EcoLogistics
Low carbon freight for sustainable cities

Supported by:
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based on a decision of the German Bundestag

ICLEI Local Governments for Sustainability

ICLEI EcoLogistics Self-Monitoring Tool User Guide

For urban freight transport emissions accounting

Version 2.0

ZLC | MIT GLOBAL SCALE NETWORK

Smart Freight Centre

despacio

This document is a project deliverable from the "*EcoLogistics: Low carbon freight for sustainable cities*" project.

ABOUT THE ECOLOGISTICS PROJECT

Supported by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) through the International Climate Initiative (IKI), ICLEI's EcoLogistics project (2017-2021) aims to increase the capacity of governmental and non-governmental actors to build strategies and policies to promote low carbon and sustainable urban freight in Argentina, Colombia and India, involving nine cities and regions:

- Argentina: Córdoba, Rosario, Santa Fe
- Colombia: Bogota, Manizales, Metropolitan Area of the Aburrá Valley (AMVA)
- India: Kochi, Shimla, Panaji

For more information, please visit: www.ecomobility.org/ecologistics

ABOUT ICLEI

ICLEI – Local Governments for Sustainability is a global network of more than 1,750 local and regional governments committed to sustainable urban development. Active in 100+ countries, we influence sustainability policy and drive local action for low emission, nature-based, equitable, resilient and circular development. Our Members and team of experts work together through peer exchange, partnerships and capacity building to create systemic change for urban sustainability.

ACKNOWLEDGEMENTS

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CREDITS

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DISCLAIMER

The EcoLogistics self-monitoring tool is designed to provide cities insights into its urban freight emissions, impacts and the relative improvements that different options could provide. The calculations are based on estimations and average emission factors.

The information contained in this user guide is based on close consultation with project partners. ICLEI does not, however, guarantee the accuracy of the information in this document and does not accept responsibility for consequences of their use. For further information, please contact ecomobility@iclei.org.

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1. Introduction

1) Background and objectives

The EcoLogistics self-monitoring tool is developed through the "***EcoLogistics: Low carbon freight for sustainable cities***" project that is funded by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) through the International Climate Initiative (IKI).

The tool can be utilized directly by cities to measure the existing greenhouse gas (GHG) emission performance of urban freight using CO_2 equivalent (CO_2e) values. It can also be used to estimate urban freight emissions in the business-as-usual scenario and allows the assessment of a target scenario wherein specific technologies or strategies that would improve fuel efficiency or reduce GHG emissions are hypothetically implemented. The tool allows cities to make meaningful comparisons over time and with other cities in terms of urban freight emissions.

The self-monitoring tool is an open, Excel-based tool. This guide provides guidance on how to use the tool in connection to the databases and the most basic questions of emission calculations.

Box 1 Definition of "City" in this user guide

The term "city" in this user guide refers to geographically discernable subnational entities, such as metropolitan areas, cities, towns, communities and neighborhoods. It is also used to indicate all levels of subnational jurisdiction and local governments as legal entities of public administration.

Source: World Resources Institute, C40 Cities Climate Leadership Group, ICLEI – Local Governments for Sustainability (ICLEI), Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC). (2014).

2) Scope

The scope of the tool is limited to the calculation of emissions from urban freight transport operations. It includes road, rail and inland waterway freight transport. Other logistics activities may contribute additionally to overall freight emissions but are not addressed at this time and may be calculated in the future updates as new information or data becomes available.

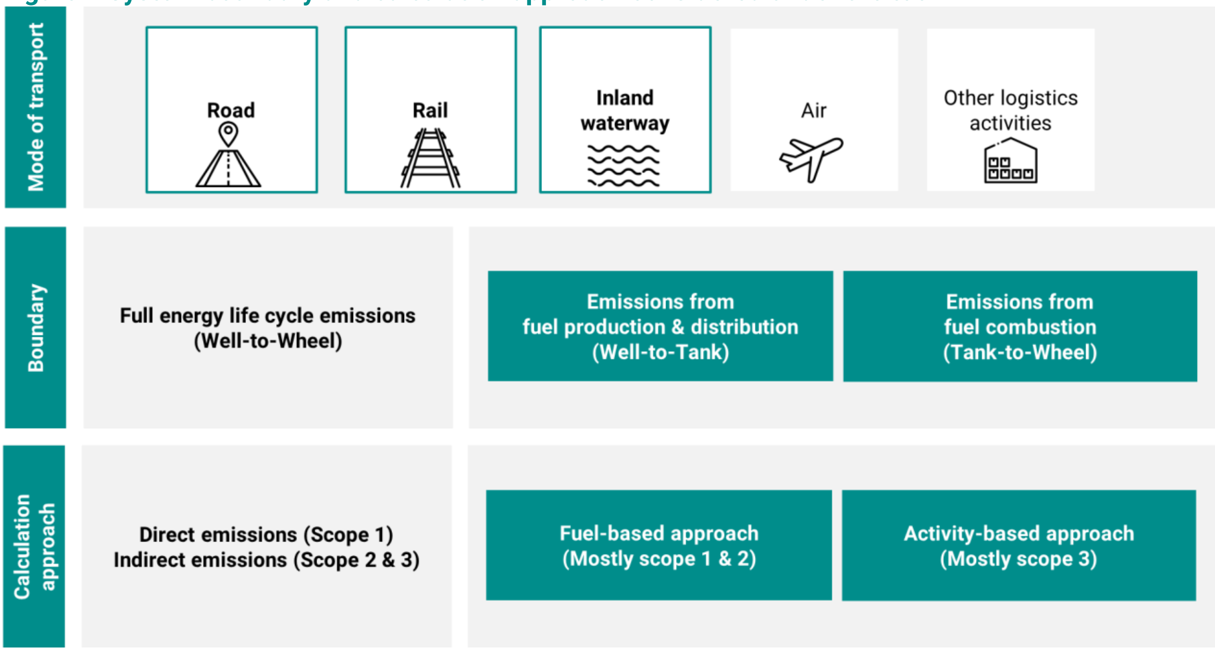
Carbon dioxide (CO_2) is the most common GHG emitted and comprises the majority of emissions for freight and logistics activities, whereas carbon dioxide equivalent (CO_2e) is a unit used to represent the global warming impact of various GHGs. Both are the standard references by which emissions are measured and are used throughout this document.

3) System boundaries

When accounting the GHG emissions of fuel used in freight vehicles, the tool includes emissions from the full life cycle, which are often referred to as well-to-wheel (WTW) emissions. WTW emissions are equivalent to the sum of indirect emissions known as well-to-tank (WTT) and direct emissions as tank-to-wheel (TTW) emissions. Figure 1 below illustrates the system boundaries considered under the self-monitoring tool.

It must be noted that indirect energy consumption and indirect emissions from the manufacture, construction, maintenance and disposal of vehicles or traffic infrastructure are excluded from the calculation.

Figure 1 System boundary and calculation approach considered under the tool



2. Application modes

This section introduces the input modes of the tool calculation front-end and the underlying parameters. Before you start, it is important to know:

- This tool works best using Microsoft Excel 2007 and up. Features might be lost if previous versions or Microsoft Excel for Mac are used.
- In any of the worksheets, users must only change or add values to the yellow and white cells.
- In any of the worksheets, you can go back to the homepage by clicking the home icon at the upper right corner of the sheet.

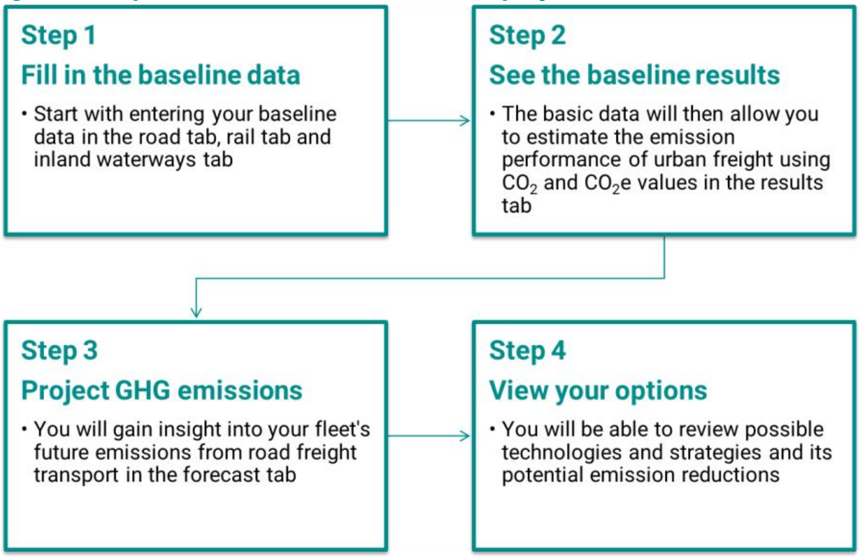
The tool provides a standardized interface and comprises of the following tabs:

1. Home (excel sheet tab is colored green)
2. City profile (tab is colored green)
3. Mode of transport (tabs are colored green)
    - Road freight transport
    - Rail freight transport
    - Inland waterways transport
4. Forecast (tab is colored green, the following tabs are colored grey)
    - Fuel technology change
    - Distance reduction
    - Eco-driving
    - Off-hour deliveries (also known as “out of hours” deliveries)
5. Results (tab is colored green)

Several worksheets are hidden, which contain back-end calculations and lists of default parameters. You can display hidden worksheets as needed by following the steps: On the Home tab, in the Cells group, click Format > Visibility > Hide & Unhide > Unhide Sheet. You'll be presented with a dialog box listing the sheets that are hidden, and you can select the one you want to unhide.

To start your calculation, you can follow the steps below:

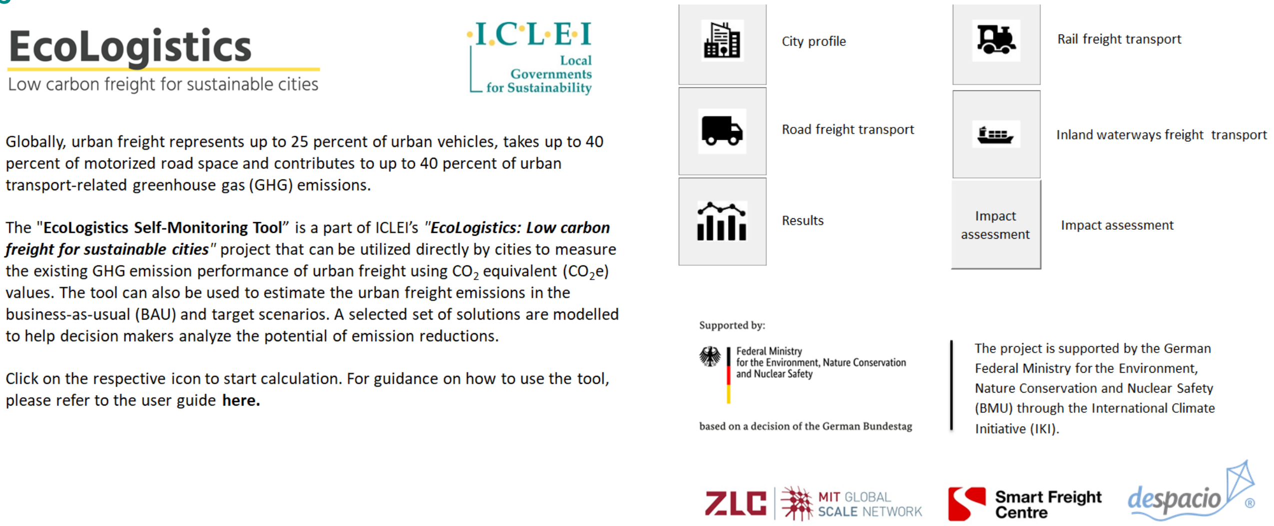
Figure 2 Steps in emission calculation and projection



1) Home tab

The “Home” tab contains the introduction of the EcoLogistics self-monitoring tool and provides an overview of the functionalities. As illustrated in Figure 3 below, each icon on the home tab redirects users to its respective tab: “City profile”, “Road transport”, “Rail transport”, “Inland waterway transport” and “Results”. “Impact assessment” button redirects users to a list of pre-defined solutions that would potentially reduce the environmental impact of urban freight transport.

