Reference Document on Transparency in the Transport Sector

Measurement, Reporting and Verification of Greenhouse Gas Emissions

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

On behalf of:

Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

Project context

GIZ works on changing transport towards a sustainable pathway and facilitating climate actions in mobility. We support decision-makers in emerging and developing countries through training and consulting services, as well as by connecting stakeholders. Our ultimate goal is to keep global temperature change to below 2 degrees Celsius.

The TRANSfer project's objective is to increase the efforts of developing countries and emerging economies for climate-friendly transport with international support. The project acts as a mitigation action preparation facility and thus specifically supports the implementation of the Nationally Determined Contributions (NDC) of the Paris Agreement. Now in its third phase TRANSfer has been supporting partner governments in Colombia, Indonesia, Peru, the Philippines, South Africa and Thailand. The TRANSfer project is implemented by GIZ and funded by the International Climate Initiative (IKI) of the German Ministry for the Environment, Nature Conservation, and Nuclear Safety (BMU).

With the aim of facilitating mitigation action development worldwide, TRANSfer published the handbook 'Navigating Transport NAMAs'. With respect to measurement, reporting and verification (MRV) the handbook is complemented by this Reference Document on Transparency in the Transport Sector; a set of so-called 'MRV blueprints' – descriptions of the MRV methodology and calculation of emission reductions for different mitigation action types in the transport sector; and the Transport Volume of the Compendium on Greenhouse Gas Baselines and Monitoring – a guide to existing methodologies for different mitigation action types (jointly published with the UNFCCC secretariat).

The Reference Document has been supported by an expert group on MRV of transport NAMAs that met three times between 2013 and 2016 and discussed the key concepts presented in this publication.

For more information, see: www.changing-transport.org

Disclaimer

Findings, interpretations and conclusions expressed in this document are based on information gathered by GIZ and its consultants, partners and contributors.

GIZ does not, however, guarantee the accuracy or completeness of information in this document, and cannot be held responsible for any errors, omissions or losses, which emerge from its use.

Acknowledgement

We would like to thank the members of the TRANSfer project MRV Expert Group for MRV in the Transport Sector for their valuable comments and inputs in the drafting of this Reference Document.

Reference Document on Transparency in the Transport Sector

Measurement, Reporting and Verification of Greenhouse Gas Emissions

2nd updated edition May 2018

Authors: Jürg Füssler (INFRAS), Sudhir Sharma, Stefan Bakker, Daniel Bongardt (GIZ), John German (ICCT), Sudhir Gotha, Jürg Grütter (Grütter Consult), Martin Herren (INFRAS), Chuck Kooshian (CCAP), Hilda Martinez (WRI Mexico), Victoria Novikova, Martin Schmied (Umweltbundesamt), Marion Vieweg (Current Future)

CONTENT

ABBREVIATIONS AND ACRONYMS

ADB	Asian Development Bank
ASIF	Activity, mode Share, vehicle Intensity and Fuel
BAU	Business-as-usual
BMU	German Federal Ministry for Environment Nature Conservation and Nuclear Safety
BRT	Bus Rapid Transit
BUR	Biennial Update Report
CAA	Clean Air Act
CAI-Asia	Clean Air Initiative for Asian Cities
CAFE	Corporate Average Fuel Economy
CARB	California Air Resource Board
CCAP	The Center for Clean Air Policy
CDM	Clean Development Mechanism
CIUDAT	Centro para Intervenciones Urbanas de Desarrollo Avanzado hacia el **Transporte** Quality Assurance/ Quality Control
CNG	Compressed Natural Gas
COP	Conference of the Parties
COPERT	COmputer Programme to calculate Emissions from Road Transport
DIW	German Institute for Economic Research
DLR	German Aerospace Center
EEA	European Environment Agency
EMEP	European Monitoring and Evaluation Programme
EPA	United States Environmental Protection Agency
EPCA	Energy Policy and Conservation Act
FESET	Fuel Economy Standard Evaluation Tool
FINDETER	Financial Institution for Development
GCF	Green Climate Fund
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHG	Greenhouse Gas

GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH
GPS	Global Positioning System
HBEFA	Handbook of Emission Factors for Road Transport
ICA	International Consultation and Analysis
ICCT	International Council on Clean Transport
ICI	International Climate Initiative
IEA	International Energy Agency
IFEU	Institut für Energie- und Umweltforschung
IPCC	Intergovernmental Panel on Climate Change
LPG	Liquefied Petroleum Gas
MOVES	Motor Vehicle Emission Simulator
MRT	Mass Rapid Transport system
MRV	Measurement, Reporting and Verification
MTOE	Megatonne of Oil Equivalent
NAMA	Nationally Appropriate Mitigation Action
NDC	Nationally Determined Contribution
NHTSA	National Highway Traffic Safety Administration
NMT	Non-Motorised Transport
OBD	On-Board Diagnostics
PEMS	Portable Emission Measurement Systems
PKM	Passenger Kilometre
QA/QC	Quality Assurance/Quality Control
TKM	Tonne Kilometre
TOD	Transit Oriented Development
TREMOD	Transport Emission Model
UNFCCC	United Nations Framework Convention on Climate Change
VKT	Vehicle Kilometre Travelled
WLTC	Worldwide harmonised Light Vehicle Test Cycle
WRI	World Resources Institute
WTT	Well-to-tank

SUMMARY

While the transport sector is a key contributor to development and economic growth, it also causes significant greenhouse gas (GHG) emissions. The main objective of this Reference Document on Transparency in the Transport Sector is to introduce the basic concepts of Measurement, Reporting and Verification (MRV) of GHG mitigation actions. The document focuses on data sources and needs for MRV. Tracking any mitigation action in the transport sector is challenging given the lack of information collection systems in many countries and the multitude of small dispersed source emitters (vehicles). However, modelling these sources based on information about motorised vehicles and their activities is a feasible approach to overcome these challenges and main content of this publication.

Well-designed MRV can increase the transparency of impacts of mitigation efforts. It enhances and improves transport planning and implementation and provides data and information for the reporting requirements under the UNFCCC. The Reference Document focuses on land transport, provides advice on good MRV practices and addresses especially policy makers in developing countries and developers of mitigation actions. It is very relevant for the implementation of Nationally Determined Contributions (NDCs) that countries submitted when ratifying the Paris Agreement.

After defining the scope and objective in the introduction (section 1), section 2 explains the approaches and key parameters for transport sector related MRV. It starts with explaining a key concept for transport sector MRV that is the "ASIF" framework. ASIF stands for "**A**ctivity," "mode **S**hare," "vehicle **I**ntensity" and "**F**uel". Data are required on the amount of people or freight that is actually travelling, how and how far they are traveling, the fuel use per passenger-km or kWh per ton-km, and the amount of GHGs released per unit of energy consumed. The section continues to discuss boundaries, emission factor databases and lists the main transport sector indicators.

A good MRV system requires harmonised and consistent definitions and methodologies for data collection, set by institutions, to ensure good planning and robust design of surveys. Section 3 explains issues related to data management in transport. It starts with key principles such as comprehensiveness, relevance, consistency, transparency, accuracy, accessibility, costs and effectiveness. It highlights the relevance of institutions in collecting, processing and reporting relevant data, since relevant information is often widely dispersed and collected by a large number of public and private institutions. It describes how institutions could use an iterative process in order to strengthen their collection and management of data. Such a process involves the prioritization and selection of key data and improving data quality over time and it recommends and proposes using a clearing house to organise institutionalisation of data management. This is complemented by an overview of methods for data collection. Furthermore, quality assurance and quality control (QA/QC) are important elements to strengthen confidence among decision makers and stakeholders. Section 3 concludes by outlining how transport data is useful for greenhouse gas inventories. Inventories can provide a useful starting point for the MRV of mitigation actions, particularly those that use bottom-up methods and provide data at a disaggregated level. The section also provides a general overview of different approaches (tiers) in developing transport sector inventories and explains the difference between the Revised 1996 IPCC Guidelines and the 2006 Guidelines.

Section 4 introduces – specifically for transport – some key concepts relevant for the impact assessment of mitigation actions by comparing the actual data resulting from mitigation action to a hypothetical situation without the action, called a baseline or Business-as-usual (BAU) scenario. Assessing the impact of a respective mitigation action, either ex-ante or ex-post, needs to take into account the particularities of the mitigation actions, as they can vary in scale, ranging from project/programmes (e.g. investments in specific urban development improvements), policies (e.g. regulation of car fleet efficiency), and sector strategies or targets (e.g. shift from road freight transport to railway). After defining the scope of the mitigation action, a causal chain is mapped to identify all positive, negative, direct and indirect changes in GHG emissions in the transport sector resulting from the action. The section also introduces the concept of an assessment boundary, which should encompass all relevant effects of the mitigation action. It also discusses the level of aggregation in the assessment especially when measures are bundled and individual effects are difficult to assess. Subsequently, a baseline or business-as-usual (BAU) scenario is defined, which is needed to set the reference level against which the impacts of the mitigation action are assessed. A good BAU scenario also enables estimating the reference level of non-GHG indicators in order to estimate other sustainable development benefits. A BAU can be static (fixed ex-ante) or dynamic (estimated using information measured during implementation of a mitigation action); it is based on past trends but it also should take into account current and anticipated developments.

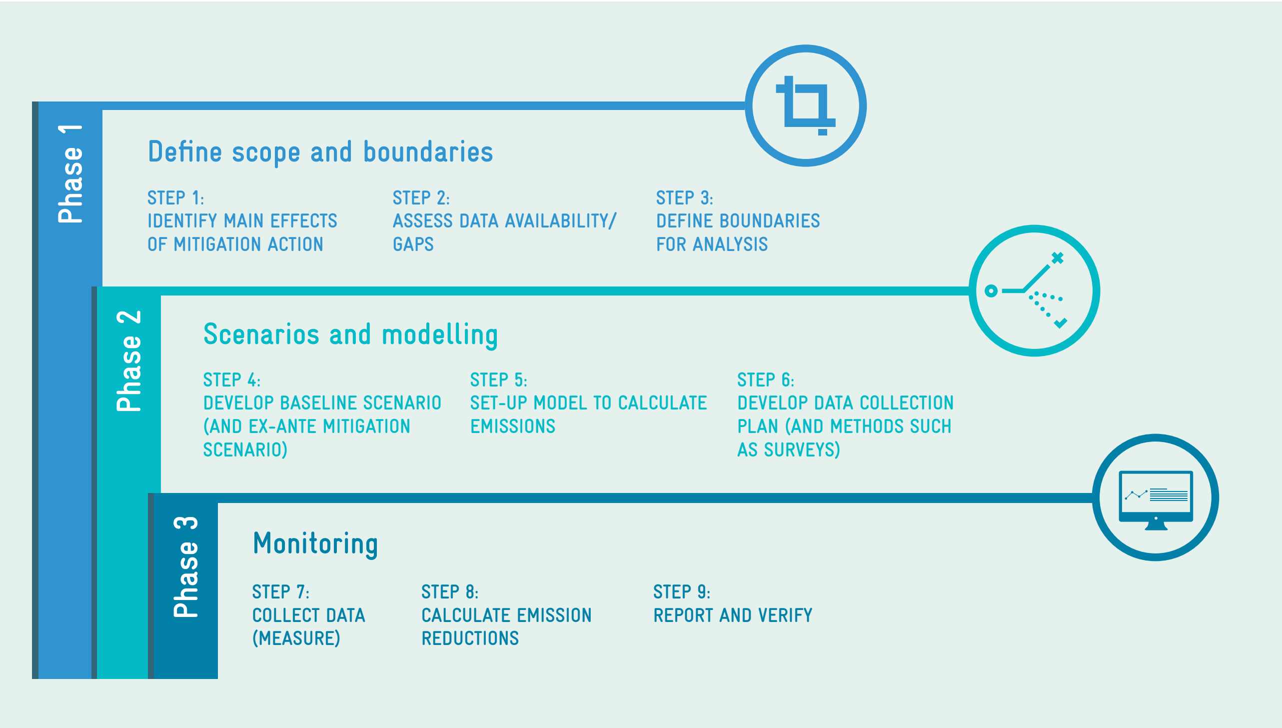


Figure 1: Three phases for setting up an MRV approach for transport mitigation actions

Section 5 delves deeper into developing a methodology for MRV of transport mitigation actions. It outlines how to develop an MRV approach for a mitigation action. It recommends including all relevant stakeholders by defining clear responsibilities and elaborates three phases and nine steps towards MRV methodologies (see Figure 1).

This process applies to both, ex-ante assessments and ex-post monitoring. Ideally, ex-ante modelling during mitigation action development is consistent with the ex-post monitoring ap-proach and uses synergies e.g. in data collection and modelling. At the same time, GHG inventories and a general understanding of emissions in the transport sector and can be improved by assessing the data collected and processed and reflecting on the lessons learnt. The section further discusses how far data collected for bottom-up inventories (as illustrated in section 3.4) can be used for the MRV of mitigation actions. Challenges to the use of inventory data, such as differences in boundary or scope can be overcome in many cases using a variety of methods. Not only can the data from inventories be used for the MRV of measures, data collected at the measure level can also be utilized to build or enhance the national level bottom-up inventory, if data definitions, collection methods and calculation methods are harmonized.

Finally, Section 6 provides four specific examples of MRV of transport mitigation actions, which illustrate practice, challenges and solutions. It looks at switching freight from road to short sea shipping in Brazil, increasing inter-urban rail in India, fuel efficiency standards in the US and transitoriented development in Colombia.

DEFINITION OF TERMS

Term	Definition
ASIF	Activity (trips in km per mode), Structure (modal share), Intensity (energy intensity by mode in MJ/km), Fuel (carbon intensity of the fuel in kg CO_2/MJ) are the four different components that determine the transport sector's GHG emissions. The framework helps to capture the characteristics of the current transport system.
Base year	A specific year of historical data against which emissions are compared over time
BAU scenario	Business-as-usual describes a scenario that would have happened in the absence of a strategy, policy, programme or project to mitigate GHG emissions.
BUR	Biennial update report is a national report submitted every two years to UNFCCC. It reports the country's GHG emissions, mitigation actions taken by country and their impacts on GHG emissions reduction, etc.
CO_2 equivalent (CO_2eq)	The universal unit of measurement to indicate the global warming potential (GWP) of each GHG, expressed in terms of the GWP of 1 unit of CO_2. It is used to evaluate releasing (or avoiding releasing) different GHGs against a common basis
Co-benefits	Co-benefits are intended or unintended positive side-effects of a mitigation measure. These are typically synergies with other objectives, such as air quality, productivity, road safety etc. associated with the reduction of greenhouse gas emissions.
COP	Conference of the Parties of the UN Framework Convention on Climate Change
Emission factor	A carbon intensity factor that converts activity data into GHG emissions data, usually given in grams of carbon dioxide equivalent per kilometre (g CO_2eq/km)
Emission reduction	Reduction in GHG emissions relative to a base year or baseline scenario
Ex-ante	An ex-ante approach establishes a future BAU scenario and estimates the expected future effects from transport mitigation actions in a variety of scenarios.
Ex-post	An ex-post MRV approach uses measured information to estimate and verify the realised GHG emissions changes during and/or after the mitigation action.
GHG	The greenhouse gases (GHG) reported by Parties of the UNFCCC contain estimates for direct greenhouse gases, such as: Carbon dioxide (CO_2), methane (CH4), nitrous oxide (N_2O), Perfluorocarbons (PFCs), Hydrofluorocarbons (HFCs), (Sulphur hexafluoride), (SF6). The various GHGs have a specific global warming potential expressed in carbon dioxide equivalents (CO_2eq).
ICA	International consultation and analysis (ICA) is a form of review currently being negotiated and designed in the UNFCCC intergovernmental process.
Indicator	Transport relevant variable used as a representation of an associated factor or quantity e.g. fuel sold and emission factors to determine CO_2 emissions.
Inventory	An emission inventory is defined as a comprehensive listing by sources of greenhouse gas and air pollutant emissions in a geographic area (community, city, district, nation, and world) during a specific time period.
Mitigation action	A measure or package of measures (e.g. strategies, policies, programmes or projects) that helps to reduce or slow down the growth of greenhouse gas emissions.
Measuring	Process where data and information are collected and compressed into key trends that describe the state of the system and support decisions on required actions.
MRV	"Measuring", "Reporting" and "Verifying" of mitigation actions
MRV System in transport sector	Entirety of MRV activities at the national level, including the institutionalisation and coordination of these activities for setup of (e.g.) a national GHG inventory, domestic or supported NAMAs, national transport policies or national mitigation goals in the transport sector.
NAMA	Nationally Appropriate Mitigation Actions (NAMAs) are voluntary mitigation measures taken by developing countries that are registered and reported by national governments to the United Nations Framework Convention on Climate Change (UNFCCC). Since the Paris Agreement is operational, developing countries no longer register NAMAs but commit to mitigate climate change in NDCs. Today, the term NAMA is often associated with mitigation actions under the NAMA Facility funding programme.

Term	Definition
National reporting	Parties to the UNFCCC must submit national reports on implementation of the Convention to the COP. Furthermore, it is a formal requirement to report on planned, current and implemented NAMAs within biennial update reports (BURs).
NDC	Nationally Determined Contributions (NDCs) are a key element of the Paris Agreement. National governments will submit their contributions to the UNFCCC every 5 years and may include targets, actions in both adaptation and mitigation.
Paris Agreement	The Paris Agreement was decided in December 2015 and ratified in December 2016. It outlines the objectives and provisions on how the UNFCCC will limit climate change to well below 2.0 degree Celsius above pre-industrial levels of global average temperature. A key element of the Agreement is nationally determined contributions (NDCs) submitted by the parties of the convention every 5 years.
Paris Rule Book	The Paris Agreement's "rule book" will establish the rules and processes needed to provide the operational guidance for fulfilling the ambition of the agreement. To do this, it will strongly build on the existing transparency provisions of the convention, including the system on national reports (NCs and BURs) and related processes of international consultation and analysis (ICA). The national GHG inventory and information to track progress in implementing and achieving the nationally determined contribution (NDC) are key elements will be key elements.
Person kilometres (or passenger kilometres) (PKM)	Distance travelled by a person or passenger multiplied by the number of persons or passengers
Policy	A set of formally described, adopted or planned legal actions, rules, guidelines to be followed and/or enforced by a government or authority. A policy typically includes its area and date of validity, its implementing organizations, and its objectives
Scenario	The description of several key variables in a possible state of the future. Scenarios are used when the total number of possible combinations of variable states is too great to analyse efficiently. A scenario has to be plausible in the sense that under certain assumptions it can occur and should contain consistent and coherent outcomes. A scenario is not a probabilistic forecast but a deterministic description of a situation whose actual probability is not completely known
Transit oriented development (TOD)	Mixed use residential and commercial urban development centred around access to public transport
Vehicle kilometres travelled (VKT)	Distance travelled by a vehicle multiplied by number of vehicles
Tonne kilometres (TKM)	Distance travelled by a tonne of freight multiplied by number of tonnes

1. INTRODUCTION

A key element of the international framework for climate change mitigation is the concept of transparency – formerly often referred to as Measurement, Reporting, and Verification (MRV, see Box 1). Its objective is to increase the "transparency of mitigation efforts made by developing countries as well as to build mutual confidence among all countries" (UNFCCC, 2010). A verified assessment ensures minimum quality and is a means to create trust and a common understanding within the United Nations Framework Convention on Climate Change (UNFCCC). In this context MRV is also a key requisite for mitigation actions to be attractive for foreign climate financing. Transparency is also a key element of the Paris Agreement and central to the Paris Rulebook and Nationally Determined Contributions (NDCs).

The transport sector contributes substantially to greenhouse gas (GHG) emissions, both, in developed as well as in developing countries. But as transport policies typically aim at facilitating trade or at enabling access to jobs, existing evaluation systems usually do not take GHG emissions into account. Even though transport statistics and impact assessments of transport policies form a good basis for GHG mitigation MRV, there are some features of the transport sector that make it more challenging to MRV than other sectors.

Definition of MRV

- **Measurement**[1]
  Collect relevant information on progress and impact of mitigation action.
- **Reporting**
  Present the measured information in a transparent and standardised manner.
- **Verification**
  Assess the completeness, consistency and reliability of the reported information through an independent process.

Box 1: Three elements of MRV according to UNFCCC, UNEP, UNDP (2013).

One challenge to evaluating transport sector emissions is the nature of millions of small mobile sources, i.e. vehicles that move independently and cannot easily be assigned to a specific location. In addition, vehicles are driven by a variety of fuels (electricity, gasoline, diesel, kerosene, CNG, biofuels, etc.) and operated by a huge number of individuals or enterprises. As a result, it is difficult to (a) collect data and (b) accurately identify the assessment boundaries and the boundaries of the different datasets. Advanced, transport related data management (or MRV) systems able to overcome such challenges often do not yet exist in developing countries.

Because of such challenges, many developing countries and international organizations see the requirement of transparency and GHG reporting as a key barrier to engaging in transport related mitigation actions. However, developing countries are eager for improved transport systems: Transport enables economic development through facilitating trade and creates social benefits such as access to jobs, shopping or leisure facilities. While especially road transport often has negative environmental impacts such as air pollution, land consumption or noise, good transport policies consider this and try to minimise the negative impacts as far as possible. Such policies often also reduce GHG emissions.

Consequently, GHG emission reductions easily become a 'co-benefit' of good transport policies. Enabling developing countries to see such benefits through MRV can trigger additional sustainable development and foster more transport related mitigation actions. This Reference Document on Transparency in the Transport Sector aims at providing the necessary background information and concepts to establish successful MRV systems in transport.

[1] Although the original UNFCCC terminology reads "measurement", the term MRV is today also often translated into monitoring, reporting and verification. In fact, monitoring may be the more suitable term since many important effects cannot be directly measured in a strict sense of the word. We nevertheless stick to the official terminology of measurement.

1.1. REASONS FOR MEASURING TRANSPORT

Transportation activity typically increases with economic activity, but at the same time drives development and economic growth. Over time, every region has experienced the same evolution of transport activity as income levels have grown, resulting in increases in trip distances and people shifting to shared motorised transport and ultimately to private cars. Accordingly, transport planners have to understand the effectiveness of options and decide on appropriate measures. They face a multitude of challenges to deliver the right kind of transport at the right place and time, at affordable prices and with minimum damage to the population's health, safety and the environment. Enhancing and improving data enable them to provide high-quality sustainable transport and meet the national development objectives.

UNFCCC reporting requirements related to GHG emissions and GHG effects of mitigation actions have concurrently increased with developing country mitigation responsibility. Countries report in bi-annual update reports (BURs). MRV systems provide data and information for reporting under the UNFCCC (e.g. GHG inventories) and catalyse international support for enhanced action (see Figure 2).

The activities of understanding, deciding and reporting involve a temporal dimension, too. MRV systems are about understanding current emission levels and how emissions developed in the past. With respect to measures the interest is rather on changes in emission levels than current levels. This involves developments over time as captured in transport sector inventory time series, as well as an ex-post perspective (What has been achieved?) and an ex-ante outlook (What is likely to be achieved?) related to individual measures or groups of measures e.g. in scenario studies.

A further need comes from the current situation in developing countries, where little data are available that would allow for consistently and systematically linking transport activities to emissions. Data collected and published in most developing countries does not establish links between transport demand, fuel consumption and the impact of policies and investments. This is a critical link that is often missing in the conventional planning process. Furthermore, not all externalities of transport (congestion, noise etc.) are related to fuel consumption but are still linked to transport demand. Transport data and indicators should address multiple dimensions and time horizons.

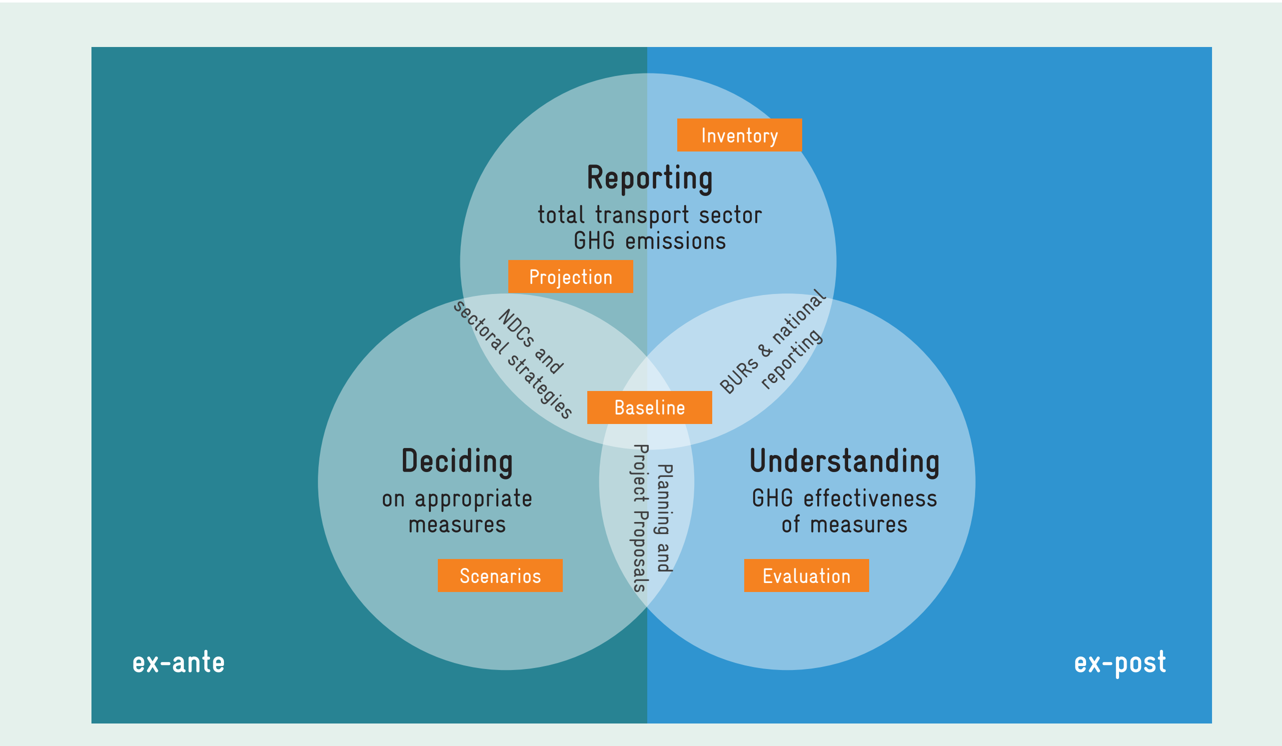


Figure 2: Purposes of MRV in the transport sector

1.2. OBJECTIVES

Countries that are transparent about their emissions (reductions) aim at a reliable and robust assessment of greenhouse gas (GHG) emissions and mitigation action performance. This doc-ument aims at helping governments and transport sector experts in developing countries to develop comprehensive national level systems for measuring developments of transport related emissions and impacts of transport mitigation actions. In the context of the Paris Agreement, such a system can help track how countries are meeting the contributions listed in their NDC. Case studies and examples are provided (throughout the document and in section 6) to illustrate real world implementation of MRV procedures to meet different needs.

The three specific objectives of the Reference Document are to:

- Understand the data needs and tools to collect and process data for comprehensive GHG inventories and monitoring the effects of mitigation actions (sections 2 and 3);
- Explain how these parameters and tools can be used for reporting on mitigation actions (sections 4 and 5);
- Outline processes required to organise quality assessment (section 3.3) as well as reporting and verification of GHG emissions (section 4.7).

1.3. SCOPE OF DOCUMENT

The report is about 'transport MRV systems'. While there is no generally agreed definition, the term usually describes a sectoral part of a national system for measuring, reporting and verifying GHG emissions. It includes data on current total transport emissions in the country (and other jurisdictions) by source and enables stakeholders to analyse the (expected) effects of transport mitigation actions. The systems ensures that data is made transparent within the country as well as internationally.

The term 'measurement, reporting and verification' itself usually refers to an ex-post perspec-tive looking back at what has been achieved. But, as said, GHG assessments usually also involve an ex-ante perspective, i.e. scenarios for possible future mitigation actions and the sector as a whole. Such ex-ante assessments are important (a) to identify the most (cost-) efficient mitigation actions and facilitate selection of policies, programmes or projects and (b) to estimate the emission reduction potential of a specific mitigation action during the proposal development. Such future development scenarios are also common practice in transport planning e.g. evaluating the impacts of large infrastructure projects such as subways or airports on traffic in a city. Ex-ante assessments are also part of any mitigation action proposal (to funders) and the mitigation action part in BUR (see below) to the UNFCCC and therefore are an integral part of MRV systems.

The key concepts linked to the UNFCCC for which MRV is relevant are the following:

- **Biennial Update Reports (BUR) and National Communications (NC):**
  BURs and NCs will include the national GHG inventory and the mitigation efforts of countries. Current BUR guidelines were decided at the UNFCCC 17th Conference of the Party in Durban in 2011 (s. decision 2/CP.17). The inventory section usually follows the Intergovernmental Panel on Climate Change's (IPCC) guidelines for GHG inventories (IPCC 1996 and 2006) but there is little guidance for the section on mitigation actions, even though this is also subject to scrutiny in the international consultation and analysis (ICA).

- **Nationally Determined Contributions (NDCs):**
  Nationally Determined Contributions (NDCs) describe countries' commitments to the Paris Climate Change Agreement adopted in November 2015. Ideally, NDCs should build on long-term strategies (e.g. until 2050) but the connection might still be missing. Specific requirements for reporting of NDCs have not been decided yet, but negotiations of the Paris rule book are ongoing.

- **Long-term strategies**
  In the context of the transparency framework of the Paris Agreement, countries have to submit long-term strategies targeting the year 2050. This links to the objective of the Paris Agreement to keep climate change well below 2.0 degrees and become carbon-neutral in the second half of the century. These long-term or mid-century strategies may build on Low Emission Development Strategies, which have been developed by many countries even before the Paris Agreement was decided.

- **Mitigation action proposals and reporting (NAMAs or climate actions listed in NDCs):**
  Mitigation efforts funded internationally will be subject to reporting and almost all donors require some sort of reporting regarding the impacts of supported climate actions. Beyond GHG inventories it is necessary to analyse the expected specific impacts of the measures, in most cases against a supposed baseline or BAU scenario, as well as achieved impacts during and after implementation. The outcomes and impacts of implemented mitigation actions as well as information on planned measures will be reported in the BURs or similar reporting procedures to be defined in the "Paris Rulebook" at COP24 (see box below).

The scope of this report (hereafter called 'Reference Document') is on transport systems in developing countries and particularly land transportation, for both passenger and freight. Consequently, the document focuses on:

- **MRV of greenhouse gas emissions:**
  While the main focus is on measuring GHG emissions and mitigation benefits, parameters for measurement of non-GHG related benefits or "sustainable development benefits" are also discussed, including e.g. improved safety, enhanced mobility, air quality, noise or economic benefits. The assessment of sustainable development benefits is also touched in this document, since this is a key driver for developing countries to take actions in the transport sector.

- **Transparency to impacts of mitigation actions:**
  Inventories are the basis for understanding (transport sector) emissions but are not sufficient to assess the impacts of specific/single mitigation actions. The question what to MRV depends a lot on NDCs mitigation contribution: Economy wide or sector-wide mitigation targets (and what kind of target, i.e. against a business-as-usual scenario, a base year or an intensity target) or to implement specific mitigation actions. While an economy-wide (or sectoral) mitigation target requires a full inventory of all emissions occurring (see section 3.3 and 3.4), commitment to a specific (sub-sector) mitigation action asks for an impact assessment of the measure taken within its specific boundaries and against a business-as-usual scenario (section 4 and 5.1).

The Paris Agreement outlines the level of ambition for climate related action and lays the foundation for a new transparency regime. The Paris Agreement's "rule book" will establish the rules and processes needed to provide the operational guidance for fulfilling the ambitions of the Agreement.

To do this, it will strongly build on the existing transparency provisions of the Convention, including the system on national reports (NCs and BURs) and related processes of international assessment and review (IAR) and international consultation and analysis (ICA).

The national GHG inventory and information to track progress in implementing and achieving the nationally determined contribution (NDC) are key elements of the transparency framework under the Paris Agreement. Transport sector inventories and the MRV of measures in the transport sector will continue to be highly relevant for the international transparency framework.

Box 2: The Paris Agreement's 'rule book'

The Reference Document builds on existing knowledge of a group of experts covering a wide range of institutions and backgrounds. Its first edition was part of a larger effort under the monitoring and MRV work stream in the TRANSfer project including the development of "MRV-Blueprints" for specific transport policies or programmes, an Expert Group on MRV-Systems in the Transport Sector and the MRV section of TRANSfer's Transport NAMA Navigating Transport NAMAs (GIZ 2014). The Reference Document also relates to the WRI GHG Protocol Policy and Action Standard and its Transport Sector Guidance and refers to some of its approaches and concepts in assessing the mitigation impact of mitigation actions (WRI 2014b).

