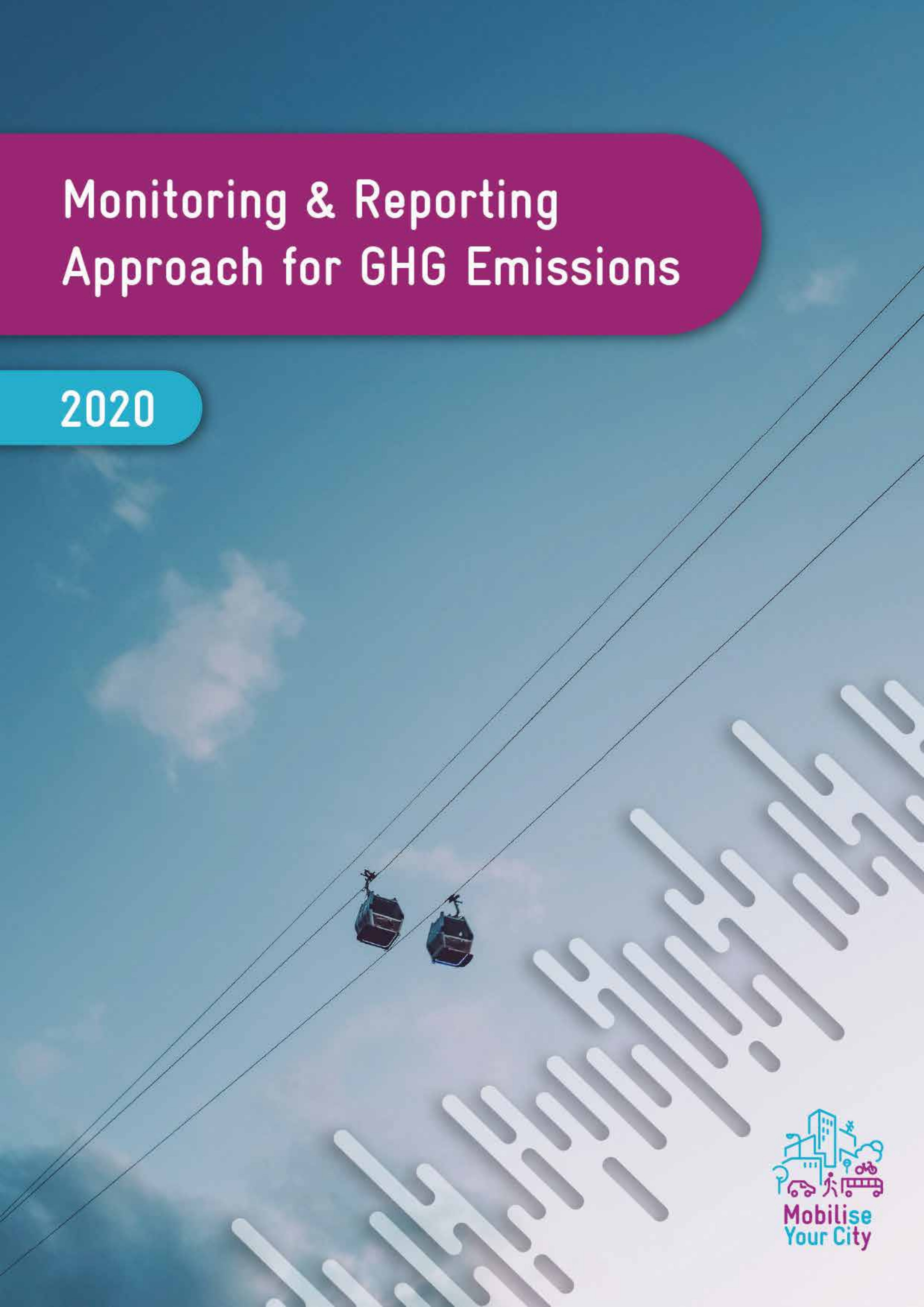
Monitoring & Reporting Approach for GHG Emissions

2020



Mobilise Your City

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UCLG United Cities and Local Governments

UN HABITAT FOR A BETTER URBAN FUTURE

ECF EUROPEAN CYCLISTS' FEDERATION

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Marrakech Partnership Global Climate Action

SUSTAINABLE mobility FOR ALL

Context of the Publication

This publication has been developed within the MobiliseYourCity Partnership in collaboration with the project "Advancing climate strategies in rapidly motorising countries", funded by the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety.

MobiliseYourCity is a partnership for integrated urban development planning in emerging and developing countries under the UN Marrakesh Partnership for Global Climate Action. MobiliseYourCity supports and engages local and national partner governments in improving urban mobility planning & finance by providing a methodological framework and technical assistance, through capacity building, and by enabling access to funding at both local and national levels. Particular attention has been paid to the methodological and advisory frameworks related to National Urban Mobility Policies and/or Programs (NUMPs) and Sustainable Urban Mobility Plans (SUMPs) that serve as the basis for the promotion of investments and development of attractive mobility services.

MobiliseYourCity is a multi-donor action, jointly co-financed by the European Commission's Directorate-General for International Cooperation and Development (DG DEVCO), the French Ministry of Ecological Transition and Solidarity (MTES), the French Facility for Global Environment (FFEM), and the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB). The initiative is implemented by its founding partners ADEME, AFD, CEREMA, CODATU, and GIZ. Besides contribution to the international climate process, MobiliseYourCity contributes to the UN's Agenda 2030, specifically Sustainable Development Goal (SDG) 11: Make cities inclusive, safe, resilient and sustainable.

The objectives

- Enable transformational changes towards more inclusive, liveable, and efficient cities.
- Foster more comprehensive, integrated and participatory urban mobility planning (local & national levels).
- Target reduction of transport-related GHG emissions in participating cities (>50% until 2050).
- Link planning with agreement on investments and optional use of financial assistance.
- Make use of innovative planning techniques and digitalization, and promote state-of-the-art mobility and transport technologies.

Contents

1. Introduction

1.1. MobiliseYourCity Partnership

MobiliseYourCity is a Partnership that supports local and national governments in developing countries in creating more inclusive, liveable, economically competitive and climate resilient cities.

It does so by providing support for the development and implementation of sustainable urban mobility plans (SUMPs) for individual cities as well as national urban mobility plans (NUMPs).

By implementing such plans, MobiliseYourCity's member cities are targeting to achieve a 50% reduction in urban transport related GHG emissions by 2050 compared to business as usual.

1.2. MobiliseYourCity indicators

Important tools for monitoring progress and the wider sustainability benefits of the SUMP/NUMP are KPIs: Key performance indicators. Three types of indicators are monitored within MobiliseYourCity projects:

1. Mandatory MobiliseYourCity Core Indicators.
2. Additional sustainable mobility indicators according to the scope and objective of individual SUMPs/NUMPs (some already available in the MobiliseYourCity Emissions Calculator)
3. Implementation indicators according to the scope of individual SUMPs/NUMPs

The first MobiliseYourCity core indicator is "Expected GHG emission reductions (of a SUMP/NUMP scenario') (in tCO2e) against a 'without SUMP/NUMP scenario' (baseline)". This indicator on absolute GHG emission levels is linked with a specific indicator "GHG emissions due to urban mobility per capita".

Another MobiliseYourCity core indicator relevant to the present guideline is KPI 2 "Modal split" indicating the share of climate friendly transport modes, mainly walking, cycling and collective transport, on total passenger transport demand.

> All MobiliseYourCity core indicators and related calculation methods are described in **MobiliseYourCity *Core Indicators and Monitoring Framework,*** available on the MobiliseYourCity knowledge platform (https://mobiliseyourcity.net/core-indicator-and-monitoring-framework).

1.3. MobiliseYourCity Emissions Calculator (Tool)

In order to support countries and cities part of the MobiliseYourCity Partnership in estimating GHG emissions, an excel-supported tool is available online[1] to calculate road and rail transport GHG

[1] Available at: https://mobiliseyourcity.net/mobiliseyourcity-emissions-calculator

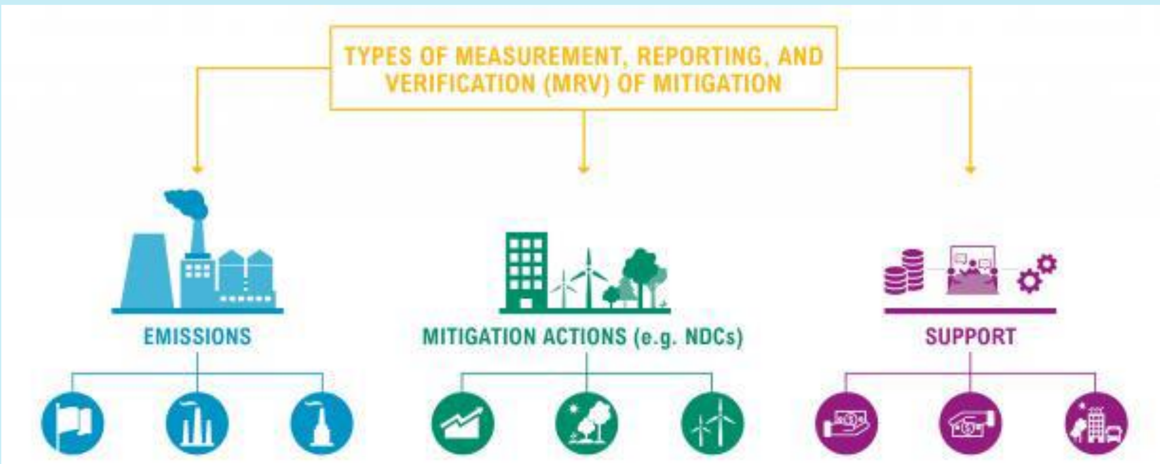
emissions: the MobiliseYourCity Emissions Calculator. This tool is a bottom-up[2] model for both national and local levels. It enables calculating transport GHG inventories, a "business as usual" (BAU) scenario as well as a climate scenario. Governments can therefore calculate the environmental effects of national and local urban mobility plans implementation. For example, what would be the impact on GHG emissions of a development of the public transport network? What would be the impact of subsidies for electric vehicles? The scope of the emissions that should be taken into account is based on a territorial principle (see Chapter 3) referring to the concept of "functional city" (see section 3.2). Basically, all traffic within the city/country must be taken into account WITHIN the functional city (traffic of inhabitants, incoming and outgoing traffic such as commuters, tourists, freight deliveries and so on).

The MobiliseYourCity Emissions Calculator can also be used for monitoring the development of MobiliseYourCity key performance indicators. The MobiliseYourCity KPI 1 and 2 (GHG emissions and modal split (pkm)) are calculated directly in the tool. The other MobiliseYourCity core indicators can be entered manually in the KPI table. We recommend using the MobiliseYourCity Emissions Calculator to gather these indicators (in the Tab "overview of results").

1.4. MRV approach

A sound framework called "MRV": Monitoring, Reporting and Verification gives the frame in which GHG emissions assessment occurs. The concept of MRV has evolved from individual UNFCCC requirements aimed at promoting the uptake, tracking and communication of climate actions (i.e. mitigation and adaptation actions), such as the mitigation of anthropogenic GHG emissions. It became over time a robust framework (for more details see Wartmann, S. et al (2018)).

Figure 1 : Types of MRV



Source: MRV Africa https://www.mrvafrica.com/

[2] Calculations based on fuel/energy consumption are referred to as *top-down*, and calculations based on distance travelled as *bottom-up*. For a comparison between the two approaches, see *Bottom-Up GHG inventory and MRV of measures* (Vieweg-Mersmann, 2017) at https://www.changing-transport.org/publication/bottom-up-data-for-mrv/

MRV systems apply to GHG emissions, mitigation actions and support received (see Figure 1). They include three main elements:

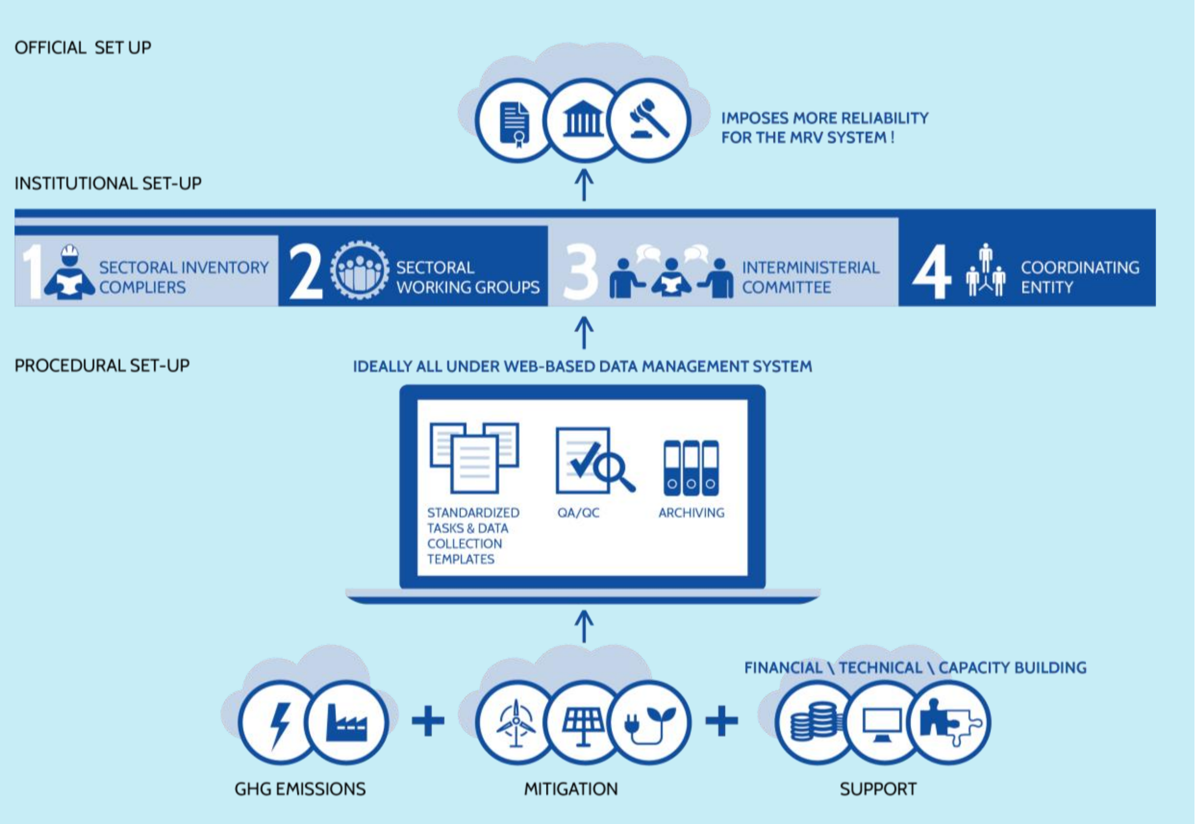
- **Monitoring** means direct measurement or estimated calculations of emissions and emission reductions following strict guidance and protocols, such as the IPCC Guidelines and CDM Methods. This can include direct measurement using devices or estimation using simple methods or complex models.
- **Reporting** means documentation intended to inform all interested parties. This includes information on methodologies, assumptions and data.
- **Verification** means specific procedures or expert reviews used to verify the quality of the data and estimates. Verification can be internal or external.