Figure 3 Interface of “Home” tab

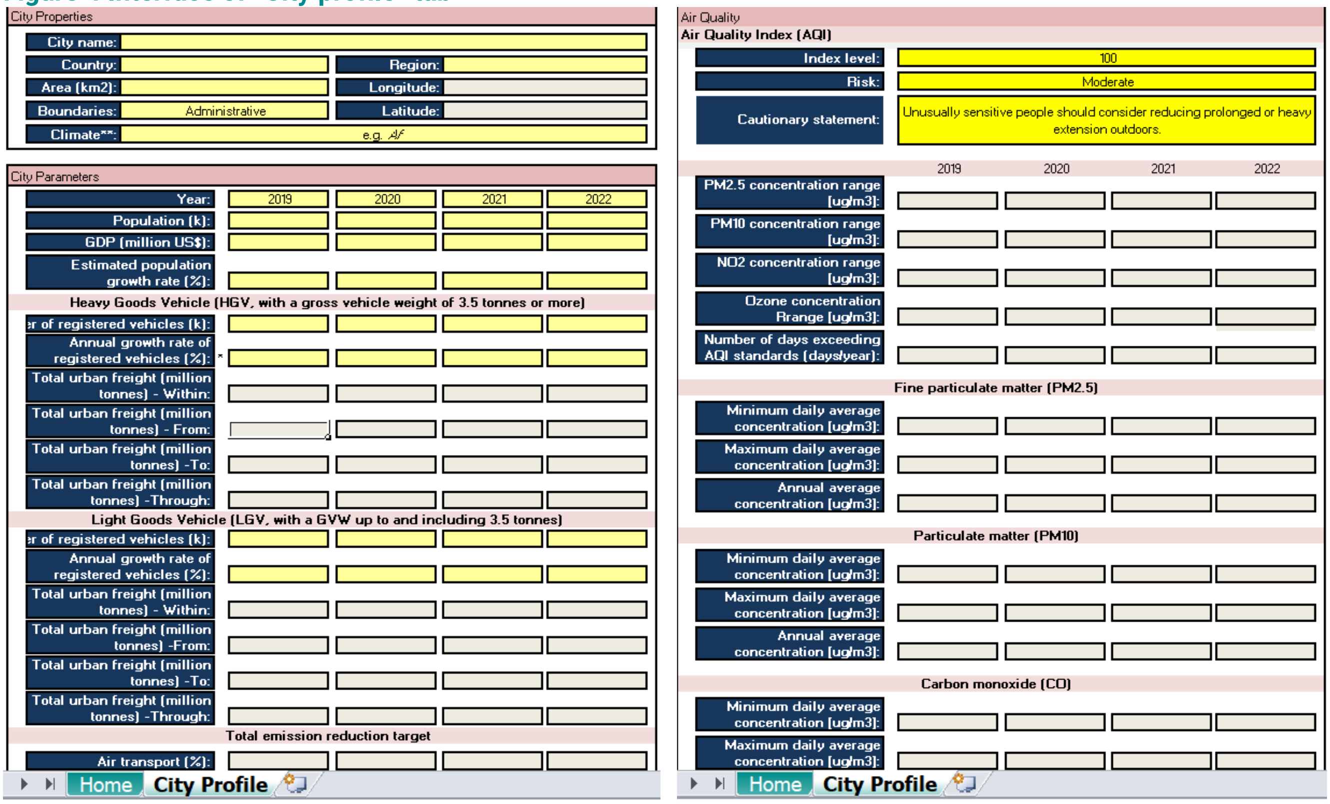


2) City profile tab

The city profile tab is designed to highlight the freight characteristics and transport activities in the urban contexts, along with dimensions of city size, geographic location and demographics. It also outlines the air quality index (AQI) and key pollutants, which is used for monitoring air pollution.

The yellow cells indicate that they are mandatory input cells, while the white cells suggest that they are optional. It should be noted that the data items on this tab are common to all cities and they contribute to the existing body of knowledge on urban freight transport. However, they are not key parameters for emission calculation. Many cities may have trouble finding reliable information about freight transport activities or tons of goods lifted for journeys within, to, through and from the city. As efforts to improve data accuracy continue to expand, users may move forward to other tabs for emission calculation.

Figure 4 Interface of "City profile" tab



City properties

- City: Fill in your city name
- Country: Fill in your country name
- Region: Choose from a dropdown menu of the following regions: Africa; East Asia; Europe; Latin America & Caribbean; North Africa, Middle East and West Asia; North America; Oceania; South Asia; Southeast Asia. It should be noted that uplifted values will be applied to emission intensity factors for local conditions in Asia and Africa. For a detailed explanation please refer to the road section.
- Climate: Fill in the climate type as per *Köppen climate classification*, one of the most widely used climate classification systems, e.g., Rosario, Argentina has a Pampean, humid subtropical climate (*Cfa/Cwa*). In contrast, Bogotá, Colombia has a subtropical highland climate (Köppen *Cfb*).
- Area: Measured in square kilometer (km^2)
- Boundaries: Choose between geographic or administrative boundaries. Any geographic boundary may be used to understand where emissions are coming from and to indicate where it can take action or influence change. In some cases, the boundary can align with the administrative border of a local government, a metropolitan area, or another geographically identifiable entity (*GPC*).

City parameters

In the city parameters section, most of the data items vary over the modeled years.

1) Socio-economic data

- Year: You can fill in the base year and the modelled years in this section, e.g., if the data is collected from 2019, this will be the base year which your city's emissions are tracked and

compared over time, as well as the base year for impact assessment and emission projections.
- Population: Historical and forecast population data in terms of thousand (k)
- Gross Domestic Product (GDP): Historical and forecast GDP defined in terms of million dollars (USD)
- Population growth rate (%): Annual population growth rate

2) ***Transport data – further divided into heavy goods vehicles (HGV, with a gross vehicle weight of 3.5 tons or more) and light goods vehicles (LGV, with a GVW up to and including 3.5 tons)***
   - Number of registered vehicles: Number of vehicles registered within the city in terms of thousand
   - Annual vehicle registration growth rate: Percentage of vehicles/year
   - Total urban freight (within): The number of goods transported within the city
   - Total urban freight (From): The number of goods transported from within the city boundary to outside the city boundary
   - Total urban freight (To): The number of goods transported from outside the city to the city
   - Total urban freight (Through): The number of goods transported in the trips that pass through the city, with both origin and destination outside the city

3) ***Total emission reduction target –*** Target of emission reductions from air, road, rail and inland waterway transport, expressed in percentage (%) of ton/year

Air quality data

On-road diesel vehicles accounted for 60 percent of transportation-attributable fine particulate matter ($PM_{2.5}$) in the EU and were responsible for nearly half of the health impacts of air pollution from vehicles worldwide in 2015[1]. Targeting emissions from on-road diesel vehicles could generate substantial benefits for public health because these vehicles account for such a high proportion of the city's transportation attributable to deaths from air pollution. Thus, this section is included.

Air Quality Index (AQI) is an internationally uniform index for reporting and forecasting daily air quality. It is divided into six categories and it uses a normalized scale from 0 to 500. The color-coded Table 1 below shows how the AQI values correlate with different levels of health concern and cautionary statements, developed by the United States Environmental Protection Agency (EPA). Users may search for city air pollution levels from existing platforms, such as the World Health Organization (WHO)'s Global Platform on Air Quality and Health[2].

Table 1 The Air Quality Index, levels of health concerns and cautionary statements

Index values	Levels of health concern	Cautionary statements
0 - 50	Good	None
51 - 100	Moderate	Unusually sensitive people should consider reducing prolonged or heavy exertion outdoors.
101 - 150	Unhealthy for sensitive groups	Active children and adults, and people with lung disease, such as asthma, should reduce prolonged or heavy exertion outdoors.
151 - 200	Unhealthy	Active children and adults, and people with lung disease, such as asthma, should avoid prolonged or heavy exertion outdoors. Everyone else, especially children, should reduce prolonged or heavy exertion outdoors.

[1] International Council on Clean Transportation. A Global Snapshot of The Air Pollution-Related Health Impacts of Transportation Sector Emissions in 2010 and 2015. (2019). Retrieved from https://theicct.org/publications/health-impacts-transport-emissions-2010-2015

[2] The Global Platform on Air Quality and Health combines ground station monitoring with satellite data for a comprehensive view of air pollution levels in over 4000 cities. Retrieved from https://breathelife2030.org/the-issue/air-quality-in-your-city/

201 - 300	Very unhealthy	Active children and adults, and people with lung disease, such as asthma, should avoid all outdoors exertion. Everyone else, especially children, should reduce prolonged or heavy exertion outdoors.
301 - 500	Hazardous	Everyone should avoid all physical activity outdoors.

The concentration levels of key air pollutants are required in the section. WHO recommends guideline values for each type of pollutant. Details can be found on its website[3].

Table 2 Data inputs in the AQI section

Air pollutants	Description	Unit	WHO guideline values
Fine particulate matter ($PM_{2.5}$)	Particles with a diameter of 2.5 microns or less	Micrograms per cubic meter ($\mu g/m^3$)	10 $\mu g/m^3$ annual mean; 25 $\mu g/m^3$ 24-hour mean
Particulate matter (PM_{10})	Particles with a diameter of 10 microns or less	$\mu g/m^3$	20 $\mu g/m^3$ annual mean; 50 $\mu g/m^3$ 24-hour mean
Nitrogen dioxide (NO_2)	A main source of nitrate aerosols	$\mu g/m^3$	40 $\mu g/m^3$ annual mean; 200 $\mu g/m^3$ 1-hour mean
Ozone (O_3)	Ozone at ground level	$\mu g/m^3$	100 $\mu g/m^3$ 8-hour mean
Carbon monoxide (CO)	A colorless, odorless and flammable gas	$\mu g/m^3$	
Sulphur dioxide (SO_2)	A colorless gas with a sharp odor	$\mu g/m^3$	20 $\mu g/m^3$ 24-hour mean; 500 $\mu g/m^3$ 10-minute mean
Number of days exceeding AQI standards	AQI values at/ below 100 are generally thought of as satisfactory	Days/year	
Minimum/maximum daily average concentration		$\mu g/m^3$	
Annual average concentration		$\mu g/m^3$	

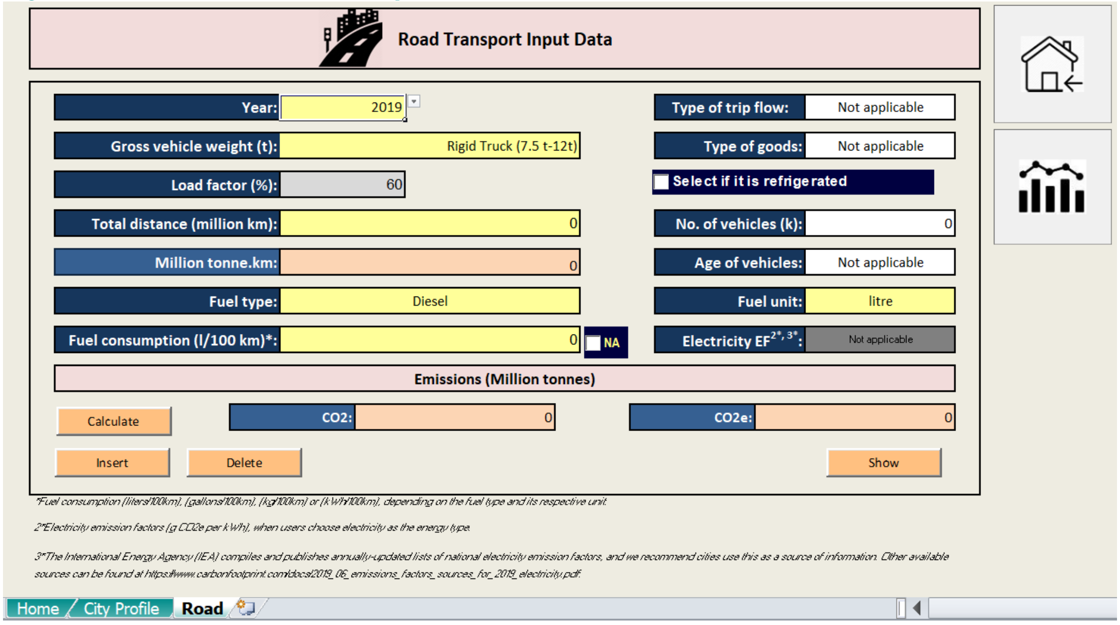
3) Input mode for all transport modes

In the input mode for each mode of transport, users only need to enter data into the yellow cells, which are the key parameters for emission calculation. The white cells in the tabs indicate that they are input cells and may improve the granularity of the data.

