TRANSfer | NAMA Partnership

Reference Document on Measurement, Reporting and Verification in the Transport Sector

Final Report

Deutsche Gesellschaft
für Internationale
Zusammenarbeit (GIZ) GmbH

On behalf of:

Federal Ministry for the
Environment, Nature Conservation,
Building and Nuclear Safety

of the Federal Republic of Germany

TRANSfer

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 to this Reference Document in the drafting process.

Reference Document on Measurement, Reporting and Verification in the Transport Sector

Final Report

February 2016

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

The TRANSfer project

The TRANSfer project is implemented by GIZ and financed by the International Climate Initiative of the German Ministry for the Environment, Nature Conversation, Building and Nuclear Safety (BMUB). Its objective is to support developing countries to develop and implement climate change mitigation strategies in the transport sector as 'Nationally Appropriate Mitigation Actions' (NAMAs).

The project provides technical assistance in the partner countries Indonesia, Columbia, Peru, the Philippines and South Africa. In addition, TRANSfer supports mutual international learning. Therefore, the project also closely cooperates with other projects under the International Climate Initiative of BMUB.

With the aim of facilitating NAMA development worldwide, TRANSfer published the handbook 'Navigating Transport NAMAs'. With respect to measurement, reporting and verification (MRV) the handbook is complemented by both, this reference document on MRV as well as a first set of so-called 'MRV blueprints' – a description of the MRV methodology and calculation of emission reductions for different NAMA types in the transport sector.

The work has been supported by an expert group on MRV of transport NAMAs that since 2013 has met three times and discussed key concepts presented in this publication.

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

Table of Contents

Abbreviations and Acronyms

BAU	Business-as-usual
BRT	Bus Rapid Transit
BUR	Biennial Update Report
CBA	Cost-Benefit Analysis
CDM	Clean Development Mechanism
CEA	Cost-Effectiveness Analysis
CER	Certified Emission Reduction
GHG	Greenhouse Gas
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH
ICA	International consultation and analysis
LEDS	Low Emission Development Strategies
MRV	Measurement, Reporting and Verification
NAMA	Nationally Appropriate Mitigation Action
NDC	(Intended) Nationally Determined Contribution (former INDC)
QA/QC	Quality Assurance/Quality Control
UNFCCC	United Nations Framework Convention on Climate Change
WRI	World Resources Institute

Summary

While the transport sector is a key contributor to development and economic growth, it also causes significant GHG emissions. The main objectives of this *Reference Document* are to introduce firstly, the basic concepts of *Measurement, Reporting and Verification* (MRV) of GHG mitigation actions in the transport sector, secondly, the data needs for MRV, and thirdly, institutional and process related details for establishing an MRV system. The complete system encompasses MRV activities and the institutionalisation and coordination of these activities applied to:

- Reporting of transport emissions (as part of GHG inventories);
- Tracking the level of achievement of national, regional or city level mitigation goals;
- Accounting of effects of NAMAs;

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). 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* gives advice on good MRV practices and addresses especially policy makers in developing countries and developers of National Appropriate Mitigation Actions (NAMAs) in transport systems with a focus on land transport in developing countries. This is very relevant for the implementation of (Intended) Nationally Determined Contributions ((INDCs/NDCs) that countries submitted in the context of the *Paris Agreement* in December 2015.

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/in 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. It continues to discuss boundaries, emission factor databases and lists the main transport sector indicators. The section also explains key principles for data collection and MRV such as comprehensiveness, relevance, consistency, transparency, accuracy, accessibility, costs and effectiveness. 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 2 finally 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. 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 focuses on impact assessment of mitigation action by comparing the actual data resulting from mitigation action to a hypothetical situation without the action, called a *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), sector strategies or targets (e.g. shift from road freight transport to railway). After defining the scope of the mitigation action, a causal chain could be mapped to identify

all positive, negative, direct and indirect changes in GHG emissions in the transport sector resulting from the action. The section also includes 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 NAMA); it is based on past trends but it also should take into account current and anticipated developments.

Section 4 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 transit oriented development in Colombia.

Finally, section 5 proposes a framework for establishing a comprehensive MRV system. It describes how institutions could use an iterative process in order to strengthen their collection and management of data. Such a process involves on the one hand, the prioritization and selection of key data and improving data quality over time and it recommends, on the other using a clearing house to organise institutionalisation of data management. The next section then outlines how to develop NAMA MRV systems. It recommends including all relevant stakeholders by defining clear responsibilities. Further, it elaborates three phases and nine steps towards NAMA MRV:

Phase 1: Define scope and boundaries

- Step 1: Identify main effects of mitigation action (see section 3.2 and 3.3)
- Step 2: Assess data availability/gaps (see section 2.1)
- Step 3: Define boundaries for analysis (see section 3.4 and 3.5)

Phase 2: Scenarios and modelling

- Step 4: Develop baseline scenario (and ex-ante mitigation scenario) (see section 3.6)
- Step 5: Set-up model to calculate emissions (see section 2.1, 2.2 and 3.7)
- Step 6: Develop data collection plan (and methods such as surveys)

Phase 3: Data management and monitoring

- Step 7: Collect data (measure)
- Step 8: Calculate emission reductions
- Step 9: Report and verify (see section 3.9)

This process applies to both, ex-ante assessments and ex-post NAMA monitoring plans. Ideally, ex-ante modelling during NAMA development is consistent with the ex-post monitoring approach 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 can be improved by collected and processed data and corresponding lessons learnt.

Definition of terms

Term	Definition
ASIF framework	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 CO2/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.
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-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.
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.
Greenhouse gases (GHG)	The GHG data reported by Parties of the UNFCCC contain estimates for direct greenhouse gases, such as: Carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), Perfluorocarbons (PFCs), Hydrofluorocarbons (HFCs), (Sulphur hexafluoride), (SF_6). The various GHGs have a specific global warming potential expressed in carbon dioxide equivalents (CO_2e).
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.
NDC	(Intended) Nationally Determined Contributions (INDCs) refer to the contributions to tackle climate change submitted by countries to UNFCCC in pursuance of decision taken at Warsaw COP in context of negotiation on a new agreement that will be applicable post 2020. INDCs should include mitigation contributions of countries in accordance with common but differentiated responsibility and equity. Countries may also include adaptation measures in the INDCs.
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 which 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 Action. NAMAs are voluntary mitigation measures taken by developing countries that are reported by national governments to the United Nations Framework Convention on Climate Change (UNFCCC).
National reporting	Parties to the UNFCCC must submit national reports on implementation of the Convention to the Conference of the Parties (COP). Furthermore, it is a formal requirement to report on planned, current and implemented NAMAs within biennial update reports (BURs).

1. Introduction

A key element of the international framework for climate change mitigation is the concept of 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, 2011a). 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. MRV also will be a central element of implementation of Intended Nationally Determined Contributions (NDCs), as part of the new agreement for post-2020 period.

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).

The transport sector contributes substantially to 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.

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 boundaries of the assessment. Advanced, transport related MRV-systems able to overcome such challenges often do not exist in developing countries yet.

Because of such challenges, many developing countries and international organizations see the requirement of MRV as a key barrier to engaging in transport related 'Nationally Appropriate Mitiga-

---

[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. In this document we nevertheless stick to the official terminology of measurement.

tion Actions' (NAMAs). But at the same time, developing countries eagerly want 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.

As a consequence, 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 MRV-Systems in the Transport Sector aims at providing the necessary background information and concepts to establish successful MRV systems for the transport sector.

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 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. Reporting is implemented in bi-annual update reports. MRV systems provide data and information for reporting under the UNFCCC (e.g. GHG inventories) and catalyse international support for enhanced action (see Figure 1).

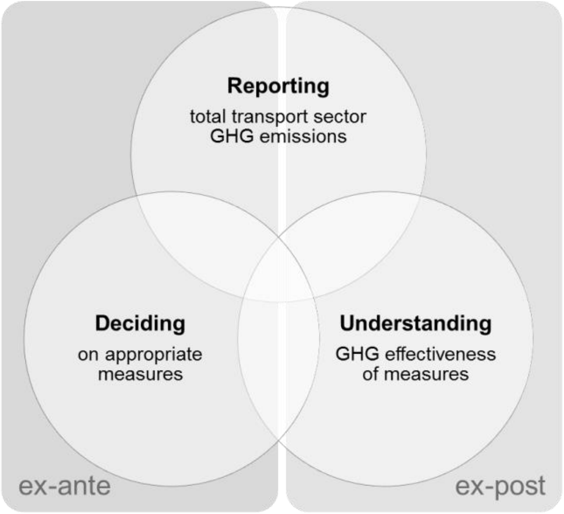


Figure 1: Purposes of MRV in the transport sector

The purposes 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, so this involves both an ex-post perspective (What has been achieved?) and an ex-ante outlook (What is likely to be achieved?).

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 which 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.

1.2. Objectives

Countries that measure, report and verify emission reductions aim at a reliable and robust assessment of greenhouse gas (GHG) emissions and mitigation action performance. This document 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 NAMAs. With the new post-2020 agreement, such a system will also help tracking how countries are meeting the contributions listed in their NDC. Case studies and examples are provided 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 effects of mitigation actions (section 2);
- Explain how these parameters and tools can be used for reporting on Nationally Appropriate Mitigation Actions (section 3);
- Outline processes required to organise sound measurement (data collection and processing), reporting and verification of GHG emissions (section 5).

1.3. Scope of document

This document 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:

A Transport MRV System should enable to (a) understand total GHG emissions in the transport sector and (b) the effects of mitigation actions.

The term ‘measurement, reporting and verification’ itself usually refers to an ex-post perspective 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 NAMA 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

NAMA proposal (to NAMA funders) and the mitigation action part in biennial update reports (see below) to the UNFCCC and therefore 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 national GHG inventory and the mitigation efforts of country, including NAMAs. Current BUR guidelines have been decided at the United National Framework Convention for Climate Change's (UNFCCC) 17th Conference of the Party in Durban in 2011 (s. decision 2.CP17). The inventory section usually follows the Intergovernmental Panel on Climate Change's (IPCC) guidelines for GHG inventories (IPCC 2007) but there is hardly any guidance for the section on mitigation actions, even though this is also subject to scrutiny in the international consultation and analysis (ICA).
- **Nationally Appropriate Mitigation Action (NAMA) proposals and reporting:**
  As defined in the Cancun agreement in 2010 (Decision 1/CP.16), all NAMAs will be measured, reported and verified domestically. Internationally supported NAMAs will also be subject to international MRV. While some data from inventories can be used for NAMA MRV, it is necessary to analyse the specific impacts of the NAMA measures, in most cases against a supposed baseline or BAU scenario. The outcomes and impacts of implemented NAMAs as well as information on planned NAMAs will be reported in the BURs.
- **Low Emission Development Strategies (LEDS) and (Intended) Nationally Determined Contributions (NDCs):**
  LEDS are a weaker concept than NAMAs. The 2010 Cancun Agreements recognise that „a low-carbon development strategy is indispensable to sustainable development" (Decision 1/CP.16, Para. 6), but there is no UNFCCC definition of LEDS. The OECD has loosely described LEDS as "forward-looking national development plans or strategies that encompass low-emission and/or climate-resilient economic growth". While LEDS usually are developed in a cross-sectoral way, there are also specific transport sector climate strategies based on scenario studies. Such documents are often developed by transport authorities in order to understand the emission reduction potential and opportunities in the sector. Later at COP 19 in Warsaw countries where asked to submit (Intended) Nationally Determined Contributions (INDCs) describing their commitments to the Paris Climate Change Agreement in November 2015. Ideally LEDS lead to NDCs but the connection might still be missing instead. Also the reporting for NDC implementation has not been decided yet.

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. Thereby the document focuses on:

- **MRV of greenhouse gas emissions:**
  While the main focus is on measuring of 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.
- **MRV of NAMAs:**
  Inventories are the basis for understanding (transport sector) emissions but are not sufficient to assess impacts of specific/single mitigation actions. The specific nature of MRV depends on whether countries commit to economy wide or sector-wide mitigation targets or NAMAs. While an economy-wide (or sectoral) mitigation target requires a full inventory of all emissions occur-

ring (see section 2.3 and 5.1), commitment to a specific (sub-sector) NAMA asks for an impact assessment of the measure taken within its specific boundaries and against a business-as-usual scenario (section 3 and 5.2).

The Reference Document builds on existing knowledge of a group of experts covering a wide range of institutions and backgrounds. It is part of a larger effort under the monitoring and MRV work stream in the TRANSfer project that includes

- The development of "MRV-Blueprints" or "NAMA Methodologies" for specific transport policies or programmes (Expert Group on MRV-Systems in the Transport Sector)
- Direct support of countries in developing their MRV-System for the transport sector (TRANSfer Transport NAMA Handbook)

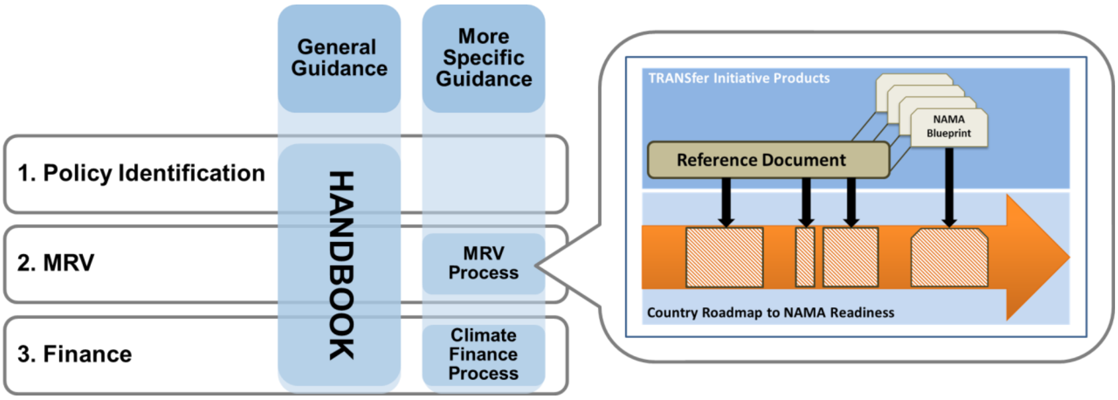


Figure 2: Overview of MRV system and respective components.