This second edition was further developed by the Advancing Transport Climate Strategies (TraCS) project again funded through the International Climate Initiative (ICI) of the German Federal Ministry for Environment Nature Conservation and Nuclear Safety (BMU). It strengthens the information on GHG inventories for transport and refers to further guidance presented in the UNFCCC's Compendium of Baselines and Monitoring – Passenger and Freight Transport (UNFCCC/GIZ 2018). The transport volume of the compendium guides readers to more than 30 existing methodologies for assessing 8 different type of mitigation actions (e.g. CDM, the TRANSfer "MRV blueprints", the TEEMP models and others).

For more information, check the website:
http://www.changing-transport.org/transparency/.

2. TRANSPORT SECTOR DATA

Often a considerable amount of transport related data – needed for GHG reporting – are already available and collected in transport institutions. Such data are the key to build consistent and costefficient MRV systems. With respect to such transport sector data there are three core questions: what do we (need to) measure, report and verify, how do we process the data and who does it? The answers to these questions depend on the objectives of the MRV system, the national circumstances and resources available. However, some common characteristics and approaches apply to the setup of all transport sector MRV systems.

In general, transport carbon emissions can be quantified based on two independent sets of data – "energy use" and "travel activity", also called the top-down approach and bottom-up approach respectively. Top-down accounting provides a snapshot of GHG emissions during a specified time period based on statistical data aggregated at a certain geographical level (e.g. the total energy consumption or total fossil fuels sold in a year). Bottom-up calculations are applied to estimate emissions in more detail and allow the identification of the causes of the emissions. The following sections describe the data that are required for different levels of accuracy.

2.1. TOP-DOWN VERSUS BOTTOM-UP APPROACH

In the transport sector the top-down approach is based on the calculation of GHG emissions based on the amount of 'fuel combusted' or 'sold' (in litre or tonnes) and conversion factors of different fuel types (in gCO_2eq/litre). It requires data on total fuel consumption, e.g. in a country (= fuel sales) or for a specific vehicle fleet (e.g. all lorries of a logistic company). Table 1 below shows typical conversion factors, in this case provided defaults from the IPCC.

Energy type	Density (kg/l)	Conversion factor ($kgCO_2$/kg)	Result ($kgCO_2$/l)
Gasoline	0.74	2.98	2.21
Diesel	0.86	3.16	2.72
Liquefied natural gas	0.45	3.06	1.38

Table 1: Direct CO_2 conversion factors (tank-to-wheel) provided by the IPCC

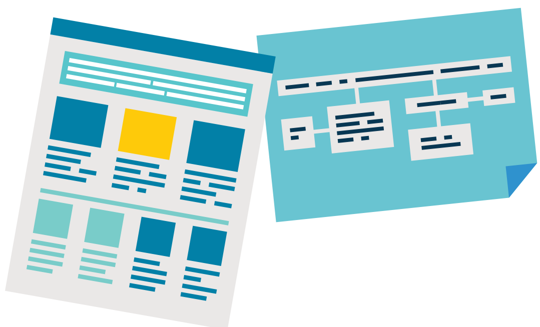
It is important to be aware of a few key terminology differences depending on the objective of the analysis. In particular the terms "activity data" and "top-down vs. bottom-up" are not uniformly used. In communicating data requirements, it is essential to clarify which definition is applied (see Box 3).

National GHG inventories require using the top-down approach. This also makes sense, as all countries can provide consistent data and diesel and gasoline are mainly transport fuels. The fact that most countries monitor fuel sales for tax purposes makes this a seemingly simple and easy way to design an energy balance. Countries also report their overall energy balance sheets to the International Energy Agency (IEA). Top down approaches, especially if based on internationally consistent datasets, also allow for comparison between countries.

However, there are a number of limitations to the approach:

- **Diverse use of fuel:** Separating transport sector effects can be difficult, as transport fuels especially diesel and to some extent LPG are also used by industrial, household, agricultural and stationary equipment. For example, diesel may be sold in bulk to a large construction company which thereafter uses the fuel for trucks (transport), stationary equipment, cement production, process energy etc. The assignment of diesel to the transport sector is based in many countries using percentage assumptions based on expert judgements. Results can change significantly between years due to changes of assumptions.

- **Distortions from cross-border activities:** For some countries the official statistics on fuel sold within the country provide limited information on the actual use within the country. This can be for various reasons. One is cross-border sales; where for example differences in taxation encourage citizens of neighbouring countries to buy their fuel across the border. The other is fuel smuggling, where fuel used in the country is not reflected in official statistics. In both cases the fuel sale numbers do not reflect transport activity in the country.



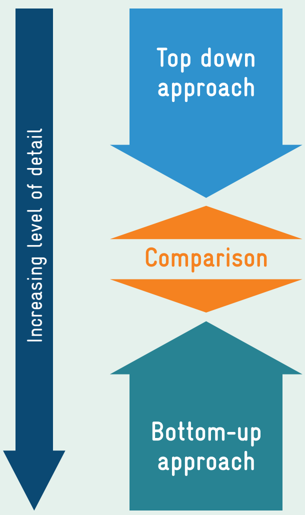
The most basic equation for calculating emissions is:

Emissions = Activity x Emission factor

In the IPCC guidelines, the emission factor always directly corresponds to the type of activity data. In the context of inventories, particularly the IPCC Guidelines, both terms in this equation are used to specify different things, for example:

	Activity	Emission factor
IPCC 2006 tier 1	Fuel used (e.g. in TJ)	CO_2eq per unit of energy (e.g. TJ)
IPCC 2006 tier 3	Distance travelled (in vehicle kilometre travelled, VKT)	CO_2eq per unit of VKT

In the MRV of transport measures the term "activity" usually refers to the distance travelled, as "vehicle kilometre (vkt)" or "passenger kilometre (pkt)"/ "tonne-km (tkm)". While the IPCC Guidelines define top-down and bottom-up based on the level of detail, not the input variable, most publications in the transport sector normally differentiate on the type of input, i.e. what type of activity data is used as illustrated below. In this sense, top-down means emissions quantified based on energy data or statistics, while bottom-up describe approaches that calculate emissions based on travel activity data.



Input

Energybased

- Fuel consumption data
- Emission factors (kgCO_2eq/TJ) based on energy content of fuels

Mileagebased

- Distance travelled (VKT)
- Emission factors (kgCO_2eq/km) based on emissions per distance travelled

- Note that the 1996 IPCC Guidelines have a different definition!
- They determine top-down and bottom-up based on the level of detail, not the input variable

Box 3: Terminology differences between inventory preparation and MRV of measures

- **Limited information value:** Collecting data on fuel consumption alone does not provide any insights to the specifics of the transport system or the implemented policy. The fuel sold can be consumed by any kind of motorised mode of transport and isolating the impact of mode, policy or investment is impossible. For example, fuel consumption data published by the International Energy Agency or by individual countries through energy balance sheets only include four types of modes (road, railways, waterways and aviation). All modes mix passenger transport and freight.

- **Coverage:** The focus on fuels does not cover transport run on electricity. In the IPCC methodology, electricity usage in transport is attributed to the energy sector. However, urban as well as inter-urban rail uses electricity. The approach therefore presents an incomplete picture. Mitigation actions such as electrifying transport will increase the electricity usage of transport and enhance this effect. If not reflected adequately within the MRV system, the top-down approach can show decreasing trends that are not reality as they are due to a fuel-switch towards electricity

- **Applicability to greenhouse gases:** The top-down approach works, with the stated limitations, well for CO_2 emissions, which are the most important source of emissions in the sector. However, the approach is not appropriate for CH_4 and N_2O emissions, which depend more strongly on the vehicle technology, fuel and operating characteristics (IPCC, 2006).

For these reasons bottom-up inventory models (see below) often complement top-down GHG inventories. Examples are TREMOD[2] in Germany, COPERT[3] in southern European countries or the global Mobility Model (MOMO)[4] of the IEA. The main purpose of such advanced bottom-up inventory and scenario models is usually to quantify air pollutant emissions. However, they facilitate quantifying GHG emissions and enable countries to reduce uncertainties and develop analysis that is more detailed. Such models often include an ex-ante perspective and enable modelling of different scenarios for future developments under certain conditions such as fleet composition and average mileages.

For ex-ante modelling, top-down data are usually of limited use, as no details regarding e.g. vehicles used in the future or land-use in future can be considered. However, bottom-up inven-tory models need to be calibrated with top-down data, so it is not a question whether to use one or the other but any bottom-up inventory model needs top-down data.

The top-down approach is also of limited applicability for tracking specific mitigation actions. Only a few mitigation actions allow reporting changes based on energy statistics as data are extremely aggregated. Only in cases when fuel consumption per vehicle or a clearly defined fleet can be tracked is the approach helpful to monitor mitigation actions. For example, this is the case for renovation of public transport bus fleets. Operators usually collect fuel consumption data, sometimes even for each single vehicle. This enables them to also use the data for reporting emission reductions. However, for any ex-ante assessments of the potential emission reductions, it is still necessary to consider the envisaged changes in fleet, mileage and fuel consumption in order to estimate emission reductions. It is also important to consider such bottom-up data, if the operations are beyond the assessment boundaries and they do not know where emissions occur.

2.2. THE ASIF FRAMEWORK

The bottom-up approach provides a mechanism to quantify emissions in much more detail. It allows monitoring carbon emissions from different policies, programmes and projects. The ASIF-framework (Schipper et al 2000) establishes a connection between mitigation actions and GHG emissions. It was developed to provide an easily understandable framework for bottom-up methodologies in the transport sector and it is also discussed in the Transport NAMA Handbook (GIZ, 2014).

The "ASIF" framework is an acronym for "activity", "structure" (or mode share), "(fuel) intensity" and "fuel (or GHG conversion factor)".

$$GHG = A * S * I * F$$

Activity and structure (A and S) describe how and how much people and freight are actually travelling. They are measured in terms of vehicle kilometre (VKT), passenger kilometre (pkm) or tonne kilometre (tkm) and disaggregated by mode type, including non-motorised transport. Passenger kilometre (or tonne kilometre) are calculated using the number of vehicles, number of trips, distances travelled and occupancy (or loading) of vehicles.

Fuel intensity (I) of a mode is generally measured in energy units per unit of activity, for example litres of fuel per vehicle kilometre (or pkm) or kWh per tkm. Fuel intensity depends on many variables including amongst others occupancy, driving behaviour, engine technology, weight, aerodynamic design and rolling resistance of tyres and congestion on the road.

[2] TREMOD – Transport Emission Model: https://www.ifeu.org/english/index.php?bereich=ver&seite=projekt_tremod
[3] COPERT 4.0 http://emisia.com/copert/
[4] IEA MOMO http://www.iea.org/etp/etpmodel/transport/

GHG conversion factor by fuel (F) is the amount of GHGs released per unit of energy consumed (in grams of carbon or pollutant per litre of fuel consumed) and is the same value as used in top-down approaches. A separate analysis should be conducted for emissions from biofuel since they imply a carbon uptake while growing and are treated separately e.g. in UNFCCC reporting. For electricity used in the transport sector, e.g. for rail or metro systems, the electricity mix in the grid is crucial information (taken from energy sector statistics).

Bottom-up approaches are not per se more detailed than top-down. They can range from indicative calculations of average or default data to very detailed modelling. An example of a indicative modelling would be to multiply the total number of cars in a country by average mileage of cars and a default fuel consumption of cars. In contrast, advanced bottom-up models can for example quantify the impacts of congestion and heavy stop-and-go traffic with plenty of acceleration and deceleration on emissions in one specific street corridor. However, more detailed modelling requires more differentiated data. Consequently, when analysing the impacts of policies and measures the level of detail in bottom-up modelling needed depends largely on the type of expected impacts. Modelling the impacts of motorisation may allow for using a indicative approach but analysing the impacts of reduced congestion requires more advanced modelling and more detailed data. In summary, the disadvantages of bottom-up approaches are as follows:

- indicative bottom-up calculations include high uncertainties;

- Detailed bottom-up calculations require an extensive amount of data collection and handling. Data needs to be collected from various data sources and careful quality assurance is required to avoid low quality data sets;

- Models typically used for bottom-up calculation usually need to be adapted to the local context and require a relatively high capacity of experts involved;

- Datasets can be inconsistent and be collected with different categories (e.g. different definitions of vehicle categories) and different boundaries (e.g. only for city centre or administrative boundary; see next section).

2.3. SCOPE AND BOUNDARIES OF DATA

Every MRV methodology defines certain boundaries. Understanding the boundaries of the various data sources is therefore crucial when collecting and managing data for the MRV approach. For example, whether the national statistics on passenger kilometre only include commercial vehicles (e.g. coaches) or also includes private vehicles is important for using this data in MRV. The term 'boundaries' refers to the scope of an analysis or assessment. A key parameter here is the geographic area that in most cases is defined by the administrative borders of a country (esp. for national inventories).

- **Territorial boundaries** such as geographic scope for which emission (and other effects) are assessed: A common issue for territorial boundaries is, whether fuels are burned in the same area where they are sold. Such effects usually occur due to price differences, which could cause grey imports (in vehicles when the driver refuels abroad, see Box 4) or even fuel smuggling. Price differences are an incentive for people to fuel their vehicles in places with cheap fuel (see figure 3 below).

- **Sectoral boundaries** such as transport modes and activities covered: A common example for sectoral boundary issues is what share of diesel sales is allocated to transport. Non-road machinery (e.g. construction machines, agricultural vehicles, fishery or industrial use) and sometimes electricity production use substantial amount of diesel fuel. When assessing mitigation actions, the inclusion or exclusion of (other) policies and measures in the assessed system is also very relevant. It is important to avoid double counting. These sectoral boundaries also refer to the issue of up-/down-stream emissions, i.e. emissions from either vehicle or infrastructure production (up-stream) or vehicle or infrastructure dismantling (down-stream). In the transport sector, most of the emissions stem from vehicle use and other emissions are usually linked to other sectors and are not accounted for in detail.

- **Temporal boundaries** describe the question for which year's effects are assessed. While inventories usually describe emissions in one specific year, temporal boundaries are especially important for assessment of mitigation actions, as impacts may occur only in the long term and are potentially excluded through limiting the assessment to a shorter time period.

- **GHGs included,** ii.e. whether it is only carbon dioxide (CO_2), the main greenhouse gas, or other GHGs such as methane (CH_4), nitrous oxide (N_2O) and other fluorinated gases covered under the Kyoto Protocol (F-gases). This so called 'basket of Kyoto gases" (CO_2, CH_4, N_2O as well as F-gases) are usually converted into CO_2 equivalents (CO_2eq) through applying the IPCC global figures of the different 'global warming potential' of the different gases. However, there are further elements that need to be considered especially for the transport sector, e.g. there is a growing discussion about black carbon and other short-lived climate pollutants as an important contributor to climate change). Another topic is whether upstream (e.g. in fuel refinery processes) or downstream emissions (e.g. in vehicle scrapping) need to be considered (see section 4.2 for details).

- **Sustainability effects** can be considered in assessment of mitigation actions. Benefits to be considered in the assessment need to be defined.

A rather simple example for boundary issues is the use of different conversion factors (carbon content of fuel in kg CO_2/energy unit). It is important to understand the sectoral boundaries of a mitigation action, when comparing it with others or reporting changes in emissions over time: for example, inventories for the transport sector that, following IPCC guidelines, do not include electricity usage and emissions but account for those in the energy sector. The rational is to avoid double counting but it leads to the fact that transport GHG emissions in national communications are exclusive of electricity-based transport emissions. If not considering this characteristic the electrification of transport (e.g. rail) might show up as decreasing (top-down) emissions while – from a strict sector perspective – GHG emission may develop differently. If electricity production is carbon-intensive emission even could go up.

Due to the above-described boundary questions, as well as other issues with data quality, the results of the top-down and bottom-up inventories usually do not match. Even different bottom-up analysis of one specific mitigation action may vary considerably because boundaries are not the same. For bottom-up calculations that use different sources of data, it means that the boundaries for each set of data can be different. Consequently, each data source needs to be analysed rather carefully. Such a quality system ensures explaining differences systematically through sector boundary issues or socioeconomic processes. Usually, correction factors help to cope with differences in the MRV system.

In order to develop MRV systems over time and enable learning and improvements, the IPCC suggested a tiered approach (see section 3.4). Starting in a simpler way with default data generates data basics that can be improved over time. In the transport sector, this may sometimes also involve a change of boundaries (e.g. fuel sold in one area, may be actually used somewhere else). Transparency about such changes in methodologies is the key for good reporting and verification.

The figure below shows the development of the net import or export caused by cross-border fuelling for Switzerland. Since gasoline is cheaper than in the adjacent countries foreign vehicle owner living near the border use Swiss filling stations. There is a net export of gasoline caused by foreigners filling up their cars in Switzerland. For diesel this is only the case in the years 2005 to 2010. Before and after that period diesel prices were higher in Switzerland than in most of the neighbour countries (e.g. Germany, Austria, and France) leading to a net import of diesel.

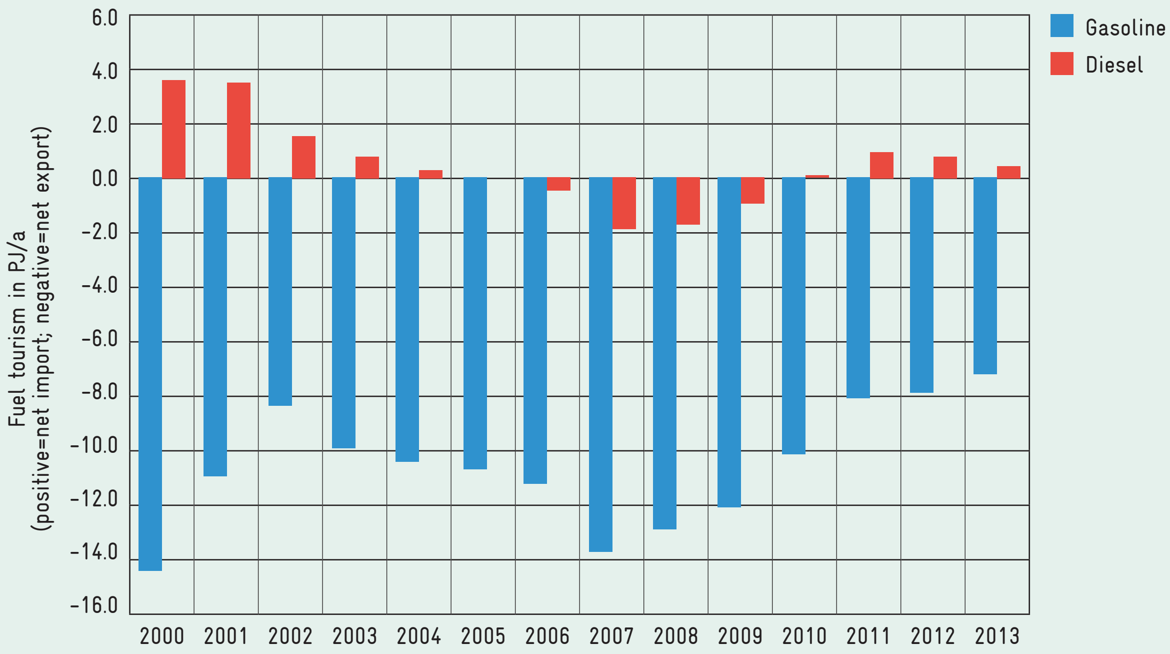


Figure 3: Cross border import/export of gasoline and diesel for Switzerland 2000–2013 in PJ/a

Box 4: Consequences of grey fuel imports to the GHG inventory of Switzerland

2.4.
OVERVIEW OF TRANSPORT SECTOR INDICATORS

As described above, top-down and bottom-up approaches need different kinds of data. Data needs for bottom-up are closely related to conventional transport planning and important for decision-making: What are likely to be the expected effects of an intervention? This perspective almost always takes the ASIF factors (see section 2.2 above) into account: The policy or measure either has an effect on 'travel activities' in terms of avoid and shift, or on the vehicles and fuels used (improve and fuels). Ex-post analysis of specific mitigation actions may consider fuel consumption data from a specific fleet (e.g. from a logistics company) so top down calculations are – at least sometimes – feasible. But in most cases boundaries are indistinct and also for ex-post accounting bottom up analysis of transport data is needed. Consequently, data on travel distances, modes and fleets are at the heart of transport MRV. This also means that bot-tom-up evaluations more easily allow the evaluation of sustainable development benefits (often called co-benefits).

Based on the classification introduced above and using the ASIF framework, we can derive a set of main indicators for the analysis of GHG emissions and GHG effects of transport measures. Of course, for the assessment of broader development impacts of actions, further indicators are required (e.g. cost factors, noise emission factors).

		Category of data	General Indicators	Options for further differentiation
Top-down	Energy use	Fuels sold / consumed	Amount of various fuels sold/used (in litre or MJ)	• by region • by vehicle types/classes
Top-down	Emission Factors for fuels (F)	Carbon content	Net Calorific Value of fuel ($kgCO_2/MJ$) for each fuel type Grid emission factors for electricity	Correction factors for indirect emissions (based on lifecycle assessment) Fuel quality e.g. sulphur content
Bottom-up	Activity (A) and Modal Shift (S)	Fleet composition	Number of vehicles by vehicle type (car, truck, motorcycle etc.)	by vehicle classes / engine size by vehicle age / technology
Bottom-up		Distances travelled	Vehicle kilometre by vehicle type (in VKT) Passenger kilometre (pkm) Tonne kilometre (tkm)	by mode by vehicle classes / engine size by vehicle age / technology
Bottom-up		Trips	Number of trips Tonnes transported Trip length	by mode by trip purposes (e.g. work, leisure etc.)
Bottom-up		Load factor	Occupancy (in persons/vehicle) Load of goods vehicles (in percent)	by mode by vehicle classes / engine size
Bottom-up	Intensity (I)	Fuel consumption	fuel consumption (in litre or kwh/km) by vehicle type	by vehicle classes (size usually related to weight) by vehicle age engine technology (e.g. Euro standards) Speed and/or congestion on the road (level of service) By load (for trucks) By gradient (for trucks) Aerodynamic design and rolling resistance of tires
Further useful statistics (e.g. used as normalising factors)		Population	Number of inhabitants (Average) household size	by urban vs. rural Working population by age with driver licence
		Economic development	GDP (or GDP per capita) (Household) income	by (sub-)sector
		Network	Length or roads, rails etc.	by road type

Table 2: Key indicators for transport MRV

Table 2 lists key indicators that are usually applied and also options for further differentiation. An extensive list of indicators or parameters, their definition and units can be found in Annex 1.

In addition to benchmark emissions from different countries or cities, other statistics, such as socioeconomic parameters (GDP/Capita and population) could be used as normalizing factors for the indicators. GHG emissions can be linked with transport activity inputs to emphasize the efficiency and performance of the measures and investments. Such indicators as GHG emissions per passenger-km or tonne-km are often referred to as 'modal carbon intensity'. Two examples of evaluating performance of transport plans according to indicators are described in Box 5.

Transport data as presented in the table above can be collected in regular institutionalised procedures and on a project basis. Examples for the latter are surveys conducted by international organisations at a specific occasion (e.g. the planning of a national railway system). The distinction is important, as it implies different institutional structures and related legislative requirements and impacts the processes used and the comparability of data. Some characteristics that differentiate the different data sets are summarized in Table 3.

Transport data must be consistent and of high quality for quantifying emissions. Policy makers in developing countries often find it difficult to justify costly data collection and modelling only to assess emission savings; however, it is more attractive to them if these data are used to improve decision-making. Therefore, it is important to be aware that many of the above listed data that are required for emission quantifications are also required for the monitoring of air pollutant emissions, congestion, travel time and vehicle activity, i.e. the overall effectiveness of transport systems. The more institutionalised data collection is, the better this is for building inventories and evaluating measures. While selecting indicators, it is important to acknowledge the importance of tools, institutional and funding support for long term measurement and monitoring of transport investments. This aspect is discussed in detail in subsequent sections.

Goals defined in transport plans often dictate the type of indicators to collect. For example, the Philippines development plan-2011-2016 has the following targets for urban transport in Metro Manila:

1. Decreased travel time from 2.17 min/km to 1.57 min/km in 2016
2. Increase in travel speed from 27.79 km/hour to 38.2 km/hour by 2016
3. Increased bus occupancy due to a reduction in the number of buses - air-conditioned from 40 to 65, non-air-conditioned from 37 to 45 (increased occupancy results in lower emissions per passenger-km).
4. Decrease in pedestrian vehicle conflict (302 in 2010 to 10 in 2016)

Travel speed, travel time, bus occupancy, number of buses and pedestrian fatalities are the main indicators proposed for evaluation of the transport plan.
In contrast, Singapore considers following targets in Land Transport Master Plan - 2013

1. 8 in10 households living within a 10-minute walk from a train station
2. 85% of public transport journeys (less than 20 km) completed within 60 minutes
3. 75 % of all journeys in peak hours undertaken on public transport

Density of train stations and households, number of trips, public transport travel time and travel speed, average trip length, mode share during peak hours are the main indicators used for evaluating the performance of the Land Transport Master Plan. Efficient transport sector monitoring, should start with and incorporate already existing efforts, such as those provided by strategies and plans at national, regional or city level. Data like these, which are already collected, can be used along with a few additional indicators to also determine the effect on carbon emissions.

Box 5: Evaluating Performance of Transport Plans

	Institutionalised data	Project oriented data
Responsibility	Collected by public institutions	Often collected by universities, research institutes or consultancies on behalf of public institutions
Frequency	Regularly (in most cases annually)	Ideally regularly, but with varying intervals, depending on availability of funds, etc.
Methods	Standardised methodologies, data formats, etc.	Ideally with standardised methodologies to allow time series development
Liability	Based on legal requirements	Based on demand and funding from public institutions
Sources	From all data sources covered by the legal framework	From voluntary participants

Table 3: Differences between institutionalised and project-oriented data

2.5. EMISSION FACTOR DATABASES

Bottom-up emission quantifications need additional information about emission factors. Transport related emission factors can be described as 'the amount of greenhouse gases (or other pollutants) per unit of distance'. Usually an emission factor describes the average specific emissions in CO_2eq/km for a given fleet composition. Such emission factors can vary considerably and subsequently lead to invalid findings. As they depend on fleet composition, fuel type, fuel quality, and maintenance of the vehicles, it is difficult to generate default values without endangering the validity of calculations. Consequently, countries usually strive to have a standard set of emission factors tailored to the local situation. Many developed countries have developed their own emission inventory tool, which – at the same time – is the official database for emission factors. In an ideal case, such emission factor databases also contain emission factors for air pollutant emissions.

Detailed emission factor databases that are differentiated by vehicle types and sizes, road and driving conditions (e.g. road gradients, ambient conditions or share of stop and go traffic) allow for detailed analysis but also require similarly detailed activity data. For N_2O and other air pollutants the number of coldstarts of vehicles is needed, because catalytic converters cannot filter air pollution emissions in the warm-up phase and emissions are considerably higher until the engine is warm. Obviously, the accurate quantification of emissions depends on both the availability of detailed travel activity data and the availability and accuracy of corresponding detailed emission factors.

Emission factors based on distance travelled can be found in several international sources. The only available comprehensive sources of such detailed emission factors are:

- EMEP/EEA Guidebook (EEA 2016) which provides emission factors for road vehicles based on data researched for the COPERT model and is structured along Euro standards;
- the European emission factor database Handbook of Emission Factors for Road Transport (HBEFA, see www.hbefa.net) that is based on the same source as EMEP/EEA but provides more detailed factors especially for cities; and
- the US-American Motor Vehicle Emission Simulator (MOVES) which is the successor of Mobile 6. (see http://www.epa.gov/otaq/models/moves/).

Other emission factor databases are either derived from those (e.g. IVE on MOVES) or considerably less detailed. The above listed databases are based on large-scale measurement programmes developed over many years and at high costs. They provide detailed emission factors (by vehicle segment, age, traffic conditions, etc.) and allow aggregating those for different areas and purposes (see Box 6), but only provide reliable data for the region and countries they were developed for. Specific databases for non-annex I countries do not exist at the moment, but some values can be found in the literature.

If no resources are available to generate country-specific data there is no other option than using and adapting emission factors from other countries to local conditions. Otherwise bottom-up calculations will not provide sufficient data quality and the analysis needs to deal with high uncertainties. When adapting emission factors, it is most important to understand the specific fleet composition in the given territory (boundary). This involves vehicle size, vehicle age, engine size and the end-of-pipe treatment (emission concepts such as Euro 5 etc.). In addition, it is important to know the operating conditions of the fleet (ambient conditions, speed, road types etc.). For an example on how HBEFA was adapted to China see GIZ 2014.

Over the last 30 years harmonised emission models and emission factor databases have been established in Europe. As the table below shows most countries in Europe use the emission model COPERT (COmputer Programme to calculate Emissions from Road Transport) for the quantification of GHG emissions and air pollutants of road transport. Some countries have developed their own models (e.g. TREMOD – Transport Emission Model in Germany). Independent of the emission model used, the underlying emission factor database of most emission models is the Handbook of Emission Factors for Road Transport (HBEFA).

HBEFA was the answer to the European member states' needs for reliable emission factors for road transport based on a harmonised methodology and regularly updated database. At the beginning HBEFA was developed on behalf of the German, Swiss and Austrian environmental agencies. Currently, the development is also financed by Sweden, Norway and France as well as the Joint Research Centre of the European Union. HBEFA was developed in such a way that it could be used directly at project (e.g. for environmental impact assessments), city (e.g. for impact assessment of measures) or national levels (e.g. monitoring and scenario analyses). Since the data requirements for using HBEFA on national levels are comprehensive, most countries calculate their emission with the COPERT model, which includes a simplified approach based on the HBEFA database (the so-called average speed approach). Countries such as Austria, Germany, Norway, Sweden and Switzerland are using the direct HBEFA database without simplifications. At the project and local level HBEFA is used directly, without simplifications. These European examples show that the emission factor databases are harmonised from the local to the national level, allowing for a comparison of the results.

Box 6: Emission models used in Europe

3. DATA MANAGEMENT IN TRANSPORT

Monitoring is a process where data and information are collected and compressed into key trends. These trends describe the state of the system and the directions of development. Finally, monitoring supports decisions on actions. Indicators are the most important elements for monitoring and measuring progress towards a defined goal. A simple indicator used for monitoring can accommodate a large volume of information. In an ideal monitoring and accounting system, the quality of data should match the principles[5] presented in Table 4.

Principle	Description	Example "person-km travelled"
Comprehensiveness	• Data are complete and available for all relevant indicators	• Complete time series without gaps • Data for all relevant vehicle types
Relevance	• Data matches the requirements from the monitoring system and the indicators	• Distribution of activity over the year may be relevant for transport planning purposes, but not for GHG emission calculations
Consistency	• Methodologies and standards are applied in the same manner in the MRV system • Data from various sources is consistent and comparable	• Same emission factors as in national inventories are used • Boundaries of different data-sets match or are adjusted through correction factors • Data from public service providers matches results from survey data
Transparency	• Assumptions are explicitly explained and choices are substantiated if no confidentiality restrictions apply	• Meta data about vehicle activity data are available (who acquired data when how and how often?) • Assumptions about assumed emission factors are substantiated (e.g. referenced to IPCC Guidelines)
Accuracy	• Aggregation, precision and uncertainty of data matches the requirements from the MRV-system	• E.g. if required local data are available on disaggregated level (e.g. differentiated into consumption by vehicle types and technology). • Uncertainties should be always estimated (if possible quantitatively)
Accessibility	• Required data are accessible by all stakeholders involved	• E.g. through shared data platforms, publication of statistics, agreements on confidentiality
Cost effectiveness	• Expenditure (economically, human resources, time) for acquisition of data should match its relevance	• Prioritization of relevant data can reduce costs for data collection, e.g. when costly surveying is required • Data can sometimes be gathered together with data that is already being collected, e.g. by adding additional questions to surveys
Frequency	• Some data requires continuous elicitation while other can be acquired only once • analysis and reporting should be relevant to the project phases or policy implementation	• Regular data collection is prerequisite for trend estimations • Emission factors of fuels tend to vary only little and does not have to be measured continuously

Table 4: Key principles for sound data management

[5] For a detailed discussion on the monitoring principles see for example WRI (2014), Litman, T. (2009), Schipper, L., & Ng, W.-S. (2006), Embarq, & CAI-Asia. (2006).

Two issues are of major importance and need to be highlighted: relevance and consistency: With the large number of individual sources, and given the variety of information required, the principle of cost effectiveness provides a limitation to some of the other principles, especially comprehensiveness, accuracy and frequency. Monitoring systems need to find the right balance, using relevance as a guideline (see section 2.4). Furthermore, transparency in data collection and of data itself is vital for quality assurance and quality control procedures, which not only reflects the 'verification' dimension in MRV systems but also the need for good data.