Default values are provided in the self-monitoring tool, however, users must note these values are placeholders and are subject to high uncertainties. Please also note that the load factors will be fixed and greyed out when users check the "NA" box. In such case, each of these values is based on a particular set of assumptions. This may lead to results that over- or underestimate emissions compared with actual conditions. Figure 5 below illustrates the interface of the road transport tab, required inputs and corresponding outputs.

[3] World Health Organization Air Quality Guidelines. (2019). Retrieved from https://www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health

Figure 5 Interface of “Road transport” tab



The following functions are common to all transport modes (road, rail and inland waterways). Users can edit the input data. Click on the yellow/white fields and the parameters can either be edited or chosen from dropdown lists.

“Calculate”
Calculate the emissions. Users are highly recommended to click on the calculate button once all the yellow fields are filled out. The tool provides an on-screen report which includes the GHG emissions in terms of CO_2 and CO_2e. However, users must note that results may not be available and will be greyed out where critical parameters for emission calculation are not available. Guidance is provided in the following sections on how to deliver the best output from the information available.

“Insert”
Insert the data. Click on the insert button and the data is stored locally in the excel spreadsheet. Note that if the parameter exists already in the database, a dialogue box is opened and the users can choose to update the field.

“Delete”
Delete the data. The data is removed from the tool.

“Show”
Show the data that is stored in the database. Click on the show button and a dialogue window is opened. Users can select a record and it will be reflected in the corresponding field.

Numerical input and rounding
Decimal notation can be used and it is denoted with a period, e.g., 1.234. Any numerical input is considered to be a rounded value – rounded to 2 digits.

4) Forecast tab

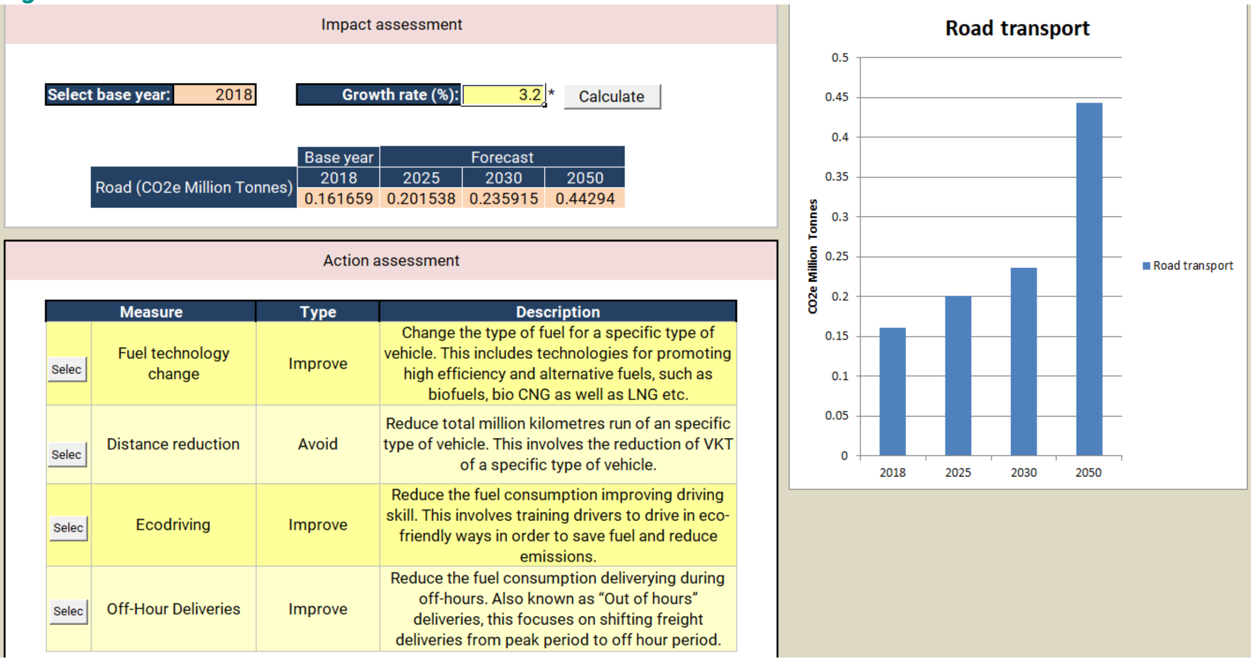
The “Forecast” tab comprises of “impact assessment” section and “action assessment” section. In the input mode, users need to enter the data in the yellow fields. The values will be automatically generated in the orange fields. Figure 6 illustrates the interface of this tab.

A limited set of socio-economic and vehicle technology variables are forecast through to 2050.

- Base year refers to the specific year against which a city’s emissions are tracked over time. It corresponds to the first year filled out in the City profile tab.

- Growth rate: To forecast road transport emissions, the demand for new road freight activity is one of the most uncertain variables in the emission reduction analysis. Details on how to predict can be found in the Forecasting emissions section.

Figure 6 Interface of "Forecast" tab



Impact assessment

Running the "Impact assessment" involves the following steps:

1. Load the input data onto the "Impact assessment" section. The base year emissions from road freight transport are calculated automatically.
2. Using the expected transport growth rate, which is based on additional historical data series, including GDP, population, among others, the future emissions for 2025, 2030 and 2050 are projected.

Action assessment

Each of the measures listed in "Forecast" tab have their spreadsheets in the tool. Figure 7 below depicts the inputs in the "Fuel technology change" assessment. The yellow cells in the scenario sheets are input cells. For most of the scenarios, several basic parameters are required:

- Base year: It corresponds to the first year filled out in the City profile tab
- Forecast year: by default it is 2050
- Vehicle type: Choose the road freight vehicle type in the dropdown list; the vehicle type and its respective fuel type should be entered in the road transport before the assessment
- Temperature condition: Whether it is refrigerated or not
- Road freight transport growth rate: It corresponds to the "Freight growth rate (%)" in the Forecast tab
- Fuel technology used: Choose the fuel type in the dropdown list; the fuel used and its respective vehicle type should be entered in the road transport tab/ database
- Uplifted values: The current default values for road transport used in the tool are for North America, Europe and South America. For road freight vehicles in Asia and Africa, uplifted values are applied to the regional values for Europe and South America.

The following input fields need to be filled out in the scenarios where specific technologies or strategies that would reduce CO_2e emissions are implemented:

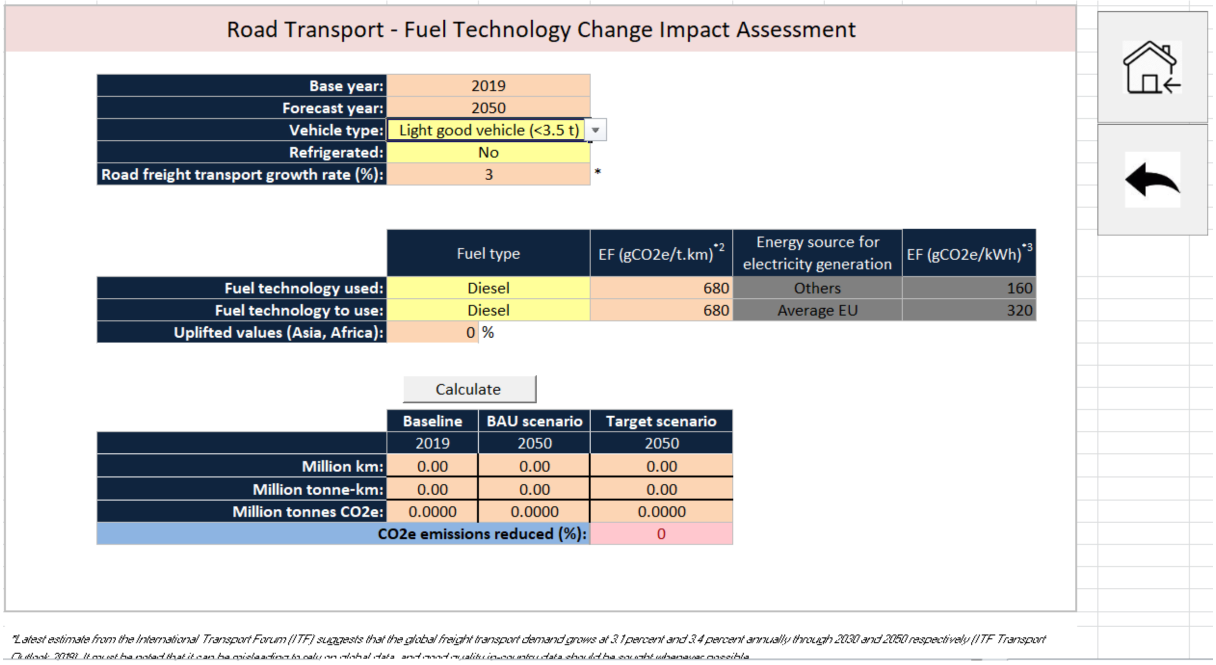
- Fuel technology to use: This parameter is required in the "Fuel technology change" tab.
- Distance reduction rate (%): This parameter is required in the "Distance reduction" tab.

- Eco-driving fuel saving rate (%): This parameter is required in the “Eco-driving” tab.
- Off-hour periods: This parameter is required in the “Off-hour delivery” tab.

Running the “Action assessment” involves the following steps:

1. Load the above mentioned basic parameters onto the tab. The base year emissions from the selected vehicle/fuel type are calculated, based on the vehicle activity data entered previously in the road transport tab/ database.
2. Using the expected freight transport growth rate, the tool forecasts the million km and million t-km for the year 2050. The CO_2 e emissions in the Business-as-usual (BAU) scenario are calculated. BAU scenario describes future emission levels on the assumption that no additional policies or actions to reduce emissions are adopted.
3. Assuming the million km and million t-km remain the same for the target scenario, the tool calculates the resulting CO_2e emissions using the corresponding fuel emission factors. The target scenario represents future emissions with the assumption of the introduction of specific policies and measures targeting GHG emission reductions.
4. The emissions in the target scenarios are then compared to those of the BAU scenario to see the potential emission reductions.

Figure 7 Interface of “Fuel technology change” tab



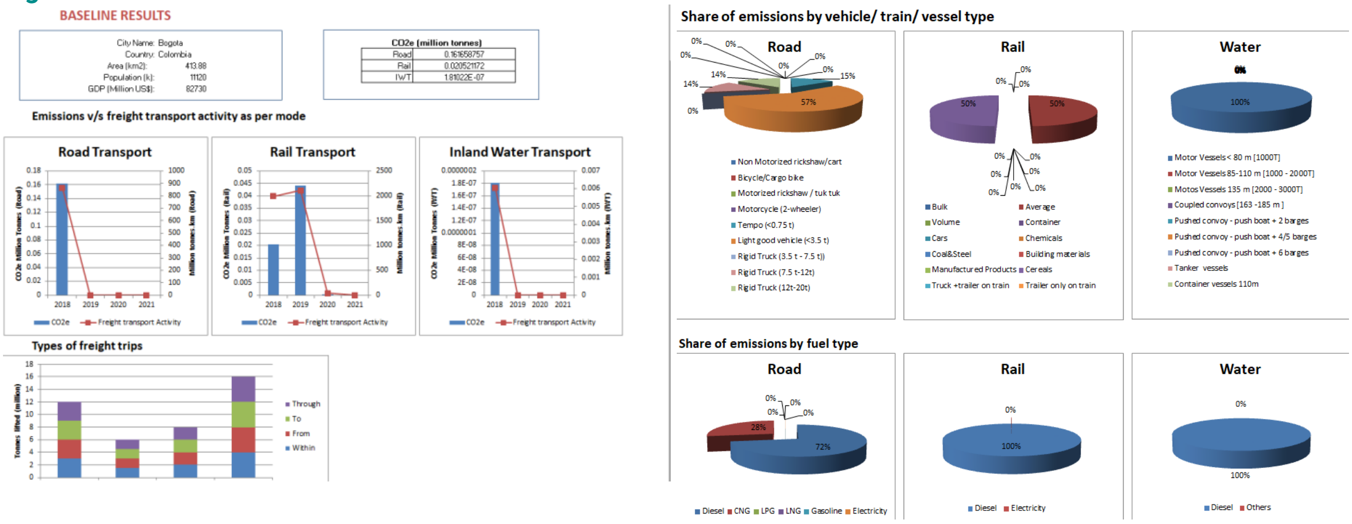
5) Results tab

The "Results" tab contains summary data of the city and its socio-economic data. It also includes a series of illustrative graphs of the following data:

- Estimated emissions from the road, rail and inland waterways transport for the base year, expressed as million tons
- Estimated emissions (million tons) and freight transport activities (million ton-kilometer, t-km) by each mode of transport over the modelled years
- Four types of freight trips, including through, to, from, within. The results are transferred from the City profile tab.
- Share of emissions by vehicle/ train/ vessel type for base year
- Share of emissions by fuel type for each mode of transport

Figure 8 below illustrates the interface of the results tab.