A complete MRV system has to be established at three set-up levels (Figure 2):

- Official set-up
- Institutional set-up
- Procedural set-up

The need for a proper institutional set-up in an MRV approach shall not be underestimated. This may include establishment of a steering committee, of a coordinating entity, identification of technical coordinator(s) or set-up of sectoral working groups.

Figure 2 : Key elements of MRV system set-up

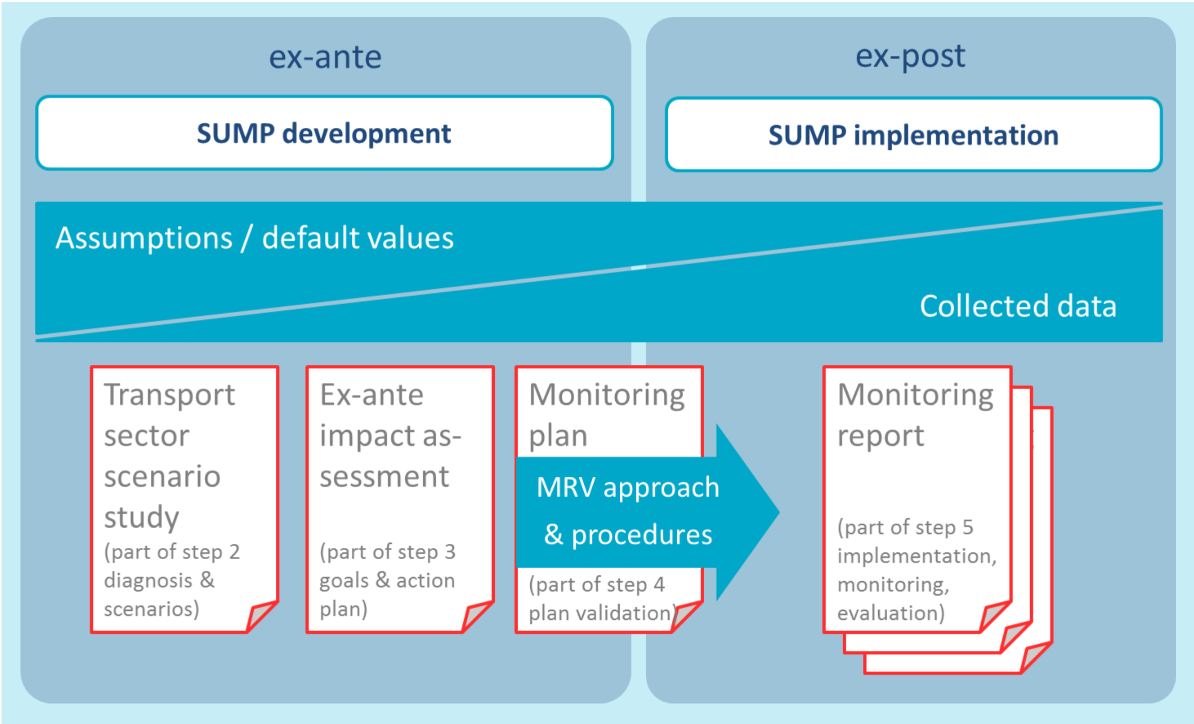


Source: MRV Africa https://www.mrvafrica.com/

More overall information on MRV system is available on MRV Africa resource centre: www.mrvafrica.com.

The present document sets out the specific MRV approach of mobility-related GHG emissions for the MobiliseYourCity Partnership, which encompasses ex-ante and ex-post evaluations as well as the periodic monitoring of GHG emissions from the mobility sector associated with the development and implementation of Sustainable Urban Mobility Plans (SUMPs) and national policies and investment programmes for urban mobility (NUMPs) (see Figure 3).

Figure 3: Emission quantification during SUMP or NUMP development and implementation

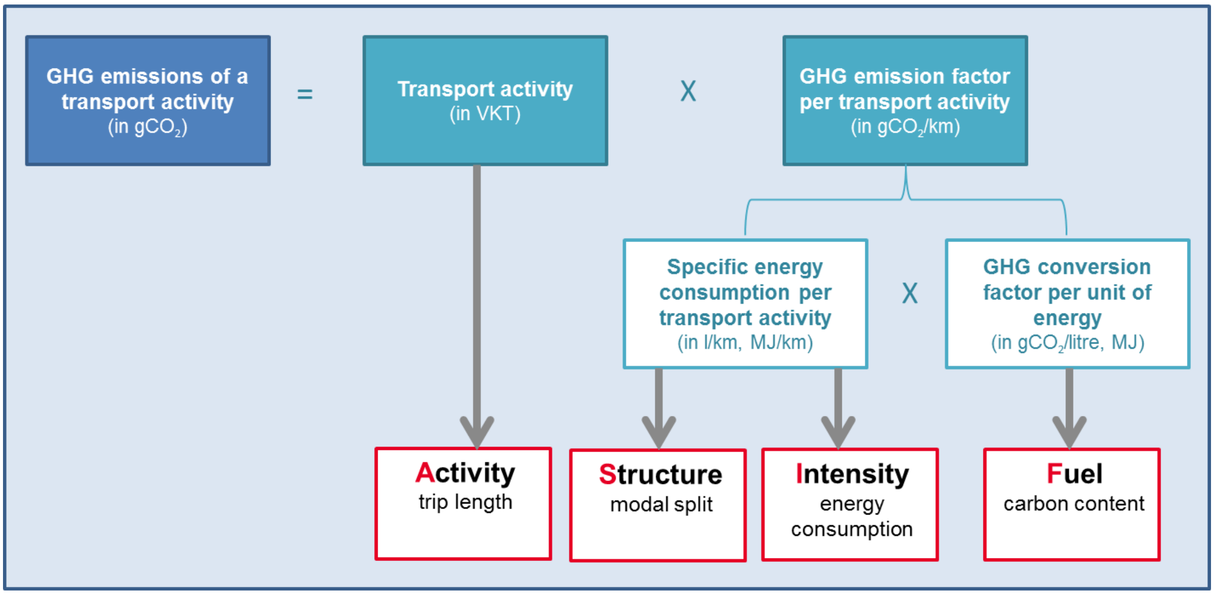


2. Methodology to Calculate and Monitor Transport Related GHG Emissions

2.1. ASIF framework

The MobiliseYourCity approach to monitoring and reporting proposes that participating cities track the development of transport related GHG emissions (CO_2, CH_4 and N_2O) at city and national level per calculation rather than per measure. First, an inventory for present GHG emissions from the transport sector should be established. The total transport related GHG emissions depend upon several parameters: transport demand (travel activity by mode), respective specific energy consumption per mode per travel activity, and specific GHG conversion factor per energy carrier per mode. The emission inventory for the transport sector is calculated using a bottom-up approach that is based on the ASIF framework as described in Figure 4.

Figure 4: ASIF Framework for the calculation of transport emissions



Ideally in the context of a SUMP, the values for the parameters should be adapted to city-specific circumstances to calculate local transport GHG emission inventories. However, the availability of data and resources for data collection usually does not permit such a level of detail/local adaptation for all parameters. At the same time, not all parameters are equally dependent on local contexts. For instance, travel activity and modal split usually vary greatly from city to city, depending on their size and level of urbanisation, as well as geographic, economic and demographic aspects. In contrast, the carbon content of fuels lies outside of the influence of cities, which means that national default factors or even IPCC default values can be used (IFEU, 2014). The calculation approach must also account for local capacities. Depending on local data availability and resources, inventories can be based on simple calculations and more aggregated data, or on more advanced modelling approaches that allow for emissions from different sources to be monitored in great detail.

2.2. Ex-ante and ex-post evaluation of NUMP and SUMP measures

The evaluation of the SUMP should be carried out in two consecutive steps:

- Ex-ante evaluations are per definition "before the event" i.e. before the implementation of the SUMP/NUMP. They focus on the future mobility-related GHG emissions of measures compared to a business as usual scenario (BAU) i.e. development of the GHG emissions without these measures. Such an ex-ante estimates potential GHG emission reductions and enables in this manner a) prioritising measures as well as b) making the implementation of SUMP/NUMP attractive to international climate finance donors.
- Ex-post means "after the event" or in our case the estimation of actual effects of the NUMP/SUMP measures on mobility-related GHG emissions i.e. after the implementation. It is a central part of the monitoring and evaluation phase (see Chapter 5.2). This ex-post assessment is compared to GHG emissions (e.g. t CO2 equivalents per year per capita) estimated for the baseline year of the SUMP/NUMP and as forecasted ex-ante in the SUMP/NUMP to evaluate the actually achieved success of the measures.

In principle, the ex-post calculations follow the same approach as ex-ante estimates. In a first simplified approach, ex-post estimations could focus only on those emission parameters being affected by SUMP/NUMP measures which have actually been implemented (see chapter Chapter 5.2). For example, if no measures have been implemented to support fleet upgrade/renewal, in a simplified ex-post analysis, it is possible omit a precise survey on fleet composition.

For the ex-post analysis, real-world data can be gathered for all calculation parameters. However, for projections in the ex-ante analysis data assumptions have to be made on the likely future development of certain parameters such as GDP or population. Whenever assumptions are made, it is important to be transparent and state those explicitly in order to understand the results (see Figure 4).

3. System Boundary for GHG Monitoring & Reporting Approach

In order to calculate mobility-related GHG emissions in inventory and scenarios, several parameters have to be defined in order to fine-tune the accounting process, namely:

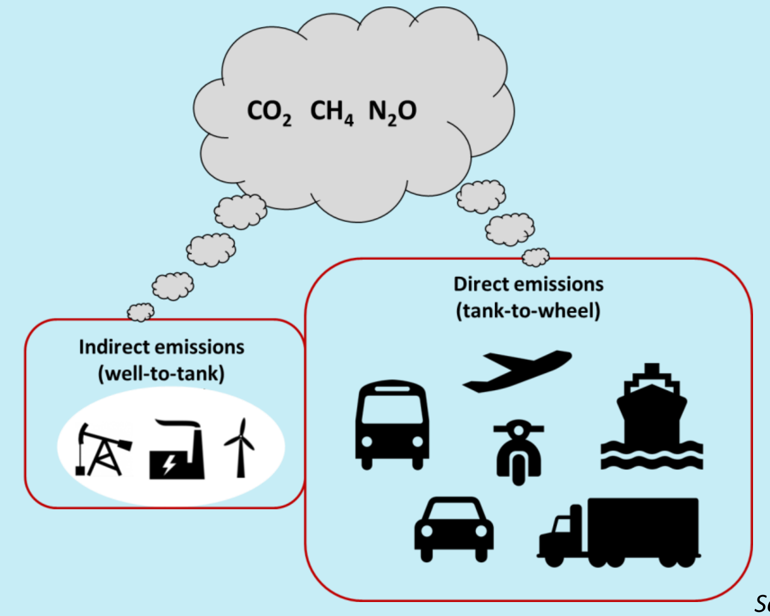
- the type of emissions/gases, which are accounted for
- the geographical scope of the SUMP/NUMP
- the transport modes covered
- the timeframe of the evaluation and the monitoring interval

3.1. Type of emissions

MobiliseYourCity cities are required to develop urban mobility-related well-to-wheel GHG emissions inventories: CO_2, CH_4 and N_2O in CO_2-equivalents (see Box 3) for the functional city. Within IPCC framework on the contrary tank-to-wheel transport GHG emissions are required as upstream emissions are already accounted for in other sectors such as energy sector. The MobiliseYourCity Emissions Calculator enables switching from one to another.

Well-to-wheel GHG emissions include direct emissions from mobile sources (tank-to-wheel) for all transport modes e.g. cars, motorbikes, buses, etc and indirect emissions from the use of electricity and upstream emissions from fuels (well-to-tank). The well-to-wheel approach is recommended to ensure the comparability of conventional propulsion systems and electric vehicles (for which emissions only occur upstream), as well as other fuel switch options. In the MobiliseYourCity Emissions Calculator, default emission factors (g CO_2/MJ) for fuel related well-to-tank emissions are implemented as they are widely independent from local activities. But the specific emissions linked to the production of electricity should be entered into the calculator by the user to reflect the local/national differences of electricity mix and related environmental impacts.

Figure 5 : Transport modes and emissions included in the GHG monitoring (ideal case)



Source: adapted from IFEU, 2014

Neither black carbon emissions (component of soot), released during diesel fuel combustion, nor air pollutants are - so far - required.

Box 1 : Transport related emissions and their warming effect

GHG emissions and their global warming potential

GHGs emitted by transport mainly consist of carbon dioxide (CO2), in addition to small amounts of methane (CH4) and nitrous oxide (N2O). In order to compare the warming effects of different GHGs, the global warming potential (GWP) is used. The GWP relates the amount of heat trapped in the atmosphere by a particular GHG to the amount of heat trapped by a similar mass of CO2. In this way, the sum of all GHG emissions can then be indicated as CO2 equivalents.

The global warming potentials (for a time horizon of 100 years) of carbon dioxide, methane and nitrous oxide are as follows (Myhre G. & ale., 2019):

CO_2: 1
CH_4: 28
N_2O: 264

Black carbon (not calculated in MobiliseYourCity)

Black carbon – a component of soot – is released by burning biomass (wood stoves and biomass burning, as well as natural wild fires), coal and diesel fuels. It is an important component of particulate matter, contributing to air pollution and leading to respiratory diseases like asthma and lung cancer. The World Health Organisation estimates that outdoor air pollution led to 3.7 million premature deaths in the year 2012 alone, of which almost 90% occurred in low- and middle-income countries (WHO, 2014). A lesser known fact is that soot also has a strong warming effect on the climate. In fact, it is the second largest man-made contributor to climate change (Bond et al., 2013). Soot warms in two ways:

1. Particles in the air absorb sunlight, generating heat in the atmosphere.
2. Winds transport soot particles to the Arctic and the Himalayas, where they settle on ice and snow like a black blanket, stopping the reflection of sunlight. Instead, radiation is absorbed, accelerates the melting of the arctic ice sheet and the Himalayan glaciers, and further intensifies global warming.

In contrast to CO2, which stays in the atmosphere for centuries, black carbon only remains for several weeks. Abating black carbon therefore has a short-term effect on climate change and an immediate effect on local air quality. The main contributors to black carbon from the transport sector are diesel vehicles without particulate filters. This includes trucks, ships, rail, utility vehicles and construction machinery (Eckermann et al., 2015).

