (INDEC) from the 2010 Census)	National energy balance	National energy balance
	I.1.1	1	Residential (1.A.4.b)																			✓				0.016703036	0.96330589	-	-	-	0	1				
3	I.1.2	2	Emissions from grid-supplied energy consumed within the city boundary																																	
	I.1.2	2	Residential (1.A.4.b)	Electricity	Electricity consumption by residential users in a year period		4376245976	KWh	MWh	0.001		CO2, CH4, N2O								1		✓	1195270.212	776.4659463	1790.247285	1197837.025	0	1195270	776	1790	1197837	0	H	Electricity consumed multiplied by the national emission factor of the grid for the activity data calendar year	National energy balance	National energy balance
	I.1.2	2	Residential (1.A.4.b)	Heat		NO																														
	I.1.2	2	Residential (1.A.4.b)	Steam		NO																														
Add	I.1.3	3	Transmission and distribution losses from grid-supplied energy			NE																												I.1.3 has not been estimated; not required for BASIC		

1

2

3

All worked examples for the inventory sheets will be presented broken down into various components, as divided above (or similar), in order to give sufficient room for a detailed explanation. Each of the segments is presented on a separate page.

Common activities reported are natural gas consumption disaggregated by user, electricity consumption by user, kerosene use for heating, and electricity generation.

The 'Description' cell is an opportunity to provide more detail on the source being estimated.

All three GHGs are reported for all sources
For wood and charcoal consumption, CO_2 is reported as CO_2(b) and therefore not included in emission totals

	GPC ref No.	Scope	GHG Emissions Source			Notation keys	Activity data		Activity data unit converter			Gas(es)
			Sub-category	Activity	Description		Amount	Units	EF unit	Default	Override	
5	**I.1.1**	**1**	**Emissions from fuel combustion within the city boundary**									
	I.1.1	1	Residential (1.A.4.b)	Natural gas	Natural gas consumption by residential users reported by the national body for gas regulation		30354	kWh				CO2, CH4, N2O
	I.1.1	1	Residential (1.A.4.b)	Liquefied Petroleum Gas (LPG)	LPG consumption by residential users		369	TJ				CO2, CH4, N2O
	I.1.1	1	Residential (1.A.4.b)	Kerosene	Kerosene consumption by residential users		0.054	TJ				CO2, CH4, N2O
	I.1.1	1	Residential (1.A.4.b)	Charcoal	Charcoal consumption for cooking by residential users		0.087	TJ				CO2, CH4, N2O
	I.1.1	1	Residential (1.A.4.b)	Wood or wood waste	Wood consumption by residential users		0.0086	TJ				CO2, CH4, N2O
3	**I.1.2**	**2**	**Emissions from grid-supplied energy consumed within the city boundary**									
	I.1.2	2	Residential (1.A.4.b)	Electricity	Electricity consumption by residential users in a year period		4376245976	kWh	MWh	0.001		CO2, CH4, N2O
	I.1.2	2	Residential (1.A.4.b)	Heating		NO						
	I.1.2	2	Residential (1.A.4.b)	Steam		NO						
Add	**I.1.3**	**3**	**Transmission and distribution losses from grid-supplied energy**			NE						

GPC ref No. refers to the coded categories used in the GPC to differentiate between sectors, these are analogous to the IPCC categories used in the 'Sub-category' column but are broader. Users select a sub-category to offer more specific classification. The most specific is the activity itself.

T&D losses are reported as Not Estimated. Emissions from heating and steam are reported as Not Occurring. Some notation keys are auto populated, if emissions *are* reported or another notation key is more appropriate, users should overwrite auto-populated notation keys.

The activity data for residential electricity consumption is given in KWh, but the EF is in MWh. The 'Activity data unit converter' columns enable the conversion from KWh to MWh. The 'Default' column cells, in grey, auto-populate once units have been selected for the original activity data and in the unit column for the multiplier.

Selected from the drop-down list and linked to the *Emission factors* sheet

Oxidation factors not known so left as default

Emissions are calculated by multiplying activity data by emission factor

Select an emission factor

OR

Enter emissions data

Emission factor	Emission factor						Oxidation factor		Emissions data	GHGs (metric tonnes CO_2e)				
	Units	CO_2	CH_4	N_2O	Total tCO_2e	CO_2(b)	Default	Override		CO_2	CH_4	N_2O	Total tCO_2e	CO_2(b)
EF_Natural Gas	tCO2e/kWh	0.0004822	0.000003	0.0000029	0.0004881	0.00009644	1		✓	1702872.993	758.8560574	904.5564204	1704536.405	0
EF_Residential_LPG	tCO2e/TJ	63.1	0.125	0.0298			1		✓	23253.76555	9.213060836	10.98196852	23273.96058	0
EF_kerosene - stationary combustion	tCO2e/TJ	71.5	0.075	0.1788		0	1		✓	3.871018538	0.004060509	0.009680253	3.8847593	0
EF_wood - stationary combustion	tCO2e/TJ	0	0.75	1.192		112	1		✓	0	0.436406946	0.104039416	0.540446361	9.775515582
EF_wood - stationary combustion	tCO2e/TJ	0	0.75	1.192		112	1		✓	0	0.006450709	0.010252327	0.016703036	0.96330589
							1		✓	1195270.312	776.4658463	1790.247285	1197837.025	0

Grey cells are auto-populated using information already entered into CIRIS or default values.

Emissions data column is ticked so emissions data has been completed.

The quality of all activity data has been assessed and documented

Sources have been selected from the drop-down list, which is linked to the *Data sources* sheet

Data Quality AD	Description of method(s) used or explanation for using notation key(s)	Source	Data quality explanation (optional)
H	Natural gas billed to residential sector (m3) multiplied by: NG density (t/m3, national data), NCV (TJ/t, IPCC 2006) and NG emission factors (t_GHG/TJ, IPCC 2006)	Natural gas operational data - Distribution; ENARGAS	High quality, city-specific data from gas utility company
L	Estimated based on national consumption multiplied by a proxy based on the population within Buenos Aires city that utilizes this fuel divided by the total population of the country (data from the National Institute of Statistics (INDEC) from the 2010 Census)	National Energy Balance; Secretariat of Energy	Scaled national data
L	Estimated based on national consumption multiplied by a proxy based on the population within Buenos Aires city that utilizes this fuel divided by the total population of the country (data from the National Institute of Statistics (INDEC) from the 2010 Census)	National Energy Balance; Secretariat of Energy	Scaled national data
L	Estimated based on national consumption multiplied by a proxy based on the population within Buenos Aires city that utilizes this fuel divided by the total population of the country (data from the National Institute of Statistics (INDEC) from the 2010 Census)	National Energy Balance; Secretariat of Energy	Scaled national data
L	Estimated based on national consumption multiplied by a proxy based on the population within Buenos Aires city that utilizes this fuel divided by the total population of the country (data from the National Institute of Statistics (INDEC) from the 2010 Census)	National Energy Balance; Secretariat of Energy	Scaled national data
H	Electricity consumed multiplied by the national emission factor of the grid for the activity data calendar year		High quality, city-specific consumption data
	I.1.3 has not been estimated; not required for BASIC		

An explanation for the data quality assessment has been given for each activity

Transportation sheet

The *Transportation* sheet is used to record activity and emissions data from transport vehicles that produce GHG emissions directly by combusting fuel or indirectly by consuming grid-supplied electricity.

Figure 12: Transportation sources; on-road transportation, aviation, railways and grid-supplied electricity

For a BASIC inventory, cities shall report all GHG emissions from combustion of fuels in transportation occurring within the city boundary in scope 1, and GHG emissions from grid-supplied electricity used for transportation within the city boundary for transportation in scope 2. Where there are significant sources of scope 3 GHG emissions associated with transboundary transportation, the notation key "Included Elsewhere" (IE) may be used. Where these sources do not occur, the notation key “Not Occurring” (NO) shall be used; where they are not significant, the notation key “NO” may be used.

For a BASIC+ inventory, cities shall report all BASIC sources and scope 3 GHG emissions associated with transboundary transportation.

How to use this sheet

Cities should complete the *Transportation* sheet following the key terms explained in **Table 14**. The *Transportation* sheet is split by transport mode, following the GPC guidelines, which are explained in **Table 16**.

Table 16: Transportation modes

Sub-sector	Definition
II.1 On-road transportation	Emissions occurring from vehicles travelling on roads including electric and fuel powered cars, taxis, buses, etc. On-road vehicles are designed for transporting people, property or material on common or public roads, thoroughfares, or highways.
II.2 Railways	Emissions occurring from vehicles travelling by rail including trams, urban railway subway systems, regional (inter-city) commuter rail transport, national rail system, and international rail systems, etc.
II.3 Water-borne transportation	Emissions occurring from marine vessels including sightseeing ferries, domestic inter-city vehicles, or international water–borne vehicles.
II.4 Aviation	Emissions produced by aircraft including helicopters, domestic inter-city flights, and international flights, etc.
II.5 Off-road transportation	Emissions produced by vehicles designed or adapted for travel on unpaved terrain, including airport ground support equipment, port vehicles, snowmobiles, etc.

As well as the transportation modes, users should identify the applicable sub-categories within each transit mode, based on where the activity took place **i.e. the scope of the activity**. The scopes applicable to the transportation sector are outlined in **Table 17**.

Table 17: Transportation scopes

Scope	Definition
Scope 1	Emissions from fuel combustion for transportation occurring in the city
Scope 2	Emissions from consumption of grid-supplied energy for transportation occurring in the city
Scope 3	Emissions from the portion of transboundary journeys occurring outside the city, and transmission and distribution losses from grid-supplied energy

Things to note

When reporting transportation emissions, be aware of the following reporting rules:

All transportation activities occurring within the city boundary must be reported. Exclusions are:

- Transportation that crosses the city boundary (does not stop). These can be reported under Scope 3 (BASIC+)
- Transportation hubs located outside the city but supporting the city. These can be reported under Scope 3 (BASIC+)

Not all combustion of fuels for "vehicles" are reported under Transportation

- Transport/vehicles used on sites to support specific industries, e.g. trucks, tractors and forklifts used on manufacturing, construction, agricultural sites, are reported in Stationary Energy sector, *not* Transportation sector.
- Transportation of waste to disposal sites is reported under Transportation and not included in the Waste sector

Electricity used in transportation (cars, trains, buses etc.) should be reported under Scope 2. This is assessed at the point of charging in the city boundary, i.e. all electricity sold from the charging station, even if the electricity is used to travel out of the city. Out of boundary charging stations are not included.

Grid-supplied energy used by transport facilities (e.g. airports, bus stations, railway stations) is included in Stationary Energy under I.2 Institutional and commercial buildings and facilities

Calculating transportation emissions

The calculation process for Transportation is the same as for Stationary energy (**Figure 10**), but the type of activity data is more variable. As such, there are more options when calculating transportation emissions. The decision on which method to use will largely depend on the activity data that is available.

Below are some brief summaries of calculation emissions for each transportation sub-sector.

For further information on the transportation subsector see chapter 7 of the GPC.

On-road Transportation

The GPC does not prescribe a specific method for calculating on-road emissions due to variations in data availability, existing transportation models, and inventory purposes. However, cities should calculate and report emissions based on one of four common methods (**Table 18**).

The calculation of on-road transportation emissions can be split into **top-down approaches**, when the amount of different types of fuels consumed is known, or **bottom-up approaches**, when the amount of activity by vehicle/mode type and/or by fuel is known. Under each approach, there are different methods. These are summarised in **Table 18**.

For more information on transportation emissions calculations check section 7.3.2. of the GPC.

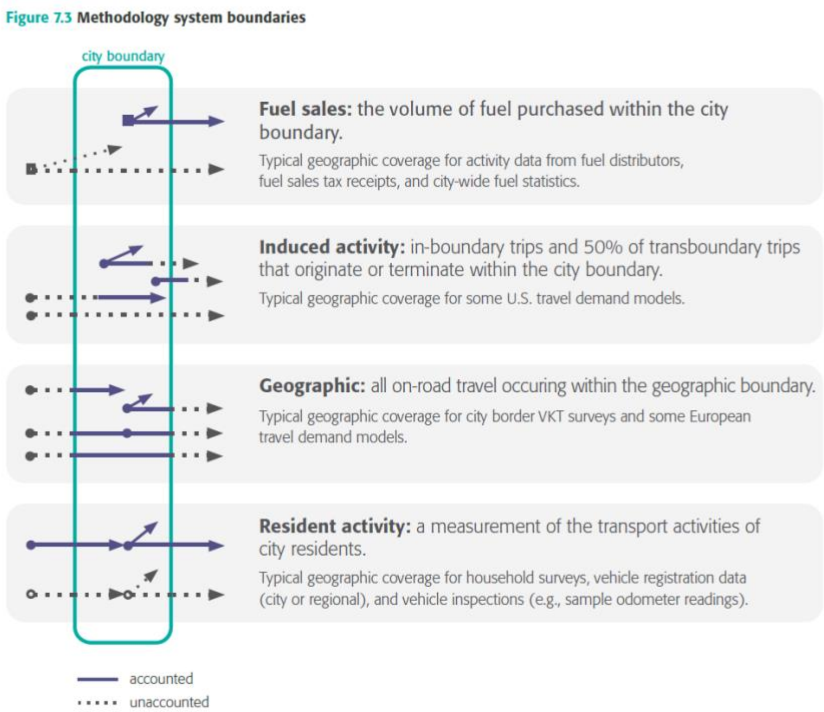
Tip: If developing an inventory for the first time, or where limited data is available, it is permitted to just report total fuel sold if there is no way of disaggregating by vehicle type. If possible, try to estimate fuel sold across the different sub-sectors, even if this means making some assumptions or allocating fuel based on national statistics or even 'expert judgement'. Disaggregating fuel in more detail, such as by vehicle type, is more useful for policy purposes but most cities start with top-down fuel sales approach and progress towards detailed bottom-up methodologies over time.

Table 18: Approaches and methods for calculation on-road transportation emissions (Table 7.2 of the GPC)

Approach Type	Method	Scope 1	Scope 2	Scope 3
Top Down	Fuel Sales Approach (e.g. volume of fuel sold within city boundary allocated to sub-categories using scaling factors based on vehicle registration by vehicle class)	All emission from fuel sold within boundary	Any electric charging station in the city boundary	N/A unless fuel sales allocated between Scope 1 and 3 by specified method
Bottom Up	City- induced Activity (e.g., US demand models)	Report in-boundary trips and in-boundary portion of 50% of transboundary trip (pass through trips excluded)		Report out-of-boundary portion of 50% trip allocation
	Geographic/ Territorial (e.g., European demand models)	All traffic occurring within city boundaries, regardless of origin or destination		N/A
	Resident Activity	Either resident activity is all Scope 1 or use origin - destination		N/A or origin-destination used

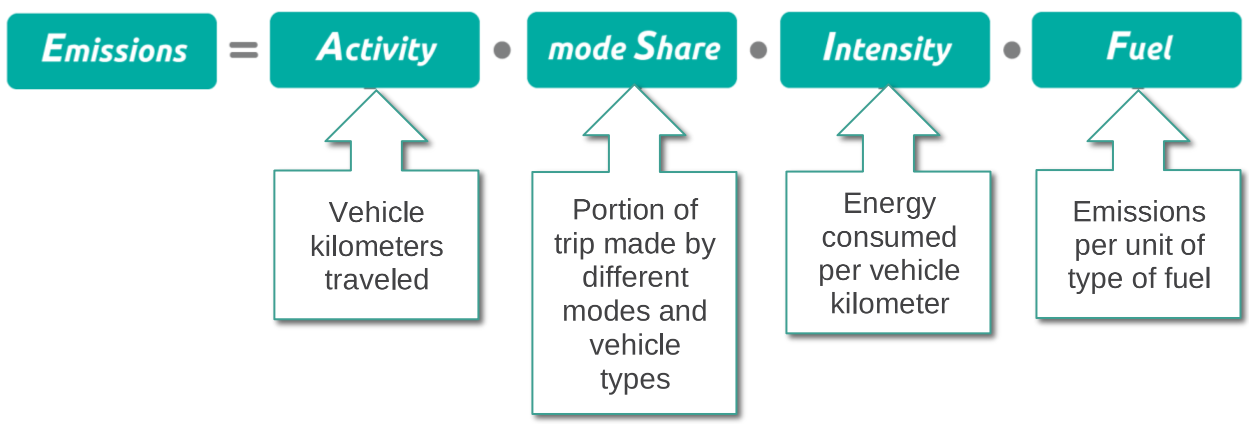
The system boundaries and a brief description of all of the methods is presented in **Figure 13**, which represents a comparison between all methods.

Figure 13: Methodology system boundaries (Figure 7.3 of the GPC)



All of the bottom up approaches follow the ASIF model (**Figure 14**). The ASIF model shows that bottom up calculations are a function of total activity, activity share across different modes, and the relative intensity of emissions from these different modes. Usually the challenging part for cities is getting to an understanding of total km travelled/activity by different mode shares; this often requires a transport model but can also be estimated from sample surveys, national statistics or even expert judgement.

Figure 14: ASIF framework



Railway Transportation

Railways can be used to transport people and goods, and are powered by a locomotive, which typically uses energy through combustion of diesel fuels or electricity (known as electric traction). Rail transit can be further divided into four sub-categories, as outlined in **Table 19**. Each can be further classified as passenger or freight.

Table 19: Railway types (Table 7.4 of the GPC)

Railway type	Examples
Urban train/subway	Tokyo transit system
Regional (intercity) commuter rail transport	Tokyo subway/train systems that connect to the adjacent cities like Yokohama, Tsukuba, and Chi
National rail	Japan national railway system operated by the Japanese Rail
International rail systems	Trans-Europe rail systems such as Eurostar

Scope 1 emissions for railway include emissions generated from the combustion of fuels occurring along the length of the rail network within the city boundary. Where there are stops within the city, emissions from these routes must be included, but cities can choose whether to include emissions from pass-through trips that do not stop in the city. Typically, rail fuel consumption will be diesel, but natural gas, coal, compressed natural gas or biofuels may also be used. Cities should aim to obtain fuel consumption data from the railway operator(s) by fuel type and by application (e.g., transit system, freight, etc.) for the distance covered within the city boundary (scope 1) and beyond the city boundary (scope 3). If data is limited, then information on the length of track within the city could be used to estimate fuel consumption by scaling national level fuel data and national total track length.

Calculating scope 2 rail emissions requires information on consumption by electricity powered rail-based transportation, which is accounted for at the point where the electricity is supplied to the rail system, regardless of trip origin or destination. Electricity consumption data should be multiplied by an appropriate electricity emission factor to calculate emissions.

Cities can effectively choose how to report scope 3 railways emissions. Scope 3 railway emissions include transboundary railway emissions (from either direct fuel combustion or grid-supplied electricity charged outside the city); this can be allocated based on the type of railway service and/or the geographic range. Generally, cities choose to apportion rail travel outside of the boundary based on, for example, city passenger numbers or tonnage/value of goods moved. For a BASIC inventory, cities are not required to report scope 3 emissions.

Table 20: Calculating Scope 3 transboundary railway emissions

Transportation system		Description
Urban Transit systems		Lines may extend outside city boundaries into suburbs within a metro area geographic range. Here, all out-of-boundary emissions could be recorded in scope 3.
Inter-city, national or international railway	**Resident travel**	Resident travel, where the number of city residents disembarking at each out-of-boundary stop (relative to the total riders on the out-of-boundary stops) can be used to scale down total emissions from the out-of-boundary stops.
	Freight quantity	Freight quantity (weight or volume), where the freight quantity coming from the city (relative to

		the total freight on the out-of-boundary stops) can be used to scale down total emissions from out-of-boundary stops.

Waterborne navigation and Aviation

> IPCC Guidelines allow for exclusion of international waterborne navigation and air travel, but accounting for these sources can be useful for a city to fully understand their emissions. The CRF states that, depending on the methodology used, data availability, and where such activities occur, local governments may choose to report GHG emissions from the in-boundary component of domestic and/or international waterborne navigation and aviation (such as the landing and take-off – LTO cycle for aviation), or assume these are all out of boundary emissions and use the notation key

The GPC requires Waterborne navigation and Aviation wholly occurring within a city to be reported in scope 1 for a BASIC inventory. Emissions from all departing ships and flights for inter-city/national/international trips should be reported in scope 3 under BASIC+.

Calculating scope 1 emissions involves similar approaches to other modes of transport; information required is either total fuel sales, estimated distance travelled, or scaling national data using appropriate scaling factors. Scope 1 activities for Waterborne navigation include local ferries, tugs, barges and pleasure boats in inland waterways. The inclusion of any ocean-going boats will be dependent on the definition of the boundary and the type of boat: small pleasure boats and ferries operating around the coastline would justifiably be included in scope 1, but visiting or ocean-going boats and larger barges, ships, tankers etc. would be classified under scope 3. Scope 1 activities under Aviation would include locally operating helicopters (commonly those used by emergency services or for sightseeing). There are rarely any aeroplanes that fall under scope 1.

Scope 2 emissions for waterborne navigation is any grid-supplied energy that marine vessels consume, and is calculated like all other scope 2 sources (i.e. all electricity at the point of consumption multiplied by relevant emission factor). Emissions from grid-supplied energy consumed by aircraft charging at airports should also be accounted for under scope 2, though this is not often occurring.

> **Tip**: be careful not to report energy consumption from port or airport buildings in *Transportation*, these should be reported under *Stationary energy*

Scope 3 emissions in this category occur from all departing trans-boundary trips powered by direct fuel combustion. For aviation, allocation to the city can be based on emissions from departing flights at airports that serve the city (categorized by domestic and international). If the airport is located outside the city boundary, it is good practice to still include a proportion of flights that are induced by the city. These emissions can be allocated to the city on the basis of passenger numbers or tonne/km. Cities can choose to disaggregate aviation activity by 'landing and take-off' (LTO) and cruise under both scope 1 and 3 emissions, by explicitly identifying them in the Subcategory column drop-down menu. Emissions from all departing ships for inter-city, national, international trips are to be reported in Scope 3 for BASIC+. Like rail emissions, a proportion of waterborne navigation emissions can be allocated to the city on the basis of passenger numbers or tonne/km.

Off-road transportation

Only scope 1 and 2 emissions are to be calculated for this sub-sector. Cities should only report under the off-road transportation sub-sector emissions from off-road transportation activities within transportation facility premises such as airports, harbours, bus terminals, and train stations. Examples of off-road vehicles might be snowmobiles, baggage trucks and transfers between terminals in airports.

Other off-road transportation activities within industrial premises and construction sites, agriculture farms, forests, aquaculture farms, and military premises, are reported under *Stationary energy*. This might include agricultural machinery, generators, forklifts and plant machinery.

Off-road emissions are commonly challenging for cities, especially where the *Transportation* sector is calculated on a top-down basis using fuel sales. *Off-road* transport is commonly reported as 'Included Elsewhere' (IE) by cities who are not able to disaggregate emissions.

Common challenges and recommendations

Common challenge 1

Often total fuel consumption data is available in the city, such as total diesel or gasoline, but disaggregating this across the different transport modes (i.e. the sub-sectors) requires consumption data by each mode, which is often not available.

Recommendations

- In the longer term, developing bottom-up models of transport activity to estimate total fuel (on the basis of vehicle numbers, efficiency and km travelled) is the most appropriate and useful approach. In the shorter term however, this is not always possible
- National Statistics sometimes provide total consumption by main transport sector – these proportions could be used to allocate total fuel across the modes
- Allocate consumption data to each mode using a proxy, for example, number of vehicles, number of known trips or economic value of different sub-sectors
- If no information is available, then expert judgement could be used through consultations with transport providers, fuel companies etc. to estimate total fuel to each mode. Other cities with similar transport patterns can also be helpful to verify assumptions, fill gaps in assumptions, or provide a proxy. Other cities' experiences can also be helpful in deciding on the best approach
- If it is still not possible to estimate the disaggregation, then report in one sector (usually On-road) and use notation key 'IE'

Common challenge 2

Data confidentiality can be a problem when obtaining information on fuel sales, where it may cause commercial confidentiality issues (if there are few operators or suppliers) or where data is deemed to be sensitive.

Recommendations

- Communicate the purpose of the data request clearly to the data supplier and explain any systems and standards in place for managing the confidentiality and security of their raw data. Often once data suppliers understand how the data will be used, they are more willing to share
- Consider whether the data can be aggregated, e.g. if there are two rail operators, consider aggregating data so neither operator can be identified
- Report total emissions only and not the activity data, and/or use notation key 'C'

Common challenge 3

Developing an approach to including transboundary emissions from transport sources can be challenging, particularly as the GPC does not prescribe a particular methodology to use. Obtaining data can also be difficult.

Recommendations

- The GPC allows cities some flexibility in reporting emissions from transboundary sources and cities should choose the most appropriate approach given their local circumstances and data availability
- It is most common to estimate emissions from whole journeys using an origin-destination (distance) and fuel efficiency approach, or more often, total fuel sales for an airport or port
  A popular way to then allocate a proportion to the city based on passenger numbers and/or tonnes of freight. This information can often be obtained from local air and sea surveys, tourism surveys, and local economic statistics of imports and exports

Worked example

Figure 15 gives an example of the *Transportation* sheet. See **Figure 11** *Stationary energy* worked example for a summary view of the full table

Figure 15: Worked example from the Transportation sheet

Provide additional information on the source of the emissions in this column. Select either 'Fleet Type' under sections II.1 and II.2 (municipal, private, public, commercial or multiple) or 'Sub-category' under sections II.3 and II.4 (in-boundary, transboundary, or otherwise noted).

Give a brief description of the activity that is emitting GHG emissions. This is an opportunity to give more detail on the activity that is being estimated; for example, a city should document the user/type of vehicle (e.g. private vehicles, commercial vehicles, buses, and sightseeing helicopters).

II.1 ON-ROAD TRANSPORTATION

	GPC ref No.	Scope	GHG Emissions Source			Notation keys
			Fleet Type	Activity	Description	
4	II.1.1	1	Emissions from fuel combustion on-road transportation occurring in the city			
	II.1.1	1	Municipal	Motor gasoline (petrol)	Municipal fuel sold within the city, reported by a national source based on invoiced sales	
	II.1.1	1	Private	Diesel oil	Total diesel sales to private owners within the city reported by a national source based on invoiced sales multiplied by the % of pure diesel	
	II.1.1	1	Public	Compressed Natural Gas (CNG)	CNG sold in fuel stations, reported in local annual statistic report	
	II.1.1	1	Commercial	Biodiesels	Total commercial diesel sales within the city reported by a national source based on invoiced sales, multiplied by the % of biodiesel in diesel	
Add	II.1.2	2	Emissions from grid-supplied energy consumed in the city for on-road transportation			NO
Add	II.1.3	3	Emissions from transboundary journeys occurring outside the city, and T&D losses from grid-supplied energy consumption			NE

Whilst not occurring here (as indicated by the NO in the notation key column) emissions from grid-supplied energy consumed in the city for transportation can be attributed to such activities as charging private electric vehicles (on-road transportation) or powering trains or trams (railways).