Figure 8 Interface of “Results” tab



3. Basic definitions and calculation methods

This section gives an overview of basic definitions, assumptions and calculation methods for freight transport used in the self-monitoring tool. The focus will be on the standard rules for all transport modes and the primary differences between them. Detailed data and rules for each mode of transport are described in the following sections.

Table 3 Transport modes, vehicles, fuel types

Mode of transport	Vehicles, trains, vessels	Fuel type
Road transport	Different types of road freight vehicles, aggregated into gross vehicle weight (GVW), including electric and fuel-powered freight vehicles	Diesel, gasoline, Liquefied Petroleum Gas (LPG), Compressed Natural Gas (CNG), Liquefied Natural Gas (LNG), Electricity, biomethane and bio LNG
Rail transport	Trains of different wagon and operating characteristics for different commodities	Diesel and electricity
Inland waterways transport	Different types of inland ships, including covered cargo, barge, pushed convoy, container, tankers	Marine diesel oil (MDO)

1) Main factors on emission calculation

The energy consumption and emissions of freight transport depend on a wide array of factors. Each transport mode has unique properties and conditions. Thus it is important to calculate emissions separately for each mode.

The following parameters are of general importance for all modes of transport:

- **Vehicle/ train/ vessel type, size and weight**
- **Payload capacity** refers to the maximum mass of freight allowed. The determination of payload is different for different modes of transport. For road transport, the payload of a vehicle is the difference between maximum vehicle weight and the empty weight of the vehicle; For trains, special wagon types are used to transport various cargo types (cars, containers, chemistry etc.), and the payload capacity of a wagon is the difference between the maximum weight and the empty weight of a wagon.
- **Load factor** is the ratio of the shipment weight to the payload capacity of a vehicle or vessel. The amount of CO_2e estimated in the tool is sensitive to load factors.

- **Empty running** is related to loaded distance allocated to the transport, usually expressed in distance empty/ total distance.
- **Cargo specification** (average, bulk and volume goods): Load factors and empty running factors vary differently for the three categories. Average goods refer to the mixed cargo of different densities (based on statistics). Bulk goods usually include coal, ore, oil, fertilizer, while volume goods include industrial parts, consumer goods, such as furniture, clothes.
- Transport **distance** travelled (kilometers, km)
- **Tonne-kilometer** (abbreviated as t-km, also written as tonne-km, tonne.km or tkm in table and formulae), refers to the transport of one ton of goods over a distance of one kilometer. To evaluate freight transport activities, it is essential to consider both the weight of the shipment and the distance the cargo is transported. As such, t-km is useful to express efficiency for freight transport in a consistent manner. Note that for some commodity types, it would be more appropriate to measure freight movement in terms of volume rather than weight.
- The **emission factor** of the energy source (including solid and liquid fuels and electricity), i.e., the amount of CO_2e emitted per unit of fuel used. It is important to be sure about the fuel type to choose the appropriate fuel emission factor.
- The **energy efficiency** of the vehicles, trains, or vessels is relevant to the characteristics of the vehicles, driving behavior, speed, road conditions, topography, and others.

Table 4 below summarizes the parameters that are critical to calculating emissions from all modes of transport, as well as the mode-specific parameters.

Table 4 Parameter characterization for each mode of transport

Mode of transport	Basic parameters	Additional parameters to improve calculation accuracy
All modes	- Vehicle/vessel type, size and weight - Payload capacity - Capacity utilization (load factor, empty trips) - Cargo type - Total weight of cargo - Distance travelled - t-km - Emission factors	- Driving conditions: number of stops, speed, acceleration etc. - Condition: ambient or temperature-controlled
Road	- Road vehicle type, size and weight - Payload capacity - Cargo type (average, bulk or volume goods)	- Journey type: long haul or multiple collections - Topography - Long-distance vs short haul - Condition: ambient or temperature-controlled - Idling time
Rail	- Train type, size and weight - Payload capacity - Cargo type (primarily cargo density) - Rail network	Topography
Inland waterway	- Vessel type, size and weight - Payload capacity - Cargo type (bulk, containers, pallets, mass-limited cargo and volume-limited cargo) - Waterway network	- Waterway classification - Stream direction (up-stream/ down-stream)

Which default data is used?

The self-monitoring tool provides default data or setting for calculation. The default emission factors are sourced from the *Global Logistics Emissions Council Framework (GLEC Framework version 2.0)*[4], which is based on average freight transport operating practices and provides a general indication of fuel consumption and emissions. The GLEC Framework is aligned with global efforts on carbon accounting for logistics operations, including the Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories, among others. The global warming potential values are drawn from the IPCC 2007 report.

In general, standard values for load factor and empty running are embedded within the default factors. However, users should use values that are representative of the specific freight operations in the city, reflecting the characteristics of their urban freight transport. Table 5 below shows key figures for empty weight, payload capacity and a maximum weight of different vehicle and vessel types.

Table 5 Empty weight and payload capacity of selected vehicles or vessels

Mode of transport	Vehicle/vessel type	Empty weight (ton)	Payload (ton)	Maximum weight (ton)
Road	Non-Motorized rickshaw/Cart	-	0.5	-
	Bicycle/Cargo bike	-	0.5	-
	Motorized rickshaw /Tuk-tuk	-	0.5	-
	Motorcycle (2-wheeler)	-	0.5	-
	Tempo	-	0.75	-
	Light good vehicle (< 3.5 t)	-	1.3	-
	Rigid Truck (3.5 t - 7.5 t)	-	2.3	-
	Rigid Truck (7.5 t - 12 t)	-	5	-
	Rigid Truck (12 t - 20 t)	-	8.4	-
	Rigid Truck (> 20 t)	-	15.3	-
	Truck and Trailer (> 20 t)	-	18.4	-
Rail*	Average/mixed wagon	23	61	84
	Container wagon	21	65	86
	Cars wagon	28	21	59
	Chemicals wagon	24	55	79
	Coal and steel wagon	26	65	91
	Building materials wagon	22	54	76
	Manufactured products wagon	23	54	77
	Cereals wagon	20	63	83
	Truck + trailer on train	-	63	-
	Trailer only on train	-	63	-
Inland waterways**	Motor Vessels < 80 m (1000 t)	-	477	-
	Motor Vessels 85 - 110 m (1000 - 2000 t)	-	1497	-
	Motor Vessels 135 m (2000 - 3000 t)	-	2135	-
	Coupled convoys 163 - 185 m	-	2903	-
	Pushed convoy - push boat + 2 barges	-	3000	-
	Pushed convoy - push boat + 4/5 barges	-	8000	-
	Pushed convoy - push boat + 6 barges	-	10000	-
	Tanker vessels	-	4195	-
	Container vessels 110 m	-	1410	-
	Container vessels 135 m	-	3141	-
	Container vessels - Coupled convoys	-	2502	-

[4] Smart Freight Centre. Global Logistics Emissions Council Framework for Logistics Emissions accounting and Reporting. (2019). Retrieved from https://www.smartfreightcentre.org/en/how-to-implement-items/what-is-glec-framework/58/

Sources: GLEC Framework (version 2.0).
IFEU, INFRAS & IVE. Ecological Transport Information Tool for Worldwide Transports: Methodology and Data Update 2018. (EcoTransIT)[5].
Smart Freight Centre & STC-NESTRA. GHG Emissions Factors for Inland Waterways Transport. (2018).
**For rail transport, the empty weight refers to the empty weight of wagon. They are average values from transport statistics.*
*** For inland waterway transport, the payload is based on weighted averages.*

2) General calculation approaches

The calculation methodology behind the self-monitoring tool is consistent and is mainly based on the *GPC* and *GLEC Framework*. Generally, the methodologies for estimating transport emissions can be categorized as fuel-based and activity-based approaches.

Fuel-based approach

The fuel-based approach uses the fuel consumption data and converts fuel use into GHG emissions with defined emission factors. This method calculates emissions based on the amount of fuel sold within the city boundary. The data on the amount of fuel sold can be obtained from fuel dispensaries or fuel sales tax receipts.

Different types of fuel emit different amounts of carbon. Thus, it is important to calculate item by item for each fuel type separately. The emission factors for biofuel and hydrogen fuel cells are not included in the guidance, as there is a lack of widely-accepted value for the WTT emissions.

This approach uses the following equation:

Equation 1 Fuel-based approach for emission calculation

CO_2 emissions =
∑ (quantity of fuel consumed (liters) × emission factor for the fuel (e.g., kg CO_2e/liter)
+
sum across grid regions:
∑ (quantity of electricity consumed (kWh) × emission factor for electricity grid (e.g., kg CO_2e/kWh))

Description	**Value**
Total CO_2e emissions in tons	Computed
Quantity of fuel consumed in liters, gallons or kilograms	User input
Emission factor for the fuel (e.g., kg CO_2e/liter, or kg CO_2e/gallon, or kg CO_2e/kg)	Default data
Emission factor for electricity grid (e.g., kg CO_2e/kWh)	Default data

Source: GPC

If fuel data is not available, users may calculate the quantities of fuel consumed from fuel spend or from the distance travelled.

[5] IFEU, INFRAS & IVE. Ecological Transport Information Tool for Worldwide Transports: Methodology and Data Update 2018. (2018). Retrieved from https://www.ecotransit.org/download/EcoTransIT_World_Methodology_ShortVersion_2018.pdf

Box 2 Additional information on emission factors

Fuel emission factors are used for converting the amount of fuel used into the GHG emissions, e.g. kg CO_2e emitted per liter of fuel consumed. They are different for different types of fuel and they may vary from country to country for the same type of fuel as different type of blends may be applied. For instance, it is common to blend relatively low percentages (5–10 percent) of biofuels into conventional fuels, which means the generalization of emission factors could lead to greater uncertainties. The GLEC Framework provides representative fuel emission factors (see Annex 1) based on global averages; however actual emission factors may vary depending on the specification of the fuel.

Electricity emission factors are used to convert electricity consumption to emissions based on the sources of energy used to create electricity. They are often expressed as mass of CO_2e released for the kilowatt hours (kWh) of electricity used. While there is a greater focus on electrification as a central element to improve air quality and decarbonize the transport sector, the electricity emission factors in some countries are changing rapidly, also facilitated by the growing investment in renewable energy technologies. The International Energy Agency (IEA) publishes lists of national electricity emission factors on an annual basis, which are available for purchase from its website.