Calculating the exact effect of black carbon is a complex and scientifically contested issue. MobiliseYourCity does not require an assessment of black carbon warming effects. It may however be of interest to cities that wish to account for particulate matter out of air quality considerations. In this case, the number of PM can also give an order of magnitude indication to the development of black carbon emissions.

Construction emissions from major infrastructure projects such as metros or highways or upstream and downstream emissions from vehicle production are not mandatorily included. However, it is important to communicate in a transparent manner whether these emission sources are included or excluded from the MRV approach.

Box 2: Focus on GHG emission accounting in MobiliseYourCity

Note: Emission monitoring in MobiliseYourCity focuses on GHG emissions i.e. CO_2, CH_4 and N_2O. Air pollutant emissions do not need to be monitored for MobiliseYourCity reporting. Cities that are interested in monitoring transport-related air quality, however, can report their local data if measurements are regularly conducted and air quality monitored.

3.2. Geographical scope

The GHG emission inventory for urban transport is the sum of all transport-related activities that can be attributed to the city or the country. This attribution can follow different rationales (see Dünnebeil et al. (2012) and Box 3). The MobiliseYourCity initiative follows a **territorial approach**, which includes emissions from inhabitants and visitors alike, and addresses all the local stakeholders that influence transport within the city's territory (inhabitants, employers, public services, industry, trade etc.) (IFEU, 2014). This follows the European principle of the functional city, which encompasses the economic and functional extent of cities based on daily people's movements (see Djikstra L. & al).

Box 3: System boundaries for emission accounting in urban transport and reasons for a territorial approach

Transport activities can be attributed to a monitoring area using different approaches. This has consequences for the informative value and the further use of the monitoring results. The most common system boundaries for monitoring urban transport emissions are:

1) **Territorial:** All transport activities of a means of transportation within the territory are covered. The territory can be defined in different ways, e.g. as the whole functional area of a city or city-governed districts only. With this approach, all transport activities within the political sphere of influence of municipal Government are covered. However, further differentiations (e.g. internal vs. origin/destination vs. transit traffic) can help understanding the drivers of traffic flows and volumes, and identify fields of action.
2) **Inhabitants:** All traffic related to city inhabitants is included, independent of the place where traffic occurs (e.g. including trips outside of the city or air travel). Contributions to traffic in the city from non-inhabitants (e.g. commuters, tourists, incoming freight transport) are *not covered* in this approach. Consequently, possible GHG emission reductions in commuter traffic or any other incoming transport are *not covered* in this monitoring system. At the same time, the inhabitants approach includes travel activities that cannot directly be influenced by municipal Government, such as long-distance travel.
3) **Origin-destination (OD) approach:** All traffic with an origin and/or destination within the city's territory is covered (boundary-crossing traffic: 50% of long-distance trips is counted). This approach reflects urban transport activities very well, but it requires high levels of data availability that only a few cities are able to meet. Furthermore, it still includes 50% of long-distance trips, which city policies have no influence on. Transit traffic is not covered.

Figure 6 : Different system boundaries for urban transport emission accounting

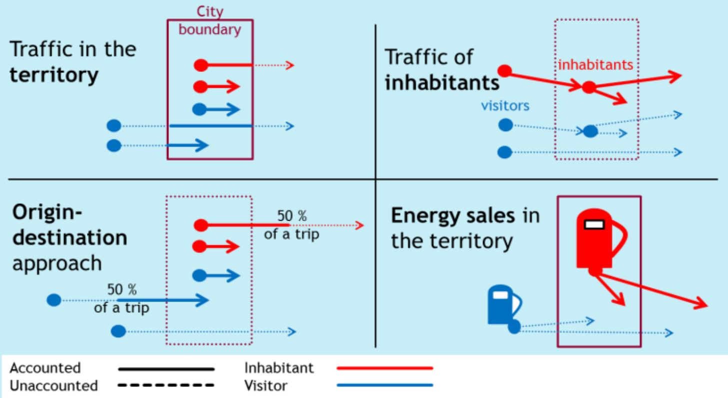


Figure source: Dünnebeil et al., 2012

4) **Energy sales:** Emissions are calculated using a top-down approach based on statistics on fuel sales in the city. This approach only allows for a rough estimation since a purely sales-based approach does not provide any information on how much of the purchased fuel is actually used within the city. It also does not provide data on actual transport activities related to the city or their causes (e.g. cars vs. trucks) – information, which is necessary for transport planning. Using energy sales data alone does not adequately monitor the effects of SUMPs, but it can be used to cross-check bottom-up calculations.

Source: Dünnebeil et al., 2012

The rationale for using the entire city territory as the assessment unit is that any measures implemented within the city territory fall into the sphere of influence of local government, and can thus be affected by the SUMP. In this way, the assessment unit directly corresponds to the geographical area where the SUMP will have the greatest expected impact. The territorial approach is also recommended by other international guidelines, such as the Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (WRI, 2014a) or the Covenant of Mayors[3], and is therefore in line with state-of-the-art international best practice.

In the context of NUMPs it is recommended to calculate global transport emissions (urban, inter-urban and rural mobility emissions) of the national transport sector in order to:

1. Compare the results of the bottom-up assessment to the national top-down assessment (i.e comparing energy consumption based on travel demand and fleet composition in the MobiliseYourCity Emissions Calculator to the energy balance i.e. fuels sales within the country). This comparison can be done in the MobiliseYourCity Emissions Calculator in the form of a quality check.
2. Be able to use the national data gathered in the context of the NUMP for inventory and reporting to the IPCC

[3] The Covenant of Mayors for Climate & Energy Initiative was launched in 2009. It brings together thousands of local and regional authorities who have voluntarily committed to implementing EU climate and energy objectives within their territory. http://www.covenantofmayors.eu/index_en.html

The focus of NUMPs is nevertheless urban mobility. This is why the share of urban mobility in the total national transport related energy consumption and hence GHG emissions should as far as possible be assessed in order not to overestimate potential GHG reduction effects of urban measures (see Section section 7.3 **Erreur ! Source du renvoi introuvable.**). In addition, in NUMP cases, it is recommended to develop as far as possible GHG MRV approaches both at national level and at local level, at least for the main cities, to get a complete picture of urban mobility GHG emissions in the country.

3.3. Transport modes to consider

Ideally, **all motorised modes** (passenger and freight transport) are included in the emission inventory. This helps paint a complete picture of the transport sector's emission profile in each territory. In reality, however, data may not be readily available for all modes. A pragmatic option is to begin with those modes that are relevant to the scope of the individual SUMP/NUMP, i.e. those modes directly affected by the measures included in the SUMP/NUMP. In most cases, this means disregarding aviation emissions (territorial boundary emissions only include take-offs and landings) and emissions of inland shipping if they are not affected by the SUMP/NUMP and only make up a small share of transport and emissions. This of course depends on each city's specific context. If a city has an airport or a port within the city territory, these emissions could account for a significant portion of transport related emissions and a deliberate decision has to be taken whether or not to include them. The MobiliseYourCity Emissions Calculator encompasses road and rail transport only. If significant, aviation and maritime emissions have to be calculated separately from the calculations done with MobiliseYourCity Emissions Calculator.

In addition, it is recommended to differentiate the emission profile for transport modes that are under the influence of local administrations (transport within the city boundary or with an origin/destination within the territory, including passenger and freight transport) and those that are hardly affected by local measures (transit traffic, public long-distance transport, such as bus, rail and aviation, as well as rail-bound and inland freight transport) (IFEU, 2014). Such a differentiation enables accounting all emissions in each territory, while highlighting those that are influenced by the SUMP/NUMP and analysing their emission development separately (on this point see 4.3). In this way, the complete emission profile can be reported and the SUMP's or NUMP's achievements can be tracked.

3.4. Timeframe

MobiliseYourCity suggests a GHG monitoring interval of 1-3 years. For ex-ante emission reduction scenarios, the timeframe has to be adopted to fit into the SUMP's or NUMP's planning cycle. Assuming that the implementation of a SUMP/NUMP will take approximately 10 years, the minimum time span for the MRV system should also be ten years. Since the full benefits will, however, not be apparent until the SUMP/NUMP measures have been implemented, annual emission reduction benefits will increase over time. This means that a longer assessment period will show larger effects, e.g. 20 years. Within the MobiliseYourCity Emissions Calculator the timeframe is extended until 2050 with reference years: base year, 2020, 2025, 2030, 2040 and 2050. 2030 and 2050 are the main reference years for MobiliseYourCity.

At the global level, the MobiliseYourCity Partnership aggregates ex-ante projected yearly GHG emissions reductions for all its reference years. It is therefore required to report at least two distinct values: the projected yearly GHG emissions in the reference years in (1) the business-as-usual scenario (see Chapter 4.2.) and (2) the climate scenario (see Chapter 4.3.), corresponding to the SUMP/NUMP. These indicators are expressed in tons CO_2 equivalent (tCO_2eq).

Once all of the above parameters have been decided upon, the system boundary for monitoring and scenarios is set. The boundary will always be a compromise between the most exact representation of the territorial emissions and the extent of locally available data and resources. Finding this compromise is a key challenge for good inventories.

The calculation of transport related emissions requires information on:

- Transport activity i.e. mileage and transport performances (pkm: person-kilometre and tkm: ton-kilometre) for each transport mode (linked to occupancy rate and vehicle load)
- Share of the transport activity by vehicle category and fuel type (modal-split)
- Vehicle fuel consumption according to vehicle category and fuel type (based on vehicle fleet)

The data collection process for these parameters is explained in the following chapters.

4. Calculate Inventory and Ex-ante GHG Emissions

Transport data have to be collected at city or at the national level respectively for SUMPs/NUMPs. The scope for the input data specified in Table 1 and Table 2 is the minimum requirement, so if data sets that are generally available at the national level can be found at the city level (e.g. fuel consumption of vehicles), it is recommended to use them if these data are reliable. The compulsory inputs, typical sources and data collection methods of the MobiliseYourCity Emissions Calculator for the base year (inventory) and the BAU scenario are respectively detailed in section 4.1and 4.2. The required inputs for the ex-ante climate scenario can be found in Chapter 4.3.

All sources and hypothesis must be cited throughout the assessment, and methodologies clearly explained.

4.1. Inventory of the Current Transport Activity and Fuel Consumption

Table 1 gives the data required in order to calculate the bottom-up inventory of urban mobility in cities or countries in the MobiliseYourCity Emissions Calculator. Table 2 shows the optional data, which improves the accuracy of the assessment. Details on methodology and sources are developed in the following two sub-chapters.

Table 1 List of compulsory data for the inventory

Category/Parameter	Unit	Sensitivity for results	Data scope for countries	Data scope for cities
Total annual vehicle kilometres travelled per vehicle category *1	■ Mio km	■ +++	■ National	■ City
Vehicle stock (total number of vehicles) per vehicle category *2	■ Nb. Of vehicles	■ +++	■ National	■ City
Average annual mileage per vehicle category *2	■ Km/veh/year	■ +++	■ National	■ City
Average mileage share by fuel type and vehicle category	■ %	■ ++	■ National	■ National
Average occupancy/load per vehicle category	■ Person or ton/vehicle	■ ++	■ National (or regional)	■ City
Average trip length per vehicle category	■ Km/trip	■ ++	■ National	■ City
Average energy consumption per vehicle category and energy type	■ L/100 km (kg for NG; kWh for e-car)	■ +++	■ National (or regional)	■ National (or regional)
Specific GHG emission factor of electricity production for road	■ gCO2/kWh	■ +	■ National	■ National
Specific GHG emission factor of electricity production for rail	■ gCO2/kWh	■ +	■ National data	■ National data

Legend: + low; ++ medium; +++ high impact. Users have to choose between the first method called *1 vehicle kilometre approach used when a transport planning tool and/or traffic counts are available or *2 the second method called fleet approach based on number of vehicles and average vehicle mileage.

Table 2 List of optional data and scope of input parameters for the inventory

Category/Parameter	Unit	Sensitivity for results	Data scope for countries	Data scope for cities
Population - Number of inhabitants	Nb of Inhab.	+	National	City
Gross domestic product (GDP) or Gross market product	USD Billion	+	National	(City)
Specific GHG emission factors of fuels (fossil, renewable)*	gCO2/kWh	National data	National	National
Fuel consumption for road and rail sectors per fuel type in the energy balance	1000 Toe	+	Energy balance (country)	Fuel sales in the territory

*Provided as defaults in the tool: IPCC values

4.1.1. Transport activity

Mileage

Mileage is the cornerstone of the calculation of transport GHG emissions. It is categorised by fuel type and vehicle category. The tool requires two inputs: Total mileage per vehicle category (incl. NMT[4]), covered in the present section and mileage share by fuel type within a vehicle category (covered in Section 4.1.2). There are three possible approaches to calculate vehicle mileage:

- Vehicle kilometre approach
- Fleet approach
- Inhabitant trips approach

[4] Non motorised traffic

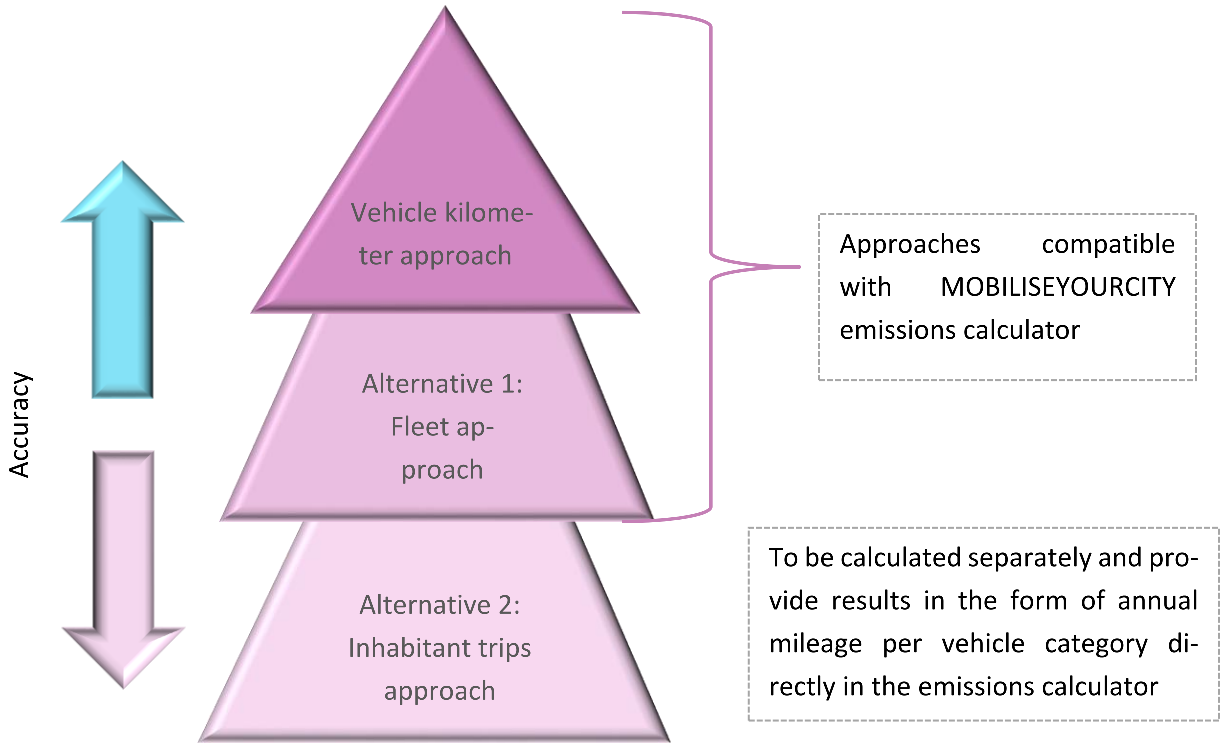


Figure 7 Three approaches to calculate vehicle mileage

- **Vehicle kilometre approach**

The first possible methodology to calculate vehicle mileage is called **vehicle kilometre approach**. Data needed for this approach can be provided by a transport planning model or derived from traffic counts (on homogenous section (i.e. on section between 2 intersections)) as detailed for road transport in Table 3. Both rely on a territorial approach (as recommended by MobiliseYourCity). One may also want to calculate mileage wih several methodologies and compare/cross-check the results.