The Reference Document builds upon to the TRANSfer Handbook *Navigating Transport NAMAs*[2] and provides an in-depth analysis of topics of the Handbook's section on MRV and puts it in the context of actual case study experiences. The Reference Document also relates to the WRI GHG Protocol Policy and Action Standard and its Transport Sector Guidance and makes reference to some of its approaches and concepts in assessing the mitigation impact of NAMAs (WRI 2014b).

---

[2] http://transport-namas.org/resources/handbook/

2. Transport sector data

The report analyses how transport sector data can be used in setting up MRV systems. Often a considerable amount of transport related data are already available and collected in transport institutions. Such data are the key to build consistent and cost-efficient MRV systems. With respect to such transport sector data there are three core questions: what do we (need to) measure, report and verify (section 2.1), how do we process the data (section 2.2) and who does it (section 2.3)? The answers to these questions depend on the objectives of the MRV system, the national circumstances and resources available. However, there are some common characteristics and approaches that apply to the setup of all transport sector MRV systems. This section provides an overview on key data, indicators and parameters as well as the institutional arrangements needed for their collection and analysis.

2.1. Approaches and key parameters for transport MRV

This section focuses on the question what approaches for data MRV exist and what parameters to measure, report and verify. 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 discuss these two approaches in more detail, describing the data that are required for different levels of accuracy.

2.1.1. Top-down approach vs. bottom-up (ASIF)

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 tons) and conversion factors of different fuel types (ink gCO_2eq/litre). It requires fuel consumption data, 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.

Table 1: Direct CO2 conversion factors (tank-to-wheel) provided by 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

The top-down approach is needed for national GHG inventories as most of diesel and gasoline fuels are used in the transport sector. The fact that fuel sales are monitored in most countries 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 change 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 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.
- **Limited information value**: Collecting data on fuel consumption alone does not provide any insights to the specifics of the transport system or the policy being implemented. 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 industries sector. However urban as well as inter-urban rail uses electricity. The approach therefore presents an incomplete picture of the sector. Strategies such as NAMAs to electrify 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 which 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).

This is also why top-down GHG inventories often are complemented with bottom-up inventory models (see below). Examples are TREMOD[3] in Germany or COPERT[4] in southern European countries. Such advanced bottom-up models have often been developed in order to quantify air pollutant emissions and only later have been used for GHG emissions as well. But these models also enable countries to reduce uncertainties and develop more detailed analysis.

---

[3] TREMOD - Transport Emission Model: https://www.ifeu.org/english/index.php?bereich=ver&seite=projekt_tremod

[4] COPERT 4.0 http://emisia.com/copert/

Usually, such advanced models, but also other models like the Mobility Model (MOMO)[5] of the International Energy Agency (IEA) or simpler spreadsheet models often include an ex-ante perspective and allow to model 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 not details regarding e.g. vehicles used in the future or land-use in future can be considered. However, bottom-up 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.

Distinguishing top-down or bottom-up is also reflected in the International Panel of Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories of the [IPCC 2006], which specify procedures for the energy sector, of which transport is part. The IPCC guidelines list three tiers of GHG emission quantification approaches. Tier 1 and 2 approaches are basically "top-down" approaches while Tier 3 methodologies complement them with "bottom-up" approaches. The tiers are differentiated by the source of the conversion factors, with tier 1 using IPCC default values and tier 2 using country-specific data. Tier 3 methodologies then reduce uncertainties in fuel sales data. The approach chosen and specific procedures and data sources are usually further defined in national level guidelines or "quality systems" for emission reporting.

- **Tier 1** represents the default method, which normally uses high level top-down data 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.
- The **tier 2** approach also describes inventories based on fuel sales energy balances, but applies country specific conversion factors that consider the locally specific nature of fuels (density, NCV, 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.
- **Tier 3** represents the most detailed method and goes beyond fuel sale statistics. However, the IPCC does not provide a tier 3 methodology. The IPCC instead encourages further improvements in determining fuel sales data. 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 shall be complemented with calculations of energy consumption of vehicles based on activity data. Tier 3 approaches also apply country specific conversion factors. This approach provides the best estimates primarily for non-CO_2 greenhouse gas emissions.

Box 2: The IPCC tiers for national greenhouse gas inventories

The top-down approach is hardly applicable for tracking of specific mitigation actions. Only 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 the approach is helpful to monitor mitigation actions. This is e.g. the case for renovation of public

---

[5] IEA MOMO http://www.iea.org/etp/etpmodel/transport/

transport bus fleets. Operators usually collect fuel consumption data, sometimes even for each single vehicle. This enables them to use the data also 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 don't know where emissions occur.

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)".

$$\mathbf{GHG = A * S * I * F}$$

Activity and structure (A and S) describe how much and how people and freight is actually travelling. They are measured in terms of vehicle kilometre (VKT), passenger kilometre (pkm) or ton kilometre (tkm) and disaggregated by mode type, including non-motorised transport. Passenger kilometre (or ton kilometre) are calculated using 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.

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 basically the same values 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 a crucial information (taken from energy sector statistics)

Bottom-up approaches are not per se more detailed than top-down. But they can range from rough calculations of average or default data to very detailed modelling. An example for a rough 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 e.g. quantify the impacts of congestions 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 impacts of policies and measures it depends largely on the type of expected impacts which level of detail in bottom-up modelling is needed. Modelling the impacts of motorisation may allow using a rough 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:

- Rough bottom-up calculation 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 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).

2.1.2. Types of boundaries for MRV

Setting boundaries is a crucial task in developing an MRV approach. Defining accurate boundaries is necessary for inventories and the assessment of mitigation actions The term 'boundaries' refers to the scope of an analysis or assessment. A key parameter here is the geographic area which in most cases is defined by the administrative borders of a country (esp. for national inventories). However there are further dimensions of boundaries. For a summary of the different elements that need to be defined to set the boundary the following categories are relevant:

- **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 driver tank abroad, see Box 3) 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 that sales of diesel cannot be completely linked to transport, because it could be used for non-road machinery (e.g. construction machines, agricultural vehicles or industrial use). This leads to the question whether such emissions are included in the transport sector or other sectors such as buildings or agriculture. When assessing mitigation actions, the inclusion or exclusion of (other) policies and measures in the assessed system is very relevant to. It is important to avoid double counting.
- **Temporal boundaries** describe the question for which years 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 on long term and are potentially excluded through limiting the assessment to a shorter time period.

Another important dimension of boundary setting includes what effects are analysed. This includes two dimensions:

- **GHGs included**, i.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 – especially in NAMA assessment – is whether upstream (e.g. in fuel refinery processes) or downstream emissions (e.g. in vehicle scrapping) need to be considered (see section 3.3 for details).
- **Sustainability effects** can be considered in assessment of mitigation actions. Benefits to be considered in the assessment need to be defined.

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.

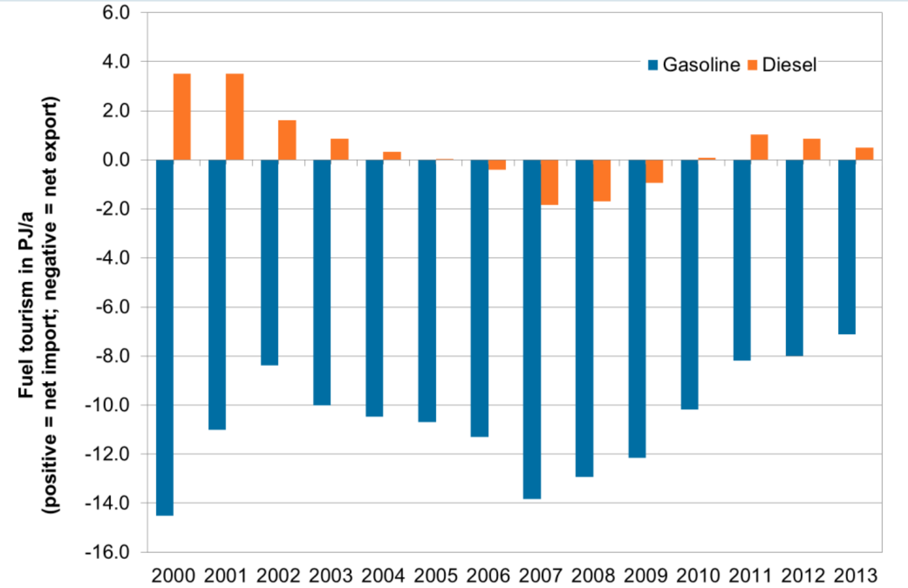


Figure 3: Cross border import/export of gasoline and diesel for Switzerland 2000-2013 in PJ/a

Box 3: Consequences of grey fuel imports to the GHG inventory of Switzerland

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 those to 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. As a consequence, each data source needs to be analysed rather carefully. This is usually called a quality system. Such a quality system ensures that differences can be clearly attributed to sector boundary issues or explained through socio-economic processes, the differences can be handled systematically through correction factors.

In order to develop MRV systems over time and enable learning and improvements, the IPCC suggested a tiered approach (see Box 2). Starting in a simpler way with default data generates data basics that can be improved over time. In the transport sector, this may some-times 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 re-porting and verification.

2.1.3. Emission factor databases

As described above, there are different data needs related to top-down and bottom-up approaches. While top-down can be rather reliable, an ex-ante perspective to emission reductions is more closely to conventional transport planning and important for decision-making: What will likely to be the expected effects of an intervention? This perspective almost always takes the ASIF factors (see section 2.1.1 above) into account: The policy or measure either have 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 are needed. Consequently, data on travel distances, modes and fleets are at the heart of transport MRV. This also means that bottom-up evaluations allow more easily the evaluation of sustainable development benefits (often called co-benefits).

However, bottom up emission quantifications needs additional information about emission factors. 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_2e/KM for a given fleet composition. Such emission factors can vary considerably and subsequently lead to bad results. As they depend on fleet composition, fuel type, fuel quality, and maintenance of the vehicles, it is hardly possible to generate default values without endangering the validity of results. As a consequence, 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 cold-starts 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.

The only available comprehensive sources of such detailed emission factors are:

- the European emission factor database Handbook of Emission Factors for Road Transport (HBEFA, see www.hbefa.net); 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. COPERT on HBEFA or IVE on MOVES) or considerably less detailed. HBEFA and MOVES are based on large-scale measurement programmes developed over many years and at high costs. Both emission factor databases provide detailed emission factors (by vehicle segment, age, traffic condition, etc.) and allow aggregating those for different areas and purposes (see Box 4).

Over the last 30 years harmonised emission models and emission factors databases have been established in Europe. As the table below shows most countries in Europe use the emission model **COPERT** (**CO**mputer **P**rogramme to calculate **E**missions from **R**oad **T**ransport) for the quantification of GHG emissions and air pollutants of road transport. Some countries have developed own models (e.g. **TREMOD** - **Tr**ansport **Em**ission **Mod**el in Germany). Independent of the emission model used the underlying emission factor database of most emission models is the **H**and**b**ook of **E**mission **Fa**ctors 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. In the meantime the development is financed additionally 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 on 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 HBEFA database (so-called average speed approach). Countries such as Austria, Germany, Norway, Sweden or Switzerland are using directly the HBEFA database without simplifications. On 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 for a comparison of the results.

Box 4: Emission models used in Europe

As said, such databases only provide reliable data for the region and countries they were developed for. In order to apply these emission factor databases in other countries, it is recommended to adapt them to local conditions. For an example see GIZ 2014. 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 end-of-pipe treatment (emission concept such as Euro 5 etc.).
- Understand operating conditions of the fleet (ambient conditions, speed, road types etc.)

2.1.4. Overview of transport sector indicators

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

Table 2: Key indicators for transport MRV

		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
	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
		Distances travelled	▪ Vehicle kilometre by vehicle type (in VKT) ▪ Passenger kilometre (pkm) ▪ Ton kilometre (tkm)	▪ by mode ▪ by vehicle classes / engine size ▪ by vehicle age / technology
		Trips	▪ Number of trips ▪ Tons transported ▪ Trip length	▪ by mode ▪ by trip purposes (e.g. work, leisure etc.)
		Load factor	▪ Occupancy (in persons/vehicle) ▪ Load of goods vehicles (in percent)	▪ by mode ▪ by vehicle classes / engine size
	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

In addition to benchmark emissions from different countries or cities, other statistics, such as socio-economic 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 ton-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.

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 27.79Km/hour to 38.2 km/hour by 2016
3. Increased occupancy due to reduction of city 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 20km) 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 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

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.

Table 3: Differences between institutionalised and project oriented data

	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

The monitoring of transport emissions can be complex, time-consuming and costly, especially if the data shall be consistent and of high quality. Policy makers in developing countries often find it difficult to justify building a costly inventory from measurements and models only to assess emission savings; however, they are more attracted 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.

2.2. Principles and approaches of sound transport sector monitoring systems

This section provides an overview of how to monitor the indicators and data as defined above. This includes key principles for good practice monitoring, elements for the general setup of monitoring systems and an overview of methods in data collection.

2.2.1. Key principles for monitoring of transport systems

Monitoring is a process where data and information are collected and compressed into key trends which describe the state of the system and the directions taken in order to support decisions on required 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[6] presented in Table 4.

