Evaluation of transport interventions in developing countries

Kerstin Robertson
Annika K. Jägerbrand
Georg F. Tschan
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Abstract

International climate policy and the United Nations Framework Convention on Climate Change (UNFCCC) with the Kyoto Protocol include different mechanisms or programmes for actions in developing countries aimed at reducing emissions of carbon dioxide (CO₂). To verify compliance, the effects of such actions, including transport measures, need to be measured, reported and verified (MRV).

However, in relation to other sectors very few transport-related projects have been initiated. Potential problems and ambiguities related to the current evaluation methodology were therefore investigated as a possible explanation for the low interest in investments in the transport sector. Other objectives of this study were to analyse the requirements for development and improvement of methods for evaluating the effects of transport policies and measures on emissions of greenhouse gases in developing countries. The analyses includes a review of different climate mechanisms, for example applied within the UNFCCC, evaluation requirements and methodologies used, the general availability of methods for evaluation of traffic and transportation, evaluation data availability, and institutional conditions in developing countries.

The main conclusions are that measuring traffic and transportation is generally a complex and demanding process, and the potential for misinterpretation of results is significant. In addition, there is a significant risk of rebound effects, especially for transport projects in developing countries aiming at modal shift. Furthermore, it seems that very short time frames are applied for evaluation of project-based mechanisms in the transport sector. Other challenges relate to institutional roles and responsibilities, the availability of personal and financial resources, and the knowledge and perspectives applied. Based on these limitations regarding transport project evaluations, further development of transport-related climate mechanisms towards a more sectoral and transformational perspective is suggested.

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Den internationella klimatpolitiken och Klimatkonventionen (UNFCCC) med Kyotoprotokollet omfattar olika mekanismer eller program för åtgärder i utvecklingsländer som syftar till att minska utsläppen av koldioxid (CO₂). För att kontrollera efterlevnaden behöver effekterna av sådana åtgärder, till exempel transportåtgärder, mätas, rapporteras och verifieras (MRV).

I förhållande till andra sektorer har dock ett mycket litet antal transportprojekt genomförts hittills. Därför har tänkbara problem och oklarheter i samband med de tillämpade metoderna för utvärdering undersöks som en möjlig förklaring till det låga intresset för investeringar inom transportsektorn. Syftet med denna studie var att analysera eventuella behov av utveckling och förbättring av dessa metoder för utvärdering av effekterna av åtgärder inom transportsektorn på utsläpp av växthusgaser i utvecklingsländer. Analyserna inkluderar översikter över: olika klimatmekanismer, tillämpade krav och metoder för utvärdering av transportåtgärder och möjligheter och metoder för utvärdering av trafik och transporter generellt samt utvärdering av tillgång till data och institutionella förhållanden i utvecklingsländer.


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Foreword

This is the final report for the project ‘MRV (Measurement, Reporting, Verification) of Transport Measures in Developing Countries’ (project number 35446-1, dnr. 2011-004699) funded by the Swedish Energy Agency’s Climate Policy Research Programme.

Kerstin Robertson, Annika K. Jägerbrand and Georg F. Tschan, the Swedish National Road and Transport Research Institute (VTI), jointly conducted the project by writing separate or joint parts of the report. Hillevi Nilsson Ternström from the Library and Information Centre (BIC) at VTI is highly appreciated and acknowledged for her support and help with the literature search.

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Linköping, December 2014

Kerstin Robertson
Research Director, Transport and Environment
Quality review

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Kvalitetsgranskning

### Abbreviations used in the text

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Term</th>
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<tbody>
<tr>
<td>ACM</td>
<td>Approved consolidated methodologies</td>
</tr>
<tr>
<td>AM</td>
<td>Approved large-scale methodologies</td>
</tr>
<tr>
<td>AMS</td>
<td>Approved small-scale methodologies</td>
</tr>
<tr>
<td>BRT</td>
<td>Bus Rapid Transit</td>
</tr>
<tr>
<td>CCNUCC</td>
<td>Convention-Cadre des Nations Unies sur les Changements Climatiques = UNFCCC</td>
</tr>
<tr>
<td>CDE</td>
<td>Carbon dioxide equivalent = CO(_2)e</td>
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<tr>
<td>CDM</td>
<td>Clean Development Mechanism</td>
</tr>
<tr>
<td>CER</td>
<td>Certified Emissions Reduction</td>
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<tr>
<td>CH(_4)</td>
<td>Methane</td>
</tr>
<tr>
<td>CO(_2)</td>
<td>Carbon dioxide</td>
</tr>
<tr>
<td>CO(_2)e</td>
<td>Carbon dioxide equivalent = CDE</td>
</tr>
<tr>
<td>COP</td>
<td>Conference Of the Parties</td>
</tr>
<tr>
<td>COP/MOP</td>
<td>Conference Of the Parties serving as the Meeting Of the Parties</td>
</tr>
<tr>
<td>CTF</td>
<td>Clean Technology Fund</td>
</tr>
<tr>
<td>CV</td>
<td>Coefficient of Variation</td>
</tr>
<tr>
<td>DED</td>
<td>Deutscher Entwicklungsdienst (German Development Service)</td>
</tr>
<tr>
<td>DNA</td>
<td>Designated National Authority</td>
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<tr>
<td>DOE</td>
<td>Designated Operational Entity</td>
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<tr>
<td>GEF</td>
<td>Global Environmental Facility</td>
</tr>
<tr>
<td>GHG</td>
<td>Greenhouse Gas</td>
</tr>
<tr>
<td>GIZ</td>
<td>Deutsche Gesellschaft für Internationale Zusammenarbeit</td>
</tr>
<tr>
<td>GTZ</td>
<td>Deutsche Gesellschaft für Technische Zusammenarbeit</td>
</tr>
<tr>
<td>InWEnt</td>
<td>Internationale Weiterbildung und Entwicklung gGmbH (Capacity Building International)</td>
</tr>
<tr>
<td>IPCC</td>
<td>Intergovernmental Panel on Climate Change</td>
</tr>
<tr>
<td>LDC</td>
<td>Least Developed Countries</td>
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<tr>
<td>LRT</td>
<td>Light Rail Transit</td>
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<tr>
<td>LUZ</td>
<td>Larger Urban Zone</td>
</tr>
<tr>
<td>MDB</td>
<td>Multilateral Development Bank</td>
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<tr>
<td>MOP</td>
<td>Meeting Of Parties</td>
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<tr>
<td>MRT</td>
<td>Mass Rapid Transit</td>
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<tr>
<td>MRTS</td>
<td>Mass Rapid Transit System</td>
</tr>
<tr>
<td>MRV</td>
<td>Measurement, Reporting, Verification (of actions)</td>
</tr>
<tr>
<td>N(_2)O</td>
<td>Nitrous oxide, laughing gas = NOS</td>
</tr>
<tr>
<td>NAMA</td>
<td>Nationally Appropriate Mitigation Action</td>
</tr>
<tr>
<td>NMT</td>
<td>Non-motorised transport</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Term</td>
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<td>--------------</td>
<td>------</td>
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<tr>
<td>NOS</td>
<td>Nitrous oxide, laughing gas = N₂O</td>
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<tr>
<td>NTS</td>
<td>National Travel Service</td>
</tr>
<tr>
<td>PDD</td>
<td>Project Design Document</td>
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<tr>
<td>PKM</td>
<td>Passenger-kilometre</td>
</tr>
<tr>
<td>PoA</td>
<td>Programmes of Activities</td>
</tr>
<tr>
<td>PT</td>
<td>Public Transport</td>
</tr>
<tr>
<td>QA/QC</td>
<td>Quality Assurance / Quality Control</td>
</tr>
<tr>
<td>RE</td>
<td>Rebound Effect</td>
</tr>
</tbody>
</table>
| SRS          | (1) Share of Road Space  
               (2) Simple Random Sampling |
| UNFCCC       | United Nations Framework Convention on Climate Change  
               = CCNUCC |
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Summary

Evaluation of transport interventions in developing countries

by Kerstin Robertson (VTI), Annika K. Jägerbrand (VTI) and Georg F. Tschan (VTI)

International climate policy and the United Nations Framework Convention on Climate Change (UNFCCC) with the Kyoto Protocol include different mechanisms or programmes for actions in developing countries aimed at reducing emissions of carbon dioxide (CO₂). To verify compliance, the effects of such actions, including transport measures, need to be measured, reported and verified (MRV).

However, in relation to other sectors very few transport-related projects have been initiated. Potential problems and ambiguities related to the current evaluation methodology were therefore investigated as a possible explanation for the low interest in investments in the transport sector. Other objectives of this study were to analyse the requirements for development and improvement of methods for evaluating the effects of transport policies and measures on emissions of greenhouse gases in developing countries. The analyses included a review of different climate mechanisms, for example applied within the UNFCCC, evaluation requirements and methodologies used, the general availability of methods for evaluation of traffic and transportation, evaluation data availability, and institutional conditions in developing countries. The project applied a highly interdisciplinary perspective based on the fact that transport systems are highly complex. Analyses were based on scientific publications and reports, interviews and data/information collection from five developing countries as case studies.

The main conclusions are that measuring traffic and transportation is generally a complex and demanding process, and the potential for misinterpretation of results is significant. In addition, there is a significant risk of rebound effects, especially for transport projects in developing countries aiming at modal shift. Furthermore, it seems that very short time frames are applied for evaluation of project-based mechanisms in the transport sector. Other challenges relate to institutional roles and responsibilities, the availability of personal and financial resources, and the knowledge and perspectives applied.

In addition, the Clean Development Mechanism (CDM) programme, for example, has relatively rigorous regulations, with detailed descriptions of project development, implementation and evaluation. Evaluation and delivery of CO₂ emissions reductions are also tightly linked to funding. Since transport project types are usually difficult to evaluate, uncertainties with respect to the delivery of CO₂ emissions reductions may be important barriers to CDM project initiation and implementation. Data availability and quality are also highly uncertain in the case study countries included in this study, and these results are most likely applicable for other developing countries as well. Furthermore, the fact that regions and households with lower per capita expenditure generally have higher direct rebound effects, due to e.g. a large unmet demand for transportation, makes the application of wider systems perspectives and longer time frames highly relevant. Based on these limitations regarding transport project evaluations, further development of transport-related climate mechanisms towards a more sectoral and transformational perspective is suggested.
Sammanfattning

Utvärdering av transportåtgärder i utvecklingsländer
av Kerstin Robertson (VTI), Annika K. Jägerbrand (VTI) och Georg F. Tschan (VTI)

Den internationella klimatpolitiken och Klimatkonventionen (UNFCCC) med Kyoto-protokollet omfattar olika mekanismer eller program för åtgärder i utvecklingsländer som syftar till att minska utsläppen av koldioxid (CO₂). För att kontrollera efterlevnaden behöver effekterna av sådana åtgärder, till exempel transportåtgärder, mätas, rapporteras och verifieras (MRV).

I förhållande till andra sektorer har dock ett mycket litet antal transportprojekt genomförts hittills. Därför har tänkbara problem och oklarheter i samband med de tillämpade metoderna för utvärdering undersöks som en möjlig förklaring till det låga intresset för investeringar inom transportsektorn. Syftet med denna studie var att analysera eventuella behov av utveckling och förbättring av dessa metoder för utvärdering av effekterna av åtgärder inom transportsektorn på utsläpp av växthusgaser i utvecklingsländer. Analyserna inkluderar översikter över: olika klimatmekanismer, tillämpade krav och metoder för utvärdering av transportåtgärder och möjligheter och metoder för utvärdering av trafik och transporter generellt samt utvärdering av tillgång till data och institutionella förhållanden i utvecklingsländer.

Projektet har tillämpat ett tvärvetenskapligt perspektiv baserat på att transportsystemen är mycket komplexa. Analyserna i studien är baserade på vetenskapliga publikationer och rapporter, intervjuer samt data/informationsinsamling från fem utvecklingsländer som fallstudier.


Dessutom har ”Clean Development Mekanism” (CDM)-programmet relativt strikta regler som omfattar detaljerade beskrivningar av projektutveckling, genomförande och utvärdering. Utvärdering och leverans av utsläppsminkningar av CO₂ är vidare tätt kopplat till finansieringen. Eftersom effekterna av transportprojekt ofta är svåra att bedöma, kan osäkerheten avseende leveranserna av minkningar av CO₂-utsläpp vara viktiga hinder för att CDM-projekt inleds och genomföras.

1. Introduction

1.1. Background

Transport is a significant contributor to total greenhouse gas (GHG) emissions, generating 25-30% of global energy-related (CO₂) emissions (IEA & OECD, 2009; OECD & ITF, 2010). By 2050, worldwide transport energy use and CO₂ emissions are anticipated to increase by nearly 80% according to the International Energy Agency (IEA) (IEA & OECD, 2009). Some transport activities, such as road haulage, air transport and car ownership, can potentially increase three- or four-fold relative to current levels. Increased transport activities are associated with several serious sustainability problems, e.g. increased dependence on fossil fuels, traffic safety issues, increased environmental and health impacts and congestion problems. Thus, it will be challenging for planners and policymakers to achieve sustainable transport development in the future, especially in underdeveloped and rapidly growing economies where transport-associated problems are particularly acute (Ribeiro et al., 2007). In addition, sustainable development of the transport sector may contribute to poverty reduction (World Bank, 2006).

It has been estimated that by 2050, freight volumes in non-OECD countries could increase by four- to five-fold compared with 2000 levels and that passenger mobility could increase from five-fold to more than six-fold over the same period (OECD, 2011). The rapid urbanisation and sprawl in developing countries puts high pressure on transport systems and the costs of accidents, pollution and congestion are rising (Dalkmann et al., 2011).

The UN Secretary-General’s Five-Year Action Agenda (25 January 2012) includes a number of strategies that aim to mobilise support for global, regional and national building blocks of sustainable development. The aim for the transport building block is to: “Convene aviation, marine, ferry, rail, road and urban public transport providers, along with Governments and investors, to develop and take action on recommendations for more sustainable transport systems that can address rising congestion and pollution worldwide, particularly in urban areas.” At the World Summit on Sustainable Development (WSSD) in Johannesburg in 2002, Member States had already agreed to “promote an integrated approach to policymaking at the national, regional and local levels for transport services and systems to promote sustainable development” (RIO, 2012). The approach included policies and planning for land use, infrastructure, public transport systems and goods delivery networks, with the aim of increasing energy efficiency, reducing pollution, congestion and adverse health effects, and limiting urban sprawl. So far, however, in relation to other sectors very few transport projects have been initiated (Hayashi & Michaelowa, 2013).

International climate policy, through the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol, include agreements on emissions levels for countries and regions, but also include different mechanisms or programmes for actions in developing countries that will contribute to reduced emissions of greenhouse gases and to sustainable development (Bumpus & Cole, 2010; UNFCCC, 2014a). The Clean Development Mechanism (CDM) and the Global Environment Facility (GEF) are two policy instruments or mechanisms within the UNFCCC which provide incentives for emissions reductions in developing countries (Bakker & Huizenga, 2010; UNFCCC, 2014a). More recently, Nationally Appropriate Mitigation Actions (NAMAs) have been suggested (UNFCCC, 2014b).

The Clean Technology Fund (CTF), established by the World Bank in cooperation with multilateral development banks, is another programme aimed at financing “transformational actions”. CTF supports a range of low-carbon technologies and initiatives within renewable energy, energy efficiency and sustainable transport. Examples of the latter are bus rapid transit (BRT), public transport (PT), high-efficiency vehicles and modal shifts (CTF, 2014). CTF programmes, including transport actions, have been set up in e.g. Colombia, Mexico, Thailand and Vietnam.
To demonstrate reduced carbon dioxide (CO₂) emissions and sustainable development, the effects of interventions need to be measured and evaluated. However, there may be a need for further development of definitions and interpretations of data and for guidelines on estimation and evaluation of transport measures and their application. Transport systems are very complex, which adds to the difficulties in evaluating actions, measures and policies. Depending on the systems limit defined, evaluation may include every geographical scale from local to global and every possible transport mode within the road, rail, sea and air sectors. Even defining the systems limit is complex, since data about local and regional traffic and transport still need to be assigned to traffic and transport generated by vehicles stationed in the area or to total traffic and transportation performed in the area. In addition, there are two main categories of transport – passenger transport and transport of goods. These subsystems differ in many respects in their composition and design, so in practice there are actually two parallel transport systems that to some extent interact and integrate.

Estimating the effects of interventions (actions, measures, policies, etc.) involves additional difficulties. First, a baseline (i.e. traffic and transportation before and without the intervention) needs to be defined in order to allow any additionality of the intervention (i.e. an additional effect) to be demonstrated. Baseline definition or setting requires data about traffic and transportation and a projection or a scenario addressing a future situation. Baseline projections may be related to economic growth, but in urban areas decoupling between economic growth and transport may also occur. Furthermore, transport interventions may lead to rebound effects, i.e. secondary effects that counteract the intended primary effects. Measurements, interpretations and evaluations of traffic and transportation and of the effects of transport interventions therefore require careful definitions of the system under study and the system boundaries.

1.2. Objective and methods

Measurement, reporting and verification (MRV) is a core requirement for transport interventions in developing countries. Therefore clear definition and understanding of measurement and monitoring is highly important for evaluations. Potential problems and ambiguities related to the current evaluation methodology was therefore investigated as a possible explanation for the low interest in investments in the transport sector. The corresponding aim of this study was to analyse the requirement for development and improvement of methods for evaluating the effects of transport policies and measures on emissions of greenhouse gases in developing countries. The analyses includes an overview of different climate mechanisms, for example applied within the UNFCCC, evaluation demands and methodologies used, the general availability of methods for evaluation of traffic and transportation, evaluation data availability, and a review of institutional conditions in developing countries.

The analyses presented in this report are based on case studies in a number of developing countries, extensive reviews of relevant literature obtained through literature searches in different databases, including scientific databases, and on interviews with experts in relevant areas. Data/information collection in case studies was based on a template (Appendix 1) and was carried out in collaboration with local experts.

The initial aim of the study needed to be extended during the course of the work since it was clear that a narrow focus on data quality and data availability for measurement and evaluation was not sufficient to develop the understanding of causes of the low interest in transport interventions. Therefore the aim was widened to include a broader systems perspective on data quality and data availability in order to identify requirements for increasing the interest for sustainable traffic and transportation interventions in developing countries.

The report is initiated with an overview of some different international carbon reduction instruments mechanisms and their evaluation requirements in Chapter 2. The transport system concept, including different geographical and temporal perspectives, is elaborated on in Chapter 3, where also the concept
of rebound effects is reviewed and discussed. Different options for measuring and monitoring of traffic and transportation are reviewed in Chapter 4, and data availability in developing countries is evaluated in Chapter 5. The corresponding institutional capacity for greenhouse gas performance tracking is referred in Chapter 6. Finally, the relevance of the currently applied evaluation methods, referred in Chapter 7, are discussed in relation to different systems perspectives, and requirements for further development of evaluation methodology is suggested in Chapter 8.
2. International carbon reduction instruments

2.1. Background

There are a number of different types of multilateral climate or carbon reduction instruments applied in international cooperation for promoting sustainable development in developing countries. This chapter provides a brief overview of some available carbon reduction instruments and measures that are relevant for the transport sector, including:

- CDM, Clean Development Mechanism¹
- GEF, Global Environment Facility²
- CTF, Clean Technology Fund³
- NAMA, Nationally Appropriate Mitigation Actions⁴.

The focus in this report is on CDM, under which certified emissions reduction credits are possible for projects in developing countries and can be used by industrialised countries to meet their targets under the Kyoto Protocol. The other mechanisms listed are included for reference. None of the instruments focuses exclusively on transport projects, but transport projects are an option in all programmes.