For rail transport with freight and passenger trains, vehicle Stock and average annual mileage (or total mileage) may be available from the national rail operator.

Table 3 Territorial approach: sources for total vehicle mileage per vehicle category

Data output	Possible data source	Means of transportation covered	Details
Vehicle mileage (vkt)	■ Transport model	■ All means of road transport	Details of transport planning model are presented in Box 4.
Vehicle mileage (vkt)	■ Vehicle activity survey (e.g. origin-destination survey)	■ All means of road transport surveyed (cars, motorcycles, trucks/buses)	Origin-destination data are required as input for transport model and show the main areas of mobility within a given territory.

Data output	Possible data source	Means of transportation covered	Details
Vehicle mileage (vkt)	Floating car data (GPS) ■	■ All means of road transport (depending on available data sources	Mileage for single vehicle in analysed time period. Extrapolation to total mileage only if analysed vehicles, perimeter and time period are representative of fleet. Warning: FCD data processing can be time-consuming.
Traffic volume for analysed road section and directions (vkt)	■ Traffic counts (directional with video or pollster or on–road sensors or manual)	■ All means of road transport (depending on the technology of the traffic counting: counter tube, camera, interviewer, etc.) Extrapolation to total mileage only valid if analysed vehicles and time period are representative of fleet.	Traffic counts should be done separately for different road types (inner-city road, urban roads and highways). They can be automated and manual and deliver the number of vehicles in a designated road length (only if the road is between 2 intersections). This traffic intensity data (number of cars per hour/day) can be multiplied with the length of the road network for each road type[5]. Warning : – Counts duration to avoid hazard event – Counts period: peak hours, weekends, etc. Perimeter: strategic points

If possible, the share of transit traffic in the territory should be estimated and reported separately, since urban transport policy has – in most cases – little influence over transit traffic.

Developing a transport model is the more comprehensive way to identify and forecast vehicle mileage for all means of transport. This is a rather costly method which usually requires comprehensive mobility surveys and counts. Nevertheless, it might be envisaged as a transport model does not serve only for the MRV of a SUMP, but is generally a helpful tool for urban mobility planning processes. More details on transport model development methodology is provided in Box 4.

Box 4 : Brief Transport planning model description for base year (i.e. inventory year)

A Transport planning model can be divided in four steps presented below:

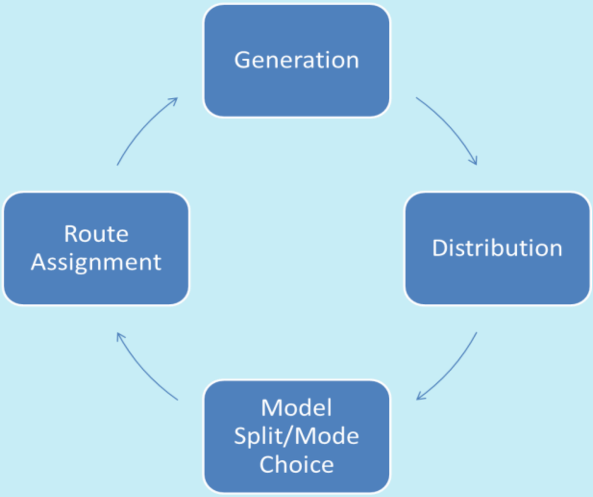
Step1: Generation and Distribution

The Generation step permits to define trips volume by zone. This step will lead to calculate volumes of trips by zone regardless of the transport mode.

The Distribution step permits to define trips direction zone to zone. This step will lead to calculate volumes of trips zone to zone regardless the transport mode.

[5] For detailed explanations (see Monitoring Greenhouse Gas Emissions of Transport Activities in Chinese Cities – A Step-by-Step Guide to Data Collection, Section 2.1.2)

The table below presents collection method to define generation & distribution data.



4 Step Model for Traffic Assignment

Table 4 Collection method for generation & distribution data.

Collection methods	Scale	Main data obtained	Weaknesses
Household survey	■ National (country) ■ Regional (region) ■ Local (city)	■ Socio economic data ■ Mobility behaviour ■ Household equipment ■ Household habits ■ Numbers of trips ■ Starting point of trip ■ Ending point of trip ■ Reason of trip ■ Trip decomposition ■ Trip duration	■ Cost of the survey ■ Difficulty of implementation ■ Delay of implementation ■ Delay of process ■ Large sample needed ■ Answers veracity
Origin-destination survey	■ Regional (region) Local (city, area)	■ Starting point of trip ■ Ending point of trip ■ Reason of trip ■ Occupancy rate ■ Type of vehicles ■ Starting hour of trip	■ Survey construction (zones) ■ Implementation on site (stop vehicles) ■ Large sample needed

Generation & Distribution step permits to obtain an origin-destination matrix. This demand matrix will be uploaded in the transport planning model.

Step2: Modal split calibration

Modal split will be calculated by using modes variables as:

- Travel time
- Travel cost

- Connection time
- Etc.

These variables are calculated by the transport model as endogenous data. Exogenous data are needed to calibrate the modal split and can be obtained by household surveys (e.g modal shares by mode).

Step3: Traffic assignment calibration

This step consists in assigning the travel demand (i.e. origin-destination matrix) on the network to obtain traffic by section. The assignment result is adjusted by traffic counts in order to make consistency between demand assigned and counts by section. For this step traffic counts are needed.

The table below presents collection method for traffic counts.

Step3: Outputs

The transport planning model gives as outputs:

- The mileage by section, vehicle types or by mode: vehicle.kilometers (vkt)
- Time spent on the network by section by vehicles types, by modes: vehicle.hours (vkh)

Collection method	Means of transportation	Data format	Fleet composition
Traffic counting with on-road sensors	■ Passenger cars Taxis ■ Buses ■ Motorcycles ■ Trucks	Traffic volumes for analysed road section	Counting can distinguish between ■ Cars ■ Motorcycles ■ trucks/buses
Directional traffic counting with video or pollster	■ Passenger cars ■ Taxis ■ Buses ■ Motorcycles ■ Trucks	Traffic volumes for analysed road section and directions	Counting can distinguish between ■ Cars ■ Motorcycles ■ trucks/buses

- **Fleet approach and inhabitant trips approach**

If the vehicle kilometre approach cannot be applied, **two alternative calculation methods** can be used**:** **fleet approach** (Option 1 in Figure 8) or **inhabitant trips approach** (Option 2).

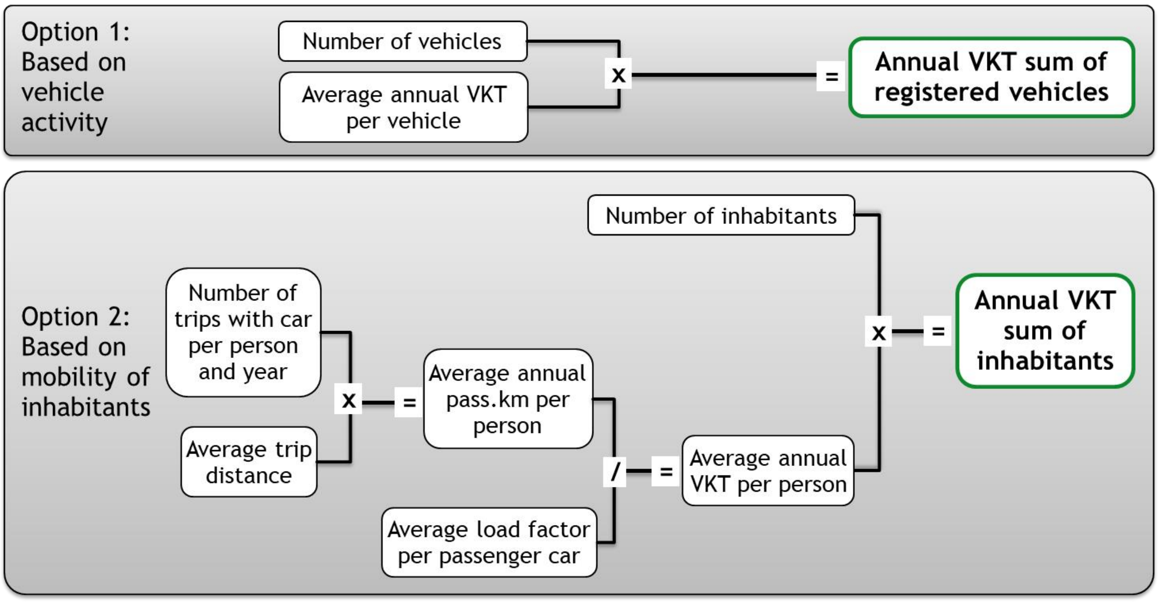


Figure 8 Alternative methods to calculate vehicle mileage

The so-called **fleet approach** (Option 1) is based on activity of vehicles. The number of registered vehicles in the urban area is multiplied with the average annual mileage per vehicle category. The different sources detailed in Table 5 can be compared or complete one another depending on their format and coverage.

Table 5 Source for alternative method Option 1 "fleet approach"

Data output	Possible data source	Means of transportation covered	Details
Vehicle stock by technical characteristics	■ Vehicle registration statistics	■ Possibly all road vehicles; characteristics depend upon collection method and can vary from country to country	The number of vehicles is normally available at the country level, in several countries also in regional or city statistics. Data can be compared with vehicle tax/insurance Fuel type should be included for further parameters (see **Erreur ! Résultat incorrect pour une table.**)
Vehicle stock by technical characteristics	■ Vehicle tax / insurances	■ All private road vehicles which must pay taxes or have insurance	Vehicles taxes or insurances may not reflect the exact number of vehicles as some users may not register (fraud) or do not have to pay a tax /have insurance. Data can be compared with vehicle registries. Fuel type should be included for further parameters (see **Erreur ! Résultat incorrect pour une table.**)

Data output	Possible data source	Means of transportation covered	Details
Technical characteristics of stock	■ Vehicle characteristics survey (e.g. at parking lots/refuelling stations)	■ All means of private road transport	Characteristics such as engine power, vehicle age or emission standard can be collected to refine – if necessary- vehicle stock data Fuel type should be included for further parameters (see **Erreur ! Résultat incorrect pour une table.**)
Average annual vehicle mileage	■ Main inspection data (odometer)	■ All private road vehicles which must carry out inspections	Most of the time these data must be completed for other vehicle types such as mopeds (no inspection required). Fuel type should be included for further parameters (see **Erreur ! Résultat incorrect pour une table.**)
Average annual mileage per vehicle	■ Vehicle activity survey (e.g. at parking lots/refuelling stations)	■ All means of private road transport	Questionnaires are designed to ask people to give their annual mileage (potentially this should be calculated based on alternative methodologies e.g. annual fuel cost divided by average fuel price). Fuel type should be specified for further parameters (see **Erreur ! Résultat incorrect pour une table.**)

Vehicle Stock and average annual mileage (or total mileage) for rail freight and passenger train may be available from the national rail operator, and buses or local trains data from the public transport operators. Further sources for public transport are provided in Annex 2.

Best data sources for freight are also transport models and traffic counts, but Option 1 can also be used based on the number of commercial vehicles and truck registered. Locally this may be misleading as most of the time freight vehicles are registered at the headquarters of a firm but may drive in other regions. If possible, the share of foreign trucks on the city territory should also be assessed as they can contribute substantial part the freight mileage in the territory (see Box 5 for possible data sources).

- **Inhabitant trips approach**

The **inhabitant trips approach** (option 2 in Figure 8) is another alternative which is not directly included in the MobiliseYourCity Emissions Calculator. It must therefore be calculated separately. The inhabitant trip approach may be used at the local level (and if no other option available, at the national level). This method applies only for passenger transport and consists in calculating the number and length of trips to derive an annual mileage per person and multiply this by the population of the territory. Please note that average trip length by vehicle category is an input of the MobiliseYourCity Emissions Calculator (to weight the modal shift effect in the climate scenario). An overview of data sources for this approach is given in Table 6. Further sources for public transport are provided in Annex 2. To convert mileage of persons (passenger kilometres) to mileage of vehicles (vehicle kilometres), also average occupancy rates (number of persons per vehicle, see next subsection) of the different means of transportation are required (see explanations in the next subsection and Table 7).

Option 2 is not appropriate for freight transport as the number of trips is almost impossible to derive.

Table 6 Data sources for alternative method Option 2 "inhabitant trips approach"

Data output	Possible data source	Means of transportation covered	Details
Number of trips	■ Household surveys / trip surveys (e.g. at parking lots/refuelling stations/market places/churches/on board for public transport)	■ Possibly all passenger vehicles	For the definition of trip, please refer to **MobiliseYourCity *Core Indicators and Monitoring Framework.***
Trip length / average trip distance	■ Household surveys / trip surveys (e.g. at parking lots/refuelling stations/market places/churches/on board for public transport)	■ Possibly all passenger vehicles	For the definition of trip, please refer to **MobiliseYourCity Core Indicators and Monitoring Framework.**
Number of trips and length	■ Trip survey	■ Informal public transport .e.g mini buses	Territorial: informal transport network might differ to geographical boundaries of the city
Trip length and number of trips per person	■ Trip survey	■ Walkers and cyclists (potentially other alternative transport modes)	The number of walkers may be complicated to derive for a large territory. Assuming one average trip length per person multiplied with the inhabitants may give an approximation. The number of bikes may be simpler to derive at the local level if counting can be carried out

Both alternative methods, fleet approach and inhabitant trips approach cover mainly mobility of inhabitants (including outgoing trips), but not incoming and transit traffic on the city's territory. However, urban mobility policies cover also incoming traffic of foreign people/vehicles. Hence, mileage of incoming traffic should be at least roughly estimated if possible. Estimating foreign vehicle traffic is not easy without a transport model and consists in applying hypothesis on average annual mileage and number of foreign vehicles. Some possible data sources are presented below in Box 5. If such surveys are not available, hypothesis could be based on local knowledge/alternative data sources (e.g. local taxes/tolling data/tourism data).

