Manual for

Calculating Greenhouse Gas Benefits *of* Global Environment Facility Transportation Projects

Prepared by the

Institute for Transportation and Development Policy

For the

Scientific and Technical Advisory Panel of the Global Environment Facility

Scientific and Technical Advisory Panel

The Scientific and Technical Advisory Panel, administered by UNEP, advises the Global Environment Facility

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CONTINUAL UPDATES

This Manual and the TEEEMP Models are continually updated as more accurate information is contributed to this process. To ensure you are working with the most current files, go online to the following internet address and download the appropriate files for your project.

http://www.unep.org/stap/calculatingghgbenefits

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The Transport Emissions Evaluation Models for Projects (TEEMP) are excel-based models for estimating GHG impacts of transport projects. The TEEMP tools were developed by the Clean Air Initiative for Asian Cities (CAI-Asia) and the Institute for Transportation and Development Policy (ITDP) for evaluating the emissions impacts of ADB's transport projects and were modified and extended for GEF projects by ITDP, CAI-Asia and Cambridge Systematics, Inc for the GEF-Scientific and Technical Advisory Panel (STAP). Models were further refined through their application to projects of the ADB and the World Bank.

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List of Abbreviations

ASIF	Activity-Structure-Intensity-Fuel
BU	Bottom-up
BRT	Bus Rapid Transit
CDM	Clean Development Mechanism
CF	Causality Factor
CO_2	Carbon dioxide
CO_2 eq	Carbon dioxide equivalent in global warming potential
DP	Direct Project
DPP	Direct post-project
GEF	Global Environment Facility
GHG	Greenhouse Gas
GWP	Global Warming Potential
IPCC	Intergovernmental Panel on Climate Change
kt or ktonnes	kilo-tonnes or 10^3 metric tonnes
M&E	Monitoring and evaluation
MRT	Mass Rapid Transit
PAD	Project Document
PM	Particulate Matter
PPG GEF	Project Preparation Grant
PIF GEF	Project Information Form
RF	Replication Factor
SOV	Single Occupancy Vehicle
TF	Turnover Factor
TAR	IPCC Third Assessment Report
TD	Top-down
TDM	Transportation Demand Management
TEEMP	Transportation Emissions Evaluation Model for Projects
t or tonnes	10^3 kg or one metric tonne
UNFCCC	UN Framework Convention on Climate Change
VKT	Vehicle Kilometers Traveled

I. Introduction, Concepts, and Definitions

GEF: Partnering for Global Environmental Benefit

The primary purpose of the Global Environment Facility (GEF) is to generate global environmental benefit. The essential path for achieving this goal is the financial support of projects whose completion delivers substantial, measurable reductions in greenhouse gases (GHG). The more projects that can be brought to fruition, the greater is the fulfillment of our purpose, and the more profound is the positive impact on the environment. This effort is a collaboration between the GEF and those applicants proposing projects designed to yield these benefits.

This Manual is designed to assist proponents in shaping their projects accurately and responsibly, and presenting them for consideration in consistent, quantifiable terms. The GEF is committed not only to supporting the national and regional goals of each group, but to extending, as far as possible, the results of these projects so that they contribute to the reduction of greenhouse gases (GHG) on a global scale.

We welcome you into this process, and encourage you to use this Manual—and all of GEF's resources—to compose your project as an asset to your community and the world.

Why this Manual?

Every GEF project requires an assessment of the greenhouse gas (GHG) emissions (in CO_2 equivalence) that the projects are expected to reduce. In 2008, the GEF developed a manual detailing specific methodologies for calculating the GHG impacts of energy efficiency, renewable energy, and clean energy technology projects. This new Manual provides the first methodology designed specifically for projects in the transportation sector. It follows the general framework, terminology, and principles of those earlier GEF modules. More importantly, it uses the lessons learned from experience to tailor these methodologies expressly for transportation projects.

The GEF models are designed to develop ex-ante estimations of the GHG impacts of transport interventions (projects) as accurately as possible, without requiring data so exacting that it discourages investment in the sector. The methodology provides uniformity in the calculations and assumptions used to estimate the GHG impact over a very diverse array of potential projects. These include projects that:

- Improve the efficiency of transportation vehicles and fuels;
- Improve public and non-motorized transportation modes;
- Price and manage transport systems more efficiently;
- Train drivers in eco-driving;
- Package multiple strategies as comprehensive, integrated implementation packages.