Select the activity. When the method is the fuel sales approach, select the appropriate fuel that is being used. For the other methods, select the metric that is being used to measure transport e.g. distance travelled per category (e.g. passengers or freight).

Include a notation key for sub-sectors where no activity is reported. Ensure that, for a BASIC inventory, all sources are either estimated or are reported as NO, IE or C. NE is not permitted for BASIC sources. Some notation keys are auto populated.

Check that activity data and emission factor units are the same. In this case, they are both in TJ.

Select the appropriate gases. For a BASIC inventory, all three gases should be reported.

No information is given on the oxidation factor so it is assumed to be the default of 1. If information is given on the oxidation factor, enter in the 'override' column.

These columns are auto-populated either by calculating emissions based on activity data and emission factors, or from the manually entered emissions data. This column also converts emissions into tonnes.

Activity data		Activity data unit converter			Gas(es)	Emission factor	Emission factor						Oxidation factor		Emissions data	GHGs (metric tonnes CO_2e)					GHGs (metric tonnes CO_2e)				
Amount	Units	EF unit	Default	Override			Units	CO_2	CH_4	N_2O	Total tCO_2e	$CO_2(b)$	Default	Override		CO_2	CH_4	N_2O	Total tCO_2e	$CO_2(b)$	CO_2	CH_4	N_2O	Total tCO_2e	$CO_2(b)$
24059	TJ				CO2, CH4, N2O	EF_Motor gasoline (petrol)	tCO2e/TJ	69.3	0.0625	0.2384			1								1667315	1504	5736	1674554	-
24378	TJ				CO2, CH4, N2O	EF_diesel oil - mobile combustion (exc. Trains)	tCO2e/TJ	74.1	0.0975	1.1622			1								1806418	2377	28332	1837127	-
5828	TJ				CO2, CH4, N2O								1		✓	326955.1214	13404.57717	5210.300865	345569.9994	-	326955	13405	5210	345570	-
1920	TJ				CO2, CH4, N2O	EF_biodiesel	tCO2e/TJ		0.0975	1.1622		74.1	1								-	187	2231	2418	142253

Select appropriate emission factor for each activity from drop-down list.

For biodiesel, CO_2 is reported as biogenic CO_2. See **Box 4.**

In some cases, only emissions data is available (rather than activity data and an appropriate emission factor). In this case, select ✓ in the 'Emissions data' column and manually enter emissions data in the adjacent GHGs (metric tonnes CO_2e) columns.

Select data source from drop-down list which is linked to the *Data sources* sheet.

Provide an assessment of the quality of the activity data. Select L, M or H.

Data Quality AD	Description of method(s) used or explanation for using notation key(s)	Source	Data quality explanation (optional)
L	Fuel sold to private owners within the city, reported by a national source based on invoiced sales	Transport fuel sales	Scaled national data
L	Fuel sales to private owners within the city reported by a national source based on invoiced sales	Transport fuel sales	Scaled national data
M	CNG sold in fuel stations, reported in local annual statistic report	Annual statistic report	Local data
M	Fuel sales to private owners within the city reported by a national source based on invoiced sales that include biodiesel % out of total fuel used	Statistics from the Argentinian Association of bio-combustibles	Local data
	II.1.2 is not occurring; there are no records of electric road transport in the city so assumed to be insignificant		
	II.1.3 has not been estimated; not required for BASIC		

Provide a brief description of the method; for example, report if national data is scaled, or if local data is multiplied by a national default emission factor. This column also gives the opportunity to document any assumptions made. Alternatively, provide an explanation for the use of notation keys - if IE is used, report where the emissions are included.

Provide a brief explanation for assessment of quality for activity data.

This is optional, however, to help reviewers to understand the inventory and to improve transparency, this should be completed.

Waste sheet

The *Waste* sheet is used to record activity and emissions data from solid waste and wastewater (together referred to as 'waste') that is disposed of and/or treated at a facility inside the city boundary, or transported to other cities for treatment. Waste disposal and treatment produces GHG emissions through aerobic or anaerobic decomposition, or incineration.

Figure 16: Waste sources; domestic and commercial waste

For a BASIC inventory, cities need to report all GHG emissions from disposal or treatment of waste generated within the city boundary, whether treated inside or outside the city boundary. Emissions from waste imported from outside the city but treated inside the city shall be excluded from BASIC/BASIC+ totals. These emissions get reported in total scope 1 emissions and form part of the *Territorial* inventory (See **Box 3**).

How to use this sheet

Users should complete the *Waste* sheet following the key terms explained in **Table 14**. The *Waste* sheet is split into sectors, following the GPC guidelines. Each sector is split into sub-sectors, which are explained in **Table 21.** It is best practice, but not a requirement, to disaggregate data as far as possible; for example, reporting emissions for waste generated from households, offices, shops, restaurants, agricultural activities, industrial installations, etc.

Table 21: Waste sub-sectors

Sub-sector	Definition
III.1 Solid waste disposal	Solid waste generated in the city disposed in landfills or open dumps
III.1.3 Solid waste disposal	*Solid waste generated outside the city and disposed in landfills or open dumps within the city*
III.2 Biological treatment of waste	Solid waste generated in the city that is treated biologically
III.2 Biological treatment of waste	*Solid waste generated outside of the city that is treated biologically within the city*
III.3 Incineration and open burning	Solid waste generated in the city incinerated or burned in the open
III.3 Incineration and open burning	*Solid waste generated outside of the city and incinerated or burned in the open within the city*
III.4 Wastewater treatment and discharge	Wastewater generated in the city
III.4 Wastewater treatment and discharge	*Wastewater generated outside of the city and treated within the city*

Things to note

When reporting waste emissions, be aware of the following reporting rules:

All Waste generated by the city must be included in the inventory • Waste disposed of in-boundary is reported in Scope 1 • Waste disposed of outside the boundary is reported in Scope 3
Scope 3 emissions are required for BASIC.
Waste generated outside the city but treated inside the city is also required for BASIC and should be reported in Scope 1 for the Territorial inventory (but note this is not recorded in the BASIC or BASIC+ total).
Emissions from energy used in waste treatment is reported in the Energy Sector.
Waste used to generate energy (biogas from landfill, waste-to-energy plants) **is reported in the Energy sector** (in I.4.4 Energy Generation if supplying an electricity grid).
Emissions from transport of waste to disposal sites is reported in the Transportation Sector.
CO_2 from the decomposition of biological material should be reported as biogenic CO_2 (see Box 4); these emissions will not be included in the inventory totals.

Calculating waste emissions

To calculate emissions from waste, cities need to know the amount of waste disposed, the type of waste (see below), where it was disposed (in or out of the city boundary), the waste treatment method and the composition of the waste, particularly the portion of degradable organic content (DOC) and the non-biogenic fraction for incineration. The GPC provides a set of default solid waste types and definitions, in line with the IPCC 2006 guidelines, which include:

- **Municipal solid waste (MSW) –** generally refers to waste collected by municipalities or other local authorities. MSW typically includes: food waste, garden and park waste, paper and cardboard, wood, textiles, disposable diapers, rubber and leather, plastics, metal, glass, and other materials (e.g., ash, dirt, dust, soil, electronic waste).
- **Sludge –** produced as a by-product of wastewater treatment. Cities can choose whether to report all sludge emissions as industrial waste, or whether to report domestic sludge as MSW and industrial sludge as industrial waste. Cities should ensure this classification is indicated when reporting sludge emissions.
- **Industrial waste -** Industrial waste generation and composition vary depending on the type of industry and processes/ technologies used and how the waste is classified by country. For example, construction and demolition waste can be included in industrial waste, MSW, or defined as a separate category. The way a country/city treats and categorises industrial waste can impact what activity data will be available. In some countries, industrial waste is managed separately, but in other countries, particularly developing countries, industrial wastes are included in the MSW stream. If this is the case, cities should report industrial waste as IE, and document that these emissions are included with MSW emissions.
- **Other waste –** *Clinical waste:* These wastes cover a range of materials including plastic syringes, animal tissues, bandages and cloths. Some countries choose to include these items under MSW. Clinical waste is usually incinerated, but on occasion may be disposed of at solid waste disposal sites (SWDS). *Hazardous waste:* Waste oil, waste solvents, ash, cinder, and other wastes with hazardous properties— such as flammability, explosiveness, causticity, and toxicity—are included

in hazardous waste. Hazardous wastes are generally collected, treated and disposed of separately from non-hazardous MSW and industrial waste streams.

The first step in estimating emissions from waste is to determine the mass of waste disposed, and the amount of degradable organic carbon (DOC) within the waste ('the proportion of the waste that will break down'), which determines the methane generation potential ('how much methane is generated per unit of waste disposed' – the emission factor).

In the case of incineration, the two main factors for quantifying emissions are the mass of waste disposed and the amount of fossil carbon it contains.

Many cities will have information on the mass of waste generated and how/where it is treated. In the absence of local or country-specific data on waste generation and disposal, the 2006 IPCC Guidelines provide national default values for:

- Waste generation rates based upon a tonnes/capita/year basis
- Default assumptions about the fraction of waste disposed in landfills (SWDS), incinerated, and composted (biological treatment)

Once the amount of waste, disposal method and location has been determined, cities will need to calculate emissions for solid waste disposal, biological treatment of waste, incineration, and wastewater.

Tip: CIRIS contains a number of useful calculators to help users to calculate waste emissions, covering each of the waste disposal sub-sectors. Detailed guidance is available in GCoM - CRF sheet

Once the amount of waste, disposal method and location has been determined, cities need to select an appropriate emission factor to multiply the quantity of waste by. For solid waste disposal, the emission factor is illustrated as methane generation potential (L_0), which is a function of degradable organic content (DOC).

To calculate CH_4 emissions from landfill, cities can choose one of two methods:

1) The **Methane Commitment method (MC)** assumes landfill emissions based on the waste disposed in a given year, regardless of when the emissions actually occur.
2) The **First Order Decay method (FOD)** assumes that degradable organic carbon (DOC) in waste decays slowly throughout a few decades, during which CH_4 and CO_2 are released provides more accurate estimate of annual emissions recommended by 2006 IPCC Guidelines for National Greenhouse Gas Inventories and the GPC **but** requires historical waste disposal information (usually at least 10 years)

Tip: For more detail on the FOD method, use the IPCC 2006 Waste model. The IPCC provide a downloadable spreadsheet to aid implementation of the FOD and calculate emissions using the FOD.

The FOD method is the preferred approach for estimating waste emissions due to its increased accuracy, and is covered in detail in the IPCC 2006 Guidelines. However, many cities find that the FOD method is not suitable as they lack historical waste data. In this case, the MC method is appropriate to use.

The GPC allows for either method to be used, and contains an overview of the benefits and disadvantages of each in Table 8.2, p 92.

For more information on the MC method, see the IPCC Revised 1996 Guidelines (the MC Method is not included in the 2006 Guidelines).

Common challenges and recommendations

Common challenge 1

Waste disposed of outside the city boundary, which is a requirement of a BASIC inventory, is often difficult to report as often only limited data is available. It is common for cities to have little knowledge of how the waste is treated.

Recommendations

- Contact waste disposal sites or waste contractors directly for information
- Look for local/national/international studies on waste treatment in the country and apply assumptions/data from those
- If there is limited information, use IPCC assumptions and apply a 'conservative' approach, i.e. if you know that the waste is incinerated but there is no information on energy recovery and it is not thought there is a system in place, report that there is no energy recovery.

Common challenge 2

Many emission factors used in the waste sector are 'lifecycle' factors; for example, emission factors accounting for future waste avoided, and transport emissions from the collection of waste included in the waste emission factor. Such emission factors are not consistent with the GPC's Waste sector reporting requirements. It is recommended that cities ensure that emission factors used in the waste sector only account for emissions from the waste itself. Separating the GPC-compatible emissions from 'lifecycle' factors adds significant complexity for cities so it is advised to be avoided.

Recommendations

- Go back to the source of the factors and see if they can be disaggregated to separate out the non-waste sector elements
- Use alternative factors / tools to calculate e.g. from IPCC, CIRIS Emission Factor Database (EFD)

Common challenge 3

Reporting waste used in incineration is a common challenge for cities, particularly identifying where waste is used for energy (to the grid), energy in industry, or just as disposal.

Recommendations

- Contact the incineration company/site or data provider to find out more information on the incineration technology and process
- Discuss with colleagues in waste management teams/departments for further information
  Ensure that if there is energy generation that it is reported in the energy sector (and that if it is going to the grid, in I.4.4 to avoid double counting).

Worked example

Figure 17 gives an example of the *Waste* sheet. See **Figure 11** *Stationary energy* worked example for a summary view of the full table.

Figure 17: Worked example from the Waste sheet

III.1 SOLID WASTE DISPOSAL

	GPC ref No.	Scope	GHG Emissions Source			Notation keys
			Treatment activity	Type of waste	Description	
2	**III.1.1**	**1**	**Emissions from solid waste generated in the city and disposed in landfills or open dumps within the city**			
	III.1.1	1	Landfill sites - Methane commitment	Municipal solid waste	Residential waste	
	III.1.1	1	Landfill sites - Methane commitment	Municipal solid waste	Private sector waste	
Add	**III.1.2**	**3**	**Emissions from solid waste generated in the city but disposed in landfills or open dumps outside the city**			NO
1	**III.1.3**	**1**	**Emissions from waste generated outside the city and disposed in landfills or open dumps within the city**			
	III.1.3	1	Landfill sites - Methane commitment	Municipal solid waste	Imported waste from outside city	

Select the activity (i.e. how the waste is treated). For landfills, there are 2 options – methane commitment and first order decay.

Waste generated outside the city and disposed of within the city is reported under III.1.3.

All waste is disposed of and treated within the city boundary so III.1.2 is reported as NO. Some notation keys are auto populated.

No conversions needed so left blank

Cells in the 'Emissions data' column are left blank as both activity data and a suitable emission factor are available for all activities

Total tCO_2e does not include emissions of $CO_2(b)$. $CO_2(b)$ is not included in emission totals.

Activity data		Activity data unit converter			Gas(es)	Emission factor	Emission factor						Emissions data	GHGs (metric tonnes CO_2e)					GHGs (metric tonnes CO_2e)				
Amount	Units	EF unit	Default	Override			Units	CO_2	CH_4	N_2O	Total tCO_2e	$CO_2(b)$		CO_2	CH_4	N_2O	Total tCO_2e	$CO_2(b)$	CO_2	CH_4	N_2O	Total tCO_2e	$CO_2(b)$
1427600	tonne				CO2, CH4	EF_landfill	tCO2e/t	0	0.2246211	0		0.274370514							0	320669	0	320669	391691
34400	tonne				CO2, CH4	EF_landfill	tCO2e/t	0	0.2246211	0		0.274370514							0	7727	0	7727	9438
129000	tonne				CO2(b), CH4	EF_landfill	tCO2e/t	0	0.2246211	0		0.274370514							0	28976	0	28976	35394

City has selected CH_4 and $CO_2(b)$

Suitable EF selected from drop-down list

There are no CO_2 emissions. CO_2 emissions from these activities are classed as biogenic, and are therefore reported as $CO_2(b)$

Brief description giving information on the method and data used, as well as general assumptions.

Relevant source is selected from drop-down list, which is linked to the 'reference' column in the *Data sources* sheet.

Data Quality AD	Description of method(s) used or explanation for using notation key(s)	Source	Data quality explanation (optional)
H	83% waste to landfill is domestic. Methane Commitment method using local Government waste data for tonnage of MSW, minus known biogas capture (85%) and known waste composition and organic carbon content. No methodology for N_2O emissions using Methane Commitment approach.	City Government waste treatment department document	High quality, city-specific data obtained from City Government waste department
H	83% waste to landfill is domestic. Methane Commitment method using local Government waste data for tonnage of MSW, minus known biogas capture (85%) and known waste composition and organic carbon content. No methodology for N_2O emissions using Methane Commitment approach.	City Government waste treatment department document	High quality, city-specific data obtained from City Government waste department
	III.1.2 does not occur. No waste sent to landfill outside city boundary		
H	83% waste to landfill is domestic. Methane Commitment method using local Government waste data for tonnage of MSW, minus known biogas capture (85%) and known waste composition and organic carbon content. No methodology for N_2O emissions using Methane Commitment approach.	City Government waste treatment department document	High quality, city-specific data obtained from City Government waste department

Data quality selected from drop-down list

Brief explanation to clarify that activity (waste disposed at landfills outside the city boundary) is not occurring as no waste is sent to landfill outside the city boundary

Brief explanation for why High data quality (H) was selected in the 'Data Quality / AD' column

IPPU sheet

The *IPPU* sheet is used to record activity and emissions data from non-energy related industrial activities that occur within the city boundary, and products used within the city boundary. These are all reported under scope 1. Scope 3 emissions of IPPU are not yet covered in the GPC's assessment boundary.

Reporting IPPU emissions is not a requirement of a BASIC inventory; however, for a BASIC+ inventory, a city must report all sources of IPPU emissions.

Figure 18: IPPU sources; industry and product use

Generally, the activity data for industrial processes relates to the amount of material *produced* (e.g. tonnes of clinker, lime, ammonia) or *consumed* (e.g. tonnes of limestone or dolomite consumed).

The main emission sources from industrial processes are those that chemically or physically transform materials; for example, the blast furnace 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 are emitted including CO_2, CH_4, N_2O and F gases.

Sources of emissions from product use include lubricants and paraffin waxes used in non-energy products, fluorinated gases (F gases) used in electronics production, and F gases used as substitutes for ozone depleting substances.

All cities will have product use emissions; however, not all cities will have emissions from industrial processes.

How to use this sheet

Cities should complete the *IPPU* sheet following the key terms explained in **Table 14**. If cities are not reporting IPPU emissions, they should ensure that they use the notation key NE and provide an explanation documenting that IPPU emissions are not a BASIC requirement, and are therefore not estimated.

> F gases (fluorinated gases) are man-made greenhouse gases which are used in a range of industrial applications, often as a substitute for ozone depleting substances.
>
> F gases include HFCs, PFCs, NF_3 and SF_6.

The *IPPU* sheet is split into two sectors; IV.1 Emissions from industrial processes occurring in the city boundary and IV.2 Emissions from product use occurring within the city boundary.

As with the other inventory sheets, if appropriate, an emission factor should be selected from the drop-down menu in the 'Emission factor' column which is populated from the *Emission factors* sheet. However, for IPPU emissions, these Emission factors come from the *IPPU emission factors* sheet which shall be populated during the set-up stage if IPPU sources are to be reported.

Calculating IPPU emissions

The GPC splits Industrial Process emissions into a number of sub-categories based on industry type, as follows:

- **Mineral industry** which includes cement, lime and glass production. To calculate mineral industry emissions, cities will need to know the mineral production industries within the city boundary, the annual mineral product output and the raw material consumption in the industrial process, and emission factors for the raw material or product.
- **Chemical industry** which includes emissions arising from the production of inorganic and organic chemicals including ammonia, nitric acid, adipic acid, and soda ash. An important factor in

calculating emissions from this sector is the technology used. As well as the technology used, a city will need to know chemical industries within the city boundary, annual mineral product output and raw material consumption in the industrial process, and emission factors for the raw material or product in different production technologies.

- **Metal industry** which includes emissions from the production of iron steel and metallurgical coke, ferroalloy, aluminium, magnesium, lead and zinc. Like the chemical industry, emissions from the metal industry depend on the technology used. As well as this, a city will need to know metal industries within the city boundary, annual mineral product output and raw material consumption in the industrial process, and emission factors for the raw material or product in different production technologies.

Cites should be aware that in certain IPPU categories, particularly large point sources of emissions, there may be emissions captured for recovery and use, or destruction. Cities should identify detailed city-specific or plant-level data on capture and abatement activities, and any abatement totals should be deducted from the emission total for that sub-sector or process.

There is further information on calculating emissions from industrial processes in Chapter 9 of the GPC.

For most industrial processes, the 2006 IPCC guidelines provide default factors which can be used if facility specific data cannot be obtained.

The GPC splits product use emissions into a number of categories according to the type of common product used, as follows:

- **Non-energy products from fuels and solvent use** refers to emissions from the use of fossil fuels as a product for primary purposes (NOT for combustion or energy production) in industrial processes. A city will need to know major users of fuel and solvents within the city boundaries, annual consumption of fuels and solvent, and emission factors for different types of fuels and solvent consumption.

Equation 9.5 in the GPC can be used to calculate emissions from non-energy product use. Chapter 9 of the GPC, in particular Table 9.7, gives further detail on calculating non-energy product emissions.

- **Emissions from the electronics industry** which includes emissions from semiconductors, thin-film-transistor flat panel displays and photovoltaic manufacturing. Some manufacturing processes use fluorinated compounds (FC) which emit GHGs. A city will need to know major electronic production activities within the city boundary, annual production capacity of the industrial facility, FC emission control technology used, and the gas fed-in and destroyed by the FC emission control system.

Chapter 9 of the GPC, in particular Table 9.8, gives further detail on calculating emissions from the electronics industry.

- **Emissions from fluorinated substitutes for ozone depleting substances** involves HFCs, and sometimes PFCs, serving as alternatives to ozone depleting substances which are in the process of being phased out. HFCs and PFCs are used in refrigeration and air conditioning, fire suppression and protection, aerosols, solvent cleaning, and foam blowing, as well as other applications. A city needs to know the major industries that use fluorinated substitutes within the city boundaries and the F gas purchase record by the major industries in the city along with their application.

Chapter 9 of the GPC, in particular Table 9.9, give further detail on calculating emissions from the electronics industry.

Common challenges and recommendations

Common challenge 1

Allocation of emissions from the use of fossil fuel between the *Stationary Energy* sector and *IPPU* can be complex. Only emissions from non-energy related industrial activities and product uses are reported under IPPU, not emissions from fuel combustion.

Recommendations

"Fuel combustion" is considered 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".

- As described in the GPC and the IPCC Guidelines, if the fuel is combusted for energy use or 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.

Common challenge 2

A challenge can be obtaining sufficient activity data in order to report a complete IPPU sector in an inventory.

Recommendation

Scale national data based on appropriate proxy, e.g. GDP for commercial refrigeration, number of vehicles for mobile air conditioning and population for aerosols. Also, quite often, data are collected for purposes other than to estimate emissions, which cities can apply default factors to in order to make an appropriate estimate of emissions; for example, Mexico City produced a comprehensive inventory of their IPPU emissions using information derived from Annual Operating Licenses which industries report to Mexico City's Secretary of the Environment.

Worked example

gives an example of the *IPPU* sheet. See ***Figure 11*** *Stationary energy* worked example for a summary view of the full table

Figure 19: Worked example from the IPPU sheet

Common activities include, lubricants used in transportation, products used in asphalt production for road paving and products used for refrigeration that are not ozone depleting substances.

Select the particular product use that the activity data corresponds to; there are relatively few options here ranging from non-energy products from fuels and solvent use, to electronics industry and products used as substitutes for ozone depleting substances.

IV.2 PRODUCT USE

	GPC ref No.	Scope	GHG Emissions Source			Notation keys	Activity data		Activity data unit converter			Gas(es)
			Industry	Product use	Description		Amount	Units	EF unit	Default	Override	
4	**IV.2**	**1**	**Emissions from product use occurring within the city boundary**									
	IV.2	1	Product_uses_as_substitutes_for_ozone_depleting_substances	Refrigeration and stationary air conditioning (2.F.1.a)	Emissions by refrigerant input to new equipment - food refrigeration. Freón 22 (HCFC-22).		4.2	tonne				HFCs
	IV.2	1	Product_uses_as_substitutes_for_ozone_depleting_substances	Refrigeration and stationary air conditioning (2.F.1.a)	Emissions by refrigerant input to new equipment - food refrigeration. R-40.		16.3	tonne				HFCs
	IV.2	1	Product_uses_as_substitutes_for_ozone_depleting_substances	Mobile air conditioning (2.F.1.b)	Emissions by refrigerant input to new equipment - air condition of vehicles. Freón 22 (HCFC-22).		2.2	tonne				HFCs
	IV.2	1	Product_uses_as_substitutes_for_ozone_depleting_substances	Refrigeration and stationary air conditioning (2.F.1.a)	Emissions by refrigerant input to new equipment - commercial and industrial refrigeration. Freón 22 (HCFC-22).		15.3	tonne				HFCs

Select from the drop-down list the industrial process that the activity data refers to. These are relatively broad categories (e.g. mobile air conditioning) but are intuitive.

Describe more specifically, the activity that the data pertains to.

Input the activity data, the units used and the gases that the activity refers to.

Input emission data as in previous examples

Emissions data	GHGs (metric tonnes CO_2e)									GHGs (metric tonnes CO_2e)								
	CO_2	CH_4	N_2O	PFC	HFC	SF_6	NF_3	Total tCO_2e	$CO_2(b)$	CO_2	CH_4	N_2O	PFC	HFC	SF_6	NF_3	Total tCO_2e	$CO_2(b)$
✓					133			133		-	-	-	-	133	-	-	133	-
✓					1118.2			1118.2		-	-	-	-	1118	-	-	1118	-
✓					13.9			13.9		-	-	-	-	14	-	-	14	-
✓					484.628			484.628		-	-	-	-	485	-	-	485	-

Emission factors not shown here as emissions data was reported directly and therefore the data was inputted manually. The IPPU sheet works as all the others in that a user can enter emissions factors and activity data as necessary; however, when selecting an emission factor from the drop-down list in the 'Emission factor' column, this will take data from the *IPPU Emission factors* sheet.

Data Quality AD	Description of method(s) used or explanation for using notation key(s)	Source	Data quality explanation (optional)
	IV.2 has not been estimated; not required for BASIC		
H	Activity Data: information reported by the industries in the Annual Operating License to the Buenos Aires' Secretary of the Environment. Emission Factor: IPCC 2006 Tier 1.	IPCC,2006. Vol 3 IPPU. Chapter 7. HFC emissions (new equipment and recharge), Equation 7.12, table 7.9	Activity Data: Information provided in the Annual Operating License, that every industry submits (HFC consumed); due to the information required is specific, it is designated as confidential.
H	Activity Data: information reported by the industries in the Annual Operating License to the Buenos Aires' Secretary of the Environment. Emission Factor: IPCC 2006 Tier 1.	IPCC,2006. Vol 3 IPPU. Chapter 7. HFC emissions (new equipment and recharge), Equation 7.12, table 7.9	Activity Data: Information provided in the Annual Operating License, that every industry submits (HFC consumed); due to the information required is specific, it is designated as confidential.
H	Activity Data: information reported by the industries in the Annual Operating License to the Buenos Aires' Secretary of the Environment. Emission Factor: IPCC 2006 Tier 1.	IPCC,2006. Vol 3 IPPU. Chapter 7. HFC emissions (new equipment and recharge), Equation 7.12, table 7.9	Activity Data: Information provided in the Annual Operating License, that every industry submits (HFC consumed); due to the information required is specific, it is designated as confidential.
H	Activity Data: information reported by the industries in the Annual Operating License to the Buenos Aires' Secretary of the Environment. Emission Factor: IPCC 2006 Tier 1.	IPCC,2006. Vol 3 IPPU. Chapter 7. HFC emissions (new equipment and recharge), Equation 7.12, table 7.9	Activity Data: Information provided in the Annual Operating License, that every industry submits (HFC consumed); due to the information required is specific, it is designated as confidential.