Table 4: Differences institutionalised and project oriented data

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	■ 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

---

[6] 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 2.1.4). Furthermore systems usually evolve from a less detailed system with fewer indicators to a more comprehensive system (see section 0). At the same time, different levels of detail and comprehensiveness can exist at different levels. Individual cities or municipalities can develop more elaborate systems to address specific transport challenges or to monitor individual actions, while information at the national level remains at a lower level of detail. Especially in such cases, it is important to consider the need for consistency, as national systems evolve and data are aggregated at higher levels. Here good coordination is required as discussed further in section 2.3.

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

- **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 are difficult to measure and therefore 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. Also top-down data from energy balances might be useful to check and balance mistakes in bottom-up inventory models.

2.2.2. Overview of methods in data collection

Once we have defined what we want to monitor and on what level, 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).

In general it is recommended using institutionalised data. Data available at different administrative levels can be used to generate meaningful transport sector data. This includes data available from vehicle registration offices, tax authorities and accident databases. Some of the sources directly deliver 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 specific target groups to report data on a regular basis. This is usually used by statistics offices and needs to be underpinned by corresponding legislation. The method can work for companies, such as freight carriers and public service providers, as far as they are working legally.

A lot of travel activity data can be observed, measured, or collected in surveys[7]. Given the fact that data for transport monitoring cover a wide range of activities in personal, public and freight transport that is carried out by large parts of the population, it is in most cases impossible to actually measure individual indicators. A direct measurement of trip lengths and overall km 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 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 a 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. E.g. for prior to its introduction the traffic effects of the Stockholm congestion charging system was model in about 100 different scenarios. This also allowed to easily estimate the emission reduction effects using the official emission factors database of Sweden (Handbook for Emission Factors, see Box 6).

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]. But also manual observations surveys 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 traffic counts and household interviews in order to achieve more accurate results through triangulation. In some countries such as China GPS devices are used to monitor mileage of vehicles.

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).

---

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

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

A good example for data collection and monitoring at national level in Asia is the Japan Statistical Yearbook. The Japan Statistical Yearbook[9] 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 data collection method by mode of transport.

Table 5: Summary of Japanese transport data collection (Source: MLIT)

Mode	Vehicles	Activity	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 (trans-port tonnage/tons-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 on-line 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)

Box 6: Example for data collection: Japan Statistical Yearbook

---

[9] http://www.stat.go.jp/english/data/nenkan/index.htm

2.3. Institutional setting for monitoring

This section provides an overview of who should monitor the indicators and data as defined in section 2.1. This includes the discussion of responsible institutions as well as the institutional set-up.

As highlighted in the previous section, data needs are complex and vary depending on measures and boundaries. The ability and cost to provide 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. We need to clearly distinguish these two different roles:

- Provision of information: data gathering, data aggregation, data processing, data analysis
- User 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 sub-agencies. 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 sufficient information. Transparency about boundaries, collection methods and uncertainties is necessary within such communication processes.

2.3.1. 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 GHG effects of measures, but for other purposes. However, some of this data will be useful for the assessment of 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 6 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. The case studies in Box 7 and Box 8 illustrate the institutional setup of involved institutions in Germany and Thailand.

Table 6: Differences institutionalised and project oriented data

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-transport 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

Transport data management in Germany delivers a wide range of relevant sector indicators. Figure 4 illustrates the different data products and the involved institutions. Both, the Federal and State Statistical Offices, supported by several specialised transport sector institutions, as well as the Federal Highway Research Institute, collect statistical data. Most data are available on an annual basis, some at shorter intervals. The legal basis for data collection are the Federal and State Statistics Acts and specific transport related laws for statistics (VerkStatG), freight (GüKG), road transport (StVG) among others (Federal Statistics Office Germany). Data are mostly collected at the individual state level by the respective transport institutions, and aggregated by the Federal Statistics Office.

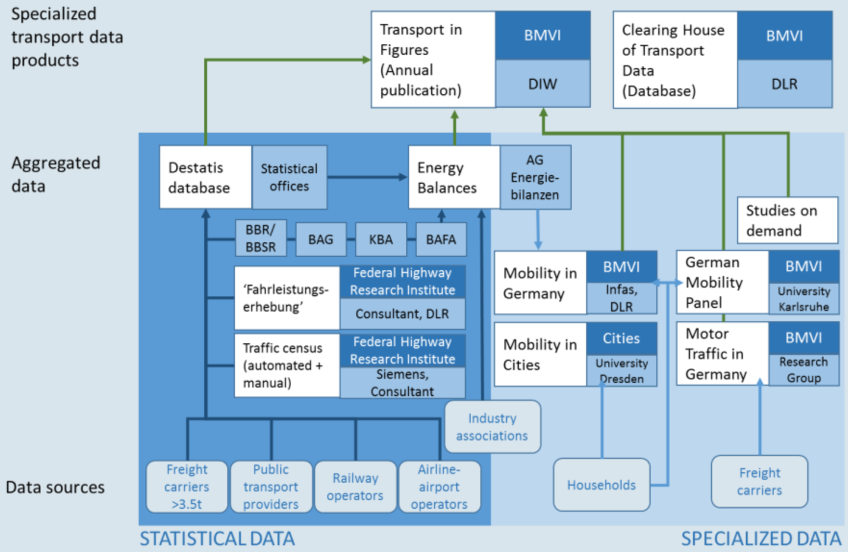


Figure 4: Transport data management in Germany

To supplement the statistical data, a number of studies are regularly commissioned. At the federal level, the Ministry of Transport commissions three major surveys: the German Mobility Panel (MOP), Mobility in Germany (MiD) and the Motor Traffic in Germany (KiD). The latter aims to supplement the statistical data on freight, which only covers larger carriers above 3.5t, with additional information on small-scale freight transport. It was conducted in 2002 and 2010 (Wermut, 2012). The first two surveys both target household mobility characteristics. 'Mobility in Germany' is a classical cross-sectional survey, which collects data from a broad selection of households at a given date (Follmer et al., 2008). The 'German Mobility Panel' aims to provide similar indicators for a smaller selection of households, but for a period (one week up to 8 weeks), surveying the same households over three years (Streit et al., 2013). Further studies may be commissioned on demand.

All results from these surveys are publicly available through the Clearing House of Transport Data which is hosted by the German Aerospace Center (DLR). Additionally, data from the German energy balances is collated annually by the German Institute for Economic Research in the publication 'Transport in Figures' (DIW, 2014). The example shows how a complex transport information system can be structured. An important element in the setup is the joint agreement on definitions and methods, to ensure compatibility of different datasets. In this way, the available information can be tailored to serve different objectives, both for transport planning and GHG emissions reporting.

Box 7: Transport data management in Germany

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, if at all, collected 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 8: Data management and reporting in Thailand

The examples above 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.

2.3.2. Organizing and institutionalizing cooperation

Experiences from GHG inventory (see section 5) and National Communication development have proven the importance of cooperation between a multitude of involved institutions and stakeholders. While developing robust GHG inventories is already a challenging task, the MRV of mitigation measures in the transport sector requires more data at a much higher resolution, with the majority of transport data users expecting full comparability of data (Badrow, Follmer, Kunert, & Ließke, 2002).

Due to the large number of stakeholders involved in transport system design, management and evaluation poses a challenge for cooperation. Information needs vary depending on the types of data (see section 2.1). Local mitigation actions require different levels of data compared to national or state-level endeavours. Limited availability of resources, both financial and technical, requires close coordination and cooperation to maximise efficiency of the system.

A sound monitoring system requires the cooperation of a wide range of actors and coordination between processes. According to Moncel, Damassa, Tawney, & Stasio (2011) key elements of monitoring systems that require coordination and cooperation include:

- **Data collection** (see also section 2.2.2):
  - Indicator definitions should be harmonised to ensure that collected data are comparable 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 9).
- **Reporting**:
  - 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.
- **Funding and capacity**: Where the implementation of transport mitigation measures and MRV efforts are supported from international sources, additional coordination may be required. Financial flows, capacity building activities and MRV requirements derived from this support benefit from coordination. Reporting requirements of funders are often similar and it is efficient to coordinate data collection, processing and reporting related to such requirements.

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 (Elsayed, 2013; UNFCCC, 2013):

- 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

Cooperation is particularly relevant if data sets from different geographic levels or regions need to be harmonised. The case study in Box 9 describes how data from such different aggregation levels could be geared to each other.

The system of transport data provision in Germany as outlined in Box 7, answers to different data needs for planning and monitoring purposes. 'Mobility in Germany' and 'Mobility in Cities' provide a good example of the cooperation process to enhance data compatibility. While the one data set looks at national level and state level data, the other looks 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 (Badrow et al., 2002).

The process to enhance comparability of the two surveys started with a workshop in March 2002. The transport ministry then formed a working group, comprised of all involved public and research institutions. Additionally, it commissioned a research project that looked at the compatibility of the two surveys (Badrow et al., 2002). Key elements were partly or fully harmonised including the survey methods and the spread of survey dates over the week and over the year. Additionally the two surveys were conducted in parallel since 2008 to enhance comparability.

Box 9: Example of enhanced cooperation for national and city level data in Germany

Since also developing countries made available a considerable amount of data, it would be good to establish or empower a data clearing house (see 2.3.2), i.e. structure that collects, stores, checks and disseminates information and data. Such a clearing house function most likely is integrated in other institutions and usually is 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 NAMA MRV missing official information could be first collected on a project basis and then be institutionalised over time. Therefore, it is important 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 institutionalisation and establish a clearing house. However, for NAMA MRV 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. Concepts for MRV of mitigation actions

The concepts and parameters discussed in section 2 are the basis to monitor transport sector mitigation activities in general. This section provides further information on how data and parameters are used to adequately measure the outcome or effect of NAMAs[10]. Effects of mitigation actions are usually measured by comparing "with mitigation action" development to a situation "without mitigation action" (baseline or business-as-usual, short BAU, scenario). The following sections describe concepts and terms that are needed to measure effects of a mitigation action (see Figure 5 for an overview). To give practical insights, those concepts are then illustrated in section 4 with practical examples from the transport sector.

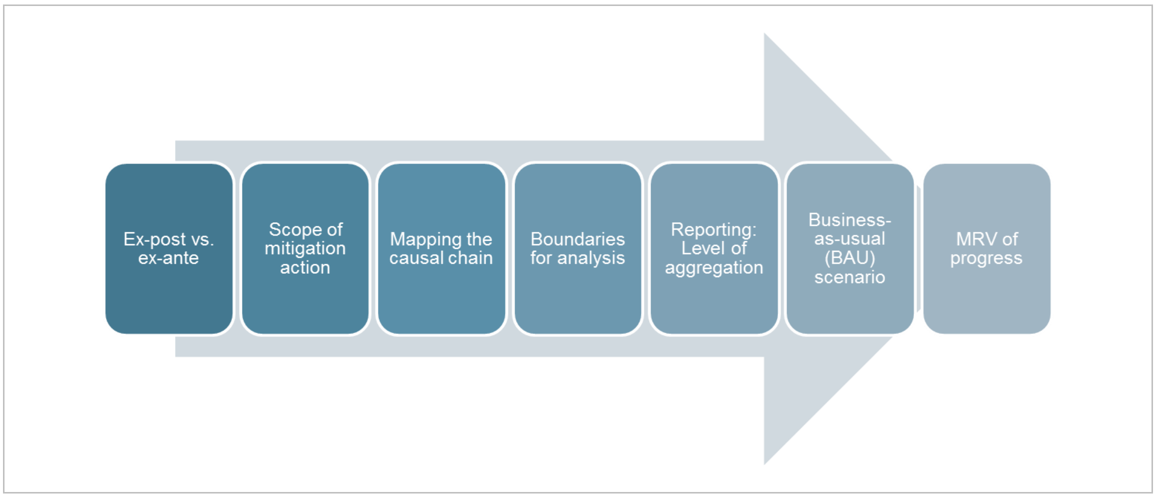


Figure 5: Cross border import/export of gasoline and diesel for Switzerland 2000-2013 in PJ/a

In the context of the TRANSfer project a number of 'MRV Blueprints' for transport NAMAs have been developed. It is envisaged to use this approach to collect a number of detailed methodologies for transport NAMA MRV. This allows describing the approaches in relevant level of detail and will significantly contribute to international learning. For further information we refer to the MRV section of the TRANSfer project website:

http://transport-namas.org/measuring-reporting-and-verification-mrv-expert-group/

Annex 2 of this report includes an exemplary outline for an MRV methodology report to a transport NAMA. The annotated outline refers to the sections in which specific concepts are described.

Further detailed step by step guidance for calculation of GHG effects from mitigation actions is also given by a variety of guidelines and methodologies such as by GEF (2015) or in approved CDM methodologies (UNFCCC, 2015a). Further see also the GHG emission methodologies and tools compiled by the Partnership for Sustainable Low Carbon Mobility (SLoCaT):

http://www.slocat.net/news/1452

---

[10] We use the term NAMA to encompass a wide range of mitigation actions, including (CDM-like) individual investment projects, broader policies and even sector strategies or targets.

3.1. Ex-post vs. ex-ante

From a conceptual perspective the term MRV of a NAMA referred to ex-post monitoring and progress reporting. But in NAMA selection and in NAMA proposals, especially when international funding should be attracted, it is also important to estimate the potential effect of an intervention before its implementation. Figure 6 illustrates the different occasions during NAMA development and implementation, when 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.