The purpose of the methodologies, however, goes beyond mere impact estimation: they are designed to encourage high quality project design, increase consistency and maintain objectivity in impact estimation.

In addition to environmental benefit, transportation projects also produce significant "local co-benefits" that, in many cases, could be the primary justification for the host country to pursue the project. Therefore, this document also seeks to articulate the related co-benefits appropriate to the unique nature of GEF projects. While co-benefits do not directly create global benefit, they increase the engagement and investment of local stakeholders in project success and they increase the replication potential of projects—both of which do result in increased global benefit. For this reason, GEF project applicants are asked to consider co-benefits in all proposals, and guidance for doing so is included in this Manual.

What Distinguishes the GEF Methodology from other Models for CO_2 Accounting?

Most of the methodologies used to measure the GHG impacts of projects focus on the emissions savings from a specific investment. The GEF model considers these impacts from multiple perspectives. Additionally, GEF projects differ in other ways such as funding schedules, project activities, and strategic market development. Because of these distinct attributes, a different technique for calculating end results must be applied.

For comparison, consider that projects under the Clean Development Mechanism (CDM) of the Kyoto Protocol must specify the technical characteristics of the hardware, location, ownership, and operating hours, in order to accurately calculate the amount of emissions reductions produced from an investment. Those methodologies are well designed for assessing GHG impacts of CDM projects, and are continually reviewed by the relevant bodies of the United Nations Framework Convention on Climate Change Convention (UNFCCC). They can also serve as helpful tools to analyze the results of GEF projects, but, by themselves, they do not satisfy the GEF model.

Also, with the CDM, proponents receive the funding for CO_2 emissions reductions only upon delivery of a Certified Emission Reductions analysis based on observed results after the project is implemented. Because the financing is directly tied to the GHG impact measurement, precision is highly important.

GEF financing, on the other hand, happens before project implementation. Thus, the GEF applicant must create a projection of the expected impact of a project in an early phase of planning, when advanced data is not available and the future impact is more difficult to forecast. In many of the developing countries where the GEF operates, transportation data is often incomplete, unreliable, or all-together non-existent. The GEF methodologies must recognize these realities, and cannot be overly data-intensive.

Also, GEF funding is not revoked if reduction targets are not attained or certified. "Success" has many measurements, and GEF weighs multiple factors in assessing the value of a project. In addition, a GEF method for GHG estimates must take into account the investments that can happen after the actual GEF intervention.

Yet another difference lies in the types of project activities supported by the GEF. Many proposed projects include additional elements such as establishing financing mechanisms that leverage local private sector financing; capacity building and technical assistance; and the development and implementation of government policies supporting climate-friendly investments. These elements do not have direct GHG impacts, yet are necessary for effectively avoiding emissions in the long run. So, they are calculated separately within GEF methodologies as "indirect" impacts.

Compared to the CDM (and some other models), GEF projects are intentionally and necessarily riskier. Their outcomes are less certain, and are subject to greater variation in the degree of uncertainty both between and within projects. Yet, because they are less rigorous and data-intensive, GEF projects are more accessible to project hosts who command fewer data resources. GEF projects are also more flexible to accommodate a more diverse array of project types. So, while it is essential to be able to estimate the GHG impact with reasonable confidence, there are other critical purposes addressed in this process. The GEF methodologies are designed specifically to address all of these intersecting factors.

Principal Attributes of the GEF Methodology

An adequate methodology to assess the effects of GEF investment in transport projects must account for the direct mitigation impact of both GEF and co-financing investments. It must also estimate the indirect impacts which come from the replication a project inspires in other places, and the market expansion which results from these investments. Since the estimates for direct and indirect impacts are fundamentally different in their accuracy and degree of certainty, the methodology must report separately on direct and indirect impacts.

To quantify and inter-relate these factors, GEF has constructed a set of formulas with extensive default factors. Identified as the **Transportation Emissions Evaluation Model for Projects (TEEMP)**, they are the core estimating tools for GEF projects and account explicitly for the factors noted above. TEEMPs are explained extensively in all Sections of this Manual.