Input data quality, method and source information as in previous examples

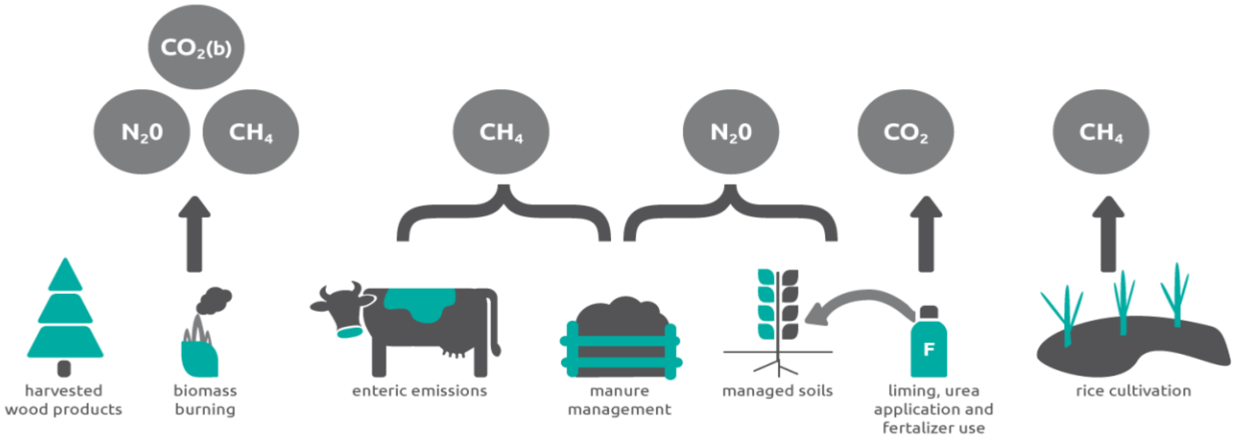
AFOLU sheet

The *AFOLU* sheet is used to record activity and emissions data from agriculture, forestry and other land use. This covers GHG emissions from activities including land-use changes that alter the composition of the soil, methane produced in the digestive processes of livestock, and nutrient management for agricultural purposes.

Reporting AFOLU emissions is not a requirement of a BASIC inventory; however, for a BASIC+ inventory, a city must report all sources of AFOLU emissions. It should be noted that many cities have very small, or no AFOLU emissions.

The main emission sources from agriculture are presented in **Figure 20.**

Figure 20: AFOLU sources and associated emissions (Figure 10.1 in the GPC)



There is often confusion regarding the reporting of biogenic CO_2 from biofuels. The 'Land' sector is where the growth and harvesting of biofuels are accounted for, through carbon stock change. So the CO_2 associated with a biofuel will be 'counted' in the land use sector (balancing uptakes and releases) hence we do not report it again when combusted for energy.	Parks and small areas of green space are very negligible in terms of emissions. We consider emissions in terms of land use *change*, so parks remaining parks are not a net sink or source to report. There is a threshold of 20 years over which we consider land use change.

How to use this sheet

Cities should complete the *AFOLU* sheet following the key terms explained in **Table 14**. If cities are not reporting AFOLU emissions, they should ensure to use the notation key NE and provide an explanation documenting that AFOLU emissions are not a BASIC requirement, and are therefore not estimated.

If cities are reporting a BASIC+ inventory and AFOLU activities occur within the boundary, these must be estimated.

If cities are reporting a BASIC+ inventory and AFOLU activities do not occur within the boundary, it should be reported as NO, with an explanation provided to state that AFOLU emissions do not occur within the city boundary.

The *AFOLU* sheet is split into three categories, as shown in **Table 22**.

Table 22: *AFOLU* sheet sub-categories

Sub-category	Example
V.1 Livestock	Madrid reported emissions from cattle, swine, sheep, poultry, horses and goats
V.2 Land	Copenhagen reported forest area within the city as a carbon sink
V.3 Aggregate sources and non-CO_2 emissions sources on land	Bogotá reported emissions from the burning of grass- and forestland, liming, and harvested wood products

The only difference between GPC and CRF categories is that the GPC category 'Aggregate sources' is re-named as 'other AFOLU' in the CRF.

Calculating AFOLU emissions

Livestock

The GPC splits livestock emissions into two sub-categories, as follows:

- **Enteric fermentation** which is a digestive process by which carbohydrates are broken down by micro-organisms into simple molecules for absorption into the blood stream. The main GHG emitted through this process is CH_4. Cities will need to know the number of different types of animals within the city boundary, the type of digestive system, and the type and amount of feed consumed.
- **Manure management** emissions occur from the decomposition of manure (CH_4), and combined nitrification and denitrification of nitrogen contained in the manure (N_2O). Emissions from manure depend on the manure management technique adopted. To calculate CH_4 emissions from manure management, cities will need to know the number of livestock by animal type, average annual temperature, as well as the relevant emission factors. Average annual temperature data can be obtained from international and national weather centres, as well as academic sources. To calculate N_2O emissions from manure management, the main factors a city will need to know are the number of livestock by animal type, the nitrogen and carbon content of the manure, the duration of storage, and the type of treatment.

More detail on calculating CH_4 emissions from manure management is given in chapter 10 of the GPC, specifically equation 10.2.

More detail on calculating N_2O emissions from manure management is given in chapter 10 of the GPC, specifically equation 10.3 and 10.4.

Land use, and land use change

Emissions and removals are based on changes in stocks of Carbon and are estimated for each land-use category. The IPCC and the GPC divide land-use into six categories: forest land, cropland, grassland, wetlands, settlements, and other (**Table 23**). This includes both land remaining in a land-use category as well as land converted to another use. Carbon stocks consist of above-ground and below-ground biomass, dead organic matter, and soil organic matter. The GPC recommends cities adopt a simplified approach to estimate land use emissions that consists of multiplying net annual carbon stock change for different land-use (and land-use change) categories by surface area.

Equations 10.5 and 10.6 in the GPC cover estimating change in carbon stock from land use.

Table 23: Land use categories (From 2006 IPCC Guidelines)

Land use category	Description
Settlement	All developed land, including transportation infrastructure and human settlements of any size
Cropland	Cropped land, including rice fields, and agro-forestry systems where the vegetation structure falls below the thresholds for Forest land
Forest land	All land with woody vegetation consistent with thresholds used to define Forest land in national inventory
Grassland	Rangelands and pasture land that are not considered Cropland, and systems with woody vegetation and other non-grass vegetation that fall below the threshold for Forest land
Wetland	Areas of peat extraction and land that is covered or saturated by water for all or part of the year
Other	Bare soil, rock, ice, and all land areas that do not fall into any of the other five categories

Aggregate sources and non-CO_2 emissions sources on land

The GPC splits emissions from aggregate sources and non-CO_2 emissions sources on land into a number of general categories, as follows:

- **Biomass burning**; when biomass is burned without energy recovery, such as periodic burning of land or accidental wildfires, GHG emissions should be reported under AFOLU. A city will need to know the area of land burnt, the mass of fuel burnt, and default factors such as a combustion factor and an emission factor.

Equation 10.7 in the GPC covers calculating emissions from biomass burning.

Biomass burned for energy should be reported under *Stationary Energy,* not AFOLU. Ensure emissions are reported as CO_2(b) rather than CO_2.

- **Liming** is used to reduce soil acidity in order to improve plant growth. Adding carbonates to the soil (such as limestone and dolomite) creates CO_2 emissions as the carbonate limes dissolve and produce bicarbonate, which later turns to CO_2 and water. A city will need to know the total amount of lime (differentiating between limestone and dolomite) applied to soils within the city.

Equation 10.8 in the GPC covers calculating emissions from liming.

- **Urea application** is used as a fertiliser and leads to emissions of CO_2 that were fixed during the industrial process of producing the fertiliser. A city needs to know the amount of urea fertilization on land within the city boundary.

Equation 10.9 in the GPC covers calculating emissions from urea application.

- **Direct N_2O from managed soils** occurs directly from soils which have had Nitrogen added to them.

Equations 10.10 to 10.18 in the GPC cover calculating direct N2O from managed soils.

- **Indirect N_2O from managed soils** takes place through volatilization of Nitrogen as NH_3 and oxides of Nitrogen (NO_x), and leaching and runoff from agricultural Nitrogen additions to managed lands**.**

Equation 10.20 in the GPC covers calculating indirect N2O from managed soils.

- **Indirect N_2O from manure management** result from volatile nitrogen losses that occur primarily in the forms of NH_3 and NO_x. To calculate, a city needs to know the amount of nitrogen excreted (from all livestock categories) and managed in each manure management system.

Equation 10.21 and 10.22 in the GPC cover calculating indirect N2O from manure management.

- **Rice cultivation** produces large quantities of CH_4. A city needs to know the amount of rice grown within the city boundary, the harvested area, the water regime, as well as some other factors.

These other factors needed are defined in equations 10.23, 10.24 and 10.25 of the GPC.

- **Harvested wood products** includes all wood that is taken from a harvest site. However, depending on the product and its use, the carbon in the wood may be stored for many years (e.g. wood panels in buildings). The IPCC allow for net emissions from harvested wood products to be reported as zero unless the annual change in wood stocks is deemed to be significant (for national inventories, ‘insignificant’ is defined as being less than the size of any key category – there is no such definition in the GPC, so it is up to the city whether to report these emissions).

Common challenges and recommendations

Common challenge 1

Few cities have reported AFOLU emissions. Often cities find that there are no significant land use activities to report, but are unclear what to report.

Recommendations

- Under a 'tier 1' approach in the IPCC Guidelines, a land type remaining a land type is assumed to have zero net emissions.
- If there are no AFOLU emissions to report, a city should report the AFOLU sector as Not Occurring (NO).

Common challenge 2

Understanding whether there are relevant AFOLU emissions to report can be challenging, particularly judging whether there are significant.

Recommendation

- Unless there are large areas of agricultural land, large livestock farms or areas of the city undergoing change from, e.g., forest or grassland to settlement, AFOLU emissions will be very minor. It is good practice to assess the scale of any relevant land use however, such as market gardens, allotments, and park land, and consider a threshold over which they should be estimated (however, there is currently no recommended threshold).
- To identify possible emission sources and judge their relevance, cities could refer to the following resources, if available:
    - land cover maps
    - statistics on areas of crops or numbers of animals
    - data on business activities, to identify crop or livestock production businesses
    - sales data for agricultural goods (e.g. fertilisers)
- Once activities have been identified, relevant activity data could be obtained from data sources including:
    - Land cover maps, e.g. data from international organisation statistics (e.g. FAO Stat)
    - Statistics on areas of crops or numbers of animals
    - City business registers or city-level surveys
    - Production data for agricultural goods
    - Expenditure data for agricultural input,
    - Industry associations and groups
    - Local knowledge, sectoral experts
    - National data, emission reports, surveys

Common challenge 3

Cities may struggle with acquiring specific data on activities that are occurring within the city.

Recommendation

If national data is available, scaling that using a suitable scaling factor e.g. agricultural land area for the city versus for the whole country. This can be adjusted through local knowledge such as the particular crop types grown in the city. Alternatively, information that may not have initially been collected for inventory purposes can be applied, similarly to how Mexico City used operating license data to fill gaps in there IPPU data.

Common challenge 4

Some emissions associated with AFOLU activity are reported in other sectors and a common challenge is accurately differentiating between these.

Recommendation

An example of this would be emissions from the manufacture of fertilisers, which are reported in *IPPU*, but emissions from the use of fertilisers, including emissions from soil as a consequence of applying fertilisers, are reported in *AFOLU*. Emissions associated with the burning of dung for fuel must be reported under *Stationary Energy*, or under *Waste* if burned without energy recovery.

Emissions that occur elsewhere in supply chains that are linked to land management are generally not included, and emissions from use of grid-supplied energy and fossil fuels for transport are not included. These emissions are measured in other categories of emissions outside of AFOLU. Examples of these exclusions include:

- Emissions from the manufacture of fertilisers applied to land (reported under IPPU)
- Emissions from use of diesel in tractors (reported under Stationary Energy)
    - Note that transportation fuel use supporting a sector is reported in Stationary Energy and not Off-road Transportation; this is reserved for activities that are solely for transport purposes (e.g. within transportation facility premises such as airports, harbours, bus terminals and train stations)
- Emissions from generation of grid electricity used to power equipment in buildings (Reported under Stationary Energy)
- Emissions from manufacture of fertilisers (reported in IPPU) and from pet animals and draught animals are excluded

Worked example

Figure 21 gives an example of the *AFOLU* sheet. See **Figure 11** *Stationary energy* worked example for a summary view of the full table.

Figure 21: Worked example from the AFOLU sheet

Common activities reported are forest management, amenity land management (e.g. golf courses), livestock farming, manure management, use of fertilisers and crop production.

Describe the GHG emission source. For livestock, this will either be enteric fermentation or manure management.

For the other AFOLU sectors, the description will likely be related to categories described in the 'Calculating AFOLU emissions' section of this guidance.

Heads of livestock, per animal category, is a typical activity data unit for this sub-sector.

V.1 LIVESTOCK

GPC ref No.	Scope	GHG Emissions Source		Notation keys	Activity data		Activity data unit converter			Gas(es)
		Activity	Description		Amount	Units	EF unit	Default	Override	
8 V.1	1	Emissions from livestock								
V.1	1	Cattle (meat)	Enteric fermentation		2,675	heads				CH4
V.1	1	Cattle (milk production)	Enteric fermentation		725	heads				CH4
V.1	1	Swine	Enteric fermentation		1,230	heads				CH4
V.1	1	Sheep	Enteric fermentation		2,150	heads				CH4
V.1	1	Cattle (meat)	Direct emissions from manure management		2,675	heads				CH4, N2O
V.1	1	Cattle (milk production)	Direct emissions from manure management		725	heads				CH4, N2O
V.1	1	Swine	Direct emissions from manure management		1,230	heads				CH4, N2O
V.1	1	Sheep	Direct emissions from manure management		2,150	heads				CH4, N2O

Type of animal is selected. If the animal type is not on the list, simply type the type into the cell.

In this case, there were two types of cattle (meat and milk production) so this is reported.

If reporting a BASIC inventory, the notation key NE should be used along with an explanation to say that AFOLU sources are not a requirement of a BASIC inventory.

CH_4 emissions are released through enteric fermentation.

CH_4 and N_2O emissions are released through manure management.

Emission factor selected from the drop-down list which is linked to the *Emission factors* sheet.

For some sources, only the emissions data is known, so this column is ticked.

These columns are auto populated.

Emission factor	Emission factor						Emissions data	GHGs (metric tonnes CO_2e)					GHGs (metric tonnes CO_2e)				
	Units	CO_2	CH_4	N_2O	Total tCO_2e	CO_2(b)		CO_2	CH_4	N_2O	Total tCO_2e	CO_2(b)	CO_2	CH_4	N_2O	Total tCO_2e	CO_2(b)
EF_Cattle (meat)	tCO2e/head		1.4										-	3745	-	3745	-
EF_Cattle (milk production)	tCO2e/head		1.8										-	1305	-	1305	-
EF_Swine	tCO2e/head		0.025										-	31	-	31	0
EF_Sheep	tCO2e/head		0.125										-	269	-	269	0
							✓		62.2419	705.7628286	768.0047286		-	334	-	334	0
							✓		24.36	495.0150857	519.3750857		-	24	495	519	-
							✓		152.397	137.0936914	289.4906914		-	152	137	289	-
							✓		7.224	94.26214286	101.4861429		-	7	94	101	-

Emission factors and units pulled through from *Emission factors* sheet.

This emissions data has been manually inputted (in metric tonnes CO_2e).

Select from H, M and L based on the descriptions given in **Table 14**.

Select the appropriate sources from the drop-down list which is linked to the *Data Sources* tab.

Data Quality AD	Description of method(s) used or explanation for using notation key(s)	Source	Data quality explanation (optional)
	V.1 has not been estimated; not required for BASIC		
H	The source mentioned refers to the activity data used. The emission factors used were based on 2006 IPCC guidelines.	Research on municipal livestock 2011	Local data on livestock numbers
H	The source mentioned refers to the activity data used. The emission factors used were based on 2006 IPCC guidelines.	Research on municipal livestock 2011	Local data on livestock numbers
H	The source mentioned refers to the activity data used. The emission factors used were based on 2006 IPCC guidelines.	Research on municipal livestock 2011	Local data on livestock numbers
H	The source mentioned refers to the activity data used. The emission factors used and calculations were based on 2006 IPCC guidelines.	Research on municipal livestock 2011	Local data on livestock numbers
H	The source mentioned refers to the activity data used. The emission factors used were based on the National Communication and calculations were based on 2006 IPCC guidelines.	Research on municipal livestock 2011	Local data on livestock numbers
H	The source mentioned refers to the activity data used. The emission factors used were based on the National Communication and calculations were based on 2006 IPCC guidelines.	Research on municipal livestock 2011	Local data on livestock numbers
H	The source mentioned refers to the activity data used. The emission factors used were based on the National Communication and calculations were based on 2006 IPCC guidelines.	Research on municipal livestock 2011	Local data on livestock numbers
H	The source mentioned refers to the activity data used. The emission factors used were based on the National Communication and calculations were based on 2006 IPCC guidelines.	Research on municipal livestock 2011	Local data on livestock numbers

A brief description of the method is required.

If a city is not reporting AFOLU emissions, an explanation should be provided here. For a BASIC inventory, it is acceptable to say that AFOLU emissions are not reported as it is not a BASIC requirement.

Provide an explanation for the data quality assessment for activity data. This is optional, but recommended to ensure a transparent and detailed inventory.

Other scope 3 sheet

The *Other scope 3* sheet is used to record activity and emissions data for any other emissions occurring outside the geographic boundary as a result of city activities. Measuring these emissions allows cities to take a more holistic approach to tackling climate change by assessing the GHG impact of all city activities, particularly emissions embodied in the supply chain of goods and services used by city residents. These emissions are not yet covered by the GPC; however, some cities are now reporting activities such as emissions from the supply of goods and services (such as water supply), construction, food and drink, and other supply chain emissions. The *Scope 3* sheet can also be used to document activities that a city would like to report for transparency, but may result in double counting if reported elsewhere.

> The GPC authors anticipate providing additional guidance for estimating emissions from key goods and services produced outside the city boundary.

For example, Oslo reported waste generated within the city but incinerated outside the country under Scope 3. Gibraltar used Scope 3 to report bunker fuel sold to international ships.

Reporting Other Scope 3 emissions is not a requirement of a BASIC or a BASIC+ inventory, but if information is available, a city should try to report as many emission sources as possible to achieve a fully transparent and detailed inventory. Other Scope 3 emissions are reported separately from the BASIC/BASIC+ totals.

Reporting other scope 3 emissions aligns with a consumption-based accounting approach (an alternative to the sector-based approached adopted by the GPC) which accounts for all goods and services consumed by city residents – emissions are reported by consumption category rather than the emission source categories set out in the GPC. Consumption-based accounting approaches are complimentary to the GPC and provide a different insight into the city's GHG emissions profile.

> For more information on city-scale consumption based accounting, consult PAS2070. For an applied case study, refer to London's PAS2070 inventory.

How to use this sheet

CIRIS splits the activities into goods and services, food, construction, and upstream emissions from energy use. If a city wishes to report in additional categories, simply overwrite in the 'activity' column.

The *Other scope 3* sheet is also completed in the same way as other sheets, following the key terms described in **Table 14**.

Calculating other scope 3 emissions

The calculation of other scope 3 emissions, as mentioned, is not covered by the GPC. For most sources, a similar approach to the other sectors will be taken (i.e. activity data multiplied by emission factor).

Worked example

Figure 22 gives an example of the *Other scope 3* sheet. See **Figure 11** *Stationary energy* worked example for a summary view of the full table.

Figure 22: Worked example from the Scope 3 sheet

Common activities reported are supply chain emissions from the consumption of food and drink, and products such construction materials. Upstream emissions for water consumption are often sometimes included here.

The activity has been selected from the drop-down list. If a city wants to report additional activities, name the activity here.

If other scope 3 emissions are not being reported, ensure to use the notation key NE.

Select which gases are being reported. As an optional sector, there is no requirement to report particular gases. However, in the interest of a complete inventory, as many gases as possible should be estimated.

VI.1 OTHER SCOPE 3

3

GPC ref No.	Scope	GHG Emissions Source		Notation keys	Activity data		Activity data unit converter			Gas(es)
		Activity	Description		Amount	Units	EF unit	Default	Override	
VI.1	**3**	**Other Scope 3**								
VI.1	3	Goods and services	Water		1775	Ml				CO2, CH4, N2O
VI.1	3	Construction	Cement and steel		914066	tonne				CO2, CH4, N2O
VI.1	3	Food	Food and drink							CO2, CH4, N2O

Emissions reported under Other scope 3 emissions, as the name suggests, will always be for scope 3 activities – so those occurring outside the city boundary.

Give a brief description of the type of activity. For example, what type of goods and services are emissions being estimated for.

Report activity data in applicable units ensuring that units match emission factor units. There are no activity data for 'Food' as the emissions were modelled and then directly entered.

Emission factor selected from the drop-down list which is linked to the *Emission factors* sheet.

For some sources, only the emissions data is known, so this column is ticked.

These columns are auto populated.

Emission factor	Emission factor						Emissions data	GHGs (metric tonnes CO_2e)					GHGs (metric tonnes CO_2e)				
	Units	CO_2	CH_4	N_2O	Total tCO_2e	$CO_2(b)$		CO_2	CH_4	N_2O	Total tCO_2e	$CO_2(b)$	CO_2	CH_4	N_2O	Total tCO_2e	$CO_2(b)$
EF_water	tCO2e/m-litre				8.607877229								-	-	-	15278	-
							✓				867021.171		-	-	-	867021	-
							✓				4090659.357		-	-	-	4090659	-

Emission factors and units pulled through from *Emission factors* sheet.

This emissions data has been manually inputted (in metric tonnes CO_2e).

Select from H, M and L based on the descriptions given in **Table 14**.

Select the appropriate sources from the drop-down list which is linked to the *Data sources* tab.

Data Quality AD	Description of method(s) used or explanation for using notation key(s)	Source	Data quality explanation (optional)
	VI.1 has not been estimated; not required for BASIC		
H	Quantity of mains water provision, disaggregated by customer and origin of supply multiplied by emission factor	Quantity of mains water provision	City-level data provided by water companies
L	Quantity of cement and steel materials used nationally apportioned to city based on its share of the value of construction output, multiplied by national emission factor.	Data on construction of buildings	Scaled national data
M	Emissions estimates from MR-EEIO model (no activity data)	MR-EEIO model	Modeled activity data

A brief description of the method is required.

If a city is not reporting Other Scope 3 emissions, an explanation should be provided here. It is acceptable to say that Other scope 3 emissions are not reported as it is not a BASIC or BASIC+ requirement.

Provide an explanation for the data quality assessment for activity data. This is optional, but recommended to ensure a transparent and detailed inventory.

Part 3: Results Tab

The *Results* tab is where the outputs from the emission estimates can be found, where trends can be identified, goals set and emissions tracked over time. The *Results* tab is also where net emissions targets can be monitored and historical inventories compared.

The information presented in this tab can allow a city to begin interpreting their data and answering questions such as:

- What would an appropriate GHG reduction target be?
- Are we on track to meet our GHG reduction target?
- What sectors should policies be targeted at?
- How do my city's emissions compare to other cities?
- How do my city's emissions relate to national emissions?

It can also clearly represent where data gaps are, allowing the city the opportunity to improve their inventory next time around.

One of the key uses of the *Results* tab is for reporting and communicating a city's data. Reporting can involve participation in the Compact of Mayors and the annual disclosure associated with that, it can also mean an official city government report or publicly available city statistics.

Communication on the other hand is tailored for different audiences. Whether it is a local community engagement strategy, the city environment webpages, infographics or social media outputs. The data and charts contained in the *Results* tab can help assist users to do this.

The *Results* tab consists of six sheets, as described in **Table 24** and in the following sections of this chapter of the guide. For each sheet, there is an explanation/description of what the sheet shows/how it works, and a worked example demonstrating the functionality.

Table 24: Sheets in the Results tab

Sheets	Description
Summary	High-level summary of the city GHG emissions inventory
Graphs	Summary graphs showing city emissions, by (sub-) sector, scope and reporting level
Overview	Detailed summary table of city emissions profile, by (sub-) sector, scope and reporting level
Analysis	Analyse city emissions profile and trend. Results can be viewed as GHG emissions, per capita, per unit land area (km^2), or per unit GDP (US$ million)
Net emissions	If your city has a net GHG emissions reduction target, use this sheet to record your emission credits and estimate your net emissions
GCoM - CRF	Additional information required under the Common Reporting Framework (CRF) of the Global Covenant of Mayors (GCoM).

Summary sheet

The first sheet of the *Results* tab is the *Summary* sheet. This page features a high-level overview of key data points. It begins with summarising the key city information, such as the inventory boundary, inventory year and population.

It then shows emissions totals across scopes and sectors as well as the cumulative total. A graph on the right hand side of the page visualises each sector total allowing users to see their city's particular balance of emissions. Understanding this can be key in the process of goal and target setting and then tracking of change over time.

Worked Example

Data from the *City Information* sheet are displayed in the *Summary* sheet, as below.

NAME OF CITY:	Autonomous City of Buenos Aires, Argentina	**POPULATION:**	3,079,071
BOUNDARY:	BASIC	**LAND AREA (km2):**	202
INVENTORY YEAR:	2013	**GDP (US$ million):**	79,384

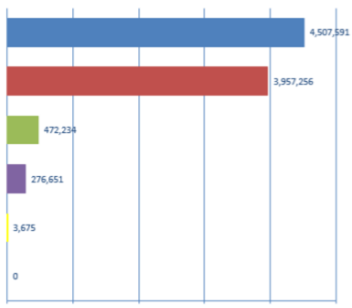
Figure 23 shows the main output on the *Summary* sheet; a high-level summary of the city emissions, broken down by scope, sector, and displayed depending on the desired GPC reporting level.

Figure 23: Summary sheet worked example

Select the GPC reporting level that emissions should be reported by from the drop-down list. See **Box 3** for information on GPC reporting levels.

Emissions by scope. See **Table 8** for further information on scopes.

BASIC+	Scope 1	Scope 2	Scope 3
Stationary	1,045,728	3,211,698	250,166
Transportation	3,877,212	64,985	15,059
Waste	383,786		88,448
IPPU	276,651		
AFOLU	3,675		
Other Scope 3			
TOTAL		9,217,408	



Emissions by sector

Inventory sectors

Emissions total, by scope and sector

Intensity indicators	Per capita	Per unit land area (km2)	Per unit GDP (US$m)
Emissions	3.0	45,622	116

Below the high-level summary, emissions intensities are derived by three categories: per capita, per unit land area and per unit of GDP. These figures are invaluable, especially for reporting, as they allow direct comparison between cities on an equalised basis.

