

EcoLogistics

Low carbon freight for sustainable cities

Supported by:



Federal Ministry
for the Environment, Nature Conservation
and Nuclear Safety

based on a decision of the German Bundestag



ICLEI EcoLogistics Self-Monitoring Tool User Guide Short Version

For urban freight transport emissions accounting

Version 2.0



This document is a project deliverable from the “EcoLogistics: Low carbon freight for sustainable cities” project. For a detailed version of the guide, please visit: <https://ecomobility.org/wpdm-package/iclei-ecologistics-self-monitoring-tool-user-guide/>

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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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.

Contents

1. Introduction	1
1) Background and objectives	1
2) What is calculated?	1
3) What are the system boundaries for emission calculation?	1
4) Which modes of transport are calculated?	1
5) How are emissions calculated?	2
6) Main factors on emission calculation	3
7) Which default data is used?	4
2. Application modes	4
1) Home tab	5
2) City profile tab	5
3) Input mode for all transport modes	8
4) Forecast tab	9
5) Results tab	11
3. Road transport	12
4. Rail transport	14
5. Inland waterways transport	15
6. Forecasting emissions	16
1) Fuel technology change	16
2) Distance reduction	17
3) Eco-driving	17
4) Off-hour deliveries	18

List of figures and tables

Figures

Figure 1 System boundary and calculation approach considered under the tool	2
Figure 2 Steps in emission calculation and projection	5
Figure 3 Interface of "Home" tab	5
Figure 4 Interface of "City profile" tab	6
Figure 5 Interface of "Road transport" tab	9
Figure 6 Interface of "Forecast" tab	10
Figure 7 Interface of "Fuel technology change" tab	11
Figure 8 Interface of "Results" tab	12
Figure 9 Estimation of potential emission reductions	16

Tables

Table 1 The Air Quality Index, levels of health concerns and cautionary statements	7
Table 2 Data inputs in the AQI section	8
Table 3 Parameters for road transport emission calculation	12
Table 4 Parameters for rail transport emission calculation	14
Table 5 Calculation parameters for inland waterway transport emission	15
Table 6 Parameters for fuel technology change projection	16
Table 7 Fuel savings from eco-driving	18
Table 8 Emission reductions from off-hour deliveries	18

Equations

Equation 1 Fuel-based approach for emission calculation	2
Equation 2 Activity-based approach for emission calculation	3

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 CO₂ equivalent (CO₂e) 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.

2) What is calculated?

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 (CO₂) is the most common GHG emitted and comprises the majority of emissions for freight and logistics activities, whereas carbon dioxide equivalent (CO₂e) 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) What are the system boundaries for emission calculation?

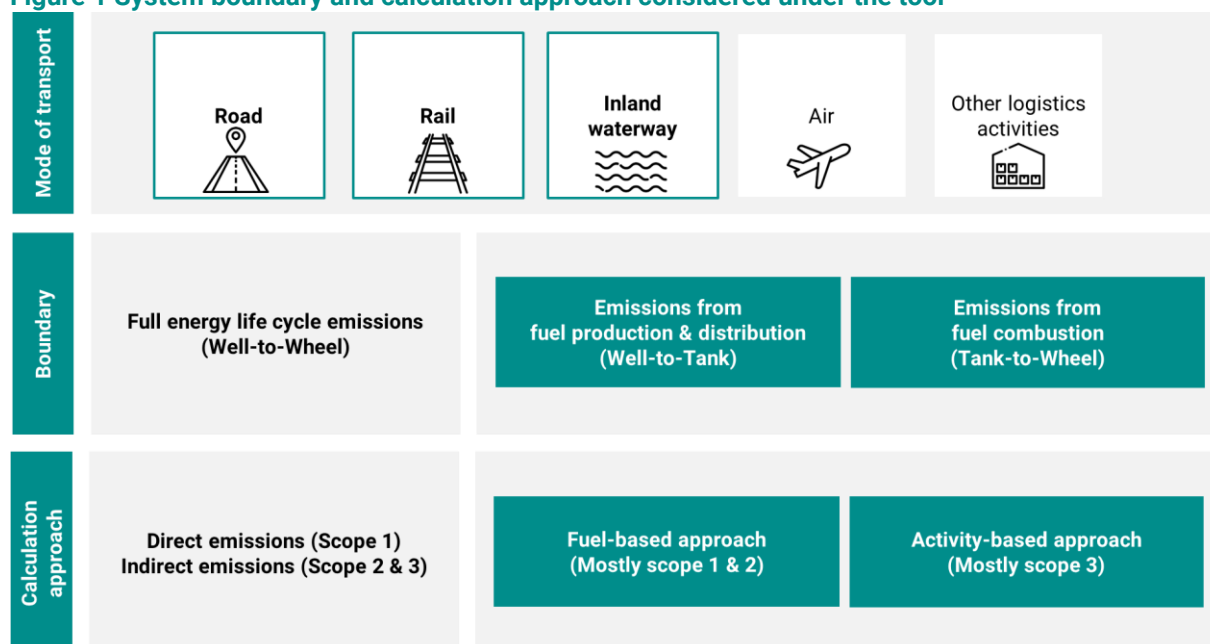
When accounting the GHG emissions of fuel used in freight vehicles, the tool includes emissions from the full life cycle, which are often referred to as well-to-wheel (WTW) emissions. WTW emissions are equivalent to the sum of indirect emissions known as well-to-tank (WTT) and direct emissions as tank-to-wheel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