It is important to note that no single, general-purpose methodology can be used to quantify GHG emission reduction effects for GEF projects. Further, a methodology that results in only one aggregate number for the portfolio does not provide meaningful and comparable values for GHG abatement costs (US$/tons) because of the following:

a. The GHG emission reductions are achieved by integrating many different strategies in GEF projects.

b. The weights of these strategies vary greatly among different projects.

c. In the interest of sustainability and replicability, the GEF-sponsored part of the project often focuses on interventions that have long-term cost-reduction effects (e.g., through capacity building or enabling environments), but by themselves do not have impacts on GHG emissions.

Intersecting these influences is the system of categorization used to organize areas of results for a GEF project. A GEF project can yield results in three general areas:

1. **Direct** CO_2 emission reductions achieved by investments that are directly part of the results of the projects;

2. **Direct post-project** emission reductions achieved through those investments that are supported by GEF-sponsored revolving financial mechanisms still active after the project's conclusion;

3. A range of **Indirect** impacts achieved through market facilitation and development.

Clearly, no single formula can be applied unilaterally to calculate these divergent impacts. For that reason, the GEF methodology estimates direct and indirect impact figures separately, and applies numerical values for uncertainties that are appropriate to each scenario. In each instance, conservative assumptions are used to account for uncertainties, including the influence of the GEF intervention itself and the possibility of shifting baselines.

The three areas of potential impacts articulated above are examined briefly in the following sub-sections, and are thoroughly detailed throughout this Manual.

What Is "Direct" GHG Impact in Transportation Sector Projects?

In the GEF methodology, there are five categories of the transport sector[1] that GEF projects can influence to reduce GHG emissions:

1. Vehicle fuel efficiency,

2. Greenhouse gas intensity of the fuel used,

3. Amount of transport activity,

4. Mode of transport chosen, and

5. Amount of capacity/occupancy used.

Direct emission reductions in any of these five categories are calculated by assessing the expected change in GHG emissions that would be attributable to the GEF (and co-financed) investments. These reductions are projected for, and totaled over, the respective lifetime of the investments both during and post implementation. (These concepts are thoroughly discussed in Section II of this Manual.)

All CO_2 savings resulting from investments made within the boundaries of a project will be counted toward a project's direct effects. The boundaries of a project are defined by the logframe (a commonly-used project management matrix used to track project activities and outcomes), either using GEF resources or the resources articulated by co-financiers, and tracked through monitoring and evaluation [M&E] systems.

The GEF methodology also includes what will be referred to in this Manual as "direct secondary impacts," often referred to by transport and environmental planners as "indirect" effects. These include such items as GHG impacts that come from changes in land use or vehicle ownership, which in turn resulted from a GEF investment. (These are detailed in Section II)

What Is "Direct Post-Project" GHG Impact of Transportation Sector Projects?

Although it is rare in transportation projects, the GEF does allow the establishment of financial mechanisms that could continue to operate after the project ends. These mechanisms may include such tools as partial credit guarantee facilities, risk mitigation facilities, or revolving funds. Such ongoing mechanisms may facilitate investments that yield GHG reductions. However, because these impacts occur or continue beyond the timeframe of scheduled project monitoring—and the fund continues to recycle itself—they are considered separately as "direct post-project impacts." These impacts can be estimated by using the same methodology as the direct impacts. The formulas used here are the same as those used in calculating direct emission reductions. However, the nature of projecting direct post-project emissions dictates that conservative assumptions be used with reference to leakage rates and financial instruments' effectiveness

1 Salon, Deborah. *An Initial View on Methodologies for Emission Baseline*, 2001. Schipper, Lee, Celine Marie-Lilliu, and Roger Gorham, June 2000, *Flexing the Link between Transport and Greenhouse Gas Emissions*, 2000.

To date, only one GEF transportation project, has used a revolving fund or credit guarantee facility. That project educated mechanics in Pakistan on improving engine efficiency with tune-ups, and provided facilities used for those tune-up services. As loans to set up the project were paid back, the funds were scheduled to be re-cycled to fund more training and facilities, continuing until the fund was depleted due to leakage.

This approach has succeeded in other GEF initiatives and in non-GEF transportation investments. Similar revolving funds might be considered when proposing GEF transportation projects. Examples could include the development of private sector parking management concessions linked to urban improvement districts; or the development of road user charging; and smart traffic management systems linked to performance contracts for corridor operations and management.