Box 5 : Foreign vehicles data collection

Data collection for foreign vehicles calculation

- Literature, research, transport statistics
- Specific counts at the border
- Specific surveys on the territory (origin-destination, trip length, frequency, etc.)
- Licence plate capture on main roads of the perimeter

Please note: The two alternative methods deliver mileage of inhabitants and, thus, do not perfectly fit to the recommended territorial approach. On national level, mileage of registered cars usually fits quite well with mileage on the territory. For large regional monitoring areas, this methodology excludes mileage of tourism and transit freight, which means an uncertainty level that one may accept at the national level.

However, for smaller territories, the mileage of inhabitants resp. registered cars largely differs from the one on the territory, as on the one hand outbound traffic of registered cars is included in the fleet approach (though not in the territory) and inbound traffic (external visitors) and transit traffic of cars not registered in the city are not covered in the calculations. Therefore, the fleet approach is suitable on national level, but at the local level the methodology is only recommended if no other data are available.

Average occupancy rate/average load

Occupancy rate is necessary to derive transport performances in person-kilometre (pkm) or ton-kilometre (tkm), used to quantify the shift measures in the Climate scenario. Alternatively the transport performance can be given – for example when data come from a transport model – and then occupancy rate is derived out of the vehicle kilometre (vkt) and the transport performance (pkm/vkt = occupancy rate). Transport statistics/literature, surveys and observations are the most current sources (Table 7).

Average load of freight vehicle in tons per vehicle category e.g. articulated trucks is more difficult to find as occupancy rate, if statistics or the literature does not provide values. The complete equation is given below:

$$Transport\ performance\ (tkm)_a = Total\ annual\ mileage_a \times \underbrace{vehicles'transportation\ capacity_a \times load\ factor_a}_{\text{average vehicle load in tons}}$$

Transportation capacity: in tons

Load factor: % of utilization of the available capacity based on ton.km a: vehicle category (ex: articulated truck)

The average load to enter in the MobiliseYourCity Emissions Calculator for one vehicle category is the weighted average6 of the payload of the vehicles included in the given category (ex: all light commercial vehicles). To calculate load, capacity and load factor have to be collected if not available in the literature e.g. freight statistics/study. Table 7 gives possible sources.

Table 7 Sources for average occupancy rate / average load

Data output	Possible data source	Means of transportation covered	Details
Occupancy rate	Trip surveys (e.g. at parking lots, refuelling stations, market places, churches, on board for public transport). Video counting or expert guess	Possibly all passenger vehicles	Occupancy rate can be obtained by surveys or extrapolation based on main roads results. Video counting can be used. Occupancy rate for a perimeter can be determined by expert guess or comparison with similar territories
Capacity and average number of passengers per vehicle	Public transport statistics	Bus & rail	Public transport operators often have own operating statistics, which include mileages as well as offered and actually provided transport performance (seat-km and passenger-km)
Capacity and load factor	Logistic firm surveys	Trucks	The fleet and truck usage must be representative of the national/local fleet Extrapolation on the entire freight vehicle fleet
	Weight stations	Trucks	Extrapolation on vehicle stock needed Warning : representativeness of fleet
	Theoretical load factor	Trucks	Computing average mileage (vkt) and vehicle stock by administrative load factor permit to calculate global theoretical load factor

[6] Based on the share in the total mileage of the vehicle category

Data output	Possible data source	Means of transportation covered	Details
Payload and empty trips	■ National statistics	■ Trucks	In some countries, freight transport statistics include mileage of registered trucks, payload (= capacity x load factor) for trips with loaded trucks and mileage with empty trucks. Calculation of average load factors of truck traffic requires including both loaded and empty trips
Freight transport performance	■ National economic statistics	■ Trucks	If national statistics on freight transport performance (number of transported tons x average transport distance) are available they can be combined with national truck mileage to estimate average load factors (which might also be applied as approximate figures on city level).

4.1.2. Energy efficiency

Mileage shares per fuel type

Once the total vehicle mileage per vehicle category is known, it must be subdivided by fuel type e.g. the share of diesel car on the car category's total mileage. There are different possibilities to derive this percentage; one of the most common options is given in the example below.

Example: in country A, 40% of registered cars are diesel cars and 60 % are gasoline cars (static vehicle stock). The average mileage has been gathered by fuel type. Diesel cars have a mileage of 15 000 km/a and gasoline cars 9 000 km/a. Then, the share of diesel cars in the car mileage ("dynamic fleet") is weighted based on combining car registration shares and fuel-specific annual vehicle mileages i.e. 53% for diesel and 47 % for gasoline.

Table 8 Sources for share of road mileage by fuel type

Data output	Possible data source	Means of transportation covered	Details
Vehicle stock (static) by fuel type	■ Vehicle registration statistics	■ Possibly all road vehicles; characteristics depend upon collection method and can vary from country to country	(see Table 5)
Fleet (dynamic) per fuel type	■ Vehicle type survey (parking surveys, traffic surveys, household surveys etc.)	■ All means of road transport surveyed (cars, motorcycles, trucks/buses)	Data on the motorisation type are gathered through survey
Fleet (dynamic) per fuel type	■ Vehicle counts or observations	■ All means of road transport observed (cars, motorcycles, trucks/buses)	Fuel type of vehicles is observed within the territory (investigators on site)
Average annual vehicle mileage (per vehicle and fuel type)	Main inspection data (odometer) or Vehicle activity survey ■ See Table 5	■ See Table 5	Average mileage may differ according to fuel type. Therefore fuel type of vehicle should be specified while gathering data on annual average mileage

Share of mileage per energy type (electric vs. diesel traction) for freight and passenger train should be available from the national rail operator.

Specific fuel consumption factors

Once transport activity i.e. mileage by mode and fuel is known, it needs to be multiplied with adequate fuel consumption factors.

Since many factors that influence fuel consumption vary significantly from country to country, country-specific emission factors are recommended. Using international default values can introduce high uncertainties and does not reflect country-specific circumstances. In addition, improvements that affect emission factors, such as changes in vehicle fleets or improvements in driving conditions cannot be reflected in emissions calculations if international defaults are used. MobiliseYourCity can provide support for this process. However, default values from international databases (e.g. HBEFA, Copert, MOVES) can still be applicable if it is known that the vehicle stock in the country has similar technical characteristics (e.g. similar vehicle sizes, high share of imported vehicles from European Union (HBEFA, Copert) etc.).

If there are no big differences in the fleet compositions across different cities within the country, using national averages for urban fleet composition is a possible approach. Where the fleet is known to be quite specific, however, these local characteristics should be accounted for.

The MobiliseYourCity Emissions Calculator requires building average energy consumption for one vehicle category and one fuel type (e.g. 25 l/100km for diesel buses). We recommend calculating a fuel consumption weighted average based on the kilometre shares of different sub-categories (bigger cars with higher specific fuel consumption tend to be more in use than small cars) as detailed in the equation below. It is possible to use sub-categories for similar vehicles (to define according to the local context). The average fuel consumption factor of one vehicle category is then the weighted average of the fuel consumption factors of each sub-category.

$$FC_{\beta}=\sum_{z}^{a}\left(\frac{Number\ of\ vehicle_a \times average\ annual\ vehicle\ mileage_a}{total\ mileage\ of\ the\ vehicle\ category} \times specific\ fuel\ consumption_a\right)$$

a -> z: vehicle sub-category, e.g. small cars
FC β: Average fuel consumption per fuel type and vehicle category e.g. diesel cars

The specific fuel consumption should ideally derive from:

- Technical parameters of the vehicle, such as vehicle size, engine type, engine capacity, vehicles' age[7] and maintenance level.
- Operating conditions, such as road type (e.g. city centre vs highway), driving cycles. These depend primarily on transport infrastructure and traffic flow.

The example in Table 9 gives an average fuel consumption of the diesel car fleet of 7,07 l/100km.

Table 9 Example deriving fuel consumption of a vehicle category

Diesel vehicles	Number of vehicles	average annual mileage	Specific fuel consumption
small	10	10 000	5
middle	15	12 000	7
big	5	15 000	10

Table 10 shows sources to collect specific fuel consumption. If average mileage per vehicle category and fuel type is not available or if vehicle categories are homogeneous, a non-weighted average of fuel consumption can be used as proxy.

[7] As emission standards, e.g. Euro 1-6 are phased in over time, data on emission concepts can be used as a proxy indicator for vehicle age.

One should pay attention to the way fuel consumption is derived and communicated (depending on the test cycles) and the real consumption of vehicles. In Europe a substantial gap is visible between type approval data in official testing procedures as NEDC (New European Driving Cycle) and the global harmonized WLTP (world harmonized light-duty vehicles test procedure[8]) and real world data. It is recommended to derive as far as possible real-world fuel consumption data[9].

If it is known from vehicle fleet analyses that the own fleet has similar characteristics to other countries, also real-world fuel consumption factors of these countries can be used at least as approximate values. E.G. the European Handbook of Emission factors (HBEFA) includes real-world fuel consumption data on a high resolution by sub-category and traffic situation, but also for individual fleets of different European countries weighted average values per vehicle category and road type. As typical passenger cars have comparable characteristics in many countries, it can therefore be an option also for other countries[10].

Table 10 Source for vehicles fuel consumption

Data output	Possible data source	Means of transportation covered	Details
Specific fuel consumption of vehicles	■ Type approval data on vehicle fuel consumption (given by car manufacturer : NEDC/WLTP)	■ All registered vehicles	NEDC/WLTP fuel consumption (given by car manufacturer) for the local fleet Warning: to obtain real world consumption, a correction factor should be applied, which also includes the vehicle age[11] Does not take into account local driving characteristics and vehicle age/maintenance
	■ Lab test cycles[12]	■ Vehicle sampled	Big sample and high investments are necessary Sample should be representative of the fleet
	■ Observed vehicles consumption (inspection data, onboard diagnostics)	■ Controlled vehicles	Real world and local data but limited to new models (electronic display) large number of vehicle sample necessary

[8] https://www.wltpfacts.eu/

[9] Read for example Zifei. Y. et al. (2018) showing data gathering in China

[10] E.g. in Bongardt et al. (2015) it is explained how emission factors from HBEFA have been adopted to fleet composition and traffic situations in Chinese cities.

[11] ICCT (2019) show that the gap between type approval data and real-world fuel consumption has increased for new passenger cars in Europe in the last years.

[12] The test procedure provides a strict guidance regarding conditions of dynamometer tests and road load (motion resistance), gear shifting, total car weight (by including optional equipment, cargo and passengers), fuel quality, ambient temperature, and tyre selection and pressure.

Average fuel consumption of public transport modes is often available from the public/local operator(s). For trains the same data may be available from the national rail operator (for freight and passenger). For average mileage refer to Table 5.

If no country-specific emission factors exist or can be calculated, international (or possibly regional) default values for real-world fuel consumption can be used as a fall-back option. Available sources are (list non-exhaustive):

- COPERT provides detailed average fuel consumption (called emission factors) per vehicle characteristics for the European fleet[13] free of charge
- HBEFA provides specific fuel consumption for European fleet. Detailed factors in high resolution (chargeable), but also a free online tool with average factors per vehicle category and fuel type for single European countries[14]
- Curb tool from the World Bank[15] (methodology on fuel consumption not specified)
- Case studies of IVE International vehicle emission model[16] (quite old)
- GFEI (Global Fuel Economy Initiative) including in-country reports (for Africa, South America, Asia etc)[17] Factors are not weighted average but directly derived from the fleet composition based on NEDC/WLTP values

It is of course recommended to cross check the obtained data and possibly follow more than one methodology to compare results.

CO_2eq emission factors per fuel

Specific GHG emission factors (CO2, CH4, N2O in gCO2e/ MJ) apply according to the different fuel types (gasoline, diesel, CNG, LNG). Defaults emission factors are available and widely used: in the MobiliseYourCity Emissions Calculator, the IPCC defaults are used for tank-to wheel emissions. Some countries may have different emission factors due to the composition and the location of the fuel production, which they can enter in the tool. Well-to-tank emissions stems from eco-transit[18]. If local upstream emission factors are available, they should be used instead.

A locally relevant factor is the CO2 content of the electricity consumed in the assessed area, which varies greatly from country to country (and possibly between regions/cities). It is an input parameter for the MobiliseYourCity Emissions Calculator. It should be available from the local electricity

[13] https://www.emisia.com/utilities/copert/documentation/

[14] https://www.hbefa.net/e/index.html; https://www.hbefa.net/Tools/DE/MainSite.asp

[15] Data set for different countries available within the tool: https://www.worldbank.org/en/topic/urbandevelopment/brief/the-curb-tool-climate-action-for-urban-sustainability

[16] http://www.issrc.org/ive/

[17] https://www.globalfueleconomy.org/in-country

[18] https://www.ecotransit.org/, EcoTransIT World is the most widely used software worldwide to automate the calculation and analysis of energy consumption and freight emissions. The software is accredited by Smart Freight Centre to be in accordance with the GLEC Framework and also meets the requirements of EN 16258 and the GHG protocol (Corporate Standard).

producers. The average CO2 content of the local electricity mix in gCO2/kWh is necessary for road and rail separately, because some rail companies produce their own electricity.

4.2. Business-as-usual scenario of future transport activity

After defining the initial situation in your city/country, it is necessary to project transport emissions into the future on a business-as-usual basis (for the definition of a business-as-usual scenario please refer to Chapter 2). The list of data required for the MobiliseYourCity Emissions Calculator is given in Table 11 and Table 12 (optional ones).