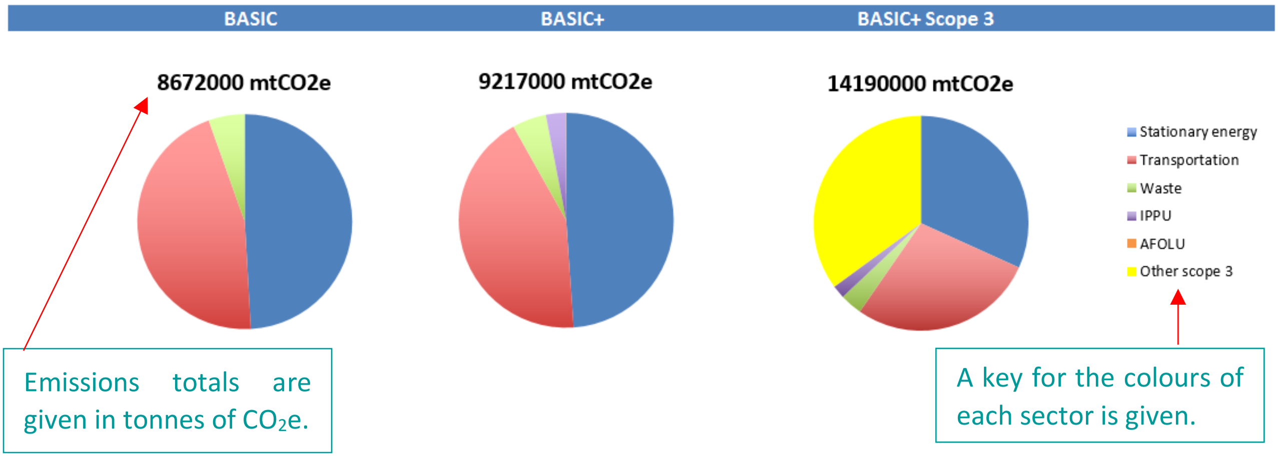
Graphs sheet

The *Graphs* sheet offers four visualisations of a city's data, broken down by inventory boundary, scope, sector and sub-sector. This page offers the most detailed graphical breakdown of the results of the inventory and therefore could be very useful to users for communication or reporting of the headline results.

Worked Example

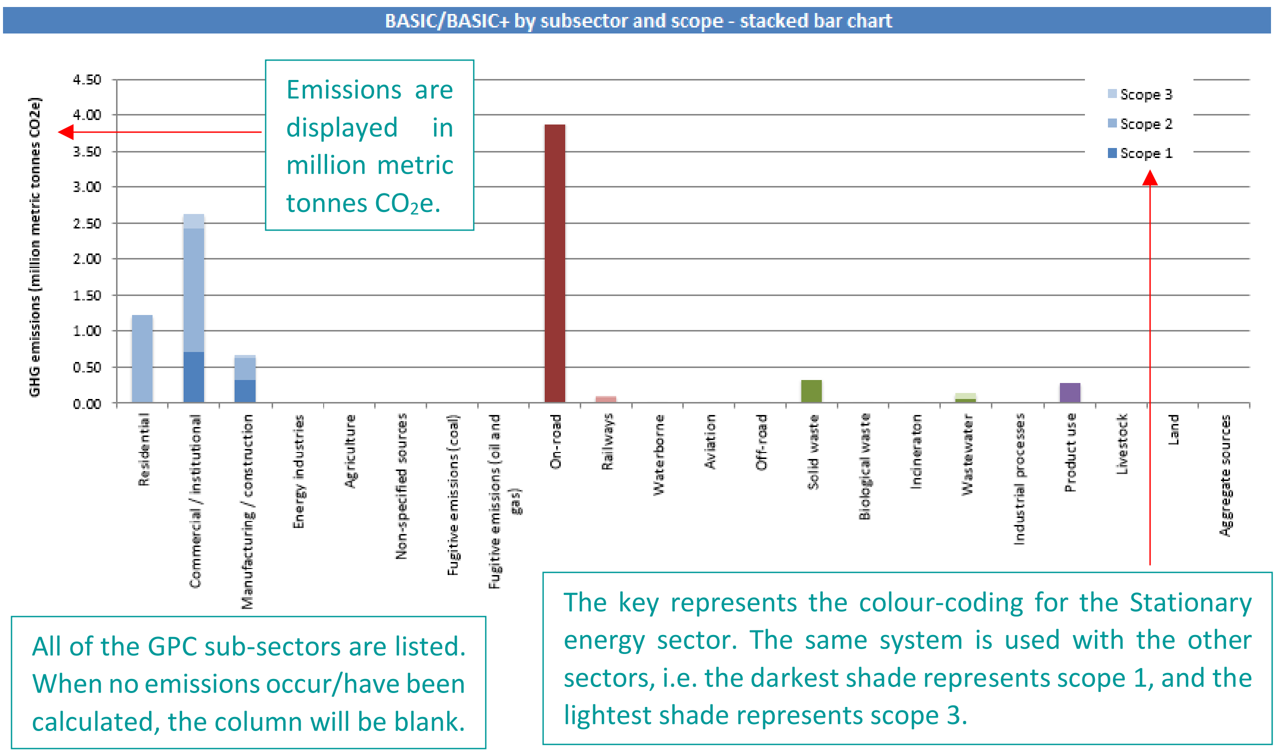
The first set of graphs, presented in **Figure 24**, are three pie charts, each representing a different GPC reporting level (see **Box 3**), and split by sector. Emission totals, by reporting level, are also given in $mtCO_2e$.

Figure 24: Pie charts on *Graphs* sheet, breaking emissions down by sector and reporting scope



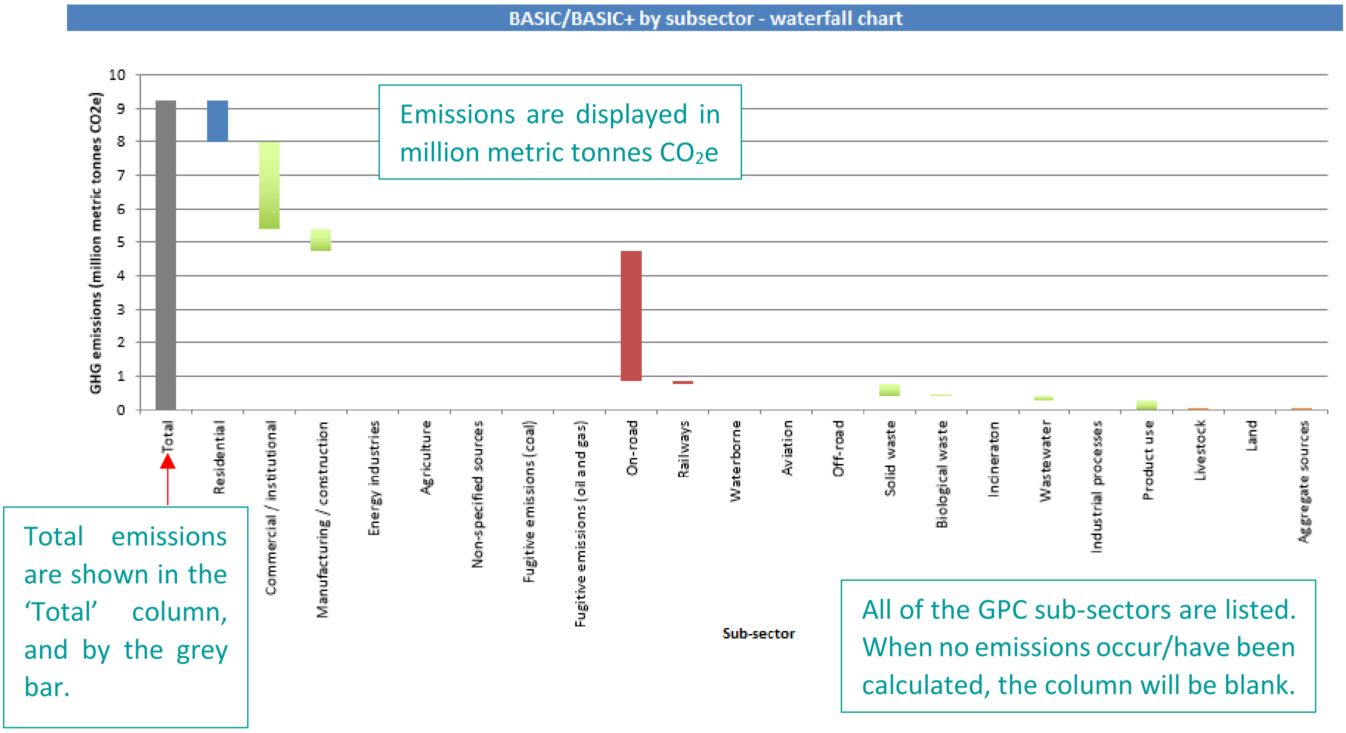
A stacked bar chart is then presented, as seen in **Figure 25**; this displays emissions totals by sub-sector and scope. Emissions are displayed comparatively so the approximate value of each component can be compared at the scope level.

Figure 25: Stacked bar chart on *Graphs* sheet, displaying emissions by sub-sector and scope



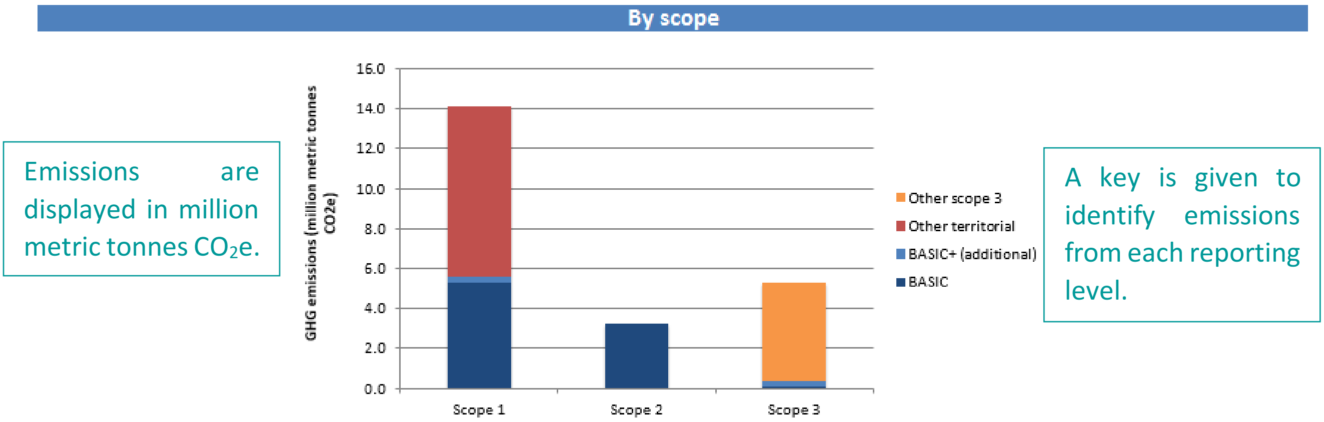
A waterfall chart is then displayed, as in **Figure 26**; this breaks the total down by each contributing sub-sector. Emissions are displayed cumulatively so the relative contribution of sector totals to the overall total can be more easily compared.

Figure 26: Waterfall chart on *Graphs* sheet, displaying emissions by sub-sector



Emissions are then displayed by scope, using a bar chart, as shown in **Figure 27**. Here, territorial emissions are shown. Territorial emissions aren't included in BASIC or BASIC+ but can be a significant contributor to a city's GHG emissions.

Figure 27: Emissions by scope in the *Graphs* sheet



Overview sheet

The *Overview* sheet features a detailed breakdown of the results of the inventory. It shows a total value for each scope, inventory boundary, sector and sub-sector; as well as overall totals. This level of detail would allow a city to be more precise with their interpretation, develop targets around specific sources by their sub-sector and communicate detail where necessary.

Worked Example

Emission totals, by sector, scope and GPC reporting level, are displayed in the first table in the *Overview* sheet, as shown in **Figure 28**.

Figure 28: Emissions by scope in the *Overview* sheet

GHG Emissions Source (By Sector)		Total GHGs (metric tonnes CO2e)					
		Scope 1	Scope 2	Scope 3	BASIC	BASIC+	BASIC+ S3
STATIONARY ENERGY	Energy use (all emissions except I.4.4)	1,045,728	3,211,698	250,166	4,257,426	4,507,591	4,507,591
	Energy generation supplied to the grid (I.4.4)	8,498,216					
TRANSPORTATION	(all II emissions)	3,877,212	64,985	15,059	3,942,196	3,957,256	3,957,256
WASTE	Waste generated in the city (III.X.1 and III.X.2)	383,786		88,448	472,234	472,234	472,234
	Waste generated outside city (III.X.3)	28,976					
IPPU	(all IV emissions)	276,651				276,651	276,651
AFOLU	(all V emissions)	3,675				3,675	3,675
OTHER SCOPE 3	(all VI emissions)			4,972,958			4,972,958
TOTAL		14,114,244	3,276,683	353,672	8,671,856	9,217,407	14,190,366

Emissions are given by GPC sector. For stationary energy, energy generation is reported separately. For waste, a distinction is made to show waste generated in and outside of the city.

Emissions by scope

Emissions by GPC reporting level

The cells in this table, and the table in **Figure 29**, are colour-coded. See the section of this guide regarding **Cell colour-coding** or the key below.

	Sources required for BASIC reporting
	Sources required for BASIC + reporting
	Sources included in Other Scope 3
	Sources required for territorial total but not for BASIC/ BASIC+ reporting
	Non-applicable emissions

A detailed table of all emissions, as metric tonnes CO_2e, is then given, as in **Figure 29**. This table splits emissions by GPC sector, as well as GPC sub-sector. Emissions are also reported by their scope, and as a total for each sub-sector and sector.

Figure 29: Emissions by sector and sub-sector in the *Graphs* sheet

GPC ref No.	GHG Emissions Source (By Sector and Sub-sector)	Total GHGs (metric tonnes CO_2e)			
		Scope 1	Scope 2	Scope 3	Total
I	STATIONARY ENERGY				
I.1	Residential buildings	23,330	1,197,837	NE	1,221,167
I.2	Commercial and institutional buildings and facilities	704,546	1,709,471	209,580	2,623,597
I.3	Manufacturing industries and construction	317,852	304,390	40,585	662,827
I.4.1/2/3	Energy industries	NO	NO	NE	
I.4.4	Energy generation supplied to the grid	8,498,216			
I.5	Agriculture, forestry and fishing activities	NO	NO	NO	
I.6	Non-specified sources	NO	NO	NO	
I.7	Fugitive emissions from mining, processing, storage, and transportation of coal	NO			
I.8	Fugitive emissions from oil and natural gas systems	NE			
SUB-TOTAL	(city induced framework only)	**1,045,728**	**3,211,698**	**250,166**	**4,507,591**
II	TRANSPORTATION				
II.1	On-road transportation	3,859,670	NO	NE	3,859,670
II.2	Railways	17,542	64,985	15,059	97,586
II.3	Waterborne navigation	NO	NO	NO	
II.4	Aviation	NO	NO	NE	
II.5	Off-road transportation	NO	NO	NO	
SUB-TOTAL	(city induced framework only)	**3,877,212**	**64,985**	**15,059**	**3,957,256**
III	WASTE				
III.1.1/2	Solid waste generated in the city	328,396		NO	328,396
III.2.1/2	Biological waste generated in the city	NO		5,262	5,262
III.3.1/2	Incinerated and burned waste generated in the city	NO		NO	
III.4.1/2	Wastewater generated in the city	55,390		83,186	138,576
III.1.3	Solid waste generated outside the city	28,976			
III.2.3	Biological waste generated outside the city	NO			
III.3.3	Incinerated and burned waste generated outside city	NO			
III.4.3	Wastewater generated outside the city	NO			
SUB-TOTAL	(city induced framework only)	**383,786**		**88,448**	**472,234**
IV	INDUSTRIAL PROCESSES and P				
IV.1	Emissions from industrial processes occurring in the city boundary	NE			
IV.2	Emissions from product use occurring within the city boundary	276,651			276,651
SUB-TOTAL	(city induced framework only)	**276,651**			**276,651**
V	AGRICULTURE, FORESTRY and				
V.1	Emissions from livestock	6,594			6,594
V.2	Emissions from land	-5,820			-5,820

The GPC sub-sector code is given.

Notation keys for sub-sectors which have no emissions reported are given.

See the colour-coding key above for information on the cell colours.

Analysis sheet

This sheet allows users compare the current inventory against previous inventories. This helps with tracking progress over time.

How to use this sheet

To do use this sheet, copy data from this page for a previous inventory and paste (using “paste special” > “values”) into the rows below the current inventory (displayed in the top row). Alternatively and if previous inventories are not reported using CIRIS, data can be entered manually to this sheet. Emissions should be added for each sub-sector, in tonnes CO_2e. Notation keys should be added for sub-sectors for which emissions have not been calculated. An inventory reporting level (BASIC, BASIC+ and Territorial) and emissions type (total GHG, per capita, per unit land area and per unit GDP) should be selected, to compare the inventories.

If emission credits have been reported, the inventory can be viewed on a net emissions basis by switching 'View total as net emissions' on.

Once all data has been inputted to the historical emissions table, a number of graphs will be populate, as shown in **Figure 30** and **Figure 32** in the Worked Example below.

Worked Example

The table in the *Analysis* sheet has an entry for each GPC sub-sector. These are colour-coded to indicate the reporting level; see the section of this guide on **Cell colour-coding. Figure 30** is an extract from the Historical emissions table in the *Analysis* sheet – the table from which this figure comes from covers every GPC-subsector; however, **Figure 30** is for illustrative purposes and does not display each sub-sector.

Figure 30: Historical emissions table in the *Analysis* sheet

The first line, shaded grey, is auto populated with current inventory data.

The table includes space to report emissions under every sub-sector.

Year	Population	Area (km2)	GDP ($m)	I.1.1	I.1.2	I.1.3	I.2.1	I.2.2	I.2.3
2013	3079071	202.04	79384	23330	1197837	NE	704546	1709471	NE
2012	29097280	202.04	73897	25663	1317621	NE	775001	1880418	NE
2011	26187552	202.04	66507	28229	1449383	NE	852501	2068460	NE

This information can be found in the *City information* sheet of previous inventories.

Ensure notation keys are entered to improve transparency.

After the historical emissions table, there are a number of graphs. CIRIS offers a number of options for how these graphs are displayed. **Table 25** explains these. The options can be changed by selecting the desired option from the drop-down menu next to each title.

Table 25: Display options for graphs in the *Analysis* sheet

Category	Options	Description
Inventory level	BASIC	See **Box 3** for information on GPC reporting levels
	BASIC+	
	Territorial	
Emissions type (tCO_2e)	Total GHG	All GHG emissions will be included
	Per capita	Emissions will be displayed per head of population
	Per unit land area (km_2)	Emissions will be displayed per unit of land area within the city boundary
	Pet unit GDP ($m)	Emissions will be displayed per million US dollars GDP reported
View total net emissions	On	If emission credits have been reported, the inventory can be viewed on a net emissions basis
	Off	Net emissions will not be considered

Once the graph options have been selected, graphs will be calculated for total emissions (**Figure 31**), and for each sector (**Figure 32**). These graphs can be copied from CIRIS and used for reporting or communications.

Figure 31: Total graph in *Analysis* sheet

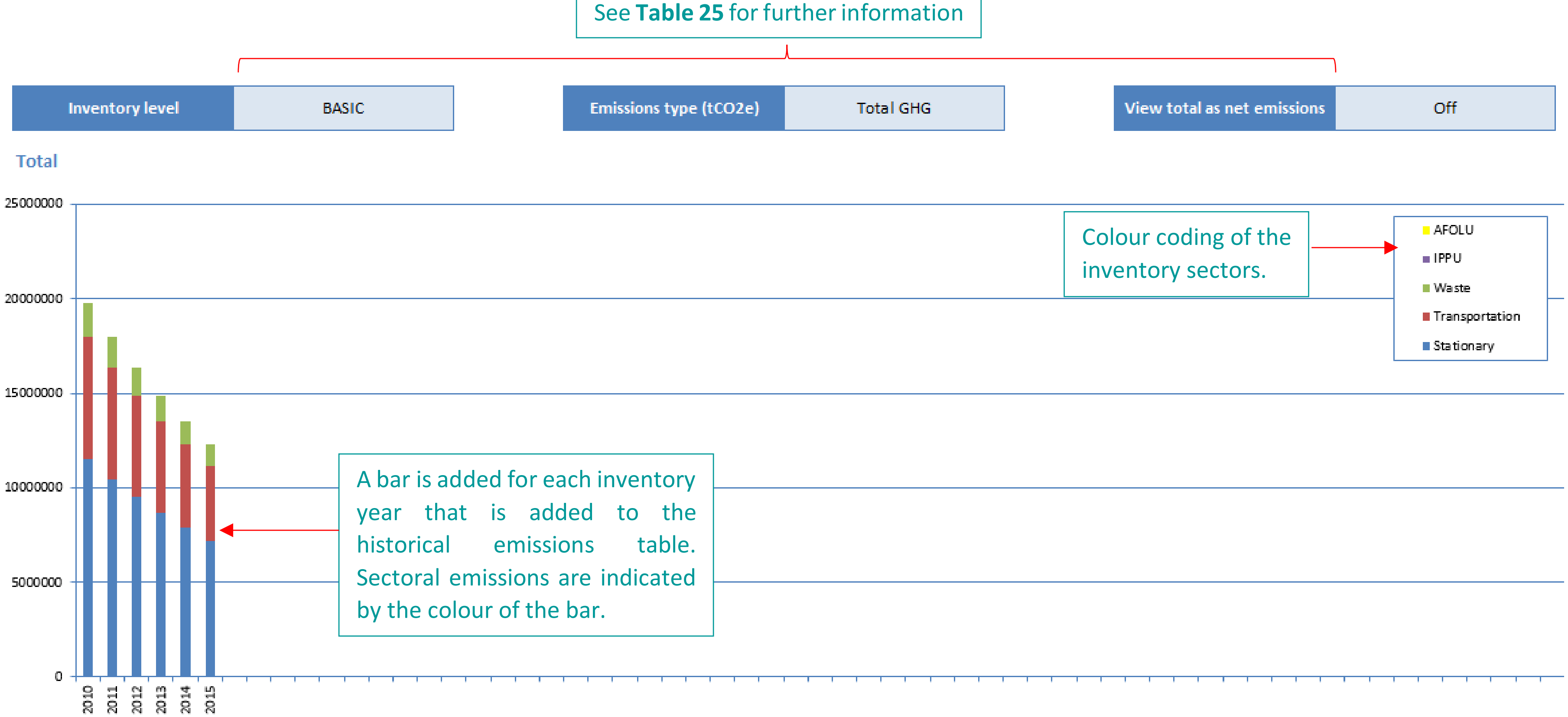
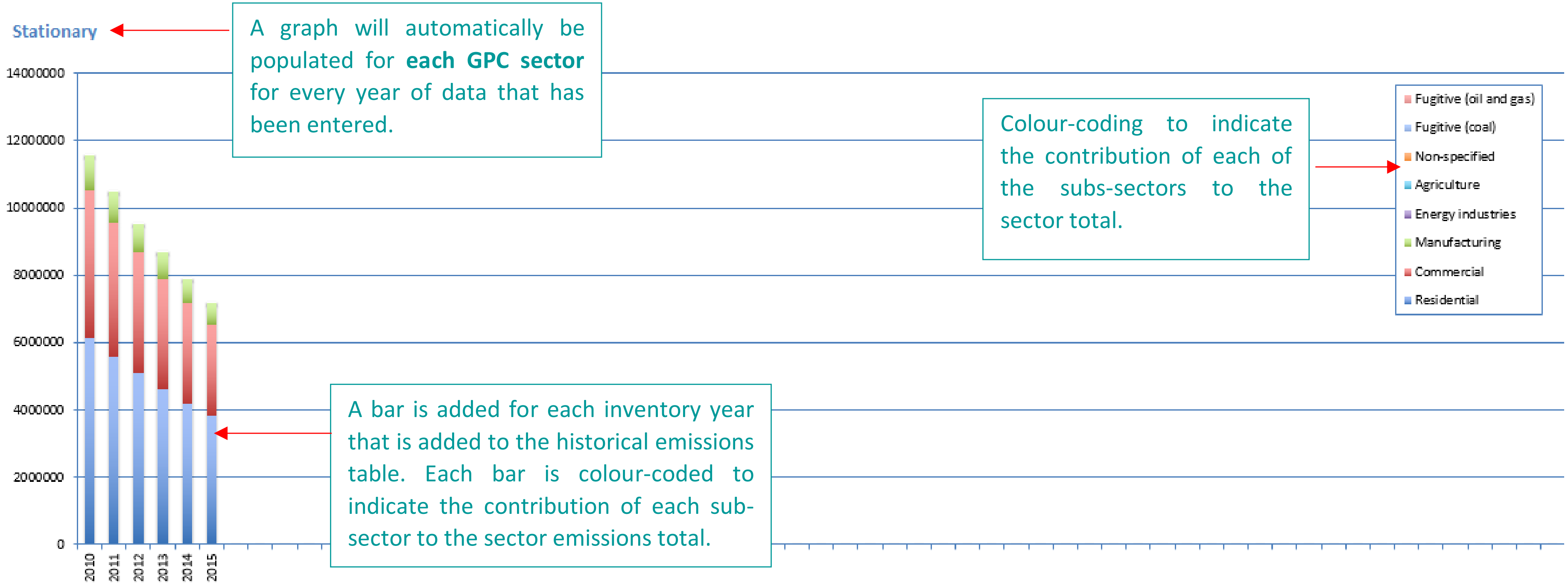


Figure 32: Sector graph in *Analysis* sheet



Net emissions sheet

The *Net Emissions* sheet is where users can account for mechanisms they have used to indirectly reduce GHG emissions or to account for different calculation methodologies. Not all cities will have such information to report. The *Net emissions* sheet accommodates three main mechanisms to calculate the net emissions totals (**Table 26**); these totals are kept separate from the actual reported inventory total and are displayed at the bottom of the page.

See Chapter 4, section 3 (page 40) of the GPC for more information on reporting Net emissions

Table 26: Methods for calculating net emissions

Method	Definition
Scope 2 emissions based on market-based method	This reflects any electricity products or programs that city consumers (individuals, businesses and local government) participate in, generally provided by the electricity supplier(s) serving the city. Scope 2 emissions can be allocated from energy generators to consumers based on "contractual instruments" such as utility-specific emission factors or energy attribute certificates. Energy suppliers can provide emissions factors for any low-carbon or renewable energy consumer labels, tariffs, or programs rather than their standard portfolio. This can reduce the overall Scope 2 emissions total. See GPC Chapter 6.5.1 (Page 67) for a description on how to report this.
Offset credit transactions	Offset credits are generated when a project is established to reduce, remove or avoid emissions. Credits for this reduction against the business as usual scenario are then sold and can be claimed as indirect emissions reductions. If offset credits are generated in the geographic boundary and sold, these should be documented in the first table under the offset-credit transactions section and will be **added** to the reported inventory results. Any offsets purchased from outside the geographic boundary (e.g. to meet a city reduction target) should be reported in the second table under the offset-credit transactions section and will be **deducted** from the reported inventory results.
Renewable energy production or investments	This is where a city can capture renewable production that otherwise only indirectly impacts scope 2 emissions (through a lower grid average emission factor) and that would not be visible in scope 1 emissions for energy generation (due to its zero emissions profile). Such emission reductions can occur within the city boundary, or can reflect investments by the city outside the city boundary (e.g. offshore wind).