2.2. Clean Development Mechanism, CDM

The Kyoto Protocol was initiated by the UNFCCC and resulted in binding targets for carbon dioxide emissions for those countries ratifying the protocol (The Kyoto Protocol, 1998). The Kyoto Protocol requires countries to reduce or limit their GHG emissions and it also enables trade of emissions reductions. The Protocol sets binding obligations on many developed countries (Annex I) to reduce their GHG emissions in two commitment periods, 1990-2008/2012 and 2013-2020. Annex I parties must prepare, and submit to the UNFCCC, National Inventory Submissions for monitoring of emissions and targets.

To encourage the private sector and developing countries to contribute to emissions reductions, the Protocol offers means for three market-based mechanisms (Kyoto mechanisms): International Emissions Trading, CDM and Joint Implementation (JI). The mechanisms aim to stimulate investment and help parties meet targets by cost-effective measures. The CDM arrangements allow developed countries (Annex I parties) to earn certified emissions reduction credits (CER) by investing in project activities that reduce emissions in developing countries⁵. The CER are each equivalent to one metric ton of CO₂. The emissions reduction credits can be included in the binding targets under the Kyoto Protocol for the developed country, but they can also be traded and sold.

The aim of the CDM is to encourage sustainable development and emissions reductions in developing countries, while providing an instrument that is standardised and offers flexibility to meet the binding targets for emissions reductions in developed countries. CDM projects can be performed in various sectors and can be of various sizes⁶, but the methodology for CDM projects to be accepted comprises similar processes. A key requirement is that the emissions reductions are additional, including real and measurable (Article 12 of the Kyoto Protocol). Additional means that they provide emissions reductions compared with what would have otherwise occurred, i.e. in the business as usual scenario,

¹ https://cdm.unfccc.int/about/index.html
² http://www.thegef.org/gef/
³ https://www.climateinvestmentfunds.org/cif/node/2
⁴ http://unfccc.int/focus/mitigation/items/7172.php
⁵ http://unfccc.int/kyoto_protocol/mechanisms/clean_development_mechanism/items/2718.php
⁶ http://www.cdmpipeline.org/cdm-projects-type.htm#1
and that the emissions reductions achieved in the CDM project would not have happened without that project (for further information, see e.g. Schneider, 2011).

The CDM projects must go through a rigorous project cycle and process of validation overseen by the CDM Executive Board. Approval for CDM projects is granted by the Designated National Authority (DNA) and subsequent CER issuance is carried out by the CDM Executive Board. The CDM project cycle consists of the following seven steps:

1. Project design by the project participant.
2. National approval by the Designated National Authority (DNA).
3. Validation by the Designated Operational Entity (DOE).
4. Registration by the Executive Board.
5. Monitoring by the project participant.
6. Verification by the DOE.
7. CER issuance by the Executive Board.

For each sector and/or size of project, there are specially developed methodologies, but there are also possibilities to apply for new methodologies to be accepted. At present, there are 90 different CDM methodologies approved. The CDM projects in the pipeline (both approved and newly submitted) are listed in the UNFCCC Registry, while the UNFCCC website provides information and support regarding the flexible mechanisms.

Concerns have been raised about the functioning of the CDM, particularly regarding its support for sustainable development (Olsen, 2007; Bumpus & Cole, 2010), but also regarding uneven regional and sectorial distribution (Bakker et al., 2011). For example, 95% of CDM projects are situated in Asian and Latin American countries, and there are very few CDM projects in the transport and building sectors. There are also concerns regarding the contributions of CDM projects to offsetting global carbon emissions (e.g. Chung, 2007; Schneider, 2009) and the difficulties in showing additionality (Bakker et al., 2011). Out of a current total of 7931 CDM projects (29 Dec 2014), there are only 32 transport CDM projects (0.4%) in the UNFCCC registered project cycle search (Table 1, Figure 1), of which 29 have been approved (Figure 1).

Table 1. Registered CDM projects in the transport sector.

<table>
<thead>
<tr>
<th>Methodology: Type</th>
<th>Methodology</th>
<th>Reg. date</th>
<th>Ref. no.</th>
<th>Project title</th>
<th>Project type</th>
<th>Host party</th>
<th>Other parties</th>
<th>Reduction [t CO₂e / year]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consolidated</td>
<td>ACM0016</td>
<td>30/05/2011</td>
<td>3869</td>
<td>BRT Lines 1-5 EDOMEX</td>
<td>BRT</td>
<td>Mexico</td>
<td>Switzerland/ Portugal</td>
<td>145863</td>
</tr>
<tr>
<td>Consolidated</td>
<td>ACM0016</td>
<td>30/06/2011</td>
<td>4463</td>
<td>Metro Delhi</td>
<td>METRO</td>
<td>India</td>
<td>Switzerland</td>
<td>529043</td>
</tr>
<tr>
<td>Consolidated ver. 2</td>
<td>ACM0016</td>
<td>04/10/2011</td>
<td>4670</td>
<td>Mumbai Metro One</td>
<td>METRO</td>
<td>India</td>
<td>Switzerland</td>
<td>195547</td>
</tr>
<tr>
<td>Consolidated ver. 2</td>
<td>ACM0016</td>
<td>10/08/2011</td>
<td>4945</td>
<td>BRT Metrobus Insurgentes</td>
<td>BRT</td>
<td>Mexico</td>
<td>Spain</td>
<td>46544</td>
</tr>
</tbody>
</table>

7 https://cdm.unfccc.int/Projects/diagram.html
8 https://cdm.unfccc.int/methodologies/index.html
9 https://cdm.unfccc.int/Projects/pac/howto/CDMProjectActivity/NewMethodology/index.html
10 https://cdm.unfccc.int/methodologies/PAmethodologies/approved
11 https://cdm.unfccc.int/Registry/index.html
12 https://cdm.unfccc.int/Projects/projsearch.html
13 https://cdm.unfccc.int/Projects/projsearch.html; accessed 2014-12-30.
<table>
<thead>
<tr>
<th>Methodology: Type</th>
<th>Methodology</th>
<th>Reg. date</th>
<th>Ref. no.</th>
<th>Project title</th>
<th>Project type</th>
<th>Host party</th>
<th>Other parties</th>
<th>Reduction [t CO₂ / year]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consolidated</td>
<td>ACM0016 ver. 2</td>
<td>12/09/2012</td>
<td>5735</td>
<td>Metro Line 12, Mexico City</td>
<td>METRO</td>
<td>Mexico</td>
<td>Switzerland</td>
<td>136983</td>
</tr>
<tr>
<td>Consolidated</td>
<td>ACM0016 ver. 2</td>
<td>22/11/2012</td>
<td>6430</td>
<td>Mode shift of passengers to MRTS for Gurgaon metro</td>
<td>METRO</td>
<td>India</td>
<td>Switzerland</td>
<td>105863</td>
</tr>
<tr>
<td>Consolidated</td>
<td>ACM0016 ver. 2</td>
<td>Reject ed</td>
<td>6814</td>
<td>Busan Metro Line 1 Daede</td>
<td>METRO</td>
<td>Republc of Korea</td>
<td>Switzerland</td>
<td>10619</td>
</tr>
<tr>
<td>Consolidated</td>
<td>ACM0016 ver. 2</td>
<td>Reject ed</td>
<td>6818</td>
<td>Daegu Metro 3th Urban Railroad</td>
<td>METRO</td>
<td>Republc of Korea</td>
<td>Switzerland</td>
<td>60350</td>
</tr>
<tr>
<td>Consolidated</td>
<td>ACM0016 ver. 2</td>
<td>Reject ed</td>
<td>6820</td>
<td>Incheon Metro Line 2</td>
<td>METRO</td>
<td>Republc of Korea</td>
<td>Switzerland</td>
<td>48064</td>
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<tr>
<td>Consolidated</td>
<td>ACM0016 ver. 3</td>
<td>24/09/2012</td>
<td>7235</td>
<td>BRT Metrobus 2-13</td>
<td>BRT</td>
<td>Mexico</td>
<td>Switzerland</td>
<td>134601</td>
</tr>
<tr>
<td>Consolidated</td>
<td>ACM0016 ver. 3</td>
<td>19/12/2012</td>
<td>7574</td>
<td>LRT System in Tunis</td>
<td>Rail</td>
<td>Tunisia</td>
<td>29193</td>
<td></td>
</tr>
<tr>
<td>Consolidated</td>
<td>ACM0016 ver. 3</td>
<td>25/02/2013</td>
<td>8149</td>
<td>Guiyang MRTS Line I Project</td>
<td>METRO</td>
<td>China</td>
<td>335188</td>
<td></td>
</tr>
<tr>
<td>Large-scale</td>
<td>AM0031 ver. 3</td>
<td>07/12/2006</td>
<td>672</td>
<td>BRT Bogotá: TransMilenio Phase II-IV</td>
<td>BRT</td>
<td>Colombia</td>
<td>Switzerland/ Netherlands</td>
<td>246563</td>
</tr>
<tr>
<td>Large-scale</td>
<td>AM0031 ver. 3</td>
<td>19/10/2010</td>
<td>3760</td>
<td>BRT Chongqing Lines 1-4, China</td>
<td>BRT</td>
<td>China</td>
<td>Switzerland/ Germany</td>
<td>218067</td>
</tr>
<tr>
<td>Large-scale</td>
<td>AM0031 ver. 3</td>
<td>07/06/2011</td>
<td>4744</td>
<td>BRT Zhengzhou, China</td>
<td>BRT</td>
<td>China</td>
<td>Switzerland/ Portugal</td>
<td>204715</td>
</tr>
<tr>
<td>Large-scale</td>
<td>AM0031 ver. 3</td>
<td>10/02/2012</td>
<td>5437</td>
<td>BRT Macrobus Guadalajara</td>
<td>BRT</td>
<td>Mexico</td>
<td>Spain</td>
<td>54365</td>
</tr>
<tr>
<td>Large-scale</td>
<td>AM0031 ver. 3</td>
<td>16/12/2011</td>
<td>5513</td>
<td>BRT Transmetro Barranquilla</td>
<td>BRT</td>
<td>Colombia</td>
<td>Spain</td>
<td>55828</td>
</tr>
<tr>
<td>Large-scale</td>
<td>AM0031 ver. 3</td>
<td>13/03/2012</td>
<td>5618</td>
<td>BRT Metropplus Medellin</td>
<td>BRT</td>
<td>Colombia</td>
<td>Switzerland</td>
<td>123479</td>
</tr>
<tr>
<td>Large-scale</td>
<td>AM0031 ver. 3</td>
<td>12/03/2012</td>
<td>5852</td>
<td>MIO Cali</td>
<td>BRT</td>
<td>Colombia</td>
<td>Netherlands</td>
<td>242187</td>
</tr>
<tr>
<td>Large-scale</td>
<td>AM0031 ver. 3</td>
<td>10/08/2012</td>
<td>6351</td>
<td>MEGABUS, Pereira</td>
<td>BRT</td>
<td>Colombia</td>
<td>Netherlands</td>
<td>33956</td>
</tr>
<tr>
<td>Large Scale</td>
<td>AM0031 ver. 3</td>
<td>03/07/2012</td>
<td>6455</td>
<td>BRT in Guatemala City</td>
<td>BRT</td>
<td>Guatemala</td>
<td>536148</td>
<td></td>
</tr>
<tr>
<td>Large-scale</td>
<td>AM0031 ver. 3</td>
<td>23/07/2012</td>
<td>6796</td>
<td>Lanzhou Bus Rapid Transit (BRT)</td>
<td>BRT</td>
<td>China</td>
<td>Sweden</td>
<td>12621</td>
</tr>
<tr>
<td>Small-scale</td>
<td>AMS-III.AQ./AMS-II.AO.</td>
<td>31/01/2013</td>
<td>8358</td>
<td>Demo. Project: Biogas from organic waste, Anyang City</td>
<td>Biofuel</td>
<td>China</td>
<td>UK, Northern Ireland</td>
<td>50739</td>
</tr>
<tr>
<td>Methodology: Type</td>
<td>Methodology</td>
<td>Reg. date</td>
<td>Ref. no.</td>
<td>Project title</td>
<td>Project type</td>
<td>Host party</td>
<td>Other parties</td>
<td>Reduction [t CO₂ / year]</td>
</tr>
<tr>
<td>------------------</td>
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<td>--------------------------</td>
</tr>
<tr>
<td>Small-scale</td>
<td>AMS-III.A.T. ver. 2</td>
<td>28/09/2012</td>
<td>7455</td>
<td>Nittsu fuel efficiency for freight transport</td>
<td>Fuel eff.</td>
<td>Malaysia</td>
<td>Japan</td>
<td>239</td>
</tr>
<tr>
<td>Small-scale</td>
<td>AMS-III.C. ver. 10</td>
<td>29/12/2007</td>
<td>1351</td>
<td>Low GHG emitting rolling stock</td>
<td>METRO</td>
<td>India</td>
<td>Japan</td>
<td>41160</td>
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<tr>
<td>Small-scale</td>
<td>AMS-III.C. ver. 11</td>
<td>04/02/2011</td>
<td>4066</td>
<td>Modal shift to rail transport</td>
<td>Goods</td>
<td>India</td>
<td></td>
<td>23001</td>
</tr>
<tr>
<td>Small-scale</td>
<td>AMS-III.C. ver. 13</td>
<td>02/11/2012</td>
<td>6708</td>
<td>Lohia Auto Ind. electric vehicles</td>
<td>Electric</td>
<td>India</td>
<td>Switzerland</td>
<td>25518</td>
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<tr>
<td>Small-scale</td>
<td>AMS-III.C. ver. 13</td>
<td>27/09/2012</td>
<td>6711</td>
<td>Hero electric vehicles</td>
<td>Electric</td>
<td>India</td>
<td>Switzerland</td>
<td>37647</td>
</tr>
<tr>
<td>Small-scale</td>
<td>AMS-III.C. ver. 13</td>
<td>02/11/2012</td>
<td>6712</td>
<td>Electrotherm electric vehicles</td>
<td>Electric</td>
<td>India</td>
<td>Switzerland</td>
<td>36175</td>
</tr>
<tr>
<td>Small-scale</td>
<td>AMS-III.C. ver. 13</td>
<td>27/09/2012</td>
<td>6713</td>
<td>EKO electric vehicles</td>
<td>Electric</td>
<td>India</td>
<td>Switzerland</td>
<td>24563</td>
</tr>
<tr>
<td>Small Scale</td>
<td>AMS-III.T.</td>
<td>17/12/2010</td>
<td>3291</td>
<td>Plant-oil production for use in vehicles</td>
<td>Biofuel</td>
<td>Paraguay</td>
<td>Switzerland</td>
<td>17188</td>
</tr>
<tr>
<td>Small-scale</td>
<td>AMS-III.U.</td>
<td>28/04/2010</td>
<td>3224</td>
<td>Cable car metro Medellin</td>
<td>Cable car</td>
<td>Colombia</td>
<td>Switzerland</td>
<td>17290</td>
</tr>
</tbody>
</table>

The uneven distribution of projects and countries that has been identified by others (see above) can also be seen in Table 1 and Figure 1:

1. There are some very dominant project types (BRT, MRT), whereas some, e.g. promotion of walking and cycling are absent and several methodologies have not been covered in proposed projects (Table 1; Figure 1).
2. There are also some very dominant host countries (India, Colombia, Mexico) among a total of only nine host countries and one dominant supporting country (Switzerland) among a total of only eight supporting countries (denoted ‘Host party’ and ‘Other party’ in Table 1).

The causes of this uneven distribution are not further analysed in this report.

The low number of transport CDM projects is suggested to be a side-effect of the strict requirements of the CDM methodologies and the fact that the requirements do not suit the transport sector. For transport projects, for example, it is very difficult to establish a realistic baseline for a CDM project, since transport operates in complex environments and consists of many small mobile emissions sources that are highly challenging to calculate, measure or estimate (Eichhorst et al., 2010). One consequence of this is that it may be difficult to demonstrate additionality, which is a requirement of CDM projects. In some cases therefore, UNFCCC methodologies use standardised indicators if there is a lack of data for the project. These uncertainties may be important barriers to CDM project implementation, since funding of the projects is tightly linked to the delivery of CO₂ emissions reductions.
Improvements to the conditions for transport CDMs have been suggested, for example simplifying the methodologies, modifying the requirement on demonstrating additionality and reducing the amount of data needed for approval of CDM projects (Bakker & Huizenga, 2010). It might also be possible to develop the CDM methodology so as to allow transport projects with a more broad design or application (such as a sectoral approach) to be created and to view transport as a system, instead of only dealing with limited parts. Adopting a sectoral approach for transport CDM would allow scaling up of activities and would perhaps be in better agreement with sustainable development (Wittneben et al., 2009). The CDM transport methodologies are further discussed and analysed in Chapter 6 of this report.

It is also possible to register coordinated implementation of a policy, measure or goal that leads to emissions reductions in the programme of activities (PoA) within the CDM. The CDM methodologies and project standard, procedure, additionality and verification must still be applied, but the PoA provides possibilities for co-ordinated efforts to be made and offers an unlimited number of component project activities (CPA). There are many benefits of PoAs, but since the CDM methodology must be used for the broad approach of the PoA, it may be difficult to fulfil the requirements on data availability and quality.

2.3. Global Environment Facility, GEF

Global Environment Facility (GEF) was established in 1991 and helps developing countries finance activities that protect the global environment. GEF addresses global environmental issues by serving as a financial mechanism for several conventions, including the Convention on Biological Diversity (CBD), the UNFCCC, the Stockholm Convention on Persistent Organic Pollutants (POPs), the UN Convention to Combat Desertification (UNCCD) and the Minamata Convention on Mercury. It also supports the implementation of the Montreal Protocol (MP) on Substances That Deplete the Ozone Layer (MP) for countries with economies in transition (GEF, 2014b). GEF serves as a partnership for collaboration with institutions, organisations and the private sector and provides funding in grants. GEF partner agencies are listed in .

14 http://cdm.unfccc.int/ProgrammeOfActivities/index.html
15 http://cdm.unfccc.int/ProgrammeOfActivities/index.html
Table 2. List of GEF partner agencies.

<table>
<thead>
<tr>
<th>GEF Partner Agencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asian Development Bank (ADB)</td>
</tr>
<tr>
<td>African Development Bank (AfDB)</td>
</tr>
<tr>
<td>Conservation International (CI)</td>
</tr>
<tr>
<td>Development Bank of Southern Africa (DBSA)</td>
</tr>
<tr>
<td>European Bank for Reconstruction and Development (EBRD)</td>
</tr>
<tr>
<td>Food and Agriculture Organization of the United Nations (FAO)</td>
</tr>
<tr>
<td>Inter-American Development Bank (IADB)</td>
</tr>
<tr>
<td>International Fund for Agricultural Development (IFAD)</td>
</tr>
<tr>
<td>International Union for Conservation of Nature (IUCN)</td>
</tr>
<tr>
<td>United Nations Development Programme (UNDP)</td>
</tr>
<tr>
<td>United Nations Environment Programme (UNEP)</td>
</tr>
<tr>
<td>United Nations Industrial Development Organization (UNIDO)</td>
</tr>
<tr>
<td>The World Bank Group</td>
</tr>
</tbody>
</table>

GEF provides funding in four different project types (GEF, 2014c): Full-sized Projects (FSPs), Medium-sized Projects (MSPs), Enabling Activities (EAs) and Programmatic Approaches (PAs). These different project types and their GEF requirements are shown in .

In addition, projects falling under the area of adaptation of climate change can also apply for funds from the Special Climate Change Fund (SCCF), the Least Developed Countries Fund (LDCF) and the Adaptation Fund (GEF, 2014c). The GEF corporate programme (SGP) is funded by GEF but implemented by the United Nations Development Programme (UNDP) and executed by the United Nations Office for Project Services (UNOPS).