Table 11 List of compulsory data for the BAU scenario

Category/Parameter	Unit	Sensitivity for results	Data scope for countries	Data scope for cities
Annual mileage growth rate per vehicle category	■ Annual %	■ +++	National	City
Average mileage share by fuel type and vehicle category in future years	■ %	■ ++	National	National
Annual change in average energy consumption of vehicles in future years	■ Annual %	■ +++	National (or regional)	National (or regional)
Specific GHG emission factor of electricity production for road	■ gCO2/kWh	■ +	National	National
Specific GHG emission factor of electricity production for rail	■ gCO2/kWh	■ +	National	National

Table 12 List of optional data for BAU scenario

Category/Parameter	Unit	Sensitivity for results	Data scope for countries	Data scope for cities
Population growth rate	■ Annual %	■ +	National	City
GDP growth rate or Gross market product (GMP) for cities	■ Annual %	■ +	National	(City)
Specific GHG emission factor of electricity production for rail	■ gCO2/kWh	■ +	National	National

4.2.1. Transport activity

Main input for transport activities in the BAU scenario is **vehicle mileage**. This input should be given in the form of an annual mileage growth rate per vehicle category in the MobiliseYourCity Emissions Calculator. If there is no official projection of future transport development already available in your country/city, it will be necessary to create an expert panel to establish forecasts. The projection of the mileage per vehicle category (annual change) is often modelled by transport planning experts (see Box 6). In simple approaches, future developments in passenger transport can be estimated using a correlation with population growth (assuming that average mobility per person does not change considerably), and future development in freight transport is correlated to GDP growth (per type of good). In case that no well-founded projection of transport development is available or can be elaborated, this might enable at least a rough estimate of future transport developments (see further explanations below).

Box 6 : Projection for transport planning model

Demand side

For the demand part, projections can be based on :

- GDP projections
- Population projections
- Consumption projections
- Urban project demand (to be considered in the perimeter)

Supply side (network)

For the supply part, projections can be based on :

- Road projects
- Public transport project
- Non-motorized transport project

Alternatively to a transport model, the fleet approach can be used with a model on future fleet renewal. It projects the future vehicle fleets taking into account number of new registrations and scrappage rate. New vehicle stocks can then be multiplied with an average mileage per vehicle category to obtain the total mileage. If scrappage rate and new registrations cannot be derived directly (for example by using historical values) future vehicle fleets can be roughly estimated thanks to logistic or Gompertz functions once calibrated with historical data.

Such sigmoid functions can also be used to directly estimate roughly mileage development if fleet data are missing. The two main parameters are: population (esp. for passenger transport) and GDP (esp. for freight). Nevertheless, several other parameters play a role such as the level of infrastructure, economic rise of the country, increasing vehicle ownership, fuel prices etc. (see for example Wu and ale (2014) or Singh (2006)). MobiliseYourCity can provide support for this process to participating cities or countries.

Operators of public transport (bus and rail) should be able to provide plans on the expected changes in the transport offer in order to derive a growth rate of vehicle kilometres and/or transport performance.

In the MobiliseYourCity Emissions Calculator **occupancy rate** and **load factors** of the inventory (base year) are used for the BAU scenario in order to limit the number of input. If this is problematic for your assessment, please contact MobiliseYourCity secretariat.

4.2.2. Energy efficiency

The first input parameter for future energy efficiency in the BAU scenario is the average mileage share by fuel type per vehicle category. This percentage can be derived based on a fleet model and the projected vehicle annual mileages. If no major change is expected in the shares of the different fuels within the vehicle categories’ mileage, the inventory values can be used also for future years (see

Table 8). If major changes in the repartition of the mileage by fuel type are expected due to trend developments or national plans that are independent from SUMP/NUMP activities (e.g. a national strategy an alternative fuels for truck transport), new percentage should be calculated for concerned vehicle categories. For public transportation, the data are much dependent on local Public transport operators (bus, rail), who should be able to plan the development of the vehicle fleet and the type of fuel, e.g. electrification of the rail network.

The second parameter is the fuel consumption per vehicle category and fuel type. Fuel efficiency changes in the BAU include all developments, which are independent from the measures in the SUMP/NUMP to be evaluated. In several countries, fuel efficiency improves over the years together with technological improvements and the tightening of norms. Nevertheless, this depends on several factors, which may counter-act with technical developments such as the increase of the average size of the fleet (e.g. if SUVs sales increase). The change in fuel consumption should be calculated in the form of an “annual change in average energy consumption per fuel type and vehicle category”.

The parameters, which play a central role in fuel economy, are:

- New registration i.e. fleet development incl. size, motorization
- Technical improvements and norms e.g. EU regulation on CO_2 emissions limits for trucks

The only way to plan this development at the national level is to have a fleet model, which can calculate fuel economy based on new registrations and expected energy efficiency. Such a model is used for example by COPERT or HBEFA. It is generally developed at the national level and cities can use the national defaults. One can fine tune these defaults for the local level if there are strong specificities e.g. local plan to reduce traffic jams (that ist not part of the SUMP).

For public transportation, the data are much dependent on the local context i.e. plan for bus fleet renewal from local operators. Rail operators should also be able to plan the development of their vehicle fleet.

There is a quite large literature on the topic “fuel efficiency”, but deriving defaults without fleet models is quite difficult, as fuel economy is very sensible to the above mentioned influencing parameters. International defaults can nevertheless be used if a (even simple) fleet model is not available. A non-exhaustive list of sources is given below:

- the GFEI (see UNEP (2011)) and the case studies available on the GFEI website
- Fuel economy in Major Car Markets of the IEA[19]

Finally, local or national electricity producers should be able to deliver specific GHG emission factor of expected future electricity production for road and rail sectors (in CO_2eq/kWh consumed).

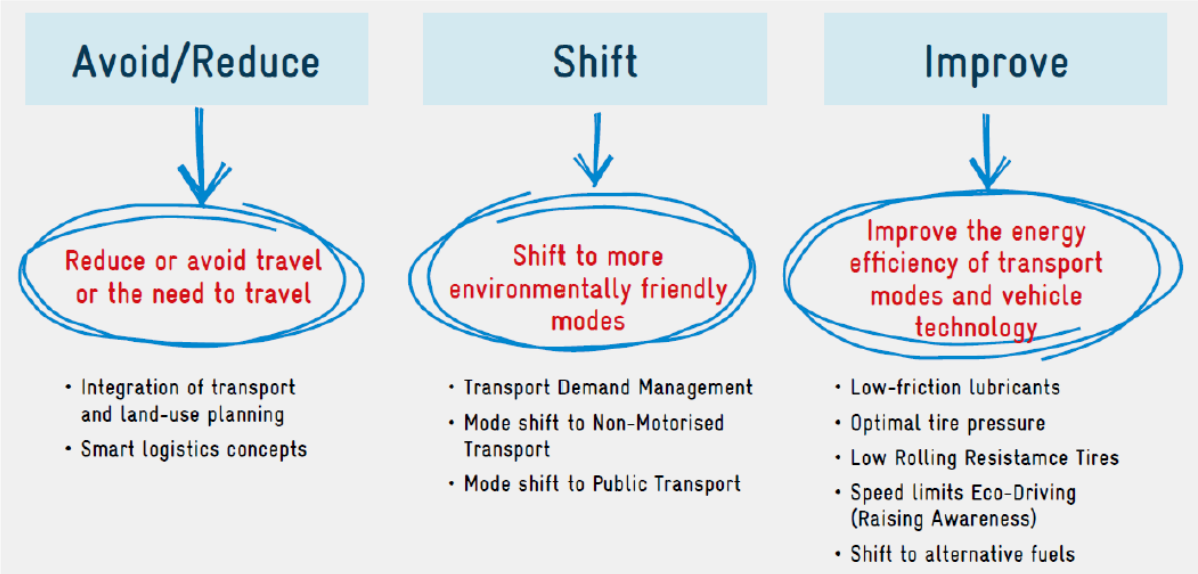
- Projection of the CO_2 eq content of the electricity mix is a relevant input for the MobiliseYourCity Emissions Calculator. This data should be provided by electricity producers or energy ministries based on the expected development of the electricity production mix (for example if it is planned to increase the share of renewable energies in the grid mix).

[19] https://www.iea.org/reports/fuel-economy-in-major-car-markets

4.3. Climate scenario and projected GHG emission reduction

Calculating the impact of NUMP/SUMP measures in the MobiliseYourCity Emissions Calculator requires bundling measures based on the ASI: Avoid-Shift-Improve approach as described in Figure 5 below.

Figure 9 ASI approach



Source: Bakker S. and al. (2016)

Please consider that the mitigations measures of SUMPs and NUMPs focus on urban mileage. This is straightforward for SUMPs and cities. However, inventory and BAU scenario in a NUMP will in most cases include total mileage on national level, not only urban mileage. Total national mileage could be used as a basis for a first simplified approach as it is very difficult to have a proper estimate of the share of emissions from urban mobility at national level. Nevertheless, if any possible it is highly recommended to separate urban mobility from rural as well as long-distance mobility in order to relate calculated measure effects (e.g. % mileage avoided) only to the particular mileage share under the action field of the NUMP and, hereby, avoid overestimating GHG reduction potentials of the NUMP. Some methodological advice how the proportional impact of urban measures on total national transport can be estimated is given in Annex 3.

4.3.1. Transport activity

The list of compulsory data to gather for both passenger and freight transport in the Climate scenario is given in g tool) is detailed in Annex 1.

Table 13 (all data are required). The user has to choose between *1 the first method where the mileage is directly given in km and pkm (e.g. taken from a transport planning tool) or *2 the second method that relies on a step-by-step approach to give the results of avoid and shift packages of measures compared to BAU. The exact “background calculation” used in the MobiliseYourCity Emissions Calculator for transport activity in the climate scenario (for the option without transport planning tool) is detailed in Annex 1.

Table 13 List of compulsory data to derive new mileage for the Climate Scenario

Category/Parameter	Data required for	Unit	Sensitivity for results	Data scope for countries	Data scope for cities
Total annual vehicle kilometres travelled per vehicle category *1	■ Passenger and freight climate scenario	■ Mio km	+++	National	City
Total annual person-kilometres transported per vehicle category *1	■ Passenger climate scenario	■ Mio pkm	+++	National	City
Total annual ton kilometres transported per vehicle category *1	■ Freight climate scenario	■ Mio tkm	+++	National	City
Avoided motorized mileage by vehicle type *2	■ Passenger and freight climate scenario	■ % of the yearly mileage	+++	National	City
Additional mileage per sustainable transport modes *2 **	■ Passenger climate scenario	■ Mio km	+++	National	City
Additional mileage per sustainable freight vehicle category*2	■ Freight climate scenario	■ Mio km	+++	National	City
Average occupancy rate of passenger transport modes ** 2	■ Passenger climate scenario	■ Passenger/vehicle	++	National	City
Average load per vehicle[2]	■ Freight climate scenario	■ Tons/vehicle	++	National	City
Origin mode of transportation of the new public transport passengers[2]	■ Passenger climate scenario	■ % of trips	+++	National	City

Category/Parameter	Data required for	Unit	Sensitivity for results	Data scope for countries	Data scope for cities
Origin mode of the shifted tkm[2]	■ Freight climate scenario	■ % of the tkm	+++	National	City
Legend: + low; ++ medium; +++ high impact; ** sustainable transport modes for passenger transport are: non-motorized transport, minibus, bus, bus rapid transit, long distance train, urban train and metro; *1 vehicle kilometre approach used when a transport planning tool and/or traffic counts are available; *2 fleet approach based on number of vehicles and average vehicle mileage.					

The option 1 with transport planning is calculated within the model based on required inputs as already explained for the BAU scenario in box 6 (section 4.2.1).

We concentrate in the following section on the step-by-step approach (option 2), which should deliver:

- For Avoid: Avoided motorized mileage per vehicle type
- For Shift: mileage and transport performance added to sustainable transport modes & share (%) of this additional transport performance shifted from cars (passenger transport) and trucks (freight transport). New occupancy rates if they are expected to change.

Depending on the type of measures implemented and the national/local context and data availability, the concrete calculation of the expected impact of the bundled measures will differ. An example of a calculation path for a dummy case study is given in the following section. We recommend relying on an expert panel to estimate the impact of the measures in the Avoid/Shift/Improve categories as well as workshops to validate the results. The end results of such a process should always be taken as an order of magnitude. The calculation of ex-ante impact of measures is a very sensitive process. Therefore it is of high importance to specify methodologies and cite all sources and assumptions. Contact MobiliseYourCity Secretariat if support is required.

Avoid measures

Avoid measures have a direct impact on the total amount of kilometres travelled by all modes as they reduce the transport demand by lower number of trips and/or the trip distances.

For example, city A plans a reduction of taxes for companies, in which more than 25% of the working time is done in home office in 2018. The effect is expected to be seen in 2020. To derive the potential effect of this measure, we have first to identify:

1) Which vehicle categories are impacted: We do not expect to have an impact on the bus service in the city, so we exclude buses and similar public transport modes. We expect a clear effect on cars and motorcycle mileage.

2) How many vehicle kilometres are saved?

- They are 10 000 companies in the city territory and the number of registered workers is 50 000 (one may exclude small businesses to ease data analysis). We consider that about 20 % of the companies will adopt home office. We hypothesize that within these companies app. 30 % of the workers stay in home office i.e. 3 000 persons (criteria: personal convenience, trip necessary to bring child at school, no place at home etc.).
- Each worker works on average 300 days per year (365 minus one free day per week, paid leave and sick leave). The average trip distance from home to work within the city is 4 km both for cars and motorcycle (data out of survey). This means saving 8 km per day per worker (from home to work and back again) and 7.2 million-kilometre per year for all workers.
- 80% of the workers are using cars and 20% are using motorcycles to go to work.

If the policy impacts the behaviour of the expected 3 000 workers, we expect a mileage reduction of 5.8 million km for cars and 1,4 million km for motorcycle per annum. This corresponds to 0.6 % of the total car and motorcycle mileage of commuter traffic within the city boundary in 2020. As commuter traffic has a share of 33% on total car and motorcycle traffic, total mileage of these transport modes in the city is reduced by 0.2 %.

If the measure is expected to have an increasing impact because new companies subscribe to this program, this impact must be calculated with updated figures for the following reference years.

If several measures impact the avoided kilometre, their bundled impact should be calculated, taking into account their possible interactions.

Shift measures

Shift measures (in passenger transport) aim to shift passengers from individual transport modes (cars, motorcycles) to public transport or non-motorized walking and cycling. Measures range from the extension of PT services (e.g. new metro line), PT ticket price reduction to (higher) parking fees in the city centres. Assessment of bundled impacts for all shift measures must consider the mileage reduction of car and motorcycle traffic, but also the increase of bus or rail mileage.

- Additional mileage per sustainable transport modes in km i.e. NMT, minibuses, bus, BRT, train, urban train, metro (for passenger) / Additional mileage per vehicle category in km (for freight)
- Average new occupancy rate of sustainable transport modes (person/vehicle) / Average load per vehicle in tons (for freight)
- Origin of new passengers / goods in the sustainable transport modes: Which share (%) of additional sustainable transport performance is shifted from cars (passenger transport) and trucks (freight transport).