Credit guarantee facilities could be used to help secure low-cost private financing for development of GEF projects, cutting the risk premium attached to bonds supporting private or public project financing. (In the United States, the Transportation Infrastructure Finance and Innovation Act - TIFIA - provides Federal credit assistance in the form of direct loans, loan guarantees, and standby lines of credit to finance surface transportation projects of national and regional significance.) Capitalization of such loan guarantee programs might be done on a national or regional basis to leverage substantial additional short-term investment capacity by expanding access to credit markets. This could accelerate the timetable of investments in such measures as BRT, non-motorized transportation network improvements, high quality vehicle registration and traffic management systems, or freight system efficiency improvements. (The process of estimating direct post-project impacts is thoroughly covered in Section II.)

What Are "Indirect" GHG Emission Savings of Transportation Sector Projects?

All GEF projects strive to catalyze replication of successful projects by emphasizing capacity building, promotion of project activities, the removal of market barriers, and development of innovative approaches. The GHG emission reductions that result from replication are referred to as "indirect" GHG impacts. They are counted separately from direct impacts because they occur outside the project logframe.

To estimate these indirect impacts, one must rely heavily upon informed assumptions and expert judgment. The potential of a project's replicability springs not only from its market potential, but also from project attributes that increase the potential for its replication. These can include the quality of the project design, the amount of co-benefits a project achieves, and activities designed specifically to encourage replication,.

Indirect impacts are measured using two different approaches, referred to as "Bottom-up" and "Top-down." Each provides a different range of potential indirect impacts.

The "Bottom-up" approach provides the lower, more conservative extent in the range of possible indirect impacts. It estimates the likely effectiveness of a project's potential power to inspire and catalyze similar projects. To arrive at this figure, the direct and direct post-project impacts of a project (calculated separately) are simply multiplied by the number of times that a successful investment under the project is likely to be replicated after the original project's activities have ended. "Bottom up" requires an expert judgment on the degree to which a project is likely to replicate within its sphere of influence.

The "Top-down" approach is generally used to find the highest extent in the range of potential indirect impacts. It estimates the combined technical and economic market potential for the project type within the 10 years after the project's lifetime. Using the maximum realizable market size further implies that there would be no baseline changes over considerable periods of time, and that all emission reductions in that sector or market can be attributed entirely to the GEF intervention.

Clearly, both of these assumptions are unlikely to hold in reality. Therefore, the assessment contains a correction factor variable, the "GEF causality factor," that expresses the degree to which the GEF intervention can take credit for these improvements. This causality factor is used to calibrate the "Top-down" estimate for the indirect benefits.

For some types of transport projects, such as bus or rail, there is currently enough historical data to support the estimation of a replication rate based on documented experience with previous projects. Accepted replication rates based on historical observations may be used instead of creating a range of indirect impacts using the two methods described above—Bottom-up and Top-down. The summaries of other types of transport sector projects—both GEF and non-GEF projects—should also be tracked so that the documented dissemination rates can be used to inform future projects.

Because the level of uncertainty and accuracy is different from those of direct or direct post-project savings, it is not appropriate to consolidate the two types of savings. Projects should be conservative in projecting the size of the affected geographic area or market when calculating likely indirect impacts. The majority of projects should not go beyond the regional or country area, although in some cases a wider sphere of influence can be permitted.

What Are Local Co-Benefits and Why Are They Important to Global Benefit?

While the main objective of GEF investments is to generate global environmental benefit, the very nature of transportation projects also produces significant local co-benefits in the areas of public health, travel time, and economic growth. In many cases, these co-benefits are the primary justification—and motivation—for the host country to pursue the project. The greater the co-benefit to the local stakeholder, the greater is their interest in implementing the project successfully. Similarly, projects with high local co-benefits are also more likely to be replicated in other cities/regions. For these reasons it is advantageous to account for co-benefits, as they are essential ingredients in transforming local investment into global impacts. The GEF methodology is designed to weigh local co-benefits in assessing a project.