4) Which modes of transport are calculated?

The following modes of transport calculated:

- Road freight transport - Different types of road vehicles, aggregated into sizes, including electric and fuel-powered freight vehicles
- Rail freight transport - Trains of different weights, including urban railway systems
- Inland waterways freight transport - Different types of inland ships, including ferries, domestic inter-city vessels

Figure 1 System boundary and calculation approach considered under the tool



5) How are emissions calculated?

The calculation methodology behind the self-monitoring tool is consistent and is mainly based on the *Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC)*¹ and *Global Logistics Emissions Council Framework (GLEC Framework version 2.0)*². 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. This approach uses the following equation:

Equation 1 Fuel-based approach for emission calculation

$$\text{CO}_2 \text{ emissions} = \sum (\text{quantity of fuel consumed (liters)} \times \text{emission factor for the fuel (e.g., kg CO}_2\text{e/liter)}) + \text{sum across grid regions: } \sum (\text{quantity of electricity consumed (kWh)} \times \text{emission factor for electricity grid (e.g., kg CO}_2\text{e/kWh)})$$

Description	Value
Total CO ₂ e emissions in tons	Computed
Quantity of fuel consumed in liters, gallons or kilograms	User input
Emission factor for the fuel (e.g., kg CO ₂ e/liter, or kg CO ₂ e/gallon)	Default data
Emission factor for electricity grid (e.g., kg CO ₂ e/kWh)	Default data

Source: GPC

¹ 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 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/>

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

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:

Σ (mass of goods transported (tons)

× distance travelled (kilometers)

× emission factor of transport mode or vehicle type (e.g., kg CO₂e/tonne-kilometer)

Description	Value
Total CO ₂ e emissions in tons	Computed
Mass of goods transported in tons	Default data provided in Error! Reference source not found.
Distance travelled in kilometers	User input
Emission intensity factor in kg CO ₂ e/t-km	Default data
Electricity emission factor(e.g., kg CO ₂ e/kWh)	Default data

6) 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**
- **Load factor** is the ratio of the shipment weight to the payload capacity of a vehicle or vessel. The amount of CO₂e estimated in the tool is sensitive to load factors.
- 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.
- **Fuel consumption**, 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.
- The **emission factor** of the energy source (including solid and liquid fuels and electricity), i.e., the amount of CO₂e emitted per unit of fuel used. It is important to be sure about the fuel type to choose the appropriate fuel emission factor.

7) Which default data is used?

The self-monitoring tool provides default data or setting for calculation. The default emission factors are sourced from the *GLEC Framework*, 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.

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.