Regarding transport projects, GEF has the possibility to fund these within the UNFCCC and by July 2012 it had funded 50 urban transport projects (GEF, 2013). GEF also has a programme aimed at creation of sustainable cities, where transport will play an important role (GEF, 2014d). In total, about 800 projects have received funding through the GEF programme. GEF project financing takes place before the project is implemented, and GEF funding is not revoked if emissions targets are not reached (ITDP, 2014). GEF projects are less rigorous and riskier but also more flexible, in that it is possible to support many different kinds of transport project types.
Table 3. The different GEF project types and their requirements (GEF, 2014c).

<table>
<thead>
<tr>
<th>Type</th>
<th>Size ($)</th>
<th>Requirements</th>
<th>GEF role</th>
<th>Project review</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full-sized projects, FSPs</td>
<td>Over 2 million</td>
<td>Must respond to national priorities and GEF focal area/LDCF/SCCF Eligibility for convention requirements</td>
<td>Work closely with GEF operational focal points &amp; GEF agency</td>
<td>Yes; are approved by GEF council</td>
</tr>
<tr>
<td>Medium-sized projects, MSPs</td>
<td>Up to 2 million</td>
<td>Higher flexibility and encourages a wide range of project concepts</td>
<td>CEO approval</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>After CEO approval, projects are followed by agencies’ own procedures (from start of implementation)</td>
<td></td>
</tr>
<tr>
<td>Enabling activities, EAs</td>
<td>Basic: 350 000 (biodiversity and climate change) + add-ons 100 000. (POP basic: 500 000; NCSAs basic: 200 000). (larger amounts require FSP processing)</td>
<td>Must be within biodiversity, climate change or persistent organic pollutants (POP), or national self-assessments of capacity building needs (NCSAs)</td>
<td>Follow the GEF project cycle</td>
<td>CEO (under the delegated authority) approval</td>
</tr>
<tr>
<td>Programmatic approaches, PAs</td>
<td>Larger than FSP or MSP</td>
<td>Partnership between country/ies, GEF and others</td>
<td>Large programmes of two different types</td>
<td>Processing methodology for the projects</td>
</tr>
</tbody>
</table>

GEF transport projects are grouped into three categories: technology solutions, urban transport systems and integrated urban systems (ITDP, 2013). Technology solutions focus on the energy efficiency of engines and motor fuels, while urban transport systems focus on transportation systems with the aim of reducing travel in single-occupancy vehicles and increasing lower-carbon modes of travelling (e.g. by PT and non-motorised transport (NMT)). The urban transport system is the most dominant category of transport GEF projects. The integrated urban system has four components: green buildings, low carbon components, green transport and green energy schemes (ITDP, 2013).

Until 2005, GEF transport projects were dominated by those of a mixed character (55%), hydrogen vehicles (22%), and BRT/NMT. There was then a slight change in direction, so that in 2009 the most dominant GEF transport project types were BRT, NMT (29% each), travel demand management (TDM) (8%), engine technology (6%) and others (ITDP, 2013). For further details on funded GEF transport projects, see ITDP (2013).

2.4. Clean Technology Fund, CTF

Clean Technology Fund (CTF) is one of four key programmes in Climate Investment Funds (CIF). The other programmes are: Forest Investment Program, Scaling Up Renewable Energy Program, and...
Pilot Program Climate Resilience. CIF helps 63 developing countries with the challenges of climate change and GHG emissions reductions. CIF has financial resources from contributor countries and is also financed through external resources (private or government).

There are three main principles for CIF projects; delivering investment to stimulate transformation, fostering partnership through a programmatic approach and learning by doing to achieve results (CIF, 2014). Delivering investment to stimulate transformation involves partnership with multilateral development banks (MDBs), co-financing with MDB and also co-financing with the private sector. Fostering partnership through a programmatic approach involves country-led approaches with multiple stakeholders to develop and implement investment plans based on policies and initiatives. Learning by doing to achieve results is a way to use previous findings on what works in order to improve results, scale up implementation and replicate successful projects or programmes.

CTF was established in 2008 and is the main programme that contains transport projects, but besides sustainable transport also has other types of projects, such as low carbon technologies, renewable energy and energy efficiencies. The programme provides funding for developing and middle income countries for “demonstration, deployment and transfer of low carbon technologies with significant potential for long-term greenhouse gas emissions savings”.

The CTF has 134 projects and programmes amounting to $6.1 billion in its pipeline and expected co-financing of $51 billion from other sources (December 2014). Financing has been approved for 70 projects to deliver 16.6 GW of renewable energy capacity, and the projects are anticipated to result in 1.7 billion tons of CO₂ reductions (during their life cycle). CTF differs from other multilateral climate instruments in that it focuses on larger transactions in a few countries or regions, see Table 4.

<table>
<thead>
<tr>
<th>CTF countries and regions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chile</td>
</tr>
<tr>
<td>Colombia</td>
</tr>
<tr>
<td>Egypt</td>
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<tr>
<td>India</td>
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<tr>
<td>Indonesia</td>
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<tr>
<td>Kazakhstan</td>
</tr>
<tr>
<td>Mexico</td>
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<tr>
<td>Morocco</td>
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<tr>
<td>Nigeria</td>
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<tr>
<td>Philippines</td>
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<tr>
<td>South Africa</td>
</tr>
<tr>
<td>Thailand</td>
</tr>
<tr>
<td>Turkey</td>
</tr>
<tr>
<td>Ukraine</td>
</tr>
<tr>
<td>Vietnam</td>
</tr>
<tr>
<td>Middle East and North Africa Region</td>
</tr>
</tbody>
</table>

Table 4. Countries and regions included in CTF.

CTF encourages participation from the private sector, but also aims to decrease technology costs and to catalyse change that can be replicated. In 2013, CTF started the Dedicated Private Sector Programs (DPSP) to reduce barriers to private financing and to generate financing for projects and operations that can deliver scale and speed to countries of priority. The DPSP take a programmatic approach.

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16 https://www.climateinvestmentfunds.org/cif/aboutus
17 https://www.climateinvestmentfunds.org/cif/Clean_Technology_Fund
18 https://www.climateinvestmentfunds.org/cif/Clean_Technology_Fund
whereby MDBs collaboratively find private sector funding openings. The DSPS have six thematic areas: geothermal power, mini-grids, mezzanine finance, energy efficiency, solar photovoltaic power and early stage renewable energy.

CTF funds projects within the areas of renewable energy, sustainable transport and energy efficiency, see Table 5. Areas and project types within CTF funding.

<table>
<thead>
<tr>
<th>Area</th>
<th>Project types</th>
</tr>
</thead>
<tbody>
<tr>
<td>Renewable energy</td>
<td>Concentrating solar power, solar photovoltaic, geothermal, wind, small hydro</td>
</tr>
<tr>
<td>Sustainable transport</td>
<td>Bus rapid transit, public transport, high-efficiency vehicles, modal shifts</td>
</tr>
<tr>
<td>Energy efficiency</td>
<td>Industry, building, district heating, municipal, lighting, appliances</td>
</tr>
</tbody>
</table>

CTF projects, and funding agents, within the transport area include:

- Market transformation through introduction of an energy-efficient electric vehicle project for the Philippines: Government of the Philippines and the Asian Development Bank (ADB)
- Cebu bus rapid transit project in the Philippines: Government of the Philippines and the International Bank for Reconstruction and Development (IBRD)
- Technological transformation programme for Bogota’s integrated public transportation system: Government of Colombia and Inter-American Development Bank (IDB).

CTF projects are evaluated through standard ex-post evaluations and some projects also have built-in impact evaluations, for example as specified by the MDBs. CTF aims to include evidence-based evaluation approaches into the project cycle, although ex-post evaluations in terms of core indicators for the projects have been in use since 2013. The core indicators for transport projects consist of calculations of tons of CO₂ equivalents avoided or reduced per year, number of passengers (as a result of CTF), annual energy savings (as a result of CTF intervention) and development indicators.

2.5. Nationally Appropriate Mitigation Actions, NAMAs

Nationally Appropriate Mitigation Actions (NAMAs) have been discussed and referred to in the meetings of the UNCCC in Bali, Copenhagen and Doha. NAMAs include any action to decrease GHG emissions (in relation to business-as-usual emissions in 2020) and are organised by a national governmental initiative. NAMAs can be policies or can have a national focus, making them broader in their scope, but must be “nationally appropriate”. The NAMA framework is intended to help increase the demand for public policies and public sector investment, as well as strongly encouraging private sector investment (Cheng, 2010).

NAMAs are separated into two groups:

1. At the National Level

Parties (countries) are invited to communicate their NAMAs by a formal submission declaring an intent to mitigate GHG emissions. The mitigation of GHG emissions is performed in accordance with the capacity of these countries and with national development goals.

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19 https://www.climateinvestmentfunds.org/cif/content/ctf-dedicated-private-sector-programs
20 https://www.climateinvestmentfunds.org/cif/measuring-results/evaluation
21 http://unfccc.int/focus/mitigation/items/7172.php
2. Individual Action Level

NAMAs at the individual action level will help countries to meet their mitigation objectives and are diverse, from sectoral programmes or policies to project-based actions in stages of preparation or implementation. Again, the NAMAs are intended to take place within the context of development goals. Individual action-level NAMAs can be registered in the NAMA Registry22.

There have been previous discussions on how to formalise the design of NAMAs and it has been suggested that they be divided into three basic effort-sharing arrangements (Linnér & Pahuja, 2012): binding commitments for all; voluntary commitments for all; or partly binding commitments (binding commitments for Annex I parties and voluntary commitments for others).

The methods for evaluation of NAMAs, NAMA MRV and NAMA guidelines are still under discussion. The supported NAMAs will eventually be subject to international MRV. Nevertheless, countries can register NAMAs in a database (UNFCCC registry22) and seek international support according to sessions 16 and 17 at the Conference of Parties (COP). The database and its prototype were presented in 201223. There is also an Ecofys NAMA database24 that registers NAMAs being developed worldwide and contributes information and makes data available in an open standard format to promote collaboration and knowledge transfer.

The NAMA database included 118 NAMAs in 2014, but only seven were under implementation (van Tilburg et al., 2014). The annual status report on nationally appropriate mitigation actions (NAMAs) for 2014 noted increasing NAMA activity, but also found that finance for implementation is too slow and identified a great need for different improvements in NAMAs. For example, the monitoring of NAMAs, as well as reporting and verification of NAMAs, needs more detailed guidelines, some of which are already planned. Furthermore, more pragmatic MRV processes for NAMAs are being discussed, to enable flexible metrics of GHG emissions and reductions. The particular need for developing countries to develop capacity for MRV processes and systems is also mentioned.

The transport sector has been identified as being particularly interesting for NAMA initiatives. As of January 2014, the transport sector had the second highest number of NAMA activities of all economic sectors (Binsted et al., 2014). There is a special transport NAMA database within the Ecofys database and its prototype was launched in October 2013. As stated above, the main aim or key element of the transport NAMAs is to reduce GHG emissions, but the relevance of “wider benefits” or co-benefits has also been raised and discussed, since these may help achieve the UNFCCC aim of sustainable development (Binsted et al., 2012). Such co-benefits include economic development, improved quality of life and lower environmental impact.

Transport NAMAs have four basic building blocks (GIZ, 2014):

1. Designing mitigation measures.
2. Measuring, reporting and verification.
3. Financing.
4. Registration.

These four elements can also be intermixed in cross-sectional approaches. A typical feature of all NAMAs is the national appropriateness, giving rise to NAMAs of different size, scope and scale. Thus, NAMAs can be tailor-made development processes and each NAMA process can be different. However, due to the individual processes of NAMAs and their national appropriateness at the national level, there seems to be a current lack of practical information on the MRV process in the implementation stage, when the NAMA is different from the existing carbon reduction mechanisms (for example CDM).

22 http://www4.unfccc.int/sites/nama/SitePages/Home.aspx
23http://unfccc.int/files/cooperation_support/nama/application/pdf/improving_the_design_of_the_prototype_of_the_registry.pdf
2.6. Summary and conclusions

A number of different types of multilateral climate or carbon reduction instruments are applied in international co-operations promoting sustainable development in developing countries, for example Clean Development Mechanism (CDM), Global Environment Facility (GEF), Clean Technology Fund (CTF) and Nationally Appropriate Mitigation Actions (NAMAs). This comparison showed that there are many similarities between these programmes, e.g. they largely address the same or similar areas.

However, there are also some differences with respect to the regulation of project development, evaluation and funding schemes. The CDM programme has the most rigorous regulations, with detailed descriptions of project development, implementation and evaluation. Evaluation and delivery of CO₂ emissions reductions are also tightly linked to funding. Since transport project types usually are difficult to evaluate, uncertainties with respect to the delivery of CO₂ emissions reductions may be important barriers to CDM project initiation and implementation.

The GEF, CTF and NAMA programmes have less rigorous CO₂ emissions evaluation demands, and also provide funding through grants. This is one possible explanation why transport projects are more frequent in these programmes.
3. Transport systems

The term ‘transport system’ is used in this report to denote all different components related to transport, i.e., infrastructure, vehicles (traffic), passengers and goods (freight haulage). Transport systems can further be classified and defined in relation to a larger physical, economic and social system.

3.1. Transport systems in developing countries

Developing countries are defined according to their Gross National Income (GNI) per capita and year\(^\text{25}\). According to the World Bank \(^\text{25}\)\,(2013), countries with a GNI of US$ 11,905 and less are defined as developing. Low GNI is usually accompanied by a varying proportion of poverty and a wide income gap.

The transport system in developing countries may vary widely with respect to both the availability and the quality of e.g., road and railroad infrastructure and traffic, but both the availability and the quality are usually much lower than in developed or industrialised countries. The current state of the transport system may for example be explained by population growth and income/motorisation rates, but is also dependent on political history \cite{gwilliams2003}. For example, rich countries have high motorisation rates but can also afford mass rapid transport (MRT) systems, while poor countries with fast population growth are less likely to have MRT systems. Generally, large, dense cities, such as megacities, have high levels of congestion and severe environmental impacts. Developing cities differ from industrialised/developed cities in terms of four main characteristics; premature congestion, a deteriorating environment, low safety and security, and declining transport for the poor \cite{gwilliams2003}.

While development of the transport system is usually defined as a key factor for further economic development, the best strategy may not necessarily be to follow in the path of developed/industrialised countries, at least not regarding urban transport. While many other conditions improve with economic growth, urban transport has proven to be a challenge from the environmental, social and economic sustainability perspectives. The situation in many cities in developing countries can be illustrated with the following quote\(^\text{26}\): “Traffic jams; polluted air; dangerous roads; funding crises; absence of parks, walkways and public spaces; spiraling car and motorcycle use; ever-greater burdens on the poor; and less livable cities: these are all increasingly familiar to people living in developing cities. Moreover, these problems are getting worse, rather than better, with economic development.”

While economic growth as such may lead to improved quality of life in some respects, other aspects may need a more people-centred planning perspective in order to be identified and prioritised in urban planning. High quality sidewalks and pedestrian streets, plazas and parks may be crucial for the development of local communities and social harmony \cite{gizsupt, santos2010, cervero2011, cervero2013, gef2013}. In general, it is important that planning and development is based on wide perspectives and a sound understanding of requirements and conditions in every specific city, whether it is located in a developing or industrialised country.

The characteristics of cities and urban transport in developing countries may of course also be very variable, but there are some general characteristics that may differ from cities in industrialised countries \cite{giz, gizsupt, santos2010, cervero2011, cervero2013, gef2013}:

- Low car ownership and small urban area used for road infrastructure for motorised traffic
- Congestion and traffic jams are common and may be severe

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\(^{25}\) http://data.worldbank.org

- Rapid population growth and dense population
- “Sprawl” due to unregulated growth of informal settlements
- Transport infrastructure for such informal settlements is usually very limited, resulting in people living in such areas either having difficulties travelling and/or having to spend a comparatively large part of their income on daily travel.
- Unregulated collective-ride services provided by informal transport operators make up a large fraction of the “public transport”
- Infrastructure for walking and cycling is often lacking and the use of motorised transport is high even for short journeys, which leads to unnecessarily high travel costs for poor people
- Poorly designed road networks and spatial mismatches between housing and jobs.

3.2. Reducing CO₂ emissions from transport

Decoupling the expected growth in global transportation from the corresponding increase in GHG emissions is one challenge for the international community, as is decoupling transport from economic growth (GEF, 2013). An overview of different types and categories of traditional interventions (measures, activities, policies) to promote reduced emissions of CO₂ from transport is presented below. CO₂ efficiency is one aspect of a sustainable transport system in accordance with e.g. the definition by CST (2005), which states that a sustainable transport system:

- Allows the basic access needs of individuals and societies to be met safely and in a manner consistent with human and ecosystem health, and with equity within and between generations
- Is affordable, operates efficiently, offers choice of transport mode and supports a vibrant economy.
- Limits emissions and waste within the planet’s ability to absorb these, minimises consumption of non-renewable resources, limits consumption of renewable resources to the sustainable yield level, reuses and recycles its components, and minimises the use of land and the production of noise.

Some examples of policies and measures in local and regional use for reducing negative effects in the transport system, such as congestion and environmental effects, and for improving sustainability are: promotion of public transport (PT) and bicycle use, use of alternative fuels and/or vehicles, regulations and economic instruments, and infrastructure development.

Furthermore, the focus has recently shifted from moving goods and people to ensuring access to goods and services, as exemplified by the Avoid-Shift-Improve (ASI) approach (Dalkmann & Brannigan, 2007; RIO, 2012; IEA, 2013), which aims to:

- Avoid the need for unnecessary travel by providing improved access to goods and services, for example by integration of land use and transport policies
- Shift travel to the most efficient mode, which in most cases will be either non-motorised or public transport for passenger transport, and to rail or water transport for freight
- Improve existing forms of transport through technological improvements to make engines and fuels less carbon intensive.

Therefore, the concept of transport policy and measures also needs to be addressed, since there are different types of policies and measures that may affect the transport system. Policies and measures “within” the transport sector with the objective of changing and improving transport infrastructure and the conditions for transportation with different modes are commonly expected to result in changes in the transport system. However, there are many additional planning sectors within urban and regional planning that may have an influence over land use and therefore also indirectly over the transport sector and the transport system (see e.g. Robertson et al., 2013).
In this report, however, the main focus is on transport sector policies and measures, i.e. “Shift” and “Improve”, since in practice these are still in many cases the dominant measures applied to improve transport sustainability in cities. Some common Transport Demand Management (TDM) strategies aiming to reduce energy consumption and pollutant emissions from passenger and freight transport (Santos et al., 2010; Litman, 2014) are presented in Table 6. The inter-sectoral perspective, i.e. “Avoid”, is raised again in the discussion in Chapter 8. Possible and potential rebound effects of different policies and measures are discussed in Section 3.3.

Table 6. Examples of policies and measures applied to improve energy efficiency and to reduce emissions from transport.

