

BEYOND

SMART CITIES

URBAN GREENHOUSE GAS INVENTORY

SPECIALIST TRAINING COURSE

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GHG AND CLIMATE CHANGE SPECIALIST CURRICULUM

OVERVIEW OF CALCULATING GHG EMISSIONS

FOR GHG & CLIMATE CHANGE PROFESSIONALS

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WHAT SHOULD YOU LEARN

Calculation methodology

Activity data

Sourcing activity data

Emission factors

Conversion of data to standard units and CO2 equivalent

CALCULATION METHODOLOGY

The GPC specifies the principles and rules for compiling a city-wide GHG emissions inventory; it does not require specific methodologies to be used to produce emissions data.

This lecture provides overarching guidance for sourcing activity data and calculating emission factors. It also sets out guidance for calculating GHG emissions consistent with the requirements

Emission calculation methodologies define the calculation formulas and necessary activity data and emission factors to determine total emissions from specified activities.

Cities should select the most appropriate methodologies based on the purpose of their inventory, availability of data, and consistency with their country's national inventory and/or other measurement and reporting programs in which they participate.



IPCC GUIDELINES AND METHODOLOGY TIERS

Unless stated otherwise, calculation methodologies referenced in the GPC are consistent with the IPCC Guidelines. Where different methodologies are used, cities should ensure they meet the requirements of the GPC and document the methodologies they have used in their inventory report.

In IPCC Guidelines, three hierarchical tiers are used to categorize the methodological complexity of emissions factors and activity data. Tier 1 uses default data and simple equations, while Tiers 2 and 3 are each more demanding in terms of complexity and data requirements. Tier 2 methodologies typically use country-specific emission factors.

These tiers, if properly implemented, successively reduce uncertainty and increase accuracy. The GPC does not use tiers to define methodologies but makes references to them when referring to IPCC Guidelines.



CALCULATION OVERVIEW

For some activities, cities will be able to use direct measurements of GHG emissions (e.g., through use of continuous emissions monitoring systems at power stations).

However, for most emission sources, cities will need to estimate GHG emissions by multiplying activity data by an emission factor associated with the activity being measured

Emission factor approach for calculating GHG emissions

GHG emissions = Activity data × Emission factor

Activity data is a quantitative measure of a level of activity that results in GHG emissions taking place during a given period of time. An emission factor is a measure of the mass of GHG emissions relative to a unit of activity.



ACTIVITY DATA

Data collection is an integral part of developing and updating a GHG inventory. This includes gathering existing data, generating new data, and adapting data for inventory use.

SOURCING ACTIVITY DATA

It is good practice to start data collection activities with an initial screening of available data sources. This will be an iterative process to improve the quality of data used and should be driven by two primary considerations:

- ✓ Data should be from reliable and robust sources
- ✓ Data should be time- and geographically-specific to the inventory boundary, and technology-specific to the activity being measured

SCALING METHODOLOGY

- ✓ Establish collection processes that lead to continuous improvement of the data sets used in the inventory (resource prioritization, planning, implementation, documentation, etc.)
- ✓ Prioritize improvements on the collection of data needed to improve estimates of key categories which are the largest, have the greatest potential to change, or have the greatest uncertainty
- ✓ Review data collection activities and methodological needs on a regular basis to guide progressive, and efficient, inventory improvement
- ✓ Work with data suppliers to support consistent and continuing information flows

DATA COLLECTION PRINCIPLES

- ✓ Where the best available activity data do not align with the geographical boundary of the city or the time period of the assessment, the data can be adapted to meet the inventory boundary by adjusting for changes in activity using a scaling factor.

Inventory data =
$$\frac{\text{Data}_{\text{available}}}{\text{Factor}} \times \text{Available Data}$$

Activity (or measured) data available which needs to be scaled to align with the inventory boundary
Inventory data = Activity (or measured) data used for the city
$$\text{Factor} = \frac{\text{Scaling factor data used for the inventory}}{\text{Activity (or measured) data used for the city}}$$

Population is one of the most common factors used to scale data because, in the absence of major technological and behavioral changes, the number of people is a good proxy for GHG emissions, particularly in the residential sector. For example, the following equation may be used for adjusting household waste data if data for the inventory year are not available:
$$\text{City household waste data 2015} = \frac{\text{City Population}_{2015}}{\text{City Population}_{2010}} \times \text{City household waste data 2010}$$

Other scaling factors, such as GDP or industry and services, may be more suitable to scale data for economic activities.