Systems usually evolve from a less detailed system with fewer indicators to a more comprehensive system. At the same time, different levels of detail and comprehensiveness can exist at different levels. Individual cities or municipalities can develop more elaborate systems than the national level. Especially in such cases, it is important to consider the need for consistency, as national systems evolve and data are aggregated at higher levels. According to Moncel, Damassa, Tawney, & Stasio (2011) key elements of monitoring systems include:

- **Data collection** (see also section 3.2):
  - Indicator definitions should be harmonised to ensure that collected data are compara-ble and can be aggregated;
  - Methodologies for collection, for example for travel surveys, should be standardised to ensure data quality, comparability and representativeness;
  - Data formats need to be compatible;
  - Timing for annual data collection aligned; and
  - Quality control mechanisms can benefit from harmonization and exchange (see Box 8).
- **Data management and reporting tools:**
  - Tools and software coordination can enhance efficiency of the system, decrease cost and allow for better sharing of information;
  - Aggregation methods should be well described;
  - Quality assurance coordination can increase efficiency and ensure comparability of data at different levels;
  - Internal and external reporting requirements at different levels should be aligned to minimise resource needs and enhance overall quality.
- **Planning and design:** systems need to ensure that the right kind of information at the required level of detail is delivered at the appropriate time for planning, design and evaluation of mitigation actions at the different levels of administration. This means taking into account legislative cycles, budgetary timelines and planning cycles at national and local level when planning the frequency and timing of MRV activities.

All these aspects require coordination and cooperation between various stakeholders and an institutional setting that serves this purpose.

3.1. INSTITUTIONAL SETTING FOR MONITORING

As highlighted in the previous section, data needs are complex and vary depending on measures and boundaries. The ability and cost to provide the required data accurately and transparently will depend, amongst other factors, on the availability of expertise and resources in institutions involved in the process. Institutions play a central role in collecting, processing and reporting relevant data, and in designing and evaluating transport systems and measures. These two different roles need to be clearly distinguished:

- Provision of information: data gathering, data aggregation, data processing, data analysis
- Use of information: planning and evaluating transport systems and measures

Good communication between institutions in these different roles is essential to ensure efficient MRV systems. The roles also exist within individual institutions, between different departments or subagencies. Communication needs to ensure that only relevant data are collected and are available at a level of detail required for the purpose. This can be especially challenging for measures at a local level, where available data at a national or regional level will not deliver sufficiently detailed information. Transparency about boundaries, collection methods and uncertainties are necessary within such communication processes. Where the implementation of transport mitigation measures and MRV efforts are supported from international sources, additional coordination may be required. Reporting requirements of funders are often similar and it is efficient to coordinate data collection, processing and reporting related to such requirements.

3.1.1.
Institutions and institutional setup

Relevant information is often widely dispersed and collected by a large number of public and private institutions. Bringing together all relevant data for evaluating individual transport measures in a consistent way is a challenge. Frequent starting points for MRV of transport measures are existing institutions that collect and process data in the transport sector. In most cases, existing data are not collected to assess the GHG effects of measures, but for other purposes. However, some of this data will be useful for the assessment of the GHG effects of transport actions and the institutions involved in collecting and processing the data often have the necessary expertise and experience to enhance data collection.

Table 5 provides an overview of institutions normally involved in effective transport data collection, processing and reporting. It describes some of their respective roles and responsibilities, as well as the type of data and indicators typically provided or processed by the institutions and related stakeholders involved. Of course, many institutions have multiple roles and responsibilities and can be involved in data generation, aggregation and use. The table provides some of the typical examples of roles institutions can take in the overall setup.

The same data can also be collected, processed and used by different institutions, often generating inefficiencies and inconsistency between datasets. Creating an overview of involved institutions in a country can help identify such situations and provide a basis for developing a more efficient system. Table 5 illustrates various settings. Box 7 describes the institutional setup of involved institutions in Thailand.The examples provide evidence on the responsibilities of individual institutions, but they do not yet provide any insights regarding the interaction of these different stakeholders. The individual interaction between data collectors, sources and aggregation and analysis depend strongly on the national circumstances, information needs and resources available, which are discussed in the following section.

> In Thailand a variety of data are collected systematically, e.g. vehicle registration, fuel consumption, highway traffic. The following organisations are involved in respective transport data gathering:
>
> - Ministry of Transport: national transport and traffic statistics (for highways), road infrastructure, vehicle registration, freight movements. Various departments publish these data annually. Transport modelling (national and for Bangkok) is often outsourced to consultancies, with the Ministry publishing and using the results, also for GHG projections.
> - Ministry of Energy: Fuel sales and fuel economy of vehicles (the latter is also collected by the Thai Automotive Institute but not necessarily shared)
> - National Statistics Office: the general census is carried out every 10 years, and intermediate household surveys with 80-100,000 random surveys are carried out every 5 years, however there are no transport-specific questions in there; every 5 years a bus survey and goods movement survey is done
> - Bangkok Metropolitan Authority: traffic statistics
>
> In addition, various other local transport agencies gather public transport ridership data. However, a lot of other important data, e.g. modal shares, occupancy rates / load factor, annual mileage, vehicle speeds, emission factors etc., is collected, if at all, on a project basis in a non-systematic manner and often without clear quality control. Such studies, carried out e.g. by consultancies, universities and international organisations (Asian Transportation Research Society), are however very important to complement the official statistics. With the need to monitor and report GHG emissions, there are discussions starting on how different organisations can work together better and how to institutionalise data management.

Box 7: Data management and reporting in Thailand

Institution	Level	Responsibilities	Type of data
Data consumption			
Legislative body	National / provincial	Provision of the legal basis for data collection and reporting requirements for operating entities; transport-related legislation	
Ministry of Transport / Infrastructure	National / provincial	Spatial planning; investment in national infrastructure; regulation of public and private transport; initiating transport-related legislation and data requirements	
Local administrations	Municipal / city	Spatial planning; investment in local infrastructure; regulation of local public transport	
Data aggregation and analysis			
Institutionalised data			
Statistics Office(s)	National / provincial	Gathering and aggregation of data at national or provincial level	Aggregated statistical data at national/ provincial but also local/ city level
Various Ministries	National / provincial	Gathering and aggregation of data at national or provincial level	Various data collected for non-trans-port planning purposes, e.g. related to taxes, working conditions, commerce, energy use, etc.
Transport Authorities	National / provincial / local (mode specific)	Regulation, planning and research on specific transport related areas, usually specialised, e.g. road transport, rail infrastructure, vehicle registration, etc.	Mode specific data: vehicle registration; freight data; passengers transported; transport infrastructure
Project oriented data			
Environmental Protection Agency	National/provincial	Research on environmental aspects of transport, e.g. air pollution, noise emissions	Safety, air pollution, other non-GHG environmental impacts
Universities / Research Institutes / Consultancies	International / national / provincial / local	Development of methodologies and tools, data collection through surveys	Household mobility patterns, preferences
Industry associations	National	Data collection and aggregation from members	Technical data on vehicle performance, expected trends, industry specific data
Original data sources			
Railway operator(s)	National / provincial / local	Delivery of data based on legal requirements or voluntary	Infrastructure, passengers carried, freight carried, cost/prices
Public transport operator(s)	Provincial / local		Infrastructure, passengers carried, cost/prices
Freight operators	National / provincial / local		Freight carried, cost/prices
Vehicle manufacturers	National		Vehicle sales, technical specifications
Energy companies	National / provincial / local		Fuel sales
Households		Voluntary delivery of data	Mobility patterns, cost/prices

Table 5: Differences between institutionalised and project-oriented data

3.1.2. Organizing and institutionalizing cooperation

Due to the large number of stakeholders involved in transport system design, data management and building, MRV-systems pose a challenge for cooperation. Limited availability of resources, both financial and technical, requires close coordination and cooperation to maximise the efficiency of the system. A sound monitoring system requires the cooperation of a wide range of actors and coordination between processes. The need for cooperation between different players and between different levels (national to local) will increase with more complex MRV approaches. Integrated approaches can create synergies, enhance efficiency and provide the basis for enhanced action. Some recommendations for better cooperation based on Elsayed (2013) and UNFCCC (2013) are:

- Assigning a central coordinating institution for transport sector monitoring
- Defining a technical coordinator or coordination team
- Harmonised indicator definitions, data collection and processing procedures, etc.
- Technical and institutional capacity building
- Clear processes for sharing data across institutions and governance levels
- Agreed QC/QA standards

The national surveys 'Mobility in Germany' and 'Mobility in Cities' provide good examples of the cooperation process to enhance data compatibility. While the first survey looks at national level and state level data, the second aims at cities and regions. The macro-level data from the national survey do not provide sufficient detail for planning in individual cities, while the city specific data does not provide more macro-level information, for example regarding developments in adjoining regions. It therefore seemed useful to ensure comparability of the two data sets. The process to enhance comparability of the two surveys started with a workshop in March 2002. The Federal Ministry of Transport then formed a working group, comprised of all the public and research institutions involved. In addition, it commissioned a research project that looked at the compatibility of the two surveys (Badrow et al., 2002). Key elements were harmonised, including the survey methods and the spread of survey dates over the week and over the year. Additionally, the timing of the surveys was harmonised since 2008 to enhance comparability.

Box 8: Example of enhanced cooperation for national and city level data in Germany

Cooperation is particularly relevant if data sets from different geographic levels or regions need to be harmonised. The case study in Box 8 describes how data from such different aggregation levels could be coordinated with each other. More details and a sample data sharing agreement are given in the publication on Responsibilities, Procedures and Regulations for GHG Inventory Creation in Germany (GIZ 2017).

Since developing countries also make a considerable amount of data available, it would be beneficial to establish or empower a data clearing house, i.e. a structure that collects, stores, checks and disseminates information and data. Such a clearing house function would most likely be integrated in other institutions and would usually be guided by statistical bureaus. In Germany the DLR is fulfilling this role and the German Institute for Economic Research (DIW) publishes this data (book and data sheets) in a comprehensive summary called 'Transport in numbers' (Verkehr in Zahlen). The data compiled is presented in a coherent manner.

When developing MRV of mitigation actions, missing official information could be first collected on a project basis and then be institutionalised over time. It is important, therefore, to develop procedures and coordination meetings and events. This could result in an iterative process to collect, check and improve data through developing standards over time. A clearing house could help to foster institutionalising data. Countries may therefore develop roadmaps on how to achieve the institutionalisation and establishment of a clearing house. However, for MRV of mitigation actions there will always be a need for some project type data collection. But the availability of institutionalised data could reduce this to a minimum and also cut MRV costs significantly.

3.2. METHODS IN DATA COLLECTION

Once we have defined what we want to monitor, on what level and who is responsible, the question is how to collect the required data with appropriate quality. The collection of high resolution and bottom up data is especially challenging for developing countries where limited resources are spent on collection of periodic data and data management is often not fully institutionalised. Quality and availability of data available in the majority of low and middle income developing countries is suspect (see IDB 2011; ADB 2009; CAI-Asia 2012; UNECE 2012, World Bank 2010).

Institutionalised data from different administrative levels includes data from vehicle registration offices, tax authorities and accident databases. Some of the sources directly deliver the required data, such as registration numbers, others deliver samples or even indirect information that can be used to estimate required data, such as accident databases supporting the estimation of occupancy levels. In an optimal case, this involves systematic data reporting. To achieve a broader basis and eliminate errors that can occur in extrapolating sample data, more systematic approaches require specifically targeted groups to report data on a regular basis. Statistics offices underpin this by corresponding legislation. The method can work for companies in the private sector, such as freight carriers and public service providers, so long as they are working legally.

Collecting data divides into two different actions: Compiling existing data and conducting surveys to generate new data. For existing data roles, responsibilities and interaction procedures between actors in the MRV process (e.g. data flow chain, data sharing) have to be assigned. For new data, methodologies for data collection must be defined. Different methodologies are available for systematic data collection. The most useful methodologies differ between various types of transport (e.g. motorised individual traffic or public transport) and can vary from country to country. Table 6 gives an overview of commonly used data collection methodologies and aspects which should be considered for passenger transport. A longer list of potential parameters for bottom-up transport MRV systems can be found in Annex 1.

Parameter	Methodologies	Aspects to consider
Vehicle fleet (new registration and stock)	• Collection of statistical data of registrations of new vehicles from local or regional administrations • Vehicle sales figures from manufacturers • Production and import statistics	• Vehicle stock may not be reliable if old vehicles are not deregistered • Cross-checks with data provided by public transport companies
Fuel economy data	• Passenger cars/light duty vehicles: Systematic collection of fuel economy data from vehicle type approval tests • Buses: Fuel economy data provided from public transport companies -> need for statistical procedures to collect this data	• Type approval data are only available for passenger cars and light duty vehicles, not for buses and trucks; additional data are only available for new registered vehicles (not for vehicle stock) • Type approval data underestimates real-world fuel consumption of vehicles -> additional investigations needed (in EU 20-30% difference)
Vehicle-km (VKT)	• Odometer data from regular vehicle inspections • Household surveys: Mobility diaries/vehicle logbooks • Manual or automatic traffic counts • GPS data logs	• Data should be separated by vehicle categories and sizes, fuel types, ideally by vehicle age • Sample sizes and frequency could be problems of surveys • Traffic counts are normally only available for part of the road network -> extrapolation is needed
Passenger-km	• Household surveys/interviews • Census data • Public transport: statistical data compiled by public transport companies (public transport patronage statistics) -> need for statistical procedures to collect this data	• Sample sizes and frequency could be problems of these surveys • Data from surveys and VKT data are independent sources and are connected via occupancy rate of vehicles -> data can be cross checked
Modal split of passenger transport	• Household surveys/interviews • Census data	• Sample sizes and frequency need to be sufficiently large to ensure reliable outcomes

Table 6: Examples of data collection methodologies for passenger transport

Travel activity data is observed, measured, or collected in surveys[6]. Given the fact that data for transport monitoring cover a wide range of activities in personal, public and freight transport it is in most cases impossible to actually measure individual indicators. A direct measurement of trip lengths and overall kilometres travelled for each individual vehicle would require all vehicles to be equipped with corresponding meters, together with an infrastructure and legal basis to collect the data. While this may be technically possible, it is not likely to be a cost-effective solution, especially for developing countries. Surveys collect data from a sample of the target group/population and statistical methods are used to estimate the data for the whole group.

Household travel and/or origin-destination surveys, occupancy surveys and commodity flow surveys are essential in determining transport demand for passengers and freight. These surveys, from which vehicle and passenger kilometres travelled by modes are estimated, use interviews to identify travel patterns and trip lengths. Interviews can be conducted in different ways, personally, by phone, mail, online or in combination. In this context travel demand models used by transport agencies for planning and policy assessment are a great source of data for emission quantification. For example, prior to its introduction, the traffic effects of the Stockholm congestion charging system was modelled in about 100 different scenarios. This also easily enabled the estimation of the emission reduction effects using the official emission factors database of Sweden (Handbook for Emission Factors, see Box 9).

A good example for data collection and monitoring at national level in Asia is the Japan Statistical Yearbook. The Japan Statistical Yearbook[7] published by the Statistics Bureau, Ministry of Internal Affairs and Communications, Japan is a gold standard in annual comprehensive data collation in Asia. The transport section contains statistics on the traffic volume by type of transport and facilities related to transportation. The table below summarises the data collection method by mode of transport.

Parameter	Methodologies	Aspects to consider	Fuel Use	Data Collection Method
Cars	Number of cars by fuel type: private conventional cars, taxis, mini cars	Km/car by fuel and type; passenger km by car type	Fuel use/km by fuel and car type	Random sampling; Survey method: enumerator survey (partially by mail)
Buses	Transit Buses; intercity buses	Vehicle kilometres and passenger-kilometres	Fuel use by type	
Rail	Intercity Rail; urban and commuter rail	Freight by type; cargo transport volume by operational mode and by vehicle type (transport tonnage/tonnes-km), passenger transport volume by operational mode and by vehicle type (number of passengers/passengers-km), transport frequency, and distance	Fuel consumption	Survey of passenger traffic receipt; survey of freight volume
Domestic Air	Number of units handled for transport and operating hours of aircraft.	Weight; capacity; number of passengers; number of passengers transported; weight of passengers transported; number of flight services; cargo weight; utilization of capacity; transport ton-kilometres	Fuel consumption	Complete enumeration using survey method by mail or online application (self-entry)
Domestic Maritime – coastal, ferries, rivers	Number and gross tonnage of incoming vessels	Passenger km Number of passengers, marine incoming and outgoing freight; land incoming and outgoing freight	Fuel Use/ passenger-km	Survey on Ports and Harbour; Land Incoming and Outgoing Freight Survey by using enumerator survey (self-entry)

Table 7: Summary of Japanese transport data collection (Source: MLIT)

Box 9: Example for data collection: Japan Statistical Yearbook

[6] Economic Commission for Europe of the United Nations (UNECE), "Glossary of Terms on Statistical Data Editing", Conference of European Statisticians Methodological material, Geneva, 2000.
[7] http://www.stat.go.jp/english/data/nenkan/index.htm

Observation supplies real, measured data for a sample, which can then be used to extrapolate data for the targeted area. In general, observation is often used to determine traffic characteristics, such as speed and vehicle occupancy. The most important example is data from traffic counts, which nowadays is often collected through sensors in roads and usually is used to analyse VKT in a given street corridor or area[8]. Manual observations surveys also deliver useful data: Observers collect the data at a prescribed location/area and moment(s) in time. Some advanced cities and countries even conduct traffic counts through video recording and automated licence place recognition. In this way, and linking such data to vehicle registration databases, it is possible to determine the exact fleet composition or analyse occupancy rates.

Mileage surveys usually use a combined methodology of (automatic) traffic counts on major roads and household interviews in order to achieve more accurate results through triangulation. Data sources for mileage can also come from sample odometer readings, for example taken from inspection records or vehicle owner surveys. This can indicate average annual mileage values differentiated by vehicle category, fuel type, age, etc. In Germany, for example, the Federal Highway Research Institute (BASt) conducts comprehensive mileage surveys every 10 years. In some countries such as China GPS devices are used to monitor mileage of vehicles. For more information see a recent methodology overview of DLR and IVT (2017).

The method for determining emission factors is usually dynamometer-based drive cycle tests to simulate typical driving conditions. It also can involve fuel consumption surveys and measurements with Portable Emission Measurement Systems (PEMS). For more details on such methodologies, see an introduction in GIZ 2014 and technical descriptions of HBEFA and MOVES (see above).

[8] This includes, for example, the roadside windshield observation method and the carousel observational methods (Gan et. al.,2008)

3.3. QUALITY ASSESSMENT AND QUALITY CONTROL

Quality assurance and quality control (QA/QC) is an important element to enhance the confidence of decision makers and stakeholders. There are a number of different ways to use the terms, depending on the context. For MRV systems in the transport sector the following definitions are useful:

- Quality control focuses on the quality of the end product, in this case the quality of data. It is usually a set of routine technical activities, performed by the personnel compiling the data.

- Quality assurance is a planned review process conducted by personnel not directly involved in the data collection and processing (Winiwarter, Mangino, Ajavon, & McCulloch, 2006). The activities are normally carried out within the group of institutions responsible for data collection, by staff members not directly involved, other departments or related agencies.

- Verification is normally carried out by independent external entities to enhance confidence that data are relevant, complete, accurate, consistent and transparent (WRI, 2014). Good examples for verification are auditing procedures for companies listed at the stock market. These corporations publish sustainability reports, which are verified by external auditors.

Many bottom-up indicators in the transport sector need to be derived using a variety of sampling, extrapolation and modelling techniques. To ensure robust data, QA/QC procedures are extremely important. They need to go beyond technical checks on data consistency and need to critically review sampling procedures, locations, methods used, etc. This is usually described in data management guidelines or systems but could be a challenge for institutions in developing countries.

QA/QC procedures have to be defined carefully. Cross checks of different data sources are very helpful in this context. For example, the evaluation of fuel sales figures by comparison with fuel production data from refineries and import statistics can be helpful to improve data quality (Grütter, 2014a). The comparison of bottom-up approaches with results from top-down calculations helps to confirm data but also to identify problems. Some derivations can be explained by different boundaries (e.g. fuel sales may include fuel that is exported or used in the residential sector), but in many cases differences point out data issues and the need to improve data collection. A crosscheck is a standard procedure for countries using bottom-up approaches (see sections 2.1 & 2.5) and should be considered in any MRV planning process. In the longterm comprehensive QA/QC procedures may even reduce the costs of a MRV system as they enable learning and improvements in data collection processes.

Issue	Options to address them
Restricted access and confidentiality	• Explaining in detail to data owners how data will be used • Aggregating data to limit the possibility to draw out important pieces of information • Signed agreements on data provision indicating the level at which data will be made public
Data gaps	• Carrying out surveys or measurements to obtain new data. • Relying on regional data, which can be compiled and aggregated. • Using expert judgements especially when statistics or calculation technics cannot be applied due to lack of data or capacities • Filling data gaps by calculating proxies for example by interpolating data or inferring missing years.

Table 8: Issues in data management and options to address them

Using a structured approach, including adequate QA/QC procedures, to estimate emissions for inventories and the MRV of measures is key to high quality analysis. However, uncertainties remain. The main concerns considered below are restricted access and data gaps. Time series consistency and crosschecks of total fuel demand are common ways to validate data and estimate uncertainties.

Central components of inventories and MRV of measures are time series data because they provide information on historical emissions trends and track the effects of strategies to reduce emissions at the national level. All emissions estimates in a time series should be estimated consistently. This means that the time series should be calculated using the same method and data sources for each year as far as possible.

The quantification of uncertainty can be described as “good practice”. Uncertainty is usually presented by giving an uncertainty range expressed in a percentage of the expected mean value of the emission (also called 95% confidence interval) or is directly provided based on expert judgement. However, there are also qualitative approaches. Further details are given in Annex I “Managing Uncertainties” of the Revised IPCC Guidelines 1996 (IPCC 1996).

3.4. LINKING TRANSPORT DATA AND GHG INVENTORIES

The top-down approach is a simple and robust way to estimate total emissions. Most countries monitor fuel sales for tax purposes and relatively robust data is available in the national energy balance. This allows calculating CO_2 emissions based on the carbon content of the fuel. This is not the case for other greenhouse gases, such as methane (CH_4), nitrous oxide (N_2O) and air pollutants. Emissions of these depend strongly on the combustion technology, emission control technologies and operating conditions. The bottom-up approach allows for the estimation of emissions of CH_4, N_2O and air pollutants, particularly the latter, it being an important element in transport planning. GHG inventories are the backbone of UNFCCC reporting.

The IPCC has established guidelines for developing GHG inventories that combine the different approaches and ensure consistency in international reporting. These inventories are used for Bi-annual Update Reports (BURs) and National Communications (NatComs) of the Parties of the UNFCCC. More and more cities and communities are developing GHG inventories. These are voluntary and not required by the IPCC. Methodologies used vary, although some tools are available, such as the WRI GHG Protocol for Cities (WRI no date). This section concentrates on national level inventories, although the main concepts also apply to sub-national inventories.

3.4.1. Transport in the IPCC guidelines

Developing countries are recommended to use the Revised 1996 IPCC Guidelines (subsequently referred to as ‘1996 guidelines’), although an increasing number of countries apply the newer IPCC 2006 Guidelines (subsequently referred to as ‘2006 guidelines’). The 1996 IPCC guidelines divide the energy sector into 3 sub-categories. The first one is “Fuel combustion activities”, of which Transport (1.A.3) is a part. Transport is further divided into 5 categories – A to E – for inventory purposes as shown in Figure 4. Transport does not consider military transport, which is included in category 1.A.5 “Other”.

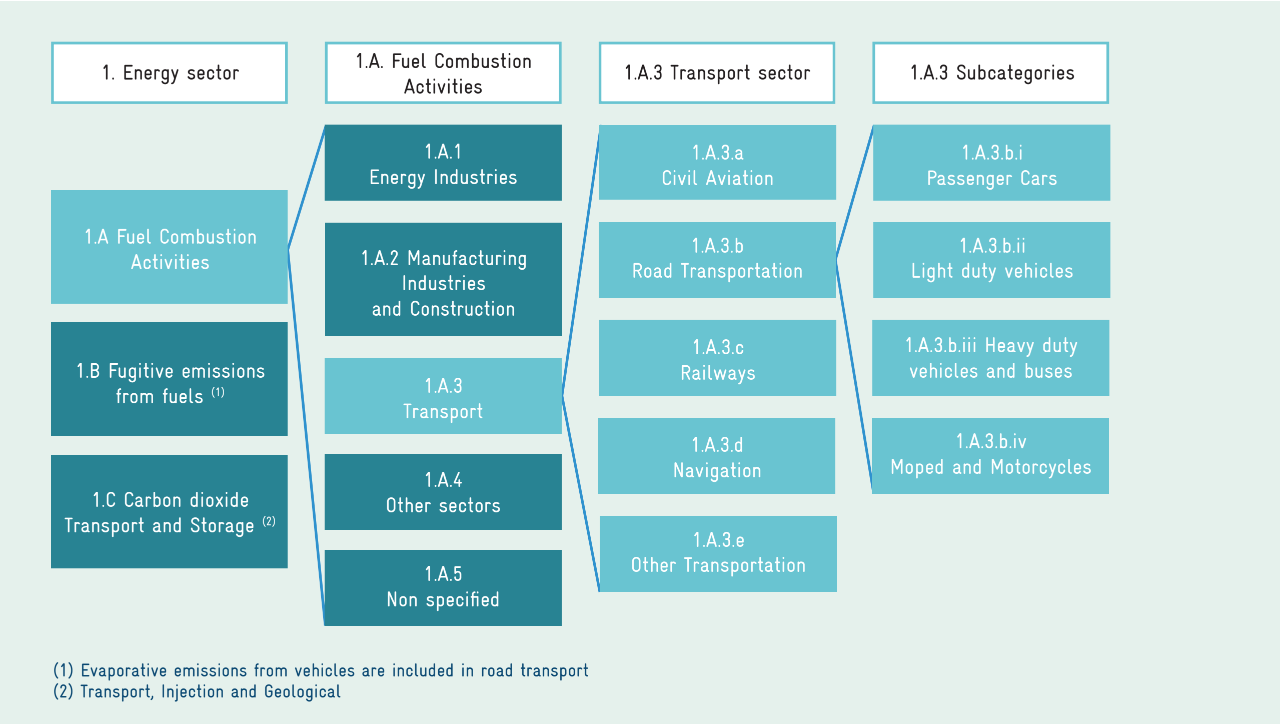
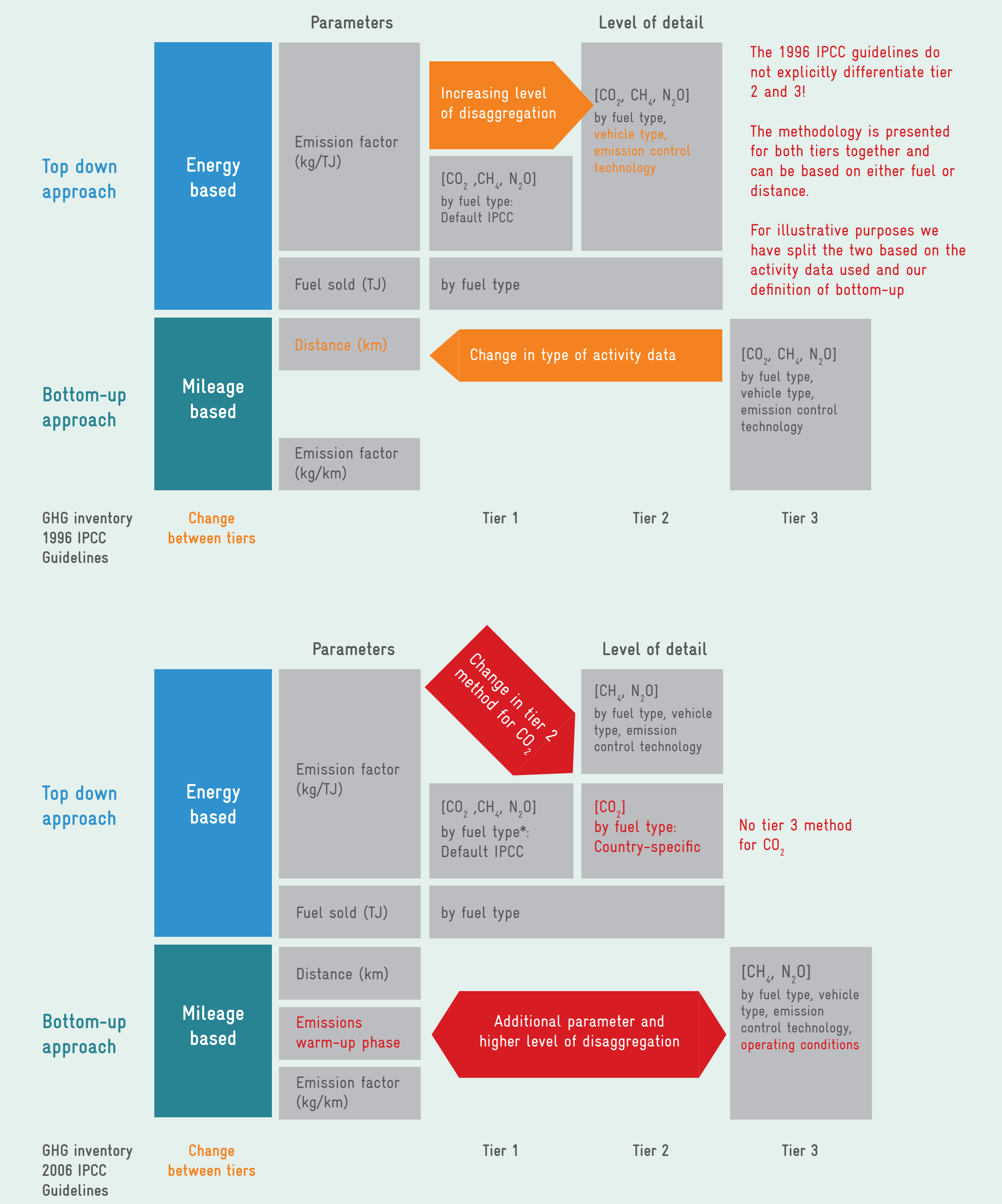


Figure 4: Energy sector categories and subcategories (example road transport)

The IPCC Guidelines 2006 further introduces the concept of "key-categories", aiming at identifying the most relevant categories either quantitatively – the favoured method – or qualitatively. In the case of limited resources, efforts should focus on these key categories. The guidelines provide a quantitative approach to select the key categories:

- Level analysis: Rank all categories along their estimated emissions and select the categories with the highest emissions, which summed up represent 95 % of total emissions. These are the key categories.
- Trend analysis: Analyse emission trends in the categories and add any category which may be relevant in the future. [IPCC, 2006]

The system in both guidelines is organized around three 'tiers' that constitute an increasing level of accuracy. Figure 5 illustrates the basic data requirements for different tiers in both guidelines and highlights the differences between tiers and between the two guidelines. The basic logic and the underlying principle of increased data requirements remains the same for both guidelines. Higher tiers require a higher level of disaggregation and include additional information.



Source: Vieweg 2017

Figure 5: Basic structure of tiers for 1996 and 2006 IPCC Guidelines

Tier 1 represents the default method, which normally uses high-level data from energy statistics together with default conversion factors (sometimes also called emission factors). The energy consumed is converted with default conversion factors for carbon content into CO_2. For other GHG emissions (e.g. CH_4, N_2O) fuel-based default conversion factors are also used although these factors depend on the combustion technologies and operating conditions (and not on the carbon content of the fuels). Therefore, the tier 1 approach has large uncertainties regarding the non-CO_2 greenhouse gas emissions. This tier is identical in both IPCC guidelines.

Tier 2 is different in the 1996 and the 2006 guidelines. In the 2006 guidelines this tier describes inventories based on fuel sales energy balances as in tier 1, but applies country specific conversion factors that consider the location specific nature of fuels (density, net calorific value, etc.). Due to the use of country-specific conversion factors the uncertainties are much lower. For CH_4 and N_2O emissions additional bottom-up indicators for tier 2 on distance travelled and emissions in the warm-up phase are required, with different levels of detail. The 1996 guidelines do not do not differentiate between tier 2 and 3. The methodology is presented for both tiers together, applies to all gases and can be based on either fuel or distance, using disaggregated data by fuel type, vehicle type and emission control technology.