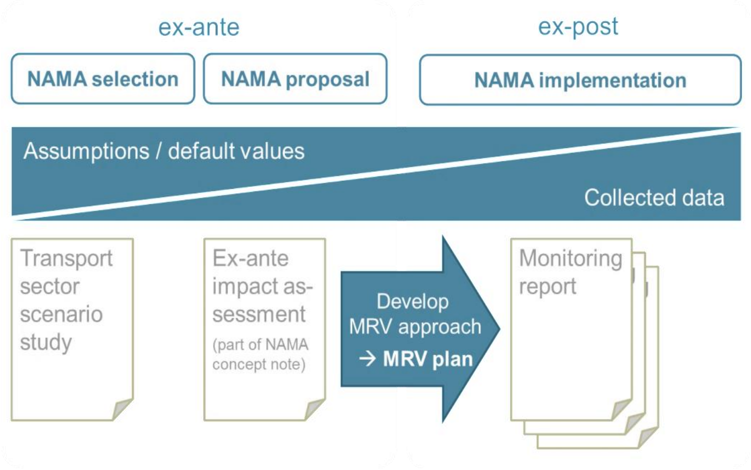


Figure 6: Occasions of emission quantification during NAMA development and implementation

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 NAMAs). 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 lies in the nature of the 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 to other sustainable development benefits.

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 socio-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 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 10: Requirements for and issues to consider in ex-ante assessments

3.2. Scope of mitigation actions

In the context of this document we use the term NAMA to encompass a wide range of mitigation actions. Figure 7 gives a schematic overview of the types of mitigation actions and overlaps with concepts like the Clean Development Mechanism (CDM) or sectoral Low Emission Development Strategies (LEDS).

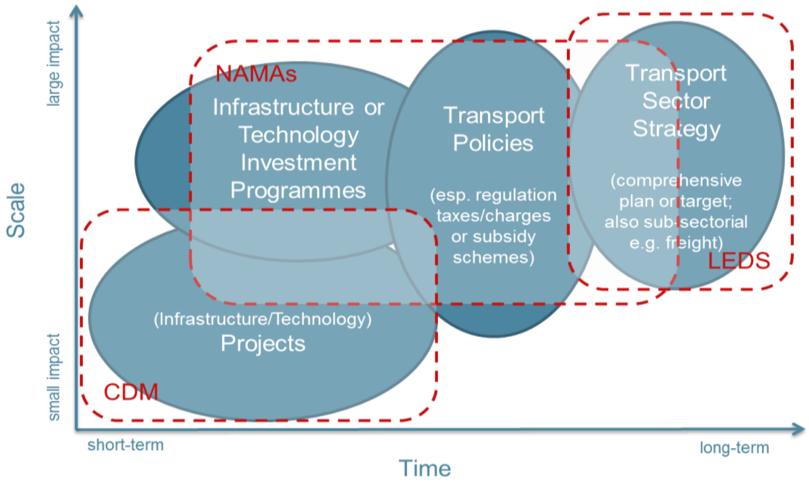


Figure 7: Types of NAMAs in comparison to CDM Projects and LEDS

NAMAs in the transport sector can range from a local road traffic regulation project, an urban planning strategy to foster public transport in a city to a national fuel efficiency standard policy. In order to monitor these actions, a measurement methodology needs to be developed that takes into account the scope and key characteristics of mitigation action under consideration. Examples of some characteristics for classifying mitigation actions are listed in Table 7 below.

Table 7: Characteristics of mitigation actions (not exhaustive)

Type	Examples
Type of mitigation action	Sector strategy, national policy, national programme, project or a mix of them;
Approach	Pricing (e.g. tax or subsidy), investment (in infrastructure, vehicles), regulation (e.g. rules, limits, standards), voluntary commitment
Targeted means of transport	freight or passenger transport on road, water or rail
Duration	short, mid- or long term oriented
Geographic scale	e.g. a single road, a city/region or entire country

Mitigation actions in passenger and freight transport either reduce emissions per kilometre travelled (improve/fuel) or lead to less vehicle kilometre travelled - especially for the polluting modes. They can also be categorised into four types of NAMAs: (1) sectoral strategies, (2) national level policies, (3) investment programmes and (4) large-scale projects (see Table 8). Please note that the categories may overlap and that other categorizations may also be used. In most cases, when mitigation actions are mentioned this refers to NAMAs. A NAMA could also include a combination of strategies, policies, programmes and policies of different types and categories.

Table 8: Categories of mitigation actions

Categories	Description	Examples
National transport climate strategy (sectoral)	■ Strategies impacting e.g. the technology standard of a specified transport (sub-) sector ■ Targets for specific transport sub-sectors e.g. freight transport	■ Regional strategy to systematically shift road freight transport to railway ■ Long term planning of urban transport infrastructure through Transit Oriented Development ■ National GHG-emission reduction targets for road freight vehicles
(National level) transport policies	■ Governmental regulations and planning ■ Taxes, financial incentive schemes, standards ■ Usually on national/aggregated scale	■ Regulation of car fleet efficiency ■ Biofuel quota ■ Taxation of fossil fuel imports or of inefficient vehicles ■ Green tire certification for trucks

Table 8 (continued): Categories of mitigation actions

Categories	Description	Examples
National Infrastructure or technology investment programmes	■ Promote an increase in projects with co-funding ■ Incentives combined with standards (e.g. certain emission limits or audits required) ■ Usually on national/aggregated scale	■ Programme to incentivise purchase of clean busses ■ Modernization of national freight vehicle fleet by providing scrapping bonus for the substitution of old vehicles
Infrastructure or technology projects	■ On local to regional scale ■ Often technology or infrastructure investment combined with some (regional or local) policies ■ Project may be partly financed by the private sector ■ Similar to CDM projects	■ Investments in specific urban development improvements (public transport, transit, pedestrian infrastructure) ■ Installation of a BRT in a city ■ Investments for switching freight from road to short sea shipping (e.g. terminals etc.)

Many NAMAs may be assigned to one or several of the above action types. This becomes evident for example from Table 9 that provides a selection of the NAMAs being developed in the transport sector by developing countries. For further, more comprehensive information see the TRANSfer Project NAMA Monitor at: http://www.transport-namadatabase.org/the-database/

Table 9: Examples of mitigation action categories in NAMAs

NAMA title	Country name	Category of action	Scope of action	Description
E-mobility readiness plan	Chile	Strategy	National	Nation-wide introduction of E-vehicles through creation of policy/regulation, appropriate infrastructure and incentives
Programme for energy efficiency in the transport sector in Chile	Chile	Strategy Programme	National	National wide programme for EE improvements through better training, fleet management and design of trucks
Santiago Transportation Green Zone	Chile	Project	Sub-national	City wide programme for use of zero or low carbon mobility options through creation of infrastructure, introduction of technology and incentives schemes
Electric vehicles NAMA	Colombia	Strategy Policy	National	Promotion of e-vehicles in all categories through policy/regulations/incentives

Table 9 (continued): Examples of mitigation action categories in NAMAs

NAMA title	Country name	Category of action	Scope of action	Description
National plan for freight transport: NAMA pilot study	Colombia	Strategy Policy	National	Improvements of freight transport, no details
Transit-oriented development	Colombia	Strategy Policy	Sub-national	Using TOD approach to mobility planning in cities
Sustainable Urban Transport Initiative	Indonesia	Programme	National	National and city level supporting framework for low carbon mobility plans and actions
Freight transport NAMA	Mexico	Programme	National	Improvement in EE of cargo vehicles through replacement, establishing standards etc.
Transport NAMA in Peru	Peru	Strategy Programme Project	National	Increase the use of public transport and Non-Motorised Transport (NMT) in urban areas
NAMA based on the Federal Mass Transit Program	Mexico	Programme	National	Development and implementation of sustainable mobility plans
Public transport development in Lebanon	Lebanon	Programme	City	Increase public transport, scrap old vehicles and intercity rail system in Beirut

The MRV approach is likely to differ for each mitigation action and cannot be related to the above mentioned categories only. However, for some "investment project type" actions measurement methodology developed under the CDM may be used. But for policies, programmes and sector strategies more elaborated approaches for MRV are required. As a consequence, for every NAMA, the relation of cause (mitigation action) and effect (emission reduction, other benefits) must be determined carefully.

3.3. 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.

Direct effects from mitigation actions

Any envisaged mitigation action in the transport sector (cause) aims at a 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 primary effect. Objective of the policy or measure is a starting point for identifying primary effects. For mitigation actions, GHG is always one of the primary effects. As NAMAs are implemented in context of sustainable development, a NAMA could also have one or more sustainable development effects. For example, a mitigation action to replace old car fleet 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, so called indirect or secondary effects. They may occasionally cause negative effects of significance that may even over-compensate the desired direct effect and 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. As another example, the implementation of a new high capacity and fast urban rail system 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 11: Direct and indirect effects from mitigation actions

For a better understanding of the relevant consequences of a mitigation action, the concept of causal-chains 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 (Step 1 and Step 2). This helps to draw the system boundaries and to define which sources and effects should be included and which not (Step 3). From this, relevant parameters for MRV (Step 4) are identified:

- **Step 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)

- **Step 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.
- **Step 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[11]
- **Step 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).

The following mapping example illustrates how the analysis of the causal chain could be conducted for the operational phase of the planned Bus Rapid Transport system (BRT). In general it can be assumed that the chain of effects is as follows:

The Introduction of BRT improves the public transport system, this:

- reduces the use of private vehicles, and increases share of public transport system, this:
- increases the occupancy rate of the public transport system, this:
- reduces the total fuel required for passenger transport, this:
- reduces the GHG emissions.

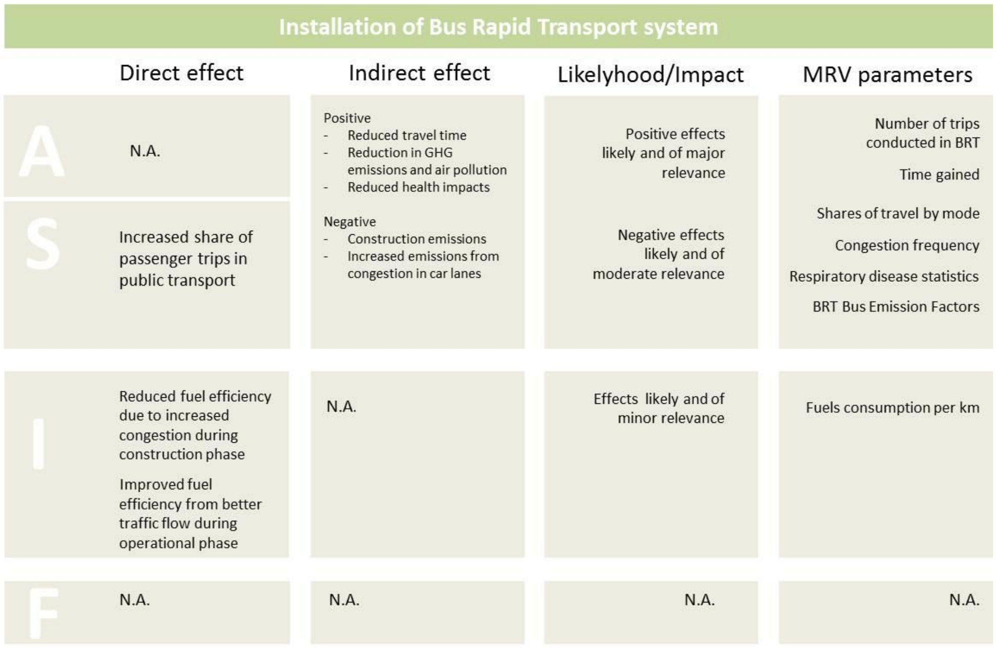
The introduction of a BRT system also has sustainable development benefits, since it:

- 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.

The Figure 8 is an example of the analytical decomposition of direct and indirect effects according to the ASIF model and respective relevance/parameter evaluation.

---

[11] 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).



Installation of Bus Rapid Transport system

	Direct effect	Indirect effect	Likelyhood/Impact	MRV parameters
A	N.A.	Positive - Reduced travel time - Reduction in GHG emissions and air pollution - Reduced health impacts Negative - Construction emissions - Increased emissions from congestion in car lanes	Positive effects likely and of major relevance Negative effects likely and of moderate relevance	Number of trips conducted in BRT Time gained Shares of travel by mode Congestion frequency Respiratory disease statistics BRT Bus Emission Factors
S	Increased share of passenger trips in public transport			
I	Reduced fuel efficiency due to increased congestion during construction phase Improved fuel efficiency from better traffic flow during operational phase	N.A.	Effects likely and of minor relevance	Fuels consumption per km
F	N.A.	N.A.	N.A.	N.A.

Figure 8: Analytical decomposition of direct and indirect effects from the installation of a BRT according to the ASIF model

Some mitigation actions even have effect 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, esp. 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 downstream 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 still are minor.

As a consequence, it is recommended to use (in most cases) default values for the analysis and do not spend efforts to collect detailed 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 4.2, 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.