- ✓ The scaling factor represents the ratio between the available data and the required inventory data, and should reflect a high degree of correlation to variations in the data. The general formula for scaling data is found in Equation 13.2.

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EMISSION FACTORS

Emission factors convert activity data into a mass of GHG emissions; tonnes of CO₂ released per kilometer travelled, for example, or the ratio of CH₄ emissions produced to amount of waste landfilled.

Emission factors may be activity-based, or life-cycle based. Activity-based emission factors include emissions at the point of the final activity (e.g. combustion of fuel). Life-cycle emission factors, on the other hand, consider emissions at every stage of a material/ fuel's life (e.g. extraction, processing, transport, combustion).

CONVERSION OF DATA TO STANDARD UNITS AND CO₂ EQUIVALENT

Name	Formula	GHG values in IPCC standard units (tCO ₂ e)	GHG values in tCO ₂ e (this assessment report tCO ₂ e)	GHG values in tCO ₂ e (this assessment report tCO ₂ e)	GHG values in tCO ₂ e (this assessment report tCO ₂ e)
Carbon dioxide	CO ₂	1	1	1	1
Methane	CH ₄	25	25	25	25
Nitrous oxide	N ₂ O	298	298	298	298
Fueller landfill	LC	21,000	21,000	21,000	21,000
Carbon landfill	LC	6,500	5,950	5,950	6,600
Hydrofluorocarbon	CF ₄	8,500	13,500	12,200	13,500
HFC-32	CF ₂	11,700	12,000	12,000	12,000
HFC-12	CF ₂	800	300	675	675
HFC-41	CF ₂	150	97	92	116
HFC-124	CF ₂	2,800	3,400	3,500	3,700
HFC-134	CF ₂	1,000	1,000	1,000	1,000
HFC-135a	CF ₂	1,000	1,000	1,000	1,000
HFC-143	CF ₂	300	330	333	336
HFC-143a	CF ₂	3,000	3,200	3,000	3,000
HFC-152a	CF ₂	100	100	100	100
HFC-227ea	CF ₂	2,000	2,000	2,000	2,000
HFC-245fa	CF ₂	6,500	5,400	5,400	6,000
HFC-245ga	CF ₂	500	640	-	716
Nitrogen trifluoride	NF ₃	-	-	12,000	16,000

✓The International System of Units (SI units) should be used for measurement and reporting of activity data, and all GHG emissions data shall be reported as metric tonnes of each GHG as indicated in Table 15.5, as well as CO₂ equivalents (CO₂e).

✓CO₂e is a universal unit of measurement that accounts for the global warming potential (GWP) when measuring and comparing GHG emissions from different gases.

MANAGING DATA QUALITY AND UNCERTAINTY

All data sources used and assumptions made when estimating GHG emissions, whether through scaling, extrapolation, interpolation, or models, will need to be referenced to ensure full transparency.

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

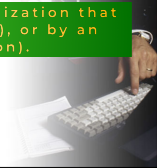
In addition to identifying the method used to calculate emissions, cities shall also evaluate the quality of both the activity data and the emission factors used. Each of these shall be assessed as high, medium or low, based on the degree to which data reflect the geographical location of the activity, the time or age of the activity and any technologies used, the assessment boundary and emission source, and whether data have been obtained from reliable and verifiable sources.

VERIFICATION



Verification involves an assessment of the completeness and accuracy of reported data. Cities may choose to verify their data to demonstrate that their calculations are in accordance with the requirements of the GPC and provide confidence to users that the reported GHG emissions are a fair reflection of a city's activities.

Verification can be performed by the same organization that conducted the GPC assessment (self-verification), or by an independent organization (third-party verification).





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