Tier 3 represents the most detailed method and goes beyond fuel sale statistics. However, the 2006 guidelines do not provide a tier 3 methodology for CO_2 emissions, as "it is not possible to produce significantly better results for CO_2 than by using the existing Tier 2" (IPCC, 2006). The IPCC instead encourages further improvements in determining fuel sales data. For other gases, there are different levels of detail to such calculations from very rough (average vehicle kilometres travelled (VKT) multiplied by the number of vehicles and the average emission factors in gCO_2/km) to very detailed emission models such as COPERT. Such data should be complemented with calculations of energy consumption of vehicles based on activity data. Tier 3 approaches also apply country specific conversion factors. The 2006 guidelines also introduce operating conditions as an explicit element in tier 3 calculations. This means for example the consideration of emissions during the warm-up phase of the engine (cold start).

The IPCC 1996 guidelines give the following general formula for estimating mobile source emissions via the bottom-up approach (covering both Tier 2 and 3):

$$\text{Emissions} = \sum (EF_{abc} \times \text{Activity}_{abc})$$

with

EF = emission factor
Activity = amount of fuel consumed or distance travelled
a = fuel type
b = vehicle type
c = emissions control technology

The bottom-up approach requires both emission factors and activity data at the level of vehicle type, fuel type and emission control technology. Figure 6 provides an example of the differentiation for passenger cars.

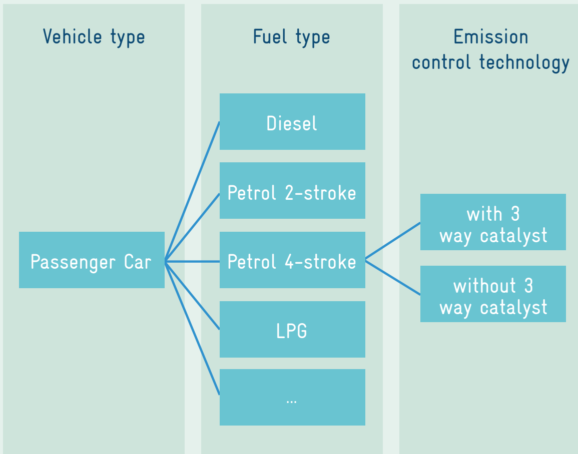


Figure 6: Example for a Tier 2/3 differentiation for passenger cars

Box 10: 1.1. Calculation approach for road transport

3.4.2. Towards bottom-up inventory models

In an ideal MRV system, bottom-up and top-down approaches are combined to compare the results as part of the quality and plausibility check and manage data consistently. Developing emission inventories that combine top-down and bottom-up approaches for transport have the following benefits:

- Advanced (bottom-up) transport GHG inventories provide more differentiated data on GHG emissions by freight or passenger transport, transport modes, vehicle types, vehicle size groups, trip purposes, etc., providing useful information for understanding where emissions originate and for developing mitigation actions.

- Comparing bottom-up and top-down data allows quality checks and plausibility discussions. Combining both approaches is a means to address accounting problems, e.g. whether the fuel is used in the transport sector or for non-road machinery in the building or agricultural sector.

- Top-down inventories only allow accounting for CO_2 emissions. Combining top-down with bottom-up inventories also allows accounting for other GHGs and air pollutants. At a local level, bottom-up methodologies are often available as they are needed for air quality planning. Such local models can also be used to build consistent modelling approaches at a national level.

This full tier 3 GHG inventory is also beneficial for the MRV of mitigation actions (see section 4). In order to create a bottom-up inventory for the transport sector it is important to determine a governmental body with adequate authority responsible for the MRV process. This body has the function of supervising the MRV system implementation, defining timetables with milestones and deadlines, facilitating communication between all actors and stakeholders in the MRV procedure and ensuring that the results meet quality requirements of national GHG inventories. As explained in section 3.3 many different public and private institutions, governmental bodies and stakeholders are involved in the collection of transport relevant data. To minimise data collection efforts, it is essential to identify all existing data sources and respective actors that provide, compile or use data. If required, stakeholder consultations and the creation of working groups can be helpful to support these steps. Best practice is to establish a clearinghouse that improves access to data and data quality.

Parameter	Issue	Proxy/solution
VKT	• No recent survey	• Carrying out a survey • Latest reports or latest estimates from recent questionnaires • GPS information
Passenger and freight loads	• No statistics	• Questionnaires • Latest reports/estimates if available
Vehicle categories	• Categories not consistent between ministries/public entities	• Harmonising categories

Table 9: Possible issues and solutions for developing a bottom-up inventory for road transport

Unfortunately, in many developing countries a bottom-up inventory tool is missing. The lack of bottom-up emission models could be overcome by adapting inventory tools from developed countries such as COPERT. The Transport Inventory Greenhouse Gases Emission Reporting TRIGGER tool[9] is a simple spreadsheet developed on behalf of the government of Viet Nam. It allows developing countries to quantify transport emissions and compare bottom-up and top-down approaches when calculating emissions. If more inventory tools are adapted, consider adapting a tool that is also able to quantify air pollutants. In this case, an additional benefit would be to enable the MRV of mitigation actions and to quantify the co-benefits of reducing air pollution.

[9] The tool is available for download at: http://www.changing-transport.org/tools/TRIGGER/

4. CONCEPTS FOR ASSESSING MITIGATION ACTIONS

The concepts and parameters discussed in section 2 are the basis for monitoring transport sector mitigation activities in general. This section provides further information on how data and parameters are used to adequately measure the outcome of a mitigation action. Effects are usually assessed by comparing "with mitigation action" outcomes to a situation "without mitigation action" (the baseline or business-as-usual scenario). The following sections describe concepts and terms that are needed to measure the effects of a mitigation action. To give practical insights, those concepts are then illustrated in section 5 with practical examples from the transport sector.

4.1. SCOPE OF ANALYSIS

For defining an appropriate MRV methodology it is important to understand the scope of the mitigation action. From a conceptual perspective, the term 'MRV' refers to ex-post monitoring and progress reporting. But in scenario studies for the transport sector (e.g. for NDC development) or for mitigation action proposals e.g. for attracting international funding it is also important to estimate the potential effect of an intervention before its implementation (ex-ante). Figure 7 illustrates the different occasions during the development and implementation of mit-igation action, when the quantification of impacts becomes relevant.

Ideally, ex-ante assessments would use the same methodology as ex-post evaluations; in reality, however, ex-ante estimations are often based on much rougher, simplified approaches than ex-post monitoring and necessarily build much more on assumptions of likely future developments instead of real-world data. In other words, the amount of measured data and the level of detail of emission quantifications increases from ex-ante to continuous ex-post assessment.

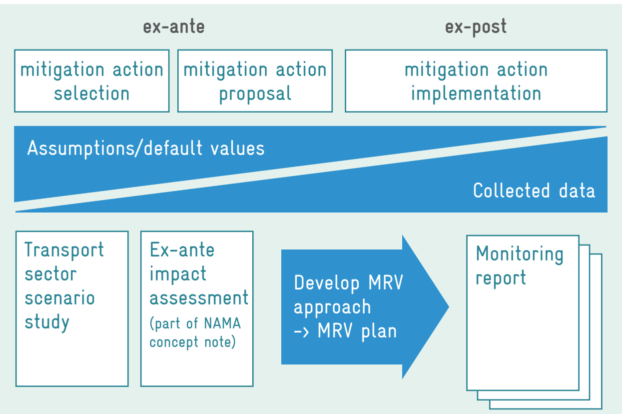


Figure 7: Occasions of emission quantification when developing and implementing a mitigation action

Requirements for an ex-ante assessment:

- Reliable transport data on the present system and its history to delineate robust trend assumptions for BAU and mitigation action scenarios
- Comprehensive historic data about macro ocio-economic trends that could impact the mitigation action and the BAU-scenario (e.g. GDP and population growth)
- Anticipation and consideration of political/ economic decisions and measures that might interfere with the effect of the mitigation action in the considered time frame

Methodological issues to consider:

- Choose realistic and conservative assumptions about the future development of key parameters, since ex-ante approaches tend to overestimate the effects from mitigation projects. For thorough data collection approaches see section 2
- Use data and experiences from similar previous ex-post evaluations to inform conception and assumptions of future ex-ante assessments
- Use the same boundaries and methodologies for ex-ante and ex-post evaluations
- For a comparison between ex-post and ex-ante approaches and further examples in the transport sector also refer to the GIZ transport NAMA handbook (GIZ, 2014)

Box 11: Requirements for and issues to consider in ex-ante assessments

Direct effects from mitigation actions

Any envisaged mitigation action in the transport sector (cause) aims at particular effects (impacts) such as reducing GHG emissions, influencing driving behaviour or road capacity improvement. This targeted impact from a transport policy or measure is defined here as a primary effect. The objectives of the policy or measure is a starting point for identifying primary effects. For mitigation actions, reducing GHG is always one of the primary effects. As mitigation actions are implemented in the context of sustainable development, a mitigation action could also have one or more sustainable development effects. For example, a mitigation action to replace old car fleets in urban areas would also enable direct reduction in local air pollution.

Indirect effects from mitigation actions

Aside from their direct effects, project mitigation actions often have further (sometimes unintended) impacts, indirect or secondary effects. They may occasionally cause negative effects of significance that may even over-compensate the desired direct effect and, consequently, need consideration. Indirect effects may be positive or negative. An example of an indirect effect is that a new BRT system might lead to a loss of car lanes, which may reduce private car use or reduce average speed / level of service of these lanes.

A special type of indirect effect is the rebound effect (WRI and GHG Protocol, 2014). Rebound effects may be seen in an increase of private vehicle travel due to reductions in costs and widespread availability of energy efficiency technologies. Another example is the implementation of a new high capacity and fast urban rail system, which may lead to more people relocating to the suburbs and commuting longer distances in the comfort of the new urban rail. Such rebounds in demand may reduce the mitigation effect of the action.

Leakage may be seen as another particular type of rebound effect. It occurs when mitigation actions have an effect outside the system boundary in such a way that it undermines the intended positive effect of the mitigation action. For example, after evaluating policies for subsidising the purchase of new efficient trucks, vehicle owners sometimes prefer to sell their vehicles outside the assessment boundary (instead of scrapping). This can reduce local emissions but the pollutant vehicles would still be used and may increase emissions elsewhere.

Box 12: Direct and indirect effects from mitigation actions

In ex-ante assessments the expected future effects of transport mitigation actions are examined, usually under a variety of scenarios. It can provide a basis for policy makers, project implementers or potential donors to make decisions or comparisons with other projects (e.g. the potential effects from various mitigation actions). The concept of an ex-ante assessment for GHG emission reduction is to anticipate the effects of mitigation actions and to compare them to a future BAU scenario. However, it is the nature of ex-ante analysis that both the mitigation scenario and the BAU-scenario are projections. In ex-post analysis the mitigation scenario is actually measured year-by-year whereas the BAU-scenario is based on certain counterfactual projections. In general, ex ante assessments may also include estimations of other sustainable development benefits.

In addition to ex-ante vs. ex-post, the scope of mitigation actions also relates to the type of action. Mitigation actions in the transport sector can range from a local public transport project, a sustainable urban mobility plan (SUMP) to a national fuel efficiency standard policy. Projects – with lower but more short-term impact – may be part of (investment) programmes e.g. into electric vehicles and (national) transport policies (e.g. fuel taxes) or a (sectoral) climate action plan. It is possible to link this scope to terms form the Paris Agreement such as CDM, GCF or GEF projects (short-term), to NDCs (mid-term) and long-term strategies (usually 2050).

In order to assess impacts of mitigation actions, a measurement methodology needs to be developed that takes into account key mechanisms of the mitigation action i.e. in what way the action is triggering change. This includes not only whether it is a strategy or project but whether the focus is on:

- Regulation, such as vehicle fuel economy standards (national) or emission-related vehicle access restrictions for certain areas (local);
- Plans, such as Sustainable Urban Mobility Plans (SUMPs) that can foster low-carbon modes, mixed use, polycentric urban development, compact urban form or national planning guidelines;
- Economic/fiscal instruments, such as fuel taxes or vehicle taxation linked to fuel economy standards (national level) or congestion charges (local) that can discourage the use of motorised vehicles and promote the adoption of more fuel-efficient vehicles.
- Public investments in infrastructure, such as walking, cycling and public transport improvements (local) and research and development of low-carbon fuels and vehicles (national).
- Campaigns or labels that encourage low-carbon lifestyles such as driver trainings and information campaigns.

In addition, the scope includes the main target group (e.g. individual people, transport providers, shippers etc.) as well as the time and geographic scale. Guidance to find methodological approaches to quantify the impact of actions is provided in the Passenger and Freight Transport Volume of the UNFCCC Compendium on Baselines and Monitoring.

4.2. MAPPING THE CAUSAL CHAIN

A transport mitigation action can cause a variety of direct (primary) and indirect (secondary) effects in the short-, mid- or long-term and occur inside or outside of the implementing system's boundaries. Furthermore, its effects may overlap with impacts from other mitigation actions. Effects can occur on various levels (local, regional, national) and influence multiple scopes at the same time (e.g. traffic density and air pollution). In order to set up a comprehensive MRV methodology it is important to consider potential direct and indirect effects of mitigation actions and identify the relevant indicators for measuring the effect.

For a better understanding of the relevant consequences of a mitigation action, the concept of causal-chain assessment is a helpful analytical tool (WRI 2014). The assessment begins by identifying and mapping all relevant causes and effects related to a specific mitigation action. This helps to draw the system boundaries and to define which sources and effects should be included and which not.

From this, relevant parameters for MRV are identified:

1. Identify the effects that are relevant to be observed in the context of the mitigation action
   - Direct GHG effects
   - Indirect GHG effects
   - Direct sustainable development effects (e.g., better transport infrastructure, safety)
   - Indirect sustainable development (e.g. local air pollution/health)
2. Map causal chain from the mitigation action to the effects
   - Determine direct effects of the mitigation action
   - For each effect identified, consider then the potential downstream indirect effects in the causal chain. E.g. less driving kilometres lead to a reduction of GHG emissions and air pollutants, as well as to an increase in productive time due to lesser time needed for travel.
3. Determine relevance of effects
   - Specify likelihood for each effect (e.g. categorise between "very unlikely, unlikely, likely and very likely").
   - Specify magnitude of effect e.g. choose between "minor, moderate and major" or consider applying a materiality threshold[10]
4. Determine parameters to measure the effects
   - According to the likelihood and relevance, identify branches of causal chains that need to undergo MRV because of their relevant positive or negative effects (e.g. significant GHG emission or traffic congestions reduction)
   - Determine indicators or parameters to identify relevant effects that can be measured, reported and verified
   - When selecting data sources for the indicators to be measured, it is crucial to strive for consistency with national level GHG inventories (e.g. use same GHG conversion factors).

[10] One criterion for this might be to determine if the impact of a specific process may lead to material changes in the estimated mitigation outcome (e.g. changes the estimated emission reduction by more than [20%]). Also the Policy and Action Standard by WRI and GHG protocol (2014) provide further guidance on assessing the relative magnitude (table 7.2).

In general, it can be assumed that the chain of effects is as follows: The Introduction of MRT improves the speed, capacity, comfort and convenience of the urban public transport system, this:

- reduces the use of private vehicles, taxi and mini-bus, and increases share of public transport system, this:
- increases the occupancy rate of the public transport system, this:
- reduces the total vehicle kilometre travelled by the same amount of passenger kilometres, this:
- reduces the total fuel-consumption, this:
- reduces CO_2 emissions.

Updating the public transport vehicle fleet or engines:

- further reduces the amount of fuel used per vehicle kilometre travelled, this:
- further reduces CO_2 emissions.

The introduction of a MRT system also has sustainable development benefits, since it:

- improves access to jobs and health care for all inhabitants on a city;
- reduces local air pollution due to reduced total fuel use, which leads to fewer health problems and reduces expenditure on health;
- reduces travel time, leaving more time for productive/leisure activities.

Box 13: Mapping the causal chain for MRT

The following mapping example illustrates how the analysis of the causal chain could be conducted for the operational phase of a planned Mass Rapid Transport system (MRT).

Some mitigation actions even have effects on upstream or downstream emissions. Upstream means emissions occurring during production of vehicles, fuel or infrastructure, downstream refer to end-of-life emissions such as scrapping or dismantling (see Figure 9). Usually, the highest effect of any transport mitigation action is related to the operation of vehicles. If the analysis includes vehicles with different fuels, especially biofuels and electricity, it is important to include upstream emissions of fuels in the analysis (carbon content). Otherwise, comparison of modes of vehicle categories may have major errors. In contrast to that, any upstream or down-stream emissions related to vehicle production or scrapping should be only considered if major emissions of the mitigation action are expected (e.g. truck scrapping scheme). Infrastructure construction may have considerable upstream emissions for projects and programmes (e.g. construction of a subway system). However, compared to 30-40 years of operation such emissions are still minor.

To deal with up- and downstream emissions it is recommended (in most cases) to use default values for the analysis and do not spend efforts to collect detailed life cycle data. For instance, the emission can be estimated in an initial ex-ante assessment but not monitored in detail. A good example for this approach is the Indian Inter-Urban Rail NAMA in section 6.2, where upstream and downstream as well as leakage emissions are not in the boundaries of the assessment but there is a section in the NAMA proposal to quantify them in the beginning.

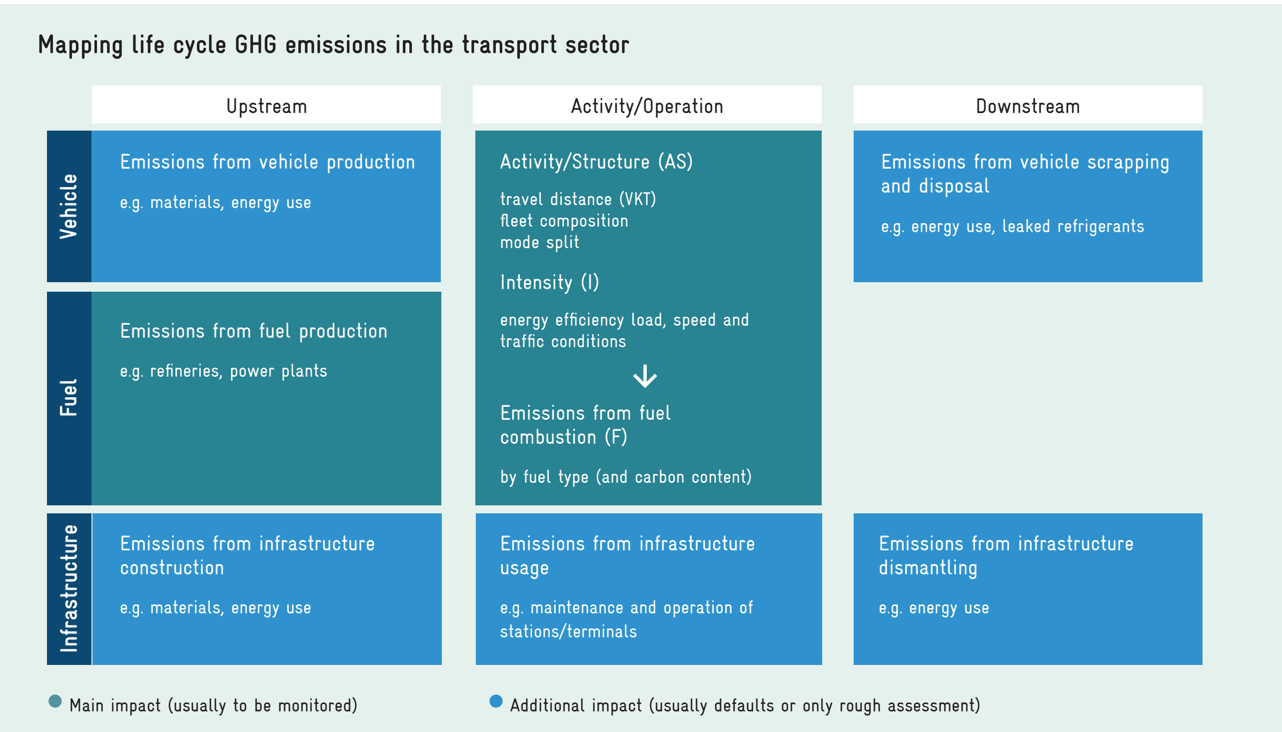


Figure 8: Mapping life-cycle GHG emissions in the transport sector (Source: UNFCCC 2018)

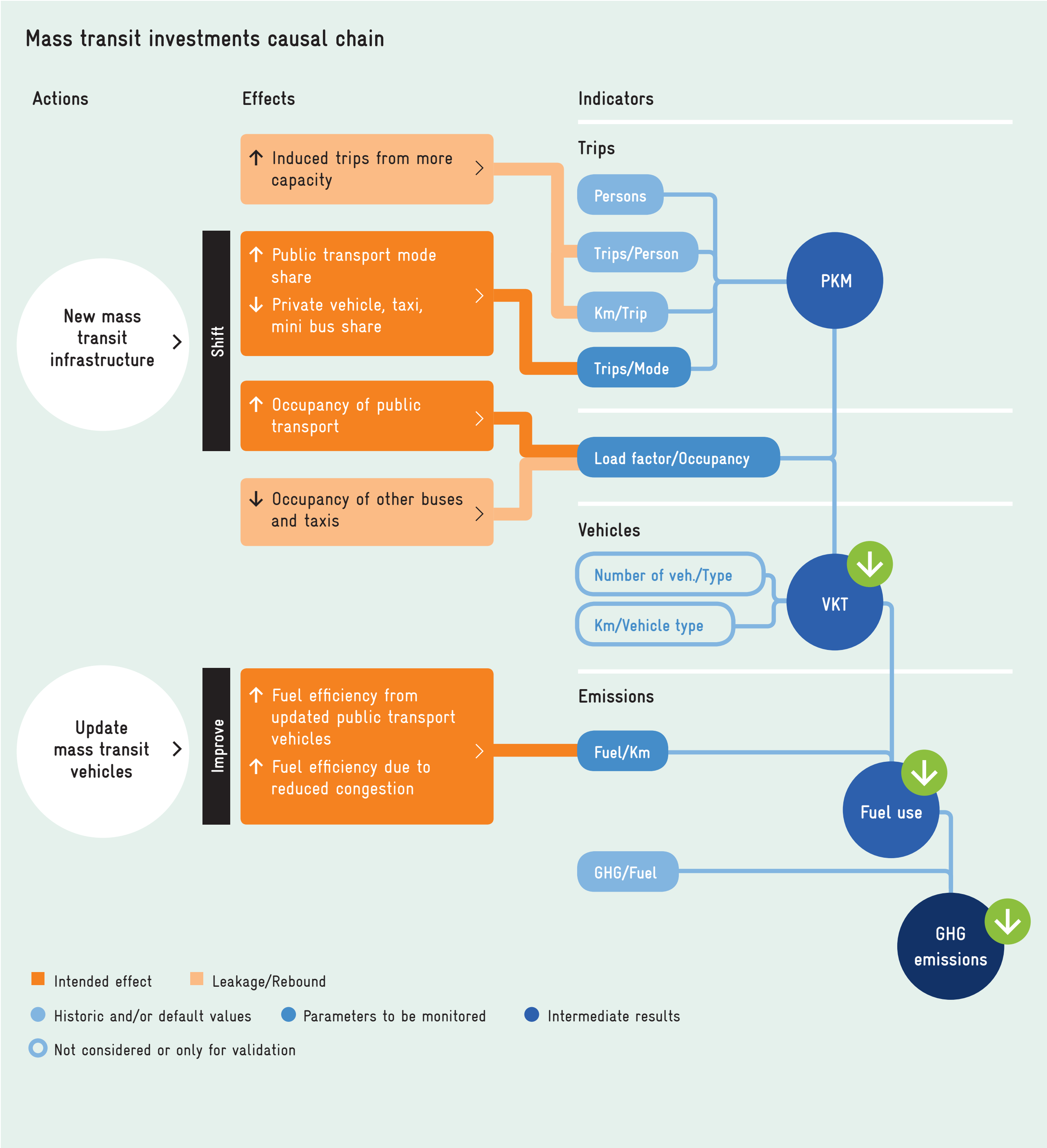


Figure 9: Mass transit investment causal chain (Source: UNFCCC 2018)

When inventories are used to track emissions from certain sub-sectors, upstream and down-stream emissions are usually accounted in other sectors and may not be considered in the MRV approach as otherwise double-counting may occur.

The assessment of different branches of the causal chains can be based on literature resources, professional judgment, expert opinion or consultations. Once the key impacts have been identified (GHG emissions, local air pollution, safer transport system, etc.) visualising a map of the causal chain shows how the policy or action leads to changes. In addition, it shows the da-ta/parameters which need to be considered for modelling (or monitoring) the effects. A key resource presenting causal chains for 8 different types of mitigation actions is the UNFCCC's Compendium of Baselines and Monitoring – Passenger and Freight Transport (UNFCCC/GIZ 2018).

4.3. BOUNDARY SETTING

Having identified the direct and indirect effects and the relevant data/parameters it is im-portant to identify the boundary of the analysis (see section 2.3). The boundary should include all the direct and significant indirect effects that result from the mitigation action as identified by the causal chain analysis (see section 2.3 for types of boundaries). All processes of the intended mitigation action where GHG emissions occur should be included within a temporal, sectoral and geographical boundary. The boundary is therefore also a specification of what data should be collected and for what period. Boundary setting also involves decisions on what GHG and which sustainable development effects are to be tracked.

In the MRT example above the temporal boundary could encompass the period between starting the construction of the MRT and a specific time after completion, e.g. one year after the system has been in place. The geographical dimension would include all roads or city districts where traffic flow is influenced by the new MRT. See Table 10 for the Transit Metropolis Programme an example of the boundaries of a national urban mobility (investment) programme (NUMP) from China.

In order to facilitate comparability, the boundary must be the same for the BAU and for the mitigation action scenario (see also next section). As described above, leakage emissions i.e. emissions that occur outside the boundaries should be analysed at least in a qualitative way in the mitigation action proposal.

Getting the boundary for the assessment of the mitigation action right is particularly important, since the MRV procedures will focus on parameters located inside the boundary. In the event the boundary is too narrow, relevant effects are neglected and MRV leads to a flawed assessment. If the boundary is too wide, the effort and therefore costs to monitor all the system components within the boundaries may be unnecessarily high. Therefore, when setting the boundaries, the following aspects should be considered good practice:

- Consider the mapping done for the causal chain assessment as the basis for your boundary setting. Make sure that all direct and significant indirect mitigation effects identified as relevant are encompassed by the boundary (which can be mapped in the same graphic).
- Specify also the temporal extent, such as the lifetime of the mitigation action, crediting periods, time interval for ex-post MRV (e.g. annually, biennial, etc.)
- Make sure to include all relevant gases into the project boundaries (e.g. methane emissions from fuelling CNG vehicles).
- Specify the spatial and physical (i.e. territorial) extent of mitigation actions, e.g. if the mitigation action takes place within the borders of a city, region or country or just on a street. Limiting assessment to a specific territory is also important, as the power of the decision-making unit is usually linked to a specific territory. However, discuss leakage at least in ex-ante assessment, maybe even include accounting of leakage emissions (i.e. occurs outside boundaries) in the monitoring approach.
- Narrow down boundaries as much as possible to the measures included in the mitigation action but remain pragmatic regarding data availability. Collecting additional, project type data, makes the MRV methodology very costly. Especially up- and downstream emissions may have to be excluded and it is often not necessary to undertake a complete lifecycle analysis (but may be needed for biofuels for example). Consider the cost-effectiveness when defining a boundary by balancing the importance of including particular effects against additional costs of monitoring.
- Understand data availability when setting boundaries. Usually various data sources have different boundaries and this must be dealt with (e.g. through correction factors). Data availability issues can justify the exclusion of some secondary effects, especially when considered minor.
- Try to avoid double counting the effects from the mitigation action with those from other mitigation actions or trends. This is particularly relevant for monitoring emission reduction actions. If CDM projects exist, there is a high risk of double counting. They should be clearly distinct from the boundary as emission savings have been sold to other countries or industries already.

Boundary elements	Description
Temporal boundary	2013-2020
Sectoral boundary	The MRV approach covers urban passenger transport by metro, bus (including BRT) and cars. E-bikes are not yet included due to missing data on travel activity.
Territorial boundary	Due to the nature of the mitigation activity, the territorial boundary distinguishes between two layers of analysis: 1. At the national level the territorial boundary includes all 37 pilot cities and their respective territorial assessment boundaries. 2. At the city level, each city must determine a suitable territorial boundary for itself. For citywide activities it is recommended to set the territorial boundary according to the boundaries that are already being used by local administrations for transport planning, cover most of the transport volume and which correspond with the available data as much as possible. In the case of Beijing the entire urban area within the 5th ring road is chosen as territorial boundary, because this corresponds to the travel demand model used by the city's Transport Commission and therefore also to the available transport statistics. It also corresponds to the area that would be affected by the assumed congestion charge and most of the activities on transit expansion.
GHGs included	The focus is on direct, activity-based GHG emissions. The monitoring covers tank to wheel CO_2, CH_4 and N_2O emissions, as well as emissions related to electricity generation, which are also included as a direct emission source. Indirect emissions of infrastructure operations are based on the electricity consumption of these services in the use phase (e.g. electricity used for congestion charging equipment or in metro stations). Other indirect upstream and construction emissions are not included in the monitoring. In order to account for upstream GHG emissions from fuel consumption, which lie outside of the assessment boundary (no refineries are within Bei-jing's 5th ring road), a default correction factor is applied for well-to-tank emissions based on literature and emissions are presented as indirect emissions. If available, national factors can replace international defaults (…). A rough estimation of construction emissions for metro expansion is provided based on existing literature to take these emissions into account as leakage. The assessment of indirect emissions does not include reduced emissions resulting from a decline in car production which, in turn, is linked to restricted demand. Reasons are the lack of data and high uncertainties on the size of the effects of the license plate lotteries on manufacturing. Not including these additional emissions savings is conservative.
Sustainability effects included	The analysis covers NOX and PM emissions from passenger transport, the land use of transport infrastructure within the territorial boundary, road accidents, jobs created, congestion developments based on the traffic performance index in the cities (if assessed by the cities). Cities with travel demand models can also calculate and report travel time developments every few years. Passenger comfort is assessed based on passenger satisfaction surveys from public transport companies. Energy security is assessed based on the net fuel savings of the mitigation activities, which are calculated anyhow for GHG emissions assessment.

Table 10: Potential system boundaries of Chinese Transit Metropolis Programme (Source: Eichhorst 2015)

4.4. LEVEL OF AGGREGATION IN ANALYSIS AND REPORTING

Project-, strategy- or policy interventions are often bundled under a mitigation action. Individual measures from the same mitigation action can aim at the same goal and interact by overlapping or reinforcing each other. This is likely when mitigation actions take place in the same (geographic) jurisdiction or national and subnational policies target the same sub-sector (e.g. a fuel tax and policies to incentivise the use of passenger cars running on alternative fuels).

Instead of assessing the effects from each activity individually, they could be assessed on an aggregate level by one single MRV approach. For example, transit oriented development (TOD) actions can range from infrastructure development (building new train stations, installation of double tracks), public transport planning (new bus service routes, increase in service frequency) and design of residential or commercial areas (e.g. to maximise access to public transport). In this case it would make sense to monitor the effects from individual mitigation actions at an aggregate level, since they all aim at improved accessibility to public transport and such an approach would be more cost effective.

Monitoring mitigation actions on aggregated levels is likely to be feasible when the assessed mitigation actions are similar and MRV data are available from each mitigation action on the same level. However, sometimes individual assessment of mitigation actions is more viable. The implementing entity should consider such issues in advance and decide on the appropriate aggregation level for MRV of the mitigation actions. Table 11 lists the advantages and disadvantages of assessing an individual mitigation action or a bundle of measures (according to WRI and the GHG Protocol, 2014).