<table>
<thead>
<tr>
<th>Passenger traffic and transportation</th>
<th>Freight traffic and transportation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Distance-based emission fees</strong></td>
<td>Gives motorists with higher polluting vehicles a greater incentive to reduce their mileage and, conversely, gives motorists who drive high mileage a greater incentive to choose low polluting vehicles.</td>
</tr>
<tr>
<td><strong>Fuel tax increases and carbon taxes</strong></td>
<td>Raising fuel price has two effects, it causes modest reductions in vehicle mileage, and over the long term encourages motorists to choose more fuel-efficient vehicles.</td>
</tr>
<tr>
<td><strong>Road pricing</strong></td>
<td>Examples of road pricing are toll roads and congestion charges</td>
</tr>
<tr>
<td><strong>Freight transport management</strong></td>
<td>For example improved scheduling and routing.</td>
</tr>
<tr>
<td><strong>Non-motorised transportation improvements and encouragement</strong></td>
<td>Cycling and walking can be particularly effective for energy efficiency and emissions reductions by reducing short motor vehicle trips</td>
</tr>
<tr>
<td><strong>Transit improvements and incentives</strong></td>
<td>A variety of strategies can encourage transit use, including increased service, more convenient and comfortable service, transit priority traffic management, lower fares, improved marketing, commuter incentives (such as employee transit benefits), improved pedestrian and bicycle access to transit stops.</td>
</tr>
<tr>
<td><strong>Ridesharing and high occupancy vehicle (HOV) priority</strong></td>
<td>High Occupancy Vehicles (HOVs) include carpools, vanpools and transit vehicles.</td>
</tr>
<tr>
<td><strong>Parking management and parking pricing</strong></td>
<td>Are effective ways to reduce automobile travel.</td>
</tr>
</tbody>
</table>

The policies and measures in Table 6 are just some examples. Additional voluntary measures for freight transport may be ecodriving, route optimisation and increased load factors (Mellin & Pyddoke, 2013). Similarly, there are also additional voluntary options for passenger transport, often addressed through mobility management measures (Litman, 2004).
As indicated above, for a number of years there has been growing consensus that developing infrastructure for motorised transport will lead to increased travel in any city (GTZ, 2004; Litman, 2014). Therefore, increased accessibility to road infrastructure and increased speed of travel may even reduce accessibility to destinations in the long run. Another consequence may be increasing travel distances, which may be referred to as a rebound effect (see further below).

Consequently, the spatial structure of urban areas, for example the density and mix of use and the spatial distribution of residential, work, shopping and leisure areas, will have a significant effect on the need for travel and travel distances (IEA, 2013; UN-Habitat, 2013). Trip generation is highly related to land use, as is modal choice, i.e. the choice to travel by e.g. car, public transport or a non-motorised mode (Robertson et al., 2013). Other relevant factors are the attractiveness of different transport modes and neighbourhood qualities.

Alleviating poverty is another complex and urgent requirement in any form of sustainable development including sustainable transport, especially in developing countries. According to Starkey & Hine (2014), there is evidence of significant benefits to e.g. agricultural production, public health, education and poverty alleviation from improving rural access, although no clear statistics are available. On the other hand, while rural road construction can directly benefit poor communities, urban transport development (such as new roads, metros, BRT) is primarily designed to reduce urban congestion caused by car use. The urban poor may benefit from transport investment, but they may also to a relatively high degree experience adverse effects from resettlement caused by road construction, as well as traffic-related pollution.

According to Bräuninger et al. (2012), policies and measures work differently in developed and developing countries. As an example, “Avoid” strategies can be more successful in developing countries, whereas in developed countries “Shift” strategies may be more relevant, since car use is already widespread. Furthermore, low income countries may endure financial restrictions and a lack of resources. Some examples of different city characteristics that may need different strategies for developing sustainable traffic and transportation according to Bräuninger et al. (2012) are presented in Table 7.

Table 7. Examples of city typologies that may require different strategies for development of sustainable traffic and transportation (as suggested by Bräuninger et al., 2012).

<table>
<thead>
<tr>
<th>City typology</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walking/Non-motorised cities</td>
<td>Shanghai in the 1980s</td>
</tr>
<tr>
<td>Motorcycle cities</td>
<td>HaNoi</td>
</tr>
<tr>
<td>Traffic-saturated motorcycle cities</td>
<td>Ho Chi Minh</td>
</tr>
<tr>
<td>Walking/Bus/Transit cities</td>
<td>Seoul, Manila in the 1970s</td>
</tr>
<tr>
<td>Traffic-saturated Bus/Transit cities</td>
<td>Bangkok, Jakarta, Manila</td>
</tr>
<tr>
<td>Transit cities</td>
<td>Hong Kong, Seoul, Singapore</td>
</tr>
<tr>
<td>Car cities</td>
<td>Houston</td>
</tr>
</tbody>
</table>

3.3. Rebound effects

Reducing GHG emissions or energy consumption within the transport sector is associated with achieving higher energy efficiency, reduced transport demand, changed transport habits or transport modality. Such transport changes will in general lead to lower energy consumption when other variables are kept constant and are therefore calculated to yield lower GHG emissions, for example in CDM or GEF projects. Unfortunately, measures, subsidies or policies implemented to reduce energy
consumption commonly cause increased energy consumption to various degrees through a behavioural response referred to as rebound effects (RE). The following sections discuss rebound effects in general and rebound effects within the transport sector and in developing countries in particular.

3.3.1 Definition of rebound effects

The paradoxical relationship between energy consumption and energy efficiency is called the rebound effect (RE). Rebound effects can be described as “the difference between the projected energy savings and the actual energy savings resulting from the increased energy efficiency” (Matos & Silva, 2011: p. 2834). The rebound effect (also called Jevons paradox) was first identified in 1865 by Jevons, who observed that technological improvements made the use of coal more efficient, but resulted in increased coal consumption (see e.g. Winebrake et al., 2012).

A rebound effect takes place since changes in policies or implemented measures or subsidies affect the price and usage of services or goods. Thus, improving energy efficiency may reduce energy costs and can increase energy consumption, thereby offsetting the reductions derived from technical progress or energy efficiency measures. It has therefore been argued that improvements in energy efficiency cannot reduce energy use (Khazzom, 1980).

Rebound effects are generally divided into direct, indirect and economy-wide rebound effects (for further details see Jägerbrand et al., 2014), but other divisions have also been suggested (Greening et al., 2000; Michaels, 2012). Direct rebound effects focus on single energy services and can be explained by the direct reaction of individuals or businesses to measures that aim at increased energy efficiency. They reflect the adjustment in consumption or production of services or goods as a response to improved energy efficiency (Michaels, 2012). There are multiple examples of direct rebound effects in the transport sector, the most common being that lowering the per-kilometre cost of driving due to increased fuel efficiency or lower fuel prices results in increased distance driven.

Indirect rebound effects involve re-spending money on other goods or services in the same sector that were saved due to the effects of improved energy efficiency (e.g. Nadel, 2012; Chitnis et al., 2013). An example within the transport sector is greater fuel efficiency of vehicles resulting in increased driving and increased demand for tyres (Michaels, 2012), with an indirect rebound effect for energy consumption in the production of tyres.

Economy-wide rebound effects are the spill-over effects of energy efficiency measures in other sectors than that addressed by energy efficiency implementation. The freed financial resources can thus be used for consumption of goods or services in other areas. An example from developed countries is that when daily transport becomes cheaper, it becomes possible to increase the length and distance of holiday travel. Such effects may lead to increased energy consumption and further increased energy use, for example in other transport modes and areas.

Rebound effects may also result in substitution effects, where a lower price of a service or good results in higher consumption of the service or good in question, while the consumption of other goods and services is reduced. This is especially relevant when considering the decisions of individuals or households.

Direct rebound effects have been widely studied, even within the transport sector, whereas indirect and economy-wide rebound effects have been studied to a much smaller extent, particularly within the transport sector. Therefore the remainder of this section mainly focuses on direct rebound effects.

The rebound effect can be defined by a simple equation (Haas & Biermayr, 2000):

\[ \text{Rebound effect (RE)} = \frac{\text{Expected savings} - \text{Actual savings}}{\text{Expected savings}} \times 100\% \]

For example, RE is 60% when a 10% engine improvement is achieved and there is a 4% decrease in fuel use, because \( \text{RE} = \frac{(10-4)}{10} \times 100\% = 60\% \) (Nadel, 2012). Consequently, in this case RE of 60%
means that 60% of the expected energy savings is offset by the increased fuel consumption and only 40% energy efficiency is actually realised. If RE is >100% and the improved energy efficiency leads to increased energy consumption, this is called a backfire effect (Winebreak et al., 2012). If RE is <0% and the actual energy savings are more than predicted, this is called super-conservation (Saunders, 2008).

3.3.2. Rebound effects in the transport sector

A review covering rebound effects within the transport sector (i.e. vehicle and fuel shifts, aviation, freight and waterborne transport, technological developments, artificial lighting and indirect and economy-wide rebound effects) has shown that while some areas have received much attention, others have been less well studied (Jägerbrand et al., 2014). The following areas have been identified as lacking substantial information on rebound effects: aviation, waterborne transport, transport planning, indirect rebound effects, time dimensions of rebound effects and transport, and aspects of human behaviour and transport.

The main findings of the review by Jägerbrand et al. (2014) were that for measures addressing passenger transportation, the direct rebound effect usually ranged between 10-70% in Europe and 10-30% in the USA, and that in developing countries with a large unmet demand for energy, high rebound effects or even backfire effects are common. For freight transport, the few studies available indicate rebound effects of 13-22% or 12-45% depending on the time frame of the studies. Economy-wide rebound effects vary between 10-100% (but are probably less than 100% most of the time) (Jägerbrand et al., 2014).

The rebound effects and their magnitude depend on data quality, time scale, geographical scale, economic conditions and study boundaries, with no current commonly agreed methodology for measuring rebound effects (except as RE in %). Therefore, rebound effects of transport measures will exist to varying degrees and there is a high risk of transferring the energy consumption into other transport areas, sectors or services when implementing such transport measures or policies. This will result in lost or underestimated energy savings, but may also lead to increased energy consumption.

3.3.3. Rebound effects in developing countries

Rebound effects in developing countries are an important aspect, since their use of fossil fuel for transportation is predicted to increase with rapid population increases and economic growth. Direct rebound effects of increased fuel efficiency in India and China are estimated to be between 96% and 107%, according to a review of rebound effects in different sectors and countries by Chakravarty et al. (2013). Detailed studies on rebound effects in the transport sector in developing countries are few and concentrate on China (e.g. Wang et al., 2012; Lin & Liu, 2013; Yu et al., 2013; Wang & Lu, 2014) and India (Roy, 2000).

In India, Roy (2000) analysed fuel price and price elasticity (1973, 1974 and 1989-1990) and concluded that due to the large unmet demand in the transport sector, “any technological improvement in the privately owned vehicles is argued to push the driving demand up, thereby generating a very high rebound”. However, that study also found that the rebound effects of fuel used for public transport, freight movement and air transport were low and concluded that the energy demand of activities and transport will produce large rebound effects when the demand is high.

Rebound effects are common in China and the average estimated effect is between 30-50% for all sectors, not only transport (see Hong et al., 2013). A study evaluating direct and indirect rebound effects in household energy consumption behaviour showed that the average direct rebound effect of cars in Beijing was 34% (Yu et al., 2013). In urban China, Wang et al. (2012) found that the direct rebound effect of passenger transport was 96% and pointed out that since China is still a developing country, demand for passenger transport services is far from being satisfied. The direct rebound effect
varied greatly depending on the region, from 2% to 246%, and the rebound effects also generally declined with an increase in per capita expenditure so that regions and households with higher per capita expenditure also had lower direct rebound effects (Wang et al., 2012). However, since the rebound effects were very high, most energy reductions from energy efficiency improvements would be offset.

Lin and Liu (2013) studied the energy rebound effect of passenger transportation in China by a linear approximation of the almost ideal demand system model (LA-AIDS model) and the effect of a refined oil pricing mechanism. They found that the rebound effect was 107%, i.e. there was a backfire effect, which they attributed to declining transport prices, inflexible refined oil prices, lack of consumer awareness of energy efficiency, residential demand for traffic services, and the fact that China is a developing country. If the refined oil pricing mechanism is reformed, the rebound effect is estimated to decrease to about 90%.

According to another study (Wang & Lu, 2014), the long-term rebound effect of Chinese road freight transport is on average 84%, but differs between eastern (52%), western (78%) and central regions (80%). However, in a very short-term perspective, the rebound effect of road freight transport in that study was found to be negative (super-conservation effect).

To summarise, based on the few studies available, energy saving or efficiency measures in the transport sector in developing countries can have rebound effects or backfire effects of much larger magnitude than those observed in developed countries in Europe or the USA. Large rebound effects or backfire effects tend to arise when there is an unmet or unsatisfied demand for transportation. Consequently, it is highly important to ensure that measures, policies or energy efficiency improvements take the risk of rebound effects or backfire effects into account.

3.4. Summary and conclusions

Transport systems in different countries, regions and cities, developed and developing, display both similarities and differences. Some components, for example many transport modes are present in all systems, but the use of different modes may vary widely, and not all modes are present everywhere. These differences are at least partly due to highly variable socio-economic conditions, but also to different cultural development patterns. Based on if the aim of policies and measures is to avoid transport, to lead to a shift to more sustainable transport or to improve existing modes of transport, it has been suggested that there may be better potential for “avoid” strategies in developing than in developed countries.

The types of policies and measures that may be used for developing more sustainable transport are also similar, but again the potential of different actions may be highly dependent on the preconditions in each specific situation. Policies and measures need to be considered with respect to medium- and long-term rebound effects in all types of countries and areas, but especially in developing countries. For example, direct rebound effect vary greatly from region to region, but generally decline with an increase in per capita expenditure. Regions and households with lower per capita expenditure therefore also generally have higher direct rebound effects due to for example to a large unmet demand for transportation (Wang et al., 2012).
4. Measuring traffic and transportation

4.1. Background

In order to understand and manage local and regional transport systems, measuring different characteristics is a requirement, for example for detecting transport patterns or demands in a specific geographical area that are not visible in agglomerated data. The use of indicators is motivated by the need to aggregate data and information in a comparable manner in order to use it in different contexts, for example local and regional planning and evaluations of policies and measures. Either *top-down* or *bottom-up* methods may be used, or both (Blok et al., 2001). Bottom-up methods in particular require complex data and information, for example about traffic volumes, the relative use of different types of transport modes, the use of types of vehicles and fuels, and modal split.

Based on mapping of available data, the concept of local and regional transport indicators is elaborated upon below. Possibilities and difficulties in evaluating local and regional transport policies, measures and indicators are identified, with the focus on urban traffic and transportation and the availability of quantitative data, covering both passenger and goods traffic and transportation. This chapter is largely based on Robertson et al. (2015).

4.2. Systems boundaries

As mentioned above, transport systems are very complex and a number of systems boundaries need to be identified and defined. First, there are two parallel transport systems, which may to some extent be integrated, i.e.:

- Transport of passengers
- Transport of goods.

Both passenger and goods transport can be measured or estimated with respect to transportation (number of passengers, tons of goods, passenger-km, ton-km) and traffic volumes (vehicle-km). The latter is the most relevant with respect to carbon dioxide emissions.

Estimates of transportation and traffic volumes also need to be related to a geographical systems boundary, for example local, urban, regional and/or national. The transport system geographical boundary can be defined in two alternative ways, either as the total transport work or as traffic volume:

- *performed* in a defined geographical region, or
- *generated* by passengers and other actors living or based in a defined geographical region (Figure 2).

Measurements and estimates of local and regional transport activities, such as baselines, effects of project-based measures and actions and sectorial measures, need to be analysed and estimated from a defined geographical systems boundary.
Figure 2. Illustration of possible transport system boundaries.

Performed local and regional traffic and transportation are commonly used indicators representing local and regional traffic and transportation. One problem with this concept is the limited availability of statistics that represent these indicators. Instead, traffic and transportation models must be used. Generated local and regional traffic and transportation is performed by residents and other actors in the area. It is to a large extent performed in the area, but some is performed outside the region. Indicators can be calculated using statistical local and regional data. The smaller the area, the greater the differences between the indicators of performed and generated traffic and transportation. With decreasing area size, the share of intra-area traffic and transportation decreases and the proportion of traffic to, from and through an area generally increases.

Whether performed or generated local and regional traffic and transportation is most suitable for use in evaluations of effects depends on the type of measure or policy introduced. Mobility management measures are probably best evaluated from the perspective of passengers and actors resident in a region (generated traffic), whereas some infrastructure measures would be best evaluated from the perspective of the total transport/traffic (performed) in a defined region. For example, for evaluating the effects of infrastructure measures or policies such as improved roads or modified traffic control, performed regional traffic indicators would be adequate, since all traffic in the area is affected. Some local and regional mobility management measures that are directed towards inhabitants in the area, on the other hand, should preferably be evaluated using generated regional traffic and transportation. For example campaigns aiming at increasing public transport in the region would also extend outside the region. The best indicator to use needs to be decided in every specific case, but some general guidelines are provided below.

4.3. Traffic and transportation data and information in Sweden

As a reference for MRV of transport activities/measures in developing countries, the availability of data regarding road transport, with examples from Sweden, is described below as an illustration of different options for data collection. Data availability is also illustrated, as a basis for analyses of the options for MRV of transport measures. National, local and regional absolute data, sample surveys and modelling are addressed.
4.3.1. Absolute data and information

Absolute data and information can be obtained from registries and complete surveys and at least supposedly include all data and information about the study object. This has the advantage that there are very few restrictions regarding the ability to further group and analyse the data.

National Road Database

Information about the road network is needed for model calculations of traffic and transportation. The Swedish Transport Agency keeps a National Road Database that includes all public and private roads and streets in Sweden. Also the bicycle network is included although this information may not be complete. The database includes data on e.g. lengths of different types or categories of streets, roads and networks, road width, surface quality, presence of railings and speed limit.

National Vehicle Register and Vehicle Inspection Register

A Vehicle register that includes all registered vehicles provides a good basis for aggregated analyses of travel and transportation with different categories of vehicles, especially for vehicles that are regularly inspected (see below) and mileage recorded. The Swedish Motor Vehicle Inspection keeps a register that includes annual distance driven for all vehicles (cars, buses, lorries, motorcycles) that are in active use.

In Sweden, all cars, motorcycles, mopeds (class 1), buses, lorries, working machines etc. are registered, including specifications about the vehicle and geographical location of the owner. Examples of the data available (on Swedish-registered vehicles) are: brand, model, fuel type, engine power and environmental class. National, local and regional evaluations of generated traffic can be developed based on this information. However, it cannot be deduced from the data where the vehicle was driven and some bias may be caused by assumptions regarding mileage during the first three years of new cars, when inspection is not required.

Public transport data

Statistics about the total numbers of passengers and distances travelled with regular PT (by bus, train, tram, metro and ferry) are collected from the local/regional operators every fourth year, but only on regional level. Data on non-regular public transport, such as school buses, are collected separately. Data available are number of trips, passenger-km, vehicle-km, seat-km and economic variables. This information has high availability in Sweden, since most PT is publicly procured, but a smaller fraction is delivered by commercial operators and therefore not available. The data represent volumes of traffic and transportation performed locally and regionally, but do not include information about travelling in different areas in a city.

National statistics about rail traffic and transportation by national operators include annual number of journeys, quantity of goods and transport performance (passenger-km and ton-km). Local and regional data are not publically available for this traffic.

4.3.2. Sample surveys

Sample surveys are based on random sampling of relevant data and information, assumed to be representative of the entire population. The statistical foundation is therefore highly important for the quality of the data collected. The level of detail or disaggregation of data possible is related to the number of samples collected in relation to the population and to the variability in the data.

Travel surveys

Travel surveys (TS) designed to deliver statistically significant results are very useful for evaluating travel habits, requirements, trends and modal split regarding passenger transport. A national travel
survey (NTS) is carried out in Sweden at irregular intervals. The NTS provides generated passenger travel statistics on a national level and shows the time and purpose of the travel, as well as the travel mode/s used. The Swedish NTS is carried out during a number of specific days and it includes questions about people’s daily travel, time at which the journey was undertaken, transport mode used and reason for the trip. The data usually cannot be used for local evaluations.

Local and regional travel surveys (LRTS) are performed by e.g. municipalities in order to determine the generated travel habits and requirements of their residents and to evaluate the frequency of use of different travel modes (modal split). The methodology used may vary, however, and LRTS are carried out at irregular intervals and with no national coordination. The possibility to compare results and data may therefore limited (Niska et al., 2010). Travel surveys are very useful for evaluating traffic and transportation generated in a specific area, but there is also a risk of misinterpretation of the results since they are very complex and the raw data must be carefully aggregated into indicators. There is also a risk of bias caused by missing data.