Source: GLEC Framework (Version 2.0)

Activity-based approach

If access to fuel consumption data is limited or incomplete, a calculation using the activity-based approach may be recommended. This approach seeks to quantify emissions within the city, including the trips that begin, end, or within the city. This requires information on vehicle kilometers travelled (VKT) for each vehicle type, vehicle occupancy, information on vehicle fuel efficiency or emission intensity factors, which are applied in multiple steps. The component variables can be disaggregated. The approach uses the equation as follows:

Equation 2 Activity-based approach for emission calculation

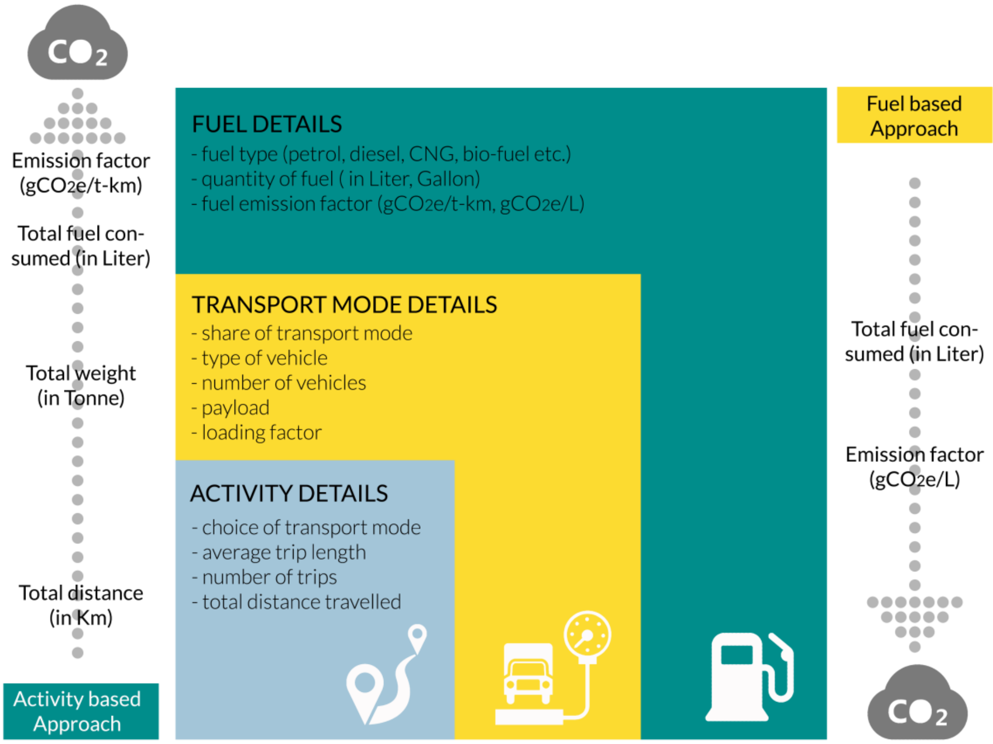
Sum across transport modes and/or vehicle types:
∑ (mass of goods transported (tons)
× distance travelled (kilometers)
× emission factor of transport mode or vehicle type (e.g., kg CO_2e/tonne-kilometer)

Description	Value
Total CO_2e emissions in tons	Computed
Mass of goods transported in tons	Default data provided in Annex 1
Distance travelled in kilometers	User input
Emission intensity factor in kg CO_2e/t-km	Default data
Emission factor for electricity grid = Electricity emission factor(e.g., kg CO_2e/kWh)	Default data

Source: GPC

The main variables required to calculate emissions from freight transport are presented in Figure 9.

Figure 9 The calculation approach for freight transport emission



How to select calculation approaches?

Cities should decide which approach to use based on the availability and quality of data and how the data will be used. For instance, the fuel-based approach can be more accurate to show the emissions from the freight transport sector, while the activity-based approach can give detailed information transport activities and help prioritize actions. See Annex 2 Comparing fuel-based and activity-based approaches for a comparison of both approaches.

Changing the calculation approach over time

Cities may be able to collect more accurate and reliable data over time, using new data collection methods and new technologies. As such, cities may update the input data or switch the calculation approach and should clearly indicate the approach used and the data sources.

4. Methodology and data for each transport mode

This section includes the methodology for the calculation of energy consumption and emissions of freight transport as well as the data sources used for each mode of transport in detail.

1) Road transport

On-road transport contributes significantly to the global transport emissions. Freight transport by road is expected to grow. Currently, the vast majority of road freight vehicles burn liquid or gaseous fuel in internal combustion engines, which produces CO_2, CH_4 and N_2O, often referred to as tailpipe emissions. Increasingly, electrification of short-distance freight vehicles is becoming a viable option.

On-road freight vehicles are designed to transport goods on public roads or highways. This category includes vehicles such as motorcycles, trucks, and waste collection vehicles. Emissions from road transport refer to the fuel or electricity used to operate road freight vehicles, and exclude the emissions related to the production of vehicles or road infrastructure.

Vehicle type characteristics and load factors

To calculate the fuel consumption and road emissions, it is essential to differentiate the types of vehicles and gather information on how heavy the vehicles are loaded. Default values are given for load factors and capacity utilization, which should be replaced by specific operational data for more accurate calculation.

Table 6 illustrates the applicable vehicle sizes, weights and default load factors in the tool.

Table 6 Classification on-road vehicles

Type of road vehicles	Payload (ton) *	Load factor (%)	Empty running (%)
Non-motorized rickshaw/cart	-	-	-
Bicycle/cargo bike	0.5	-	-
Motorized rickshaw/tuk tuk	0.5	-	-
Motorcycle (Two-wheeler)	0.5	-	-
Tempo	0.75	-	-
Light good vehicle (< 3.5 t)	1.3	In the range of 24% and 36%*	
Rigid truck (3.5 t - 7.5 t)	2.3	60%	17%
Rigid truck (7.5 t - 12 t)	5	60%	17%
Rigid truck (12 t - 20 t)	8.4	60%	17%
Rigid truck (> 20 t)	15.3	60%	17%
Truck and trailer (> 20 t)	18.4	60%	17%

** LGVs running on petrol have a combined load factor & empty running of 24 percent; when fueled by other types of energy sources, e.g., diesel, CNG, LPG, a standard value of 36 percent for load factor and empty running is embedded within the default factors.*
Source: GLEC Framework

Parameters for emission calculation

Table 7 below shows the requirements for the estimation of road transport emissions.

Table 7 Parameters for road transport emission calculation

Parameter	Description	Unit
Year of assessment	Select the modelled year, e.g., 2019; Base year corresponds to the first year filled out in City profile tab	
Gross vehicle weight (GVW)	Select the type of vehicle	Ton (t)
Load factor	Load factors make a significant impact on energy use and emissions. Standard values for empty running and load factors are embedded within the default emission intensity factors for different types of vehicles (See Annex 1).	Percentage (%)
Total distance	Actual distance should be inputted if available. In general, only vehicle operators have access to actual distance travelled. Cities can seek carriers and logistics companies for the activity data; when a sampling survey is used, cities can scale up the activity data to the city-scale.	Million km
Ton-kilometer (t-km)	The tool uses the following equation: t-km = Payload capacity (t) x Load factor (%) x Total distance (km)	Million t-km
Fuel type	The calculation depends on the fuel type. Most on-road freight vehicles burn diesel or gasoline, while other potential types include electricity, CNG, LNG, LPG, biomethane, and bio LNG.	
Unit	Fuel use is usually reported using mass (kg) as the unit; In practice, liquid fuels are measured by volume (liters or	

	gallons). In the dropdown-list, users can select the preferred unit to specify fuel consumption. The data can be provided in the following units: Diesel: kg, liters, gallons Gasoline: kg, liters, gallons LPG: kg, liters, gallons CNG: kg LNG: kg Electricity: kilowatt-hours (kWh) Biomethane: kg Bio LNG: kg	
Fuel consumption	Fuel consumption figures, expressed as liters per 100 kilometers (L/100 km), refer to the amount of fuel the vehicle needs to travel a certain distance. In general, the lower the value, the more economic a vehicle is. Fleet-wide fuel consumption rates depend on an array of factors: freight vehicle mix, fuel mix of freight vehicle stock, vehicle age, distance travelled, average speed and congestion level etc. They can typically be derived by dividing total fuel use by total kilometers.	Liter/100km, gallon/100km, kg/100km or kWh/100km, depending on the fuel type, but this is automatically selected.
Electricity EF	When users select electricity as the energy type, additional information about emission intensity of electricity generation (g CO2e/kWh) is required. In the dropdown list, the following values are provided: • In regions where coal-based electricity generation is commonplace: 850 g CO_2e/kWh • Fossil-based: 500 g CO_2e/kWh • Average EU: 320 g CO_2e/kWh • On the way to renewable energy: 200 g CO_2e/kWh • Largely decarbonized: 30 g CO_2e/kWh • Not applicable: A dialogue box is presented, asking users to select the energy source for its electricity generation. • Others*: A default value of 160 g CO2e/kWh is provided, however it must be noted that the value is only a placeholder and users need to enter the value in the “Electricity EF” hidden worksheet. To unhide the worksheet, you can follow the steps: On the Home tab, in the Cells group, click Format > Visibility > Hide & Unhide > Unhide Sheet. You'll be presented with a dialog box listing the sheets that are hidden, so select the “Electricity EF” and enter the value there. *While some countries publish their own electricity emission factors[6], there is no guarantee that they are calculated on the same basis. Therefore the emissions per kWh should be used with caution and the databases should be updated regularly. For users who have little knowledge of their national electricity emission factors, the figures above are a suitable starting point. It should also be noted that the values are only applicable	

[6] Available sources can be found here: https://www.carbonfootprint.com/docs/2019_06_emissions_factors_sources_for_2019_electricity.pdf

	to vans (up to 3.5 t), rigid trucks (3.5 t - 7.5 t GVW) and rigid trucks (7.5 t- 12 t GVW), as well as rail transport where the locomotive uses electricity as its energy source.	
Type of trip flow (optional)	Select between within, through, to, from	
Type of goods (optional)	Select between average, bulk and volume goods	
Refrigerated (optional)	Temperature controlled or not, when users choose "refrigerated", for vans (up to 3.5 t GVW), a 15% uplift will be applied to the values presented in Annex 1 Default emission factors; For heavier vehicles (> 3.5 t GVW) a 12% uplift will be applied.	
Number of vehicles (optional)	Many vehicle registration databases do not deregister vehicles that are scrapped or out of service. This might give higher emission factors to the calculation.	Thousand (k)
Age of vehicles (optional)	Select between 0 – 5, 5 – 10, 10 – 15, Over 15 or Not applicable.	

2) Rail transport

It is estimated that approximately 7 percent of global freight transport activity (in terms of tonnekm) were shipped by rail in 2015, which contributed to 4 percent of the GHG emissions from the transportation sector[7].

Railways are powered by locomotives, which typically use energy through the combustion of diesel or electricity. Previous studies indicate that CO_2 emissions per t-km are significantly lower for electric traction.

Emissions from rail transport include the energy used to move cargo under its power or hauled by another vehicle. Similar to road transport, the most accurate way to calculate emissions from rail transport is to use direct measurements of fuel consumed. Cities should obtain fuel consumption data from the railway operators by fuel types when available.

Train type and load factors

The tool takes into account different train types, defined by the gross ton weight of the train and the cargo types.

Table 8 Train type, payload and load factors

Train Type	Gross ton weight train (ton)	Empty weight wagon (ton)	Payload capacity wagon (ton)	Load factor (%)	Empty running (%)	Max. total weight wagon (ton)
Average/mixed	1000	23	61	60%	33%	84
Container	1000	21	65	50%	17%	86
Cars	700	28	21	85%	33%	59
Chemicals	1200	24	55	100%	50%	79
Coal & steel	1700	26	65	100%	50%	91
Building materials	1200	22	54	100%	50%	76
Manufactured products	1200	23	54	75%	38%	77
Cereals	1300	20	63	100%	38%	83

[7] International Energy Agency & International Union of Railways. Railway Handbook 2017: Energy Consumption and CO_2 Emissions. (2017). Retrieved from https://uic.org/IMG/pdf/handbook_iea-uic_2017_web3.pdf

Truck + trailer on train	-	-	63	85%	33%	-
Trailer only on train	-	-	63	85%	33%	-
Source: GLEC Framework (Version 2.0) and EcoTransIT World Methodology and Data Update 2018.						

Parameters for emission calculation

For the self-monitoring tool, it is desirable to include all the parameters with the most notable impact on the end results, while taking into account the availability of data for these parameters.

The parameters affecting rail transport emission calculation is listed in Table 9 below. The estimate should be based on actual operating data, if not publicly available datasets.

Table 9 Parameters for rail transport emission calculation

Parameter	Description	Unit
Year	Select the year for assessment in the dropdown-list	
Train type	Train types can be divided into general cargo types (average, bulk and volume goods) and dedicated cargo types (container, cars, chemistry etc.).	
Load factor	For rail transport, there is no well-established load factor. Existing tools estimate the load factor based on net and gross ton-kilometers for the above-mentioned cargo types.	Percentage (%)
Total distance	The actual rail network distance should be used in the calculation. In practice, rail distance can be hard to find, but some existing tools can be useful, for instance, EcoTransIT's online tool[8].	km
t-km	Similar to other transport modes, t-km is the key unit for rail transport, representing one ton of cargo moving for one kilometer. Actual or estimated shipment weight based on the mass of cargo should be used to calculate t-km, if available.	Million t-km
Type of traction	Diesel and electricity are the most common fuel types for rail transport. Cities should obtain fuel consumption data from railway operators by fuel type. Where detailed activity data are unavailable, cities can use queries or surveys to calculate the fuel use and amount of goods transported, scale down regional or national fuel consumption based on city population or other indicators.	Liters or gallons for diesel, Kwh for electricity
Fuel consumption	Depending on the fuel type, fuel consumption estimates for rail freight vary widely.	Liters/100km, gallons/100km or kWh/100km
Electricity EF	Similar to the road transport tab, when the locomotive uses electricity as its energy source, additional information about emission intensity of electricity generation is required, Please refer to Table 7 for data input requirements and Box 2 for more information about emission factors.	
Number of wagons (optional)	The tool assumes a default number of wagons (20) when using the activity-based approach.	