Example: Bus mileage in the city is expanded by 1 000 km per year. Average occupancy rate of these new buses is 12 persons per vehicle. Thus, public transport performance increases by 12 000 pkm per year. Of these new passengers about 50 % have shifted from car traffic – accordingly, car transport performance is reduced by 6 000 pkm per year. As the average load of the cars is 1.2 persons, car mileage is reduced by 5 000 km.

4.3.2. Energy efficiency

Once all Avoid and Shift measures are assessed and the corresponding impact entered in the MobiliseYourCity Emissions Calculator, SUMP/NUMP measures affecting the penetration of alternative fuel and the energy efficiency of vehicles must be assessed. Please note: Only those changes should be accounted for in the climate scenario that are addressed by the SUMP/NUMP measures. If future fuel type changes or efficiency improvements are initiated by other programs (e.g. national fuel strategy) that are not part of the NUMP they have to be considered already in the BAU (see section 4.2.2).

In the same way as above, similar measures should be bundled and deliver measure impacts for each reference year in the form of:

- the share of the mileage per fuel type for each vehicle category (%)
- the specific energy consumption per vehicle category and energy type (l/100km kg for natural gas and kWh for e-cars))

Mileage share per fuel type

The mileage share per fuel type within a vehicle category is impacted by measures which affect the shares of different fuel types in the vehicle stock in urban areas (e.g. subsidies for alternative fuel vehicles, driving bans for diesel cars) or the average annual mileage per fuel type (e.g. tax increase on one fuel type). An example how to calculate the impact is given below. In our example only urban areas are considered. Please consider that for NUMPs, only the impact of the measures in the urban area should be quantified.

Example: Experts expect 300 additional registrations of e-cars in urban areas in 2030 thanks to local subsidies. With an average annual urban mileage of 5 000 km per e-car total additional e-car mileage is 1.5 million km in 2030. Compared to the expected total national car mileage in 2030 of 60 million km, additional e-cars represent a mileage share of 2.5 %. If the BAU already considers e-cars (e.g. market trend), this measure-driven additional mileage has to be added to the BAU electric mileage share.

Specific fuel consumption

The specific fuel consumption per vehicle category and fuel type is impacted by measures targeting fuel efficiency such as fuel efficiency standards. The quantification of the impact of the NUMP/SUMP measures requires assessing:

- the type of fuel concerned by the measure
- the share of the vehicles impacted within a vehicle category
- The expected fuel consumption reduction in %

Fuel efficiency standards usually are valid for the whole country, but not on city level. They should only be assigned to the climate scenario if they are part of a NUMP to be evaluated. Otherwise, they have to be considered already in the BAU as their impacts should not be attributed to NUMP activities.

Example: A CO_2 emission limit for trucks is implemented and requires a reduction of specific fuel consumption of new diesel trucks between 2020 and 2030 by 20 %. Fuel saving technologies are gradually introduced in new trucks (i.e. 2 % efficiency gain per year compared to BAU). The number of new diesel trucks is 15 000 per year representing 5 % of the total diesel truck fleet. Accordingly, total share of trucks in 2030 affected by the measure is 50 % (= new registrations 2021-2030), they are on average 10 % more fuel-efficient compared to BAU. Accordingly, total truck fleet is 5 % more fuel-efficient in 2030. If average fuel consumption of the diesel truck fleet in BAU 2030 is 20 l/100km, in the climate scenario an average fuel consumption of 18 l/100km is reached.

5. Monitoring GHG Emissions and Ex-post Evaluating Effects of Measures

Ex-post evaluations deliver the resulting GHG emissions after the implementation of SUMP/NUMPS measures based on renewed assessment of the transport activity in a country/city. Data gathering methodologies and sources are therefore quite similar to the inventory in the initial year. However, resources for conducting ex-post evaluation being often scarce, data analysis work should first concentrate on the inputs, which have been impacted by the NUMP/SUMP, but also on not NUMP/SUMP-related parameters that have been affected substantially due to other reasons (e.g. other national or international action plans, economic crises).

5.1. Mobility Observatory

Establishing a mobility observatory is an effective and reliable way to update data and ensure a continual monitoring of GHG emissions and KPIs. The objective of the mobility observatory is to develop a governance structure which regroups all mobility actors in territory, to sustain the inventory and monitoring process of transport GHG emissions. This observatory will define a tool to enable the monitoring of reference figures and analyses on mobility in a territory.

The monitoring will concern different missions such as:

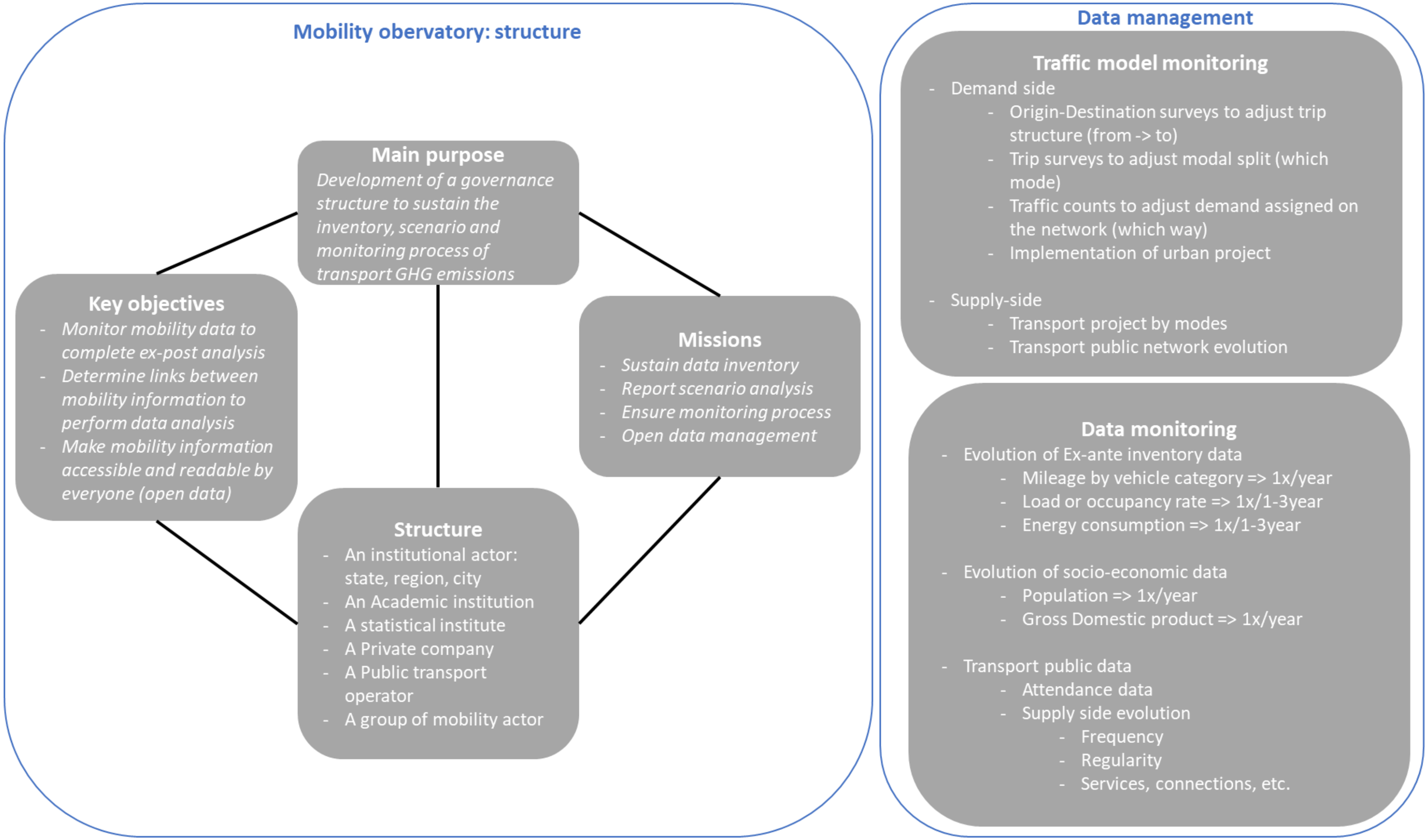
- Sustain data inventory
- Report scenario analysis
- Ensure monitoring process
- Open data management
- Traffic model monitoring

Main important data (some are cited below) for specific points will be collected and analysed at regular time intervals to give trends. Some data that could be exploited:

- Traffic counts (roads, public transport, etc.) by types
- Results of surveys (vehicle activity, mobility behaviour)
- Vehicle statistics (e.g. car stock by drive concept and age)
- Public transport data
- Etc.

A continual monitoring of data permits to calculate the impact of a transport project on GHG emissions.

Figure 10 Observatory structure



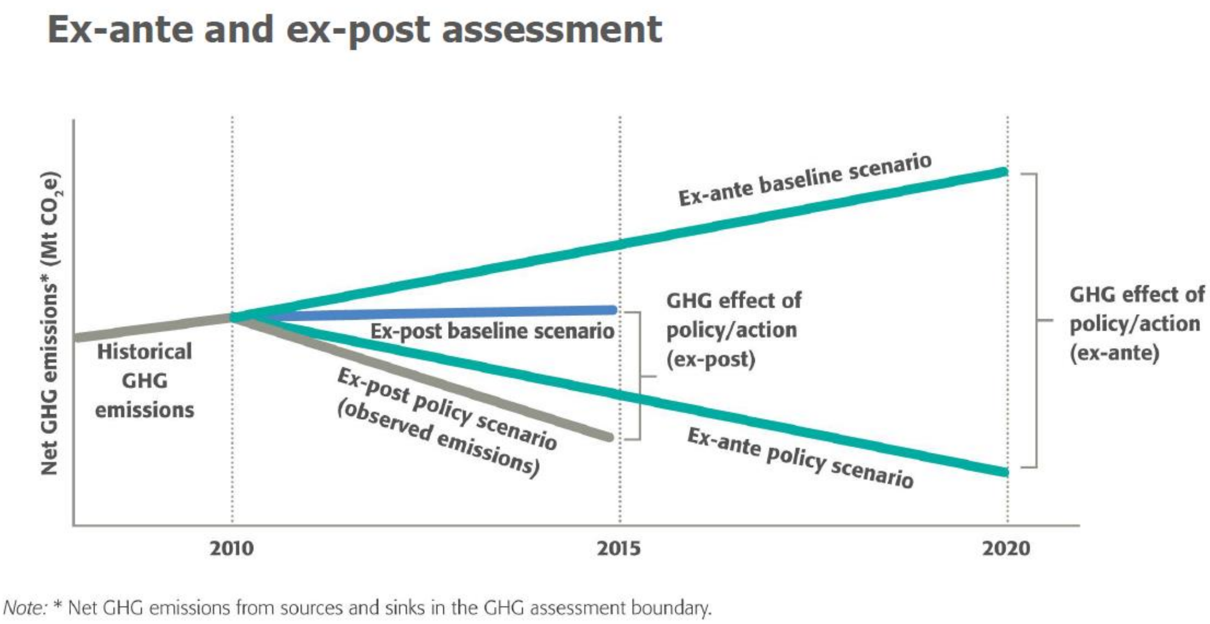
5.2. Ex-post Evaluation of GHG Emissions

In order to evaluate the mobility-related GHG emissions after the implementation of the NUMP/SUMP, a transport GHG emission inventory must be carried out as for the base year in the ex-ante evaluation (for example carried out in base year 0, see section 4.1). Comparing this GHG inventory of the new monitoring year to the base year shows the real development of GHGs in the time frame. Additional comparisons can be helpful for particular sections (e.g. only passenger transport) or for specific developments (e.g. GHG emissions per inhabitant). Now, these developments can be compared to existing GHG emission paths forecasted in the SUMP/NUMP to evaluate if the city/country is well on track to meet the targets or if measures need to be enforced.

> For example: the SUMP of a city estimated that 400kg CO2e were emitted per capita in 2020 in the city due to urban transport. The SUMP forecasted that, in 2025, 350kg CO2e will be emitted per capita if the SUMP is implemented as planned. An ex-post evaluation is conducted for 2025, which estimates emissions at 375kg CO2e per capita. SUMP targets for this city are hence only halfway met in 2025.

Simple comparison of monitoring results shows if the city/country is on track for its GHG targets. However, it does not allow for an evaluation to what extent these developments have been achieved by the implementation of the SUMP/NUMP. GHG reductions can also be the consequence of unexpected further developments that are not driven by the SUMP/NUMP measures and might have even stronger impact on GHG reductions, e.g. strong reduction of freight transport in consequence of a economic crisis. It is, therefore, helpful to update also the ex-ante baseline (BAU scenario, section 4.2) based on important real developments of parameters not affected by the NUMP/SUMP (e.g. GDP, population, electricity mix, trend development of passenger and freight transport demand). Comparing real GHG emissions development to this ex-post baseline reveals the “real GHG effect of the SUMP/NUMP” (see Figure 11).

Figure 11: Scheme of ex-ante and ex-post assessment of GHG emissions



Source: WRI (2014b)

Finally, real GHG emission developments can also be compared to projected GHG emissions developments in the (updated) ex-ante climate scenario to analyse reasons for gaps, which concern the implementation of the SUMP/NUMP measures, such as:

- Delayed or weakened implementation of the SUMP/NUMP measures
- Over or under-estimation of the impacts of the measures
- Other measure-related factors that were not originally planned played a role

The effort to invest in ex-post GHG emissions calculation is generally lower as for the ex-ante assessment as collection methods and sources are known, and not all data must be updated. The data to update in priority are given in Table 14. Parameters with high priority should be updated in all cases.

Other parameters can be taken out of the ex-ante assessment if they are not impacted by the SUMP measures and if no other significant changes occurred compared to the original BAU calculations (e.g. due to overall national mitigation measures). For example if the SUMP only consists in avoid and shift measures, energy efficiency parameters do not need to be updated if we expect no change with the ex-ante BAU values.

Table 14 Update priority for ex-post assessment

Category/Parameter	Unit	Priority for update
Total annual vehicle kilometres travelled per vehicle category *1	Mio km	high
Vehicle stock (total number of vehicles) per vehicle category *2	Nb. Of vehicles	high
Average annual mileage per vehicle category *2	Km/veh/year	high
Average occupancy/load per vehicle category	Person or ton/vehicle	Depending on SUMP/NUMP
Average trip length per vehicle category	Km/trip	Depending on SUMP/NUMP
Average mileage share by fuel type and vehicle category	%	Depending on SUMP/NUMP
Average energy consumption per vehicle category and energy type	L/100 km (kg for natural gas and kWh for e-cars)	Depending on SUMP/NUMP
Population - Number of inhabitants	Nb of Inhab.	high
Gross domestic product (GDP) or Gross market product	USD Billion	high
Specific GHG emission factor of electricity production for road	gCO2/kWh	high
Specific GHG emission factor of electricity production for rail	gCO2/kWh	high
Specific GHG emission factors of fuels (fossil, renewable)	gCO2/kWh	Depending on SUMP/NUMP
Fuel consumption for road and rail sectors per fuel type in the energy balance	1000 Toe	high

*1 vehicle kilometre approach used when a transport planning tool and/or traffic counts are available; *2 fleet approach based on number of vehicles and average vehicle mileage.