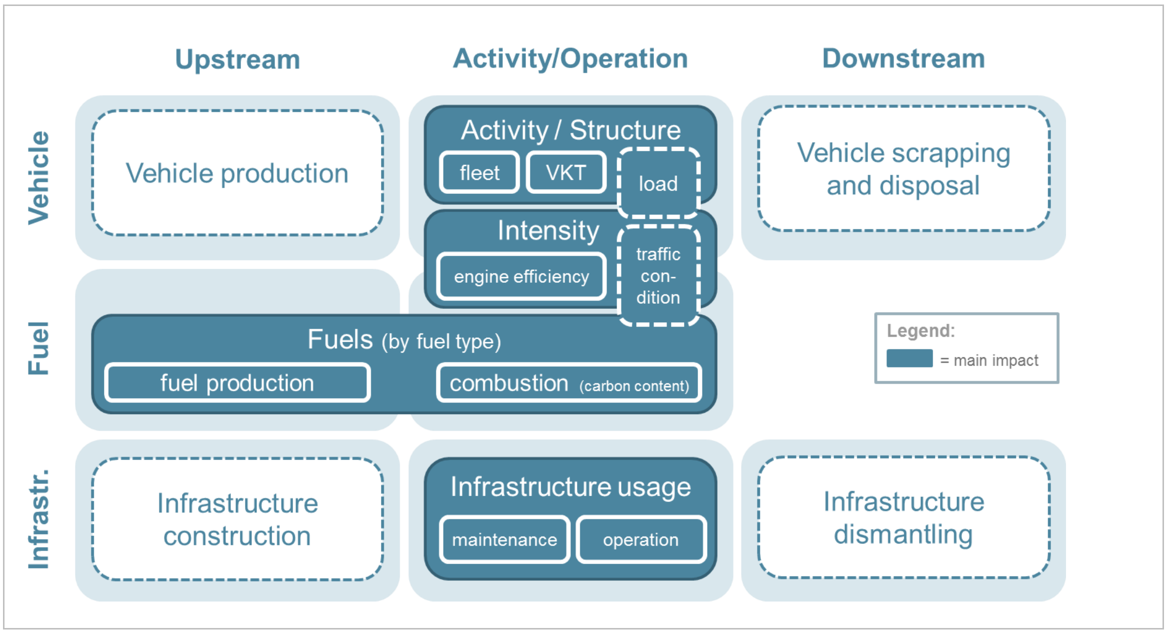


Figure 9: Mapping life-cycle GHG emissions in the transport sector

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 that the implementer would like to achieve have been identified (GHG emissions, local air pollution, safer transport system, etc.), developing a map of the causal chain allows the user and relevant stakeholders to understand in visual terms how the policy or action leads to changes in the identified effects and the data/parameters which need to be considered for MRV of the effects.

3.4. Boundaries setting

Having identified the direct and indirect effects and the relevant data/parameters it is important to identify the boundary of the analysis (see section 2.1.2). 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 2.1.2 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 decision on what GHGs and which sustainable development effects to be tracked.

In the BRT example in section 3.23 the temporal boundary could encompass the period between starting the construction of the BRT 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 BRT. See Table 10 and section 4 for further examples.

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 NAMA proposal.

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

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 boundary. 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 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 within Beijing'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 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 NO_X 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 anyhow), which is also an important aspects of the aims of the Transit Metropolis Programme. 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 of 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.

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 case the boundary is too narrow, relevant effects are neglected and MRV lead to wrong results. Is it 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 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 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 decision making unit usually is linked to a specific territory. However, discuss leakage at least in ex-ante assessment, maybe even include accounting of leakage emissions (i.e. occur outside boundaries) in 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 e.g. biofuels). 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 of the effects from the mitigation action with those from other mitigation actions or trends. This is particularly relevant for monitoring of emission reductions actions. For NAMAs, other mitigation actions such as CDM projects, GEF projects or other NAMAs should be clearly distinct from the boundary.

3.5. Level of aggregation in analysis and reporting

Project-, strategy- or policy interventions are often bundled under a mitigation action. Individual measures from the same NAMA can actually 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, it could be assessed on an aggregate level by one single MRV approach. For example Transport 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 on aggregate level, since they all aim at improved accessibility to public transport and such 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. The Table 11 lists advantages and disadvantages of assessing an individual mitigation action or a bundle of measures (according to WRI and the GHG Protocol, 2014).

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

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

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

- Firstly, identify all 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

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

Type of NAMA	Example for a transport NAMA	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 passenger 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 transport 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 passenger 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)

3.6. Baseline and the concept of "BAU" scenario

Baseline, reference or business-as-usual (BAU) scenario are terms commonly used to define the reference level against which the 'mitigation scenarios' are compared to[12]. 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).

$$\mathbf{ER = BE - AE}$$

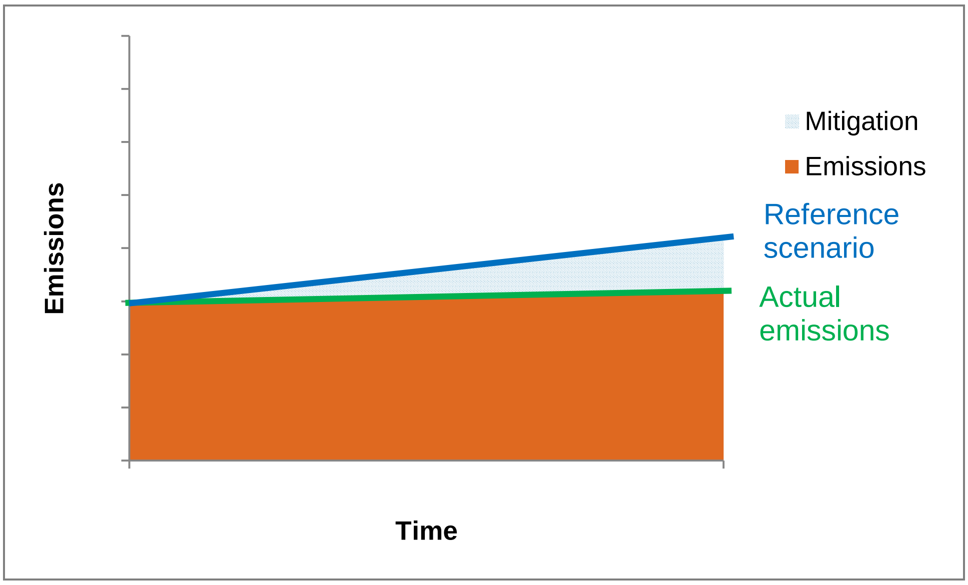


Figure 10: Mitigation Outcome of a NAMA (Source: adapted from Füssler et al. 2014.)

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. In the following, key concepts for establishing BAU scenarios are presented.

3.6.1. 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

---

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

the mitigation action, e.g. to estimate the GHG effect from policies or strategies as in the case of introduction of 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.

3.6.2. Methodology for estimating BAU values

A key principle is to use official projections if possible. This approach reduces efforts 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 depending on the context, so usually no general rule can be derived. It is recommended to review the drivers considered with stakeholders that understand the local situation and have a good overview on reasons for developments. In an ideal case, stakeholders with different background agree on business-as-usual trends and what drivers must be observed during implementation of the NAMA.

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.

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 the policy/regulator changes anticipated.

BAU scenario development depends on the individual type of mitigation action included in a NAMA (e.g. project, policy or sectoral strategy) 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 BRT project, the BAU is what would have provided the service of moving a passenger from one point to another point in absence of the BRT. 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 BRT.

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 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 thumb of rule to apply. For example, in the case of NAMA to improve the fuel efficiency of the freight trucks, fixing fuel efficiency of freight trucks at existing levels in the baseline may overestimate the emissions reductions. In such a NAMA it is important to consider the effect of technology improvements, policies that change fuel prices, or air pollution related measures that may influence the choice of freight trucks, etc.

3.6.3. 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 it 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 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 survey of the passengers using the BRT system to determine the mode share they would have used, in case the BRT option would not be available, multiplied by the current estimation of GHG intensity of different modes of passenger transport.

3.6.4. 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 NAMA is the year 2020 (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 2025, the BAU projection for the NAMA should use that same period. In most cases the effect of NAMA implementation would go beyond the end date of the NAMA.

Modelling the BAU scenario: The identification of the relevant causal-chains (see 3.33.2) and the definition of the correct boundary of the NAMA (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 NAMAs should be clearly distinct from the NAMA 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, methodology for evolution of these drivers over the timeframe of the BAU and assumptions 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, demand growth, changing national and sectorial priorities, etc. Secondary drivers can include changes in technology, 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 broader measures such as sector wide NAMAs, one may use comprehensive transport sector models, esp. 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. 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.

3.6.5. 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 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 2.1). Rectifying such shortcomings may require technical capacity building and/or national or international technical assistance. Building the data set should be seen 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 4), 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 NAMA. 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 2.1.1) 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. This 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 NAMA scenario, may not need socio-economic data for establishing BAU. For example, a fuel efficiency improvement project where the GHG effect is measured as the difference between BAU efficiency and NAMA efficiency, 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.

For example, in a BRT project 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 (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 doesn't affect the whole system, effect allowing us to define a statistically representative part of population that is not affected by the mitigation action and that reflects the BAU scenario. For example, in case of a transit oriented demand (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 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 12: Baseline scenarios for non-GHG impact assessment

3.6.6. 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 BAU scenario is using conservative estimates i.e. that the BAU emissions estimated should be on the lower rather than the higher side. 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 with uncertainties in the BAU scenario, i.e. assessment of possible future measures whose outcomes might be unknown at present.

Consistency in approach of developing BAU across NAMAs 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 NAMA GHG emissions-reduction calculations.

3.7. Modelling NAMA emissions

In most cases, NAMA emissions cannot be directly measured. An exception are NAMAs that deal with emission reductions in e.g. public transport fleets or truck fleets and few operators can directly track energy consumption. For all other cases, NAMA emissions still need to be modelled. Usually the modelling follows the same principles as the modelling of baseline emissions but uses (more) measured data instead of assumptions (figure 6). A key concept for modelling NAMA emissions are reliable emission factors (section 2.1.3). Recommendations on modelling mitigation action emissions for transport are:

- If possible, develop 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 mean to reduce emissions or to quantify detailed avoid 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.
- If there are already models (including emission factors), review potential shortcomings and consider to update/improve the model instead of developing a new one.
- Consider whether well to tank (upstream) emissions are needed and available. Especially, when alternative fuels or electricity is used, it is important factor to consider. Usually default values for

the upstream part are sufficient to understand effects in shift measures, but some Fuel measures need detailed data.

3.8. Dealing with data gaps: MRV of progress

The approaches discussed so far in section 3 focused on accounting of greenhouse gas (GHG) emissions at the national, programme and project levels. Yet outside of specific guidance by the UNFCCC, the MRV process between NAMA implementers and NAMA supporters is potentially quite flexible and can be tailored to the specific NAMA under development as well as to the needs of both parties. This can be expedient for transport NAMAs that have unclear BAU, limited short term reductions or complex causal chains. Moreover, while GHG reduction is a key goal of NAMAs, demonstrating progress on sustainable development may be important to garnering domestic political support for NAMAs 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 or outputs of the NAMA. Such a broader approach to MRV for NAMAs might therefore be one that includes – in addition to GHG – metrics for intervention (i.e. implementation of activities), progress and sustainable development.

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

NAMA funders and implementers are concerned with getting effective, accountable actions underway as soon as possible. NAMA design 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 NAMA effect and its contribution to sustainable development.

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

- **Intervention metrics** would demonstrate that individual NAMA 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 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 NAMA. 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), 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 as well but may need additional research. E.g. health may require to also analysing air pollutant emissions and road safety developments related to the NAMA. To limit the workload, it is recommend analysing mostly direct effects and discussing indirect effect in a qualitative way.

A key advantage of such 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 NAMA's effect on GHG emissions. For a case study example of this approach see section 4.4 on Transit Oriented Development in Colombia.

3.9. Reporting and Verification

Reporting and verification in the transport sector does not differ from overall GHG or NAMA reporting and verification. In 2013, "general guidelines for domestic measurement, reporting and verification of domestically sup- ported nationally appropriate mitigation actions by developing country Parties" were adopted[13] . However, these guidelines for NAMA MRV are fully voluntary and general in nature – the responsibility for implementation and monitoring of NAMAs lie with the host country. Due to the variety of possible actions a one-size-fits-all approach to MRV is not realistic anyhow. However, it needs to be considered especially when designing an MRV system. It is important to first ask, "Who needs to receive what kind of information?". 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 NAMA, including national banks, or international donors like the Green Climate Fund or the NAMA Facility.

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 information on the nature of the action, coverage (i.e. sectors and gases), quantitative goals and process indicators;

b) Information on methodologies and assumptions;

c) Objectives of the action and steps taken or envisaged to achieve that action;

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 market mechanisms.

Box 13: Reporting requirements in Biennial Update Reports (Source: Decision 2.CP17)

---

[13] Read more: Decision 21/CP.19 (Document FCCC/CP/2013/10/Add.2) available at http://unfccc.int/resource/docs/2013/cop19/eng/10a02.pdf

Table 13: Reporting requirements for NAMAs (Source: GIZ 2015)

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 NAMAs as well as costs & support needs are key elements in any proposal for NAMA 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 ongoing finance
UNFCCC NAMA Registry	Gain international recognition for efforts and potentially attract climate finance	Estimated emission reductions (ex-ante) are necessary, in addition to general information on the action and cost estimates
UNFCCC Biennial Update Reports (BURs)	International reporting on efforts to address climate change	Information on NAMAs in design and implementation phases both have to be reported. In the design phase, the estimated emission reductions of each NAMA (ex-ante and ex-post) must to be provided. In the case of NAMAs already being implemented, information on current progress and effects must also be reported

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.

For NAMAs, no strict, mandatory rules for NAMA MRV are expected in the foreseeable future. Instead, a set of good practice standards is likely to emerge based on experiences gained in the current bottom-up process of NAMA development. The responsibility for NAMA reporting lies within the national government, which must draft and submit the UNFCCC National Communications and Biennial Update Reports. In most countries this is 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 NAMAs. As a consequence, the UNFCCC reporting requirements call for extended communication between departments and ministries of a country.

For internationally supported NAMAs, 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 NAMA 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 NAMA. 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 NAMA implementation, requests an assessment of the impact of any individual NAMA 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 verifiable. It is not enough to merely claim that a NAMA reduces GHG emissions by x tons of CO_2eq – supporting information must be given 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). Don't allow them 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 will be a review process for Biennial Update Reports called International Consultation and Analysis (ICA). International donors will have a range of different auditing procedures, which they can apply to verify given information. It will be important to provide information on NAMAs 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 your NAMA.

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.