3) Inland waterways transport

Freight transport by inland waterways transport comprises a relatively small share of the urban freight sector.

[8] See more https://www.ecotransit.org/calculation.en.html

Water transportation includes ships, ferries and boats operating within the city boundary. The emissions from inland waterways refer to the movement of cargo along stretches of water.

Representative vessel types and load factors

A wide range of vessel sizes and cargo types can be distinguished. The GLEC Framework suggests using the following vessel classes for Europe.

Table 10 Vessel types and payload

Vessel type	Payload (ton)	Combined load factor & Empty running (%)
Motor Vessels < 80 m (1000 t)	477	55%
Motor Vessels 85 - 110 m (1000 - 2000 t)	1497	52%
Motor Vessels 135 m (2000 - 3000 t)	2135	50%
Coupled convoys 163 - 185 m	2903	61%
Pushed convoy - push boat + 2 barges	3000	70%
Pushed convoy - push boat + 4/5 barges	8000	70%
Pushed convoy - push boat + 6 barges	10000	70%
Tanker vessels	4195	65%
Container vessels 110 m	1410	75%
Container vessels 135 m	3141	75%
Container vessels - Coupled convoys	2502	68%
Source: GLEC Framework (Version 2.0) and Smart Freight Centre & STC-NESTRA. GHG Emissions Factors for Inland Waterways Transport. (2018).		

Parameters for emission calculation

The parameters affecting inland waterway transport emission calculations are summarized below.

Table 11 Calculation parameters for inland waterway transport emission

Parameter	Description	Unit
Year	Choose the year for assessment in the dropdown-list	
Vessel type	Select type of vessel. The tool suggests using the above-mentioned vessel classes (incl. typical payload of a representative vessel belonging to that vessel class), however, it is acknowledged that a wide range of vessel types and sizes can be distinguished depending on the country and region, e.g., in the US and South America the preferred vessels used for inland navigation are largely pushed convoys.	
Load factor	Average load factors for the above-mentioned vessel types are used; Generally, it is in the range of 45 - 75 percent, depending on vessel types. If the load factor is known to be different from the representatives incorporated in the default values, cities should work to obtain a fuel efficiency value that reflects the actual conditions.	Percentage (%)
Total distance	Actual waterway network distance should be used, based on the origin and destination of the freight trip. For instance, data from the vessel log book.	km
t-km	A consistent approach to calculating weight, distance and t-km is required to streamline data sharing and improve the accuracy of results. Actual shipment weight should be used, if available. Cities can obtain data using official records of surveys to determine the weight of cargo.	
Fuel type	Marine diesel fuel is the assumed fuel type for inland water transport. Cities can seek this data from shipping companies	

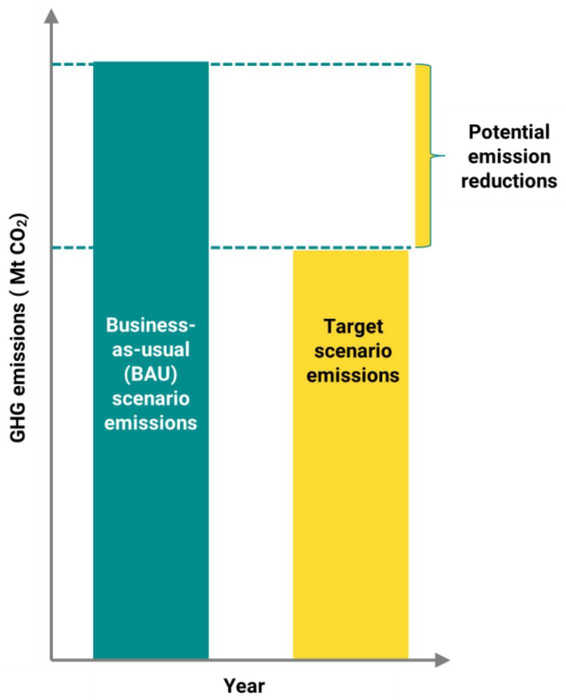
	and fuel suppliers.	
Fuel consumption	Provide information on the fuel consumption in terms of liters/ 100km or gallons/ 100km.	Liters/100km or gallons/100km
Type of trip flow (optional)	Specify the type of freight trip	
Type of goods (optional)	Specify cargo type that is transported by representative vessel: Bulk/ Containers/ Pallets/ Mass-limited/ Volume-limited, when unknown, choose not applicable	
Number of vessels (optional)	Specify the number of vessels per vessel class registered in the city	Thousand (k)
Age of vessels (optional)		

5. Forecasting emissions

In the self-monitoring tool, collected data can be used to determine current emissions. Analysis can also be used to project future emissions under circumstances that may happen without intervention, which is often called business-as-usual (BAU). The measurement of current freight movement data serves as the basis for the BAU calculation, which must then be projected into the future for ex-ante analysis or ex-post analysis.

Besides, the tool estimates target scenarios where specific policies or strategies are hypothetically implemented by the city. The target scenario considers additional measures which allow the freight transport sector to deviate from the BAU emission trajectory.
Figure 10 depicts how emission reductions are calculated for each of the scenarios.

Figure 10 Estimation of potential emission reductions



In broad terms, opportunities to reduce GHG emissions from freight transport can be divided into the following categories:

- **Avoid** (and reduce) the freight volume and haul distance
- **Shift** (and maintain) to more sustainable modes of freight transportation
- **Improve** the logistics operations by use of technologies and better operation

The target scenario considers different measures in isolation as determined based on local development priorities, feasibility, costs and benefits assessment.
Table 12 below depicts a balanced combination of "Avoid-Shift-Improve" strategies that are applicable for urban freight movement.

Table 12 Selected measures for impact assessment

Measure	Type	Brief description
Fuel technology change	Improve	This includes new technologies that promote high efficiency and alternative fuels, such as biofuels, bio CNG, LNG.
Distance reduction	Avoid	This involves the reduction of VKT of a specific type of vehicle.
Eco-driving	Improve	This encourages behavioral change amongst drivers to drive in eco-friendly ways to save fuel and reduce emissions.
Off-hour deliveries (OHD)	Improve	Also known as "Out-of-hours" deliveries, this focuses on shifting freight deliveries from peak period to off-hour period.

It is important to estimate freight transport growth rate for emission reduction forecasting. There are several general approaches for projecting the amount of freight activity:

1. **Use the global freight demand growth rate based on economic projections**: It is well established that demand for freight transport is primarily driven by trade and economic growth.
2. **Use national or regional freight demand models based on commodity flows**: Some national or state level government agencies prepare a commodity-based freight model, as part of a larger travel demand forecasting model.
3. **Expert judgment** based on historic trends

In order to provide indicative estimates to fill data gaps, insights from existing global and regional studies on freight transport are used in the tool to estimate the road freight transport growth rate. Latest estimate from the International Transport Forum (ITF) suggests that the global freight transport demand grows at 3.1 percent and 3.4 percent annually through 2030 and 2050 respectively (ITF Transport Outlook 2019[9]). However, the accuracy of growth projections is uncertain, in light of the current instability of the global economy. It must be noted that it can be misleading to rely on global data, and good quality in-country data should be sought whenever possible.

1) Fuel technology change

Fuel technology change refers to adopting technologies that promote high efficiency and alternative fuels, such as biofuels, CNG, LNG. These actions are intended to cut overall GHG emissions by reducing the use of carbon-intensive fuels. The reduced carbon intensity of the new fuels can be from reduced upstream emissions. The required input data is listed as follows:

Table 13 Parameters for fuel technology change projection

Parameter	Description	Unit
Base year	The base year corresponds to the first year filled out in the City profile tab	
Forecast year	By default the forecast year is 2050	
Vehicle type	Select vehicle type. It should be noted that the vehicle type and its fuel type should be entered in the road transport tab/ database before the impact assessment.	
Refrigerated	Specify whether the vehicle is refrigerated or not	
Road freight	The rate corresponds to the growth rate filled out in the forecast tab. A	Percent

[9] OECD/ITF (Organization for Economic Co-operation and International Transport Forum). ITF Transport Outlook 2019. (2019). Retrieved from https://www.oecd-ilibrary.org/transport/itf-transport-outlook-2019_transp_outlook-en-2019-en

transport growth rate	default value of 3 percent is provided in the tool, using the estimated global freight demand growth rate. However, it must be noted that the value is only a placeholder and may not reflect actual conditions. It is recommended that users apply more locally-suited numbers, if available.	age (%)
Fuel technology used	Current fuel type, which serves as the basis for the base year's emission calculation. Similar to the vehicle type input field above, the fuel type should be entered in the road transport tab/ database before the impact assessment. A default corresponding emission intensity factor is provided based on the vehicle type and fuel type. See Annex 1 for more details. When users select electricity as the energy type, an additional input is required, i.e. electricity emission factors. Please refer to Table 7 for data input requirements and Box 2 for more information about electricity emission factors.	
Fuel technology to use	Forecast change in fuel type. Same as above, a default value of emission intensity factor is automatically selected, if applicable. It should be noted that in the following scenarios, a dialogue window is opened, indicating that the calculation for selected option is not available and the results are unlikely to be accurate: • LGV (< 3.5 t): Switching from diesel to gasoline • Rigid truck (12 - 20 t): Switching from diesel to LNG • Rigid truck (> 20 t): Switching from diesel to LNG • Truck and trailer (> 20 t): Switching from diesel to LNG **See** **Box 3 below for more information.**	
Uplift value to use in Asia and Africa	In line with the GLEC Framework, the tool recommends the emission intensity values for road vehicles (European and South American values) as a starting point. In Asia and Africa an uplifted value of 13% should be applied for light goods vehicles (< 3.5 t) and an uplifted value of 22% should be applied for heavier vehicles (> 3.5 t).	Percent age (%)

To calculate the GHG emissions in the target scenario, the tool assumes the million km and million t-km remain the same as those in the BAU scenario. Broadly speaking, each scenario discussed below is based on a particular set of assumptions and the results are unlikely to be highly accurate. However, it may be considered as a suitable starting point where there is limited access to data or little detailed knowledge.

Box 3 Special considerations for LNG

In the fuel technology change assessment, the GHG emissions seem to increase for heavier trucks (> 12 t) switching from diesel to LNG. It is acknowledged that the emission factors for LNG as a road transport fuel are still evolving and have higher uncertainty than for established fuels such as diesel. Nonetheless, there is a growing consensus that on a full GHG impact basis, fossil LNG is not yielding the benefits claimed by fuel and truck suppliers.

Some studies suggest that the use of trucks running on LNG instead of diesel is not a suitable measure for climate protection in road freight transport. Although LNG trucks have lower tailpipe CO_2 emissions, they emit other types of GHGs elsewhere. In particular, the operation of the vehicles leads to considerable methane emissions. When taking into account non-CO_2 GHG emissions, spark ignition natural gas engine (SI-NG) trucks have approximately the same WTW GHG emissions as diesel trucks (-2 % to +1 %).

Source: Private communication from Alan Lewis; ÖI - Oeko-Institut e.V. (2020): Mottschall, M.; Kasten, P.; ICCT - International Council on Clean Transportation (2020): Rodriguez, F. Decarbonization of on-road freight transport and the role of LNG from a German perspective.

2) Distance reduction

To calculate the impact of distance reduction on GHG emissions, we assume the fuel type used remains the same but million km and million t-km are reduced according to the parameter "Distance reduction (%)". Other parameters are the same as those in Table 13.

3) Eco-driving

Eco-driving is based on a series of techniques that drivers can adapt to reduce fuel consumption and GHG emissions. This includes reducing the use of air conditioning, minimizing engine idling, maintaining steady speed, avoiding sharp acceleration and braking. Additional non-behavioral measures include regular vehicle maintenance.

The input parameters are similar to those in Table 13. For the parameter "Eco-driving fuel saving rate", we assume an average value of 10 percent based on existing studies. However, the extent to which drivers commit to eco-driving behavior is a major uncertainty factor. The results are highly variable in terms of context: vehicle type, road type, traffic flow and so on[10]. Table 14 describes the fuel savings from eco-driving program.

In this tool, fuel savings are assumed to be equivalent to emission savings, which is commonly used by other studies looking at CO_2 effects. While this would be true in percentage terms, the absolute emission reduction from fuel saving would vary according to the fuel being used. Assuming km and t-km remain the same values in the BAU scenario, the resulting emissions are calculated by multiplying the BAU emissions with (1 - Eco-driving fuel saving rate).