How to use this sheet

The *Net emissions* sheet requires users to enter information regarding any emission reductions achieved through mechanisms such as offset credits and renewable energy production/investments. Information should be added to the tables in the *Net emissions* sheet, as per the worked examples below. Data should be entered in all of the white cells. Grey cells perform calculations so should not be overwritten. All credits shall be entered as positive numbers.

Worked example

Figure 33 to **Figure 36** provide worked examples of the tables contained in the Net Emissions sheet.

Figure 33: Scope 2 emissions based on market-based method table in *Net emissions* sheet

Contractual instruments and programs can include: Energy attribute certificates (e.g. Renewable Energy Certificates (RECs) and Guarantees of Origin (GOs)), direct contracts and supplier-specific emission rates.

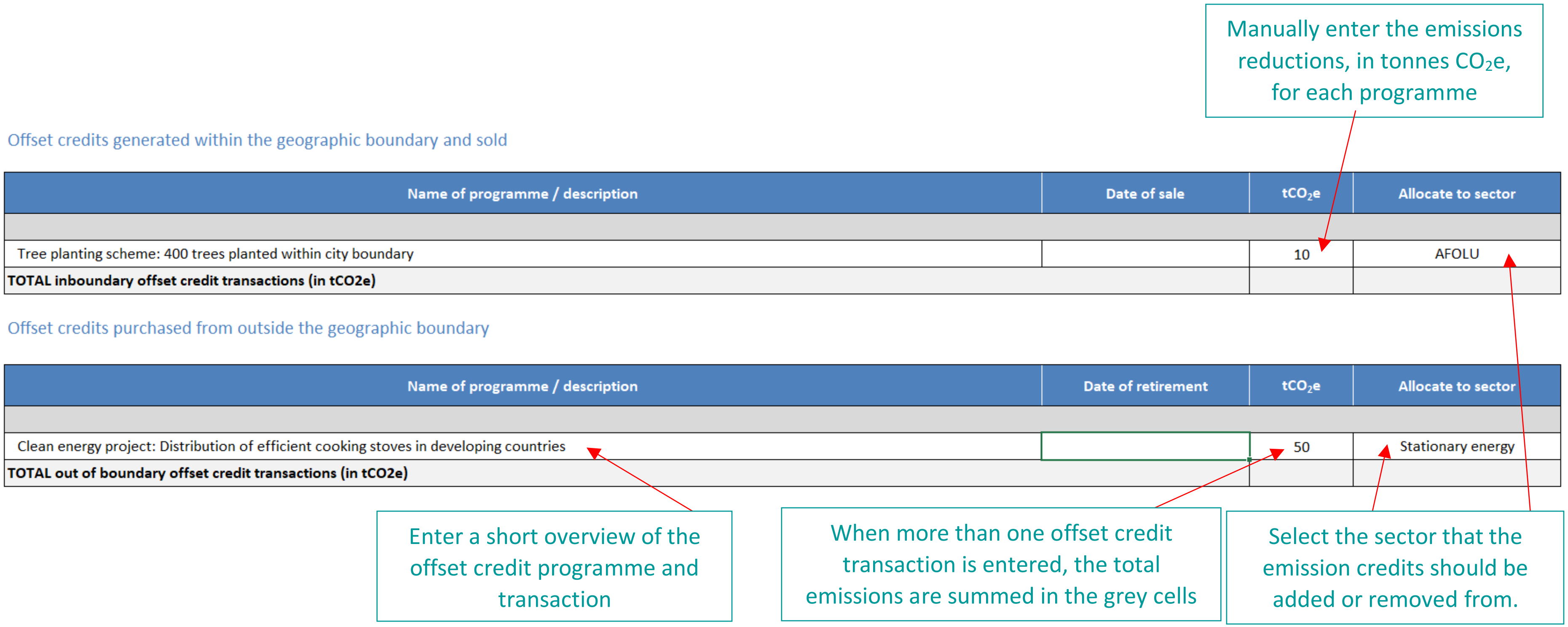
Input the emission factor of the specific emission source the instrument or program cited, covers. Ensure the emission factor units match the activity data (quantity of energy) units.

Contractual instrument or program type	Quantity of energy		Emission factor		tCO2e	Allocate to sector
	Amount	Units	Amount	Units		
Renewable Energy Certificate from utility company	46272	MWh	150	Kg CO_2e/MWh	6940.80	Stationary energy
TOTAL market-based scope 2 emissions (in tCO2e)					6940.80	

Ensure this is reported in **tonnes CO_2e**; this may require some conversions. See *Conversion Factors* sheet for common conversion factors.

Select the GPC sector that the emission reductions should apply to; this will most commonly be stationary energy.

Figure 34: Offset credit transactions tables in *Net emissions* sheet



Offset credits generated within the geographic boundary and sold

Name of programme / description	Date of sale	tCO_2e	Allocate to sector
Tree planting scheme: 400 trees planted within city boundary		10	AFOLU
TOTAL inboundary offset credit transactions (in tCO2e)			

Offset credits purchased from outside the geographic boundary

Name of programme / description	Date of retirement	tCO_2e	Allocate to sector
Clean energy project: Distribution of efficient cooking stoves in developing countries		50	Stationary energy
TOTAL out of boundary offset credit transactions (in tCO2e)			

Figure 35: Renewable energy production or investments in *Net emissions* sheet

Enter the name of the renewable energy technology type

To calculate avoided emissions as a result of renewable energy production, enter in the "Benchmark energy source" column the energy source that is substituted by renewable energy, and the emission factor of the benchmark energy source specified.

Enter the amount of reduction in emissions that have already been reflected in the gross emissions of your inventory via a lower grid emission factor, in order to avoid double counting. For more guidance on how to calculate this, please refer to GHG Protocol Scope 2 Guidance.

Technology type	Energy supplied to grid		Located in city boundary?	% outside boundary	Benchmark energy source	Emission factor		Correction (tCO_2e)	tCO_2e	Allocate to sector
	Amount	Units				Amount	Units			
Wind power	233,854	MWh	Yes		Grid-supplied electricity	0.45	t CO2e/MWh	4,677	100,557	Stationary energy
Waste	94,203	MWh	Yes		Grid-supplied electricity	0.45	t CO2e/MWh	1,884	40,507	Stationary energy
Biomass	142,695	MWh	Yes		Grid-supplied electricity	0.45	t CO2e/MWh	2,854	61,359	Stationary energy
Solar PV	736	MWh	Yes		Grid-supplied electricity	0.45	t CO2e/MWh	15	316	Stationary energy
TOTAL renewable energy production or investments (in tCO2e)									202,740	

Enter the amount of energy that is generated and supplied to the grid for each technology type. Ensure the unit is also entered.

Select 'yes' or 'no' depending on where the renewable energy production takes place.

If 'no' is selected under 'located in city boundary?', enter the % of the energy that is produced.

Emissions are automatically calculated, in tonnes CO_2e, by multiplying the amount of grid-supplied energy by the emission factor. Emissions are then totalled for all technology types.

Select the sector that emission reduction will be credited to.

Figure 36: Net Emissions Summary table in *Net emissions* sheet

Emissions are given by GPC sector. For stationary energy, energy generation is reported separately. For waste, a distinction is made to show waste generated in and outside of the city.

Total emission reductions, allocated by sector, and displayed in tCO_2e.

GHG Emissions Source (By Sector)		Total GHGs (metric tonnes CO2e)			Reductions (tCO2e)	Total net GHGs (metric tonnes CO2e)		
		Scope 1	Scope 2	Scope 3		BASIC	BASIC+	BASIC+ S3
STATIONARY ENERGY	Energy use (all emissions except I.4.4)	1,045,728	3,211,698	250,166	122977	4,134,449	4,384,615	4,384,615
	Energy generation supplied to the grid (I.4.4)	8,498,216						
TRANSPORTATION	(all II emissions)	3,877,212	64,985	15,059		3,942,197	3,957,256	3,957,256
WASTE	Waste generated in the city (III.X.1 and III.X.2)	383,786		88,448		472,234	472,234	472,234
	Waste generated outside city (III.X.3)	28,976						
IPPU	(all IV emissions)	276,651					276,651	276,651
AFOLU	(all V emissions)	3,675			-10		3,685	3,685
OTHER SCOPE 3	(all VI emissions)			4,972,958				4,972,958
TOTAL		14,114,244	3,276,683	353,673	122,967	8,548,880	9,094,441	14,067,399

Emissions totals are given by sector and scope, in tonnes CO_2e. See the section of this guide about **Cell colour-coding** for more information on the cell colours.

Total net GHG emissions, in tonnes CO_2e, by GPC reporting level (**Box 3**); this takes into account the emission reductions recorded in the previous column.

GCoM - CRF sheet

The *GCoM - CRF* sheet is used to report the additional information required by the Global Covenant of Mayors Common Reporting Framework (GCoM CRF). The sheet contains five tables: emissions covered by any relevant Emissions Trading System; local government-owned energy generation facilities; distributed local renewable energy generation within the city boundary (**Table 27: additional information required by the GCoM CRF.**); and two Output Tables that match the GHG emissions recorded in CIRIS to the formatting of the CRF table in the CDP-ICLEI Unified Reporting System (***Table 28***).

Visit https://www.globalcovenantofmayors.org/our-initiatives/data4cities/common-global-reporting-framework/ for more information.

Table 27: additional information required by the GCoM CRF.

Information required	Description
Emissions covered by any relevant Emissions Trading System	GHG emissions from sources covered by a regional or national emissions trading scheme (ETS), or similar, should be identified.
Local government-owned energy generation facilities	All GHG emissions from generation of grid-supplied energy within the city boundary, and all GHG emissions from generation of grid-supplied energy by facilities owned (full or partial) by the local government outside the city boundary shall be reported and disaggregated by electricity-only, combined heat and power (CHP), and heat/cold production plants.
Distributed local renewable energy generation within the city boundary	Local governments should report all activity data for distributed local renewable energy generation.

Table 28: CRF Output tables required for the CDP-ICLEI Unified Reporting System

Information required	Description
CRF Output Table	This table automatically reports emissions from CIRIS in the format of the CRF to the ‘City-wide GHG Emissions’ section of the CDP-ICLEI Unified Reporting System
Emissions by sector and scope	This table automatically provides a summary of emissions by sector and scope as defined in GPC into the format of the CDP-ICLEI Unified Reporting System

How to use this sheet

Information should be added to the tables in the *GCoM - CRF* sheet, as per the worked examples below. Data should be entered in all of the white cells. The ‘Add’ function allows you to select the required number of rows for each section.

Worked example

Figure 37 to **Figure 41** provide examples of the tables contained in the GCoM - CRF sheet.

Figure 37: Emissions Trading Systems table in GCoM - CRF sheet.

	Facility registration number (if available)	Name of relevant facility	Trading system / Programme	Emissions (t CO2e)	If these emissions are reported in the inventory, indicate the relevant the sector (eg I.4.4 row 3)
3					
	XYZ	Castleford Powerstation	Castleford trading system	6,787	1.4.4 row 3

Emissions from sources covered by a regional or national emissions trading system (ETS) should be identified and described, i.e. the names and/or registration number of relevant facilities and the trading scheme are specified (optional).

Figure 38: Generation of grid-supplied energy by facilities owned (fully or partially) by the local government outside the city boundary table in GCoM - CRF sheet.

	GHG emissions source		Notation key	Activity data		Activity data unit converter			Gas(es)	Emission factor
	Sub-category	Activity		Amount	Unit	EF unit	Default	Override		
2										
	Electricity generation (1.A.1.a.i)	Electricity generation		8,579,042	GWh				CO2, CH4, N2O	EF_electricity
					Please select					Please select

Specify the GHG emission source by selecting the appropriate Sub-category and Activity from the dropdown menu.

Use the 'Activity data unit converter' if activity data units do not match the emission factor selected.

Emissions factors should be recorded in the main 'Emission factors' tab.

Emission factor						Oxidation factor		Emissions data	GHGs (metric tonnes CO_2e)				
Units	CO_2	CH_4	N_2O	Total tCO_2e	$CO_2(b)$	Default	Override		CO_2	CH_4	N_2O	Total tCO_2e	$CO_2(b)$
tCO2e/kWh	0.000788796	6.86047E-07	1.57767E-06			1							
tCO2e/	0	0	0	0	0								

GHGs (metric tonnes CO_2e)					Data Quality	Description of method(s) used or explanation for using notation key(s)	Source
CO_2	CH_4	N_2O	Total tCO_2e	$CO_2(b)$	AD		
6767	6	14	6787	-	Please select	Power station energy consumption multiplied by IPCC emission factor	Castleford energy consumption data
					Please select		Please select

Information to fill this table are similar to what's required for the GHG emission inventory but note that the information in this sheet does not affect the values in the GHG emission inventory.

Figure 39: Distributed local renewable energy generation table in GCoM - CRF sheet.

	Type of renewable energy	Energy generated		Description of methods used	Source
		Amount	Units		
1					
	Solar PV	72	MWh	Energy generation multiplied by emission factor	Castleford energy

Local governments should report all activity data for distributed local renewable energy generation within the city boundary. If possible, it is recommended that information is disaggregated by the type of renewable energy.

Figure 40: CRF Output Table

The purpose of these tables is present the GPC inventory data in the format required by the CRF reporting table in the CDP-ICLEI Unified Reporting System. These tables are auto-populated using activity data, emissions data and notation keys from the inventory sheets in CIRIS. This can facilitate completion of the questions in the CDP-ICLEI Unified Reporting System.

Sectors and Sub-Sectors	Direct Emissions (tCO2e)		Indirect emissions from the use of grid-supplied electricity, heat, steam and/or cooling		Emissions occurring outside the city boundary as a result of in-city activities		Please explain any excluded sources, identify any emissions covered under an ETS and provide any other comments
	Emissions in tCO2e	Notation key (if needed)	Emissions in tCo2e	Notation Key (if needed)	Emissions in tCo2e	Notation key (if needed)	
Stationary energy > Residential buildings	-		-		-	NE	
Stationary energy > Commercial buildings & facilities	-		-		-	NE	
Stationary energy > Institutional buildings & facilities	-		-		-	NE	
Stationary energy > Industrial buildings & facilities	-		-		-	NE	
Stationary energy > Agriculture	-	NO	-	NO	-	NE	
Stationary energy > Fugitive emissions	-					NE	
Total Stationary Energy	-		-		-	NE	
Transportation > On-road	-		-		-	NE	
Transportation > Rail	-		-		-	NE	
Transportation > Waterborne navigation	-		-		-	NE	
Transportation > Aviation	-		-	NO	-	NE	
Transportation > Off-road	-	NO	-	NO	-	NE	
Total Transport	-		-		-	NE	
Waste > Solid waste disposal	-				-		
Waste > Biological treatment	-				-		
Waste > Incineration and open burning	-				-		
Waste > Wastewater	-				-		
Total Waste	-				-		
IPPU > Industrial process	-	NE				NE	
IPPU > Produce Use	-	NE				NE	
Total IPPU	-	NE			-	NE	
AFOLU > Livestock	-	NE				NE	
AFOLU > Land use	-	NE				NE	
AFOLU > Other AFOLU	-	NE				NE	
Total AFOLU	-	NE			-	NE	
Generation of grid-supplied energy > Electricity-only generation	-					NE	
Generation of grid-supplied energy > CHP generation	-					NE	
Generation of grid-supplied energy > Heat/cold generation	-					NE	
Generation of grid-supplied energy > Local renewable generation		NO				NE	
Total Generation of grid-supplied energy	-						
Total Emissions (excluding generation of grid-supplied energy)	-		-		-		

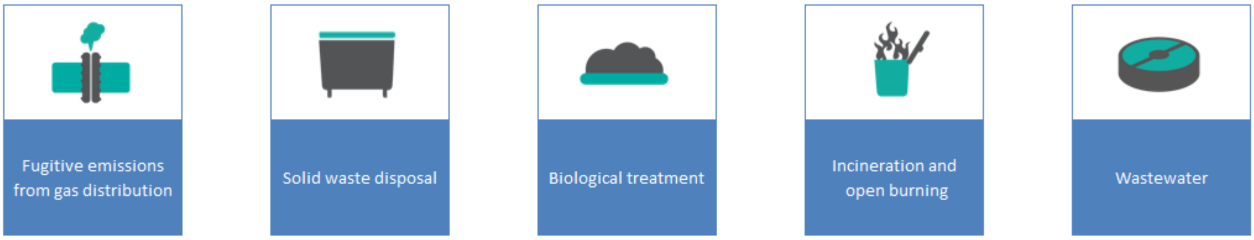
Cities have the option to manually add data in these five cells for the optional CRF sub-sectors not covered by the GPC.

Figure 41: CRF Output Table

Sector and scope (GPC reference number)	Total Emissions	
	Emissions in tCO2e	Where data is not available please explain why
Stationary Energy: energy use - Scope 1 (I.X.1)	-	
Stationary Energy: energy use - Scope 2 (I.X.2)	-	
Stationary Energy: energy use - Scope 3 (I.X.3)	-	
Transportation - Scope 1 ((II.X.1)	-	
Transportation - Scope 2 ((II.X.2)	-	
Transportation - Scope 3 (II.X.3)	-	
Waste: waste generated within the city boundary - Scope 1 (III.X.3)	-	
Waste: waste generated within the city boundary - Scope 3 (III.X.3)	-	
Industrial Processes and Product Use - Scope 1 (IV)	-	
Agriculture, Forestry and Land Use - Scope 1 (V)	-	
TOTAL Scope 1 (Territorial) emissions	-	
Total Scope 2 emissions	-	
Total Scope 3 emissions	-	
TOTAL BASIC emissions	-	
TOTAL BASIC+ emissions	-	

Part 4: Calculators

The *Calculators* tab of CIRIS contains five built-in tools to support cities with reporting emissions from activities that are more complex to estimate. These include fugitive emissions from gas distribution in the Stationary energy sector, as well as emissions from solid waste disposal, biological treatment of waste, Incineration and open burning of waste, and emissions from wastewater treatment.



The calculators contain formulas and default values from the IPCC Guidelines, with space for manually entering city-specific information that might be available.

The calculators are intended to help users calculate emissions by providing a simple interface, and to estimate emissions using default values if city-specific information is limited. Please note that where possible the default values should always be replaced by city-specific values. Default values should only be used if no other data is available, or to compare results estimated using another methodology.

Overview

Each of the calculators is structured in a similar format with the following sections:

1. Instructions: This is the first section for each of the calculators. Common instructions that apply to all calculators are as follows:

- Grey cells contain formulas and default values based on IPCC 2006 Guidelines for National Greenhouse Gas Inventories. These values should not be modified.
- White cells are for user-entered data ('override'). Where applicable, these can be used to override the default data in the grey cells.
- Red cells must be completed for the tool to function.

Activity Data	Unit	Net-calorific value		
		TJ/Gg		kWh/tonne[2]
Value	Value	Default[1]	Override	Value
		48		13,333

Must be completed with key city data, e.g. waste volume, population, gas sales.

Default values. Footnotes provide further information and references.

User-entered values to override defaults e.g. city-specific conversion factors.

2. City Information: This section collects information necessary for the tool to function. As explained above, red cells must be completed with the relevant city-specific information. Information in grey cells (e.g. city name, country and GWP) is auto-populated from information previously entered in to CIRIS.

3. Emissions Summary: This section will display the automatically calculated results once all the other necessary sections have been completed. No user entry is required in this section. Results presented in this section should then be added (either copied and pasted or cells can be linked) into the relevant sub-sector, sector, and sheet in the *Inventory* tab. More guidance on entering the emissions summary information in to the *Inventory* sheets of CIRIS is given for each calculator later in this guidance.

4, 5, 6. Calculations: These sections contain the *formulas* and *calculation tables* that set out the key information and steps required to calculate emissions. The number and names of those sections vary per calculator, and reflect both the complexity of calculations, the different methods required, parameters to include and/or the different gases reported. The *formulas* are taken from the IPCC 2006 Guidelines, the GPC or other relevant sources. They are fully documented and explained in the calculators for transparency purposes. They are also built into the *calculation tables,* which set out the information required for calculations and work out the results. The results then feed into the Emissions Summary section above. There are grey, red and white cells to be completed as above.

Data Tables: This final section in all calculators provides reference tables of default data that are used by the calculators, from sources such as the IPCC 2006 guidelines, the GPC and FAOSTAT[7]. The tables are provided and fully referenced for transparency purposes.

The following sections of the User Guide provide specific guidance on using each of the calculators.

[7] http://faostat.fao.org/

Fugitive gas calculator

There are a variety of sources of fugitive gas leaks, including fugitive equipment leaks, evaporation losses, venting, flaring and accidental releases. This calculator has been designed to help cities estimate fugitive emissions from the *distribution of gas to end users via low pressure distribution systems within cities*, because this is the most common and most significant activity that cities report in sub-sector I.8. All natural gas distribution systems will have some fugitive emissions so any city with a gas network should estimate fugitive leaks.

Fugitive emissions from gas distribution should be reported under **I.8 Fugitive emissions from oil and natural gas systems.** Note that other sources of fugitive leaks from oil and gas systems should also be reported here if occurring.

2. City information

The first step is to select whether the city is in a developed or a developing country; this should be selected from the drop-down list in the red cell in the 'Development status' row.

City information	Default	
City	Autonomous City of Buenos Aires	
Country	Argentina	
Development status	Developed	< Select from list
Global Warming Potential	4AR	

3. Emissions summary

This section will be populated once all the necessary information has been completed in the other sections of the calculator. An example of the emissions summary table is given and explained below. It is this emissions information that should be copied and pasted under I.8 Fugitive emissions from oil and natural gas systems in the *Stationary* sheet under the Inventory tab.

Source	Total tCO_2e		
	CO_2	CH_4	Total
Fugitive emissions	81	43,484	43,565

The emission totals are taken from the final columns of the Calculation table below.

4. Carbon dioxide (CO_2) and methane (CH_4) emissions from gas distribution

In order to generate the totals presented above, this section must be completed. This section contains formulas and a calculation table.

Formulas

The following formulas are given under the Formulas title; in this User Guide, formulas are fully annotated to offer further detail.

The activity data is the amount of gas sold in the city; this can be obtained from sources such as utility companies, national regulatory bodies, or city statistical reports.

Here, the activity data is by volume (cubic metres, m^3). Activity data can also be reported in energy or mass units and the calculation table can convert this into m^3.

Σ = the sum of

CO_2 emissions $= \Sigma$ (V * EF)	
V	= Volume of utility sales, m3
EF	= Emission factor, tCO2/m3

CH_4 emissions $= \Sigma$ (V * EF)	
V	= Volume of utility sales, m3
EF	= Emission factor, tCH4/m3

The emission factor will define the amount of GHG per unit of activity data. The calculator offers default EFs, but city-specific EFs can also be entered.

Ensure the emission factor and activity data are in the same units (e.g. m^3). If not, the calculation table can convert to m3 from other units.

Calculation table

There is one table under the *Calculation table* title in this calculator. A worked example is given below and is fully annotated to offer further detail. As explained previously, grey cells are auto-populated using information already entered in to CIRIS. Red cells will need to be populated either by selecting from the drop-down list or manually entered.

Note that when emissions are reported in CIRIS in the *Stationary* sheet, all information about the activity data and calculation should be included, e.g. the data source, description of the activity data (such as the sub-sector it relates to) and reference to the use of the CIRIS calculator should be made.

The following footnotes are given in the calculation table to offer transparency on data sources:

[1] Net Calorific Values for fuels, Table 1.2, Volume 2 Chapter 1, IPCC 2006 Guidelines http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_1_Ch1_Introduction.pdf

[2] The conversion from GJ to kWh is 277.78 (See Conversion factors tab)

[3] Source: WRI/WBCSD stationary combustion calculation tool version 3.3. Note: Density value is highly sensitive to changes in temperature and pressure. Value indicated is based on room temperature and standard atmospheric pressure.

[4] Default emission factors from Table 4.2.4 for developed countries and Table 4.2.5 for developing countries, Chapter 4, IPCC 2006

Insert the **amount** of natural gas sold/consumed within the city boundary.

Select the activity data **unit** from the drop-down list.

The density of fuel is required if the activity data is reported in mass or volume units in order to convert to energy units.

In this example, a national natural gas density value was available from the national GHG inventory so this was inputted in the white ‘Override’ cells.

Default emission factors (EFs) from the IPCC 2006 guidelines are used. The equation selects whether to use EFs for developed or developing countries. If a country or city-specific EF is available, input it into the white ‘Override’ columns ensuring consistent units.

Activity Data	Unit	Net-calorific value			Density, kg/m^3		Conversions		Emission factors, t/m^3				CO_2	CH_4		Total
		TJ/Gg		kWh/tonne[2]			kWh	m^3	CO_2		CH_4		tCO_2	tCH_4	tCO_2e	tCO_2e
Value	Value	Default[1]	Override	Value	Default[3]	Override	Value	Value	Default[4]	Override	Default[4]	Override	Value	Value	Value	Value
1223690000	m3	48		13,333	0.70	0.719		1223690000	0.000000051		0.0000011		62	1346	33651	33714
260847000	m3	48		13,333	0.70	0.719		260847000	0.000000051		0.0000011		13	287	7173	7187
96701000	m3	48		13,333	0.70	0.719		96701000	0.000000051		0.0000011		5	106	2659	2664
		48		13,333	0.70											
		48		13,333	0.70											
												Total	81	1739	43484	43565

Net-calorific value (NCV) is used to convert from physical units (e.g tonnes or m^3) to energy units (e.g. TJ). The NCV refers to the amount of energy released when a known amount of fuel is completely combusted under conditions similar to those in which it is normally used.

The grey cells are auto-populated and use default values. If a city-specific NCV is known, it should be manually added in the white ‘Override’ cells.

The ‘kWh/tonne’ column is used by the calculation table to convert the default or manual NCV into the correct units for the calculation.

These columns convert the activity data into m^3. If the activity data is reported as a mass, e.g. tonnes, then the calculator needs to first convert into kWh using the kWh/tonne column.

These columns multiply the activity data by the emission factors, all in the same units (i.e. m^3). For CH_4, emissions are also converted to tCO_2e using the GWP displayed in the first table (**2. City information)** which is linked to the City information sheet in CIRIS.

The ‘Total tCO2e’ column sums emissions of CO_2 and CH_4 (as tCO_2e).

Data tables

A table is included at bottom of the calculator, to provide default values for the various parameters used in the calculations tables in this calculator, based on IPCC 2006 Volume 2 Chapter 4 Fugitive Emissions Table 4.2.4 and 4.2.5: Tier 1 Emission Factors for Fugitive Emissions From Oil and Gas Operations in Developed Countries/ Developing Countries and Countries with Economies in Transition.