Road freight survey
In Sweden, official national statistics on generated domestic and international road freight transport with Swedish-registered vehicles are collected and published annually. Data and information are collected through a continuous survey which includes about 12 000 vehicles (from a total of about 56 000) annually. The data include vehicle data, kilometres driven, amount of loaded goods and ton-km.

The road freight survey may lead so some underestimation of traffic and due to biases in the reported data from the carriers and to varying quality of the data reported. Freight data are not available locally or regionally.

Traffic flow data
Traffic counting of performed traffic is carried out nationally on the Swedish road network, in a rolling schedule. Some roads are monitored year-round for a number of years, but for most monitored roads a random sampling strategy for a short period is applied. Different categories of vehicles can be distinguished, but numbers of passengers and loading data (transportation) cannot be registered.

Traffic counts can also be made locally and regionally, by the local or regional authority. In order to extrapolate from traffic counts to performed traffic in a specific geographical area, the statistical design of the measurement programme is crucial.

4.3.3. Model calculations
As a complement to absolute and sample data, modelling is used for calculating the effects of different measures and policies on national, regional and local passenger and freight traffic and transportation and for developing forecasts of future traffic and transportation. Models may be used both for estimating performed and generated traffic and passenger and freight transportation. In Sweden, different national, local and regional models are used for estimating future traffic and transportation. The reliability of traffic and transportation modelling output is related to the quality of the input data, the quality of the relationships used in different sub-models and the assumptions applied, e.g. regarding future growth.

Depending on the objective, different methods may be used for estimating emissions of CO₂ from traffic. Top-down calculations based on aggregated data or statistics on fuel consumption and average emissions factors can be used, e.g. for estimating national emissions or for evaluating bottom-up calculations (Blok et al., 2001). Bottom-up calculations need to be used for evaluation of local measures and policies. The main use of modelling is, however, in planning where evaluations and estimations of effects on traffic and transportation of policies and measures are of interest.
Unfortunately, sales statistics for fuels are not available locally or regionally, which makes it difficult to follow up on the use of alternative fuels. Calculations based on vehicle data are also uncertain, since engines often run on several fuels.

4.4. Summary and conclusions

Data and information about national, local and regional traffic and transportation can be extracted and developed using different methods and with different characteristics. Some data may be extracted from registers that are more or less complete or absolute, such as vehicle registers. In some cases vehicle inspections may be used for adding data such as mileage to basic registry data. This type of data may also be extracted for specific local and regional geographical areas to produce generated traffic data (i.e. traffic generated by vehicles registered in the geographical area).

Unfortunately, no comprehensive methods or databases exist for obtaining transportation data, either of passengers or of goods. In order to obtain such information, statistics from operators need to be collected or survey methods can be applied. Statistics need to be carefully evaluated to avoid or correct for biases in the reported data. Some complementary data collection or development is also required, since not all relevant modes are included in such statistics. For example, data on passenger transportation by private cars, bicycles and walking are only available through surveys.

Travel surveys are the most comprehensive and flexible method for analysing transportation behaviour and modal split and they can be designed to cover different geographical areas, from local to national. However, they need to be carefully designed in order to deliver statistically significant data. Moreover, interpretation and presentation of the results is critical, because of the complexity of the data.

Modelling can be used to complement other data extraction methods and is primarily used for scenario and prognosis development and analyses of traffic and transportation effects of policies and measures.
5. Traffic and transportation data availability in developing countries

A sample survey was carried out in the present study in order to evaluate the availability of data and information regarding traffic and transportation in five developing countries: Colombia, Brazil, Mexico, Thailand and Vietnam. These countries were chosen to include developing countries of different population sizes, cultural backgrounds and stages of economic development (Table 8). The countries represent lower middle income and higher middle income countries according to the World Bank classification.

Table 8. Population, gross national income (GNI) and total CO₂ emissions in the case study countries

<table>
<thead>
<tr>
<th></th>
<th>Colombia</th>
<th>Brazil</th>
<th>Mexico</th>
<th>Thailand</th>
<th>Vietnam</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population, total 2013 (million)</td>
<td>48</td>
<td>200</td>
<td>122</td>
<td>67</td>
<td>90</td>
</tr>
<tr>
<td>Population, largest city 2013 (million)</td>
<td>9</td>
<td>21</td>
<td>21</td>
<td>9</td>
<td>7</td>
</tr>
<tr>
<td>GNI per capita 2013 (US$)</td>
<td>7560</td>
<td>11690</td>
<td>9940</td>
<td>5370</td>
<td>1730</td>
</tr>
<tr>
<td>CO₂ emissions 2010 (metric tons per capita)</td>
<td>1.6</td>
<td>2.2</td>
<td>3.8</td>
<td>4.4</td>
<td>1.7</td>
</tr>
</tbody>
</table>

For comparison, Sweden, which is a high income country, has a total population of 10 million, the population in the largest city is 1.4 million, the GNI per capita is US$ 59240, and CO₂ emissions per capita are 5.6 metric tons. In population terms, Sweden is a relatively small country, but its GNI per capita is significantly higher and the CO₂ emissions per capita are high compared with the five case study countries (Table 8). However, compared with other developed countries, the CO₂ emissions per capita in Sweden are low or very low.

Information about traffic and transportation data availability was collected with assistance from consultants with transport expertise in the different case study countries, using a template as a guide (Appendix 1). The template included the following subject areas:

- Carbon dioxide inventories and reporting
- Vehicle data
- Fuel consumption
- Passenger transport
- Freight transport.

Data availability on national, local and regional scale was addressed, focusing on road and rail traffic and transportation.

5.1. Carbon dioxide inventories and reporting

All five case study countries are non-Annex 1 parties to the UNFCCC. This means that they submit national communications only upon availability of financial resources. All of the case study countries have submitted one or several national communications, and at least one since 2010 according to the UNFCCC database (http://unfccc.int).

Local and regional inventories also exist and are reported for four of the five case study countries. Since there are no mandatory regulations on reporting, local and regional inventories are based on
different non-mandatory ambitions. Some examples of cities and regions that have produced inventories are Bogota and Cundinamarca (Colombia), Sao Paulo, Rio de Janeiro and Belo Horizonte (Brazil), Mexico City (Mexico), and Khon Kaen city and Klang city (Thailand).

Examples of data used for the transport sector inventories are: current fleet, fuel consumption and emissions factors (Sao Paulo and Rio de Janeiro). Data from companies may also be used (Mexico City). It is worth mentioning that Mexico City updates the information every two years and has a standardised methodology for reporting. For Thailand, it is reported that different organisations and companies are aware of their GHG emissions and interested in calculating carbon footprint for their own products and services. One example from Vietnam is a GHG inventory for the cement sector that is presently under development by the Ministry of Natural Resources and Environment.

5.2. Vehicle registers, mileage and emissions factors

Vehicle registers are kept in all case study countries, although the models and systems for data collection vary. The register is commonly kept under the Ministry of Transport or equivalent, but there are also other solutions, such as the statistics bureau. Examples of categories of vehicles used in the different case study countries are presented in Table 9. Similar, but not identical categories are used in the different countries. Data collection, on the other hand, is usually compiled in different states or regions and reported to the central authority. This may cause difficulties with respect to quality assurance, since different regions may apply different methodologies, which in turn may generate errors. Data and information about vehicles may be based on sales statistics compiled by the automotive industry or equivalent, but it can also be collected by local authorities, which in some cases may engage private consultants. However, there are also systems based on vehicle owners’ reporting of new vehicles.

In order to estimate the current fleet, a scrapping curve is needed to obtain the contribution rate of each type of vehicle to the fleet in operation in a particular year. The scrapping rate is based on an estimate of the life length of different vehicles.
Table 9. Examples of categories of vehicles used in registries in the different case study countries.

<table>
<thead>
<tr>
<th>Colombia</th>
<th>Brazil</th>
<th>Mexico</th>
<th>Thailand</th>
<th>Vietnam</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automobile</td>
<td>Categories:</td>
<td></td>
<td>(A) Vehicle under Motor Vehicle Act</td>
<td>Types of vehicles in the transportation system are categorised by:</td>
</tr>
<tr>
<td>Compact van (Utilitario)</td>
<td>• Heavy-duty vehicles</td>
<td></td>
<td>A.1 Sedan (Max. 7 pass.)</td>
<td>• Personal car and classification according to number of seats</td>
</tr>
<tr>
<td>Camper (Camperio)</td>
<td>• Light-duty vehicles</td>
<td></td>
<td>A.2 Microbus, passenger van</td>
<td>• Bus</td>
</tr>
<tr>
<td>Taxi</td>
<td>• Motorcycles</td>
<td></td>
<td>A.3 Van, pick-up</td>
<td>• Truck</td>
</tr>
<tr>
<td>Van</td>
<td>National statistics include:</td>
<td></td>
<td>A.4 Motor-tricycle</td>
<td>• Special vehicles</td>
</tr>
<tr>
<td>Microbus</td>
<td>• Passenger car</td>
<td></td>
<td>A.5 Interprovincial taxi</td>
<td>• Others</td>
</tr>
<tr>
<td>Small bus (Buseta)</td>
<td>• Compact van</td>
<td></td>
<td>A.6 Urban taxi</td>
<td></td>
</tr>
<tr>
<td>Bus</td>
<td>• Truck</td>
<td></td>
<td>A.7 Fixed route taxi</td>
<td></td>
</tr>
<tr>
<td>Pick-up</td>
<td>• Small truck</td>
<td></td>
<td>A.8 Motor-tricycle taxi (Tuk Tuk)</td>
<td></td>
</tr>
<tr>
<td>Truck (Camione)</td>
<td>• Trailer</td>
<td></td>
<td>A.9 Hotel taxi</td>
<td></td>
</tr>
<tr>
<td>Small truck (Camioneta)</td>
<td>• Pick-up</td>
<td></td>
<td>A.10 Tour taxi</td>
<td></td>
</tr>
<tr>
<td>Dump truck (Voloqueta)</td>
<td>• Moped</td>
<td></td>
<td>A.11 Car for hire</td>
<td></td>
</tr>
<tr>
<td>Trailer</td>
<td>• Bus</td>
<td></td>
<td>A.12 Motorcycle</td>
<td></td>
</tr>
<tr>
<td>Unclassified</td>
<td>• Micro-bus</td>
<td></td>
<td>A.13 Tractor</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Motorcycle</td>
<td></td>
<td>A.14 Road roller</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Scooter</td>
<td></td>
<td>A.15 Farm vehicle</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• ATV</td>
<td></td>
<td>A.16 Automobile trailer</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Sidecar</td>
<td></td>
<td>A.17 Public motorcycle</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Tricycle</td>
<td></td>
<td>(B) Vehicle under Land Transport Act</td>
<td></td>
</tr>
</tbody>
</table>

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As an example of a vehicle register, the following data are available in the Vietnamese vehicle register:

- Vehicle usage (km per year) by years of operation (survey)
- Vehicle ownership (number of vehicles per province, per type)
- Active vehicle population and use (survey)
- Vehicles per fuel type
- Vehicle age
- Vehicle mileage (survey)
- Vehicle emissions (survey)
- Vehicle emissions in accordance with national standards
- Vehicle compliance with EURO emissions control standard
- A number of parameters relevant to vehicle inspection and certification, such as: production year, country of origin, permissible loading capacity, gross and tare weight, wheel base, tyre specifications, engine capacity.

As indicated in the list, some variables are collected using survey methodology.

**Emissions of CO₂** from the transport sector may be calculated in a top-down manner, based on national sales or consumption of fuels. Evaluations of effects of local actions and measures, however, may need to be evaluated through bottom-up methods. In order to identify e.g. the effects of shifts in type vehicle use or modal shift, bottom-up calculations based on information about e.g. vehicle fleet composition, mileage for different types of vehicles and relevant emissions factors are required.

**Data on mileage** for different categories of vehicles generally seem to be very poor, although systems for vehicle inspection are successively being developed. One alternative for generating mileage data is by surveys, for example as applied in Vietnam. Through the vehicle testing and certification programme, data on a number of parameters are collected. However, mileage, emissions and safety are determined based on an annual sample with a limited number of cars (by a Type Approval Centre). In recent years, 1000-3000 cars have been surveyed annually to determine emissions and mileage. No information about the risk for sample bias was provided.

In general, national statistics regarding national fuel consumption for different modes of transport (road, rail, etc.) are available. The dominant fuels are:

- Diesel (mainly heavy-duty vehicles)
- Petrol (mainly light-duty vehicles)

but smaller amounts of:

- Ethanol bio-fuel (5% ethanol, 95% diesel oil or petrol)
- Compressed natural gas (less than 5% of the total national fleet)
- Liquefied petroleum gas (less than 5% of the total national fleet)

are also used, although the use varies between countries. There are also blends of diesel and biodiesel (for example 95% diesel and 5% biodiesel). Data on fuel consumption on regional or local level are not available, but data on energy consumption by type of vehicle may in some cases be collected from transport companies and other companies.

Data on emissions factors or emissions rate per kilometre for different modes or categories of vehicles (for CO₂, CO, NOₓ, HC, CH₄, PM, SO₂) are generally obtained from the vehicle manufacturers, who are obliged to provide this information, or in specific projects. For example, emissions tests are carried out annually on samples of vehicles and emissions factors for major emission pollutants are calculated by vehicle types, for example light-duty vehicle, heavy-duty vehicle or motorcycle. Tests are usually carried out to obtain emissions factors under typical driving cycles.
Annual national bottom-up calculations of emissions of carbon dioxide are based on data on the current vehicle fleet and emission factors, although such data may be very uncertain due to a lack of availability of mileage data for different vehicle categories. There are also examples of cities that develop emissions inventories that are based on statistics about the existence of vehicle categories, mileage and emissions factors. Such inventories may be used for rough assessments of total emissions, whereas they would be too uncertain for evaluations of effects of measures and actions.

5.3. Passenger transport data

Information and data about passenger transport may be collected through travel surveys and from operators providing public transportation. Both methods need careful design and evaluation of the data and information collected. Both methods are used in the case study countries.

For example in Colombia, the SISETU (Sistema de Información, Seguimiento y Evaluación del Transporte Urbano) database was developed to provide an overview of urban transport in cities around the country and as a tool for inquiry and report indicators of urban public transport. The database was initiated with data from cities with BRT systems, but it is anticipated that in the future new cities will be incorporated into this information system. Each transmission operator entity has to report information regarding the indicators requested by the Ministry of Transport quarterly or annually, depending on the indicator. The following indicators are included in the database:

- Travel generalised cost
- Travel generalised cost for people with low income (strata 1 and 2)
- Transit service quality
- Average transit time for people with low income (strata 1 and 2)
- Mass transit service quality for vulnerable people
- SITM (Sistema Integrado de Transporte Masivo) user proportion with access to private vehicles
- Passengers using private vehicles in mixed traffic lanes in mass transit corridors
- Private vehicle average time in mixed traffic lanes in mass transit corridors
- Transit accidents per million passengers
- PM$_{10}$, O$_3$, SO$_2$ and SO$_2$ emissions
- IPK, passengers per kilometre
- Transit fee
- Transit daily incomes
- Mass transit operation cost per kilometre
- Mass transit occupancy
- Transit volume on parallel roads
- Transit occupancy on parallel roads
- Mass transit travel time
- Low income people’s access to the transit
- Mass transit operating subsidy
- Mass transit passenger proportion using feeder buses
- Passengers per square metre in mass transit waiting areas
- Mass transit vehicles per hour
- Passengers using mass transit per hour.

The data entered are not complete, however. Problems with the website have resulted in some data being reported by other methods. Furthermore, some of the indicators requested by the Ministry of Transport are not the responsibility of the management bodies, so they are unable to collect this information. Another problem is that each city develops its own methodology to collect the data and
no standardised methodology is used. This is a problem, because the resulting information for the indicators is not comparable between cities. The same applies for the travel surveys.

Brazil has no national travel survey, but is planning to create one. Data collection regarding public transport is carried out by the National Association of Public Transport through a questionnaire and by personal contact with around 60 cities. The response rate is about 40%. Some data considered essential are therefore estimated based on the information provided by cities that answered the questionnaire.

Information about BRT travel is collected by BRTdata.org directly from cities with priority lanes for buses (through contact with the Transit Agency and/or city officials), official websites and documents. The data are based on measurements, surveys and statistics (in a quality assurance process the data are compared with data from similarly sized cities. If there are significant differences, the information is double-checked with the city responsible. The following indicators are included:

- Passenger transport
- Infrastructure (length, stations)
- Standard fare
- Vehicle fleet
- Commercial speed and frequency.

For the purposes of estimating travel by mode and travel time, a number of models using socio-economic variables are used. The basic model functions have been developed considering the trips obtained in an origin-destination travel survey of the Metropolitan Region of São Paulo and a set of socio-economic information for all modes (rail, bus, taxi, cars, non-motorised). The following indicators are used:

- Trips by mode and by city category
- Modal share for all city categories
- Distance travelled by users by mode, by city category
- Travel time by mode and by city category
- Mobility index by mode and by income
- Energy consumption by mode
- Total emissions per passenger and per modal share
- Mobility costs per habitant by mode and by city category.

In addition, household surveys are conducted by IPEA (Brazilian Research Institute of Applied Economic) in 212 cities to obtain information about the travel behaviour of neighbourhoods.

In Mexico, basic statistics on passenger and freight road transport are collected by the National Ministry of Communications and Transport (SCT). Local and regional passenger transport (number of passengers per month) is surveyed in three cities (bus and rail). The data are collected through a questionnaire for electric transport and the passenger transport network. The information is collected statistically with specific parameters defined by the National Institute of Geography and Statistics (INEGI), which collects the data in order to assure the quality. However, there is a lack of information, since only three cities are considered in the collection.

Mexico has no national travel survey, but a few specific cities have conducted local travel surveys. Each state or municipality operates and manages its own public transport system and the information derived from it, so it is difficult to gather the information at a national level. Moreover, the information often does not exist locally.

In Thailand, data about vehicle-km travelled (VKT) and passenger-km travelled (PKT) on national highways are collected by the Department of Highways (DOH) within the Ministry of Transport,
which reports annual average daily traffic (AADT), categorised by vehicle type, on the highways every year. However, information about average vehicle occupancy is based on data from 1994.

Data on the number of public bus passengers in Bangkok are collected annually using a questionnaire from the Bangkok Mass Transit Authority (BMTA), a state-enterprise bus operator in Bangkok and surrounding provinces, and from the Department of Land Transport (DLT), Ministry of Transport, which is responsible for intercity bus routes and servicing bus terminals. Information about fleet, number of trips, service kilometres, fuel consumption, number of tickets etc. can be obtained from annual reports. Data on the number of bus passenger trips by private bus companies are not collected regularly and no statistics are available from other cities.

Data on the number of rail passengers are collected annually by the State Railway of Thailand (SRT), which operates nation-wide railways, and three mass rapid transit (MRT) operators in Bangkok. The statistics on number of rail passengers are collected through ticket sales for SRT and automatically recorded through electronic gates for the MRT systems.

Aggregated data are available for passenger transport in Vietnam. The available statistics distinguish between the number of passengers and km travelled per province by four modes of transport (railway, road, waterway and aviation). Bus operators are required to report information on trips made, distances travelled and passengers transported to the local government (Department of Transport). However, after reporting the data are not published or further analysed. No data are collected with respect to fuel consumption, CO₂ emissions or fleet information on public transport by road or rail. Statistics per vehicle type are not available. The data are collected by the local Department of Statistics in each province or city using report templates and then submitted to the General Statistics Office of Vietnam periodically. There is no national travel survey to collect passenger transportation data.