Table 14 Fuel savings from eco-driving

Urban networks	Fuel saving rate (%)	Remarks
Mixed roads	Average 10%	Only limited benefits for HGVs as driving dynamics are constrained by the traffic volume and road layout
Junctions, traffic lights, bends	Up to 25%	Eco-driving can save up to 25% of CO_2 for HGVs in very localised situations
Congested situations	0%	Little or no CO_2 benefit

[10] Recent study on freight transport operations in Colombia show that after the eco-driving campaign, an average reduction of 6.8 percent is obtained when fuel consumption is measured in terms of liters per ton-100 km.

and motorways		
Source: "ITS4CV" – ITS for Commercial Vehicles. Study of the scope of Intelligent Transport Systems for reducing CO2 emissions and increasing safety of heavy goods vehicles, buses and coaches. (2016). Retrieved from http://erticonetwork.com/wp-content/uploads/2016/09/ITS4CV-Report-final-2016-09-09.pdf		

4) Off-hour deliveries

Off-hour deliveries (OHD) focus on shifting freight deliveries from peak period to off hour period to improve safety and reduce congestion and emissions

A large body of research on OHD assessed the environmental impacts and the potential emission reductions attributable to the implementation of OHD program. The magnitude of the emission reductions depends on the extent of the change of delivery time. Table 15 below indicates that OHD reduces emission by 13 to 56 percent compared to deliveries during regular hours in similar routes.

Table 15 Emission reductions from off-hour deliveries

Off-hour periods	Description	Emission reduction rate (%)
19.00 – 6.00	Late night and early morning periods (Full OHD)	Average 56% (45% - 67%)
18.00 – 22.00	Partial off-hour (Partial OHD)	Average 13%
6.00 – 19.00	Regular hours	0%
Source: Holguín-Veras, José & Encarnación, Trilce & Gonzalez-Calderon, Carlos & Winebrake, James & Wang, Cara & Kyle, Sofia & Herazo-Padilla, Nilson & Kalahasthi, Lokesh & Adarme, Wilson & Cantillo, Victor & Yoshizaki, Hugo & Garrido, Rodrigo. (2016). Direct impacts of off-hour deliveries on urban freight emissions. Transportation Research Part D: Transport and Environment.		

Annex 1 Default emission factors

1) Fuel emission factors

Fuel emission factors are critical in the calculation of emissions from freight transport. Table 16 below shows CO_2 and CO_2e emissions for the WTT, TTW and WTW phases. Values are presented by volume and mass, where appropriate. The following values are derived from GLEC Framework (version 2.0), which itself draws heavily on other credible sources including the European standard EN16258/JEC[11], IATA RP1678[12]/ICAO, Clean Cargo Working Group (CCWG) and Handbook of Emission Factors (HBEFA) etc.

You can find these values in the hidden worksheet of "fuel emission factors" in the Tool. To unhide the sheet, you can go to the home tab, click Format > Visibility > Hide & Unhide > Unhide Sheet.

Table 16 Fuel emission factors

Fuel type	Unit	kg CO_2/kg fuel WTW CO_2	kg CO_2e/kg fuel WTW CO_2e	kg CO_2/l fuel WTW CO_2	kg CO_2e/l fuel WTW CO_2e
Bio LNG	kg	N/A	1.04	N/A	N/A
Biomethane	kg	N/A	0.49	N/A	N/A
CNG	kg	N/A	3.07	N/A	N/A
Diesel	Liters	3.86	3.90	3.21	3.24
Diesel**	Gallons	N/A	N/A	0.85	0.86
Gasoline	Liters	3.78	3.86	2.82	2.88
Gasoline**	Gallons	N/A	N/A	0.75	0.76
Heavy fuel oil (HFO)*	Liters	3.38	3.41	3.28	3.31
HFO*	Gallons	N/A	N/A	0.87	0.88
LNG	kg	N/A	3.62	N/A	N/A
LPG	Liters	3.43	3.46	1.89	1.90
LPG**	Gallons	N/A	N/A	0.50	0.50
Marine diesel oil (MDO)	Liters	3.89	3.92	3.50	3.53
MDO**	Gallons	N/A	N/A	0.93	0.93

Sources: GLEC Framework (Version 2.0).
** CO_2e has been derived from CO_2 according to a scaling factor; See GLEC Framework (Version 2.0) Module 1 for examples of uplift scaling values from TTW to WTW.*
*** The emission factors have been converted from kg CO2 /l fuel to kg CO2/gallon fuel using the equation: 1 Liter (l) = 1 US Gallon X 3.78.*

2) Road transport emission intensity factors

Emission intensity factors are often expressed as GHG emissions per t-km. The tool uses representative values of emission intensities recommended by GLEC Framework. The main datasets are primarily based on North America and Europe and provide generic information, thus may not be accurate in reflecting the actual conditions in each city.

Table 17 Road transport emission intensity factors (Fuel)

Type of road vehicles (Vehicle size)	Load factor (%)	Empty running (%)	Fuel	WTW emission intensity (g CO_2e/t-	WTW emission intensity (g CO_2e/t-km) (Refrigerated)*	Uplift values in Asia and Africa

[11] European Committee for Standardization. EN 16258: Methodology for calculation and declaration of energy consumption and 16258GHG emissions of transport services (freight and passengers). (2012).
[12] International Air Transport Association. Recommended Practice 1678. (2014).

				km) (Ambient)		(%)**
Light goods vehicle (< 3.5 t)	36%***		Diesel, 5% biodiesel blend (B5)	680	780	13%
	24%***		Petrol	1000	1150	13%
	36%***		CNG	620	710	13%
	36%***		LPG	660	760	13%
Rigid truck (3.5 t - 7.5 t)	60%	17%	Diesel, B5	370	415	22%
			CNG	360	405	22%
Rigid truck (7.5 t - 12 t)	60%	17%	Diesel, B5	240	270	22%
			CNG	220	250	22%
Rigid truck (12 t - 20 t)	60%	17%	Diesel, B5	150	170	22%
			CNG	150	170	22%
			LNG	180	200	22%
Rigid truck (> 20 t)	60%	17%	Diesel, B5	120	145	22%
			CNG	120	145	22%
			LNG	140	170	22%
Truck and trailer (> 20 t)	60%	17%	Diesel, B5	90	100	22%
			CNG	90	100	22%
			LNG	90	100	22%

Source: GLEC Framework (Version 2.0)
**Refrigerated freight vehicles: apply a 15% uplift to the values for vans (up to 3.5 t); Apply a 12% uplift for heavier vehicles (> 3.5 t).*
***In Asia and Africa, apply a13% uplift to the values for vans (up to 3.5 t); Apply a 22% uplift for heavier vehicles (> 3.5 t).*
**** Combined load factor and empty running*

Table 18 Road transport emission intensity factors (Electricity)

Type of road vehicles (Vehicle size)	Load factor (%)	Empty running (%)	WTW emission intensity (kWh/t-km) (Ambient)
Light goods vehicle (< 3.5 t)	Combined load factor & empty running: 31%		1.1
Rigid truck (3.5 t - 7.5 t)	60%	17%	0.5
Rigid truck (7.5 t - 12 t)	60%	17%	0.4

Source: GLEC Framework (Version 2.0) and International Energy Agency (IEA).
**Refrigerated freight vehicles: apply a 15% uplift to the values for vans (up to 3.5 t); Apply a 12% uplift for heavier vehicles (> 3.5 t).*
***In India, apply a13% uplift to the values for vans (up to 3.5 t); Apply a 22% uplift for heavier vehicles (> 3.5 t).*

For cities where only limited data are available, GLEC Framework recommends the following WTW emission intensity values for road vehicles (in Europe and South America) as a starting point. However it must be noted that these values are based on a set of high-level assumptions thus the results are unlikely to be accurate.

- Light Goods Vehicle (<3.5 t): 680 g CO_2e/t-km (WTW)
- Urban truck (3.5 - 7.5 t): 370 g CO_2e/t-km (WTW)
- Medium Goods Vehicle (7.5 - 20 t): 200 g CO_2e/t-km (WTW)
- Heavy Good Vehicle (>20 t): 92 g CO_2e/t-km (WTW)

3) Rail transport emission intensity factors

Table 19 Rail diesel traction emission intensity factors

Train Type	Payload	Load factor (%)	Empty running	Emission intensity

	(ton)		(%)	(g CO2e/t-km) WTW
Average/mixed	61	60%	33%	28
Container	65	50%	17%	25
Cars	21	85%	33%	60
Chemicals	55	100%	50%	24
Coal and steel	65	100%	50%	19
Building materials	54	100%	50%	23
Manufactured products	54	75%	38%	24
Cereals	63	100%	38%	18
Truck + trailer on train	63	85%	33%	130
Trailer only on train	63	85%	33%	90
Source: GLEC Framework (Version 2.0)				

If the train is powered by electricity, users should choose the appropriate electricity emission factors and electricity grid factor.

Table 20 Rail electricity traction emission intensity factors

Train Type	Payload (ton)	Load factor (%)	Empty running (%)	Consumption factor (kWh/t-km) *
Average/mixed	61	60%	33%	0.0322
Container	65	50%	17%	0.0294
Cars	21	85%	33%	0.0693
Chemistry	55	100%	50%	0.0277
Coal and steel	65	100%	50%	0.0215
Building materials	54	100%	50%	0.0268
Manufactured products	54	75%	38%	0.0282
Cereals	63	100%	38%	0.0212
Truck + trailer on train	63	85%	33%	N/A
Trailer only on train	63	85%	33%	N/A
Source: GLEC Framework (Version 2.0) and EcoTransIT World Methodology and Data Update 2018.				

The Indian railways currently transport the following cargo types: coal, iron and steel, cement and food grains. By taking into account India's specific conditions, national electricity grid and power generation sources, the following emission intensity factors are recommended to calculate the emissions for Indian railway freight movement.

Box 4 Rail transport emission intensity factors in India

CO_2 emissions per net-ton-km for diesel locomotive = 0.00951 kg
CO_2 emissions per net-ton-km for electric locomotive = 0.01146 kg
CO_2 emissions per net-ton-km for mixed goods train = 0.01072 kg

Sources: India GHG Program, India Specific Rail Transport Emission Factors for Passenger Travel and Material Transport. (2015).
Eswara AK. Carbon emissions from Indian Railways – An estimation for transportation of goods during 2010-2011. (2012).

4) Inland waterway transport emission intensity factors

The following factors are recommended by the GLEC Framework as the representative values. The datasets are primarily based on European water transport operations and may not reflect the actual conditions in other continents. If applicable, cities should seek to obtain in-country data.

Table 21 Inland waterway transport emission intensity factors

Type of vessels	Payload (ton)	Combined load factor & empty running (%)	Emission intensity (g CO_2e/tkm) WTW
Motor Vessels < 80 m (1000 t)	477	55%	30
Motor Vessels 85 - 110 m (1000 - 2000 t)	1497	52%	19
Motor Vessels 135 m (2000 - 3000 t)	2135	50%	19
Coupled convoys 163 - 185 m	2903	61%	17
Pushed convoy - push boat + 2 barges	3000	70%	17
Pushed convoy - push boat + 4/5 barges	8000	70%	10
Pushed convoy - push boat + 6 barges	10000	70%	7.4
Tanker vessels	4195	65%	21
Container vessels 110 m	1410	75%	26
Container vessels 135 m	3141	75%	20
Container vessels - Coupled convoys	2502	68%	20

Source: Smart Freight Centre & STC-NESTRA. GHG Emissions Factors for Inland Waterways Transport. (2018).