Integrating into CIRIS inventory sheets

Once the *Calculation table* has been completed, the emissions data presented in section *3. Emission Summary* needs to be added to section *I.8 Fugitive emissions from oil and natural gas systems* in the *Stationary* sheet under the *Inventory* tab. Detailed guidance on how to report section I.8 is given below:

1. Select 'Gas' from the Sub-category column, and 'Distribution' from the Activity column, adding a description to explain the data source is fugitive emissions from the distribution of gas to end users via low pressure distribution systems within the city.

I.8 FUGITIVE EMISSIONS FROM OIL AND NATURAL GAS SYSTEMS

GPC ref No.	Scope	GHG Emissions Source		
		Sub-category	Activity	Description
I.8.1	**1**	**Emissions from fugitive emissions within the city boundary**		
I.8.1	1	Gas	Distribution (1.B.2.b.iii.5)	Fugitive emissions from the distribution of gas to end users via low pressure distribution systems within the city.

2. Input the activity data and units, as was inputted in to the Calculation table.
3. Select CO_2 and CH_4 under 'Gas(es)'
4. Leave the 'Emission factor' cells empty. The Fugitive Gas emission factors are not available in the *Emission factors sheet* to select[8].
5. Select ✓ in the 'Emissions data' column. Copy and paste tCO_2, tCH_4 (as tCO_2e) and total tCO_2e, from the Emission summary table into the appropriate 'GHGs (metric tonnes CO_2e)' columns under *I.8 Fugitive emissions from oil and natural gas systems* in the *Stationary* sheet under the *Inventory* tab.

Emissions data	GHGs (metric tonnes CO_2e)				
	CO_2	CH_4	N_2O	Total tCO_2e	$CO_2(b)$
✓	81	43,484			

6. Complete the activity data quality assessment by selecting L, M or H.
7. Add a description of method(s) used to highlight that the fugitive emissions calculator was used to calculate this source.
8. Select the activity data source from the drop-down list.
9. Provide an explanation for the activity data assessment (optional).

[8] If users wish to add the emission factors from the CIRIS calculator manually to the *Emission factors* tab, to also undertake the calculation in the *Stationary* sheet then this is possible. The above approach is intended to be the most time-efficient.

Solid waste disposal calculator

Emissions from solid waste disposed of in landfill landfills or dump sites, including disposal in an unmanaged site, disposal in a managed dump or disposal in a sanitary landfill, are generated from the decomposition of organic material. The quantification of GHG emissions from solid waste disposal and treatment is determined by two main factors: the mass of waste disposed, and the amount of degradable organic carbon (DOC) within the waste, which determines the methane generation potential. Emissions from landfills further vary depending on the characteristics of the landfill itself, e.g. if waste is buried deep underground and decomposes without oxygen, a larger proportion of methane is produced. As this is a more potent greenhouse gas, landfill emissions can be significant.

Furthermore, Methane emissions from landfills occur several decades after disposal as waste takes time to break down. Waste disposed in a given year therefore contributes to emissions in that year, and future years. Similarly, emissions to the atmosphere from a landfill in a given year include emissions from waste disposed in previous years.

The GPC provides two methods to calculate emissions from solid waste:

- the First Order Decay (FOD) method
- the Methane Commitment (MC) method

For further information on both waste calculation methodologies, see section 8.3 of the GPC.

If a city chooses to use the FOD method, the GPC recommends to use the IPCC Waste Model (2006).

The *Solid waste disposal calculator* has been designed to help cities estimate CO_2 and CH_4 emissions from solid waste disposal using the **Methane Commitment (MC)** method. The MC method assumes landfill emissions based on the waste disposed in a given year, regardless of when the emissions actually occur, and is therefore simpler and requires less data than the FOD method. N2O emissions from landfill are considered trace and not calculated in this calculator.

Tip: For more detail on the FOD method, use the IPCC 2006 Waste model available at http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/5_Volume5/IPCC_Waste_Model.xls. The IPCC provide a downloadable spreadsheet to aid implementation of the FOD method.

2. City Information

Like other calculators, the first step is to complete the City information section. As explained previously, grey cells are auto-populated using information already entered in to CIRIS. Red cells will need to be populated either by selecting from the drop-down list or manually entered. A worked example is given below with further guidance on completing this section.

Input data on the amount of waste disposed to landfill within the inventory year. Ensure this is in metric tonnes.

Cities can search for city-specific data from surveys or statistics, or refer to the country and regional averages data on generation and treatment of MSWs provided in the IPCC 2006 Guidelines (vol. 5: waste, chapter 2, Annex 2A.1 waste generation, composition and management data).

Enter the landfill gas collection efficiency as a %. This is referred as "CE" in many of the formulas used in this calculator. If landfill-specific information is not known, assume:

- 0% for landfill without active gas collection
- 60% for landfill with daily soil cover and active gas collections
- 75% for landfill with intermediate soil cover and active gas collection
- 95% for landfill with final cover and active gas collection

In a modern landfill, an average of 85% of the landfill gas is usually collected.

City information	Default	
City	Autonomous City of Buenos Aires	
Country	Argentina	
Region	America	< Select from list
Sub-region	South America	< Select from list
Total waste deposited in landfill metric tonnes	1,462,000	< Enter amount
Landfill gas collection efficiency	0%	< Enter percentage
Proportion of landfill gas collected used as energy source	0%	< Enter percentage
Management of landfill	Managed	< Select from list
Global Warming Potential	4AR	

This relates to the amount of the collected landfill gas that is used for energy generation, i.e. energy is recovered from the landfill gas combusted.

This proportion of landfill gas should be reported under *Stationary,* if combusted in the city.

Specify whether and how the landfill site is managed by selecting from the drop-down list which contains the following broad categories:

- Managed: This is where there are vent pipes that allow landfill gas to get out of the waste and be collected, burnt or released to the air in a controlled way
- Unmanaged (⩾5 m deep or < 5m deep)
- Uncategorised.

The management type affects the amount of methane generated, and the default values provided by IPCC for Methane Correction Factor, which will be explained later in this User Guide and are built in the calculator, vary for different types.

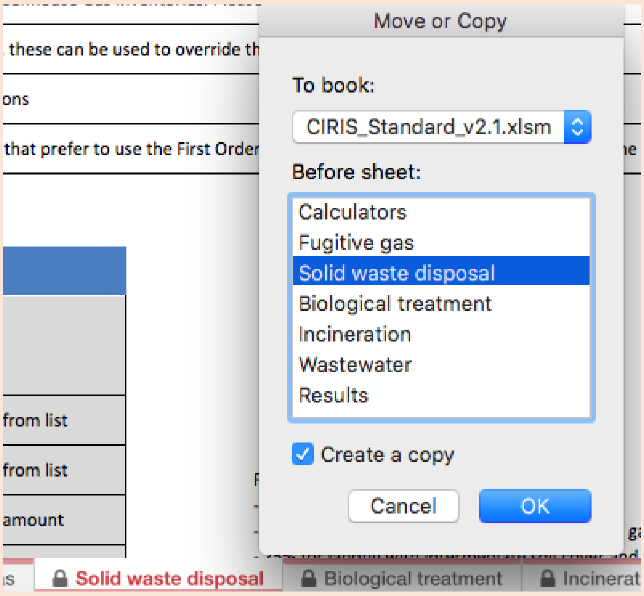
Important note:

As shown in the worked example above, the *City Information* table requires users to specify the key characteristics of the landfill site(s), i.e. whether and how it is managed, whether and how much % of landfill gas is collected. These are important to determine and calculate the landfill emissions.

This calculator enables only one data entry at a time. Therefore, for cities with more than one landfill site with different characteristics, please start afresh for each type of landfill site(s). The "Total waste deposited" field must also correspond to the type of landfill site(s) specified.

If the calculator needs to be used multiple times in the situation described above, it is suggested to save them as separate versions to refer back to as needed. Alternatively, save copies of this calculator sheet and add to the CIRIS workbook currently in use (see the Tip box below on how to do this)

Tip: To copy a sheet to the current or another Excel workbook, right click on the tab of this sheet at bottom of the screen, and select "Move or Copy". A window will then pop up, asking which workbook and where in the workbook you would like to copy the sheet to. The current workbook is given as the default. Ensure the "Create a copy" box is ticked and click Ok to complete. See the illustration on the right.



3. Emission Summary

The emissions summary table will be automatically populated once all the necessary information has been completed in the other sections of the calculator. A worked example is given and explained below. It is this emissions information that should be copied and pasted under *III.1 Solid Waste Disposal* and *I.4 Energy Generation* in the *Inventory* sheets.

Source	Total GHGs (metric tonnes CO_2e)				Sector where emissions sould be reported
	CH_4	N_2O	Total	$CO_2(b)$	
Direct release of landfill gas to atmosphere	2,002,384	Trace	2,002,384	269,209	Waste
Combustion of landfill gas with energy recovery	0	Trace		0	Stationary Energy
Combustion of landfill gas without energy recovery	0	Trace		0	Waste
Total	2,002,384	Trace	2,002,384	269,209	

Emissions are divided by gas and presented in unit of CO2e.

$CO_2(b)$ is counted separately, as explained in **Box 4**.

The final column indicates to the user which sector these emissions should be reported.

In order to generate the emission totals presented above, the following three sections of the calculator must be completed (users can choose between 5 and 6 depending on whether there is landfill gas collection in place). These sections are explained in details in the paragraphs below.

4. Calculation of methane generated using methane commitment method
5. Calculation of GHG emissions from landfills without landfill gas collection systems
6. GHG emissions for landfills with landfill gas collection systems

4. Methane generated using methane commitment method (GPC Chapter 8.3.2, Page 92)

This section sets out three interdependent *formulas* from the GPC guidelines for calculating methane generated from the landfill site using MC method, and three *calculation tables* that correspond to each formula which is also built into the tables.

Formulas

GPC equation 8.3: Methane commitment estimate for solid waste (adapted)

A =	= MSWx L0
A	= Methane generated in landfill, measured in metric tonnes
MSW_x	= Mass of solid waste sent to landfill in inventory year, measured in metric tonnes
L_0	= Methane generation potential

L_0 gives the amount of methane that could be generated from waste and is a function of the amount of degradable organic carbon (DOC) within the waste.

- L_0 is calculated in GPC equation 8.4.
- DOC is calculated in GPC equation 8.1.

This is the activity data (waste tonnage) populated in the City information table.

GPC equation 8.4: Methane generation potential (L_0)

Methane generation potential (L_0) is an emission factor that specifies the amount of CH_4 generated per tonne of solid waste. L_0 is based on the portion of degradable organic carbon (DOC) that is present in solid waste, which is in turn based on the composition of the waste stream. It is calculated using the below formulas:

Default factors from the GPC. The equation uses the 'Management of landfill' specific in the City information table to auto-fill this information.

L_0	= MCF * DOC * DOCF * F * 16/12
MCF	= Methane correction factor based on type of landfill site for the year of deposition: Managed = 1, Unmanaged (≥5m) = 0.8, Unmanaged (<5m) = 0.4,
DOC	= Degradable organic carbon in year of deposition, fraction (metric tonnes C/metric tonnes waste); GPC equation 8.1
DOC_F	= Fraction of DOC that is ultimately degraded (reflects the fact that some organic carbon does not degrade); assumed equal to 0.6
F	= Fraction of methane in landfill gas generated; assumed equal to 0.5
16/12	= Molecular weight ratio of CH4 and carbon

DOC refers to the amount of degradable organic carbon within the waste; this is calculated separately: **see below.**

Accounts for the weight of methane being 16/12 that of carbon.

Assumes that half of landfill gas is methane.

DOC_f considers that not all DOC will be degraded. A default of 0.6 is applied – implying that 60% of DOC is ultimately degraded.

GPC equation 8.1: Degradable organic carbon (DOC)

DOC	= (0.15 x A) + (0.2 x B) + (0.4 x C) + (0.43 x D) + (0.24 x E) + (0.15 x F)
A	= Fraction of solid waste that is food
B	= Fraction of solid waste that is garden waste and other plant debris
C	= Fraction of solid waste that is paper
D	= Fraction of solid waste that is wood
E	= Fraction of solid waste that is textiles
F	= Fraction of solid waste that is industrial waste
Other	= Fraction of waste that is other; assumed to be zero under IPCC Tier 1 default

Country and region average data available from IPCCC

Default values from IPCC 2006 Guidelines - Volume 5: Waste, Chapter 2 (Table 2.3 and Table 2.4).

Calculation tables

Beneath the formulas are the Calculation tables that are used to calculate the methane generated from the landfill sites. There are three calculation tables, corresponding to each of the three equations above:

Methane commitment estimate for solid waste sent to landfill (GPC equation 8.3)

This calculation table summarises the results of equation 8.3. All cells are grey, meaning they will be automatically populated and no user entry is required.

Total waste deposited in landfill metric tonnes	Methane generation potential (L_0)	Methane generated (A), tCH_4
Value	Value	Value
1462000	0.061	88,995

This takes the total waste deposited in landfill metric tonnes from the 2. City information section at beginning of this Calcualtor.

This shows the L_0 as calculated in equation 8.4 table below. If this has not been calculated, this box will read 'Complete equation 8.4'.

This multiplies the total waste deposited in landfill by the L_0 to give the total tonnes of methane generated.

Methane generation potential (GPC equation 8.4)

This calculation table summarises the results of equation 8.4, to generate the methane generation potential (L_0) to be used in equation 8.3. Enter city-specific values (% composition of waste) in the white cells if they are available.

Methane Correction Factor (MCF)		Degradable organic carbon in year of deposition (DOC)	Fraction of DOC that is ultimately degraded (DOC_f)		Fraction of methane in landfill gas (%) (F)		Molecular weight ratio of CH4 and carbon	Methane generation potential, L_0
Default	Override	Value	Default	Override	Default	Override	Default	
1.0		0.1522	0.6		50%		1.3	0.061

A default value is applied on basis of the type of '**Management of landfill'** specified in the previous section 2. City information. If a specific MCF is known, enter it in the Override .

A default of 0.6 is applied. If a local specific value is known, enter it in the Override column.

Assumes that half of landfill gas is methane. If a city-specific % is known, add it in the Override column.

= 16/12

This is the value (L_0) that is calculated by multiplying all the values in this table using equation

This is the DOC value calculated using equation 8.1 **(See the next page for details).**

Degradable organic carbon (DOC) (GPC equation 8.1, adapted to include additional waste types)

This table calculates the DOC value, which is then used in the generation of L_0 in the table above. Enter city-specific values (% composition of waste) in the white cells if they are available. Further explanations are given in the worked example below (the table is split across three lines for presentation purposes).

The region and sub-region dictate the default MSW composition provided in the IPCC 2006 Volume 5 Chapter 2: Waste Generation, Composition and Management Data, Table 2.3 (also presented under the Data Tables at bottom of the calculator sheet). This uses information presented in the City information table. The default composition are then auto-populated in the 'Default' cells. If city-specific data is known, this should be entered the 'Override' cells. **Always ensure the total equals 100%.**

The default values for degradable organic carbon (DOC) are taken from IPCC 2006 Volume 5 Chapter 2: Waste Generation, Composition and Management Data, from Table 2.4.

Region	Region	Sub-region	Food waste		Paper / cardboard		Wood		Textiles	
Value	Value	Value	Default	Override	Default	Override	Default	Override	Default	Override
Composition of MSW (%)	America	South America	45%	50%	17%	10%	5%		3%	
DOC			0.15		0.40		0.43		0.24	

Garden and Park waste		Nappies		Rubber / leather		Plastics		Metal		Glass		Other, inert waste	
Default	Override	Default	Override	Default	Override	Default	Override	Default	Override	Default	Override	Default	Override
No default >	4%	No default >		0.7%		10.8%	5%	2.9%		3.3%		13.0%	
0.20		0.24		0.39		0.00		0.00		0.00		0.00	

City-specific composition data overrides default data and fills gaps where no default data are available

Industrial		Construction and demolition		Clinical waste		Sewage sludge		Fossil liquid waste		Total (must add to 100%)
Default	Override	Default	Override	Default	Override	Default	Override	Default	Override	Check
No default >		No default >	4%	No default >		No default >		No default >		100%
0.00		No default >		No default >		No default >		No default >		

5. GHG emissions from landfills without landfill gas collection systems

Once the amount of methane generated is calculated in the section 4 above, complete section 5 or 6 to work out how much is emitted to the atmosphere.

Emissions from landfills that **do not** have any landfill gas collection are calculated in section 5. GHG emissions from landfills without landfill gas collection systems. Emissions from landfills that have landfill gas collection are calculated in section 6. GHG emissions for landfills with landfill gas collection systems.

Each section is constructed in a similar way, with formulas spelled out and explained first, followed by Calculation tables.

Formulas

Two formulas are used here, one to calculate CH4 emissions, and the other to calculate CO2 emissions. These are the two main GHGs in landfill gases. Note that CO2 directly emitted from landfill are biogenic as they are resulted from decomposition of organic components in the waste.

GPC equation 8.3: Methane commitment estimate for solid waste (adapted)

This formula uses the methane generation, calculated previously, and applies factors for the efficiency of collection and oxidation and specified GWP, to estimate total methane emissions as CO_2e.

GWP taken from information presented in the 2. City information section of this calculator to convert tonnes of CH_4 to tonnes of CO_2e.

CH_4 (tCO_2e)	= A x (1-CE) x (1-OX) * GWP
A	= CH4 generation from GPC equation 8.3, measured in tonnes CH4
CE	= Collection efficiency
OX	= Oxidation factor; 0.1 for well-managed landfills, 0 for unmanaged landfills

This is calculated in the previous section.

The oxidation factor (OX) reflects the amount of CH_4 from landfills that is oxidised by methanotrophic micro-organisms in the soil and converted to CO2. If 'managed' is selected in the 'Management of landfill' in the 2. City information section of the calculator, this will be 0.1 (10%). For unmanaged sites, this will be 0.

Collection efficiency refers to the fraction of methane recovered at the landfill. In this section, for landfill without landfill gas collection systems, this will be 0%. This value is auto-populated from the 'Landfill gas collection efficiency' category in the 2. City information section of the calculator.

EPA equation 2-3: CO_2 Emissions for Landfills without Gas Collection Systems

Biogenic CO_2 is also required to be reported under the GPC, however the GPC does not provide an equation for biogenic CO_2 from landfills so an equation from the US Environmental Protection Agency (US EPA) is used here. As explained below, CO2 emissions are back-calculated from the amount of methane generated.

$tCO_{2(b)}$	= A x (1-CE) * ((1-F)/F) + OX) * 44/16
A	= CH4 generation from GPC equation 8.3, measured in tonnes CH4
CE	= Collection efficiency
F	= Fraction of methane in landfill gas generated; assumed equal to 0.5
OX	= Oxidation factor; 0.1 for well-managed landfills, 0 for unmanaged landfills
44/16	= Molecular weight ratio of CO2 to CH4

This is calculated in the previous section.

See explanation in equation 8.3

This depends on the amount of infiltration air, and it is commonly assumed that 50% of carbon degraded within landfill will be converted to 50% and the remaining 50% converted to CO2.

Accounts for the weight of CO_2 being 44/16 that of CH_4.

See explanation in equation 8.3 above

Calculation table

After the formulas section, the Calculation table (below) is used to calculate the methane generation from solid waste disposed in each landfill without landfill gas collection systems. The Calculation table calculates the equations explained above. There is no user input required in this table; all information is taken from the City Information table and calculation tables from previous steps or sections.

Value is calculated in equation 8.3 so is auto-populated.

This is assumed to be 50%. If city-specific information is available, this should be entered under 'Override'.

= 44/16

These columns calculate equation 8.3. The tCO_2e column converts the tCH_4 into CO_2 using the GWP from the City information table.

Methane generated (A), tCH_4	Collection efficiency (CE)	Fraction of methane in landfill gas (%) (F)		Oxidation factor (OX)	Molecular weight ratio of CO_2 to CH_4	$tCO_{2(b)}$	Total CH_4 emissions	
							tCH_4	tCO_2e
Value	Value	Default	Override	Value	Value	Value	Value	
96,451	0%	50%		10%	2.75	291,764	86,806	2,170,149

This value is auto-populated from the 'Landfill gas collection efficiency' field in the 2. City information section of the calculator.

If 'managed' is selected in the 'Management of landfill' in the 2. City information section of the calculator, this will be 0.1 (10%). For unmanaged sites, this will be 0.

This calculates $CO_{2(b)}$, in tonnes, from landfills without gas collection systems using EPA equation 2-3.

6. GHG emissions for landfills with landfill gas collection systems

For landfills **with** landfill gas collection, emissions are calculated under 6. GHG emissions for landfills with landfill gas collection systems. Total quantities of CH4 and CO2 contained in the recovered landfill gas can be directly measured, or estimated on basis of the average landfill gas collection efficiency. The quantities of CH4 and CO2 released from uncollected landfill gas can then be back-calculated based on the assumed landfill gas collection system efficiency or by a comparison of the quantity of CH4 recovered and the modelled CH4 generation quantity. This is a relatively complex process and so the section is split into three steps:

- *Step 1: Calculate recovered gases*
- *Step 2: Calculate CO_2 emissions*
- *Step 3: Calculate CH_4 emissions*

Step 1. Recovered gases

Formulas

The first step is to calculate recovered gases, i.e. gases recovered from landfill gas collection system. This include CH4 and CO2, which are calculatedly separately using two formulas from US EPA, as explained below.

EPA equation 2-5: Recovered CH_4 for Landfills with Gas Collection Systems

RCH_4	$= A * CE$
A	= CH4 generation from GPC equation 8.3, measured in tonnes CH4
CE	= Collection efficiency

Calculated in equation 8.3 in the 4. Methane Generated section of the calculator.

Collection efficiency refers to the fraction of methane recovered at the landfill.

EPA equation 2-6: Recovered CO_2*(b) *for Landfills with Gas Collection Systems (adapted)

$RCO_{2(b)}$	$= A * CE * ((1-F)/F) * 44/16$
A	= CH4 generation from GPC equation 8.3, measured in tonnes CH4
CE	= Collection efficiency
F	= Fraction of methane in landfill gas generated; assumed equal to 0.5
44/16	= Molecular weight ratio of CO2 to CH4

Calculated in equation 8.3 in the 4. Methane Generated section of the calculator.

Accounts for the weight of CO_2 being 44/16 that of CH_4.

Calculation table

After the formulas section, the Calculation table (below) is used to calculate the methane generation from solid waste disposed in each landfill with landfill gas collection systems. The Calculation table calculates the equations explained above. There is no user input required in this table; all information is taken from the City Information table and calculation tables from previous steps or sections.

Value is calculated in equation 8.3 in the 4. Methane Generated section of the calculator, and is auto-populated here.

This is generally assumed to be 50%. If city-specific information is available, this should be entered in the 'Override' column.

This is calculated following EPA equation 2-6. In this specific example, the value is 0 as there is no landfill gas collection.

CH4 generated (A), tCH_4	Collection efficiency (CE)	Fraction of methane in landfill gas (F), %		Molecular weight ratio of CO_2 to CH_4	RCO_2, tCO_2	RCH_4, tCH_4
Value	Value	Default	Override	Value	Value	Value
96,451	0%	50%		2.75	0	0

This value is auto-populated from the 'Landfill gas collection efficiency' previously specified in the 2. City information section in the calculator.

= 44/16

This is calculated following EPA equation 2-5. In this specific example, the value is 0 as there is no landfill gas collection.

Step 2. CO_2 emissions

Once recovered gases have been calculated from step 1 above, the next step is to calculate CO_2 emissions. This includes: CO2 recovered from the landfill gas collection system; CO2 resulted from combustion of CH4 that is recovered; and CO2 emissions that is not recovered by gas collection system. The first two can be accounted for using the first formula provided below, and the unrecovered CO2 emissions can be calculated using the second formula. Both formulas are explained below.

Formulas

EPA equation 2-7: Estimate of CO_2 Emissions from Recovery System and Destruction Device

$tCO_{2(b)}$	= RCO2 + (RCH4 * DE * (44/16))
RCO2	= Recovered CO2 from EPA equation 2-5, measured in tonnes CH4
RCH4	= Recovered CH4 from EPA equation 2-6, measured in tonnes CH4
DE	= Destruction efficiency; assumed equal to 0.9
44/16	= Molecular weight ratio of CO2 to CH4

Calculated in relevant equations in Step 1: Recovered Gases

Accounts for the weight of CO_2 being 44/16 that of CH_4.

A small portion of the recovered CH_4 will not be converted to CO_2, either due to incomplete combustion of the CH_4 (i.e., the destruction efficiency of the unit) or due to bypassing or otherwise not operating the combustion device.

EPA equation 2-8: Estimate of CO_2 Emissions from unrecovered landfill gas

$tCO_{2(b)}$	= ((1-CE)/CE) * RCO2 + (OX * ((1-CE)/CE) *RCH4) *44/16
RCO2	= Recovered CO2 from EPA equation 2-5, measured in tonnes CH4
RCH4	= Recovered CH4 from EPA equation 2-6, measured in tonnes CH4
CE	= Collection efficiency
OX	= Oxidation factor; 0.1 for well-managed landfills, 0 for unmanaged landfills
44/16	= Molecular weight ratio of CO2 to CH4

Calculated in relevant equations in Step 1: Recovered Gases

Calculation table

The formulas are then used to calculate CO_2 emissions from solid waste disposed at landfill sites. This is carried out in the next calculation table. As before, there is no user input required in this table; all information is taken from the City Information table and calculation tables from previous steps and sections.

Calculated by EPA equation 2-5 in step 1 above.

This is commonly assumed to be 90%. If city-specific information is available, overwrite this in the 'Override' column

As a managed site, this is assumed to be 0.1 (10%).

This is calculated following EPA equation 2-7. There is no recovery in this specific example used. If there is recovery, this value will be greater than 0.

$RCO_{2(b)}$, tCO_2	RCH_4, tCH_4	Destruction efficiency (DE), %		Collection efficiency (CE)	Oxidation factor (OX)	Molecular weight ratio of CO_2 to CH_4	CO_2 emissions from recovery and burning, $tCO_{2(b)}$	CO_2 emissions from un-recovered gas, $tCO_2(b)$	Total CO_2 emissions, $tCO_{2(b)}$
Value	Value	Default	Override	Value	Value	Value	Value	Value	Value
0	0	90%		0%	10%	2.75	0	291,764	291,764

Calculated by EPA equation 2-6 in step 1 above.

In this specific example, the value is 0% as no landfill gas is collected.

= 44/16

This is calculated following EPA equation 2-8.

The sum of the previous 2 columns

Step 3. CH_4 emissions

After calculating the CO2 emissions, the final step is to calculate CH4 emissions. This is the CH4 that is recovered but not combusted, and the CH4 that is not recovered (i.e. the landfill gas collection system efficiency is usually less than 100%). There are two *Formulas* for calculating each of them.

Formulas

EPA equation HH-6: Uncombusted CH_4 emissions

This equation calculates CH_4, in tCO_2e, from recovered gas as calculated in Step 1, taking into account destruction efficiency.