The following steps might lead to a sound decision whether to consider aggregation of mitigation actions for MRV:

- Firstly, identify all the individual mitigation actions of the project or policy. Try to sort them according to similarities such as mitigation actions concerning a specific sector, similar types of mitigation actions or mitigation actions aiming at the same emission sources.
- Secondly, identify potential levels of aggregation. Individual mitigation activities (interventions) represent the most disaggregated level. The next aggregation level might subsume all measures of the same type or measures that occur in a specific geographic area. The bundling of all measures then represents the most aggregated level.
- Finally, select an appropriate level of aggregation

Approach	Advantages	Disadvantages
Individual mitigation action assessment	• Decision makers may want information on the effectiveness or cost-effectiveness of individual mitigation actions in order to make decisions about which mitigation actions should be supported • May be simpler than assessing a bundle in some cases, since the causal chain and range of effects for a package may be significantly more complex	• The estimated effects from assessments of individual policies cannot be straightforwardly summed up to determine total effects (due to interactions)
Aggregated assessment	• Captures the interactions between mitigation actions in the bundle and better reflects the total effects of it • May be simpler than undertaking individual assessments in some cases, since it avoids the need to disaggregate the effects of individual mitigation actions	• Does not show the effectiveness of individual mitigation actions

Table 11: Advantages and disadvantages from assessing on mitigation action or on aggregated level

Type of mitigation action	Example for a transport action	Boundary (territorial and sectoral)	Level of aggregation for monitoring
National transport climate strategy (sectoral)	Sectoral emission reduction target in national transport strategy	Territorial: Country, no international transport Sectoral: all land transport	National transport GHG emission inventory (top-down, but bottom-up preferred due to boundary issues); basically institutionalised data
National level transport policies	Fuel economy standard for pas-senger cars	Territorial: Country, no international transport Sectoral: all passenger cars	Detailed bottom-up inventory of emissions from passenger cars; (basically, institutionalised data e.g. fleet registration databases)
	Green tire certification for trucks	Territorial: Country, no international transport Sectoral: road freight transport	Bottom-up scheme to track and calculate emissions from trucks and technology changes (institutionalised data, e.g. from freight associations)
National infrastructure or technology investment programmes	Public Transport Investment Programme	Territorial: Administrative borders of participating cities Sectoral: only passenger transport	GHG inventory of passenger trans-port in each participating city (e.g. institutionalised data from urban transport authority)
	Truck scrapping scheme	Territorial: Country Sectoral: road freight transport	Scheme to track changes in vehicle types and calculate emission savings (institutionalised data e.g. freight associations)
Infrastructure or technology projects	Bus rapid transit (BRT) in major city	Territorial: all corridor Sectoral: all passenger transport	Bottom-up scheme to track pas-senger modal shift and passenger transport emission in corridor (project level data in surveys)
	Intermodal freight hub at major port	Territorial: freight transport with origin or destination in hub Sectoral: all relevant freight transport modes	Bottom-up scheme to calculate modal shift (project level data in surveys)

Table 12: Examples, boundaries and MRV approaches for different types of mitigation actions

4.5. BASELINE AND THE CONCEPT OF "BAU" SCENARIO

Baseline, reference or a business-as-usual (BAU) scenario are terms commonly used to define the reference level against which the 'mitigation scenarios' are compared[11]. Similarly, the BAU scenario also enables estimating the reference level of indicators that are not related to GHG emissions in order to estimate other sustainable development benefits. The emission reductions (ER) resulting from a specific mitigation action equals the difference in emissions in the BAU scenario (BE) and the actual emissions with the activity (AE).

$$ER = BE - AE$$

Figure 10 illustrates that the mitigation outcome of a specific mitigation action that reduces GHG emissions is the difference between on the one hand, the emissions in the (hypothetic) BAU or reference scenario without the mitigation action and on the other, the actual emissions with the mitigation action.

In the context of the UNFCCC, the conference of the Parties (COP) decided in Cancun that "developing country Parties will take nationally appropriate mitigation actions in context of sustainable development aimed at achieving a deviation in emissions relative to 'business-as-usual' emissions in 2020". Developing countries also agreed to report information on their mitigation actions including GHG effects through BURs to the UNFCCC.

Establishing a BAU scenario to assess the GHG effects is a key element to enable country to report on the GHG effects and assess against the goal of deviation from BAU emissions in 2020. The key concepts for establishing BAU scenarios are presented below.

4.5.1. Identifying parameters for establishing a baseline

A starting point for establishing the BAU scenario could be the parameters identified for MRV through the causal chain. These parameters capture the information needed to assess the effect of the mitigation action, e.g. to estimate the GHG effect from policies or strategies as in the case of the introduction of a BRT system in a city where a key parameter is total passenger km travelled and the share of the passengers in the system carried by the BRT system. To assess the GHG effect of the BRT system, both the passenger km travelled and share of different modes of transport in the BAU-scenario have to be estimated, possibly in surveys with BRT passengers (e.g. by asking what mode of transport would have been used in absence of the BRT) or through control group approaches.

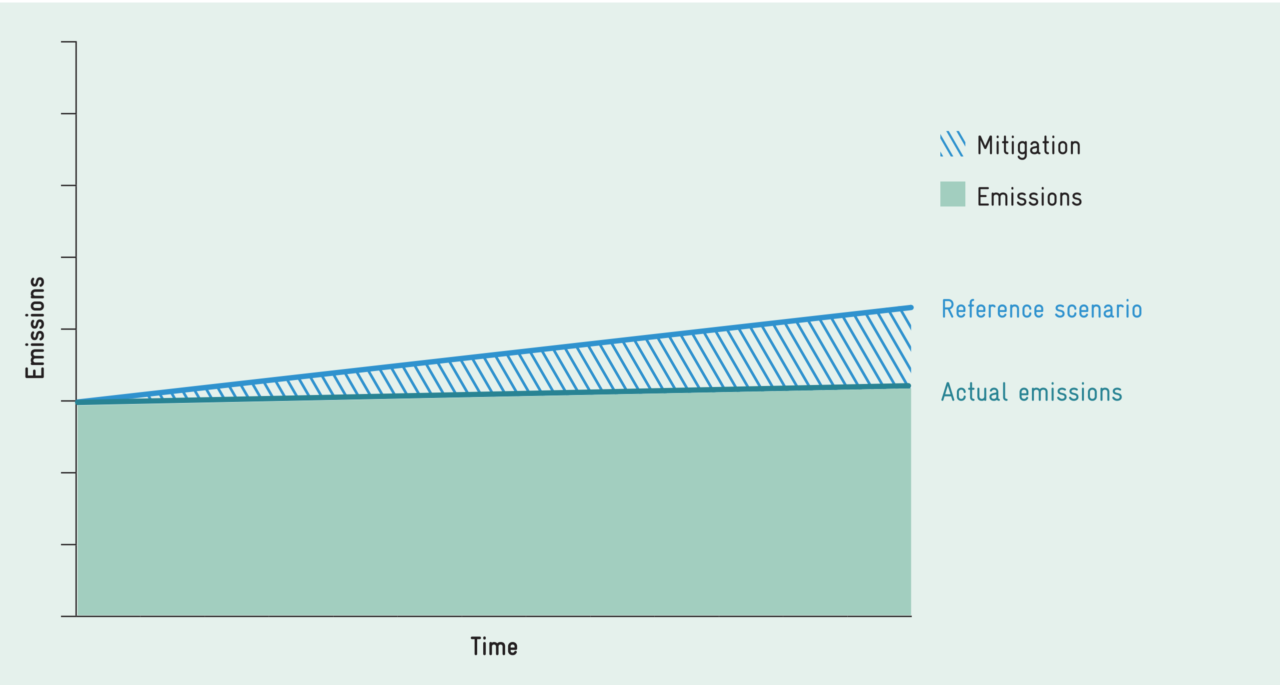


Figure 10: Mitigation Outcome of a mitigation action (Source: adapted from Füssler et al. 2014.)

[11] Baseline would be an alternative term used for BAU.

4.5.2. Methodology for estimating BAU values

A key principle is to use official projections if possible. This approach reduces effort and makes the approach consistent with national statistics.

Estimating the BAU level of the MRV parameters depends on the underlying key drivers that influence the parameter in consideration. For example, amongst other factors, the growth in passenger volume depends on economic growth in the city, increase in population of the city and cost of transportation. Establishing the BAU scenario for growth in passenger traffic would require developing methods for assessing the relationship between the MRV parameter and the key drivers, as well as a methodology for projections of the key drivers into the future. Establishing relationships between those factors and indicators has been notoriously difficult.

A common approach is to analyse historical trends (either lineal or with other algorisms like the Gompertz function for vehicle growth rates) and project such developments in the future. How changes influence the parameters is very much dependent on the context, so usually no general rule can be derived. It is recommended to review the proposed drivers with stakehold-ers that understand the local situation and have a good overview of the reasons for the developments. In an ideal case, stakeholders with different backgrounds agree on business-as-usual trends and what drivers must be observed during implementation of the mitigation action.

An alternative way to explore correlations with key drivers are control group approaches, where the development in a sufficiently similar region or city is monitored. Here, the challenge lies in identifying suitable control groups that may be expected to be subject to similar drivers as the region of the mitigation action. A challenge in both approaches is their rather high transaction costs. Further approaches such as expert judgements or travel demand modelling are provided in the UNFCCC's Compendium of Baselines and Monitoring – Passenger and Freight Transport (UNFCCC/GIZ 2018).

Projection of future trends depends on both the past trends, which are encapsulated in the existing situation, and an assessment of likely developments in the future. Likely future developments include both the technological trends as well as any policy/regulator changes anticipated. Therefore, BAU scenario development depends on the individual type of mitigation action included in a mitigation action since any BAU is context specific. In context of a project, as it is the case in CDM, the BAU scenario (baseline) reflects the most likely alternative available to deliver the same output/service as the project. For example, in the case of a MRT project, the BAU is what would have provided the service of moving a passenger from one point to another point in absence of the MRT. Passengers could have used existing public transport, private vehicles, non-motorised transport, or a combination of all this in taking the same trip which is taken using the MRT.

In the context of sub-sectoral/sectoral/national BAU scenarios, the issue is less related to investment decisions (as in the CDM), but rather to the types of anticipated decisions and developments in the future. As a consequence, consideration of technological development, market conditions and the effects of existing policies/measures on investment decisions becomes even more relevant. Therefore, in this context effectiveness of implementation of policies/measures is a useful rule of thumb to apply. For example, in the case of improving the fuel efficiency of the freight trucks, fixing fuel efficiency at existing levels in the baseline may overestimate the emissions reductions. In such a mitigation action, it is important to consider the effect of technology improvements that occurs for other reasons, e.g. due to changing fuel prices.

4.5.3. Pre-determined and dynamic BAU

Further, as discussed in Schneider, Füssler and Herren (2013), the BAU scenario GHG emissions could be either pre-determined (i.e. fixed) or they could be dynamic and be established using current data for the year of estimating the GHG effects. As mentioned above, GHG emissions are a product of activity and the emission intensity. A pre-determined BAU scenario could be fully fixed or it could be partially fixed upfront. For example, the emission intensity in the BAU scenario could be fixed upfront and the actual total BAU scenario GHG emissions could be estimated as the product of the fixed GHG intensity with actual activity data observed. In this case the BAU scenario focuses on determining the GHG intensity of the activity (gCO_2 per person-km), while the activity data (no. of person-km travelled) is taken from the actual situation of the mitigation activity.

A dynamic BAU scenario is where both, the GHG intensity and the activity data, are based on the measurements during the implementation. For example, in the case of CDM methodology for BRT the BAU (baseline) emissions are estimated based on surveys of the passengers using the BRT system to determine the mode share they would have used, if the BRT option was not available, multiplied by the current estimation of GHG intensity of different modes of passenger transport.

4.5.4.
Key factors in establishing BAU scenario

The following key factors should be considered in developing a BAU scenario:

Starting year and timeframe: BAU scenario emissions are the expected trajectory of emissions (not a constant value) for a period of time. The minimum target year for defining a BAU for a mitigation action is the year 2020 (the Cancun agreement goal is to reduce GHG emissions below BAU in 2020) but 2030 or even 2050 is advisable. The BAU scenario should also be aligned with any set timeframe for a national goal that might exist. For example, if there is a national goal of 20% emissions reduction from BAU levels by 2030, the BAU projection for the mitigation action should use that same period. In most cases the effect of implementing a mitigation action would go beyond the accounting period, e.g. for which international support is provided.

Modelling the BAU scenario: The identification of the relevant causal-chains (see 4.24.1) and the definition of the correct boundary of the mitigation action (see 3.4) is the key to modelling the BAU scenario. Setting the boundary ensures that all mitigation action is considered and no mitigation action is counted twice in evaluations. Therefore, other mitigation actions such as CDM projects, GEF projects or other mitigation actions should be clearly distinct from the boundary.

Modelling framework and/or projection methodology: All projections are based on assumptions about the future evolution of the key factors driving emission growth. Important steps in developing a BAU scenario therefore include identifying the drivers for change in activities within the defined scope of the BAU. Further, the methodology for the evolution of these drivers over the timeframe of the BAU and the assumptions made need to be clearly identified. These drivers can vary significantly by country, and analysing the trends involved can help improve the credibility of a BAU. Macroeconomic factors are relevant for all drivers as they set the framework for overall demand and production in the economy – Macroeconomic factors include GDP growth, energy prices, and changes in population, consumption growth, de-mand growth, changing national and sectorial priorities, etc. Secondary drivers can include changes in technology, changes in consumer preferences, changes in capital market, access to finance, local capacity, etc. The consideration of policies/measures already in place is also relevant in making projections on the key drivers.

The forecast methods used to predict trends of driving factors and the assumptions made regarding technology, learning and development also have an effect on the outcomes. Forecasts could be based on simple extrapolations (of historical trends) or could be based on models. This of course influences the outcome. Modelling could be either done bottom-up in a detailed approach developing the effects of various elements of the mitigation action or top-down, based on known economic interaction of key parameters and their reaction to constraints.

The following principles are useful to consider when establishing BAU scenarios:

- Check the availability of models. For policies with an impact on shift, one may use comprehensive transport sector models, especially for ex-ante assessment.
- Be transparent about assumptions that often are implicitly included in baseline models but later could be a reason for critique.
- If no specific methodology is available, linear extrapolation of past trends of key variables over a period of several years may be suitable. However, consider whether there are alternatives (e.g. a reference group approach) and check whether it is plausible to use other growth functions (e.g. Gompertz function for vehicle population).
- In an optimal case, scenario development (including baselines) requires extensive review through experts with local knowledge and experiences (stakeholder participation). If possible, workshops that facilitate agreement between stakeholders or Delphi methods should be used. This avoids not only mistakes but also mitigates the risk of massive critique on the baseline methodology.
- However, also consider future data collection possibilities when establishing the BAU data and avoid complex data acquisition procedures that may challenge future measurement.

4.5.5.
Uncertainty in BAU scenario and data

The process of setting the baseline using projections is subject to a large number of inputs, which combine technical approaches and assumptions as well as aspects subject to political influences. Defining the purpose and determining the assumptions and methods used will influence the resulting emissions BAU. Assumptions of the future always imply uncertainties and assessing the uncertainties and undertaking sensitivity analysis to assess the impact of key drivers on BAU is an important step in developing a robust BAU scenario. This process can be influenced by policy design considerations and stakeholder consultations, as well as by technical capabilities and the availability of data.

Usually, the main challenge to establishing BAU emissions lies in the availability of data, which may not exist or be incomplete or outdated (see also section 2.4). Rectifying such shortcomings may require technical capacity building and/or national or international technical assistance. Building the data set should be considered in conjunction with the future demand for data acquisition and maintenance, ensuring that once data has been established for the BAU scenario, it can be accessed regularly as part of the MRV system.

Data should be aligned with the national GHG inventory (see also section 5.2), using the inventory as the data source if it is viable or, alternatively, adding more detail to the inventory by upgrading data acquisition as part of the implementation of the policy, programme or project. If there are no existing data, standards or methodologies, BAU emissions may be estimated using simple assumptions, as long as they are transparently documented and published.

In situations in which there is a general absence of data or data acquisition systems, consider whether or not conservative estimates could work, or if a standardised BAU will help to replace the lack of concrete data.

The parameters relevant for the "ASIF" framework for monitoring actual transport system (section 2.1) also determine the data needed for defining the BAU reference scenario emissions. Along with the data needs mentioned in section 2, establishing a robust BAU may require socio-economic data related to determinants of the core transport sector data.

The socio-economic data required for establishing BAU depends on the nature of the mitigation action (investment project, policy/regulation, and sectoral/sub-sectoral targets) as well as the approach and resources available for establishing BAU. Such data are needed for estimating the mitigation action level and also the share of different modes of transport. Some types of mitigation actions, where the mitigation action level is measured as part of the mitigation action scenario, may not need socio-economic data for establishing BAU. For example, in a fuel efficiency improvement project where the GHG effect is measured as the difference between the efficiency in the BAU and the mitigation scenario, multiplied by total passenger/ton-km, the BAU projection of efficiency may not require socio-economic data. This is in general a case where a dynamic baseline could be established.

In a BRT project for example, the key factors for estimating BAU emissions are modal share and activity of passengers using the BRT corridors. Key data for estimating the activity and share are population growth, employment creation, income, relative costs, and, for a more detailed analysis, land use development (which influences the number of trips and trip lengths, which in turn influence the mode use behaviour). In a dynamic BAU, as is the case in CDM methodologies, the data on baseline mode share could be determined through surveys of other corridors during the operational phase of BRT corridors.

The dynamic BAU approach works only if the mitigation action does not affect the whole system, effectively allowing for the definition of a statistically representative part of the population that is not affected by the mitigation action and that reflects the BAU scenario. For ex-ample, in case of a transit oriented development (TOD) project, the mitigation action is linked to designing a public transport system for urban area, and its implementation changes the future development of urban areas away from the BAU development. Establishment of BAU involves projection of demand within the study area which is connected to growth in the city, viz., population growth, income growth, employment growth, pattern of development of urban areas, etc. Establishing BAU for a TOD project would require data for distinguishing the performance and penetration of mitigation actions within the urban area from the other drivers of change.

Socio-economic data for projects is required where more sophisticated approaches are used to establish the BAU scenario. The use of socio-economic parameters to estimate the activity levels and shares could be based on a simple model, such as past growth rates, or elasticity of economic growth, or could be based on detailed analysis and modelling. In most cases the socio-economic data are required for planning purposes and detailed feasibility reports for transport projects collect such information for design purposes and also for assessing the financial feasibility of the projects. Collecting data on socio-economic parameters is not necessarily additional activity and could be integrated with the existing information gathering process for planning and decision making.

Box 14: Baseline scenarios for non-GHG impact assessment

4.5.6. Other considerations

Transparency is very important in reporting the baseline development, because it will enable those considering the report to understand how it was developed and how to assess the influence of various elements considered in developing the final projections. The reporting should include information on data used, key driving factors of GHG emissions, assumptions for the key driving factors, methodology/model assumptions, etc. Another important element in establishing a BAU scenario is using conservative estimates i.e. that the BAU emissions estimated should be on the lower rather than the higher side of the possible range. The choice of approach, assumptions, methodology, parameters, data sources and key factors for developing a BAU should result in a conservative estimate of BAU emissions taking account of uncertainties. Each and every possible uncertainty embedded in the BAU scenario needs to be highlighted.

This precaution will prevent the carbon balance appraisal from showing a massive but unrealistic mitigation potential for a project, compared to an unlikely predicted situation without the project. The conservative aspect is linked to the choice of assumptions and key parameters as well as uncertainties in the BAU scenario, i.e. the assessment of possible future measures whose outcomes might be unknown at present.

Consistency in approach to developing a BAU across mitigation actions is essential, although variations in the level of detail are likely, but at the minimum the consistency in defining scope/ boundaries should be maintained. Again, transparency is the key to ensuring consistency, particularly in relation to underlying assumptions, in order to prevent arbitrariness of GHG emissions-reduction calculations.

4.6. DIFFERENT METRICS FOR TRACKING PROGRESS

The approaches discussed so far in section 4 focus on accounting for greenhouse gas (GHG) emissions at the national, programme and project levels. Yet in cases where there is international support the MRV process between implementers and supporting donors is potentially quite flexible and can be tailored to the specific case as well as to the needs of both parties. This can be expedient for transport mitigation actions that have unclear BAU, limited short term reductions or complex causal chains. Moreover, while GHG reduction is a key goal of mitigation actions, demonstrating progress on sustainable development may be important to garnering domestic political support for mitigation actions and attracting domestic investments necessary for implementation.

One way to take advantage of this potential flexibility is to expand MRV to the beginning and middle of the causal chain. While the ASIF equation is valuable for analysing the intermediate causes that lead to reduced GHG emissions, the actual causal chain often originates outside of the ASIF framework with the implementation of mitigation activities. Such a broader approach to MRV for mitigation actions might therefore be one that includes – in addition to GHG – metrics for intervention (i.e. implementation of activities), progress and sustainable develop-ment.

Intervention metrics are particularly helpful in the early stages of mitigation action implementation, and can demonstrate the mitigation action is being implemented as planned, whereas progress metrics can show meaningful progress against a reliable historic baseline (e.g. the number of logistics companies that organise themselves in alliances to improve their load factor).

Donors and implementers are concerned with getting effective, accountable actions underway as soon as possible. The proposal of a mitigation action should include definition of meaningful metrics that address key host and donor country concerns and that can be practically tracked from the very beginning. It is crucial that the metrics track factors that can be measured with certainty and are within a country's policy control. A flexible approach will need to address the requirements for accountability and support assessment of the mitigation action effect and its contribution to sustainable development.

An MRV framework for a complex, policy and project-based transport mitigation action might include three levels of transport metrics as well as a sustainability dimension:

- Intervention metrics would demonstrate that individual measures are implemented and produce results. Sample action metrics could include rewriting housing policy to encourage TOD, construction of a bus rapid transit (BRT) line, or implementation of congestion pricing.
- Progress metrics could include penetration rates of action effects, such as the share of trips taken on public transit, changes in the average trip length in a city, or motorisation rate reductions. These metrics are helpful in assessing the transformational potential of the mitigation action. Of course, many of these metrics are also necessary to calculate GHG effects using the ASIF framework or more complex models. Progress metrics should ideally be compared to historic data and trends to evaluate overall effectiveness and avoid uncertainties associated with BAU forecasts.

- GHG metrics fall into traditional MRV constructs and would include measures of aggregate GHG emissions, reference levels, and reductions against a baseline. This has been described in the sections above.

- Sustainable Development metrics could include median incomes, the amount of leveraged private and public investment (e.g., in new development near transit stations), household travel time and cost savings, expanded access to clean energy, better air quality, and health improvements. While indicators for sustainable development often can be derived from ASIF parameters they may also need additional research. For example, health improvements may require the analysis of air pollutant emissions and road safety developments related to the mitigation action. To limit the workload, it is recommend analysing mostly direct effects and discussing indirect effect in a qualitative way.

A key advantage of such a MRV framework is that it can be phased in over time. The implementation metrics are useable even before a good data collection baseline is established. As data collection capacity is advanced, the progress metrics become easier to obtain and more useful. After a historic trend is established it is possible to then compare to BAU projections and offer a reasonable assessment of the action's effect on GHG emissions. For a case study example of this approach see section 6.4 on Transit Oriented Development in Colombia.

4.7. REPORTING AND VERIFICATION

Reporting and verification needs to be considered when designing an MRV system. Emission reductions in the transport sector may need to be reported to three different audiences:

- domestic stakeholders, including the national government and general public;

- the UNFCCC; and

- any financial institution or donor that finances or supports a mitigation action, including national banks, or international donors like the Green Climate Fund or the NAMA Facility.

Each of these audiences may require different information (see Table 13). GHG emission reduction is certainly one key element, but some institutions may be more interested in other information. Costs typically rank high for national governments and financial institutions, while progress on contributions to sustainable development are of interest to national stakeholders, including the government, the media, the public and NGOs.

No strict, mandatory rules for MRV of mitigation actions are expected in the foreseeable future. Instead, a set of good practice standards is likely to emerge based on experiences gained in NDC implementation. The responsibility for submitting the UNFCCC National Communications and Biennial Update Reports is in most countries delegated to a unit within the Environmental Ministry. However, the necessary data must come from transport experts, mainly within the Transport Ministry or other institutions charged with implementing the NDC. Therefore, extended communication between departments and ministries of a country is needed.

Target group "Who to report to?"	Objective "Why to report?"	Required Information "What to report?"
Domestic	Inform domestic planning and decision-making processes; respond to stakeholder demand	Based on objectives and standards of country. Sustainable development effects could be of higher importance than estimation of emission reductions (ex-ante and/or ex-post)
International donor	Attract climate finance (ex-ante) Account for successful implementation (ex-post)	Estimated emission reductions of mitigation actions as well as costs & support needs are key elements in any proposal for international support (ex-ante). Based on donor requirements, other effects may also need to be included, such as contributions towards sustainable development, long-term & transformational potential towards low-carbon development, innovation ambition etc.) Ex-post estimates and implementation progress reports are important during implementation to receive on-going finance
UNFCCC Biennial Update Reports (BURs) or National Communications (Nat-Coms)	International reporting on efforts to address climate change	Information on mitigation actions in design and implementation phases both have to be reported. In the design phase, the estimated emission reductions of each mitigation action (ex-ante and ex-post) must be provided. In the case of mitigation actions already being implemented, information on current progress and effects must also be reported

Table 13: Reporting requirements for mitigation actions (Source: GIZ 2014)

Non-Annex 1 countries should report in their Biennial Update Reports on their mitigation actions. Specifically, they should provide the following information in tabular format:

a) Name and description of the mitigation action, including coverage (i.e. gases);

b) Objectives of the action, indicators and steps taken or envisaged to achieve that action;

c) Information on methodologies and assumptions;

d) Information on the progress of implementation of the mitigation actions and the underlying steps taken or envisaged, and the results achieved, such as estimated outcomes (metrics depending on type of action) and estimated emission reductions, to the extent possible;

e) Information on international support or market mechanisms.

Box 15: Reporting requirements in Biennial Update Reports (Source: Decision 2/CP.17)

For internationally supported mitigation actions, information must be provided to institutions that provide capacity development, technology or financial support. Estimates of costs and impacts (ex-ante) are part of any mitigation action proposal. During implementation, information on the action's status will need to be communicated (e.g. length of railway lines built to date). During and after implementation, actions taken, costs and impacts will have to be documented (ex-post). This is similar to many grants or support given for transport measures in the past by development banks. The key difference is that donors also require information on the GHG impact of a mitigation action. The kind of information requested varies from donor to donor and even from programme to programme. For example, the NAMA Facility, an early funder of mitigation action implementation, requests an assessment of the impact of any individual mitigation action on the greater transformation towards a low-carbon society, in addition to quantified GHG emission reduction impacts. At present, most donors do not have fixed requirements, but all usually require a mix of GHG impact and other sustainable development effects.

Information reported to the UNFCCC or to international donors must be transparent. Even if experts under the ICA process do not need access to the models or data themselves, it makes nevertheless sense to ensure that the agencies responsible for reporting have access to models and particularly input data. It is not enough to merely claim that a mitigation action reduces GHG emissions by x tonnes of CO_2eq – supporting information should be available so that an external reviewer can judge the validity of such claims. As a consequence, when hiring consultancies, define tasks carefully, and require transparency of model and data (review). They should not be allowed to keep models secret or not accessible by others.

The process of independently checking the accuracy and reliability of reported information or the procedures used to generate information includes the following activities among others:

- Description of the methods used to calculate emission reductions;
- Key assumptions made;
- Repeated checks for completeness and consistency;
- Validity and reliability of the information reported;
- Assessment of processes and measurement devices;
- Further quality control activities according to monitoring plan.

Within the UNFCCC there is a review process for Biennial Update Reports called International Consultation and Analysis (ICA). International donors have a range of different auditing procedures, which they can apply to verify given information. It will be important to provide information on mitigation actions and specifically their GHG impact in such a way that the quality of this information can be assessed and verified by external reviewers. This transparency is important to increasing the credibility of mitigation actions.

A well-prepared project and monitoring plan facilitates smooth verification and reduces the costs of verifying emission reductions. The Validation and Verification Standard by the UNFCCC (2015b, V.7.0) provides comprehensive best practice guidance on what verifying procedures could be taken. For the transport sector a relevant aspect is to strive for consistency with national GHG inventories when using data for MRV of mitigation actions. This includes e.g. using the same default emission factors.

5. DEVELOPING MRV METHODOLOGIES

Developing a MRV methodology for GHG mitigation actions in the transport sector can be a challenging task for developing countries. Considering all direct and indirect effects of causal chains for mitigation actions can result in the need for an extensive set of reliable data to ensure GHG reductions are quantified accurately. However, identifying emission savings can be an integral management tool for planning and implementation of transport policies, measures and strategies. MRV systems and approaches help managers, planners, implementers, policy-makers and donors acquire "the necessary information to make informed decisions" (UNEP, 2014). This concluding section completes the previous ones with information on how to establish a process for developing a MRV methodology for a mitigation action in the transport sector.

The basis for any MRV methodology is general transport data that is collected in the sector. Countries, federal states, regional governments or cities collect a lot of transport data for the enforcement of laws and regulations on a regular basis (e.g. statistical data like vehicle registration data). In addition, transport data are also collected irregularly on demand (e.g. travel surveys) for the assessment of new policies and planning processes. Therefore, data are available in many cases; the access to data, the definition of appropriate boundaries and the quality of data are the real challenges (SSATP, 2015).

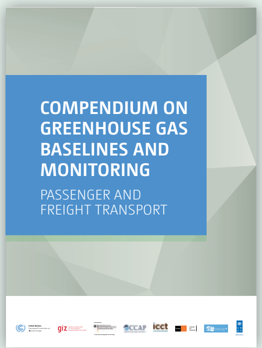
The assessment of GHG mitigation actions may furthermore cause the need for additional, localised data at the project level (see for example the discussion about institutionalised and project-oriented data in section 2.1.4). Since project level data are usually not available at the beginning of a MRV process, a first step can be to use so-called default values from the national, regional or city level instead or use secondary data borrowed from literature. In later stages of the MRV process the secondary data can be replaced by primary data (see Box 17). To fill initial data gaps, roadmaps for structured and optimised data collection and evaluation are needed for the assessment of transport mitigation actions. In this context, MRV methodologies for the assessment of transport mitigation actions should consider national GHG inventories (see further section 5.2).

The Passenger and Freight Transport Volume of the Compendium on GHG Baselines and Monitoring is a comprehensive guide to existing methodologies for greenhouse gas (GHG) quantification. It covers different types of transport mitigation actions, highlighting specific aspects of the general calculation logic of individual types of actions.

The Passenger and Freight Transport Volume guides readers through existing methodologies for the mitigation action they are considering. The methodologies presented in the Transport Volume were chosen with a view to cover a broad range of different mitigation action types in terms of scale, type of intervention and affected modes. So far, the Transport Volume covers more than 30 methodologies and tools, which are structured into eight different mitigation action types:

- Intra-urban mass rapid transit investments
- Comprehensive urban transport programmes
- Vehicle efficiency improvement programmes
- Alternative fuels incentives
- Inter-urban rail infrastructure
- Freight transport infrastructure investments to shift mode
- National fuel economy standards
- Pricing policies (forthcoming)

This document is available for download at https://www.changing-transport.org/publication/



Box 16: Passenger and Freight Transport Volume of the UNFCCC's Compendium of Baselines and Monitoring

Secondary data are often derived from published international or national databases, governmental statistics on a national or regional level, travel activity surveys, literature studies, companies and industry associations (WRI, 2014a). Secondary data can be based on international, national, subnational, regional or local sources. Activity data used for a MRV system of mitigation actions are very often based on national or regional data sources while emission factors are mostly taken from international or national databases (e.g. national GHG inventories). The declared objective must be that secondary data fits geographically, temporally, and technologically to the transport mitigation action being assessed. That means that secondary data can be used for the assessment but the data have to be adapted to the local situation of the GHG mitigation action considered.

For example, average emission factors (in gCO_2/km) included in national or international databases can be localised by considering local vehicle fleet composition. This adaption step is very often done within MRV systems for quantification of GHG emission effects. But the emission factors can also be localised in a more accurate way if local driving conditions like the typical share of stop-and-go traffic are considered (Schmied et al., 2014). This example shows that different adaption and localization steps are possible depending on data availability. Emission factors based on national data, but adapted to local situations, can be more reliable and representative than measured data that are collected over a short time period.

Particularly for ex-ante evaluations, the starting point can be secondary data, but for ex-post assessments of GHG mitigation actions secondary data should be replaced by primary data or adapted secondary data (WRI, 2014a). Transport activity data for ex-post analyses should especially be based on primary data; otherwise the MRV system does not indicate the real effect of the mitigation action. This shows that in normal cases a mix of primary and secondary data will be used for MRV systems of GHG mitigation actions in the transport sector. The share of primary data and adapted secondary data should be increased from ex-ante to ex-post analyses.

Box 17: Use of secondary data for the assessment of transport mitigation actions

5.1. STEPS IN DEVELOPING MRV OF MITIGATION ACTIONS

In order to develop an approach for MRV of mitigation actions, the concepts presented in section 2 and 3 are important. Similar to national GHG inventories, a first step is the assignment of a coordinating body for MRV processes of the mitigation action; this includes the clarification of funding of the MRV process (personnel and financial resources). The succeeding process is basically structured into 3 phases:

1. Identifying scope and boundaries,

2. Developing the methodology and model, and

3. Implementation and monitoring.

Each of these phases can be further separated into 3 steps that are also considered in the sug-gested outline for MRV methodology documents in Annex II:

Critical steps for developing a MRV approach for a mitigation action system are boundary setting (step 3) and baseline development (step 4). Setting boundaries is closely interlinked with identifying the causal chain (step 1) and the availability of data (step 2). The scenario and modelling phase always starts with the baseline that usually is based on historical data. In most cas-es, even base year emissions cannot be directly measured. An exception is, for example, actions that deal with emission reductions in public transport fleets or truck fleets where few operators can directly track energy consumption. For all other cases, emissions still need to be modelled based on transport data – both for baseline and for the mitigation scenario. The mitigation scenario then builds upon the baseline by varying key impact factors identified during mapping of the causal chain. The models to be selected for calculating emissions need to reflect these key impact variables. For modelling impacts of road charges, for example, the model needs to be able to consider elasticities.