For public transport, the basis for calculation of number of passengers transported is (bus) ticket sales per route and the data only cover passenger transport conducted through licensed transportation companies. In the case of the public bus operators, the number of passengers transported directly affects the subsidies they obtain from the local government. Hence, it is possible that public bus operators provide an overestimate of the actual passengers transported. Private passenger transport companies are only allowed to transport passengers using vehicles that are approved/licensed by the local Department of Transport. However, it is possible that they operate additional vehicles. Transport using these vehicles would not be reported. It is also possible that private companies subcontract part of the work to other not-licensed companies that go unreported.

5.4. Freight transport data

In Colombia, the SIRTCC (Sistema de información para la regulación del transporte de carga por carretera) freight database, under the Ministry of Transport, includes the following indicators:

- Type of good transported (weight, volume, description)
- Trip origin
- Travel destination
- Distance between trip origin and travel destination
- Vehicle description
- Start time travel
- End time travel
- Travel fee.

Carriers are required to report freight transport to the SIRTCC database, but not all the freight transport companies upload their freight manifesto online, so the system only has approximately 30% coverage.
In Brazil, the annual *statistics* report of the ANTT (National Agency of Land Transportation) on road transportation of goods includes vehicle fleet (age, type) and purpose of trips. Rail transportation of goods reporting includes infrastructure (length in km), number of accidents, fleet and investments. All data obtained from the database are provided by the mandatory registration of carriers and vehicles. The report does not provide information about traffic and transport.

The National Ministry of Communications and Transport (SCT) collects *basic statistics* on freight road transport in Mexico. It includes the following information for heavy-duty vehicles in a federal register:

- Fleet by type of vehicle and age
- Number of vehicles/usage (dangerous substances and materials, cranes, freight, passengers, etc.)
- Number of vehicles per state
- Tons transported (ton-km).

The volume of freight transport in Thailand is estimated based on *survey data* collected by the Department of Land Transport (DLT) 10 years ago. The data include volume and origin-destination of goods transport by type of goods. The data quality highly depends on whether the assumptions used in forecasts based on the 10-year-old data are valid.

The volume of freight in Vietnam is based on *statistics* reported by transportation operators, combined with customs data for maritime transport. The primary parameters reported are:

- Total volume of freight per year per province (in tons)
- Total volume of freight per year, per province, per type of transport (railway, road, inland waterway, maritime transport) (in tons).

The current reporting structure for data and/or statistics for road, rail and boat are based on reporting templates and decisions/regulations from the central government. At local government level, some statistics are collected, but not actively published. No secondary data, such as fuel consumption, distances travelled or emissions data, are reported. The data do not include transportation of freight by other enterprises (e.g. vehicles owned by companies to transport their own products). The Department of Transport also performs annual surveys to confirm the accuracy of the reported figures.

Similarly to passenger transport, freight transporters in Vietnam are only allowed to use vehicles or vessels that are approved/licensed by the local Department of Transport. However, it is possible that they operate additional vehicles or that work is subcontracted to other parties. Transport using these vehicles would not be reported.

### 5.5. Summary and conclusions

In conclusion, data and information about traffic and transportation are available to some degree in all five case study countries (Colombia, Brazil, Mexico, Thailand and Vietnam). However, the coverage and quality of the data seem to be very variable. This was also the conclusion of SLoCat (2010).

All five countries run vehicle registries, although there may be ambiguities, primarily regarding scrapping. There may also be significant shares of motorised vehicles that are not required to be registered in developing countries. Mileage data seem to be lacking to a large extent, e.g. vehicle inspection may be done mainly through spot checks and usually does not include recordings of mileage.

Passenger traffic and transportation is usually recorded to some degree, for example information about the number of trips with BRT or other bus systems may be collected from operators, but a complete set of data is generally lacking. Trip length is not known, for example. The data reported may also be uncertain. Some local or regional travel surveys of unknown quality are reported, but national travel
surveys are generally lacking. Information may therefore be lacking on travel by car, motorised two-wheelers, cycling and walking, and also regarding travel not reported by bus operators. Similarly, data regarding freight traffic and transportation are highly uncertain. The possibility to use the available traffic and transportation data and information for evaluations of policies and measures is discussed in Chapter 8.
6. Capacity for greenhouse gas performance tracking in developing countries

The aim of the recent World Resources Institute (WRI) project Measurement and Performance Tracking (MAPT) was to contribute to building the capacity to measure GHG emissions within developing countries, including the transport sector. The current situation was studied in six developing countries (Colombia, Brazil, Ethiopia, South Africa, Thailand, India) and capacity needs were identified (MAPT, 2014). These six countries should be viewed as examples, since capacity improvements are required in the majority of developing and developed countries. The capacity for GHG performance tracking was broken down into four categories:

- Human resources,
- Institutions,
- Information and technology
- Financial resources

and the study was organised around six components of GHG management:

- Civil society policy implementation
- National GHG emissions inventories
- Mitigation accounting,
- Institutions
- Industry
- Forestry and land use.

Information was collected through WRI partnering with stakeholders, including government agencies, the business community and civil society organisations, using a questionnaire for interviews, in workshops and focus group sessions (MAPT, 2014). Barriers and capacity needs were identified and published in separate country reports (see below) and a summary working paper (MAPT, 2014).

Some main general findings were a need to develop human resources and to build both institutional and technical capacity. A general need for more financial resources was also identified. This related to corporate GHG accounting, as well as to national GHG and mitigation actions accounting.

The project also identified a general need for improved coordination both within and between institutions, including e.g. designation of lead institution/s, mandates, legal agreements, leadership, roles and responsibilities, and to develop effective information sharing mechanisms. Staff capacity needs to be improved and financial resources for the institutions need to be allocated.

In Colombia, the National Development Plan 2010-2014 included the creation of a National Climate Change System, a Low Carbon Development Strategy and a National Adaptation to Climate Change Plan under the Ministry of the Environment and Sustainable Development (MADS) (MAPT, 2011a).

To improve the quality of the measurements for the inventories of GHG in Colombia, the Institute of Hydrology, Meteorology and Environmental Studies (IDEAM) has listed a series of actions that need to be carried out (MAPT, 2011a). In the energy area, information on fuel use and technologies is needed and the control on industry and transportation emissions needs to be strengthened, since participation compared with the national total remained almost constant between 2000 and 2004, at approximately 37%.

The following capacity needs were identified by MAPT (2014): Development of a legal framework, definition of a lead MRV institution, institutional roles and responsibilities, increased permanent and experienced staffing, development of an online information platform, and financial resources.

In 2009, Brazil passed a law creating the National Climate Change Policy, including domestic targets by sector and mitigation actions for the reduction of GHG emissions by 2020 (MAPT, 2011b; MAPT,
The policy and the law require that these mitigation actions be quantified and verified, which requires an effective MRV system. The policy is implemented in a number of plans, among them a Transport Plan. Nationally appropriate mitigation actions (NAMAs) are now being developed, for example addressing energy efficiency, alternative energy sources and increased use of biofuels.

The institutional framework in place for the implementation of the National Climate Change Policy and Planning in Brazil includes the Ministry of Foreign Affairs (MRE), the Ministry of Science, Technology and Innovation (MCTI), the Ministry of the Environment (MMA) and an inter-ministerial committee and commission (MAPT, 2014).

Within industry, including the transport sector, no specific federal level policy or law mandates that companies report their GHG emissions. There is, however, a focus on MRV of GHG emissions at state level. Climate change laws that require some form of mandatory reporting by large companies have been introduced e.g. in the states of Rio de Janeiro and São Paulo.

In conclusion, the Brazilian government has taken concerted action to reduce emissions of GHG and the technical capacity is high (MAPT, 2014). Moreover, a number of areas for further development have been identified, including: institutional leadership and staffing, personnel dedicated to MRV activities, improved technical capacity and staffing for corporate reporting, development of country-specific emissions factors, a common emissions factors database, and improved organisation and sharing of data.

In Thailand, the Ministry of Natural Resources and Environment (MoNRE) is responsible for government policies relating to climate (MAPT, 2012). Several offices and technical committees are established within the Ministry. Some examples of government policies that are relevant for transport are the Economic Restructuring Policy, which includes the use of financial instruments to promote the eco-car and alternative fuel industry; the Energy Policy, which includes supporting production and use of alternative energy sources; and the Policy on Land, Natural Resources and Environment, which includes the promotion of urban development with the goal of making Thailand a low-carbon society.

Thailand also has in place a National Master Plan on Climate Change 2008-2012, an Energy Conservation Plan 2011-2030, a Renewable Energy Development Plan 2008-2022, and a National Transport Master Plan 2011-2020. The latter includes strategies to promote and encourage the switch to rail and water transport (modal shift) and the promotion and development of technology for the use of clean and environmentally friendly vehicles.

Although there are several relevant policies and plans in place, the following capacity needs have been identified for Thailand (MAPT, 2012; MAPT, 2014):

- Lack of a specific designated organisation that is fully in charge of coordinating and responding to the national GHG information and registry system; and lack of a specific organisation that collects all GHG information for the country
- The existing laws and regulations do not cover GHG accounting and reporting
- The existing GHG-related information reporting format does not cover the entire GHG information
- Lack of financial, technical and human resources support for GHG accounting and reporting system development.

India has adopted several policies relating to GHG emissions and climate change (MAPT, 2011c; MAPT, 2014). These include e.g. a National Action Plan on Climate Change (NAPCC), a market-based scheme for improving energy efficiency, a coal tax, ambitions to reduce the GHG emissions intensity in relation to GDP, and ambitions to improve energy efficiency in energy-intensive large industries. State-level plans are being developed to facilitate implementation of the NAPCC at state level. There is also a National Mission for Sustainable Habitat under the Ministry of Urban Development that includes the objective to improve the energy efficiency of public transport.
The Climate Change Division in the Ministry of Environment and Forests is the primary agency for GHG emissions monitoring. The Bureau of Energy Efficiency is responsible for developing energy efficiency policy guidance, and an Expert Group on Low-Carbon Strategies for Inclusive Growth has been formed to support the development of a roadmap for reducing emissions intensity.

It can be concluded that overall, India has significant technical expertise and also to some extent capacity for GHG monitoring (MAPT, 2014). Some need for strengthened capacity has been identified, for example data collection and information systems for tracking the effects of mitigation actions and policies. Further institutionalisation of a national inventory management authority and a management system would be relevant, as well as an institutional framework to support micro- to medium-sized enterprises. Further development of data quality assurance, methodologies and guidance would further improve performance tracking.

Promoting a low-carbon development with the aim of becoming a carbon-neutral middle-income country by 2025 is a national priority in Ethiopia through the country’s Climate-Resilient Green Economy (CRGE) strategy (MAPT, 2011d; MAPT, 2014). The CRGE strategy is part of a five-year Growth and Transformation Plan, and the transport sector was identified by the MAPT project as one of seven sectors with high potential for mitigation of GHGs, although agriculture and forestry dominate. The CRGE strategy is implemented by the Prime Minister’s Office in cooperation with the Environmental Protection Authority/Ministry of Environment and Forestry, and the Ethiopian Development Research Institute.

A number of areas where the institutional, human resources and technical capacities could be strengthened have been identified, in order to develop an effective system for monitoring GHG emissions (MAPT, 2014). Defined institutional mandates, a legal framework and dedicated financial resources have also been suggested. Staffing and key personnel dedicated to GHG reporting are lacking, and training is required from a long-term perspective. At present, no technical capacity in terms of guidelines, methodologies and tools is available. Consequently, there is no existing platform for data collection in Ethiopia.

In South Africa, the Department of Environmental Affairs (DEA) is responsible for climate change issues and is the key interface in the UNFCCC (MAPT, 2011c; MAPT, 2014). The DEA therefore has both the knowledge and experience to coordinate a national MRV system. Furthermore, the DEA maintains e.g. the Environmental Statistical System and the South African Air Quality Information system. The energy sector is also the responsibility of the Department of Energy (DoE), which has the mandate to collect energy and emissions data. The DoE runs a central energy database, but it is not officially accessible to other departments. Data from the electricity sector are not available to the DoE, however, since the main electricity provider reports to the Department of Public Enterprises, and energy and emissions data are not publicly available. In addition, the Department of Transport (DoT) and the Department of Trade and Industry (DTI) are working with energy efficiency. In conclusion, there are many uncoordinated data collection initiatives in the area.

The following recommendations have been put forward (MAPT, 2011c; MAPT, 2014):

i. Coordinate MRV efforts under government guidance.
ii. Build on existing structures.
iii. Develop guidelines and standards.
iv. Fund training and capacity building.
v. Create long-term incentives for reporting.

6.1. National GHG emissions inventories

Regarding mitigation accounting, some key findings were identified in the six developing countries included in the MAPT project (MAPT, 2014). First, there was generally a common need to quantify GHG reductions from mitigation actions and policies and to track performance in relation to
mitigation goals. Examples of motives for mitigation accounting were tracking of effectiveness and performance of actions and policies, progress reporting, information and building support.

Furthermore, the project report concluded that many countries have limited experience of accounting for mitigation actions and policies, and that current practices lack consistency and transparency. A need for international guidelines at national and subnational level, as well as for actions and policies accounting, was also identified (MAPT, 2014).

Countries that have produced national GHG inventories may to some extent have established institutional, personnel and technical inventory system capacity (MAPT, 2014). However, most countries, both developing and developed, need to further improve their systems. A general overview of requirements for further capacity development was put together in the MAPT project:

**Human resources**
- Staff dedicated to measurement and performance-tracking activities
- Staff with technical measurement and performance-tracking skills
- Training for staff related to measurement and performance tracking
- Accredited monitoring and verification personnel
- Experience in measuring GHG reductions resulting from actions and policies
- Improved technical capacity and staffing for corporate reporting
- Training and capacity building for data collection.

**Institutions**
- Formalised system for data collection
- Lead institution
- Clarity of mandates, roles and responsibilities to avoid duplication of responsibilities and activities.

**Information and technology**
- Data platform
- Guidelines and standards for data collection
- Reliable activity data
- Regular data collection and analysis
- Country-specific emissions factors
- Improved performance tracking of mitigation policies
- Appropriate GHG accounting methodologies
- Guidance on accounting for upstream and downstream emissions
- User-friendly reporting template for emitting entities and for civil society to use to monitor progress
- Harmonised and comparable corporate reporting
- High spatial resolution imagery in the forestry sector
- Capability to model and project GHG trends
- Mechanism to estimate GHG emissions
- Robust quality assurance and quality control procedures
- Verification.

**Financial resources**
- Adequate financial resources for hiring and retaining staff, training staff and procuring necessary technologies.
6.2. Summary and conclusions

The following general conclusions were drawn in the MAPT project (quotes from MAPT, 2014):

"A need for capacity building was identified in the following areas: development of guidelines, development of systems and institutions, including lead institution, for collecting data, coordination, skilled staffing, development of technical knowledge, implementation of databases and tools for collecting and managing data, a legal framework or mandate, and financial resources."

"Some of the major recurring issues that emerged from the scoping exercise included a need for improved coordination both within and across institutions, effective information sharing mechanisms, strong leadership from the designated lead institution, clear institutional roles and responsibilities, institutional mandates and legal agreements, improved staff capacity, and financial resources for institutions."

“In general, we found that a concerted effort is needed to build human resources, institutional, and technical capacity in countries to help companies effectively measure and manage their emissions, although a range of capacities already exist and provide a good foundation to build on.”
Measurement, reporting and verification of transport interventions

This chapter provides an overview of how MRV is defined, as well as additionality and baseline settings, and discusses different methodologies for assessments. The current CDM transport methodology is examined and some comparisons made with the GEF methodology, since more transport projects have been approved in the GEF programme.

7.1. MRV definition

Article 12 in the Kyoto Protocol to the UNFCCC (Kyoto Protocol)\(^27\) has, within the definition of CDM, stated how to estimate emissions reductions:

“Emission reductions resulting from each project activity shall be certified by operational entities to be designated by the Conference of the Parties serving as the meeting of the Parties to this Protocol, on the basis of:

(a) Voluntary participation approved by each Party involved;

(b) Real, measurable, and long-term benefits related to the mitigation of climate change; and

(c) Reductions in emissions that are additional to any that would occur in the absence of the certified project activity.”

The Bali Action Plan highlighted the relevance of measurable, verifiable and reportable GHG mitigation actions for the post-2012 climate framework and the need to develop the MRV framework, for example with respect to metrics for different types of actions\(^28\). Similarly, it concluded that the definition and choice of metrics for emissions baselines need further development\(^29\). The objective of the MRV system is to have a high-quality process of measurable, transparent and validated data to ensure that emissions reductions are real and related to measures and actions aimed at mitigating emissions of GHG.

The aim of measurements or monitoring is to keep track of GHG (emitted or avoided) and the financing, capacity building and technologies for mitigating efforts (GIZ, 2014). Reporting refers to reporting the progress of climate-related activities of parties in general and, for projects, on the reporting of information, actions, emissions reductions, GHG and details regarding the projects. The project report must contain enough information to enable the emissions reductions or mitigation efforts to be verified by an independent authority. Thus, the reporting must ensure that the data included are consistent, credible and comparable between different projects. For example, metrics and indicators must be based on similar background data and if models or default values are used this must be clearly stated, since it may affect the emissions reduction amount.

The verification process should confirm that the reported information is correct and that the methodologies have been applied, i.e. function as a quality assurance and control system. The verification should also result in improvements, provide recommendations and identify potential for improvement of the methodological process at the end. The verification process is often performed by an agency related to the project or an independent authority. For CER, verification is an especially important step in the CDM procedure.

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\(^27\) [http://unfccc.int/essential_background/kyoto_protocol/items/1678.php](http://unfccc.int/essential_background/kyoto_protocol/items/1678.php)


For international carbon reduction instruments in general, there are many different MRV processes and systems (Hinostroza, 2011). For transport projects in particular, the data collection process may be especially challenging, since transport often crosses boundaries, represents small mobile sources and forms part of complex systems.

7.2. Additionality

The UNFCCC has developed a specific tool to demonstrate and assess additionality of a proposed project (CDM, 2012). The tool is available on the UNFCCC website.

A step-wise approach is applied to demonstrate and assess additionality, and the following steps are included (Figure 3):

a) Demonstration of whether the proposed project activity is the first-of-its-kind.

b) Identification of alternatives to the project activity.

c) Investment analysis to determine that the proposed project activity is either: 1) not the most economically or financially attractive, or 2) not economically or financially feasible.

d) Barriers analysis.

e) Common practice analysis.

![Figure 3. Flowchart of the step-wise approach to demonstrate additionality of a CDM project. After CDM (2012).](https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-01-v5.2.pdf/history_view)

For a project to qualify as a CDM project, it must be demonstrated that it would not have been realised without the CDM programme support. Conceptually, however, additionality may also be interpreted quantitatively as a CO₂ emissions reduction that would not otherwise have occurred or in terms of a proposed activity that will produce something additional in the future relative to a reference scenario which can be referred to as a baseline (Gillenwater, 2012).

A few projects are considered to be additional without further proof necessary. These belong the so-called “micro-scale project” activities in Least Developed Countries (LDCs). Projects which are considered “first-of-their-kind” in a country are also automatically additional within this scheme (ADB, 2013).

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30 https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-01-v5.2.pdf/history_view
7.3. Baseline definition and setting

In order to be able to demonstrate quantitative additionality of a CDM project, i.e. in this case an additional reduction of CO\textsubscript{2} emissions that otherwise would not have occurred, a baseline scenario must be demonstrated. A baseline model in principle is described in Figure 4 (MAPT (2014)). So far, no UNFCCC standardised baseline methodologies have been approved in the transport sector, leaving it up to each project to develop and suggest the method for baseline development (Hayashi & Michaelowa, 2013). This is also reflected in the specific CDM methodologies, in which project-specific guidelines are given to prove additionality before the project start.