CH_4 (tCO_2e)	= RCH4 * (1 - DE) * GWP
RCH4	= Recovered CH4 from EPA equation 2-6, measured in tonnes CH4
DE	= Destruction efficiency; assumed equal to 0.9

Calculated in Step 1: Recovered Gases

A small portion of the recovered CH_4 will not be converted to CO_2, either due to incomplete combustion of the CH_4 (i.e., the destruction efficiency of the unit) or due to bypassing or otherwise not operating the combustion device.

EPA equation HH-8: Emissions of uncollected gas from the surface of the landfill

This equation calculates CH_4, in tCO_2e, from uncollected landfill gas.

CH_4 (tCO_2e)	= (A - RCH4) * (1 - OX) * GWP
A	= Cubic meters of landfill gas produced per day (m3/day)
RCH4	= Recovered CO2 from EPA equation 2-6, measured in tonnes CH4
OX	= Oxidation factor; 0.1 for well-managed landfills, 0 for unmanaged landfills

Calculated in previous Step 1: Recovered Gases

The oxidation factor (OX) reflects the amount of CH_4 from landfills that is oxidized by methanotrophic micro-organisms in the soil. If 'managed' is selected in the 'Management of landfill' in the section 2. City information of the calculator, this will be 0.1 (10%). For unmanaged sites, this will be 0.

Calculation table

The formulas above are then used to calculate CH_4 emissions uncollected and collected but un-combusted, in the calculation table below. As before, there is no user input required in this table; all information is taken from the City Information table and calculation tables from previous steps or sections. A worked example is given below with further explanation.

Value is calculated in equation 8.3 in previous section 4. Methane Generated and is auto-populated here.

DE is usually assumed to be 0.9 (90%). If city-specific information is known, enter under 'Override'.

Calculates from uncombusted CH4 using EPA equation HH-6.

Calculates uncollected CH4 using EPA equation HH-8.

CH4 generated (A), tCH4	RCH4, tCH_4	Destruction efficiency (DE), %		Oxidation factor (OX)	Uncombusted emissions		Uncollected emissions	
					tCH_4	tCO_2e	tCH_4	tCO_2e
Value	Value	Default	Manual	Value	Value		Value	
94,855	0	90%		10%	0	0	85,369	2,390,335

Calculated by EPA equation 2-6 in Step 1: Recovered Gases

For a managed site, this is assumed to be 0.1 (10%).

The tCO_2e column converts CH_4 to CO_2e using the appropriate GWP.

Data tables

Four tables are included to provide default values for the various parameters used in the calculations tables in this calculator, based on the IPCC guidance. These four tables are:

- IPCC 2006 Volume 5 Chapter 2: Waste Generation, Composition and Management Data, Table 2.3: MSW composition data by percent - regional defaults
- IPCC 2006 Volume 5 Chapter 3: Solid Waste Disposal, Table 3.3: Recommended Default Methane Generation Rate (k) Values Under Tier 1
- IPCC Guidelines Volume 5, Chapter 2, Table 2.4: Default dry matter content, DOC content, total carbon content and fossil carbon fraction of different MSW components
- IPCC Guidelines Volume 5, Chapter 2, Table 2.5: Default DOC and fossil carbon content in industrial waste

Integrating into CIRIS inventory sheets

Once all steps have been completed, the emissions data from section 3. Emissions Summary need to be added to CIRIS in sub-sector III.1 Solid waste disposal (or I.4 Energy Generation) in the *Waste* (or *Stationary*) sheet under the Inventory tab. To do so, follow these steps:

Tip: As noted in the introduction to this section, this calculator enables only one entry at a time. For cities with more than one landfill site, sites both in and out of the boundary, or with different characteristics, please start afresh for each. It is suggested to save these as separate versions of this calculator sheet to refer back to if needed.

1. If the landfill is within the city boundary, emissions should be reported under III.1.1. If the landfill is outside of the, emissions should be reported under III.1.2. If the waste treated is imported from outside the city boundary, emissions should be reported under III.1.3.
2. Select 'Landfill sites – Methane Commitment' in the 'Activity' column.
3. Select 'Municipal Solid Waste' in the 'type' column.
4. In the 'description' column, provide any further details. This could, for example, include some basic information on the landfill site or the waste type (e.g. residential or private sector waste).

III.1 SOLID WASTE DISPOSAL

GPC ref No.	Scope	GHG Emissions Source		
		Treatment activity	Type of waste	Description
III.1.1	1	Emissions from solid waste generated in the city and disposed in landfills or open dumps within the city		
III.1.1	1	Landfill sites - Methane commitment	Municipal solid waste	*Some basic information on the landfill site or the waste type (e.g. residential or private sector waste).*

5. Input the activity data and units, as was inputted in to the Calculation table in the calculator.
6. Select the gases reported in the calculator under 'Gas(es)'.
7. Leave the 'Emission factor' cells empty. Select ✓ in the 'Emissions data' column.
8. Copy and paste tCO_2, tCH_4 (as tCO_2e) and total tCO_2e, from the Emission summary table of the calculator into the appropriate 'GHGs (metric tonnes CO_2e)' columns under III.1 Solid waste disposal (or I.4 Energy Industries) in the *Waste* (or *Stationary*) sheet under the Inventory tab.
9. Emissions in the Emission summary table under the category 'Combustion of landfill gas with energy recovery' should be reported under I.4 Energy Industries.

Emissions data	GHGs (metric tonnes CO_2e)				
	CO_2	CH_4	N_2O	Total tCO_2e	CO_2(b)
✓		2,002,384			269,209

10. Complete the activity data quality assessment by selecting L, M or H.
11. Add a brief description of method(s) used to highlight that the CIRIS solid waste disposal emissions calculator was used to calculate this source.
12. Select the activity data source from the drop-down list.
13. Provide an explanation for the activity data assessment (optional).

Biological treatment calculator

This calculator has been designed to help cities estimate CH_4 and N_2O emissions from biological treatment of waste. Treating waste biologically reduces overall waste volume for final disposal (in landfill or incineration) and reduces the toxicity of the waste.

Biological treatment of waste refers to composting or anaerobic digestion of organic waste, such as food waste, garden waste, sludge, and waste from other organic sources.

2. City Information

Like other calculators, the first step is to complete the City information section of the calculator. It asks for information on the total organic waste treated biologically and the type of waste. Cities can search for city-specific data from surveys or statistics, or refer to the country and regional averages data on generation and treatment of MSWs provided in the IPCC 2006 Guidelines (vol. 5: waste, chapter 2, Annex 2A.1 waste generation, composition and management data).

City information	Default
City	Autonomous City of Buenos Aires
Country	Argentina
Total organic waste treated biologically in metric tonnes	105,233
Type of waste	Wet waste
Global Warming Potential	4AR

Grey cells in the 'Default' column are auto-populated with information already inputted into CIRIS.

This is the activity data and should be in metric tonnes.

Select whether the activity data is referring to dry or wet waste. The IPCC guidelines assume wet waste has 60% moisture content.

3. Emission summary

The Emissions summary table, as illustrated below, will be auto-populated once all the necessary information has been completed in the other sections of the calculator. Information from this table that should then be copied and pasted under *III.2 Biological treatment of waste* in the *Waste* sheet under the Inventory tab.

Source	Total GHGs (metric tonnes CO_2e)		
	CH_4	N_2O	Total
Composting	4,209	3,011	7,220
Anaerobic digestion	1,263	Not occurring	1,263
Total	5,472	3,011	8,483

Emission totals taken from the final columns of the Calculation table in section 4 of the calculator.

4. Calculations for methane (CH_4) and nitrous oxide (N_2O) emissions from biological treatment of waste

This section enables the calculation of main GHGs from biological treatment of waste. It displays the formulas used in the calculation, followed by the calculation table.

Formulas

The formulas used by this calculator are displayed and further explained below. They apply to both composting and anaerobic digestion, just using different activity data (M), emission factors (EF), and amount of recovered gas (R) as specified in the calculation tables.

GPC equation 8.5: Direct emissions from biologically treated solid waste

To convert between units (g to kg)

CH_4 emissions	$= \Sigma i\ (Mi * EFi) * 0{,}001 - Ri$
M_i	= Mass of organic waste treated by biological treatment type i, Gg
EF_i	= Emission factor for treatment i, gCH4/kg waste treated
i	= Composting or anaerobic digestion
R_i	= Total amount of CH4 recovered, t CH4; default 0

The amount of CH_4 recovered is assumed to be 0.

N_2O emissions	$= \Sigma i\ (Mi * EFi) * 0{,}001$
M_i	= Mass of organic waste treated by biological treatment type i, Gg
EF_i	= Emission factor for treatment i, gN2O/kg waste treated
i	= Composting or anaerobic digestion

Default emission factors from IPCC 2006 Guidelines are provided and built within the calculator. Default values are different for CH4 and N2O, and also different between composting and anaerobic digestion. This can be overridden by city-specific emission factors.

.

Calculation table

The following calculation table uses the previously described formulas. Cities need to input data into the red cells in order for the calculation to be completed.

The treatment type, either anaerobic digestion or composting, should be selected here.

Enter the amount of waste treated by different methods, the total of which should add up to the total amount reported in section 2. City Information.

Alternatively, enter the % of the total organic waste treated by each type of biological treatment.

Emission factors are auto-populated from the 2006 IPCC guidelines (see the footnote, and the Data Tables). If a city-specific EF is known, enter them under 'Override.

The amount of CH_4 recovered is assumed to be 0. If there is CH_4 recovery, the tonnes of CH_4 recovered should be entered under 'Override'.

Treatment type	Organic waste treated		Emission factor[1]				Amount of CH_4 recovered, tCH_4		Total GHG emissions				
	Mass, tonnes	or % of total waste	CH_4, gCH_4/kg waste treated		N_2O, gN_2O/kg waste treated				CH_4		N_2O		Total
									tCH_4	tCO_2e	tN_2O	tCO_2e	tCO_2e
			Default	Override	Default	Override	Default	Override					
Anaerobic digestion	63,140	60%	0.8		0.00		0		51	1263	0	0	1263
Composting	42,093	40%	4.0		0.24		0		168	4209	10	3011	7220
Please select							0						
Please select							0						
Please select							0						
		100%	Must add to 100%					Total	219	5472	10	3011	8483

CH_4 and N_2O emissions (and as tCO_2e) calculated using CH_4 and N_2O equations explained in formulas sections.

Total tCO_2e for each treatment type.

Integrating into CIRIS inventory sheets

Once all steps have been completed, the emissions data from 3. Emissions Summary needs to be copied and pasted under III.2 Biological treatment of waste in the *Waste* sheet under the Inventory tab. To do so, follow these steps:

> Ensure that emissions from waste generated by the city are reported as III.2.1 (if treated within the city boundary) and III.2.2 (if treated outside the city boundary). Waste generated outside the city but treated within the city is reported under III.2.3.

1. Under the relevant scope (i.e. III.2.1, III.2.2, or III.2.3), select 'composting' or 'anaerobic digestion' in the 'Treatment Activity' column, depending on what is suitable.
2. Select the appropriate waste type in the 'type of waste' column. If this is not known, select 'All organic waste'.
3. In the 'description' column, provide any further details. This could, for example, include some basic information on the landfill site or further information on the waste type (e.g. residential or private sector waste).

III.2 BIOLOGICAL TREATMENT OF WASTE

GPC ref No.	Scope	GHG Emissions Source	
		Treatment activity	Type of waste
III.2.1	**1**	**Emissions from solid waste generated in the city that is treated biologically in the city**	
III.2.1	1	Composting	Food waste
III.2.1	1	Anaerobic digestion	Sludge

4. Input the activity data and units, as was inputted in to the Calculation table In the calculator.
5. Select the gases reported in the calculator under 'Gas(es)'.
6. Leave the 'Emission factor' cells empty. Select ✓ in the 'Emissions data' column.
7. Copy and paste tCO_2, tCH_4 (as tCO_2e) and total tCO_2e, from the Emission summary table of the calculator into the appropriate 'GHGs (metric tonnes CO2e)' columns under III.2 Biological treatment of waste in the *Waste* sheet under the Inventory tab.

Emissions data	GHGs (metric tonnes CO_2e)				
	CO_2	CH_4	N_2O	Total tCO_2e	CO_2(b)
✓		4,209	3,011		
✓		1,263			

8. Complete the activity data quality assessment by selecting L, M or H.
9. Add a description of method(s) used to highlight that the CIRIS biological treatment of waste emissions calculator was used to calculate this source.
10. Select the activity data source from the drop-down list.
11. Provide an explanation for the activity data assessment (optional).

Incineration and Open Burning calculator

This calculator has been designed to help cities estimate non-biogenic CO_2, CH_4 and N_2O emissions from the incineration and open burning of solid waste.

Incineration is a controlled, industrial process, often with energy recovery, where inputs and emissions can be measured and data is often available. By contrast, open burning is an uncontrolled, often illegal process with different emissions and can typically only be estimated based on waste collection rates. Emissions from incineration and open burning should be calculated separately, using different activity data and emission factors. Note also that where energy is recovered from incineration, related emissions should be reported in the *Stationary* sector.

2. City Information

The first step is to complete the City information table. To do so, select the type of incineration and enter the total organic waste sent for incineration or open burning. Cities can search for city-specific data from surveys or statistics, or refer to the country and regional averages data on generation and treatment of MSWs provided in the IPCC 2006 Guidelines (vol. 5: waste, chapter 2, Annex 2A.1 waste generation, composition and management data).

City information	Default	
City	Autonomous City of Buenos Aires	
Country	Argentina	
Region	America	< Select from list
Sub-region	South America	< Select from list
Management	Incineration	< Select from list
Total waste sent for incineration in metric tonnes	416	< Enter amount
Global Warming Potential	4AR	

Select the region and sub-region from the drop-down list.

Select either incineration or open burning.

This is the activity data and should be in metric tonnes.

3. Emission summary

The emission summary table will be auto-populated once all calculations (section 4 to 6) are completed. The emission summary table displays the emissions information that should be copied and pasted under III.3 Incineration and open burning in the *Waste* sheet under the Inventory tab.

Emission totals taken from the final column of the Calculation table for each pollutant; and then summed to reach the 'Total'.

Source	Total GHGs (metric tonnes CO_2e)			
	CO_2	CH_4	N_2O	Total
Incineration	182	0	9	191

4. Non-biogenic CO2 emissions from the incineration of waste

This section calculates the non-biogenic CO_2 emissions from incineration and open burning of waste.

Formula

This equation calculates the non-biogenic CO_2 emissions from incineration of waste, taking into account the composition of the waste being incinerated and the fraction of carbon within the waste.

GPC equation 8.6: Non-biogenic CO_2 emissions from the incineration of waste

CO_2 emissions	= m * Σi (WFi * dmi * Cfi * FCFi * OFi) * (44/12)
m	= Mass of waste incinerated, in tonnes
WFi	= Fraction of waste containing type i matter
dm_i	= Dry matter content in the type i matter
CF_i	= Fraction of carbon in the dry matter of type i matter
FCF_i	= Fraction of fossil carbon in the total carbon component of type i matter
OF_i	= Oxidation fraction or factor
44/12	= Molecular weight ratio of CO2 and carbon
i	= Matter type of the Solid Waste incinerated, such as paper/cardboard, textile, food waste, etc.

Default factors available

This is the activity data entered in the City information table.

The type of waste as a fraction of the total waste (e.g. paper and cardboard might make up 17% of total waste).

The proportion of each waste type (i) that is dry matter.

The proportion of carbon the dry fraction of the waste type.

The proportion of total carbon in the waste type that is fossil carbon.

The oxidation fraction/factor reflects the amount of CO_2 that is ultimately combusted. If 'incineration' is selected in the 'Management' category in the City information table, this will be 1 (100%), which assumes complete combustion. For open burning of MSW, US EPA gives a range between 49 and 67% and the IPCC a default value of 58%. This calculator uses 58% as the default value.

Refers to each type of waste within the total mass of waste incinerated. **This calculation is carried out for each waste type (i) and then summed up**

To convert C into CO_2

Calculation table

The following calculation table uses the above formula to produce an estimate of fossil CO_2 emissions from incineration. Note that for display purposes, the table is split across two pages. As explained previously, grey cells are auto-populated using information already entered in to CIRIS, white cells are optional.

This is the activity data entered in the City information table.

The calculator assumes all waste is MSW by default, but this can be manually overwritten in the subsequent 'Override' columns.

The types of waste incinerated are categorised into IPCC default composition categories.

Auto-populated using IPCC default data for country and regional averages (See 'IPCC Guidelines Volume 5, Chapter 2, Table 2.4: Default dry matter content, DOC content, total carbon content and fossil carbon fraction of different MSW components' under Data Tables).

No default values are given for industrial/clinical waste or sewage sludge. This can be overwritten.

Mass of waste incinerated, tonnes	Waste type	MSW type of waste incinerated (type i matter)	% waste containing type i matter (WF_i)		Dry matter content in the type i matter (dm_i)	
Value			Default	Override	Default	Override
416	MSW	Food waste	44.9%		40%	
		Paper / Cardboard	17.1%		90%	
		Wood	4.7%		85%	
		Textiles	2.6%		80%	
		Garden and Park waste	No default >		40%	
		Nappies	No default >		40%	
		Rubber / Leather	0.7%		84%	
		Plastics	10.8%	15.0%	100%	
		Metal	2.9%	2.0%	100%	
		Glass	3.3%	0.1%	100%	
		Other, inert waste	13.0%		90%	
	Industrial waste		No default >		No default >	
	Clinical waste		No default >		No default >	
	Sewage sludge		No default >		No default >	
	Fossil liquid waste		No default >		No default >	
		Total	100%	100%	Must add to 100%	

Where city-specific data is available for any of the categories, overwrite the default parameters by completing the 'Override' columns.

Auto-populated using IPCC defaults (See 'IPCC Guidelines Volume 5, Chapter 2, Table 2.4: Default dry matter content, DOC content, total carbon content and fossil carbon fraction of different MSW components' under Data Tables).

Checks to ensure the total equals 100%

Auto-populated using IPCC defaults (See 'IPCC Guidelines Volume 5, Chapter 2, Table 2.4: Default dry matter content, DOC content, total carbon content and fossil carbon fraction of different MSW components' under DATA TABLES).

3.67 = 44/12

Fraction of carbon in the dry matter of type i matter (CF_i)		Fraction of fossil carbon in the total carbon component of type i matter (FCF_i)		Oxidation fraction or factor (OF_i)		Molecular weight ratio of CO2 and carbon	Total CO_2 emissions
Default	Override	Default	Override	Default	Override	Default	Value
38%		0%		100%		3.67	0
46%		1%		100%		3.67	1
50%		0%		100%		3.67	0
50%		20%		100%		3.67	3
49%		0%		100%		3.67	0
70%		10%		100%		3.67	0
67%		20%		100%		3.67	1
75%		100%		100%		3.67	171
0%		0%		100%		3.67	0
0%		0%		100%		3.67	0
3%		100%		100%		3.67	5
No default >		No default >		100%		3.67	0
No default >		No default >		100%		3.67	0
No default >		No default >		100%		3.67	0
No default >		No default >		100%		3.67	0
						Total	182

If 'incineration' is selected in the 'Management' category in the City information table, this will be 100%. For open burning of MSW, the US EPA gives a range between 49 and 67%; a default value of 58% is used from the IPCC. (See 'GPC Table 8.4, Default data for CO2 emission factors for incineration and open burning' under DATA TABLES).

Calculated following GPC equation 8.6 given above

5. Methane (CH_4) emissions from the incineration of solid waste

This step calculates the CH_4 emissions from incineration and open burning of MSW. Note that this step only calculates emissions from MSW (not other types of waste – calculations will need to be undertaken manually for other waste types, if relevant).

Formula

GPC Equation 8.7: CH_4 emissions from the incineration of waste

$$CH_4 \text{ emissions} \quad \Sigma(IW_i \cdot EF_i) \cdot 10^{-6}$$

IW_i	= Amount of solid waste type i incinerated or open burned, tonnes
EF_i	= Aggregate CH4 emission factor, g CH4/tonne waste type i
10^{-6}	= Converting factor from gCH4 to t CH4
i	= Category or type of waste incinerated, specified as follows: municipal solid waste, industrial waste, sludge (except sewage sludge), sewage sludge

Activity data for each waste type (i) – in this calculation, i will be MSW.

Emission factor for each waste type, taking into account the type of incineration and technology used.

Type of waste. Note that default emission factors are only available for MSW.

To convert unit from gram to tonne

Calculation table (MSW only)

The following calculation table uses the above formula to produce an estimate of CH_4 emissions from incineration.

Enter the amount of MSW incinerated (in tonnes) for each incineration and technology type as defined in the subsequent columns

This calculation is used to estimate MSW emissions only.

Default emission factor from 'GPC Table 8.5, CH4 emission factors for incineration of MSW' under DATA TABLES. Override if a city-specific factor is known.

10^{-6} used to convert unit from gram to tonne

Calculated following GPC equation 8.7 and then converting to tCO_2e

Waste incinerated, tonnes	Type of waste	Type of incineration	Technology	CH_4 emission factor, gCH_4/tonne waste type i		Converting factor from gCH_4 to tCH_4	Total CH_4 emissions	
							tCH_4	tCO_2e
Value		Select	Select	Default	Override	Default	Value	
	MSW	Continuous incineration	Stoker	0.2		0.000001		
	MSW	Continuous incineration	Fluidised bed	0.0		0.000001		
	MSW	Semi-continuous incineratior	Stoker	6.0		0.000001		
	MSW	Semi-continuous incineratior	Fluidised bed	188.0		0.000001		
320	MSW	Batch type incineration	Stoker	60.0		0.000001	0.019	0.480
	MSW	Batch type incineration	Fluidised bed	237.0		0.000001		
						Total	0	0

Continuous incineration – an incinerator that is permanently running. These incinerators are those without daily start-up and shutdown.

Semi-continuous incineration – incinerators that are usually started-up and shutdown at least once a day.

Batch type incineration – incinerators that operate in a non-continuous manner. They are filled with waste before the initiation of burning, and the door stays closed until the ash has cooled inside.

Stoker – consists of a series of stepped fire grates that move back and forth to enable efficient contact between waste and air to ensure stable combustion.

Fluidised bed - a bed of sand, combustion ash or other sand-like material is suspended in an upward flowing airstream to enhance combustion and promote efficient heat transfer and uniform mixing.

6. Nitrous oxide (N_2O) emissions from the incineration of solid waste

The next step is to calculate N_2O emissions from the incineration of solid waste; this follows a similar method to calculating CH_4 emissions from incineration; however, different emission factors are used, and the calculator considers various types of waste (e.g. not just MSW).

Formula

GPC Equation 8.8: N_2O emissions from the incineration of waste

Activity data for each waste type (i)

Emission factor for each waste type, taking into account the type of incineration and technology used.

N_2O emissions	=Σ(IWi * EFi) * 10-6
IW_i	= Amount of solid waste type i incinerated or open burned, tonnes
EF_i	= Aggregate N2O emission factor, g N2O/tonne waste type i
10^{-6}	= Converting factor from gN2O to tN2O
i	= Category or type of waste incinerated, specified as follows: municipal solid waste, industrial waste, sludge (except sewage sludge), sewage sludge

To convert unit from gram to tonne

Calculation table

The following calculation table uses the above formula to produce an estimate of N_2O emissions from incineration.

Enter the amount of each waste type incinerated (in tonnes) for each incineration and technology type.

If the activity data is on a wet basis, select 'wet weight'.

If it is on a dry weight basis, select 'dry weight'.

10^{-6} used to convert unit from gram to tonne.

Waste incinerated, tonnes	Type of waste	Type of technology/management practice	Weight basis	N_2O emission factor, g N_2O/tonne waste type i		Converting factor from gN_2O to tN_2O	Total N_2O emissions	
							tNO_2	tCO_2e
Value				Default	Override	Default		
	MSW	Continuous and semi-continuous incinerators	Wet weight	50		0.000001		
320	MSW	Batch type incinerators	Wet weight	60		0.000001	0.02	5.72
	MSW	Open burning	Dry weight	150		0.000001		
96	Industrial waste	All types of incineration	Wet weight	100		0.000001	0.01	2.86
	Sludge (except sewage sludge)	All types of incineration	Wet weight	450		0.000001		
	Sewage sludge	Incineration	Dry weight	990		0.000001		
	Sewage sludge	Incineration	Wet weight	900		0.000001		
						Total	0	9

Each type of waste has the types of technology/ management practice auto populated. See the descriptions under the calculation table for step 5.

Default emission factor from 'GPC Table 8.6, Default N_2O emission factors for different types of waste and management practices' in the DATA TABLES.

If a city-specific emission factor is known, overwrite in 'Override' column ensuring it is in g N_2O/tonne waste type.

Calculated following GPC equation 8.8 and then converting to tCO_2e.

Integrating into CIRIS inventory sheets

Once all steps have been completed, the emissions data from 3. Emissions Summary needs to be copied and pasted under *III.3 Incineration and open burning of waste* in the *Waste* sheet under the *Inventory* tab. To do so, follow these steps:

1. Under the relevant scope (i.e. III.3.1, III.3.2, or III.3.3), select 'Open burning of waste (4.C.1)' or 'Waste incineration (4.C.2)' in the 'Activity' column, consistent with the options selected in the calculator.
2. Select the appropriate waste type in the 'type' column.
3. In the 'description' column, provide any further details. This could, for example, include some basic information on the incinerator type or further information on the waste type (e.g. domestic/ commercial/ industrial waste/ sewage sludge, etc.).

III.3 INCINERATION AND OPEN BURNING

GPC ref No.	Scope	GHG Emissions Source		
		Treatment activity	Type of waste	Description
III.3.1	**1**	**Emissions from waste generated and treated within the city**		
III.3.1	1	Waste incineration (4.C.2)	Municipal solid waste	Residual waste after recycling

4. Input the activity data and units, as was inputted in to the City information table (e.g. tonnes of waste incinerated).
5. Select CO_2, N_2O and CH_4 under 'Gas(es)'.
6. Leave the 'Emission factor' cells empty. Select ✓ in the 'Emissions data' column.
7. Copy and paste tCO_2, tCH_4 (as tCO_2e), tNO_2 (as tCO_2e) and total tCO_2e, from the Emission summary table into the appropriate 'GHGs (metric tonnes CO2e)' columns under III.3 incineration and open burning of waste in the *Waste* sheet under the Inventory tab.

Emissions data	GHGs (metric tonnes CO_2e)				
	CO_2	CH_4	N_2O	Total tCO_2e	CO_2(b)
✓	182.23	0.48	8.58		

8. Complete the activity data quality assessment by selecting L, M or H.
9. Add a description of method(s) used to highlight that the CIRIS incineration emissions calculator was used to calculate this source.
10. Select the activity data source from the drop-down list.
11. Provide an explanation for the activity data assessment (optional).

Wastewater

The wastewater calculator has been designed to help cities estimate CH_4 and N_2O emissions from treatment of domestic, commercial and industrial wastewater.

2. City information

Same as other calculator sheets, grey cells are auto-populated with information already entered into CIRIS, white cells are for overriding default data in grey cells, and only red cells must be populated.