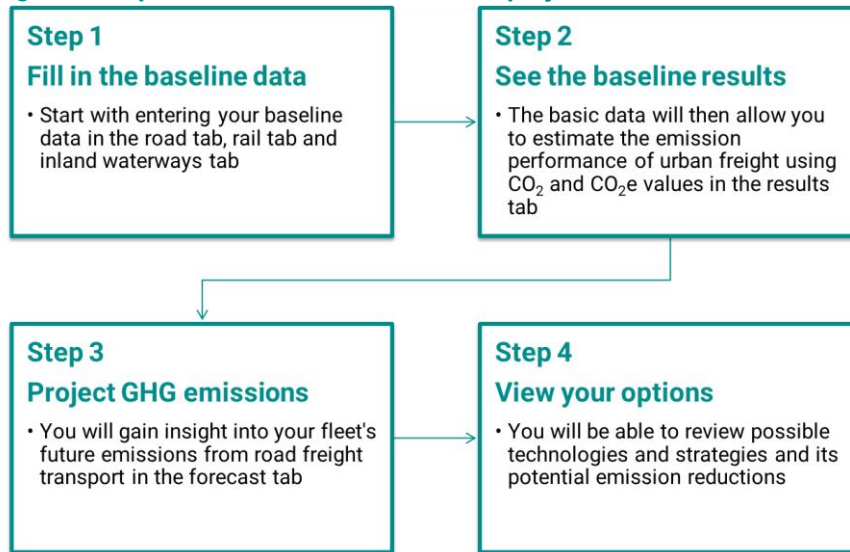
The tool provides a standardized interface and comprises of the following tabs:

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

EcoLogistics
Low carbon freight for sustainable cities

Globally, urban freight represents up to 25 percent of urban vehicles, takes up to 40 percent of motorized road space and contributes to up to 40 percent of urban transport-related greenhouse gas (GHG) emissions.

The "EcoLogistics Self-Monitoring Tool" is a part of ICLEI's "EcoLogistics: Low carbon freight for sustainable cities" project that can be utilized directly by cities to measure the existing GHG emission performance of urban freight using CO₂ equivalent (CO₂e) values. The tool can also be used to estimate the urban freight emissions in the business-as-usual (BAU) and target scenarios. A selected set of solutions are modelled to help decision makers analyze the potential of emission reductions.

Click on the respective icon to start calculation. For guidance on how to use the tool, please refer to the user guide [here](#).

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Navigation icons:
 - City profile (Building icon)
 - Road freight transport (Truck icon)
 - Rail freight transport (Train icon)
 - Inland waterways freight transport (Ship icon)
 - Results (Bar chart icon)
 - Impact assessment (Document icon)

Logos: ZLC, MIT GLOBAL SCALE NETWORK, Smart Freight Centre, despacio

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

The screenshot displays the 'City profile' tab interface, divided into two main sections: 'City Properties' and 'Air Quality'.

City Properties: This section contains input fields for:

- City name
- Country
- Area (km²)
- Boundaries (Administrative)
- Climate (e.g., Af)
- Region
- Longitude
- Latitude

City Parameters: This section is organized into tables for different vehicle types and freight metrics across the years 2019, 2020, 2021, and 2022.

- General Parameters:** Year, Population (k), GDP (million US\$), and Estimated population growth rate (%).
- Heavy Goods Vehicle (HGV, with a gross vehicle weight of 3.5 tonnes or more):** Number of registered vehicles (k), Annual growth rate of registered vehicles (%), and Total urban freight (million tonnes) - Within, -From, -To, -Through.
- Light Goods Vehicle (LGV, with a GVW up to and including 3.5 tonnes):** Number of registered vehicles (k), Annual growth rate of registered vehicles (%), and Total urban freight (million tonnes) - Within, -From, -To, -Through.
- Other Parameters:** Total emission reduction target and Air transport (%).

Air Quality: This section displays the Air Quality Index (AQI) and various pollutant concentrations.

- AQI Summary:** Index level (100), Risk (Moderate), and a cautionary statement: 'Unusually sensitive people should consider reducing prolonged or heavy extension outdoors.'
- Concentration Tables:** Tables for PM2.5, PM10, NO2, Ozone, and Carbon monoxide (CO) showing minimum and maximum daily average concentrations (ug/m³) and annual average concentrations for the years 2019, 2020, 2021, and 2022.

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 (km²)
- 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 2015³. 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 Health⁴.

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.

³ 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>

⁴ 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 website⁵.