6. Step-by-step approach to GHG monitoring and reporting

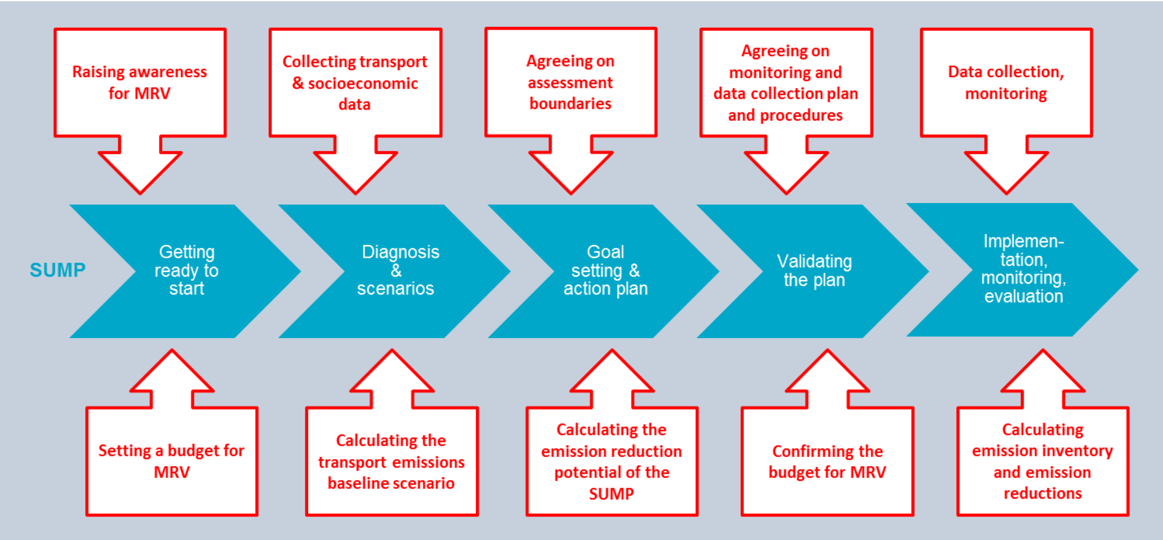
The previous sections set out the MobiliseYourCity approach to GHG monitoring and reporting. They also highlighted how these principles fit into the broader monitoring framework, including sustainable mobility and implementation indicators. A rough impact assessment should already be conducted initially to identify each SUMP's or NUMP's emission reduction potential. The following checklist sums up the key elements of a successful Monitoring, Reporting and Verification process during the development and implementation of SUMPs or NUMPs. Figure 12 illustrates how the MRV process aligns with the main steps of the SUMP/NUMP process.

Checklist Monitoring and Reporting	
SUMP Step 1: *Getting ready to start*	
The needs for external support on MRV are assessed	
A budget for MRV is set	
SUMP Step 2: *Diagnosis & scenarios*	
Transport data availability is checked and available data collected	
Baseline scenario for transport emission development is calculated and assumptions are agreed upon among relevant stakeholders	
SUMP Step 3: *Goal setting and action plan development*	
Expected effects of the planned SUMP and actions are described (cause-effect relation/logical framework)	
Scope of the monitoring approach is set (assessment boundaries)	
GHG impact of the SUMP has been calculated ex-ante	
Limitations of the GHG emission quantification are described (uncertainties)	
Sustainable mobility benefits have been assessed ex-ante	
SUMP Step 4: *Validation of the action plan*	
If necessary, adjust the ex-ante GHG impact calculation to the validated action plan for the SUMP	
Data needs and collection methods have been identified and agreed by relevant stakeholders	
Responsibilities for MRV have been assigned	
Precise budget for MRV has been confirmed	
A monitoring plan and procedures have been developed, including quality assurance	
SUMP Step 5: *Implementation and monitoring*	
Data is collected, processed and quality controlled continuously	
Emission inventory is calculated every 1-3 years	
The baseline scenario is recalculated ex-post and emission reductions are assessed every 1-3 years	
Supporting information to verify the GHG impact can be provided	
Implementation monitoring report is produced annually	
Sustainable mobility report is produced every 5 years (mid-term assessment)	

In reality, this process must be adapted to local circumstances and decision-making processes. As a result, timing may vary from city to city.

Data collection and management, as well as emission calculations, are iterative processes that can be improved over time as data availability increases. To ensure consistency and transparency in emission reporting it is important to clearly document all data sources, definitions and assumptions. If done correctly, monitoring and reporting can greatly improve the information basis for transport planning and vice versa. Most of the data needed for emission calculations must also be collected as part of the development of a sound SUMP/NUMP. At the same time, monitoring reports can be used to communicate progress, highlight the impacts of SUMP/NUMP implementation and help secure on-going support from stakeholders.

Figure 12: Overview of MRV steps in the SUMP/NUMP process



7. Appendix

7.1. Methodology of Mileage Activity in the Climate Scenario in MobiliseYourCity Emissions Calculator

In MobiliseYourCity Emissions Calculator, there are two options to derive transport activity for the climate scenario. The first one is based on a transport-planning tool, which should deliver the mileage for each projected year: 2020, 2025, 2030, 2040 and 2050. The methodology of projecting transport activity is then embedded in the transport-planning model.

There is a second option for users which do not have access to such a model. In this case, MobiliseYourCity tool calculates mileage activity of the climate scenario based on BAU values and the given share of kilometres shifted or avoided. A so-called "autonomous approach" is used in order to calculate the development of the mileage between the projected years. This means that the measures implemented in one year reduce transport activity in the implementation year, but do not affect the future growth of transport activity in the following years. This can be categorised as a conservative approach, which is described in a hypothetical example displayed in Table 15 and Figure 13.

Table 15 Exemplary values of the mileage in the BAU and the climate scenario

vkt	2015	2020	2030	2040
BAU	■ 100	■ 110	■ 150	■ 170
Cumulated shift/avoid measures	■ 0	■ 20	■ 20	■ 35
Scenario	■ 100	■ 90	■ 130	■ 135

- 2020: Mileage in the BAU scenario increases 2015-2020 by 10 km from 100 km to 110 km. Shift or avoid measures lead to a 20 km reduction compared to BAU in the climate scenario: 90 km.
- 2030: Mileage in original BAU increases by additional 40 km to 150 km. As there are no further shift/avoid measures in this time frame, this absolute mileage increase is added in the tool also for the climate scenario: 130 km. In this time frame without additional measures, mileage in climate scenario runs parallel to BAU scenario.
- 2040: BAU mileage increases by additional 20 km to 170 km. This absolute mileage increase is added in the tool for the climate scenario as a first step. However, this interim result (150 km) is reduced in the tool by the indicated effect of additional shift/avoid measures for this time frame (15 km). Thus, total mileage 2040 in the climate scenario is 135 km.
- The total gap between BAU and climate scenario of 35 km (170-135 km) is the cumulated amount of kilometres avoided or shifted in the climate scenario.

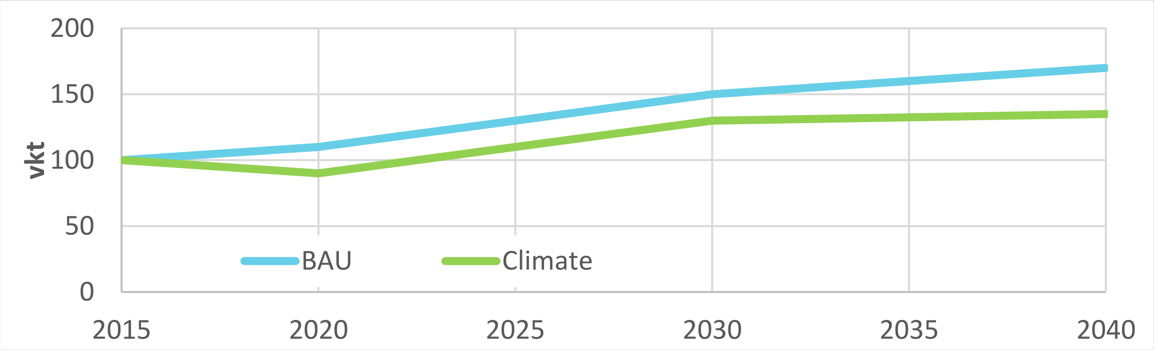


Figure 13. Exemplary development of transport activity (vkt) for the climate scenario in comparison to the BAU scenario

7.2. Further Possible Data Sources for Public Transport

Data to be derive	Data source	Means of transportation covered	Data format	System boundaries
Vehicle mileage (vkt) Transport performances (pkm) Transport capacity (seat/vehicle) Load factors (p/vehicle)	■ Public transport companies	■ - Bus - Subway - Regional train	For the entire public transport network or for different routes: ■ - Final energy consumption - Mileage - Pkm - Transport capacity - Load factors	■ Territorial: public transport network might differ to geographical boundaries of the city
Vehicle mileage (vkt)	■ Public transport network plans	■ - Bus - Subway - Regional train	■ Length of each public transport route	■ Territorial: public transport network might differ to geographical boundaries of the city
Vehicle mileage (vkt)	■ Public transport timetables	■ - Bus - Subway - Regional train	■ Service frequency of each public transport route (e.g. number of buses per day)	■ Territorial: public transport network might differ to geographical boundaries of the city
Vehicle mileage (vkt)	■ IC cards	■ - Bus - Subway	■ - Number of passenger trips - Pkm (only subway)	■ Territorial: public transport network might differ to geographical boundaries of the city

Data to be derive	Data source	Means of transportation covered	Data format	System boundaries
Transport performances (pkm)	■ Car hailing apps	■ - Taxi	■ - Number of passenger trips - Pkm	■ Territorial: public transport network might differ to geographical boundaries of the city
Vehicle mileage (vkt)	■ Trip survey	■ -Mini-buses	- Number of passenger trips ■ -Length of transport route survey	■ Territorial: informal transport network might differ to geographical boundaries of the city

7.3. Share of Urban Transport on National Transport Activity

Within the MobiliseYourCity framework, the focus is on urban mobility. This means that the climate scenario should only address impact on urban GHG emissions. However, the inventory in a NUMP (national context) will in most cases include total mileage on national level. Therefore, it should be tried, as far as possible, to separate urban mobility from rural as well as long-distance mobility in order to calculate measure effects (e.g. % mileage avoided) only for the particular mileage share under the action field of the NUMP. If specific measure effects of the NUMP are linked to the whole national mileage instead of urban mileage this will cause substantial overestimation of GHG reduction potentials.

If a national transport model is used for estimating measure effects, which includes differentiated data for urban, rural and long-distance mileages, the output of the model can directly be used, as calculations in the model should already relate effects of urban measures to the whole national mileage.

If there is no national transport model, pre-calculations outside the MobiliseYourCity tool are required to which extent the avoided and shifted kilometres in urban areas affect the total national mileage, occupancy rate and load factors. These pre-calculation results serve as input in the MobiliseYourCity tool. Example: Urban mileage is reduced by 20 %, but urban mileage contributes only 30 % to total national mileage. In this case, MobiliseYourCity tool input for avoided mileage is not 20 %, but only 6 % (20 % x 30 %).

Share of urban mileage on total national mileage can be roughly estimated in several ways, we propose two simple approaches below, which can be complementary:

1) Urban mileage per vehicle category can be separated from the national mileage (top-down). For example by defining the share of the fleet dedicated to urban transport (e.g. based on the place of registration of the vehicles or the motorisation rate in urban and rural areas for private modes). The urban fleet is then be multiplied with an urban average mileage per vehicle. If no estimates on urban mileage per vehicle are available, national average can be used as proxy.
2) The urban mileage of the cities for the different vehicle categories within the country is added up (bottom-up). In this case the mileage of the cities has to be collected and added. The

feasibility of such an option depends on the number of cities and the local data availability. This solution is also suited for public transport and potentially freight if local data are available.

Example: National mileage for cars is calculated based on a vehicle approach. The result is 48 million kilometres per year for 8 000 cars registered and a national average mileage of 6 000 km/a for cars. How to calculate the urban mileage?

National annual total mileage	National average annual mileage	Number of vehicles
48 000 000	■ 6 000	■ 8 000

- As we have no local-specific information on vehicle registrations, we estimate number of vehicles in urban areas based on the motorisation rate. Assuming a motorisation of 50 cars per 1 000 inhabitants and 100 000 inhabitants in urban areas, calculated urban vehicle stock is 5000 vehicles – 62.5 % of total vehicle stock.
- From a case study for one of the cities in the country, we know the average urban mileage per vehicle in this city: 4 000 km per year. We assume this value for all urban areas in the country.
- Now, urban total mileage in the country can be calculated as follows:
  5 000 vehicles x 4 000 km/veh./year = 20 000 000 km/year = 42 % of national total mileage.

The input for avoid measures in the MobiliseYourCity Emissions Calculator is in percentage of the total BAU mileage in the given year. In a NUMP, this is the national total mileage. We assume in our example that the bundled effect of the NUMPs' avoid measures saves 5 % of the urban car mileage i.e. 1 000 000km. This corresponds to app. 2.1 % of the national car mileage. This values is to enter in the tool.

Concerning shift measures, all calculations in the tool are based on the inputs for public transport. Hence, bottom-up calculations of the expansion of urban public transport services should be done:

1) First input is the increase of mileage for public transport. This information will be derived by adding up the expected increase of mileage of public transport modes due to the NUMP measures in the different urban areas.
2) Second input is the occupancy rate. As the impact of local measures on the national occupancy rate is generally very small and quite complicated to calculate we recommend letting the national average occupancy rate unchanged. For special cases, please contact the secretariat for further options.
3) The last shift parameter is the origin mode of the added kilometres (in percentage of the trips). This input can be difficult to calculate out of a bundle of local measures in different cities. We recommend simplifying the methodology and calculating the weighted average of origin modes based on the additional mileage as shown in the table below.

new bus kilometres	% of the new trips from cars users	% of the new trips from motorcycle users	% of the new trips from NMT
city A	■ 10.000	■ 50%	■ 40%
city B	■ 20.000	■ 60%	■ 30%
city C	■ 7.000	■ 70%	■ 15%
Total	■ 37.000	■ 59%	■ 30%

The results are entered in the tool in the line "goal transport mode" for bus: the origin mode of the new bus kilometres are 59% cars, 30% motorcycle and 11% NMT.

7.4. References

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