There are, however, a number of approved methodologies for transport projects within the UNFCCC CDM programme. These are further elaborated upon below.

![Figure 4. Model in principle of baseline scenario. After MAPT (2014).](image)

7.4. CDM transport projects

There are three common main strategies to reduce GHG emissions in CDM transport projects (Grütter 2007), i.e. by reduction of:

- Emissions per kilometre
- Emissions per unit transported
- Distances or number of trips

Reducing emissions per kilometre includes project types aiming for technology/vehicle change, behavioural change (and fleet management), fuel switching and infrastructure projects (Grütter, 2007). For example, a switch to electric vehicles or biofuels or improved eco-driving aims to reduce emissions per kilometre. Emissions per unit transported refer to passenger or freight transportation and can be divided into mode switch, use of larger units and improved occupational rates (Grütter, 2007). For example, reduced used by private cars, changing to larger public transport systems or carpooling will reduce emissions for such transport.

For public transport, the most common project types to reduce emissions are BRT, light-duty rail and metro lines. BRT constitutes projects aiming to create exclusive right-of-way lanes and a more
efficient bus transport system to increase public transportation (Grütter, 2007). Rail-based projects include metro lines and rail transport systems.

By autumn 2014, there were 29 approved transport CDM projects (see Figure 1). The majority of transport CDM projects are in the public transport sector, such as BRT, metro and cable car, while other types of project are not very common. For example, projects on promotion of walking and cycling, freight transport, fuel efficiency, biofuel and rail projects are few or lacking, as are projects aiming at reducing distances or number of trips.

7.5. Methodologies for MRV of CDM transport projects

Each implementation of a CDM project rests on the application of a methodology that provides a list of measurable parameters which will produce standardised and comparable data (an overview of the methodologies can be found in Appendix 2). Since there is a wide range of possible projects, a large number of specific methodologies have been developed. These methodologies are grouped according to the so-called Sectoral Scopes of the CDM, which in turn derive from a grouping included in Annex A of the Kyoto Protocol\(^{31}\). The Sectoral Scopes are divided into 15 groups that comprise topics concerning energy, industry, transport, agriculture and forestry.

The general strategy of the overarching classification of the methodologies approved by the UNFCCC is to distinguish between (1) large-scale project methodologies (their codes starting with “AM”) and (2) small-scale projects (“AMS”). By default, projects are classified as large-scale, but the possibility exists to implement a small-scale CDM project which requires less effort and resources\(^{32}\). The distinction is made by the UNFCCC Board and depends on the emissions reductions expected from the proposed project. Small-scale projects are thus defined as resulting in reductions of no more than 60 000 tons CO\(_2\)e per year. They are also characterised by a simpler administrative procedure (ADB, 2013). The idea behind small-scale project methodologies is to facilitate the implementation of projects in general.

In addition to large-scale and small-scale project methodologies, there is a third group of so-called (3) consolidated project methodologies (codes starting with “ACM”). This group comprises methodologies which are a compromise between having many complex, specialised methodologies and the desire to provide few simple, concise guidelines for CDM projects. Thus, consolidated methodologies can be seen as an attempt to align and harmonise the CDM project process\(^{33}\).

For the transport sector (CDM Sectoral Scope 7; see Table 1) each methodology – large-scale, small-scale or consolidated – consists of two distinct parts: one for the establishment of the Baseline, and one for the Monitoring of the project\(^{34}\). The measuring procedures to collect the data for both parts are described in each specific methodology. Because the determination of the amount of GHG reductions caused by a project rests on the definition of a baseline, the establishment of this baseline, i.e. the “tare weight”, requires special attention.

7.5.1. CDM methodology baselines

The aim of any CDM project is to reduce GHG emissions to a level considerably below that before the start of the project. It is essential that these reductions are also measurable (Lee, 2005). In order to do this, it is necessary to measure and document (“determine”) the pre-project emissions and conditions

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\(^{32}\) https://cdm.unfccc.int/Projects/pac/pac_ssc.html; accessed 2014-12-22.
\(^{33}\) CDM Rulebook: Consolidation of approved methodologies. URL: http://www.cdmrulebook.org/525.html; accessed 2014-12-22.
carefully. This procedure establishes the Baseline, the calibration or “null” level against which the outcome of the project activities is compared. This baseline level can be seen as the emissions that would be produced if the proposed CDM project had not been implemented. In other words, as defined in Annex 21 of the EB 69 Report, the baseline “is the scenario that most reasonably represents the anthropogenic emissions by sources of greenhouse gases that would occur in the absence of the proposed project activity”\textsuperscript{35} Consequently, the GHG emissions should be lower after the implementation of the proposed project compared with the baseline emissions (ADB, 2013).

For the purposes of comparability, general guidelines for the determination of pre-project baseline emissions are given by the CDM executive board\textsuperscript{35}. Here, a series of five steps is provided, which are, consecutively: the identification of (1) the output, (2) the project activity and (3) the number of measures which are part of the project; (4) the determination of expected relationships between the measures; and finally, (5) the determination of the baseline itself, which is in turn divided into several sub-steps. These guidelines need to be further specified with respect to specific parameters or measurement techniques. For this, one has to refer to the project-specific CDM methodologies.

7.5.2. CDM transport methodologies

The transport sector comprises Scope Number 7 with a total of 16 methodologies, including four large-scale methodologies (AM), eleven small-scale methodologies (AMS) and one consolidated methodology (AMC) (Table 10; see also Appendix 2). AMS-III.AO, which belongs to sectoral Scope 13 (Waste handling and disposal) is also included, since it addresses biogas production. Considering the total number of sectoral scopes (15) there are relatively few methodologies available in the transport sector.

As mentioned previously, on 31 December 2014 a total of 7931 CDM projects had been registered at the UNFCCC, but only 32 were within the transport sector\textsuperscript{36}, which corresponds to 0.4%. Of these, three were rejected by the UNFCCC Board, leaving 29 approved projects (Table 1, Figure 1).

The low number of CDM projects in the transport sector does not seem to be due to difficulties in creating new project methodologies. For example, in a case where an existing methodology is considered insufficient for a project activity, methodologies can relatively easily be either revised or newly created. New methodologies can essentially be proposed by anyone and have only to be approved by the CDM Executive Board\textsuperscript{37}. There are also a number of methodologies that have not yet been applied in any project.

For a more detailed description of the different methodologies available in the transport sector, please refer to the CDM Methodology Booklet, which is freely available in its 6th edition on the UNFCCC website\textsuperscript{38} (downloadable as a PDF file\textsuperscript{39}). A comparative overview of the methodologies for the transport sector can also be found in Appendix 2.

\begin{footnotesize}
\textsuperscript{36} \url{https://cdm.unfccc.int/Projects/projsearch.html}; accessed 2014-12-30.
\textsuperscript{37} \url{https://cdm.unfccc.int/methodologies/documentation/1411/Meth_Booklet_2014_Named.pdf}; accessed 2014-12-29.
\textsuperscript{38} \url{https://cdm.unfccc.int/methodologies/documentation/index.html}; accessed 2014-12-30.
\textsuperscript{39} \url{https://cdm.unfccc.int/methodologies/documentation/1411/Meth_Booklet_2014_Named.pdf}; accessed 2014-12-30.
\end{footnotesize}
Table 10. CDM methodologies in the transport sector\textsuperscript{40}.

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<td>Cable cars for mass rapid transit system (MRTS)</td>
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</table>

7.6. Methodologies for MRV of GEF transport projects

There are many differences in the basic MRV process between CDM and GEF projects. GEF projects calculate emissions reductions before the implementation of the project and are less data-intensive than CDM projects (ITDP, 2014). GEF project emissions or impacts are calculated with reasonable

\textsuperscript{40} https://cdm.unfccc.int/DOE/scopes.html; accessed 2014-12-30.
confidence, whereas CDM project calculations are very detailed and intensive. GEF projects include direct GHG impacts identified within five different areas (ITDP 2014):

1. Vehicle fuel efficiency.
2. Greenhouse gas intensity of fuel used.
3. Amount of transport activity.
4. Mode of transport chosen.
5. Amount of capacity/occupancy used.

The direct emissions for the five areas are also calculated for the lifetime of investments and added together, during and after implementation (post-project emissions). For direct GHG emissions, a GEF template is used, see below.

GEF project MRV also includes indirect GHG emissions savings and local co-benefits. Indirect GHG emissions are based on replication of previous project evaluations using bottom-up or top-down methods. Replication is used for projects where much knowledge exists regarding historical data, for example for bus or rail projects. For the indirect GHG emissions savings some uncertainty exists and therefore a “GEF causality factor” is included in the methodology. The direct and indirect GHG emissions are not calculated together due to the uncertainties in the indirect estimations, and a conservative approach is taken with regard to the size of the affected area (geographically).

For direct emissions calculations, GEF methodology uses the Transportation Emissions Evaluation Model for Projects (TEEMP), a series of models in MS Excel format for the different types of transport projects. TEEMP offers a streamlined process for estimating the emissions impact of the GEF projects. There are TEEMP models in five different categories (ITDP, 2014):

1. Transport efficiency projects.
2. Public transportation projects.
3. Non-motorized transportation projects.
4. Transportation demand management projects.
5. Comprehensive regional transport initiatives.

The sequence of the GEF methodology follows four consistent steps by calculation of GHG emissions reductions (included in the TEEMP models):

1. Establish a baseline (using all data available)
2. Calculate the direct emissions impact for the GEF scenario. The difference between this calculation and the baseline is the emissions impact of the project.
3. Estimate the direct post-project emissions reductions (if any). This is the impact of the project beyond the timetable of the project.
4. Calculate the direct emissions reductions.

GEF project GHG emissions reduction assessments are performed somewhat differently depending on the project type, but follow some general rules. All GHG impacts are converted to tons of CO₂-equivalents and the CO₂ reductions are calculated for the whole lifetime of the project (maximum 20 years). No discounting for future reductions is possible. GEF impact estimation must include as much data as possible, irrespective of whether the TEEMP model is used or not. However, if there are no data available it is possible to use default values in the TEEMP. Project calculations should be transparent, cautious and conservative in assumptions on GHG emissions reductions.

41 http://www.thegef.org/gef/pubs/STAP/CO2-Calculator
Data needed for the GEF methodologies are based on the following “input channels” (in the TEEMP Excel sheet): lifetime of the investment, baseline scenarios and emissions factors. For more details on the specific data needed, it would be necessary to disseminate the TEEMP models for each transport project type (see ITDP, 2014).

GEF monitoring takes place on three levels: project and programme level, portfolio level, and national and global level (GEF, 2011). For transport GEF projects, the monitoring of the project level is most relevant. Full-sized projects are evaluated at the end of their implementation, with a number of minimum requirements. For example the evaluation must be undertaken independently of the project management or, if undertaken by project management, must be reviewed by the GEF agency or other independent quality assurance mechanism of the agency (GEF, 2011). The project evaluation includes for example assessments on achievements, whether targeted objectives were met, basic data for the evaluation (key questions and the methodology), and lessons for broader applicability.

7.7. Summary and conclusions

This chapter provides an overview of methodologies for MRV, including determination of baselines and additionality. The focus is on CDM methodologies, but GEF methodology is also discussed, since more transport projects have been approved in the GEF programme. There are in total 16 CDM transport methodologies available, of which only seven have yet been applied in projects. The low number of CDM projects in the transport sector does not seem to be due to difficulties in creating new project methodologies. For example, in a case where an existing methodology is considered insufficient for a project activity, methodologies can relatively easily be either revised or newly created.

There are, however, several differences in the basic MRV process between CDM and for example GEF projects. GEF projects calculate emissions reductions before the implementation of the project and are less data-intensive than CDM projects. Furthermore, the GEF project financing takes place before projects are implemented, and GEF funding is not revoked if emissions targets are not reached. GEF projects are less rigorous and riskier, but also more flexible in that it is possible to support many different kinds of transport project types. This indicates that the small number of CDM transport projects may be a consequence of demanding project requirements and evaluation, in combination with the condition that project funding is linked to the reporting of CO₂ emissions reductions.
8. Discussion and conclusions

In general, transport systems are very complex. The variables that define a specific system in a specific city or a country are numerous, and include variables related to the transport infrastructure, to the availability and cost of different transport modes and fuels, and to the requirements and preferences of the people and other actors that are dependent on and use the system. Transport systems therefore cannot easily be isolated from their spatial context, which is most likely the strongest driver for their creation and expansion in developing and developed cities and countries (Cervero, 2013; IEA, 2013; UN-Habitat, 2013).

The need for integrated approaches between e.g. land use and transport planning has therefore been widely recognised, but there are also other planning sectors that may be highly relevant for the transport system and need to be integrated with transport planning. Basically, all development that has implications for the movement of people or goods needs to consider the transport effects. This has been concluded many times previously, but the level of implementation in practical planning and development is still limited, as demonstrated in studies from developed countries where difficulties and obstacles to establishing integrated planning are found (see e.g. Schöller-Schwedes, 2010; Aretun & Robertson, 2013). Therefore, a highly relevant question is whether integration of planning sectors is a viable strategy that should be promoted or if other strategies should be developed. For example, it has been suggested that the concept of “building livable communities” may be used to promote development of mixed use neighbourhoods and discourage zoning of cities (UN-Habitat, 2013).

As indicated in Chapter 3, transport systems in developing countries, especially urban systems, can be assumed to be even more complex than those in developed countries. Some factors that may contribute to this are rapid and unregulated growth of urban areas, large inequalities in income, and significant shares of transport being carried out by unregulated operators. Further development of planning strategies in developing countries therefore remains a high-priority issue, e.g. in order to improve conditions relating to transport in urban areas and to avoid uncontrolled transport growth.

The focus in this report was on CO₂ emissions reductions in transport systems in developing countries and how this can be addressed through different instruments such as the flexible CDM under the UNFCCC). So far, relatively few transport projects have been carried out in the CDM programme, but there are some examples. In total, about 30 projects have been approved (see Chapter 6), of which the dominant project types are BRT development (13 projects), metro development (9 projects) and promotion of electric vehicles (4 projects), which are all examples that address “Shift” measures “within” the transport system.

The difficulties in getting international carbon reduction instruments implemented and successful within the transport sector has been repeatedly demonstrated in CDM projects, where transport only represents 0.4% of all projects. Transport projects are somewhat more successful in GEF and CTF projects and there is increasing interest in the transport area in NAMA projects. These carbon reduction instruments (GEF, CTF, NAMA) implement MRV processes and systems which, in comparison with CDM, are much less data-intensive and allow more flexible project types. This may indicate that the transport CDM methodology and MRV process is not optimal for the transport sector and that projects with a more sectoral approach with less data-intensive validation processes are more attractive.

Efforts to increase the CO₂ efficiency of transport systems may follow several different alternatives. From a short-term perspective, the transport demand being the same, the modal split can be shifted towards more fuel-efficient modes or modes using alternative (non-fossil) fuels. However, it is very unclear whether such shifts generally are sustainable from a longer time perspective, since there are indications that they may result in significant rebound effects (see Chapter 3) that radically reduce the initial effect (IEA, 2013). Unless other complementary measures are also implemented, measures such as lower travel costs may lead to increased travel frequency or longer journeys. In another example,
measures that aim for a shift from car to public transport, such as BRT and MRT, may lead to rebound effects due to increased motorised travel rather than a one-to-one shift from car to public transport. The shift may primarily occur from other modes and it may lead to longer journeys that contribute to increasing urban sprawl in a somewhat longer time perspective. The currently approved transport projects in the CDM programme may therefore require complementary measures in order to deliver long-term CO₂ reductions (Cervero, 2013).

Such effects call for holistic, integrated perspectives in planning and development. Nationally appropriate mitigation actions (NAMAs) represent a “new” wider, or sectoral, perspective. NAMAs as an instrument for transferring funding from developed to developing countries need further elaboration, as does the requirement for MRV. This is further discussed below.

Different methods for measuring traffic and transportation, data availability and quality and institutional capacities are described in Chapters 4-6. Measuring traffic and transportation is generally difficult and demanding and the potential for misinterpretation of results is significant, especially regarding bottom-up evaluations. Top-down evaluations are easier to achieve and to interpret correctly, but are of limited use for evaluation of local and regional policies and measures, since they are based on aggregated data. One main conclusion from the overview of evaluation is that MRV of traffic and transportation in developed as well as developing countries needs to be strictly defined in order to produce validated data and information. That said, the obstacles may be larger in developing countries, as indicated by the greater degree of complexity and sometimes more unclear roles and responsibilities of ministries and agencies identified by the MAPT project discussed in Chapter 7 (Kumar & Agarwal, 2013; MAPT, 2014). The problems relating to measurement and evaluation methods are consequently only one perspective of ambiguities related to evaluating transport policies and measures. Other challenges relate to institutional roles and responsibilities, the availability of personal and financial resources, and the knowledge and perspectives applied.

In the short term (a few years) perspective the evaluation of MRT projects, according to the CDM methodology, is based on survey methodology using a questionnaire for interviews of MRT passengers. The survey populations should be statistically significant (although this is not specified in detail) and should include questions regarding both the current journey and what mode/s would have been used had the MRT not existed (or if the journey would have been made). Emissions of CO₂ and baseline emissions must be calculated from information about the use of alternative travel modes and emissions factors (emissions per passenger-km).

This example of the CDM methodological tools is similar to the evaluation tools of the other MRT systems. The survey method includes the whole current journey, as well as the alternative journey if the MRT had not been available. Question about whether the journey is induced by the MRT are included. This represents a relevant evaluation methodology from a short-term perspective, since it includes additional information about the whole journey made by the passenger and the alternative journey had the MRT not been available. The main weakness from the short-term perspective is the general complexity of the methodology, including the baseline emissions factors, which require several assumptions about emissions levels and load factors of different modes. From a medium or long-term perspective, the structural aspect of the MRT system is not included in the evaluation. Since new transportation options may have significant effects on the continued development of urban form and land use (Cervero, 2013), which in turn will affect the transport system, this is a major weakness of the programme.

Consequently, the inter-sectoral perspective, i.e. avoid or reduce travel, which should be a high priority in developing, as well as developed, countries, is generally not covered by the evaluations in the CDM programme and therefore is not covered in the development of projects and programmes. Based on the limitations of the project approach, further development of CDM towards a more sectoral perspective has been suggested (Wittneben et al., 2009). NAMA programmes include wider, and more long-term, perspectives and would be able to cover the relevant issues, but would also require
alternative methods for evaluation that cover both transport and additional planning areas (van Tilburg et al., 2014).

However, NAMAs continue to be defined very broadly within the UNFCCC negotiations (van Tilburg et al., 2014), but two key perspectives to include when working towards systemic change are suggested:

1. Portfolio impacts are more important than single project outcomes.

This underlines the relevance of a more holistic perspective in the development of programmes such as NAMAs which aim at transformational change.

2. The future is uncertain – and risk should be accepted.

This highlights an aspect of CDM transport projects that are more or less required to succeed within a very specific, relatively short time perspective, although the effects of e.g. BRT development may require a medium- or long-term perspective to be fully implemented. NAMAs may be transformational instruments for sustainable development, including sustainable transport. Their sectoral perspective may be the catalyst for achieving more thorough structural changes that are sustainable from a wider transformational perspective. This perspective is underlined by Mersmann & Wehnert (2014), who highlight the need for transformational change, based on systems perspectives of complex systems. They argue that it is not possible to measure whether a single project is transformational or not. Rather, inter-sectoral programs of portfolios are required in order to achieve desired change of complex systems. Furthermore, evaluation methodology must be developed in the direction of assessment rather than measurement. This calls for further development of the strategies applied in project-based mechanisms such as the CDM programme.
References


Bumpus AG and Cole JC, 2010, How can the current CDM deliver sustainable development?, WIREs Climate Change, Volume 1, 541-547, John Wiley & Sons, Ltd.