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 (µg/m ³)	10 µg/m ³ annual mean; 25 µg/m ³ 24-hour mean
Particulate matter (PM ₁₀)	Particles with a diameter of 10 microns or less	µg/m ³	20 µg/m ³ annual mean; 50 µg/m ³ 24-hour mean
Nitrogen dioxide (NO ₂)	A main source of nitrate aerosols	µg/m ³	40 µg/m ³ annual mean; 200 µg/m ³ 1-hour mean
Ozone (O ₃)	Ozone at ground level	µg/m ³	100 µg/m ³ 8-hour mean
Carbon monoxide (CO)	A colorless, odorless and flammable gas	µg/m ³	
Sulphur dioxide (SO ₂)	A colorless gas with a sharp odor	µg/m ³	20 µg/m ³ 24-hour mean; 500 µg/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		µg/m ³	
Annual average concentration		µg/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.

⁵ World Health Organization Air Quality Guidelines. (2019). Retrieved from [https://www.who.int/news-room/fact-sheets/detail/ambient-\(outdoor\)-air-quality-and-health](https://www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health)

Figure 5 Interface of “Road transport” tab

Road Transport Input Data

Year: 2019

Gross vehicle weight (t): Rigid Truck (7.5 t-12t)

Load factor (%): 60

Total distance (million km): 0

Million tonne.km: 0

Fuel type: Diesel

Fuel consumption (l/100 km)*: 0

Type of trip flow: Not applicable

Type of goods: Not applicable

Select if it is refrigerated:

No. of vehicles (k): 0

Age of vehicles: Not applicable

Fuel unit: litre

Electricity EF** 2*, 3*': Not applicable

Emissions (Million tonnes)

Calculate CO2: 0 CO2e: 0

Insert Delete Show

*Fuel consumption (liters/100km), (gallons/100km), (kg/100km) or (kWh/100km), depending on the fuel type and its respective unit

**Electricity emission factors (g CO2e per kWh), when users choose electricity as the energy type

***The International Energy Agency (IEA) compiles and publishes annually-updated lists of national electricity emission factors, and we recommend cities use this as a source of information. Other available sources can be found at https://www.carbonfootprint.com/docs/2019_06_emissions_factors_sources_for_2019_electricity.pdf.

Home / City Profile / Road

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 CO₂ and CO₂e. 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

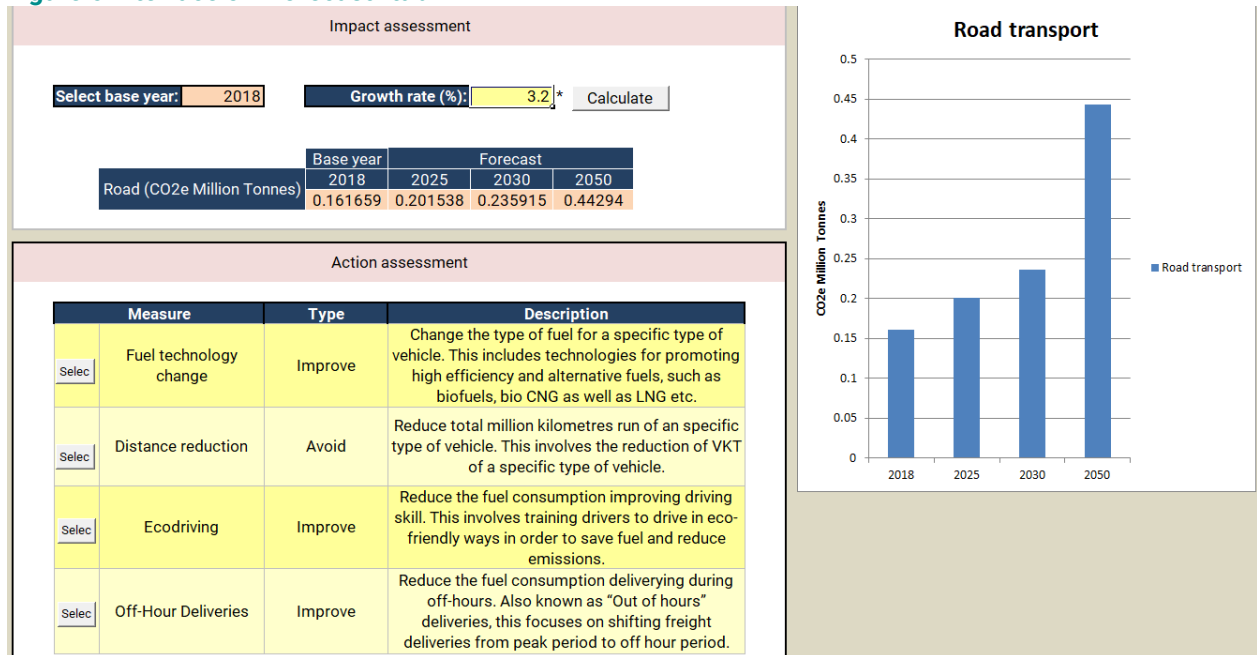
The “Forecast” tab comprises of “impact assessment” section and “action assessment” section. In the input mode, users need to enter the data in the yellow fields. The values will be automatically generated in the orange fields. Figure 6 illustrates the interface of this tab.