Either select the country your city is in, or a country that is similar to the one your city is located in. This instructs the calculator to use IPCC default factors for the country and region specified.

Select a region from the drop-down list that either contains your city or is a similar region to where your city is located. This instructs the calculator to use IPCC default BOD values for the region chosen.

These are devices installed under kitchen sinks to shred waste food. If present, the fraction for this non-consumed protein added to wastewater is included in the N_2O calculation; a default of 1.1 is applied without garbage disposals, and 1.4 with.

City information		Default	Override
City		Autonomous City of Buenos Aires	
Country		Argentina	
Proxy region/country for wastewater BOD value		Asia_MiddleEast_LatinAmerica	< Select from list
Proxy country for wastewater treatment type		Brazil	< Select from list
Proxy country for protein consumption		Argentina	< Select from list
Garbage disposal		No garbage disposals	< Select from list
Population		3,079,071	
Global Warming Potential		4AR	
Fraction of population in income group (U)	% urban high income	25%	
	% urban low income	59%	
	% rural	16%	
	Check	100%	< Use default values
Climate (wet/dry)		Dry	< Select from list

Select what type of climate the city experiences. If this is not known, it can be inferred from http://people.eng.unimelb.edu.au/mpeel/koppen.html

From 'IPCC 2006 Volume 5 Chapter 6: Wastewater, Table 6.5: Suggested Values for Degree of Treatment, Discharge Pathway or Method for Each Income Group for Selected Countries' under DATA TABLES, using the country selected in this table. These data enables auto-calculation of % of wastewater treated by different types of treatment.

If city-specific or better quality of data are available, enter them in the "Override" column. **Ensure they add up to 100%, or the check cell will say "Needs to add up to 100%" as a warning.**

3. Emission summary

The emission summary table will be auto-populated once all calculations (section 4 and 5) are completed. These are explained below. The emission summary table displays the emissions information that should be copied and pasted under *III.4 Wastewater* in the *Waste* sheet under the *Inventory* tab

Source	Total GHGs (metric tonnes CO_2e)		
	CH_4	N_2O	Total
Domestic / Commercial	483,822	57,313	541,135
Industrial	23,647		23,647
Total	507,469	57,313	564,782

4. Domestic and commercial wastewater

This section calculates emissions from domestic and commercial wastewater. It is further broken down into estimating CH_4 and N_2O emissions separately.

4a. Methane (CH_4) emissions from domestic/commercial wastewater

Formula

Three tiers of formulas are used to calculate emissions of methane from domestic and commercial wastewater. Calculations should be carried out for each waste type (i). For domestic wastewater, this can be disaggregated by income group for each wastewater treatment and handling system.

The formula below is the main one that calculates the total methane generated from wastewater:

GPC equation 8.9: CH_4 generation from wastewater treatment

To convert unit from kg to tonne

TOW refers to the organic content of water and is calculated in equation 8.10 below.

CH4 emissions	= Σi [(TOWi - Si) * EFi - Ri] * 0.001
TOWi	= Organic content of wastewater, kgBOD for domestic wastewater, kgCOD for industrial wastewater
Si	= Organic component removed as sludge, kgBOD/yr or kgCOD/yr; default 0
EF	= Emission factor, kgCH4 per kg BOD or kgCH4 per kg COD
R	= Amount of CH4 recovered, kgCH4/yr; default 0

Assumed to be 0 by default. If there is sludge removal, the organic component removed should be subtracted from the total organic content of wastewater

Calculated in equation 8.10 below.

If there is any methane recovered, e.g. gas capture, it should be subtracted from the total. The default assumption is 0.

GPC equation 8.10: Organic content and emission factors in domestic wastewater

The equation below calculates the total organics in wastewater in inventory year, kg BOD/yr, which is then used in the formula 8.9 above.

City population auto-populated in city information table.

To convert unit from kg to tonnes

TOW	= [P * BOD * I * 365] * 0.001
P	= Population
BOD	= City-specific per capita biochemical oxygen demand, g/person/day
I	= Correction factor for additional industrial BOD discharged into sewers; 1.25 for collected wastewater, 1.00 for uncollected
365	= Number of days per year

Biological oxygen demand (BOD) indicates only the amount of carbon that is aerobically biodegradable.

This expresses the BOD from industries and establishments (e.g. restaurants, butchers or grocery stores) that is co-discharged with domestic wastewater. In some countries, information from industrial discharge permits may be available to improve I. Otherwise, expert judgment is recommended.

The equation below calculates the emission factor for each treatment and handling system.

EF	= B * MCF * U * T
B	= Maximum CH4 producing capacity, default 0.6kgCH4/kgBOD
MCF	= Methane correction factor (fraction)
U	= Fraction of population in income group i
T	= Degree of utilisation of treatment/discharge pathway or system for each income group fraction i

The maximum amount of CH_4 that can be produced from a given quantity of organics (as expressed in BOD or COD) in the wastewater.

The fraction of waste from each income group that uses each treatment/discharge pathway.

This uses the default or city-specific information under the 'Fraction of population in income group (U)' category in the city information table.

The MCF indicates the extent to which the CH_4 producing capacity (B) is realised in each type treatment/discharge pathway and system. It is an indication of the degree to which the system is anaerobic.

Calculation table

The following calculation table uses the above formula to produce an estimate of methane from domestic and commercial wastewater. Note that for display purposes, the table is split horizontally across the next three pages.

The % water treated by different methods, by high and low income areas, is auto-populated. The table looks up default values for each type of treatment under each income group, as provided in 'IPCC 2006 Volume 5 Chapter 6: Wastewater, Table 6.5' under DATA TABLES, using the Proxy country for wastewater treatment as selected in the city information table. It then multiplies those default values by the income group split as defined in the city information table.

Under each type of treatment, there is the option to specify specific methods. If city-specific or better quality of data are available, enter the % of total water treated against each relevant type of treatment in the white cells to override the default treatment %s. Ensure the total adds up to 100%. If not known, leave blank.

There is a row in the table for each wastewater treatment type.

Treatment	General treatment				Specific treatment (optional)		
	Type of treatment	% water treated (U*T)[1]			Type of treatment	Comment	% water treated
		Urban: high	Urban: low	Rural			Override
Non-treated	None	0%	11.8%	7%	Sea, river and lake discharge	Rivers with high organics loadings can turn anaerobic	5%
	Sewer	20.0%	23.6%	2%	Stagnant sewer	Open and warm	10%
					Flowing sewer (open/closed)	Fast moving, clean (CH_4 from pump stations insignificant)	25%
Treated	Septic System	0.0%	0.0%	0%	Septic System	Half of BOD settles in anaerobic tank	
	Latrine	5.0%	23.6%	7%	Latrine	Dry climate, ground water table < latrine, 3-5 persons	
					Latrine	Dry climate, ground water table < latrine, many users	30%
					Latrine	Wet climate/flush water use, ground water table > latrine	30%
					Latrine	Regular sediment removal for fertilizer	
	Other	0%	0.0%	0%	Aerobic treat-ment plant	Must be well managed	
					Aerobic treat-ment plant	Not well managed. Overloaded	
					Anaerobic digester: sludge	CH_4 recovery is not considered here	
					Anaerobic reactor	CH_4 recovery is not considered here	
					Anaerobic shallow lagoon	Depth less than 2 metres	
					Anaerobic deep lagoon	Depth more than 2 metres	
							100%

If manually entering treatment data, ensure it adds to 100%.

Population is auto-populated from the City information table, for each treatment type. It will display “Go to Set-up” until data is entered there.

This part of the table calculates the organic content of wastewater (TOW) from GPC equation 8.10.

Enables calculation for the whole year.

This column returns the calculation results of TOW from all domestic-commercial wastewater discharged.

Each row represents the different wastewater treatment types

Organic content of wastewater (TOW)							Organic component removed as sludge, kgBOD/yr or kgCOD/yr (S)	
Population (P)	Biochemical Oxygen Demand, g/person/day (BOD)		Correction factor for industrial discharge, I		Days per year	Total		
Value	Default[2]	Override	Default[3]	Override	Value	Value	Default	Override
3079071	40		1.25		365	56193046	0	
3079071	40		1.25		365	56193046	0	
3079071	40		1.25		365	56193046	0	
3079071	40		1.25		365	56193046	0	
3079071	40		1.25		365	56193046	0	
3079071	40		1.25		365	56193046	0	
3079071	40		1.25		365	56193046	0	

BOD for the proxy region for wastewater treatment as chosen in the city information table is looked up from ‘IPCC 2006 Volume 5 Chapter 6: Wastewater, Table 6.4 Estimated BOD values in domestic wastewater for selected regions and countries’ under DATA TABLES. If a city or country-specific factor is known, enter it into the ‘Override’ column.

For collected wastewater, this is assumed to be 1.25. For uncollected, the default is 1. If a city or country-specific value is known, enter in the ‘Override’ column.

The organic component removed as sludge (S) is assumed to be 0. If local data or better quality of data is known, enter in the white cells to override default values.

This part of the calculation table works out the appropriate EF for each wastewater treatment stream.

Auto-calculated following EF equation previously described.

Final calculation of total CH_4 emissions from domestic wastewater, converted to tCO_2e.

Each row represents the different wastewater treatment types

Maximum CH_4 producing capacity,		Emission factor (EF): Methane correction factor (MCF): General[5]			Specific		Total	Amount of CH_4 recovered, $kgCH_4/yr$		Total CH_4 emissions: tCH_4	tCO_2e
Default[4]	Override	Urban: high	Urban: low	Rural	Default[6]	Override	Value	Default	Override	Value	Value
0.6		0	0.5	0.5	0.1		0.003	0		169	4214
0.6		0	0.5	0.5	0.5		0.03	0		1686	42145
0.6					0.0		0	0		0	0
0.6		0.5	0.5	0.5	0.5		0	0		0	0
0.6		0.1	0.5	0.5	0.1		0.0954	0		5361	134020
0.6					0.5		0.09	0		5057	126434
0.6					0.7		0.126	0		7080	177008
0.6					0.1		0	0		0	0

0.6 is the default provided in table 6.2 in IPCC 2006 Volume 5 Chapter 6: Wastewater. The value is based on expert judgement. If a city or country-specific value is known, enter in the white cells to override.

These values are inferred using expert judgement, for each general treatment method, from the values in 'IPCC 2006 Volume 5 Chapter 6: wastewater, Table 6.3' under DATA TABLES.

These values are from 'IPCC 2006 Volume 5 Chapter 6: wastewater, Table 6.3' under DATA TABLES.

If there is any methane recovered, e.g. gas capture, it should be entered here to subtract from the total. The default assumption is 0.

4b. Nitrous Oxide (N_2O) emissions from domestic-commercial wastewater

Formula

The following formulas are used to calculate emissions of N_2O from domestic and commercial wastewater, adapted from GPC equation 8.11 *Indirect N_2O emissions from wastewater effluent.*

The calculation is based on population (in the City information table) and there is default information available for all other parameters, but it is advisable to report city-specific information if available.

The formula below is the main calculator that calculates the total N_2O from wastewater, including direct emissions from centralised wastewater treatment process and indirect emissions from effluent.

N_2O emissions	**= N2OEFFLUENT + N2OPLANTS**
$N_2O_{EFFLUENT}$	= N2O emissions from wastewater effluent
N_2O_{PLANTS}	= N2O emissions from centralised wastewater treatment processes

These values are described in the following equations.

IPCC Equation 6.9: N_2O Emissions from centralised wastewater treatment processes

The calculator includes the option to estimate N_2O emissions from advanced centralised wastewater treatment plants. These are typically much smaller than those from effluent and may only be of interest for cities that have predominantly advanced centralised wastewater treatment plants with controlled nitrification and denitrification steps. The total N_2O emissions from centralised wastewater treatment processes in inventory year (kg N_2O/yr) is calculated as follows, then added to the calculation for effluent (as per the formula above):

N_2O_{PLANTS}	**= P * TPLANT * FIND-COM * EFPLANT**
P	= Population
T_{PLANT}	= Degree of utilisation of modern, centralised WWT plants; default 0%
$F_{IND-COM}$	= Fraction for industrial and commercial co-discharged protein; default 1.25
EF_{PLANT}	= Emission factor; 0.0032 kgN2O/person/yr

The % of plants that are deemed to be advanced centralised wastewater treatment plants.

The overall emission factor to estimate N_2O emissions from such plants is 3.2 g N_2O/person/year (IPCC 2006 Guidelines, Vol 5 Chapter 6 Box 6.1). No country specific emission factors are available.

Fraction of industrial and commercial co-discharged protein. Default = 1.25.

(IPCC 2006 Guidelines, Vol 5 Chapter 6 Box 6.1 - based on data in Metcalf & Eddy (2003) and expert judgment).

GPC Equation 8.11: Indirect N_2O emissions from wastewater effluent

This is the main equation for estimating emissions from wastewater effluent.

$N_2O_{EFFLUENT}$	**= [(P * Protein * FNPR * FNON-CON * FIND-COM) - NSLUDGE - NWWT] * EFEFFLUENT *44/28**
P	= Population
Protein	= Annual per capita protein consumption, kg/person/yr
F_{NPR}	= Fraction of nitrogen in protein; 0.16 kgN per kg protein
$F_{NON\text{-}CON}$	= Fraction for non-consumed protein added to wastewater; default 1.1 without garbage disposals, 1.4 with
$F_{IND\text{-}COM}$	= Fraction for industrial and commercial co-discharged protein into sewer system; default 1.25
N_{SLUDGE}	= Nitrogen removed with sludge, kgN/yr; default 0
N_{WWT}	= N2OPLANTS * 28/44, kgN/yr; default 0
$EF_{EFFLUENT}$	= Emission factor for N2O emissions from discharge to wastewater, kgN2O-N/kgN2O; default 0.005kgN2O-N/kgN
44/28	= Conversion of kgN2O-N into kgN2O

Default daily protein consumption figures are available for each country.

The amount of nitrogen in protein

Accounts for non-consumed protein in wastewater e.g. from under-sink garbage disposal systems (taken from city information table).

Factor for industrial and commercial co-discharged protein into the sewer system.

To account for any Nitrogen which is removed from wastewater.

Amount of nitrogen in kg in every kg of wastewater effluent. Default 0.005.

Convert nitrogen to N_2O based on molecular weight ratio

When a city chooses to include N_2O emissions from plants (see the previous equation), the amount of nitrogen associated with these emissions (NWWT) must be back calculated and subtracted from the $N_2O_{EFFLUENT}$.

NWWT can be calculated by multiplying N_2O_{PLANTS} (IPCC 2006 Equation 6.9) by 28/44, using the molecular weights.

Calculation table

The following calculation table uses the above formula to produce an estimate of nitrous oxide from domestic and commercial wastewater. Note that for display purposes, the table is split horizontally across two rows on the page below.

A default value is looked up using the selected country/proxy country for protein consumption in the City information table, from 'Daily protein consumption' under DATA TABLES. This figure is then multiplied by 365 and divided by 1,000 to give kg/person/year (from g/person/day)

If 'no garbage disposal' is selected under Garbage Disposal in the City information table, the default is 1.1. If 'garbage disposal' is selected, the default is 1.4. If specific value is known, overwrite under 'Override'.

Auto-populated from city information table

Population	Degree of advanced WWT plants	Annual per capita protein consumption, kg/person/yr		Fraction of nitrogen in protein, F_{NPR}	Fraction to adjust for non-consumed protein, $F_{NON\text{-}CON}$		Fraction of industrial / commercial co-discarged protein, $F_{IND\text{-}COM}$	
Value	Override	Default[1]	Override	Default	Default[2]	Override	Default	Override
3079071	0%	36.14		0.16	1.1		1.25	

If advanced centralised wastewater treatment plants are used, add the % here (otherwise the calculation assumes 0).

kg nitrogen per kg protein

Factor for industrial and commercial co-discharged protein into the sewer system.

If no nitrogen is removed with sludge, this is assumed to be 0. If there is nitrogen removal, enter the amount in kg of N under 'Override'.

Nitrogen removed with sludge, kg N (N_{sludge})		Emission factor, $kgN_2O\text{-}N/kgN_2O$ ($EF_{EFFLUENT}$)[4]		Total N_2O, kgN_2O		Total N_2O emissions	
				Effluent	Advanced WWT plants	tN_2O	tCO_2e
Default	Override	Default	Override	Value	Value	Value	Value
0		0.005		192325	0	192	57313

This is the IPCC default EF for N_2O emissions from domestic wastewater nitrogen effluent.

Calculated using the $N_2O_{EFFLUENT}$ equation.

Calculated using the N_2O_{PLANTS} equation.

This is the sum of total N_2O from effluent and from advanced WWT plants, as N_2O, and multiplied by the relevant GWP.

5. Industrial wastewater

The GPC only provides guidance for domestic wastewater treatment. For industrial wastewater treatment, see Volume 5 Chapter 6: Wastewater, section 6.2.3, of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. This section calculates emissions from industrial wastewater based on IPCC guidelines; this is only done for CH_4 emissions.

Formula

The following formulas are used to calculate CH_4 emissions from industrial wastewater. Emissions are derived from the amount of organically degradable material in the wastewater (TOW), which is calculated from industrial output (tonnes/year), wastewater generation W (m3/tonne of product), and degradable organics concentration in the wastewater COD (kg COD/m^3). Default water generation rates are available but it is advisable to report city- and industry-specific information if possible.

IPCC equation 6.4: Total CH_4 emissions from industrial wastewater

Total CH_4 emissions, calculated for each industry, i. using the formula below:

CH_4 emissions	= Σi [(TOWi - Si) * EFi - Ri] * 0.001
TOWi	= Organic content of wastewater, kgCOD
Si	= Organic component removed as sludge, kgCOD/yr; default 0
EF	= Emission factor, kgCH4 per kg COD
R	= Amount of CH4 recovered, kgCH4/yr; default 0

TOW refers to the organic content of water and is calculated in the next equation.

Assumed to be 0

Calculated in EF equation below.

Recovered CH_4 (e.g. biogas capture) will be city-specific and different for each industrial category

IPCC equation 6.6: Organically degradable material in industrial wastewater

TOW is calculated for each industry, i.

TOW	= [P * W * COD]
P	= Total industrial product for each industrial category, tonnes
W	= Wastewater generated by each industrial sector, m3/tonne
COD	= Chemical oxygen demand for each industrial sector, kg/m3

Wastewater generated per tonne of industrial product. Default values are available.

Chemical Oxygen Demand (COD) measures the total material available for chemical oxidation (both biodegradable and non-biodegradable). In some countries, COD and total water usage per sector data may be available directly from a regulatory agency. An alternative is to obtain data on industrial output and tonnes COD produced per tonne of product from the literature. Default data is available from the IPCC and found in the DATA TABLES at end of the calculator sheet.

IPCC equation 6.5: CH_4 emission factor for industrial wastewater

The emission factor is calculated for each industry, i.

EF	**= B * MCF * T**
B	= Maximum CH4 producing capacity; default 0.25kgCH4/kgCOD
MCF	= Methane correction factor (fraction)
T	= Degree of utilisation of treatment method

This calculator uses 'IPCC 2006 Volume 5 Chapter 6: Wastewater, Table 6.8: Default MCF values for industrial wastewater' under DATA TABLES.

The % of treatment method used (e.g. aerobic treatment, anaerobic digestion).

Calculation table

The following calculation table uses the above formulas to produce an estimate of methane from industrial wastewater. Same as other calculator sheets, grey cells contain default data or data previously entered in the CIRIS, white cells are optional for populating and are for city-specific or better quality of data to override default data, and red cells must be populated.

Note that for display purposes, the table is split horizontally across three pages. Note also, that only two lines are shown in this example; the calculation table in the calculator has space for many more entries.

Select the industry type from the drop-down list. These represent some of the major wastewater-generating industries. If an industry is not on the list, it can be and should be manually added; note however, IPCC default factors are only available for the industries listed.

Calculated following the TOW equation described above. If an industry specific value is known, enter under 'Override'.

Organic component removed as sludge (Si) refers to organic material that is taken out of wastewater sludge. This is assumed to be 0.

Industry		Wastewater generation (m3/tonne)		Chemical oxygen demand (COD; kg/m3)		Total organically degradable carbon in wastewater (TOW; kgCOD/year)		Removals per year			
Type (select)	Total product (tonnes)							Organic component removed as sludge (kg COD/yr)		Amount of CH_4 recovered (kg CH_4/yr)	
Select	Value	Default[1]	Override	Default[1]	Override	Default	Override	Default	Override	Default	Override
Dairy products	62,400	7	8	2.7		1,347,840		0		0	
Sugar refining	120,000	11		3.2		4,224,000		0		0	

Enter the total tonnes of product produced for each industry within the inventory year

Default factors are taken from 'IPCC 2006 Volume 5 Chapter 6: Wastewater, Table 6.9: Examples of industrial wastewater data' under DATA TABLES. The appropriate values are selected based on the industry type selected. If industry-specific values are known, enter under 'Override'.

Amount of CH_4 recovered (R), in kg of CH_4, refers to any CH_4 that is recovered during the process of treating industrial wastewater. This is assumed to be 0. Enter data manually in 'Override' column, if biogas capture is present.

These treatment methods refer to how the industrial wastewater is treated. They correspond with the default Methane Correction Factor (MCF) values in 'IPCC 2006 Volume 5 Chapter 6: Wastewater, Table 6.8: Default MCF values for industrial wastewater' under DATA TABLES.

The default value is 0.25 from 2006 IPCC Guidelines. City specific values are preferred – if known, enter in the 'Override' column.

Treatment method (%)								Maximum CH4 producing capacity (B_o, kg CH_4/kg COD)	
Aerobic treatment plant - well managed	Aerobic treatment plant - not well managed	Anaerobic digester for sludge	Anaerobic digester (e.g. UASB, fixed film reactor)	Anaerobic shallow lagoon < 2 metres	Anaerobic deep lagoon > 2 metres	Sea, river and lake discharge	Must add up to 100%		
Value	Value	Value	Value	Value	Value	Value	Value	Default	Override
	100%						100%	0.25	
		100%					100%	0.25	

In the red cells, enter the % of each treatment method for each industry type.

This cell ensures that the treatment methods equal 100% for each industrial source. This cell will be green if it equals 100%, and grey if not.

This section of the calculation table displays the default MCF for each treatment type (in grey cells). Default MCFs are used from 'IPCC 2006 Volume 5 Chapter 6: Wastewater, Table 6.8: Default MCF values for industrial wastewater' under DATA TABLES. They will be over-ridden if city specific MCF values are populated in the white cells under 'Override' columns.

Methane correction factors (MCF)[2]													
Aerobic treatment plant - well managed		Aerobic treatment plant - not well managed		Anaerobic digester for sludge[3]		Anaerobic digester (e.g. UASB, fixed film reactor)[3]		Anaerobic shallow lagoon < 2 metres		Anaerobic deep lagoon > 2 metres		Sea, river and lake discharge	
Default	Override	Default	Override	Default	Override	Default	Override	Default	Override	Default	Override	Default	Override
0		0.3		0		0		0		0		0	
0		0		0.8		0		0		0		0	

Calculated following EF equation, taking into account the treatment method and the corresponding MCF.

CH_4 emission factor ($kgCH_4$/kg COD)	Total CH_4 emissions	
	tCH_4	tCO_2e
Value	Value	Value
0.08	101	2527
0.10	422	10560

Calculated following CH_4 emissions equation. Firstly this is presented in CH_4, and then in CH_4 as tCO_2e, using the appropriate GWP.

Integrating into CIRIS inventory sheets

Once all steps have been completed, the emissions data from 3. Emissions Summary needs to be copied and pasted under III.4 Wastewater treatment and discharge in the *Waste* sheet under the Inventory tab. To do so, follow these steps:

> Wastewater that is generated inside the boundary and treated inside the boundary should be reported under III.4.1
>
> Wastewater that is generated within but treated outside the boundary should be reported under III.4.2
>
> Wastewater that is generated outside but treated within the boundary should be reported under III.4.3

1. Under the relevant scope, select either 'All wastewater', 'domestic wastewater', or 'industrial wastewater' in the 'Activity' column, depending on what is suitable.
2. In the 'description' column, provide any further details. This could, for example, include some basic information (e.g. the industry types for industrial wastewater, or where untreated wastewater is discharged).
3. For domestic wastewater, enter the population as the activity data. For industrial wastewater, enter the tonnes of product produced under activity data and units.

III.4 WASTEWATER TREATMENT AND DISCHARGE

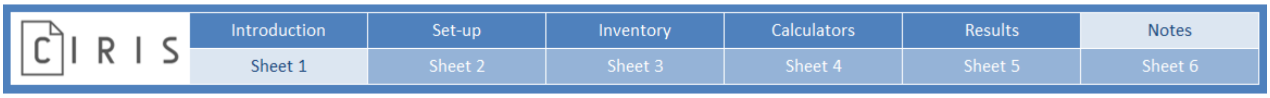
GPC ref No.	Scope	GHG Emissions Source			Notation keys	Activity data	
		Treatment activity	Type of waste	Description		Amount	Unit
III.4.1	**1**	**Emissions from wastewater generated and treated within the city**					
III.4.1	1	Domestic wastewater (4.D.1)	All residential and commercial wastewater from the city, 60% latrine, 40% untreated			3,079,071	Population
III.4.1	1	Industrial wastewater (4.D.2)	Dairy products			62,400	tonnes/product
III.4.1	1	Industrial wastewater (4.D.2)	Sugar refining			120,000	tonnes/product

4. Select N_2O and CH_4 under 'Gas(es)' for domestic and commercial wastewater, CH_4 for industrial wastewater.
5. Leave the 'Emission factor' cells empty. Select ✓ in the 'Emissions data' column.
6. Copy and paste tCH_4 and tN_2O (as tCO_2e) and total tCO_2e, from the Emission summary table into the appropriate 'GHGs (metric tonnes CO_2e)' columns under III.4 Wastewater treatment and discharge in the *Waste* sheet under the Inventory tab.

Emissions data	GHGs (metric tonnes CO_2e)				
	CO_2	CH_4	N_2O	Total tCO_2e	$CO_2(b)$
✓		483,822	57,313		
✓		2,527			
✓		21,120			

7. Complete the activity data quality assessment by selecting L, M or H.
8. Add a description of method(s) used to highlight that the wastewater calculator was used to calculate this source.
9. Select the activity data source from the drop-down list.
10. Provide an explanation for the activity data assessment (optional).

Notes tab



CIRIS also contains six blank sheets to support users with the compilation and reporting of data in CIRIS.

These are optional, but could be used to support the following:

- Undertaking calculations
  - Aggregation or disaggregation of activity data to input into CIRIS sub-sectors
  - Scaling or other adjustment to data
  - Converting data between units or to a common unit
- Undertaking checks on data
  - Checking trends in data over time
  - Graphically showing data or results to check for anomalies
  - Back-calculating results to identify an emission factor or activity data value
  - Comparing results with those generated elsewhere e.g. from other tools or reports
- Documentation
  - Saving raw data obtained from suppliers, or other important information
  - Taking notes on methods, assumptions and approaches used
  - Documenting contact details or deadlines
  - Tracking changes between versions