4. 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 3. 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. As real NAMAs are still in an infant stage, the examples refer to mitigation actions that not yet have been registered as NAMAs but are treated as such. The only exception is the TOD NAMA in Colombia. For further, more detailed examples see the MRV Blueprints published at:

http://transport-namas.org/measuring-reporting-and-verification-mrv-expert-group/

Also check the MRV section of the TRANSfer Handbook "Navigating Transport NAMAs".

http://www.transport-namas.org/handbook/

4.1. 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 Santa Catarina. The project shifts the transportation of around 1.100.000 tons of coils per year from road transportation by trucks to ocean shipping by barges, leading to estimated emissions reductions of around 120.000 tons of $CO2_2$/year[14].

The ArcelorMittal Tubarão project implementation has also resulted in the number of sustainable 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 ocean resulted in replacing over 40.000 round-trips made by trucks with an average load capacity of 27 tons, which resulted in reduced local air pollution from road transportation and reduced impact 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.

---

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

[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"

Options for Methodological Approaches

To estimate emission reduction outcomes of 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 3 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 $kgCO_{2e}$ for trucks to 16.3 $kgCO_{2e}$ for ocean barges as well as 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 a 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 us to set the boundary for data collection needed to track the emission reduction and sustainable development effects of the project. 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 states Espírito Santo and Santa Catarina, the boundary for data collection include all these states. The choice of data and parameters that need to be collected within these boundaries to quantify emissions reductions resulting from the project 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 has been considerable 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).

---

[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 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 the 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 a quite narrow scope and provides methodological approaches to estimate emissions 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 still 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 3.5). 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 UN-FCCC 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;

---

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

[20] Available at URL: http://cdm.unfccc.int/methodologies/DB/4DOIK2WYP8P3AGAVJKT0CHY1NXJ4QP

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.

More specifically, baseline emissions are estimated using the following variables: transportation distance (from origin to destination point) by road using trucks, baseline emissions factor and amount of cargo transported by the newly developed infrastructure. Baseline emissions factor is determined using a default emissions factor[21] in gCO_2/ton-kilometre available in the AM0090 methodology[22]. The use of the 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 monitored 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 still 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 2.3, 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 AM090 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 devel-

---

[21] Another option is to use historical records on fuel consumption of trucks transporting the cargo type, net calorific value and the CO_2 emissions factor of fuel used as well as records on the amount of cargo transported, and the transportation 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 consistency, 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 URL: http://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-17-v1.pdf/history_view

opment, 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.

To quantify 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.

4.2. 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 turned into the predominant 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 India Rail-way (IR). 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 locos 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 IR.

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 in for freight and passenger transports. The increased supply leads to rail being competitive in terms of price and reliability, so freight and passengers using rail instead of other modes due to rail being competitive in terms of price and reliability. 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 locos. 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 under no direct control of IR (leakage emissions) are not included. However for matter of transparency a specific section has been included in the NAMA on indirect or leakage emissions sources including an estimation of their potential GHG effect. Electricity generation based emissions are included as direct emission source 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).

Table 14: Effects and Impacts of Rail NAMA (Source: Grütter Consulting, 2014)

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%

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 thereby tkm i.e. amount of freight in tons transported over distance and for passengers pkm i.e. amount of passengers transported over distance in km.

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 such 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 observed 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.

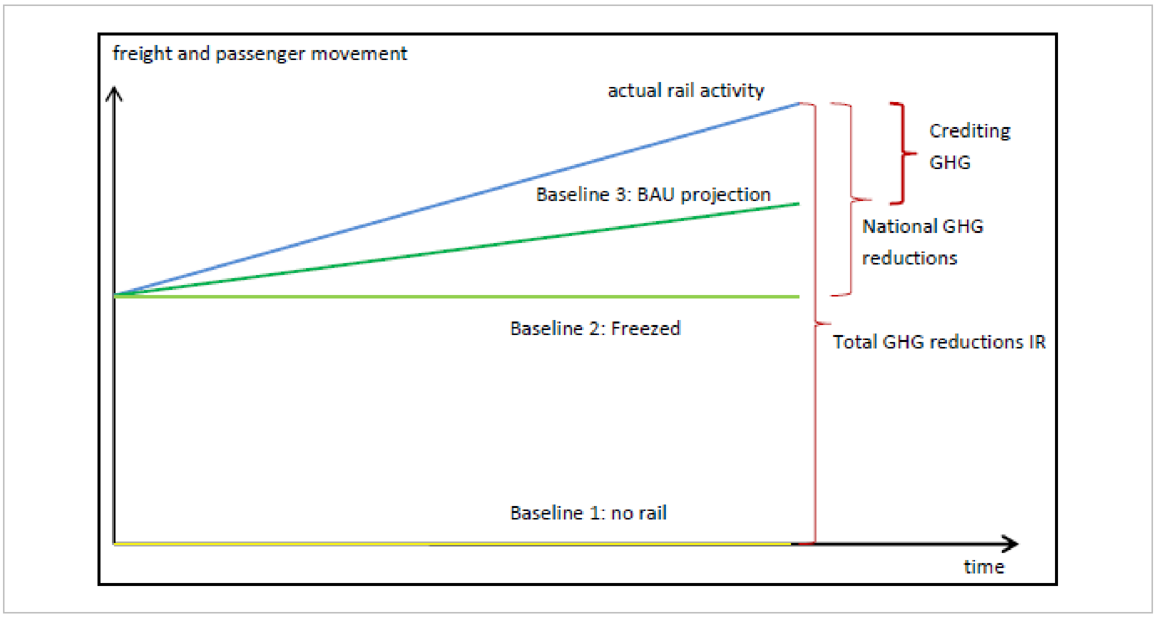


Figure 11: Baseline Approaches

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 12 below) as well as GHGs 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 are not required for emission reduc-

tion 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 (basically trucks, buses and passenger cars) and the occupation rate of different vehicle categories being basically cars and inter-urban buses. These factors together with the emission factor per fuel allow determining the emissions per pkm and tkm for different modes of transit.
- **Step 5: Sustainable development parameters:**
  The parameters looked at are: job creation, accidentally 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.

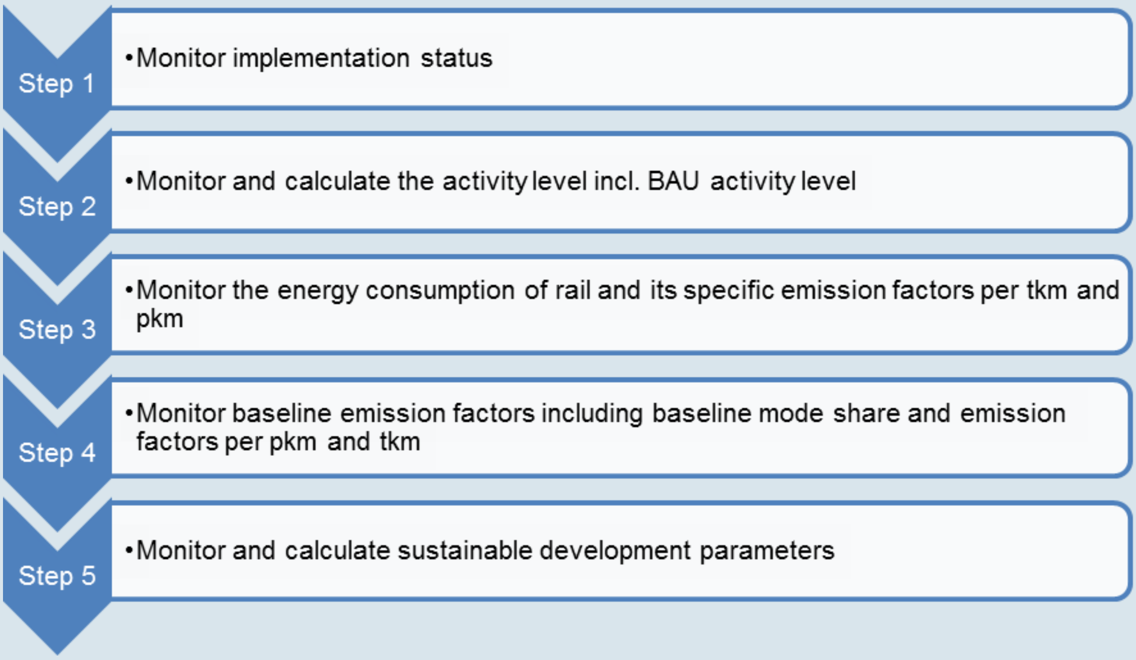


Figure 12: Steps/Elements of Monitoring

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 IR has since 2013 done a client satisfaction survey realised of rail customers upon which the questions of baseline mode usage and origin-destination of trip have been added.

Findings

Following conclusions and experiences were made with this NAMA:

- Broadening the scope can simplify baseline determination and monitoring a lot. Whilst this does not allow for reporting with precision the effect of singular measures e.g. double tracking of Line "Y", it does allow to determine with a good level of confidence the GHG effect of combined rail measures, thereby also including important synergy effects (e.g. additional freight 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 your NAMA to a sectoral or subsectoral approach such as nationwide inter-urban transport simplifies baseline and monitoring, requires less 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 as appropriate. Monitoring can be done with limited efforts and can give precise results. This again can serve for designing appropriate low carbon growth strategies.
- It is considered as useful to develop various baselines. Baselines are hypothetical future scenarios. They can be used for different purposes and give different types of information. Hence, the same monitoring data serves for example 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 consumptions and mode shares are not available.

4.3. 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 13 summarises the fuel economy requirements and the actual compliance to date.

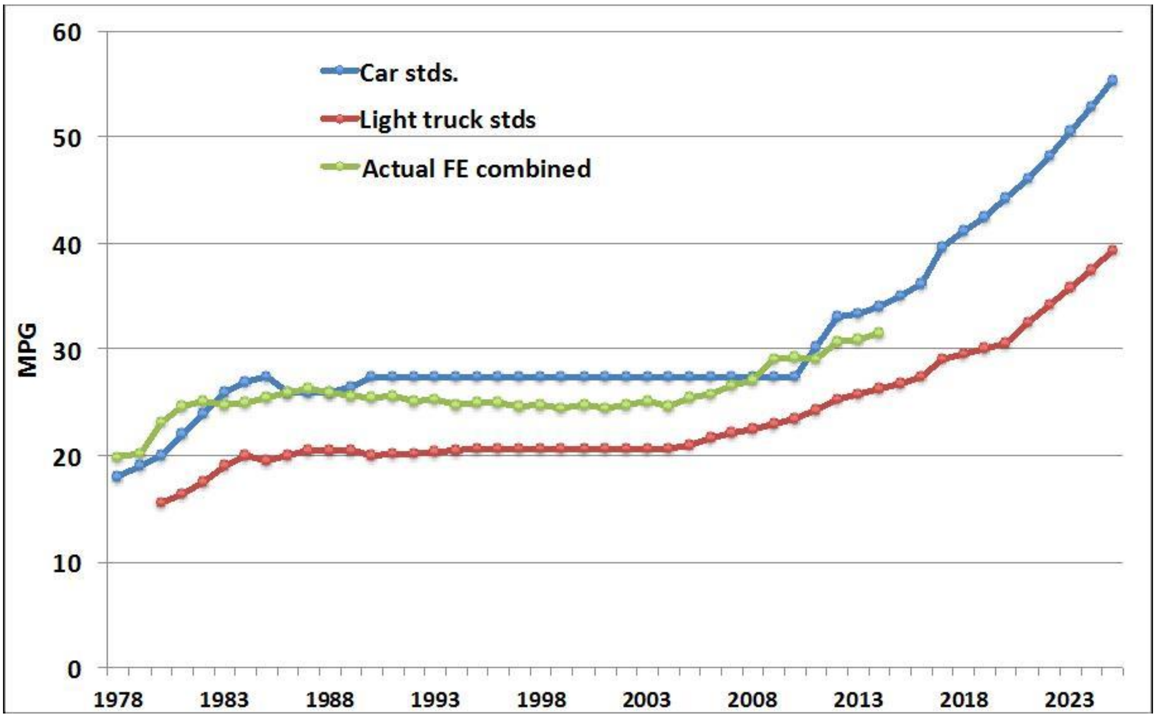


Figure 13: U.S. CAFE standards for cars and light trucks; Actual new vehicle fuel economy for combined car and light truck fleet

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 preserve incentives for manufacturers to use lightweight materials to improve fuel efficiency. Under a weight-based system, a manufacturer that uses lightweight 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 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 NHTSA and 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 case of 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 rulemakings 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. 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 upon 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 FTP (urban) and highway cycles, Japan uses the JC08 cycle, and Europe and most other countries use the NEDC cycle. 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 (WLTP).

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 attribute-based 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 accurately is linked to the vehicles they are supposed to represent. Over the years the EPA has established detailed procedures and requirement to ensure that the proper vehicles are tested with accurate loads and representative equipment and calibrations. This can be seen in the relabeling 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. EPA paid for expensive computer simulations of the efficiency of advanced technologies, paid for expensive tear-down 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 pack-ages, and issued various reports totalling thousands of pages. NHTSA and CARB also conducted extensive technology analyses and 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, such 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 a lot of 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 expense. Assuming that the region requires OBD systems, the good news is that data loggers that plug into the OBD port are rapidly coming down in cost. Fortunately, these adjustments are usually much smaller than the reductions measured on the dynamometer test cycles.

Institutional setting

The U.S. Congress passed the Energy Policy and Conservation Act (EPCA) in 1975. EPCA clearly laid out authority for NHTSA to set fuel efficiency standards and for EPA to conduct testing and enforcement. EPCA also included passenger car fuel efficiency standards for 1978 through 1985, requirements for NHTSA to establish light truck efficiency standards and passenger car standards after 1985, and requirements for 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 rulemakings 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 EPA and the California Air Resource Board (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 EPA and CARB and fuel efficiency standards from NHTSA. All other states are forbidden from setting new vehicle emission or efficiency standards.