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 CO₂e 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 CO₂e 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 CO₂e 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

Road Transport - Fuel Technology Change Impact Assessment				
Base year:	2019			
Forecast year:	2050			
Vehicle type:	Light good vehicle (<3.5 t)			
Refrigerated:	No			
Road freight transport growth rate (%):	3	*		
	Fuel type	EF (gCO ₂ e/t.km) ^{*2}	Energy source for electricity generation	EF (gCO ₂ e/kWh) ^{*3}
Fuel technology used:	Diesel	680	Others	160
Fuel technology to use:	Diesel	680	Average EU	320
Uplifted values (Asia, Africa):	0 %			
Calculate				
	Baseline	BAU scenario	Target scenario	
	2019	2050	2050	
Million km:	0.00	0.00	0.00	
Million tonne-km:	0.00	0.00	0.00	
Million tonnes CO ₂ e:	0.0000	0.0000	0.0000	
CO ₂ e emissions reduced (%):			0	

*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 2018). It must be noted that it can be misleading to rely on global data, and good quality country data should be sought whenever possible.

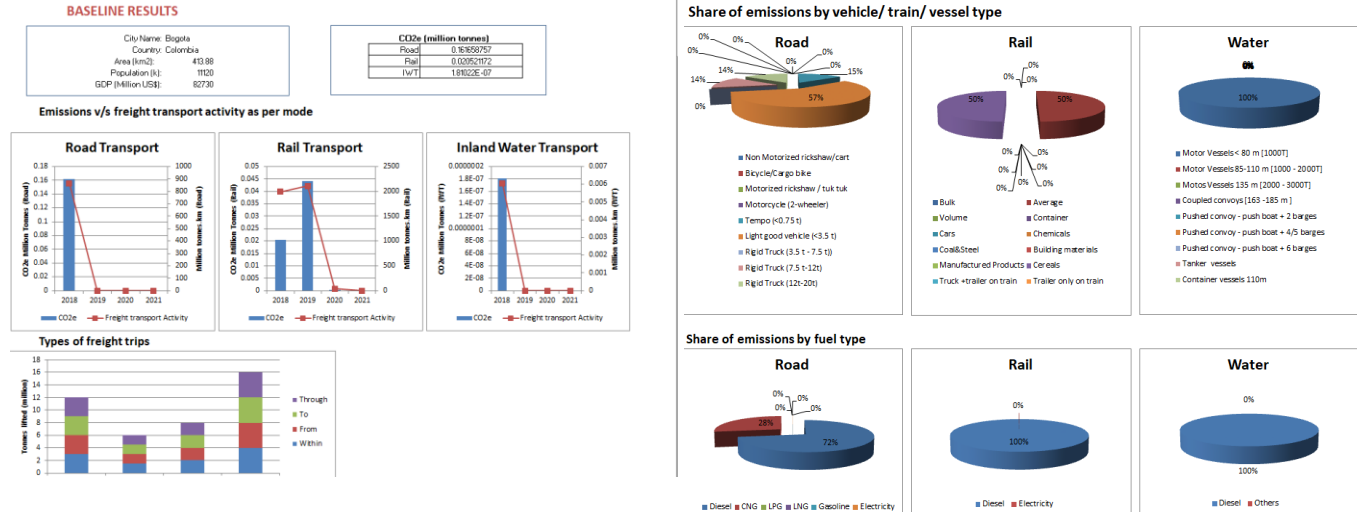
5) Results tab

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. 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 CO₂, CH₄ and N₂O, 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. Table 3 below shows the requirements for the estimation of road transport emissions.