CDM, 2012, TOOL01, Methodological tool. Tool for the demonstration and assessment of additionality, Version 07.0.0, UNFCCC.


Grüttner JM, 2007, The CDM in the transport sector, Module 5d, GTZ, Division 44 Environment and infrastructure, Eschborn, Germany

Hayashi D and Michaelowa A, 2013, Standardization of baseline and additionality determination under the CDM, Climate Policy, 13:2, 191-209, DOI: 10.1080/14693062.2013.745114


Appendix 1. Template for transport data/information survey*

Country:

Date

Data/information survey carried out by:

*The aim of the survey is to collect information about what data and information is available about transport and traffic (i.e. a type of meta-analysis).

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Carbon dioxide inventories and reporting*

What inventories are done? At what frequency? And on what data/information are inventories related to the transport system based? National participation in trading emission systems/carbon credit systems?

**National**

Reporting/publications

Based on (data/information)

Method/s for data/information generation

Database/s

Publication/s

Update frequency

Organization responsible for reporting

Comments

National participation in trading emission systems/carbon credit systems?

**Regional/local**

Reporting/publications

Based on (data/information)

Method/s for data/information generation

Database/s

Publication/s

Update frequency

Organization responsible for reporting

Comments
Passenger transport*

National data – all modes

General data/information about passenger transport may for example be available from national travel surveys.

Data/information available
Method/s for data/information generation
Database/s
Publication/s
Update frequency
Data/information quality and quality assurance
Organization responsible for data/information
Comments

National data – public transport (road)

Data/information about the extent of public transport (passenger transport and traffic), for example by bus, may be available from operators.

Data/information available
  - Passenger transport
  - Traffic (& miles travelled, & traffic flow?)
  - Fuel consumption
  - CO₂ data
  - Vehicle fleet
Method/s for data/information generation
Database/s
Publication/s
Update frequency
Data/information quality and quality assurance
Organization responsible for data/information
Comments
National data – public transport (rail)

Data/information about the extent of public transport (passenger transport and traffic) by rail, including metro, may be available from operators.

- Data/information available
  - Passenger transport
  - Traffic
  - Fuel consumption
  - CO₂ / Energy data

Method/s for data/information generation

Database/s

Publication/s

Update frequency

Data/information quality and quality assurance

Organization responsible for data/information

Comments

Regional/local data

Data/information about the extent of local/regional public transport (passenger transport and traffic) by bus and rail may be available from operators. In that case insert data/information in tables (copy from above).
Transport of goods*

National data

National data/information about transport of goods and goods traffic by road, rail, and boat. Insert data into different tables, if relevant.

Data/information available
- Goods transport
- Goods traffic
- Fuel consumption
  - CO₂ data

Method/s for data/information generation
Database/s
Publication/s
Update frequency
Data/information quality and quality assurance
Organization responsible for data/information
Comments

Regional/local data

Data/information about the extent of local/regional transport of goods and goods traffic by road, rail, and boat. If available, insert data/information in tables (copy from above).
Overall transport data/information*

National data

Vehicles, mileage, emission factors

What is the availability of data and information about vehicles used in the transport system? Is data/information about mileage and emission factors of different vehicles or types/categories of vehicles available? At what level of detail is this data/information available?

Types/categories of vehicles used in the transport system (passenger, goods):

Origin of data/information:

One table per vehicle type/category (copy/paste):

<table>
<thead>
<tr>
<th>Vehicle type/category</th>
<th>Data/information available (e.g. age, mileage, emissions)</th>
<th>Method/s for data/information generation</th>
<th>Database/s</th>
<th>Publication/s</th>
<th>Update frequency</th>
<th>Data/information quality and quality assurance</th>
<th>Organization responsible for data/information</th>
<th>Comments</th>
</tr>
</thead>
</table>

Fuel consumption

Types of fuels used in the transport system:

Origin of data/information:

One table per fuel type (copy/paste):

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Data/information available</th>
<th>Method/s for data/information generation</th>
<th>Database/s</th>
<th>Publication/s</th>
<th>Update frequency</th>
<th>Data/information quality and quality assurance</th>
<th>Organization responsible for data/information</th>
<th>Comments</th>
</tr>
</thead>
</table>
Regional/local data

Is data/information about fuel consumption available on regional/local level? In that case insert data/information in tables (copy from above).

VTI
Contact persons:
Kerstin Robertson, kerstin.robertson@vti.se
Annika Jägerbrand, annika.jagerbrand@vti.se
### Appendix 2. Parameters of Transport CDM Methodologies.

<table>
<thead>
<tr>
<th>Methodology</th>
<th>Typical project(s)</th>
<th>Type of GHG emissions mitigation action</th>
<th>Parameters at validation (= baseline)</th>
<th>Parameters monitored</th>
<th>Baseline scenario</th>
<th>Project scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACM 0016</td>
<td>Establishment and operation of rail-based or bus-based mass rapid transit systems in urban or suburban regions for passenger transport by replacing a traditional urban bus-driven public transport system.</td>
<td>• Energy efficiency. • Displacement of more-GHG and, if gaseous fuels are used, CH4-intensive transport modes (existing fleet of buses operating under mixed traffic conditions) by less-GHG-intensive ones (newly developed rail-based systems or segregated bus lanes).</td>
<td>Extensive survey with the passengers to determine the baseline scenario.</td>
<td>• The no. of passengers transported in the project; • Specific fuel consumption, occupancy rates, travelled distances, speed of vehicles.</td>
<td>Passengers are transported using a diverse transport system involving buses, trains, cars, non-motorized transport modes, etc. operating under mixed traffic conditions.</td>
<td>Passengers are transported using newly developed rail-based systems or segregated bus lanes that partially displace the existing bus-driven transport system operated under mixed traffic conditions.</td>
</tr>
<tr>
<td>AM 0031</td>
<td>Construction and operation of a new bus rapid transit system (BRT) for urban transport of passengers. Replacement, extensions or expansions of existing bus rapid transit systems (adding new routes and lines) are also allowed.</td>
<td>• Energy efficiency. • Displacement of more-GHG-intensive transportation modes by less-GHG-intensive ones.</td>
<td>• Baseline distance and transport mode, which are obtained through a comprehensive survey involving the users of the project transport system; • Specific fuel consumption, occupancy rates and travelled distances of different transport modes (including the project); • Policies affecting the baseline (i.e. modal split of passengers, fuel usage of vehicles, maximum vehicle age).</td>
<td>• Number of passengers transported in the project; • Total consumption of fuel/electricity in the project.</td>
<td>Passengers are transported using a diverse transport system involving buses, trains, cars, non-motorized transport modes, etc. operating under mixed traffic conditions.</td>
<td>Passengers are transported using the newly developed bus rapid transit system that partially displaces the existing transport system operating under mixed traffic conditions.</td>
</tr>
<tr>
<td>Methodology</td>
<td>Typical project(s)</td>
<td>Type of GHG emissions mitigation action</td>
<td>Parameters at validation (= baseline)</td>
<td>Parameters monitored</td>
<td>Baseline scenario</td>
<td>Project scenario</td>
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</tr>
<tr>
<td>AM 0090</td>
<td>Transportation of cargo using barges, ships or trains.</td>
<td>• Energy efficiency. • Displacement of a more-carbon-intensive transportation mode.</td>
<td>• Distance of the baseline trip route (both forward and return trips).</td>
<td>• Fuel and/or electricity consumption by the project transportation mode; • Amount of cargo transported by the project transportation mode (both forward and return trips).</td>
<td>The cargo is transported using trucks.</td>
<td>The cargo is transported using barges, ships or trains.</td>
</tr>
<tr>
<td>AM 0101</td>
<td>Establishment and operation of a new high speed rail system. Extension of an existing high speed rail system. Replacement or upgrading of a conventional rail system to the high speed rail system.</td>
<td>• Energy efficiency • Displacement of more GHG-intensive transport modes (airplanes, buses, conventional rail, motorcycles and personal cars) by less-GHG intensive one (high speed rail).</td>
<td>• Data on parameters necessary to determine the baseline emission factors per passenger-kilometre of the relevant modes of transport and total trip distance travelled by passengers per baseline mode of transport.</td>
<td>• Total number of passengers travelled by the project high speed rail system; • Share of the project passengers or the number of passengers who would have travelled by the relevant modes of transport in absence of the project activity; • Passenger trip distances.</td>
<td>Passengers transported between cities using a conventional transport system including buses, trains, cars, motorcycles and airplanes.</td>
<td>Passengers are transported between cities by the high-speed passenger rail-based system that partially displaces the existing modes of inter-urban transport.</td>
</tr>
<tr>
<td>AM 0110</td>
<td>Transportation of liquid fuels using newly constructed pipeline.</td>
<td>• Energy efficiency. Displacement of a more-carbon-intensive transportation mode.</td>
<td>• Amount of fuel consumed by the trucks for transportation of liquid fuel in route; • Distance of the baseline route; • Amount of liquid fuel transported in trucks.</td>
<td>• Amount of liquid fuel transported by the pipeline.</td>
<td>Liquid fuels are transported by trucks.</td>
<td>Liquid fuels are transported using a newly constructed pipeline.</td>
</tr>
<tr>
<td>AMS-III.AA.</td>
<td>Retrofit of the engine of existing/used vehicles for commercial passengers transport (e.g. buses, motorized rickshaws, taxis) which results in energy efficiency measures in transportation reduce GHG emissions due to decreased fuel consumption.</td>
<td>• Energy efficiency. Energy efficiency measures in transportation reduce GHG emissions due to decreased fuel consumption.</td>
<td>• Determination of the remaining technical lifetime of the retrofitted vehicles.</td>
<td>• Fuel efficiency of the baseline and project vehicle; • Annual average distance travelled by project vehicles; • Number of theoretically operating project vehicles; • Share of project vehicles in operation.</td>
<td>Passengers are transported using less-fuel-efficient vehicles.</td>
<td>Passengers are transported using retrofitted more-fuel-efficient vehicles.</td>
</tr>
<tr>
<td>Methodology</td>
<td>Typical project(s)</td>
<td>Type of GHG emissions mitigation action</td>
<td>Parameters at validation (= baseline)</td>
<td>Parameters monitored</td>
<td>Baseline scenario</td>
<td>Project scenario</td>
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<tr>
<td>AMS-III.AK.</td>
<td>Biodiesel production that is used for transportation applications, where the biodiesel is produced from oilseed cultivated on dedicated plantations and from waste oil/fat.</td>
<td>Increased fuel efficiency of the vehicles.</td>
<td>NA</td>
<td>• Renewable energy. Displacement of more-carbon-intensive fossil fuel for combustion in vehicles/transportation applications by use of renewable biomass.</td>
<td>Petrodiesel would be used in the transportation applications.</td>
<td>Oil crops are cultivated, blended biodiesel is produced and used in the transportation applications.</td>
</tr>
<tr>
<td>AMS-III.AO.</td>
<td>The project activity is the controlled biological treatment of biomass or other organic matters through anaerobic digestion in closed reactors equipped with biogas recovery and a combustion/flaring system.</td>
<td>• GHG formation avoidance. Methane formation avoidance.</td>
<td>• Location and characteristics of the disposal site of the biomass used for digestion, in the baseline condition.</td>
<td>• Quantity of solid waste (excluding manure); • Parameters for calculating methane emissions from physical leakage of methane; • Parameters related to emissions from electricity and/or fuel consumption.</td>
<td>Biomass or other organic matter would have otherwise been left to decay anaerobically.</td>
<td>Biological treatment of biomass or other organic matters through anaerobic digestion in closed reactors equipped with biogas recovery and a combustion/flaring system.</td>
</tr>
<tr>
<td>Methodology</td>
<td>Typical project(s)</td>
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<tr>
<td>AMS-III.AP.</td>
<td>Demand side activities associated with the installation of post-fit type Idling Stop devices in passenger vehicles used for public transport (e.g. buses).</td>
<td>• Energy Efficiency. Reduction of fossil fuel use and corresponding emissions through energy efficiency improvements.</td>
<td>NA</td>
<td>• Cumulative Idling Period of all vehicles of type i in year y; • Total number of times of Idling Stop of vehicle i in the year y.</td>
<td>Vehicles used for public transportation continue idling.</td>
<td>Vehicles used for public transportation using a post-fit type Idling Stop device that will turn off the vehicle engine and prevent idling.</td>
</tr>
<tr>
<td>AMS-III.AQ.</td>
<td>Production of Biogenic Compressed Natural Gas (Bio-CNG) from renewable biomass and use in transportation applications. The Bio-CNG is derived from various sources such as biomass from dedicated plantations; waste water treatment; manure management; biomass residues.</td>
<td>• Renewable Energy. Displacement of more-GHG-intensive fossil fuel for combustion in vehicles.</td>
<td>• Determine fraction of gasoline (on mass basis) in the blend where national regulations require mandatory blending of the fuels with biofuels; • Amount of gasoline consumption in the baseline vehicles ex ante.</td>
<td>• Amount of Bio-CNG produced/distributed/sold/consumed directly to retailers, filling stations; • Parameters for calculating methane emissions from physical leakage of methane; • Parameters for determining project emissions from renewable biomass cultivation.</td>
<td>Gasoline or CNG are used in the baseline vehicles.</td>
<td>Only Bio-CNG are used in the project vehicles.</td>
</tr>
<tr>
<td>AMS-III.AT.</td>
<td>Project activities that install digital tachograph systems or another device that monitors vehicle</td>
<td>• Energy Efficiency. Reduction of fossil fuel use and corresponding emissions through energy efficiency improvements.</td>
<td>NA</td>
<td>• Total distance travelled by each vehicle; • The vehicles are identified based on the age, characteristics and load capacity and availability of historical data;</td>
<td>Fossil fuel consumption due to inefficient driving.</td>
<td>A digital tachograph system or similar device reduces fossil fuel consumption in vehicles by providing to the driver feedback against...</td>
</tr>
<tr>
<td>Methodology</td>
<td>Typical project(s)</td>
<td>Type of GHG emissions mitigation action</td>
<td>Parameters at validation (= baseline)</td>
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<tr>
<td>AMS-III.AY.</td>
<td>Introduction and operation of new LNG buses for passengers transportation to existing and new routes.</td>
<td>• Fuel switch. Displacement of more-GHG-intensive vehicles.</td>
<td>• Baseline fuel data (NCV and emission factor).</td>
<td>• Annual average distance of transportation per tonne of freight by each project vehicle; • Consumption of fuel by vehicle; • Total annual goods transported by each project vehicle; • Annual monitoring to check if devices have become a mandatory practice, or that highly-enforced anti-idling policies or legislation have been put into place; • Monitoring to ensure that all device and feedback systems including fuel flow sensors (meters) are operating correctly and have not been disabled.</td>
<td>Buses use diesel or comparable fossil fuel.</td>
<td>Buses use LNG only.</td>
</tr>
<tr>
<td>AMS-III.BC.</td>
<td>Improvement of the operational efficiency of vehicle fleets (e.g. fleets of trucks, buses, cars, taxis or motorized tricycles).</td>
<td>• Energy efficiency. Fossil fuels savings through various equipment and/or activity improvement.</td>
<td>NA</td>
<td>• Specific baseline and project fuel consumption of the vehicle categories; • Average gross weight per vehicle of the vehicle categories; • Activity levels (travelled distance) of the project vehicle categories.</td>
<td>Fossil fuel consumption due to inefficient operation of vehicle fleets.</td>
<td>Reduced fossil fuel consumption due to improved operational efficiency of vehicle fleets.</td>
</tr>
<tr>
<td>Methodology</td>
<td>Typical project(s)</td>
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<tr>
<td>AMS-III.C.</td>
<td>Operation of electric and hybrid vehicles for providing transportation services.</td>
<td>• Fuel switch. Displacement of more-GHG-intensive vehicles.</td>
<td>• If applicable: grid emission factor (can also be monitored ex post).</td>
<td>• Number of electric/hybrid vehicles operated under the project;</td>
<td>Operation of more-GHG-emitting vehicles for providing transportation services.</td>
<td>Operation of less-GHG-emitting vehicles with electric/hybrid engines for providing transportation services.</td>
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<td>• Quantity of fossil fuel used e.g. for hybrid vehicles and electricity consumption for all electric and hybrid vehicles to determine specific electricity/fossil fuel consumption per km;</td>
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<td>• Annual average distance driven by project vehicles.</td>
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<td>AMS-III.S.</td>
<td>Introduction and operation of new less-greenhouse-gas-emitting vehicles (e.g. CNG, LPG, electric or hybrid) for commercial passengers and freight transport, operating on routes with comparable conditions. Retrofitting of existing vehicles is also applicable.</td>
<td>• Fuel switch. Displacement of more-GHG-intensive vehicles.</td>
<td>• Efficiency of baseline vehicles (can also be monitored ex post).</td>
<td>• Total annual distance travelled and passengers or goods transported by project and baseline vehicles on route;</td>
<td>Passengers and freight are transported using more-GHG-intensive transportation modes.</td>
<td>Passengers and freight are transported using new less-greenhouse-gas-emitting vehicles or retrofitted existing vehicles on routes.</td>
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<td>• Annual average distance of transportation per person or tonne of freight per baseline and project vehicle;</td>
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<td>• Service level in terms of total passengers or volume of goods transported on route before and after project implementation.</td>
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<td>AMS-III.T.</td>
<td>Plant oil production that is used for transportation applications, where the plant oil is produced from pressed and filtered oilseeds from plants</td>
<td>• Fuel switch. Displacement of more-GHG-intensive petrodiesel for transport.</td>
<td>NA</td>
<td>• Crop harvest and oil content of the oilseeds as well as net calorific value and amount of plant oil produced by the project per crop source;</td>
<td>Petrodiesel would be used in the transportation applications.</td>
<td>Oil crops are cultivated, plant oil is produced and used in the transportation applications displacing petrodiesel.</td>
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<tr>
<td>Methodology</td>
<td>Typical project(s)</td>
<td>Type of GHG emissions mitigation action</td>
<td>Parameters at validation (= baseline)</td>
<td>Parameters monitored</td>
<td>Baseline scenario</td>
<td>Project scenario</td>
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<td>AMS-III.U.</td>
<td>Construction and operation of cable cars for urban transport of passengers substituting traditional road-based transport trips. Extensions of existing cable cars are not allowed.</td>
<td>• Energy efficiency; • Fuel switch. Displacement of more-GHG-intensive vehicles.</td>
<td>• Occupancy rate of vehicles category; • If applicable: grid emission factor (can also be monitored ex post).</td>
<td>for the cultivation of plant oil per crop source; • Leakage emissions due to a shift of pre-project activities and the competing uses of biomass; • In case of use of pure plant oil it shall be monitored and verified by random sampling that the vehicles have carried out engine conversions.</td>
<td>• Total passengers transported by the project; • By survey: trip distance of passengers using the baseline mode and the trip distance of passengers using the project mode from their trip origin to the project entry station and from project exit station to their final destination; • By survey: share of the passengers that would have used the baseline mode; • Share of the passengers using the project mode from trip origin to the project entry station and from project exit station to their final destination; • Quantity of electricity consumed by the cable car for traction.</td>
<td>Passengers are transported under mixed traffic conditions using a diverse transport system involving buses, trains, cars, non-motorized transport modes, etc. Passengers are transported using cable cars, thus reducing fossil fuel consumption and GHG emissions.</td>
</tr>
</tbody>
</table>

The Swedish National Road and Transport Research Institute (VTI), is an independent and internationally prominent research institute in the transport sector. Its principal task is to conduct research and development related to infrastructure, traffic and transport. The institute holds the quality management systems certificate ISO 9001 and the environmental management systems certificate ISO 14001. Some of its test methods are also certified by Swedac. VTI has about 200 employees and is located in Linköping (head office), Stockholm, Gothenburg, Borlänge and Lund.