A common problem in developing countries is lack of or no access to data. If data are available, it is often of low quality or no time series exist. Consequently, after the definition of data needs, data gaps have to be identified. Particularly for ex-ante evaluation the starting point can be secondary data to fill data gaps (e.g. from national GHG inventories or national transport MRV systems). Later, this secondary data should be replaced step by step over time by localised secondary data or new data collection procedures.

Phase 1

Define scope and boundaries

Step 1:
Identify main effects of mitigation action

- Identify scope of mitigation action
- Recognise direct and indirect effects along ASIF framework (GHG/co-benefits)
- Check if upstream/downstream emission must be included
- Conclude key indicators to track GHG emissions and effects on transport activities, e.g. consider to develop a causal chain

Step 2:
Assess data availability/gaps

- Check for institutionalised data (e.g. statistics)
- Check other available data sources (e.g. research, development aid projects)
- Define data to be collected

Step 3:
Define boundaries for analysis

- Define scope of analysis (spatial, temporal, sectoral)
- Define GHGs to be assessed
- Identify other major benefits in terms of sustainable development (co-benefits)
- Define the level of aggregation for reporting (see section 3.5)
- Refine data collection requirements based on boundaries

Phase 2

Scenarios and modelling

Step 4:
Develop baseline scenario (and ex-ante mitigation scenario)

- Develop baseline assumptions (e.g. literature review, expert judgment)
- Collect socioeconomic data such as GDP, population, etc. as key factors
- Develop assumptions for mitigation scenario (e.g. literature review, etc.)

Step 5:
Set-up model to calculate emissions

- Develop methodology for calculation of NAMA emissions and baseline emissions
- Decide what approach to emission factors is suitable

Step 6:
Develop data collection plan (and methods such as surveys)

- Define data collection methods and document them properly (methodology reports)
- Define roles and responsibilities and how data are processed between institutions
- Develop quality assurance procedures and assign responsibilities
- Outline improvements in data collection
- Describe how verification can be executed

Phase 3

Monitoring

Step 7:
Collect data (measure)

- Collect institutionalised data
- Conduct surveys, observations etc.
- Conduct quality control
- Update baseline assumptions in every reporting year in case of dynamic baselines
- Manage and document data to ensure verification

Step 8:
Calculate emission reductions

- Calculate baseline emissions
- Calculate NAMA (scenario, in case of ex-ante) emissions
- Calculate emission reductions
- Calculate uncertainties

Step 9:
Report and verify

- Create and update MRV plan
- Publish MRV report annually
- Conclude useful improvements to the methodology
- Document data and procedures carefully to facilitate verification

Figure 11: Three phases and 9 steps for setting up an MRV system

Recommendations on modelling mitigation action emissions for transport are:

- If possible, develop a VKT based model and use VKT based emission factors instead of passenger km or ton km based models. This reduces uncertainty, as no data on load factors is needed. In order to consider load factor as a means to reduce emissions or to quantify detailed avoidance or shift effects, pkm/tkm based models are necessary. However, pkm/tkm emission factors must be aligned with official/measured emission factors and assumptions on load factors need to be transparent.

- If possible, use official emission factor databases. If no detailed data and emission models are available, localise emission factors from other countries. Usually official transport emission models used for emission inventories – calibrated with top-down data – are the best source and ensure consistency (section 2.5).

- If there are already models (including emission factors), review potential shortcomings and consider whether to update/improve the model instead of developing a new one.

- Consider whether well to tank (upstream) emissions data are needed and available. This is an important factor to consider, especially when alternative fuels or electricity is used. Usually default values for the upstream part are sufficient to understand effects in shift measures, but some fuel measures need detailed data.

The process described in Figure 11 is valid for both ex-ante assessments and ex-post mitigation action monitoring plans. Ideally, ex-ante modelling during mitigation action development is consistent with the ex-post monitoring approach and uses synergies. In monitoring (ex-post) the "mitigation scenario" is replaced by calculating real emissions and comparing them to the baseline. As a principle, ex-post assessments must involve quite a lot of primary data; otherwise the MRV system does not indicate the real effects of the mitigation action introduced (WRI, 2014a). Data that represents the highest assumed effects should be prioritised in setting up data collection procedures. E.g. a monitoring system for a fuel economy policy must have a reliable vehicle registration database as a basis. This database must include vehicle size and fuel consumption and ideally vehicle age in order to show efficiency improvements over time.

5.2. USING BOTTOM-UP INVENTORIES FOR THE MRV OF MEASURES

Bottom-up inventory models are an important basis for the MRV of actions. It is recommended that these tools are developed over time (see section 3.4.2) to improve data quality and establish better procedures for collecting and managing data.

5.2.1. Inventories as a source of data

Fuel-based top-down approaches normally lack the level of detail required for the MRV of measures. Bottom-up inventory models are usually the source for base year data and historical trends and are therefore important for establishing a BAU scenario (see section 4.5). They will also help developing countries to paint a clearer picture of their current transport situations, highlight implementation successes and help with MRV of mitigation actions. Emission inventories can be a very useful source of data during the monitoring phase (see next section) but they are also helpful for the analysis of future scenarios for the sector (by providing data on past developments, which can inform assumptions about the future) and identifying the key categories or biggest polluting vehicle types or sub-sectors.

In understanding the usefulness of inventories for the MRV of measures a differentiation is needed between data that is reported as part of the inventory, for example in BURs, and underlying data that is used to generate the inventory. The inventory as officially reported mainly contains the final results, i.e. total emissions per gas and emission factors used. This includes emissions per sub-sector (civil aviation, road transportation, railways, navigation and other) and fuel sold by fuel type per sub-sector. For bottom-up inventory models (tier 2 and 3) information provided is emissions per vehicle category and fuel sold per vehicle category and fuel type. This data can be used especially for indicative ex-ante estimates of potential effects for some types of measures, mainly those changing fleet composition

Particularly for bottom-up inventories the input data required for preparation contains a lot of information also required for the MRV of measures, including distance travelled (vkt) per cate-gory, emission control technology and operating conditions including the calculation basis for vkt and cold start emissions. The underlying data may be included in inventory reports but will mostly be available from the modelling group / institution that is responsible for the bottom-up calculations and not shown in the inventory itself. However, the data from the inventory tool still has to be complemented with additional, measure-specific data as illustrated in Figure 12.

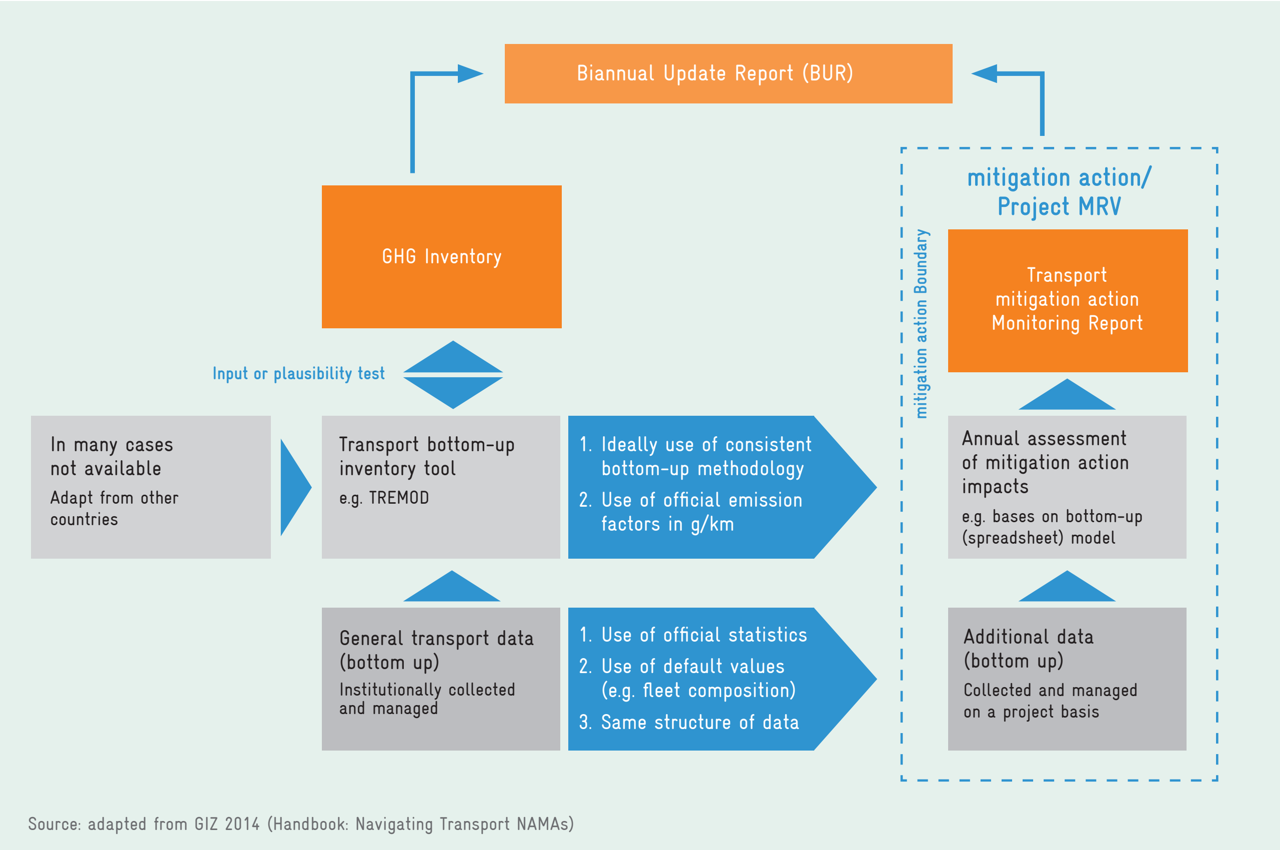


Figure 12: Relationship between inventory and MRV of measures

For example, vehicle-based efficiency standards are a widely used measure to reduce negative effects of vehicle emissions. The measure not only reduces GHG emissions, but also cuts air pollutants from vehicles. This has positive health effects, particularly in larger cities. There is a large range of different design options, such as:

- Subject of the regulation: fuel efficiency vs. GHG emissions
- Specificity: standard set for fleet vs. individual vehicle classes

The design of the standard will impact which types of effects are intended and need to be monitored. Most regulations are designed in a way that they aim to change:

- Fleet composition[12]: distribution between vehicles using innovative technologies or alternative fuels, such as hybrid or electric cars
- Fuel efficiency: improvement in fuel efficiency of the overall fleet.

Figure 13 illustrates which type of inventory data can be used to support the MRV of targeted parameters for this measure.

As the measure is normally implemented at the national level there are no issues with the geographic boundary. For ex-ante assessments tier 2 input data may be useful to make assumptions on potential effects, using fleet composition and fuel efficiency data at the disaggregated level and default/average values for emission factors and operating conditions. There can be large differences between country-specific data, particularly related to emission factors, and IPCC default values or international/regional default data (Kijmanawat et al 2016). For the MRV of measures it is therefore advisable to use country-specific data wherever possible.

For ex-post assessment more detailed data will be required. A bottom-up (tier 3) inventory can provide data on distance travelled, including fleet composition and emission factors (GHG/fuel). Data for the distance travelled (vkt) of new vehicles actually sold/registered can either be calculated as the difference between two inventories or can be collected externally (e.g. reported sales data, vehicle registration data, manufacturer information). Exact efficiency data will need to be collected from other sources, e.g. directly from manufacturers or from local technical institutes, research centres or universities that conduct measurements.

[12] Fleet composition is mainly relevant if standards are set for the fleet, not individual vehicle categories and manufacturers can "compensate" for less efficient models with highly efficient models or other fuels / propulsion technologies

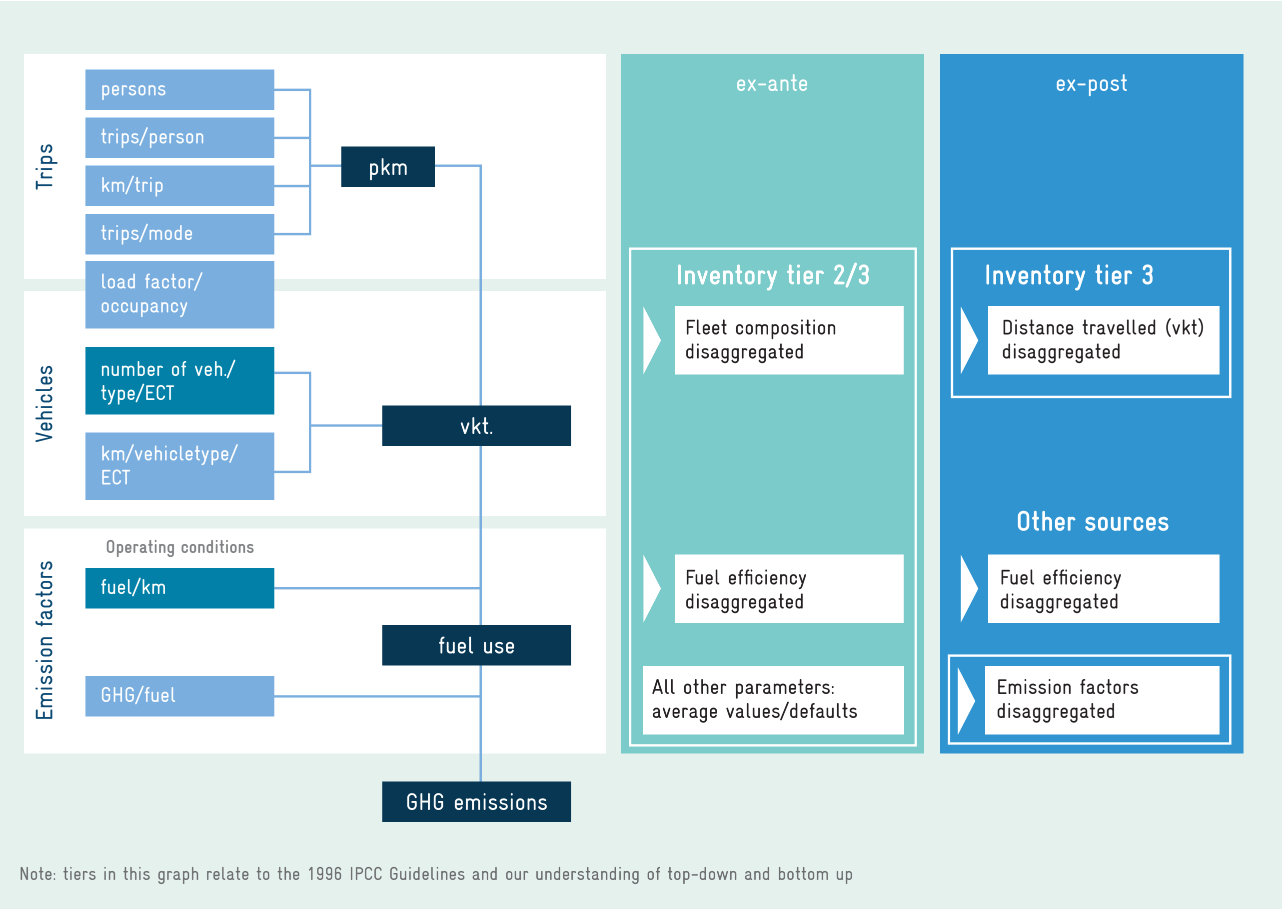


Figure 13: Targeted parameters and use of inventory data for vehicle-based efficiency standards

5.2.2. Boundaries of inventories and MRV methodologies vary

A fundamental element in analysing GHG and other effects of transport activity is the determination of the boundary. The main dimensions for boundary setting are the geographical scope of analysis, whether upstream or downstream activities are covered, which sub-sectors are addressed, which gases are covered and what the time frame for analysis is. Table 14 provides an overview of the differences between boundaries for the MRV of actions and transport sector inventories.

The boundary for national inventories is very clearly defined in the IPCC Guidelines[13]. Boundaries for the MRV of measures need to be defined based on the characteristics of the measure. There is a wider range of options that will be largely determined by the nature of the measure, the objective of the analysis and availability of data. Apart from national scale measures, such as emission standards or taxes, most other measures in the sector will have a smaller geographic scope and measures can overlap with other measures as illustrated in Figure 14.

For measures at a national scale, data from the inventory can often be used directly. This does not only relate to the reported GHG data, but also the underlying data used to calculate the inventory.

[13] In the context of the UNFCCC only at national scale. However, there are also many regional and city-level initiatives that create inventories for their jurisdictions

For measures at other levels, the inventory can provide for example:

- Emission factors (GHG/fuel or GHG/km)
- Default values for fleet composition, activity (for ex-ante assessment)
- Actual data, if e.g. survey areas are selected that cover the area of the measure or proxy-data if survey area(s) are comparable

If inventories are developed using bottom-up methods, the underlying data can also provide a useful source for sub-national level measures. In the case of bottom-up inventories, data is normally collected at the local level or using surveys that aim to produce representative results. Such data is then aggregated to the national level inventory. The underlying data can be utilized for the MRV of measures.

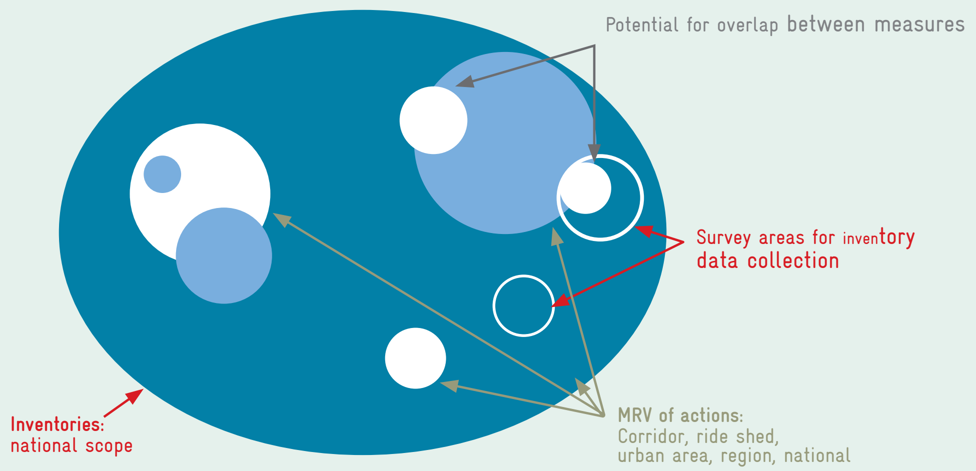
Different from an inventory that aims to represent the complete emissions from a country and avoid double counting in different sectors, MRV of mitigation actions need to consider up- and downstream emissions. For example, introducing electric buses requires accounting for emissions from electricity production. In order to compare them to conventional diesel buses, up-stream emissions for fuel consumption must also be considered. Inventory tools do not include emissions from electricity used for transport nor are biofuels or upstream emissions of any other fuels included.

For the MRV of measures, potentially all elements of the life-cycle can be relevant, depending on the nature of the measure. For larger infrastructure measures, such as railways or metros, maintenance and operation can also pose significant sources of emissions and should be considered, particularly when conducting the analysis ex-ante to support decision-making.

Dimension	MRV of actions	Inventories
Geographical	Corridor, ride shed, urban area, region, national	National territory
Upstream/ downstream	Energy industries sector (electricity, production + transport of fuel), agriculture and forestry sectors (biofuels), may also consider infrastructure construction, mobile fuel combustion	Mobile fuel combustion (direct emissions from vehicles' energy use)
Transport sub-sector	Depending on type of measure	All sub-sectors (excl. international aviation, maritime bunkers and military transport)
Gases covered	Depending on measure, potentially also including other air pollutants	CO_2, CH_4, N_2O
Time frame for analysis	Depending on type of measure	1 year (every two years as part of BURs)

Source: adapted from UNFCCC 2018

Table 14: Boundary dimensions



Source: Vieweg 2017

Figure 14: Differences in geographic scope

6. CASE STUDIES: MRV OF MITIGATION ACTIONS

This section discusses how to develop a methodology for estimating e.g. emission reductions based on the concepts discussed in section 4. The examples provided cover a broad range of countries and levels of complexity. For each example a description of the mitigation action, the methodological approaches chosen, a description of data collection and monitoring and a discussion of the institutional setting is provided.

For further, more detailed examples see the MRV Blueprints published at:
https://www.changing-transport.org/publications/?_sf_s=mrv%20blueprint

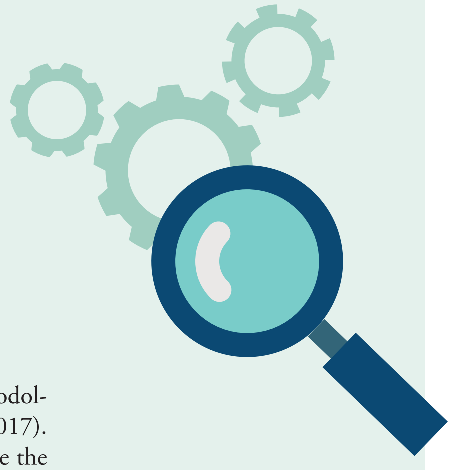
Also check examples provided in the MRV section of the TRANSfer Handbook "Navigating Transport NAMAs":
https://www.changing-transport.org/publication/navigating-transport-namas/

All case studies were written for the first edition of the reference document published in early 2016. Since then, further examples have been published.

For the most recent examples check :
https://www.changing-transport.org/publications/

For example, in September 2017, The ICCT and GIZ released an evaluation methodology for fuel efficiency standards using sample data from Mexico (GIZ/The ICCT 2017). The Fuel Economy Standard Evaluation Tool (FESET) is a similar methodology like the case on the USA in section 6.3.

The tool and a related user guide can be downloaded here:
https://www.changing-transport.org/tool/feset/



6.1. SWITCHING FREIGHT TO SHORT SEA SHIPPING (BRAZIL)

The multimodal and intermodal nature of freight transport, that involves highways, railways, waterways, air transport, terminals and intermodal transfers, offers ample opportunities not only to reduce GHG emissions, but also enhance regional and national economic development and provide a wide range of sustainable development benefits. Nowadays, publicly funded freight infrastructure development projects have been increasingly focusing on the development of freight corridors, ports, terminals and intermodal facilities to connect different modes. An example of such a project involves the development of waterway infrastructure to shift freight transport from road to waterways.

This project had been developed and implemented in Brazil by ArcelorMittal Tubarão, a company belonging to ArcelorMittal Group specializing in the production of slabs and hot rolled steel coils. The hot rolled steel coils are produced at an ArcelorMittal Tubarão plant located in the state of Espirito Santo and transported to the company ArcelorMittal Vega located the state of Santa Catarina. The project shifts the transportation of around 1.100.000 tonnes of coils per year from road transportation by trucks to ocean shipping by barges, leading to estimated emissions reductions of around 120.000 tonnes of CO_2/year[14].

[14] CDM PDD "Hot rolled steel coils transportation through ocean barges at ArcelorMittal Tubarão" available at: http://cdm.unfccc.int/methodologies/PAmethodologies/pnm/byref/NM0320

The ArcelorMittal Tubarão project implementation has also resulted in the number of sustain-able development benefits. These include the generation of jobs for skilled labour and creation of around 100 jobs related to handling, transporting and storing hot rolled steel coils[15]. It has also contributed to transferring knowledge and know-how related to using ocean shipping for cargo transportation that, in spite of long coastal lines of the country, was barely used in Brazil prior to this project. Shifting cargo transportation to the ocean resulted in replacing over 40,000 round-trips made by trucks with an average load capacity of 27 tonnes, which resulted in reduced local air pollution from road transportation and reduced impacts on road infrastructure in five states of Brazil; Espírito Santo, Rio de Janeiro, São Paulo, Paraná and Santa Catarina[16]. The project can also be replicated for the transportation of other types of cargo and in other regions and countries to utilise domestic or coastal waterways.

Options for Methodological Approaches

To estimate emission reduction outcomes for the ArcelorMittal Tubarão project, it is important to conduct an analysis of its causal chain, define the boundary for data collection, decide on the level of aggregation and choose a method to estimate emission reductions. These steps determine the choice of data and parameters that will need to be collected for estimating emission reductions (for more details on each aspect see section 4 above). The description of each step is provided below.

The causal-chain analysis has been conducted to map all plausible effects that the implementation of the project is likely to cause. The development of coastal shipping infrastructure, design and deployment of ocean barges and shifting the transportation of hot rolled steel coils from road to ocean shipping causes the following effects: It reduces emissions per ton of coils transported from 72.8 $kgCO_2eq$ for trucks to 16.3 $kgCO_2eq$ for ocean barges. As well, it results in sustainable development effects that include; reduced impact on road infrastructure, reduced local air pollution, decreased delivery time (from around 20 days by road and rail to 3 days by ocean) and the generation of jobs related to handling, transporting, and storage of steel coils. Furthermore, since at the time of project implementation coastal shipping had been underdeveloped and underutilised in Brazil, the implementation of the ArcelorMittal Tubarão project can serve as an example for tapping the large and underutilised potential of this less-carbon emitting mode of freight transport in the country.

The identification of the effects of the ArcelorMittal Tubarão project enables the boundary for data collection needed to track the emission reduction and sustainable development effects of the project to be set. Since the project involves the shift of transportation of hot rolled steel coils from the road transportation network of five states in Brazil, Espírito Santo, Rio de Janeiro, São Paulo, Paraná and Santa Catarina to ocean barges that cruise between the ports in Espírito Santo and Santa Catarina, the boundary for data collection includes all these states. The choice of data and parameters that need to be collected within these boundaries to quantify emission reductions resulting from the project's implementation depends on the choice of a method to quantify mitigation outcomes. The choice of a method to develop a baseline and MRV emission reductions, in turn, is dictated by data quality and availability in the country as well as the availability of expertise to conduct the analysis.

The most widely used tools and methods utilised in the assessment of mitigation outcomes of freight infrastructure development projects include modelling tools and estimates based on focused data collection using CDM methodologies. The details on the approaches, their benefits and challenges associated with their use are described below.

There is a considerable body of experience in intermodal freight transportation planning and analysis, and a number of models[17] and tools[18] have been developed to support related decision and policy making. Numerous classification schemes have been proposed in research literature to classify existing methodological approaches to freight transportation modelling (see, e.g., Pendyala et al. 2000, Cambridge Systematics 2003 and de Jong et al. 2004).

[15] CDM PDD "Hot rolled steel coils transportation through ocean barges at ArcelorMittal Tubarão"
[16] CDM PDD "Hot rolled steel coils transportation through ocean barges at ArcelorMittal Tubarão"
[17] Examples of such models include the Swedish national freight model system (SAMGODS), the Dutch models TEM and SMILE, the Norwegian national freight model system (NEMO), the Italian national model system, the Walloon region freight model system in Belgium (WFTM). There are also international freight models such as the SCENES and NEAC models for Europe, and models for specific international corridors in Scandinavia and Alpine crossings.
[18] Both the SAMGODS and NEMO models use the STAN software for multi-modal assignment, the WFTM model uses the NODUS multi-modal assignment software.

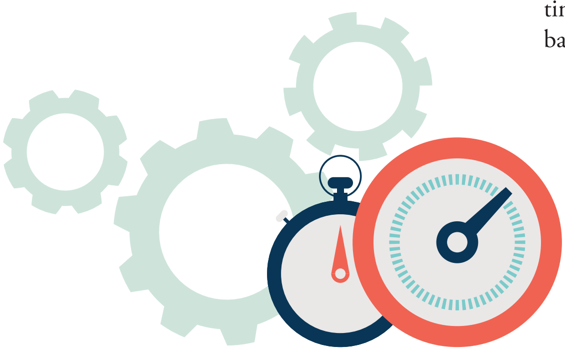
Most of the existing freight transport models can be categorised into two broad categories depending on modelling methodologies used (ORNL 2007):

1. Econometric models that include models based on trend and time series analysis, elasticity methods and network modes of economics and logistics;

2. Aggregate models that include commodity-based four-step models and truck-based origin-destination factoring models.

Being aware of the scarcity of data and insufficiency of experience in freight transport modelling in many developing countries, the CDM had developed a number of methodological approaches for setting baselines and Measurement, Reporting and Verifying emissions reductions. Methodological approaches suitable for the ArcelorMittal Tubarão project include those described in the CDM methodological tool "Baseline emissions for modal shift measures in inter-urban cargo transport"[19] and the CDM AM0090 methodology "Modal shift in transportation of cargo from road transportation to water or rail transportation"[20].

CDM methodology AM0090 provides a number of methodological approaches suitable to a varying degree of data availability in a country and covering all modes of freight transport (excluding aviation) and provides default values for each mode and cargo type to address a lack of data that many (especially developing) countries may face. The tool has quite a narrow scope and provides methodological approaches to estimate emission reductions from projects shifting cargo transport from road to waterways or rail lines, which is directly suitable to estimating mitigation outcomes of the ArcelorMittal Tubarão project of shifting the transportation of hot rolled still coils to ocean barges. Therefore, the CDM methodology AM0090 was chosen as the method to estimate mitigation outcomes from the ArcelorMittal Tubarão project. A brief overview of data needs and monitored parameters are provided in the section below. The full description of data requirements and parameters along with calculation procedures are described in the methodology document.



The choice of a CDM methodology with a quite narrow scope and applicability, to estimate the mitigation outcome of the ArcelorMittal Tubarão project, and the nature of the infrastructure and production of barges dedicated to transport a specific type of cargo, hot rolled steel coils, suggests that the appropriate level of aggregation for the assessment of this project is individual project-level assessment (for more details on the level of aggregation see Section 4.4). The chosen method also dictates the approach to establish the baseline, which in this case is a pre-determined BAU that is fixed prior to the project implementation and relies on historical data for estimating the GHG intensity (emission factor) of transporting a ton of hot rolled steel coils by truck, multiplied with actual activity data observed in order to estimate baseline emissions in the monitored period of time.

Data collection and monitoring

To facilitate MRV of emission reductions from the ArcelorMittal Tubarão project a monitoring plan was developed. According to the Guidance for NAMA design (UNDP, UNEP and UNFCCC 2013), a monitoring plan should specify:

1. Methodologies used to calculate mitigation benefits;

2. Assumptions and default values used and relevant data sources;

3. Level of accuracy to be applied;

4. Frequency of monitoring and reporting of monitored parameters;

5. Description of data storage plan;

6. Responsibilities of specific actors with regard to monitoring and reporting.

The CDM AM0090 methodology project provides guidance on these aspects of the monitoring plan. According to this methodology, annual ton-kilometres of cargo transported by the newly developed infrastructure should be monitored and used to estimate baseline and project emissions. The difference between baseline and project emissions is emission reductions.

[19] Available at: http://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-17-v1.pdf/history_view
[20] Available at: http://cdm.unfccc.int/methodologies/DB/4DOIK2WYP8P3AGAVJKT0CHY1NXJ4QP

More specifically, baseline emissions are estimated using the following variables: transportation distance (from origin to destination point) by road using trucks, the baseline emissions factor and the amount of cargo transported by the newly developed infrastructure. The baseline emissions factor is determined using a default emissions factor[21] in gCO_2/tonne-kilometre available in the AM0090 methodology[22]. The use of default emissions factors enable a conservative estimate of baseline emissions and allows estimation of baseline emissions in situations when there are no historic records on fuel consumption of trucks or when infrastructure developers would like to reduce costs for data collection. Baseline emissions are estimated using a moni-tored amount of cargo transported by the barges and multiplied by the baseline emissions factor.

To estimate emissions from the ArcelorMittal Tubarão project after its implementation, data on the consumption of fuel by ocean barges used for transporting hot rolled steel coils needed to be monitored along with the amount of cargo transported by the barges. The two amounts are multiplied to estimate baseline emissions, as described above.

The difference between project emissions and baseline emissions equals the emissions reductions that the implementation of the project brings about.

Institutional setting

As described in section 3.3, different institutions can be involved in transport data collection, processing and reporting depending on the complexity of mitigation action and data needed to estimate its mitigation outcomes. The AM0090 methodology provides many default values for emission rates, and hence does not require complex data collection. The company that developed and implemented the project, ArcelorMittal Tubarão, collected all remaining parameters required for estimating mitigation outcomes of the project.

Findings

Transport is one of the fastest growing sources of greenhouse gas emissions in Brazil (2nd National Communication of Brazil). The implementation of the ArcelorMittal Tubarão project provided a good example of how mitigating emissions from freight transport by shifting it to less GHG-emitting alternatives such as waterways enables the country to enhance its regional economic development, effectively removing bottlenecks on freight transport networks, reducing delivery time and expanding shipping alternatives, reducing air pollution as well as providing a wide range of social sustainable development benefits related to the creation of employment opportunities.