Table 3 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.	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	

	<p>preferred unit to specify fuel consumption. The data can be provided in the following units:</p> <p>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</p>	
Fuel consumption	<p>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.</p>	<p>Liter/100km, gallon/100km, kg/100km or kWh/100km, depending on the fuel type, but this is automatically selected.</p>
Electricity EF	<p>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:</p> <ul style="list-style-type: none"> • In regions where coal-based electricity generation is commonplace: 850 g CO₂e/kWh • Fossil-based: 500 g CO₂e/kWh • Average EU: 320 g CO₂e/kWh • On the way to renewable energy: 200 g CO₂e/kWh • Largely decarbonized: 30 g CO₂e/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. <p>*While some countries publish their own electricity emission factors⁶, 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.</p> <p>It should also be noted that the values are only applicable to vans (up to 3.5 t), rigid trucks (3.5 t - 7.5 t GVW) and</p>	

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

	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 Error! Reference source not found. ; 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.	

4. 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 sector⁷. Railways are powered by locomotives, which typically use energy through the combustion of diesel or electricity. Previous studies indicate that CO₂ emissions per t-km are significantly lower for electric traction.

The parameters affecting rail transport emission calculation is listed in Table 4 below. The estimate should be based on actual operating data, if not publicly available datasets.

Table 4 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	Liters or gallons for diesel, Kwh for electricity

⁷ International Energy Agency & International Union of Railways. Railway Handbook 2017: Energy Consumption and CO₂ Emissions. (2017). Retrieved from https://uic.org/IMG/pdf/handbook_iea-uic_2017_web3.pdf

⁸ See more <https://www.ecotransit.org/calculation.en.html>

	indicators.	
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 3 for data input requirements.	
Number of wagons (optional)	The tool assumes a default number of wagons (20) when using the activity-based approach.	

5. Inland waterways transport

Freight transport by inland waterways transport comprises a relatively small share of the urban freight sector. 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. The parameters affecting inland waterway transport emission calculations are summarized below.

Table 5 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	Specify the number of vessels per vessel class registered in	Thousand (k)

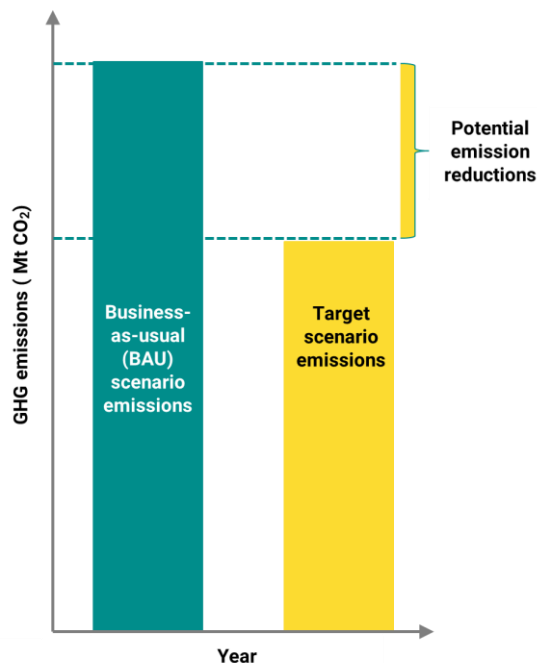
vessels (optional)	the city	
Age of vessels (optional)		

6. 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 9 depicts how emission reductions are calculated for each of the scenarios.

Figure 9 Estimation of potential emission reductions



The target scenario considers different measures in isolation as determined based on local development priorities, feasibility, costs and benefits assessment,

including: “Fuel technology change”, “Distance reduction”, “Eco-driving” and “Off-hour deliveries”.

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 6 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 transport growth rate	The rate corresponds to the growth rate filled out in the forecast tab. A 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.	Percent age (%)
Fuel technology used	<p>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.</p> <p>A default corresponding emission intensity factor is provided based on the vehicle type and fuel type. See Error! Reference source not found. or more details. When users select electricity as the energy type, an additional input is required, i.e. electricity emission factors.</p> <p>Please refer to Table 3 for data input requirements and Error! Reference source not found. for more information about electricity emission factors.</p>	
Fuel technology to use	<p>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:</p> <ul style="list-style-type: none"> • 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 	
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.

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 6.

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 7. 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 on⁹. Table 7 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 CO₂ 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 7 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 and motorways	0%	Little or no CO ₂ benefit

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 8 below indicates that OHD reduces emission by 13 to 56 percent compared to deliveries during regular hours in similar routes.

Table 8 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.

⁹ 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.