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 would 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 will likely not be realised.
- It is important to have clear statutory authority for setting efficiency standards.

4.4. 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 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. They expect transportation sector emissions to increase three-fold 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 GHGs. 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 14: 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 is MRV'd separately 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 is 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 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?

In addressing these challenges we begin 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 we acknowledge 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 we must therefore include a demonstration of short term metrics as well as long term. We set the MRV boundary at the neighbourhood level, and developed a tiered set of metrics as described in Section3.1.8, to overcome this challenge. National GHG reduction and spread of TOD nationally is the ultimate impact goal, however, so we included a metric of the catalytic effect at the national level. Sustainable development benefits are important goals too, so we included a social benefit metric.

Attributing an unambiguous causal link between the activities and the impacts of this TOD NAMA is another challenge. Our 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 X. 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, we use neighbourhood level changes in those variables to calculate neighbourhood GHG reductions. At the impact level we look at national GHG reduction trends, social sustainable development benefits and the national spread of TOD.

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.

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

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 us to MRV 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. We will try to match intervention and control neighbourhoods 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.

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

Our “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. We assumed a graduated 25% reduction in emission factors up to 2040.

Table 15: First tier (Output) Technical Cooperation metrics

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*:	The number of targeted cities that achieve one of these TOD development process technical benchmarks with assistance from CIUDAT:	■ 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
a) Planning for TOD(corridor, activity centre, station area) with stakeholder participation	■ Plan for TOD approved with community and private sector engagement	
b) Pre-feasibility GHG, economic, site and market analyses for TOD	■ Pre-feasibility GHG, economic, site or market analyses for TOD completed	
c) Policy/Regulatory/incentive alignment for TOD project entitlement	■ Local and national TOD policy or regulation or incentive approved / applied	
d) Preliminary architecture and urban design for TOD project	■ Preliminary architectural or urban designs completed for TOD project	
e) Package proposal application(s) and deliver to FC staff to enable financial feasibility analysis, additional design and engineering, and other FC outputs	■ Project proposal delivered to FC staff	

Indicator metrics were specified for three levels of analysis, as discussed above. These levels are described below and labelled Outputs, Outcomes and Impacts. The output reports will be the first to be submitted, perhaps even on a six month schedule. Outcomes and Impacts will lag, as data collection capacity is increased under the NAMA implementation work plan.

CIUDAT local technical assistance interventions have the goal of causing TOD projects to move forward more quickly and with better design to maximise GHG reductions and financial leverage. There are many steps in the development process that must occur before the first construction begins on any real estate project. Technical cooperation interventions are expected to cause projects to move ahead during the early steps of the process shown below in the column "output expectation".

The outcomes are the expected results of the outputs that are expected to cause progress toward GHG reduction effects. They are monitored vis-à-vis the control neighbourhoods within the same pilot city as the intervention. The indicators in this example are labelled mandatory and sector specific to conform to requirements of the funder.

Table 16: Second Tier (Outcome) Technical Cooperation Metrics

Second Tier (Outcome) Technical Cooperation Metrics		
Expected Outcome	**Indicators**	**Data Source**
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 tons CO2e 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

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

Table 17: Third Tier (Effect) Technical Cooperation Metrics

Third Tier (Effect) Technical Cooperation Metrics		
Expected Effect	**Indicators**	**Data Source**
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 indicators:** 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

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
- **DNP**: land development, infrastructure expenditures
- **Findeter**: local financing, Sustainable Cities support
- **APC**: leveraged international investments
- **City agencies** planning, transportation, housing, economic development…
- **Universities** (Los Andes, EFAIT)
- **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 required to serve many purposes including assessing implementation progress, GHGs, sustainable development benefits and enhance 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.

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 we can build an MRV framework that shows where and how the interventions are having an effect at different levels. This can only offer not only improved accountability for donors and the international community, but 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 us evaluate the effect of an intervention within limited temporal or geographical boundaries. Using a difference of differences technique, with careful selection of control areas, we may be able to overcome some of the objections to MRV of intervention types whose effects cannot be seen directly. We hope this will allow us to isolate the effects of the intervention and provide useable information for replication and up scaling.

While all NAMAs may not 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.

5. Towards building transport MRV systems

On the one hand establishing an MRV system for GHG mitigation actions in the transport sector can be a challenging task, especially for developing countries. Considering all direct and indirect effects of causal chains for NAMAs can result in the need for an extensive set of reliable data to properly ensure the quantification of GHG reductions. On the other hand MRV 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 system.

The basis for any MRV system 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 on 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 also Box 14). To fill initial data gaps roadmaps for structured and optimised data collection and evaluation are needed for the assessment of GHG mitigation actions of transport NAMAs. In this context MRV systems for the assessment of transport NAMAs should be linked to national GHG inventories.

Finally, this means that any sector wide top-down GHG inventory that is based on fuel consumption data and energy balances – in an ideal case – should be complemented and aligned with bottom up models on transport emissions based on vehicle population data, mileage data and emission factors. This not only allows better understanding transport sector emissions and triangulating top-down data, but also links inventories to NAMA MRV, which requires bottom-up data to attribute effects to single mitigation actions.

This section builds on the hypothesis that developing MRV systems is basically about improving statistical systems. For a transport MRV system two basic statistical systems are relevant: The transport data system (information on vehicle characteristics, transport infrastructure and travel activities) and a GHG emission factor database. Those are needed both for national GHG inventories and for MRV of transport NAMAs. Consistency between national inventories and MRV of mitigation actions is key for fulfilling verification requirements. As a consequence, it is recommended to improve the transport GHG inventory along with NAMA development. Since developing countries now have the obligation to submit biennial update reports (BURs) under the UNFCCC they have to implement a well-functioning GHG inventory on the national level.

Secondary data are often derived from published international or national databases, governmental statistics on 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 NAMA 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, which 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). Especially transport activity data for ex-post analyses should be based on primary data; otherwise the MRV system does not indicate the real effect of the NAMA. 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.

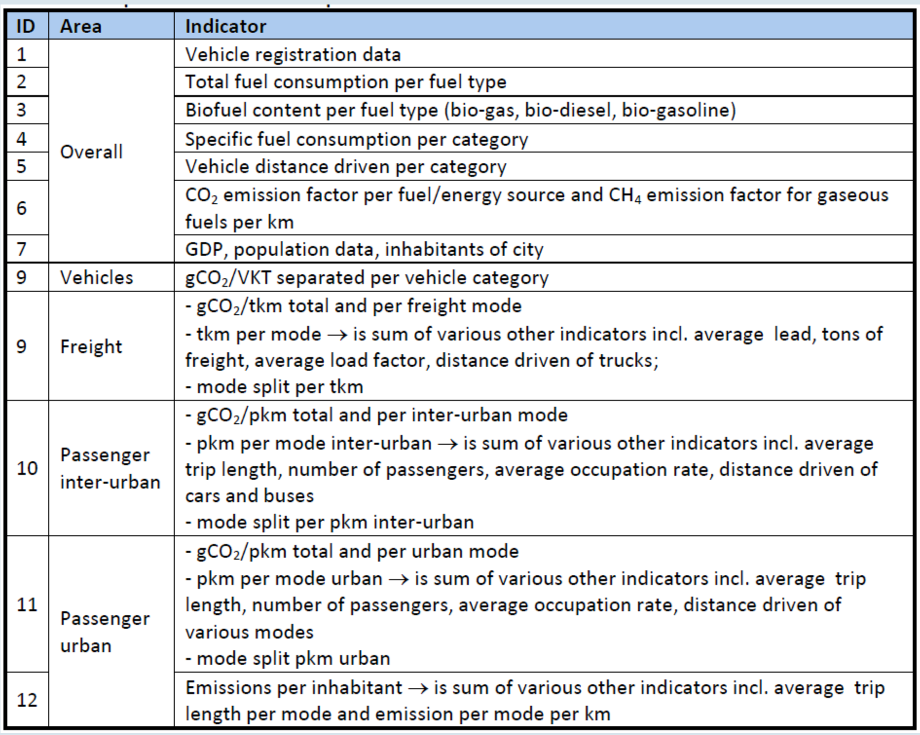
Box 14: Use of secondary data for the assessment of transport NAMAs

5.1. National transport data system and GHG inventory

The results of bottom-up calculations of emissions in GHG inventories should ideally be compared to results from top-down calculations. This involves systematically connecting transport data and developing emission factors. 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 machineries in the building or agricultural sector.
- Top-down inventories only allow accounting CO2 emissions. Combining top-down with bottom-up inventories also allows accounting of other GHGs and air pollutants. On local level, bottom-up methodologies are often available as they are needed for air quality planning. Such local models can be used to build consistent modelling approaches also on national level.

To monitor the effects of mitigation actions on GHG emissions Grütter (2014a) suggests a bottom-up approach. This approach does not have the objective to measure the effects of individual measures in a precise way, but to identify the overall effects of the sustainable transport policies on GHG emissions of the transport sector in Indonesia. For this so called "macro level" approach general data as well as data in the areas of vehicles, freight transport, passenger interurban and passenger urban transport are needed. The following table gives an overview of the data needed for this approach (Grütter, 2014b):



ID	Area	Indicator
1	Overall	Vehicle registration data
2		Total fuel consumption per fuel type
3		Biofuel content per fuel type (bio-gas, bio-diesel, bio-gasoline)
4		Specific fuel consumption per category
5		Vehicle distance driven per category
6		CO_2 emission factor per fuel/energy source and CH_4 emission factor for gaseous fuels per km
7		GDP, population data, inhabitants of city
9	Vehicles	gCO_2/VKT separated per vehicle category
9	Freight	- gCO_2/tkm total and per freight mode - tkm per mode → is sum of various other indicators incl. average lead, tons of freight, average load factor, distance driven of trucks; - mode split per tkm
10	Passenger inter-urban	- gCO_2/pkm total and per inter-urban mode - pkm per mode inter-urban → is sum of various other indicators incl. average trip length, number of passengers, average occupation rate, distance driven of cars and buses - mode split per pkm inter-urban
11	Passenger urban	- gCO_2/pkm total and per urban mode - pkm per mode urban → is sum of various other indicators incl. average trip length, number of passengers, average occupation rate, distance driven of various modes - mode split pkm urban
12		Emissions per inhabitant → is sum of various other indicators incl. average trip length per mode and emission per mode per km

Besides these transport and emission focused data, Grütter (2014a) suggests to measure additional core activity indicators "to assess the impacts, make plausible results measured and to provide for explanations of changes monitored" (Grütter 2014a). Exemplary activity related indicators include (Grütter 2014a):

- Investment in transport, road, rail, shipping, public urban transport, mass rapid transit system (MRTS), non-motorised transit (NMT): absolute and relative to GDP;
- Km built in MRTS (separate metro, light rail transit/tram and bus rapid transit), inter urban rail (separating high speed rail), and grade-separated bike lanes,
- Time savings.

Box 15: Data needed for a transport MRV system in Indonesia

As bottom-up emission inventories are an important basis for MRV systems it is recommended to develop them over time. This certainly means to improve the data quality and establish better procedures for collecting and managing data. Bottom-up inventories are usually the source for base year data and historical development and therefore important for establishing a BAU scenario (see section 3.6). Such transport sector inventories will help developing countries to paint a clearer picture of their current transport situations, highlight implementation successes and help with MRV of NAMAs. Emission inventories can be a very useful source of information for monitoring the effects of mitigation actions (see next section). 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 in the end NAMA selection, e.g. when identifying the biggest polluter.

In order to create a bottom-up inventory for the transport sector – and in this way improve the basics for transport NAMA MRV – 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 2.3 many different public and private institutions, governmental bodies and stakeholders are involved in the collection of transport relevant data. To minimise one's own 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 creation of working groups can be helpful to support these steps. Best practice is to establish a data clearing house that improves access to data and data quality.

In this context, data availability and possible data gaps have to be identified. In most cases the analysis of data availability is focused on transport data but emission factors are also needed for GHG emission quantification. Besides the analyses of data availability it is also important to include an analysis of the MRV capacities, available tools and skills. Clear documentation of data collection procedures and approaches is beneficial. National commission research institutions or consultancies are in charge of the data collection on their behalf.

The actual data collection can be divided into two different approaches: Already existing data and data which have to be newly compiled. 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 18 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.

Another important aspect of building up MRV systems is quality assessment and quality control (QA/QC). QA/QC procedures have to be thoroughly defined. 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 need to improve data collection. A cross-check is a standard procedure for countries using bottom-up approaches (see sections 2.1.1 & 2.1.3) and should be considered in any MRV planning process. In the long-term comprehensive QA/QC procedures may even reduce costs of MRV system as they enable learning and improvements in data collection processes.

Table 18: Examples of data collection methodologies for passenger transport

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

5.2. Steps towards NAMA MRV

Unfortunately, in many developing countries a bottom-up inventory tool is missing. Bottom-up modelling allows plausibility tests and corrections to the top-down energy balance based GHG inventory and provides inputs in terms of methodology and localised emission factors to transport NAMA MRV. Figure 15 shows how NAMA MRV can benefit from national transport data systems and bottom-up inventories.