The quantification of mitigation outcomes of such actions is a very data intensive exercise. Regional and national freight models can be developed for such purposes. However, they require a lot of data and expert knowledge in modelling in order to generate trustworthy results. Since many developing countries' data are lacking or insufficient, the starting point to establishing a robust MRV framework for transport data collection can be to utilise approaches developed under the CDM. These require focused data collection, which reduces transaction costs, and also offer a number of conservative default values. This allows countries to effectively address existing data gaps and prioritise future data collection work, gradually building a pool of relevant, good-quality, consistent time series of data to underpin similar efforts in the future. It helps to increase domestic expertise and to build institutions for robust data collection, which would allow moving to more sophisticated methods of freight infrastructure planning and mitigation scenarios in the future.

[21] Another option is to use historical records on fuel consumption of trucks transporting the cargo type, net calorific value and the CO2 emissions factor of fuel used as well as records on the amount of cargo transported, and the trans-portation distance of the cargo transported by trucks. This option allows estimating baseline emissions more precisely and yields larger emissions reductions resulting from the infrastructure development project. For the sake of consisten-cy, all data used in estimations of the baseline emissions factor should be collected during the same period. If historical records are not available, this data can also be obtained from surveys.

[22] For more default values and emission factors for different modes of transport and cargo types transported see the CDM methodological tool "Baseline emissions for modal shift measures in inter-urban cargo transport" available at: http://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-17-v1.pdf/history_view

6.2. INTER-URBAN RAIL IN INDIA

The scope of this NAMA is to expand inter-urban rail transport all over India. It can therefore be called a programme embedded in a rail or inter-urban transport strategy. The NAMA includes GHG reductions achieved by moving passenger and freight by rail instead of road, ships or plane transportation. Over the last 2 decades road systems have turned into the pre-dominant mode of transport in India.

The NAMA objective is to reduce GHG emissions through low-carbon inter-urban passenger and freight transport. The core action taken is infrastructure and equipment investment in In-dia Railway. Concrete actions until 2030 include the construction of 6 dedicated freight corridors totalling 9,500 km of new tracks; 38,500 km of multiple tracking; 30,000 km of new tracks; speed upgrading of existing services; 20,000 km of electrification; 43,000 additional locomotives and over 1.3 million additional carriages as well as technological upgrading of rail operations. The total investment required is around 800 billion USD of which 50% can be financed internally by India Railway.

Options for Methodological Approaches

The boundary is a territorial boundary including all inter-urban rail operations in India. The NAMA looks at the entire rail sector including freight as well as passenger transport and not just at the new rail lines. This is different from a CDM project-based approach in which a new line or investment is looked at. It reflects more a sectoral approach. This is justified as numerous synergy effects occur e.g. freight may be transported entirely by rail over longer distances on all tracks if new tracks are built and not only for the new track lines.

The NAMA activity is basically infrastructure investment to increase the supply of transport capacity of rail for freight and passenger transport. The increased supply leads to rail being competitive in terms of price and reliability, so freight and passengers using rail instead of other transport modes. The effect of the NAMA is on “shift” within the ASIF framework. To a minor extent, investments are also made in improving rail efficiency through electrification and more efficient locomotives. This results in lower emissions per tkm and pkm of rail transport and also additional emission reductions.

From a GHG perspective the focus is on direct emissions. Upstream and downstream emissions and those not under the direct control of IR (leakage emissions) are not included. How-ever, as a matter of transparency a specific section has been included in the NAMA on indirect or leakage emission sources including an estimation of their potential GHG effect. Electricity generation based emissions are included as direct emission sources in accordance with the CDM procedure. The table below includes the direct and indirect effects of the NAMA as well as the calculated absolute and relative effects (relative to the projected emission reductions).

GHG emission reductions are based on the difference between rail-based emissions relative to emissions of alternative transport modes for inter-urban freight and passenger transport. This includes an activity level (amount of freight and passengers transported) and an emission factor component, both of which change over time.

A separation is made between passenger transport and freight transport as both have distinct activity indicators as well as distinct emission factors. The activity indicator for freight is tkm i.e. amount of freight in tonnes transported over distance and for passengers pkm i.e. number of passengers transported over distance in km.

The following baseline approaches for the activity level were studied:

1. **No rail:** This baseline describes the future situation in absence of any rail transport in India. This baseline is useful to assess the impact of rail in India i.e. what sustainable development benefits result due to the existence of a rail system in the country.

2. **Frozen baseline:** The passenger and freight activity in terms of pkm and tkm are frozen at their current level (in absolute terms). This baseline allows determining and separating the effect of expansion investments from that required to maintain current performance levels.

3. **Business-as-usual projection:** This baseline models the expected future movement of passengers and freight. This can be based on historic trends or it can be based on a correlation/regression baseline, which projects rail freight and passenger movement based on oberved relations with core parameters to determine supply of pkm and tkm. This baseline models the expected future movement of passengers and freight.

The following graph shows in an exemplary manner the three baseline approaches.

Effects		Impact annual average emissions 2012-2030	Impact as % of emission reductions
Direct effects	Increased rail tkm increasing rail freight emissions	12.6 $MtCO_2$	Total emission reductions 152 $MtCO_2$ per annum (frozen baseline)
	Increased rail pkm increasing rail passenger emissions	10.3 $MtCO_2$	
	Mode shift road to rail freight reducing road-based freight emissions (baseline)	123.7 $MtCO_2$	
	Mode shift road (bus, car) and plane to rail reducing passenger road/plane emissions (baseline)	51.5 $MtCO_2$	
Indirect effects	Rail construction	5.7 $MtCO_2$	4%
	Rail carriage production	0.9 $MtCO_2$	‹1%
	Upstream well-to-tank (WTT) diesel fuel emissions increased rail activity	2.0 $MtCO_2$	1%
	Road construction not considering mode shift to accommodate trucks, buses, cars which shift to rail (baseline)	0.5 $MtCO_2$ (avoided)	‹1%
	Vehicle production emissions without mode shift (baseline)	7.4 $MtCO_2$ (avoided)	5%
	Upstream WTT diesel and gasoline emissions of fuel without mode shift (baseline)	33.0 $MtCO_2$ (avoided)	22%
	Congestion effect and induced traffic	n.d.	‹1%

Table 15: Effects and Impacts of Rail NAMA (Source: Grütter Consulting, 2014)

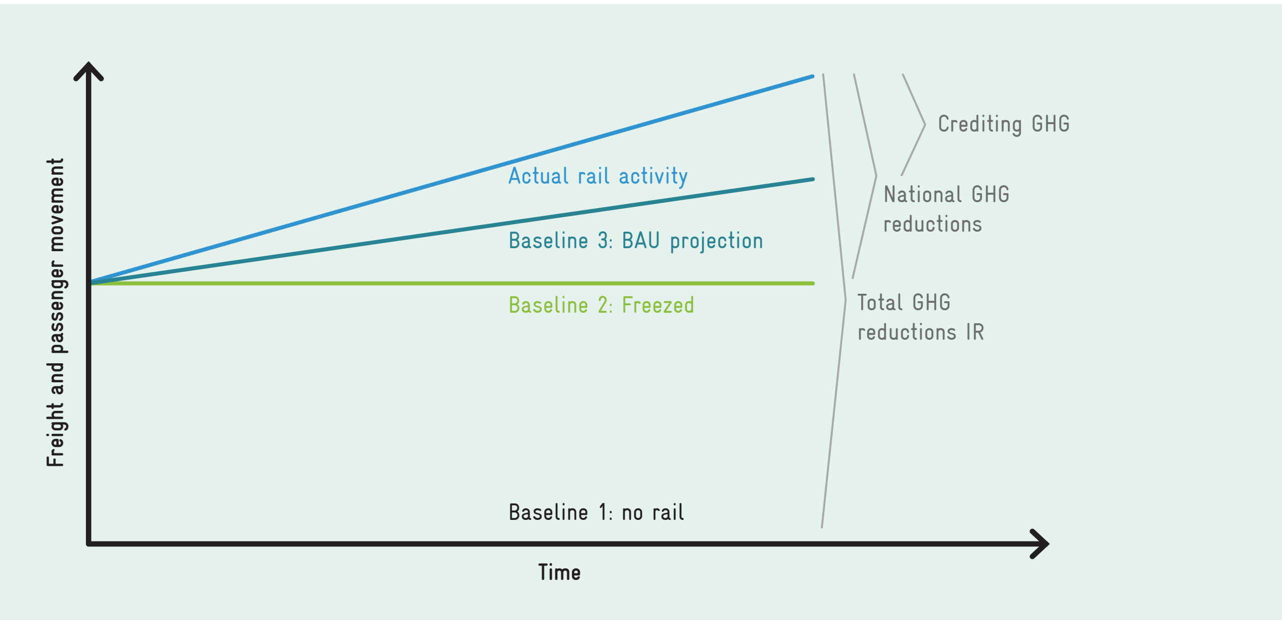


Figure 15: Baseline Approaches

Data Collection and Monitoring

Monitoring is required for the baseline determination as well as for determining activity or project emissions. Sustainable development effects (see Figure 16 below) as well as GHG are monitored.

- **Step 1: Implementation status:**

  The physical implementation of the NAMA is monitored and compared to projections. Core parameters include distance of new tracks built, distance of new double tracking rails and number of newly acquired coaches, carriages and trains. This data is not required for emission reduction calculations but shows the progress of the NAMA and can be used for plausibility of the monitored activity levels and emission reductions.

- **Step 2: Activity level:**

  The activity level in terms of pkm and tkm is monitored and together with the monitored GDP growth rate and the elasticity factor, the BAU activity level is calculated. The BAU activity level can then be compared to the actual recorded level to determine additional rail transport levels.

- **Step 3: Energy consumption rail:**

  The electricity and diesel fuel consumption for freight and for passenger transport is monitored. Together with the tkm and pkm of rail and the emission factor of diesel and electricity this allows calculating the specific emission factor per tkm and per pkm of rail.

- **Step 4: Baseline emission factors:**

  Factors which are revised in regular intervals include the passenger mode split used by rail passengers, the specific fuel consumption of different vehicles (essentially trucks, buses and passenger cars) and the occupation rate of different vehicle categories; cars and inter-urban buses. These factors together with the emission factor per fuel allow the determination of emissions per pkm and tkm for different modes of transit.

- **Step 5: Sustainable development parameters:**

  The parameters looked at are: job creation, accidents and local air pollutants.

Monitoring of baseline emission factors and the mode shares are only made every 5th year as no large changes from year to year are expected.

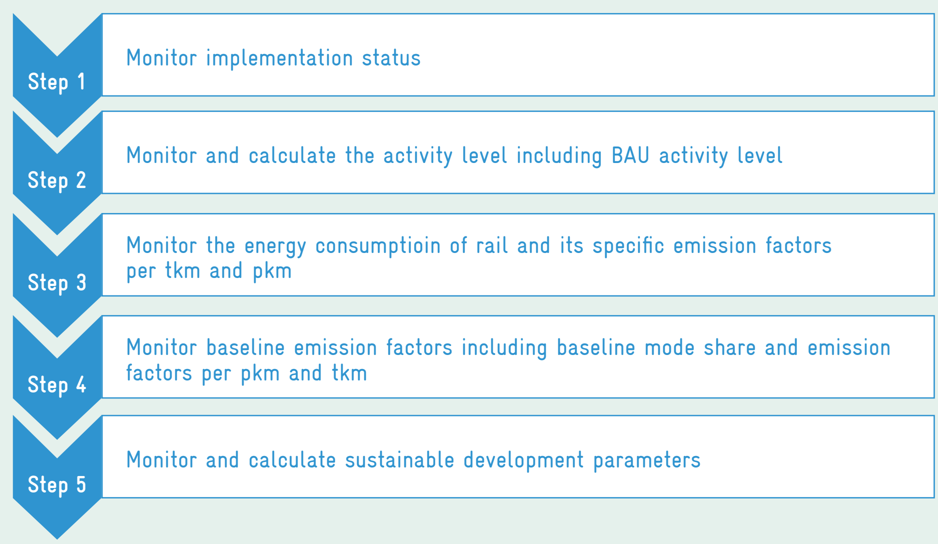


Figure 16: Steps/Elements of Monitoring

Institutional Setting

The NAMA is embedded in IR which is part of the Ministry of Railways. IR has a department for climate change which tracks and monitors required data and performs the surveys. The most demanding task in terms of finance is potentially the regular passenger survey and the update of emission factors per mode (trucks and buses basically). However, since 2013 IR has done a client satisfaction survey of rail customers within which questions of baseline mode usage and the origin-destination of trip have been added.

Findings

The following conclusions and experiences were made with this NAMA:

- Broadening the scope can considerably simplify baseline determination and monitoring. Whilst this does not allow for reporting with precision the effect of singular measures e.g. double tracking of Line “Y”, it does allow the determination, with a good level of confidence, of the GHG effect of combined rail measures, thereby also including important synergy effects (e.g. additional freight transported due to having a larger network or the combined effect of higher speed plus new destinations). Stand-alone projects have a methodological complexity in separating cause-effects from the singular project activity from other activities realised at the same time. Scaling up a NAMA to a sectoral or sub-sectoral approach such as nationwide inter-urban transport simplifies baseline and monitoring, requires fewer assumptions concerning separation of effects, and is less complicated and questionable concerning system boundary definition.

- For inter-urban transport an approach based on a dynamic baseline for emission factors and activity levels is considered appropriate. Monitoring can be done with limited efforts and can give precise results. This can also serve for designing appropriate low carbon growth strategies.

- The development of various baselines is considered useful. Baselines are hypothetical future scenarios. They can be used for different purposes and give different types of information. For example, the same monitoring data serves to determine the carbon footprint, the reduction effect of expansion investments or the effect of “additional” investments.

- Monitoring can rely to a significant extent on already existing data. However, for the establishment of a reliable baseline some core data such as load factor, specific fuel consump-tions and mode shares are not available.

6.3. FUEL EFFICIENCY STANDARDS IN THE USA

The United States enacted fuel efficiency standards and vehicle fuel economy label requirements in response to the first oil crisis in 1973. By law, the standards were set at the national level and apply to all new vehicles. The standards primarily target improved technology to reduce fuel consumption. There have been two major phases in the standards. The first was implemented in the late 1970s and early 1980s and required car fuel economy to double and light truck fuel economy to increase by about 50%. This was followed by a long period of low fuel prices and stagnant new vehicle fuel efficiency. In fact, overall fuel economy decreased slightly as the fleet mix shifted from cars to light trucks. The second phase started when light truck fuel economy standards were increased by about 2% per year from 2005 to 2010. This was followed by a change to standards that are adjusted by the vehicle size (footprint) in 2011, which enabled much more aggressive standards to be implemented starting with the 2012 model year. Standards were adopted in two stages, the first for model years 2012 to 2016 and the second for model years 2017 to 2025. Both stages require fuel economy improvements of over 4% per year. Figure 17 summarises the fuel economy requirements and the actual compliance to date.

Options for methodological approaches to setting fuel efficiency standards

Unlike non-policy NAMAs, there are fewer options for boundary conditions for standards. Because of the large investments needed to improve vehicle efficiency, the boundary must be as large as possible. This, as in the case of the US, usually means an entire country. In the case of Europe, the boundary is even larger and encompasses the entire EU.

Standards can be designed to primarily target technology improvements, or to also target vehicle market segment sales. In the US, the standards prior to 2012 (2011 for light trucks) required each manufacturer to meet the same standard. These standards, without size or weight adjustment, push consumers to purchase smaller vehicles. Consumers generally dislike this, plus it requires manufacturers of larger/heavier vehicles to do more than manufacturers of smaller/lighter vehicles. In response, the US adopted size adjustments, based upon the vehicle footprint (wheelbase times track width), staring with 2011 for light trucks and 2012 for cars. This assigns larger, heavier vehicles a less stringent target and smaller, lighter vehicles a more stringent target. This is done to specifically target vehicle technology and avoid impacting consumer choices and manufacturer competitive impacts. In fact, every region that has adopted standards has also adopted a size or weight adjustment, although size adjustments work better than weight adjustments because they

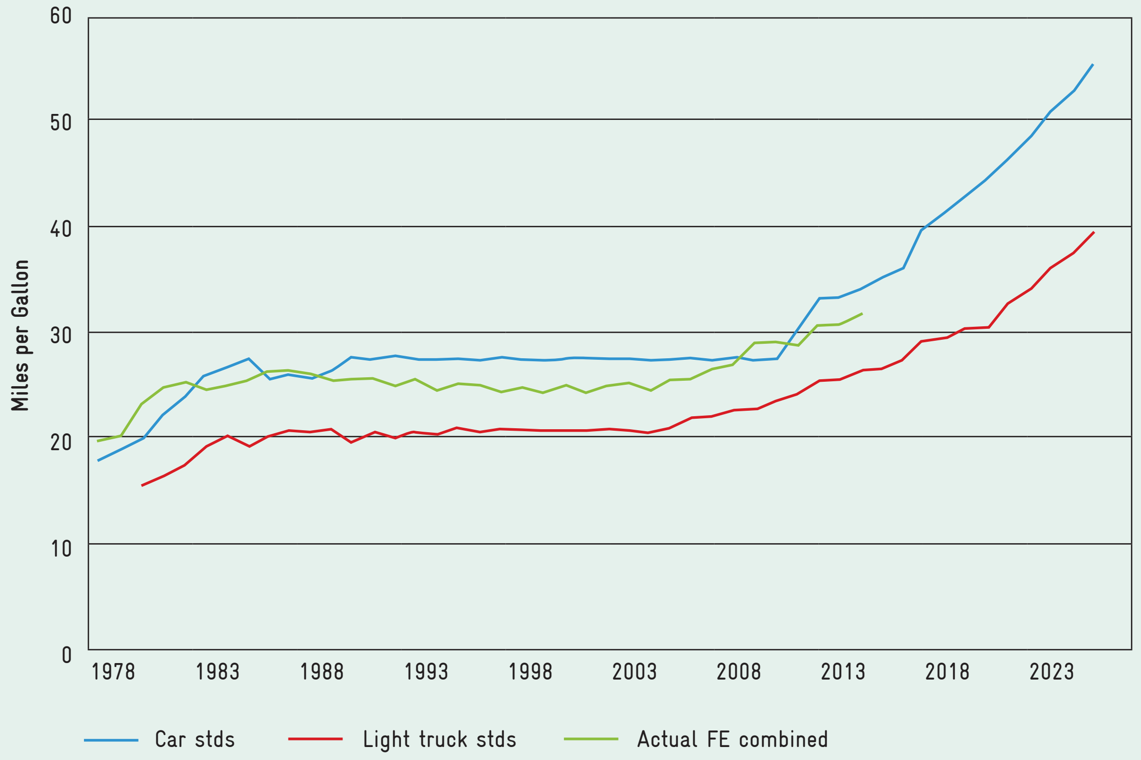


Figure 17: U.S. CAFE standards for cars and light trucks; Actual new vehicle fuel economy for combined car and light truck fleet

preserve incentives for manufacturers to use lightweight materials to improve fuel efficiency. Under a weight-based system, a manufacturer that uses light-weight materials is penalised with a more stringent target. The U.S. also adopted size-based standards because they offer better incentives for safe vehicle designs than weight-base standards.

Activity is needed to estimate and evaluate the fuel consumption and CO_2 benefits from the standards, but because standards target efficiency technology the policy makes no explicit attempt to reduce vehicle activity. In fact, the lower fuel cost associated with the improved vehicle efficiency can have a "rebound" effect, which reduces the benefits from fuel efficiency standards: Higher efficiency vehicles consume less fuel and cost less to drive. This, in turn encourages owners to drive more. Although it has been analysed and debated for over 30 years in the U.S., the size of the rebound effect is still highly uncertain. The most recent estimate used in the U.S. rulemaking is that the rebound effect is likely to be around 10% (i.e. a 10% reduction in fuel cost will result in 1% more miles travelled).

Because fuel efficiency standards are set using a standardised chassis dynamometer test, fuel consumption reductions on the standardised test procedures do not necessarily match fuel consumption reductions that occur in the real world. Evaluating real world fuel consumption reductions is technically not required when setting standards, but it is an essential element of justifying the need and benefits of the standards. The difference between the standardised test and real-world fuel consumption was analysed by the NHTSA and the EPA and included in the calculated benefits.

Construction of the baseline is relatively simple in theory, although not necessarily when implemented. One important factor is to estimate what would have happened in the future in the absence of standards. This is difficult to do even in the best of circumstances, as it depends on highly uncertain factors such as future fuel prices and economic growth. The U.S. and the EU have been monitoring fuel efficiency for decades, including periods when they did not have increases in fuel efficiency standards, and their experience can be used as a guide. In the US, after rapid increases in the fuel efficiency standards from 1978 to 1987, the standards remained unchanged from 1988 through 2004. During this period there was no increase in average vehicle fuel economy. Instead the average size and performance (acceleration) increased while fuel economy remained essential unchanged. As a consequence, the U.S. assumed in their rule-makings that baseline vehicle efficiency/CO_2 emission rates per km would be frozen after existing standards come to an end. In Europe, average vehicle efficiency increased by about 1% per year prior to adoption of mandatory standards in 2008. It can be argued that the "frozen" assumption may not always be the proper approach and that technology improvements would occur even in the absence of standards (e.g. BAU projection). Interestingly, every region that has adopted efficiency/CO_2 standards has assumed a frozen baseline, including the EU.

It is very difficult to measure and enforce requirements for fuel efficiency in actual operation. In-use fuel efficiency is heavily influenced by factors such as ambient temperature, trip length, vehicle speed, vehicle acceleration, traffic congestion, wind, rain, accessory usage (such as air conditioning), vehicle operating condition, and aftermarket tires. The EPA established standardised testing requirements on a chassis dynamometer. This allowed the ambient and driving conditions to be controlled and the tests to be accurately repeated, ensuring that manufacturers are treated equitably and the requirements could be enforced. Every other region that has adopted fuel efficiency standards has also based them on chassis dynamometer testing.

Construction of the baseline requires two basic elements. The first is dynamometer test data on a representative sample of each manufacturer's vehicle fleet. This is straightforward in theory, but difficult to do accurately. Requiring testing of every different variation offered by a manufacturer would solve the accuracy issue but would require thousands of dynamometer tests for full-line vehicle manufacturers. This workload would create an enormous expense and burden on both manufacturers and the government. Every region with standards has developed procedures allowing manufacturers to group similar vehicles together and test only one vehicle from each group. This reduces the workload and expense to manageable levels, but it potentially allows manufacturers to test the most efficient version within each test group. The U.S. addressed this potential problem by regulating which vehicle must be tested within each group and by mandating the use of representative tires and vehicle loads, backed up by in-use enforcement. The EU has little enforcement and there is substantial evidence that representative vehicles are not being tested in Europe (ICCT 2014).

The second element to construction of a proper baseline is vehicle sales. These are needed to calculate the average fuel efficiency of each manufacturer's vehicle fleet. The U.S. requires manufacturers to submit data on the actual production of each vehicle in their fleet. Due to the availability of accurate vehicle registration data from organizations such as RL Polk, there is no evidence of manufacturers falsifying their production data, although this may be an issue in developing countries.

Another option is selection of the test cycle(s) to be used. The U.S. uses a weighted average of the Federal Test Procedure (FTP, urban) and highway cycles, Japan uses the JC08 cycle, and Europe and most other countries use the New European Driving Cycle (NEDC). In addition, there is a movement in many countries, including in Europe, to develop and adopt the worldwide harmonised light vehicle test cycle (WLTC). No cycle can represent all real-world driving, and, in addition, typical driving patterns and ambient conditions differ from one region to another. Selection of a more representative test cycle for the specific region can improve the effectiveness of the fuel economy standards. Development of a test cycle specific for the region would yield the best results, but it would require a sophisticated study of real world driving behaviour and it would run counter to efforts to try to harmonise testing requirements (WLTC).

Setting the proper level for future standards is perhaps the most important option – and the most difficult. This requires knowledge of the baseline fleet composition and an assessment of future technology introduction, including the pace of technology adoption, technology costs, technology benefits, synergies between technologies, factors that limit the adoption of specific technologies to specific vehicles, and consumer acceptance issues. It is no accident that the U.S. and Europe have adopted standards that require the most aggressive adoption of efficiency technology, as they are the only regions that have the resources and technical expertise to be able to overcome manufacturer opposition and set aggressive technology requirements.

Penalties for non-compliance must also be set. In the U.S., NHTSA has set a fee of $55 for each mpg the fleet is short of the standard multiplied by the number of vehicles in the manufacturer's fleet. This provides a strong incentive for manufacturers to comply with the standards, while allowing manufacturers to pay fees if they find they cannot get to the required level. In the U.S., manufacturers are also allowed to carry credits for overcompliance forward for 5 years and back for 3 years.

Data collection and monitoring

Data collection is different for monitoring compliance with the standards, for setting new standards, and for monitoring benefits.

Data collection for monitoring standards is reasonably straightforward. Manufacturers are required to submit fuel efficiency data on representative vehicles using a predefined chassis dynamometer test procedure. Manufacturers are also required to submit actual sales or production data. These data are used to calculate the average fuel efficiency for each manufacturer's fleet, which is compared with the standard for that manufacturer (under an attributebased system, each manufacturer has its own standard, based upon the average size or weight of its vehicle fleet).

The primary concern is assuring that the submitted data is accurately linked to the vehicles they are supposed to represent. Over the years the EPA has established detailed procedures and requirements to ensure that the proper vehicles are tested with accurate loads and representative equipment and calibrations. This can be seen in the relabelling of the fuel efficiency of a number of vehicles built by Hyundai, Kia, Ford, Mercedes, and Mini in the US over the last two years, after EPA found manufacturers were not following proper procedures.

Data collection for setting standards is much more difficult. This includes collecting data on manufacturer's future product plans, technology benefits and costs, how costs will likely come down over time, and how rapidly new technologies will penetrate the fleet. This requires substantial expertise and resources. For example, in the U.S. the EPA paid for expensive computer simulations of the efficiency of advanced technologies, paid for expensive teardown studies to assess technology cost, paid for lightweight material studies including expensive crash simulations, developed a model to assess the effectiveness and cost of hundreds of technology packages, and issued various reports totalling thousands of pages. The NHTSA and the California Air Resource Board (CARB) also conducted extensive technology analyses and the NHTSA developed its own model of technology effectiveness and cost. While other regions have not gone to this extent, it illustrates the difficulty in setting standards. Mexico and Saudi Arabia avoided much of this difficult by harmonizing with the U.S. standards, meaning that they primarily had to assess differences in the vehicle fleet between their countries and the U.S.

Assessing the real-world benefits is also difficult. Research needs to be done on the rebound effect and the impacts of real world driving conditions on average fuel consumption. Even in the U.S. and Europe, with decades of studies, these estimates are subject to considerable uncertainty. Accurately assessing the real-world offset requires gathering real world data that properly represents the wide variety of in-use driving conditions. This is difficult and expensive. However, assuming that the region requires OBD systems, then the cost of data loggers that plug into the OBD port are rapidly reducing..

Institutional setting

The U.S. Congress passed the Energy Policy and Conservation Act (EPCA) in 1975. The EPCA clearly laid out authority for the NHTSA to set fuel efficiency standards and for the EPA to conduct testing and enforcement. The EPCA also included passenger car fuel efficiency standards for 1978 through 1985, requirements for the NHTSA to establish light truck efficiency standards and passenger car standards after 1985, and requirements for the EPA to establish testing procedures and a fuel economy labelling program. The U.S. Congress updated the requirements in 2007 with the Energy Independence and Security Act. The regulatory agencies, in turn, have issued numerous rules over the years to implement and enforce the statutory requirements. A strong law and strong regulatory action are both needed to set effective fuel efficiency standards.

A significant change occurred in 2008, when the U.S. Supreme Court ruled that CO_2 is a pollutant under the Clean Air Act (CAA). Both the EPA and the CARB are permitted to regulate vehicle pollutants under the CAA. Vehicle standards set since 2008 have been a joint collaboration of CO_2 standards from the EPA and the CARB and fuel efficiency standards from the NHTSA. All other states are forbidden from setting new vehicle emission or efficiency stand-ards.

Findings

- Gathering baseline data on current vehicles and their efficiency is an essential first step in setting fuel efficiency standards. Regions can develop testing requirements for vehicles manufactured in or imported to their region or can require documentation of efficiency from certification in the U.S. or Europe. A side benefit is that this data can also be used to establish a fuel economy labelling system.

- Establishing effective standards is a difficult process requiring substantial expertise. Instead, regions may wish to follow the example of Mexico, which largely harmonised their fuel efficiency requirements with the U.S. The size-based adjustments in the U.S. allow the standards to be automatically adjusted to different fleet mixes in different regions. Issues with the cost and feasibility of adopting aggressive U.S. standards can be addressed by delaying the effective date by 3 to 5 years (for example, adopt 2016 U.S. standards for 2020). Adoption of the EU standards could also be effective and this would allow adoption of the WLTC, although enforcement in the EU is not as good as in the US and the EU's weight-based standards are not as effective as size-based standards. In either case, harmonization would allow regions to adopt standards whose cost-effectiveness has already been demonstrated. If a region wants to set its own standards, the next best approach would be to enlist the help of an organization with expertise in helping regions set standards, such as the International Council on Clean Transportation.

- Developing a test cycle specific to driving conditions in the region would create a more effective standard, but this must be assessed against the difficulty in obtaining data on actual driving conditions and the drive to harmonise requirements worldwide. In general, adoption of the WLTC or the U.S. test cycles is likely to be preferred.

- While it is not essential to setting standards, gathering data on fuel consumption from vehicles in use would have several benefits. It would allow for a more accurate estimate of the benefits of the standards, it would improve the accuracy of fuel economy labels, and it would provide feedback on the effectiveness of the test cycle and the enforcement provisions.

- Effective enforcement provisions will ensure that the anticipated benefits are actually achieved. Otherwise, the projected benefits are not likely to be realised.

- It is important to have clear statutory authority for setting efficiency standards.

6.4. TRANSIT ORIENTED DEVELOPMENT (TOD) IN COLOMBIA

City planners and policy makers in Colombia want to reverse the trend of new development on city outskirts and abandonment or underutilization of land in central city areas, and instead promote more compact transit oriented mixed-use neighbourhoods. Through this NAMA, coordinated infrastructure investments from the public sector can guide and complement private development in urban areas to create (TOD) neighbourhoods.

The Ministries of Transport, Housing, and Environment and the National Planning Department coordinate on this NAMA with The Center for Clean Air Policy (CCAP) and FINDETER (Colombian National Development Bank) through CIUDAT, (Centro para Intervenciones Urbanas de Desarrollo Avanzado hacia el Transporte). CIUDAT will use NAMA support to develop national policies for TOD replication, and also provide financial and technical assistance on specific TOD implementation projects in response to locally-articulated requests.

The local level interventions will revise the model TOD neighbourhoods with regard to any gaps in the extended process of planning, financing and construction, ultimately resulting in prominent examples of the new urban development paradigm. These catalytic, high-profile projects will then attract international and private capital seeking quality investment potential and demonstrate the economic opportunity of TOD as Colombia continues its robust growth. The TOD NAMA will transform urban development in Colombia, shifting how and where public and private investments are made and increase the return on Colombia's continuing investments in mass transit and social housing.

BAU and Causal Chain

The sector wide business-as-usual (BAU) scenario was taken from the Colombian Low Carbon Development Strategy. Transportation sector emissions are expected to increase threefold to 65 Mt annually by 2040 due to a rise in motorisation, linked to the country's economic growth. Motorisation rates are expected to increase from 70 to 320 light duty vehicles and from 77 to 250 motorcycles per 1000 inhabitants over the next 30 years.

The causal model of the TOD NAMA is aimed at both avoiding trip demand and shifting trips away from private vehicles. It will reduce GHG emissions by creating more compact urban environments that also provide alternatives to automobile travel. This will cause residents to reduce their total vehicle kilometres travelled (VKT) in private vehicles by substituting non-motorised trips, increasing their share of transit trips and driving shorter average trip lengths. Fewer VKT translates directly to lower GHG emissions. The NAMA is also expected to have long term effects on the motorisation rate by steering population growth to neighbourhoods that offer travel mode choices.

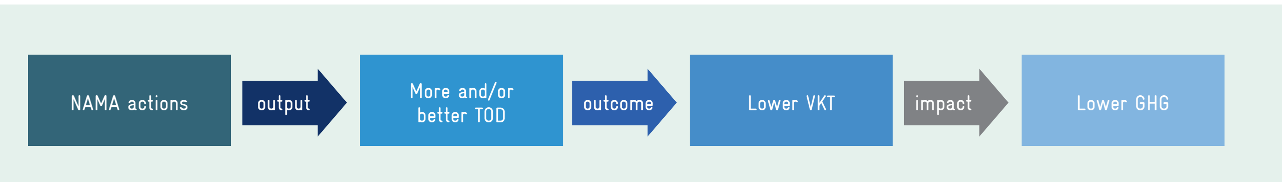


Figure 18: Causal chain of a TOD NAMA

The NAMA intervention actions will fall into three categories:

1. Developing national and/or local level policies that increase public investment that supports TOD (e.g. location requirements for social housing, coordination of transport and land use plans) or encourage private TOD investment (e.g. public private partnerships to develop station areas, zoning that allows higher density, etc.)