Annex 2 Comparing fuel-based and activity-based approaches

Table 22 Comparing fuel-based and activity-based approaches

Approach	Fuel-based approach	Activity-based approach
Calculation equations	Total CO_2 emissions = ∑ (quantity of fuel consumed (liters or gallons) × emission factor for the fuel (e.g., kg CO_2e/liter)) + sum across grid regions: ∑ (quantity of electricity consumed (kWh) × emission factor for electricity grid (e.g., kg CO_2e/kWh) If fuel data is not available, users may calculate the quantities of fuel consumed using fuel spend or from distance travelled. ***1) Calculate fuel use from fuel spend*** Total fuel use = total fuel spend (e.g., \$)/ average fuel price (e.g., \$/liter) ***2) Calculate fuel use from distance travelled*** Sum across transport steps: Σ (total distance travelled (e.g., km) × fuel efficiency of vehicle (e.g., liters/km)) Allocated fuel use = total fuel consumed (e.g., liters) × $\left[\frac{\text{mass/volume of company's goods}}{\text{Mass/Volume of goods transported}}\right]$ *Source: GPC*	Total CO_2 emissions across transport modes and/or vehicle types = ∑ (mass of goods transported (tons) × distance travelled (kilometers) × emission factor of transport mode or vehicle type (kg CO_2e/ton or volume/kilometer) *Source: GPC*
Key data needed	- Quantities of fuel consumed; - Amount spent on fuel and average cost of fuel; and If applicable: - Actual distances provided by transportation suppliers; - Average fuel efficiency of the vehicle, expressed in units of fuel consumed per kilometer; - Mass of goods transported; - Information on whether the products are refrigerated	- Mass or volume of the goods transported; - Actual distances provided by transportation suppliers; - Average fuel efficiency of the transport activity, expressed as fuel consumed per t-km; - Information on whether the products are refrigerated
Emission factors	- Fuel emission factors, expressed in emissions per unit of energy consumed (e.g., kg CO_2e/liters) - For electric vehicles (if applicable), electricity emission factors, expressed in emissions per unit of electricity consumed (e.g., kg	- Emission intensity factor by mode of transport (e.g., road, rail, inland waterway) or vehicle/vessel types (e.g., articulated lorry, container vessel), expressed in units of greenhouse gases equivalent (CO_2e) per unit of mass (ton) or volume

	CO_2e/kWh)	travelled (e.g., km)
Advantages	- It differentiates emissions and fuel consumption by vehicle type - It gives an accurate representation of the CO_2 emissions from the overall freight vehicle fleet; - Ease-of-use and potentially small data needs that are a closer match to company data - Less time-consuming to conduct	- It differentiates emissions and fuel consumption by vehicle type - It can produce detailed data for urban freight transport and transport planning - Takes input at a more aggregated level that matches typical economic or general transport activity surveys
Disadvantages	- Lack of technological detail - Time-consuming to disaggregate vehicle fleet into specific vehicle type, if not done already	- Can be resources-intensive and time-consuming - It requires different data collection needs than the fuel-based approach
Challenges	Gathering reliable data on fuel use and vehicle activity from companies can be challenging.	Gathering data about transport activity (distance travelled plus vehicle loading) and vehicle characteristics can be challenging.

Annex 3 Important calculation parameters

Parameter	Fuel consumption	
Unit	Mass (kg) or volume (liter or gallon)	
Description	Amount of fuel used by the vehicles in the city based on fuel type and vehicle type	
Data source When estimating fuel use, the following sequence is often used:	**Data source**	**Conditions for using data source**
	A. Data from the logistics companies or carriers, in the form of fuel receipts	Preferred source
	B. Estimates of fuel purchases	If A is not available
	C. Nationally published values	If A is not available; Values should be based on well-documented and reliable sources.
Remarks	For freight road transport, different fuel types are used: including diesel, gasoline, electricity, hydrogen, other diesel oils, CNG, LNG and biodiesel.	

Parameter	Fuel emission factor	
Unit	Kg CO_2e/kg fuel	
Description	Mass of CO_2e released for fuel used	
Data source	**Data source**	**Conditions for using data source**
	A. Direct measurements from real vehicle operations	Preferred source
	B. Modeled data	If A is not available
	C. National emission factor sources	If A is not available; Values should be based on well-documented and reliable sources.
	D. Standard values from international standards, databases and methodologies with a particular focus on the logistics sector, such as the GLEC Framework	If A is not available; It is accepted practice to use representative values which are based on the most credible sources and are developed by specialists.
Remarks	Whenever possible the factors have been chosen with the aim of maximizing overlap with existing transportation standards, published sources and national standards. However, it must be noted that the values cannot be guaranteed, actual emissions may vary widely depending on the efficiency of the fuel production and distribution systems.	

Parameter	Weight	
Unit	Ton	
Description	The amount of goods being transported	
Data source	**Data source**	**Conditions for using data source**
	A. Actual shipment weight data from invoices, bill of lading data from transport companies or other company records	Preferred source
	B. Estimated weight based on the mass of cargo	If A is not available
Remarks		

Parameter	Distance
Data unit	Kilometer (km)
Description	Vehicle kilometers travelled (VKT)

Data source	Four common approaches to calculating distance are as follows:	
	Approach	**Conditions for using data source**
	A. Actual distance	Preferred source, but generally only known by the carriers
	B. Planned distance	If A is not available; It is widely accepted and tends to be the shortest distance by taking into account real operation conditions
	C. Shortest feasible distance (SFD)	If A is not available; Usually do not reflect real operating conditions
	D. Great circle distance (GCD)	Currently focused on the air transport; It is the shortest distance between the start and end point.
	Other sources of data: Roadside traffic surveys; Origin-Destination (O-D) surveys; Historical data from the city	
Remarks	The actual distance travelled should be taken into account; however, in the majority of cases only vehicle operators have information about VKT. Thus planned distance is usually used for road transport calculation. Whenever possible, data from existing O-D surveys or other local studies should be accessed and used to determine the freight vehicle distance travelled.	

Parameter	**Ton-kilometer**
Unit	Ton-kilometer (t-km)
Description	It represents the transport of one ton of goods over a distance of one kilometer.
Data source	Measurements or data from existing surveys
Remarks	It should be noted that ton-kilometers should be calculated separately for different fuel types and transport services. For some modes and commodity types it would be more appropriate to measure freight movement in terms of volume rather than weight. However, the statistics on the volume of freight is often lacking.

Parameter	**Load factor**	
Unit	Percentage (%)	
Description	The degree of utilization of the maximum payload capacity of a vehicle	
Data source	**Data source**	**Conditions for using data source**
	A. Primary data from carriers	Preferred source
	B. Estimated year averages based on national statistics for different types of vehicles	If A is not available
Remarks	The amount of fuel consumed, hence the emissions emitted is very sensitive to load factors, particularly in the case of road transport.	

Parameter	**Empty running**	
Unit	Percentage (%)	
Description	Calculated as a percentage of total vehicle-kilometers that are run empty	
Data source	**Data source**	**Conditions for using data source**
	A. Primary data from carriers	Preferred source
	B. Estimated year averages based on national statistics for different types of vehicles	If A is not available

Remarks	The average load factors and empty running affects the amount of freight traffic required to move the t-kms.

Parameter	Number of registered vehicles
Unit	Number
Description	The number of vehicles registered in the city
Data source	Vehicle registration database in the city
Remarks	Many vehicle registration databases do not deregister vehicles that are scrapped or out of service. This might give higher emission factors to the calculation. When most vehicles are registered in the city, the emissions are often calculated from the active population of vehicles registered multiply by annual VKT per vehicle.

Parameter	Emission intensity factors	
Unit	kg CO_2e/ t-km	
Description	Expressed as the total CO_2e emissions divided per ton-kilometers; used to describe the CO_2e intensity of freight transport	
Data source	**Data source**	**Conditions for using data source**
	A. Direct measurements from real vehicle operations	Preferred source
	B. Modeled data	If A is not available
	C. National emission factor sources	If A is not available; Values should be based on well-documented and reliable sources.
	D. Standard values from international standards, databases and methodologies with a particular focus on the logistics sector, such as the GLEC Framework	If A is not available; It is accepted practice to use representative values which are based on the most credible sources and are developed by specialists.
Remarks	Default factors for various types of vehicles are included in Annex 1. Standard values for empty running and load factors are embedded within the default factors. Other emission intensity metrics include: kg CO_2e per TEU-kilometer, ton, kilometer, TEU, shipment, item, revenue, TEU/ton throughput, container lifts.	

Abbreviation

Abbreviations	Definition
CNG	Compressed natural gas
CO	Carbon monoxide
CO_2	Carbon dioxide
CO_2e	Carbon dioxide-equivalent
GCD	Great Circle Distance
GDP	Gross domestic product
GLEC	Global Logistics Emissions Council
GHG	Greenhouse gas
GVW	Gross vehicle weight
HDV	Heavy-duty vehicles
ITF	International Transport Forum
kg	Kilogram
kWh	Kilowatt-hour
LDV	Light-duty vehicles
LHDT	Light heavy-duty vehicles
LNG	Liquefied natural gas
LPG	Liquefied petroleum gas
MDO	Marine diesel oil
MDV	Medium-duty vehicle
NO_2	Nitrous dioxide
NMT	Non-motorized transport
O_3	Ozone
$PM_{2.5}$	Fine particulate matter
PM_{10}	Particulate matter
SO_2	Sulfur dioxide
TEU	Twenty-foot equivalent unit
TTW	Tank-to-wheels
VKT	Vehicle kilometer traveled
WTT	Well-to-tank
WTW	Well-to-wheel

Glossary

Name	Brief description
Activity-based approach	Methodology that provides measurement of activity, such as vehicle miles traveled or ton-kilometers moved, which is multiplied by an emission factor to estimate total emissions. Well-suited for planning situations and Scope 3 calculations.
Activity data	A quantitative measure of a level of economic activity that results in greenhouse gas (GHG) emissions. Activity data are multiplied by an emission factor to estimate the GHG emissions associated with a process or an operation.
Base year	A specific year of historical data against which emissions are compared over time.
Baseline scenario	Baseline scenarios are projections of GHG emissions and their key drivers as they might evolve in a future in which no explicit actions are taken to reduce GHG emissions.
Business- as-usual (BAU) scenario	A reference case that represents future events or conditions most likely to occur as a result of implemented and adopted policies and actions. Sometimes used as an alternative term to "baseline scenario".
Cargo	A collection or quantity of goods carried on a means of transport from one place to another; cargo can consist of either liquid or solid materials or substances, without any packaging (e.g. bulk cargo), or of loss items of unpacked goods, packages, unitized goods (on pallets or in containers) or goods loaded on transport units and carried on active means of transport.
CO_2 equivalent (CO_2e)	Carbon dioxide equivalent is a unit that describes the impact of different greenhouse gases as a single measure related to the global warming potential of carbon dioxide.
CO_2e intensity factors	A way to express the CO_2e intensity of freight transport; expressed as the total CO_2e emissions divided by the total work done, expressed in ton-kilometers
Emission	The release of GHGs into the atmosphere.
Emission factor	A carbon intensity factor that converts activity data into GHG emissions data, usually given ins gram carbon dioxide equivalents per kilometer (g CO_2e/km).
Empty running	Empty running is calculated as the percentage of total vehicle-kilometers that are run empty.
Ex-ante	Analysis that is done before an intervention is taken.
Ex-post	Analysis that is done after an intervention is taken.
Freight transport demand	A measure of the volume of freight transport, typically expressed by ton-kilometer.
Fuel life cycle	The various stages from the production to the use phase of fossil and alternative fuels.
Fuel-based approach	Methodologies that use actual fuel consumption data to estimate emissions, based on the content of the fuel and assumptions regarding its combustion.
Greenhouse gas (GHG)	Gases that trap heat in the atmosphere, including Carbon dioxide (CO_2), Methane (CH_4), Nitrous oxide (N_2O), and Fluorinated gases.
Load factor	Load factor is the ratio of the shipment weight to the payload capacity of a vehicle or vessel.
Mitigation action	A policy, program, project or measure that is expected to reduce GHG emissions if it is implemented. A mitigation action is an intervention
Parameter	A variable that is part of an equation used to estimate emissions.
Payload	The payload of a truck is the total weight minus the actual weight of the vehicle and is equal to the vehicle load capacity.
Scope 1 emissions	GHG emissions from sources located within the city boundary.

Name	Brief description
Scope 2 emissions	GHG emissions occurring as a consequence of the use of grid-supplied electricity, heat, steam and/or cooling within the city boundary
Scope 3 emissions	All other GHG emissions that occur outside the city boundary as a result of activities taking place within the city boundary.
System boundary	Definition of the limits of coverage of a calculation – in the case of the GLEC Framework limited to an assessment of which phases of the transport supply chain are and are not included in a particular transport system.
Ton	Metric unit of mass equal to 1000 kilograms.
Ton-kilometer (t-km)	A unit of measurement of goods transport which represents the transport of one ton of goods over a distance of one kilometer. Ton-kilometers is also written as ton-km or t-km in tables and formulae.
Vehicle kilometers travelled (VKT)	Distance travelled by a vehicle multiplied by number of vehicles.
Upstream emissions	Emissions linked to energy operational processes such as extraction or cultivation of primary energy, refining, transformation, transport and distribution of energy.

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