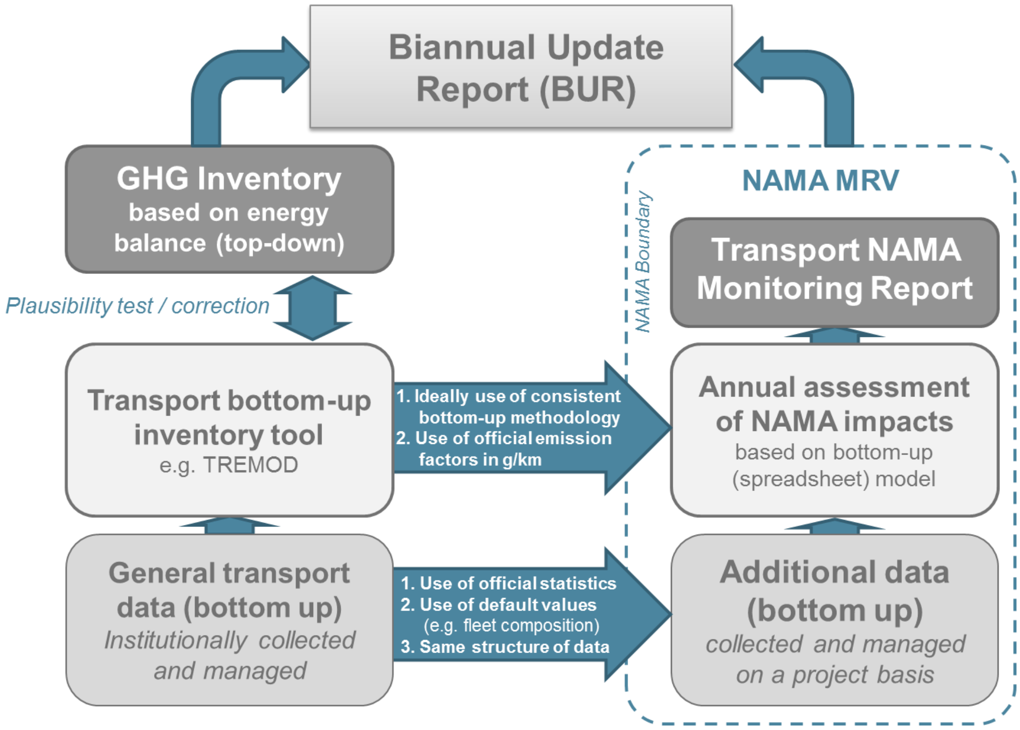


Figure 15: Towards a consistent approach to MRV: Consistency between national inventories and MRV of mitigation actions.

The lack of bottom-up emission models could be overcome by adapting inventory tools from developed countries such as COPERT. If foreign inventory tools are adapted, consider adapting a tool that is also able to quantify air pollutants. In this case, the additional benefit would be to enable NAMA MRV to also quantify air pollution reduction benefits of mitigation actions.

In order to develop an approach for NAMA MRV, 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 NAMA; this includes the clarification of funding of the MRV process (personnel and financial resources). The succeeding process then can be separated 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 suggested outline for MRV methodology documents in Annex II:

Phase 1: Define scope and boundaries

Step 1: Identify main effects of mitigation action (see section 3.2 and 3.3)

- 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 (see also section 2.1)

- 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 (see section 3.4 and 3.5)

- 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) (see section 3.6)

- 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 (see section 2.1, 2.2 and 3.7)

- 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: Data management and 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 (see section 3.9)

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

Critical steps for developing a NAMA MRV 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 baseline development in contrast is based on the boundaries. 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. As a consequence, after the definition of data needs, data gaps have to be identified.

The process needs to be considered for both, ex-ante assessments and ex-post NAMA monitoring plans. Ideally, ex-ante modelling during NAMA development is consistent with the ex-post monitoring approach and uses synergies. At the same time data collected and processed and corresponding lessons learnt can also be used for improving GHG inventories and general understanding of emissions in the transport sector. 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.

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 data base as a basis. This database must include vehicle size and fuel consumption and ideally also vehicle age in order to show efficiency improvements over the years.

5.3. Conclusions

Developing a comprehensive but feasible methodology is the key challenge for NAMA MRV. It also is the basis for sound reporting and verification. Ideally, such a methodology is consistent with national GHG inventories. It can only be consistent if the national GHG inventory complements the energy balances with a bottom-up emission model. Such emission models are usually used to quantify air pollutant emissions but they also provide GHG (also non CO_2 GHGs) emission factors per km and by vehicle types. This is a key source of information for NAMA MRV.

The second important source for NAMA MRV is transport activity data in terms of vehicle kilometres travelled (VKT). Such data are usually collected by transport institutions or company associations and it is often collected in national (and regional/local) statistical systems. Ideally, a clearing house coordinates data collection and ensures quality assessment and control. This reduces costs for monitoring of individual NAMAs and allows access to data also for planning and research.

For all types of data bear in mind to use officially collected data as much as possible and cooperate with agencies that are developing official statistics. Procedures for data exchange (sometimes in specific formats) should also be agreed on for succeeding years (monitoring). Carefully discuss with agencies when inconsistencies in official data are obvious and cannot be explained through e.g. different boundaries.

In addition to institutionalised data, NAMA MRV usually involves collecting project level data in order to track the expected effects. When collecting such data make sure the terms, definitions and categories used are in line with official statistics. Data collection methods can be aligned with other research conducted to ensure optimal use and achieve time series of data. This also reduces efforts to develop questionnaires and avoids applying correction factors to match data. In any case, data management, quality assessment and plausibility checks are very important to a sustainable and verifiable MRV approach. Databases and (spread sheet) models need to be designed carefully and data input and management procedures should be clearly described. Staffs need to be trained.

In order to identify the key effects, mapping the causal chain is suggested. For transport the key focus is on the ASIF framework, as measures usually have an effect on transport activity (A), modal structure (S), vehicle intensity (I) and/or fuels (F). In most cases up- or downstream emissions are only estimated roughly in an ex-ante assessment as they are minor compared to emission of vehicle operation. However, upstream emissions have to be considered when evaluating measures that involve vehicles powered by electricity or biofuels (e.g. for electric cars or rail). Without considering related upstream emissions the analysis cannot provide a complete picture of the effects.

As many measures have effects on more than one of the ASIF dimensions and there are various measures with overlapping effects, it is often difficult to clearly attribute effects to a single measure. One good way to cope with synergies and trade-offs between measures can be to calculate GHG effects (and monitor them) as a package. While this may lead to some additional efforts to track individual measures in terms of their effectiveness (non-GHG effects), monitoring of GHGs is eased and uncertainties are reduced. A good example is the urban transport blueprint that suggests tracking GHGs of an urban transport policy package (e.g. defined in urban mobility plans).

Regarding boundaries, usually the (country, region or city) territory is monitored as this is linked to influence of decision making unit. Leakage emissions outside the boundaries could be described and analysed in an ex-ante assessment. Boundaries can sometimes be further narrowed down on subsectors (e.g. focus on passenger vehicles only). However, we often have to remain pragmatic regarding data availability. Collection of additional, project type data, can lead to high monitoring costs. In this respect it is important to understand data availability when setting boundaries. Usually various data sources have different boundaries and this must be dealt with (e.g. through correction factors).

In addition to boundaries, baseline development is a key challenge in developing MRV systems. Usually baselines are business-as-usual (BAU) scenarios based on historic projections, but in some cases alternatives such as a reference group approach can also be considered. For BAU it is recommended to use official forecasts as much as possible. This not only reduces efforts but also increases acceptance and consistency. If own projections have to be developed check carefully whether it is plausible to use linear projections or if other growth functions are needed (e.g. Gompertz function for vehicle population projections).

Furthermore, it is important to be transparent about assumptions that often are implicitly included in baseline models but could later become a reason for critique. In cases with high uncertainty, better use conservative assumptions. In an optimal case, scenario development (including baselines) is extensively reviewed by experts with local knowledge and experiences (stakeholder participation). If possible workshops should be organised that facilitate an agreement process between stakeholders or Delphi methods should be used. This not only ensures better quality but mitigates the risk of critique.

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 ton 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 no CO2 released per unit of energy consumed	gCO2/kJ
Other pollutants emission factors	Emission factors for PM/NOX/BC 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	Ton 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

Annex 1 (continued)

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 population	ktoe/capita
Transport fuel consumption per PKM	Passenger Transport CO2 emissions per transport activity (passenger-km) (per mode &total)	MJ/PKM
Transport fuel consumption per TKM	Freight Transport CO2 emissions per transport activity (ton-km) (per mode &total)	MJ/Tkm
CO_2 emissions	Transport emissions of Carbon dioxide (CO2)	M Tons (Mt)
Transport CO_2 emissions per GDP	Total CO2 emissions from transport per unit of income (Gross Domestic Product)	gCO_2 per US dollar
Transport CO_2 emissions per capita	Total CO2emissions from transport per population	kgCO2/Capita
CO_2 emissions per PKM	Passenger Transport CO2 emissions per transport activity (passenger-km)	gCO_2 per pkm
CO_2 emissions per TKM	Freight Transport CO2 emissions per transport activity (ton-km)	gCO_2 per tkm
CO_2 emissions per VKT	Road Transport CO2 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/ton
PM emissions	Transport PM Emissions	Tons
NO_x emissions	Transport NO_X Emissions	Tons
Accident fatality/VKT	Road accident fatalities per vehicle kilometres travel	

Annex 2: Exemplary outline for MRV methodology report

The following outline is an example on how 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 contents will always be very similar.

The presented outline is based on the work on four transport NAMA '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 9 steps described for NAMA MRV in section 5.2 of the 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 (GOI) which includes a shift towards green growth and emphasises rail investment as a means to reduce the carbon footprint of transport."
>
> (Source: http://transport-namas.org/wp-content/uploads/2014/10/TRANSfer_MRV-Blueprint_Railway-NAMA_India_draft.pdf)

- Refer to current situation and existing policies (ca. 1 page)
- Describe interventions i.e. the (bundle of) measures included in the NAMAs 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) (see section 3.3)

- 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 (see section 2.1)

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

---

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

2.3 System boundaries (see section 2.1.2 and 3.4)

- 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)

3. Conclusion on MRV approach and indicators to be tracked (see section 2.1, 2.2 and 3.8)

- 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 (see section 3.6)

- 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
- Shortly describe the uncertainties related to the baseline calculation

5. Assessment of the impact (ex-post) (see section 3.7)

- 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? (see section 3.9)

- 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* (see section 3.9)

- Describe transparency (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 NAMA MRV 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. 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, from http://www.dlr.de/cs/en/desktopdefault.aspx/1177_read-2160/

Eichhorst (2015): Draft MRV Blueprint on Urban Transport Programmes, GIZ, TRANSfer Project from http://www.transport-namas.org

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.

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

Federal Statistics Office Germany. (n.d.). Rechtsgrundlagen. DESTATIS. 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: Additionaltiy assessment & baseline setting under pledges. Commissioned by the Swiss Federal Office of the Environment and the Dutch Ministry of Infrastructure and the Environment. Zurich. 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 Rord Journal of the Transportation Research Board 12/2008; 2049(-1).

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

GIZ (2014): Modelling GHG Emissions of Road Transport in China –Paper, Beijing/China. http://transport-namas.org/modelling-ghg-emissions-of-road-transport-in-china/

GIZ (2015): Navigating Transport NAMAs. A practical handbook on Nationally Appropriate Mitigation Actions (NAMAs) in the transport sector. Eschborn, Germany.

Grütter, Jürg (2014): MRV Transport Indonesia. Report realised by Grütter Consulting on behalf of GIZ.

ICCT (2014): from laboratory to road: a 2014 update, 2014, http://www.theicct.org/laboratory-road-2014-update).

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

IPCC. (2006). 2006 IPCC Guidelines for national Greenhouse Gas Inventories. Mobile Combustion. IPCC Guidelines for National Greenhouse Gas Inventories (pp. 1–78). Geneva: International Panel on Climate Change (IPCC).

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

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

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/.

Prof. Dr. rer.nat. Manfred Wermut, et al. (2012): “Kraftfahrzeugverkehr in Deutschland 2010” (KiD 2010) – Ergebnisse im Überblick. WVI, IVT, DLR and KBA for the Ministry of Transport.

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. Fullpaper 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 (MOP) - 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): 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. Available at URL: http://www.mitigationpartnership.net/undp-unep-unfccc-2013-guidance-nama-design-building-country-experiences

UNECE (2012): UNDA Seventh Tranche. Project E: Development and implementation of a monitoring and assessment tool for CO2 emissions in inland transport to facilitate climate change mitigation. CO2 emissions from inland transport: statistics, mitigation polices, and modelling tools. Transport Division. UNECE.

UNFCCC, UNEP, UNDP (2013): 'Guidance for NAMA design – building on country experiences', Bonn, Germany, http://unfccc.int/files/cooperation_support/nama/application/pdf/guidance_for_nama _design_(2013)_final.pdf).

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

UNFCCC. (2015a): CDM Methodology Booklet. Sixth edition - Information up to EB 79. Online available from: http://cdm.unfccc.int/methodologies/documentation/index.html (23.04.2015)

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

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). 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.

2nd National Communication of Brazil to the UNFCCC. Available at URL: http://unfccc.int/ national_reports/non-annex_i_natcom/submitted_natcom/items/653.php

Items from named contributors do not necessarily reflect the views of the company/the editors.

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
February 2016

Authors
Daniel Bongardt (GIZ), Jürg Füssler (INFRAS, lead author), John German (ICCT), Sudhir Gotha, Jürg Grütter (Grütter Consult), Martin Herren (INFRAS), Chuck Kooshian (CCAP), Hilda Martinez (WRI / CTS-Embarq Mexico), Victoria Novikova (UNFCCC), Martin Schmied (Umweltbundesamt), Sudhir Sharma (RISOE, lead author), Marion Vieweg (Current Future)

Deutsche Gesellschaft für
Internationale Zusammenarbeit (GIZ) GmbH

Sitz der Gesellschaft
Bonn und Eschborn

Dag-Hammarskjöld-Weg 1-5
65760 Eschborn/Deutschland
T +49 61 96 79-0
F +49 61 96 79-11 15
E info@giz.de
I www.giz.de