2. Technical or capacity building assistance for planning, feasibility and design activities in specific corridors, station area or other locations that set the stage for the ultimate construction of TOD infrastructure or buildings.

3. Financial assistance for construction, or activities directly leading to construction, of TOD infrastructure or buildings. This aspect has a separate MRV system and not discussed in detail here.

Methodological Options

This causal chain implies that indicators should look at the amount of TOD, the amount of VKT and the GHG emissions. However, there are a number of challenges:

- Defining successful "TOD" resulting from a NAMA action is not always clear.

- There are a range of intervention types; the boundary area of an intervention and time between an intervention and TOD results may be different for each intervention type.

- The attribution of cause between an intervention and "TOD" can be direct, in the case of finance given for construction, or indirect, such as in a national policy's effect on a project.

- The direct causal link between particular instances of TOD and levels of VKT can be ambiguous

- The NAMA is designed to produce pilot TOD examples that "catalytically" transform development patterns in Colombian cities. How can this catalytic effect be measured?

Addressing these challenges begins with the concept that TOD is a characteristic of neighbourhoods; it is often defined as applying to an area within walking distance of a high capacity transit station or corridor. These neighbourhoods as a whole typically have lower VKT per capita than neighbourhoods with similar demographic characteristics that are not TOD. The local interventions will be made at the level of the neighbourhood or project in most instances and many activities will not result in immediate construction of mixed use buildings. However, the activities are expected to advance the neighbourhood or project through one or more steps of a sequential process of planning, design, engineering and construction, ultimately resulting in more TOD and/or better design for GHG reduction potential. Based on this we can use documented evidence of advancement, for example a plan that is approved or the design of a street facility, to demonstrate a successful output of the intervention targeted at that step of the process.

When considering the boundaries of the MRV it is acknowledged that national level or city level change is difficult to measure in 4 years, which is the length of the NAMA funding. In order to satisfy the funders a demonstration of short term as well as long term metrics must be included. The MRV boundary is set at the neighbourhood level, and a tiered set of metrics as described in Section 3.1.8 were developed to overcome this challenge. National GHG reduction and spread of TOD nationally is the ultimate impact goal, however, so a metric of the catalytic effect at the national level was included. Sustainable development benefits are important goals too, so a social benefit metric was also included.

Attributing an unambiguous causal link between the activities and the impacts of this TOD NAMA is another challenge. The tiered metrics look at the relationship between the activities and TOD, between TOD and VKT, and between VKT and GHG. These correspond to the arrows in figure 18. The metrics corresponding to the output arrow demonstrate how a neighbourhood or project improves through the extended TOD process. At the outcome arrow, because the baseline VKT was derived from trip rates, mode share, and trip length values, neighbourhood level changes in those variables are used to calculate neighbourhood GHG reductions. At the impact level, national GHG reduction trends, social sustainable development benefits and the national spread of TOD are considered.

The final aspect of MRV design was to decide how to determine the difference from BAU. Setting the boundaries at the neighbourhood level requires the difficult task to come up with a counterfactual (BAU) projection for each neighbourhood. Each neighbourhood has different characteristics that directly influence trip lengths and rates, motorisation and mode share. This problem was addressed by using control neighbourhoods and looking at the "difference of differences" between them and the intervention areas. This method looks at the magnitude of change in key variables in control and intervention areas over the same period of time and determines if the difference in changes is significant.

$$y = [(\overline{Y_2}|D=1)-(\overline{Y_2}|D=0]-[\overline{Y_1}|D=1)-(\overline{Y_1}|D=0)]$$

This technique establishes the counterfactual by assuming that BAU in the intervention neighbourhoods without the intervention would have been the same as what occurred in the control areas. This allows MRV for a range of different areas and intervention types. A down side of this method, however, is that BAU may not be the same for each neighbourhood and may not match the original, national level BAU used for ex-ante analysis. For this technique to work, control neighbourhoods must be chosen carefully in order to match them to the intervention areas as closely as possible. Intervention and control neighbourhoods should be matched within each pilot city using variables that may correlate with TOD such as geographical size, population and demographic characteristics, stage in TOD process and availability and access to transit.

Selected technical cooperation indicators and data sources

This NAMA addresses emissions from passenger road transport vehicles. The basic formula for estimating BAU on-road emissions was a version of the ASIF equation, as follows.

The "BAU" case up to the year 2040 was calculated using this equation and future parameters from various documented official sources. As can be seen, the key variables are all likely to be affected by TOD except for the vehicle emission factors. A graduated 25% reduction in emis-sion factors up to 2040 was assumed.

Daily passenger road transport GHG emissions=

$$\sum_{\text{each mode}} \left(\frac{\text{Total daily passenger trips x modeshare \%}}{\text{occupancy rate}} \right) \text{x (average trip length x GHG emission factor)}$$

First tier (Output) technical cooperation metrics		
Expected Output	**Indicator**	**Data Sources**
Local technical assistance activities cause TOD projects in at least 3 of the CIUDAT selected catalytic cities to advance through one or more key urban development process technical benchmarks: a) Planning for TOD (corridor, activity centre, station area) with stakeholder participation b) Pre-feasibility GHG, economic, site and market analyses for TOD c) Policy/Regulatory/incentive alignment for TOD project entitlement d) Preliminary architecture and urban design for TOD project e) Package proposal application(s) and deliver to Findeter staff to enable financial feasibility analysis, additional design and engineering, and other Findeter outputs	The number of targeted cities that achieve one of these TOD development process technical benchmarks with assistance from CIUDAT: • Plan for TOD approved with community and private sector engagement • Pre-feasibility GHG, economic, site or market analyses for TOD completed • Local and national TOD policy or regulation or incentive approved / applied • Preliminary architectural or urban designs completed for TOD project • Project proposal delivered to Findeter staff	• Legislative actions recorded and plans filed publicly • Contracts, MOUs, meeting minutes, reports • Analysis completed and copy to CIUDAT • Published changes to laws or regulations • Impact evaluation reports • Proposal application packages

Table 16: First tier (Output) Technical Cooperation metrics

First tier (Output) technical cooperation metrics		
Expected Output	**Indicator**	**Data Sources**
GHG has decreased and public and private investment* has increased compared to BAU(control) in catalytic TOD neighbourhoods that reduce growth in private motorised vehicle travel because they have key urban design characteristics: Walkable, bikeable, mixed use, transit access, compact, diverse income levels *part of the Financial Cooperation indicators	**Mandatory GHG indicator:** Estimated cumulative neighbourhood transportation emissions reduction in tonnes CO_2eq calculated as the difference between TOD intervention neighbourhood's and control neighbourhood's emissions found using data derived from the following **sector specific indicators:** • Vehicle ownership/capita • VKT/capita • Average trip length • Transit and NMT mode share	• Public finance/investment records • Records of private development • Vehicle registration • Household travel surveys • Transit ridership information

Table 17: Second Tier (Outcome) Technical Cooperation Metrics

The overall effects of the project are to be monitored by using the following metrics:

First tier (Output) technical cooperation metrics		
Expected Output	**Indicator**	**Data Sources**
Colombia's standard urban development model has transformed to an articulated Transit Oriented Development model that maximises the GHG reductions and sustainable development benefits of existing and future public transit investment	**Mandatory indicator:** Number of TOD neighbourhoods initiated in Colombia both inside and outside pilot cities National transport GHG reduction trend Reduction in average transport costs per person (e.g., as % of household budget)	• Local sources, including household mobility surveys, travel models • Fuel sales records • Vehicle registration and fleet models • Employment and home ownership records

Table 18: Third Tier (Effect) Technical Cooperation Metrics

Institutional setting

The collection of local data will be delegated to the recipients of the technical and financial assistance as part of the assistance agreement. Because the assistance is likely to go in most cases to city governments, much of the institutional structure for data collection will already be in place. CIUDAT will offer capacity building assistance for data collection as part of any intervention.

Partnering will be essential for broad and high-quality measurement. The following is an initial list of potential Colombian partnering organizations and the type of data they could potentially assist with.

- **Min Transporte:** travel data (mode split, trip length), vehicle ownership
- **Min Ambiente:** GHG data, fuel use data
- **Min Vivienda:** location of housing investments
- **Departamento Nacional de Planeación:** land development, infrastructure expenditures
- **Findeter:** local financing, Sustainable Cities support
- **Agencia Presidencial de Cooperación:** leveraged international investments
- **City agencies** planning, transportation, housing, economic development…
- **Universities** (Los Andes, EAFIT)
- **NGOs** – Public Private development partnership tracking socio-economic data
- **Business groups** – Chambers of commerce: real estate investments, property values, retail sales

Findings

A complex, vertically integrated (policy, programme, project), cross sector, long term NAMA such as the Colombia TOD NAMA proposal presents unique MRV challenges, even before considering co-benefit metrics, long term versus short term evaluation, or special requirements from funders. When all is taken into consideration, practical and meaningful metrics are re-quired to serve many purposes including assessing implementation progress, GHG, sustainable development benefits and enhanced policy performance. Some of these are short-term, others will take longer to manifest. Some metrics span multiple sector categories such as share of development and investment levels in TOD areas.

The CCAP learned that one key to such a challenge is to develop a clear causal chain model and have metrics that look at various places along the chain. By focusing on specific critical points in the process an MRV framework that shows where and how the interventions are having an effect at different levels can be built. This offers not only improved accountability for donors and the international community, but also guidance for implementers on how to make more effective interventions and increase performance and penetration.

A second lesson is that comparing treated, or intervention, areas with similar control areas can help to evaluate the effect of an intervention within limited temporal or geographical boundaries. Using a difference of differences technique, with careful selection of control areas, may enable some of the objections to MRV of intervention types whose effects cannot be seen directly to be overcome. We hope this will allow for the isolate of the effects of the intervention and provide useable information for replication and upscaling.

While not all NAMAs may require control area methodology, or a tiered approach, these models may prove useful for other broadly conceived transport NAMAs that have some of the same characteristics as the TOD NAMA.

ANNEXES

ANNEX 1: RELEVANT PARAMETERS FOR BOTTOM-UP TRANSPORT MRV

Parameter	Definition	Unit
Vehicle registration	Vehicle registration by fuel type, technology type, age, vehicle class (size) etc.	
Motorisation index	Number of vehicles for 1000 population	
PKM	Total passenger kilometres travel within boundary/Year (per mode & total)	pkm
TKM	Total tonne kilometres travel within boundary/Year (per mode & total)	tkm
Trip mode share	Total passenger/freight trip share distributed among different modes	%
Load factor	Average load to total vehicle freight capacity by mode	%
Occupancy	Average vehicle occupancy by mode	
Mode shift	Share of passengers transported by project mode who would have used alternate transport mode in absence of project	%
Specific fuel consumption by each mode	Fuel economy of each mode per fuel and technology type	l/100km
Vehicle distance driven per category	Vehicle distance driven by each mode by fuel and technology type	km
Average speed	Average speed of each mode/type of road	km/h
CO_2 emission factor	Amount of carbon dioxid released per unit of energy consumed	gCO_2/kJ
Other pollutants emission factors	Emission factors for Particulate Matter/NOX/Black Carbon in kg/km per vehicle-fuel type and technology type	kg/km per vehicle-fuel type
VKT/capita	Vehicle kilometres travelled per person per year	km/person
PKM/capita	Passengers kilometres travelled per person per year	km
TKM/capita	Tonne kilometres travelled per year	km
Market share of alternative fuels for road transport	Market share of alternative fuels for road transport	%
Electricity consumption	Electricity consumed by different transport modes	MWh
Kilometres of infrastructure	Kilometres of infrastructure by type built	km

Parameter	Definition	Unit
Fuel consumption of transport sector	Total fuel consumed by mode per fuel type and technology type	MTOE
Transport energy consumption per GDP	Total fuel consumption from transport per unit of income (Gross Domestic Product)	ktoe/USD
Transport energy consumption per capita	Total fuel consumption from transport per person	ktoe/capita
Transport fuel consumption per PKM	Passenger Transport CO_2 emissions per transport activity (passenger-km) (per mode & total)	MJ/PKM
Transport fuel consumption per TKM	Freight Transport CO_2 emissions per transport activity (tonne-km) (per mode &total)	MJ/Tkm
CO_2 emissions	Transport emissions of Carbon dioxide (CO_2)	M Tonnes (Mt)
Transport CO_2 emissions per GDP	Total CO_2 emissions from transport per unit of income (Gross Domestic Product)	gCO_2 per US dollar
Transport CO_2 emissions per capita	Total CO_2 emissions from transport per person	kgCO_2/Capita
CO_2 emissions per PKM	Passenger Transport CO_2 emissions per transport activity (passenger-km)	gCO_2 per pkm
CO_2 emissions per TKM	Freight Transport CO_2 emissions per transport activity (tonne-km)	gCO_2 per tkm
CO_2 emissions per VKT	Road Transport CO_2 emissions per transport activity (vehicle km travelled)	gCO_2 per VKT
Infrastructure/project investment	Annual Investment for transport at national/city level or Total project investment	USD
$/ CO_2 emissions	Ratio of total project/programme investment by Carbon savings obtained	USD/tonne
PM emissions	Transport PM Emissions	Tonnes
NOx emissions	Transport NO_x Emissions	Tonnes
Accident fatality/VKT	Road accident fatalities per vehicle kilometres travel	1/VKT

ANNEX 2: EXEMPLARY OUTLINE FOR MRV METHODOLOGY REPORT

The following outline is an example what a methodology report for a transport NAMA could look like. Such a methodology report will make the approach transparent and is a key resource for verification and replication. It includes annotations regarding the contents of the various sections. MRV methodology documents could be structured differently but the contents will always be very similar.

The presented outline is based on the work on four transport 'MRV Blueprints' as well as the 'MRV Blueprint Template' developed in the context of the TRANSfer MRV expert group[23]. It is also based on the 3 phases and 9 steps described for MRV of mitigation actions in section 5.1 of this reference document.

1. Short description of the mitigation action (limit to 2-3 pages)

- Describe scope and objectives of the NAMA in a nutshell (ca. 0.5 page)
  - Include general description of the GHG mitigation effect (refer to ASIF)
  - Indicate boundaries

Example: "The scope of the NAMA is inter-urban rail transport in India. It includes the GHG reductions achieved by moving passenger and freight from modes such as road or plane towards rail. Within the framework of avoid, shift and improve, the NAMA is basically a shift project (road and air to rail) with improvement components (rail efficiency). Traffic avoidance is not targeted. The NAMA includes as GHG gases CO_2 and CH_4 due to the nature of transport emissions. The starting date of the NAMA is January 2012 in line with the XII 5-year plan of the Government of India which includes a shift towards green growth and emphasises rail investment as a means to reduce the carbon footprint of transport." (Source: https://www.changing-transport.org/publication/mrv-blueprint-based-india-railways-nama/)

- Refer to current situation and existing policies (ca. 1 page)
- Describe interventions i.e. the (bundle of) measures included in the mitigation action and mention stakeholders involved (ca. 1 page)

2. Scope and boundaries of monitoring approach

2.1 Causal chains from NAMA to emissions (cause-effect relation)
- List and document used tools (e.g. causal chain, ASIF check list, etc.)
- Describe GHG effects in detail (direct vs. indirect; travel activity, upstream, downstream)
- Discuss sustainable development benefits
- Discuss potential interaction with other transport sector policies and measures

2.2 Describe data availability
- Discuss optimal data availability (list indicators)
- Describe real data availability: institutionalised data, project-oriented data
- Use checklist for data availability (include new annex based on ICT study)

2.3 System boundaries
- Describe/summarise monitoring boundaries chosen (temporal, sectoral, territorial, greenhouse gases and sustainability effects)

Boundary elements	Description
Temporal boundary	Timescale
Sectoral boundary	Modes and activities covered
Territorial boundary	Geographic boundary
GHGs included	GHGs covered Mention whether or not indirect / construction /upstream /downstream emissions are covered or not
Sustainability effects included	All sustainability effects included in the monitoring, e.g. air pollutants, air pollutants

- Discuss (potential) leakage emissions (emissions that occur outside of the project boundary)

[23] MRV expert group website: http://transferproject.org/measuring-reporting-and-verification-mrv-expert-group/

3. Conclusion on MRV approach and indicators to be tracked

- Shortly summarise chosen MRV approach
- List key indicators (or assumptions) needed for GHG emission calculation
- List progress/implementation indicators to be tracked
- List indicators that describe sustainable development effects
- Discuss potential progress/implementation/process indicators for specific interventions or measures

4. The baseline

- Identification of baseline scenario
  - Describe baseline methodology for ex-post baseline calculation (dynamic baseline)
  - Point out differences to ex-ante assessment (business-as-usual scenario)
  - Describe and explain assumptions (explain consistency with official forecasts if available, e.g. assumptions for GDP growth, car ownership etc.)
  - Formula for calculation
- Describe data needs to be collected for dynamic ex-post baselines (e.g. GDP / income levels when projecting car-ownership)
- Results: calculation of baseline emissions
- Briefly describe the uncertainties related to the baseline calculation

5. Assessment of the impact (ex-post)

- Explain potential methodological changes of ex-post approach to ex-ante mitigation scenario
- Results: Calculation of NAMA emissions
  - Describe the model used for calculation
  - Formula
  - Data needs (and potential assumptions such as 'average fleet composition')
  - Results
- Results: Emission reductions (baseline minus NAMA emissions)
- Assessment of consistency and uncertainties involved
- Describe consistency between data sets etc.
- Uncertainties of baseline, NAMA emissions, emission reductions
- Assessment of progress/implementation
- Assessment of sustainable development effects

6. Ex-post monitoring procedures and reporting: who, what, when?

- Institutional setting
- Monitoring parameters and schedule (list each indicator, information sources for each indicator, monitoring interval and any comments)
- Short description of the data management system (needed for verification)

7. Verification - only when verification results are available

- Describe data management (documented data sources, data collection methodologies etc.)
- Document results of verification

8. Suggestions for improvement

- Conclude suggestions for the improvement of the MRV system in the future
- Explain how the MRV of mitigation actions can be further nestled within the national MRV system

9. Annexes

- Documentation of data, data categories, defaults (e.g. emission factors),
- Documentation of survey design
- Methodology for ex-ante assessment (optional)
- Definition of key terms

10. Bibliography

LIST OF TABLES

LIST OF FIGURES

LIST OF BOXES

REFERENCES

ADB (2009): *Transport and Carbon Dioxide Emissions: Forecasts, Options Analysis, and Evaluation. ADB sustainable development working paper series.* No 9. Asian Development Bank.

Ahrens, G.-A., Ließke, F., Wittwer, R., & Hubrich, S. (2009): *Endbericht zur Verkehrserhebung "Mobilität in Städten – SrV 2008" (Vol. 49).* Dresden, Germany: Technical University Dresden.

Badrow, A., Follmer, R., Kunert, U., & Ließke, F. (2002): *Die Krux der Vergleichbarkeit.* Der Nahverkehr, 09, 1–11.

CAI-Asia (2012): *GHG and Air Pollutant Indicators for Transport and Energy Sectors in Asia. CAI-Asia.* Online available at: http://cleanairinitiative.org/portal/projects/MeasuringAPandGHGEmissions

Cambridge Systematics (2003): *Methods for forecasting state wide freight movements and related performance measures. National Cooperative Highway Research Programme (NCHRP).* Project 8-43. Transportation Research Board. National Research Council, Washington, DC.

De Jong, G., Gunn, H.F., and Walker, W. (2004): *National and international freight transport models: overview and ideas for further development.* Transport Reviews. 24 (1). pp. 103-124. ISSN 1464-5327.

DIW (2014): *Verkehr in Zahlen.* Berlin, Germany: Ministry of Transport.

DLR. (n.d.): *Clearing House of Transport Data.* Retrieved October 09, 2014. Online available at: http://www.dlr.de/cs/en/desktopdefault.aspx/1177_read-2160/

DLR, IVT (2017): *Approaches for Establishing In-Use Vehicle Stock and Vehicle Mileages.* August 2017. Online available at: https://www.changing-transport.org/publication/in-use-vehicle-stock-and-mileages/

Eichhorst (2015): *Draft MRV Blueprint on Urban Transport Programmes, GIZ, TRANSfer Project.* Online available at: https://www.changing-transport.org/publication/draft-for-mrv-blueprint-for-urban-passenger-transport-namas/

Embarq, & CAI-Asia (2006): *Sustainable urban transport in Asia: making the vision a reality: main report.* Asian Development Bank and EMBARQ, The World Resource Institute Center for Transport and Environment.

EMEP/EEA (2016): *Air pollutant emission inventory guidebook 2016.* Online available at: https://www.eea.europa.eu/publications/emep-eea-guidebook-2016

EMISIA (2005): COPERT 4. Online available at: http://emisia.com/products/copert.

Elsayed, S. (2013): *Institutional Arrangements for MRV.* International Partnership on Mitigation and MRV.

Federal Statistics Office Germany. (n.d.): *Rechtsgrundlagen.* Statistisches Bundesamt. Retrieved October 09, 2014, from https://www.destatis.de/DE/Methoden/Rechtsgrundlagen/Statistikbereiche/TransportVerkehr/TransportVerkehr.html

Follmer, R., Lenz, B., Gruschwitz, D., Jesske, B., Quandt, S., Nobis, C., Mehlin, M. (2008): *MiD 2008 Mobilität in Deutschland 2008.* Bonn and Berlin, Germany: infas GmbH and DLR for the Ministry of Transport.

Füssler, J., Herren, M., Kollmuss, A. with Lazarus, M., and Schneider, L. (2014): *Crediting emission reductions in New Market Based Mechanisms – Part II: Additionality assessment & baseline setting under pledges.* Commissioned by the Swiss Federal Office of the Environment and the Dutch Ministry of Infrastructure and the Environment. Zurich. Online available at: http://www.infras.ch/e/projekte/displayprojectitem.php?id=5183

Gan A., Liu K., Shen D., Jung R. (2008): *Prototype Information System for Estimating Average Vehicle Occupancies from Traffic Accident Records.* Transportation Research Board Journal of the Transportation Research Board 12/2008; 2049(-1).

GEF (2014): *Manual for Calculating Greenhouse Gas Benefits of Global Environment Facility.* Transportation Projects. Scientific and Technical Advisory Panel. Arlington, USA.

GIZ (2014): *Modelling GHG Emissions of Road Transport in China–Paper, Beijing/China.* Online available at: https://www.changing-transport.org/publication/modelling-road-transport-emissions-in-china/

GIZ (2014): *Navigating Transport NAMAs. A practical handbook on Nationally Appropriate Mitigation Actions (NAMAs) in the transport sector.* Eschborn, Germany.

GIZ (2017) Scherer, Elena: *Responsibilities, Procedures and Regulations for GHG Inventory Creation in Germany.* Online available at: https://www.changing-transport.org/publication/responsibilities-transport-ghg-inventory-germany/

Grütter, Jürg (2014): *MRV Transport Indonesia.* Published by GIZ.

IEA (2017): *Mobility Model (MoMo).* Online available at: http://www.iea.org/etp/etpmodel/transport/

ICCT (2014): *From laboratory to road: A 2014 update, International Council on Clean Transport (ICCT), 2014.* Online available at: http://www.theicct.org/laboratory-road-2014-update

ICCT/GIZ (2017): *Fuel Economy Standards Evaluation Tool (FESET).* Online available at: https://www.changing-transport.org/tool/feset/

IDB (2011): *Assessment of Latin America transport data availability and quality.* Inter-American Development Bank, Washington.

IFEU (2014): *Transport Emission Model (TREMOD).* Online available at: https://www.ifeu.de/methoden/modelle/tremod/

IPCC (1996): *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories.* Online available at: https://www.ipcc-nggip.iges.or.jp/public/gl/invs6a.html

IPCC (2006): *2006 IPCC Guidelines for National Greenhouse Gas Inventories. Mobile Combustion.* IPCC Guidelines for National Greenhouse Gas Inventories (pp. 1–78). Geneva: Intergovernmental Panel on Climate Change (IPCC). Online available at: https://www.ipcc-nggip.iges.or.jp/public/2006gl/

Litman, T. (2009): *Sustainable Transportation Indicator Data Quality and Availability.* Transportation Research Board Annual Meeting, 8.

Kijmanawat, K., N. Wongchavalidkul, P. Sungsomboon, S. Bakker (2016): *Monitoring transport GHG emissions in Thailand. Towards a measurement, reporting and verification system for the land transport sector.* Published by GIZ, www.transportandclimatechange.org

MAPT (2014): *National GHG Inventory Data Management Systems.* Retrieved from https://sites.google.com/site/maptpartnerresearch/national-ghg-inventory-case-study-series/national-ghg-inventory-data-management-systems

MLIT: *Ministry of Land, Infrastructure, Transport and Tourism, Japan.*

Moncel, R., Damassa, T., Tawney, L., & Stasio, K. (2011): *The international partnership on mitigation and measurement reporting and verification (MRV): Lessons and next steps.* Washington D.C.: World Resources Institute (WRI).

Muller, L. and Meier, D. (2009): *Beispielstatistik 1998, Beispielmaterialien Nr. 111,* Bundesamt für Beispiele und Vorlagen, Bern 2009.

ORNL (2007): *Oak Ridge National Laboratory (ORNL). Lehman Centre for Transportation Research.* Integrating data and models for analysis of freight movements on multimodal transportation systems for Florida. Report.

Pendyala, R.M., Shankar, V. N., and McCullough, R.G. (2000): *Freight travel demand modelling: Synthesis of approaches and development of a framework.* Transportation Research Record 1725. Transportation Research Board. National Research Council. Washington, DC. 9-16.

PKB 2000: *Beispielstatistik 1998, Beispielmaterialien Nr. 111,* Bundesamt für Beispiele und Vorlagen, Bern 1999. Retrieved on 2.2.2014 from www.pkb.ti/abc/.

Schipper L, Marie-Lilliu C, and Gorham R (2000): *Flexing the Link Between Tranport and Green House Gas Emissions.* International Energy Agency, Paris, France, 86 pp.

Schipper, L., & Ng, W.-S. (2006): The Partnership for Sustainable Urban Transport in Asia (PSUTA) Indicator Manual.

Schmied, M.; Wüthrich, P; Keller, M., Bongardt, B.; Sun, S. (2014): *Localizing the Handbook of Emission Factors for Road Transport to Chinese Cities.* Full paper for the 20th International Conference Transport and Air Pollution (TAP), September 18 - 19, 2014, Graz.

SSATP (Africa Transport Policy Program) (2015): *Alberto Nogales: In Search of Evidence to Define Transport Policies – Transport Sector Data Management Systems: Policy Note & Guidelines.* Washington.

Streit, T., Chlond, B., Vortisch, P., Kagerbauer, M., Weiss, C., & Zumkeller, D. (2013): *Deutsches Mobilitätspanel – Wissenschaftliche Begleitung und Auswertungen Bericht 2012/2013: Alltagsmobilität und Fahrleistungen.* Karlsruhe, Germany: Karlsruher Institute for Technology for the Ministry of Transport.

United Nations Environment Programme (UNEP, 2014): *Sudhir Sharma: Nationally Appropriate Mitigation Action: Understanding the MRV framework for developing countries.* Nairobi.

United Nations Development Programme (UNDP), United Nations Environment Programme (UNEP) and United Nations Framework Convention on Climate Change (UNFCCC) (2013): *Guidance for NAMA Design – Building on Country Experiences.* Online available at: http://www.mitigationpartnership.net/undp-unep-unfccc-2013-guidance-nama-design-building-country-experiences

UNECE (2000): *Economic Commission for Europe of the United Nations (UNECE), "Glossary of Terms on Statistical Data Editing", Conference of European Statisticians Methodological material, Geneva.*

UNECE (2012): UNDA Seventh Tranche. Project E: *Development and implementation of a monitoring and assessment tool for CO_2 emissions in inland transport to facilitate climate change mitigation.* CO_2 emissions from inland transport: statistics, mitigation polices, and modelling tools. Transport Division. UNECE.

UNFCCC (2009): *CDM PDD "Hot rolled steel coils transportation through ocean barges at ArcelorMittal Tubarão".* Online available at: http://cdm.unfccc.int/methodologies/PAmethodologies/pnm/byref/NM0320

UNFCCC (2010): *The Cancun Agreements: Outcome of the work of the Ad Hoc Working Group on Long-term Cooperative Action under the Convention,* Decision 1/CP.16, COP 16, Cancun. Online available at: http://unfccc.int/resource/docs/2010/cop16/eng/07a01.pdf#page=2

UNFCCC (2011): *Report of the Conference of the Parties on its seventeenth session (Decision 2.CP17).* Online available at: https://unfccc.int/resource/docs/2011/cop17/eng/09a01.pdf

UNFCCC, UNEP, UNDP (2013): *'Guidance for NAMA design – building on country experiences'*, Bonn, Germany. Online available at: http://unfccc.int/files/cooperation_support/nama/application/pdf/ guid-ance_for_nama__design_(2013)_final.pdf

UNFCCC. (2013): *CGE Training Materials – Biennial Update Reports: Institutional Arrangements.* Consultative Group of Experts (CGE).

UNFCCC (2014): *"Baseline emissions for modal shift measures in inter-urban cargo transport".* Online available at: http://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-17-v1.pdf/history_view

UNFCCC. (2015a): *CDM Methodology Booklet.* Sixth edition – Information up to EB 79. Online available at: http://cdm.unfccc.int/methodologies/documentation/index.html

UNFCCC (2015b): *CDM validation and verification standard.* Version 7.0. CDM-EB65-A04-STAN. Bonn, Germany.

UNFCCC, GIZ (2018): *Compendium of Baselines and Monitoring – Passenger and Freight Transport, 2nd revised edition, February 2018.*

Vieweg (2017): *Bottom-Up GHG Inventory and MRV of Measures, Synergies and Limitations in the Transport Sector, May 2017.*

Wermut, M. et al. (2012): *Kraftfahrzeugverkehr in Deutschland 2010 (KiD 2010) – Ergebnisse im Überblick.* WVI, IVT, DLR and KBA for the Ministry of Transport.

Winiwarter, W., Mangino, J., Ajavon, A.-L. N., & McCulloch, A. (2006): *Chapter 6: Quality assurance / quality control and verification (pp. 1–31).* Geneva: IPCC Guidelines for National Greenhouse Gas Inventories.

World Bank (2010): *Building an effective knowledge base. The smart road to sustainable transport.* World Bank, Washington.

WRI (2014a): *Policy and Action Standard. An accounting and reporting standard for estimating the greenhouse gas effects of policies and actions. Final draft for public comment.* Washington D.C.: World Resources Institute (WRI). Online available at: www.ghgprotocol.org/policy-and-action-standard

WRI (2014b): *GHG Protocol Policy and Action Standard. Road Transport Sector Guidance. Draft.* World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD). May 2014.

WRI (n.d): *Greenhouse Gas Protocol, Global Protocol for Community-Scale Greenhouse Gas Emission Inventories.* Online available at: http://www.ghgprotocol.org/sites/default/files/ghgp/standards/GHGP_GPC_0.pdf

2nd National Communication of Brazil to the UNFCCC, 2010. Online available at: https://unfccc.int/process/transparency-and-reporting/reporting-and-review-under-convention/national-communications-0

Published by
Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

Registered offices
Bonn and Eschborn, Germany

Friedrich-Ebert-Allee 40
53113 Bonn, Germany

T +49 (0)228 4460-1416
F +49 (0)228 446080-1416

E info@giz.de
I www.giz.de

Date
May 2018

Authors
Jürg Füssler (INFRAS), Sudhir Sharma (UDP), Stefan Bakker, Daniel Bongardt (GIZ), John German (ICCT), Sudhir Gotha, Jürg Grütter (Grütter Consult), Martin Herren (INFRAS), Chuck Kooshian (CCAP), Hilda Martinez (WRI Mexico), Victoria Novikova, Martin Schmied (Umweltbundesamt), Marion Vieweg (Current Future)

Deutsche Gesellschaft für
Internationale Zusammenarbeit (GIZ) GmbH

Registered offices
Bonn and Eschborn

Friedrich-Ebert-Allee 36 + 40
53113 Bonn, Germany
T +49 228 44 60-0
F +49 228 44 60-17 66

Dag-Hammarskjöld-Weg 1 - 5
65760 Eschborn, Germany
T +49 61 96 79-0
F +49 61 96 79-11 15

E info@giz.de
I www.giz.de