Table 1: Three Types of GHG Emission Reductions in GEF Projects

Evaluation Tool	Direct	Direct post-project	Indirect
Definition of Reduction Type:	Project activities and investments whose outputs and secondary impacts are tracked in the project's logframe	Investments supported by mechanisms (e.g., revolving funds) that continue operating after the end of the project	Project components that encourage replication such as study tours, capacity building, public promotion, etc.
Logframe level	Has a corresponding activity or investment with an output that is tracked in the logframe	Not corresponding to a specific logframe level	Outcome/impact on level of global environmental objective
Quantification method	Use of GEF TEEMP models with default values (or provision of additional data)	Based on assumptions of functioning post-project mechanisms	Based on the replication rate o the project using Bottom-up or Top-down methods
Quality of assessment	Highest level of certainty and accuracy for minimal data inputs (lower than the CDM)	Reasonable level of accuracy, medium level of certainty	Lower levels of accuracy and certainty

II. Overview for Applying GEF Tools and Methodologies

TEEMPs: The Core of the GEF Methodology

The process of calculating GHG reductions from GEF projects has several steps. The complexity depends on the number and type of project components involved. As discussed in Section I, these can include Direct GHG emission reductions, Direct Post-Project reductions and Indirect reductions. Since there are many different ways to achieve GHG reductions in the transport sector, there is no "one size fits all" methodology that can effectively evaluate their impact.

To confidently project the GHG reductions for a GEF project, specific methodologies have been developed for common types of transport projects. At the heart of these methodologies are a series of models (Excel-format formulas) called the Transportation Emissions Evaluation Model for Projects (TEEMP). The methodologies are derived from international experience and best practices, and are kept as simple as possible.

TEEMP models streamline the process of estimating emissions impacts for transportation projects in five categories:

I. Transportation Efficiency Projects (Clean Vehicles/ Fuels)

II. Public Transportation Projects (Bus/Rail)

III. Non-Motorized Transportation Projects

IV. Transportation Demand Management Projects

V. Comprehensive Regional Transport Initiatives

Currently, TEEMP models exist for bike-sharing, bike-ways, bus rapid transit (BRT), expressways alternatives, mass rapid transit (MRT), pedestrian facility improvements, railway alternatives, as well as several different transport demand management (TDM) programs. Each of the models has a "Basic Guide" and "Home" worksheet tab which explain how to get started using the model. When using these spreadsheet models the cells are color-coded according to the following scheme:

TEEMP Spreadsheet Model Cell Color-Coding

Green Cells	Required User input
Red Cells	Default Value, which can be replaced with local data, if available
Blue Cells	Output: GHG Impact *(User does not modify)*
Yellow/Orange Cells	Internal Calculation Cells *(User does not modify)*

The TEEMPs can provide an ex-ante estimation of the direct GHG impact of a project in a consistent way with very little local data. This is possible because the formulas use conservative default values. These values are based on research, observed results from similar projects, and expert opinion. However, when local data is available, it can easily be inputted into the models to provide a more accurate—and potentially larger—estimation of the direct GHG impact.

TEEMP Release 1.0 was developed with support from the Asian Development Bank (ADB). It was used to estimate the carbon footprint of ADB's transportation projects between 2000-2009 and to evaluate various strategies that might reduce transport CO_2 emissions. TEEMP Release 1.1 has been expanded and enhanced with support from the United Nations Environment Program and Climate Works Foundation for GEF. Version 1.1 addresses more types of interventions and transport management strategies.

In 2010-2011 the TEEMP models are being more fully validated and enhanced, by applying them to various projects for which data is available, and/or is being collected. Through these refinements, many region-specific default values have been updated and made more accurate. This process of enhancing and updating the models is continuous. To ensure you are working with the current values and models, we strongly advise you download the most recent formulas at the http://www.unep.org/stap/calculatingghgbenefits.

Sequence of the GEF Methodology

Even though there is a vast variability in the types of GEF projects, there is a consistent sequence that is followed in calculating CO_2 emission reductions for a GEF application:

1. **Establish a baseline**: Calculate the estimated baseline emissions of the scenario without a GEF intervention. The baseline emissions estimation will be compared against the estimated GHG emissions reduction achieved by the GEF project. When using TEEMP models to find direct impact, no separate baseline need be established in this step because TEEMP models automatically calculate a baseline by using a market-shed analysis approach. Instead, the user should be sure to input all dependable local transport data that is available into the TEEMP model. If dependable local data is unavailable, default values are provided.
2. **Calculate the direct emissions impact for the GEF scenario**. This includes all GEF and co-financing investments that are tracked in the logframe during the project's implementation. The difference between this GEF project scenario emissions and the baseline emissions equals the direct emission impact of the project. If TEEMP models are used, this figure is the model's main output.
3. **Estimate the direct post-project emission reductions, if any are expected.** Direct post-project impacts occur beyond the supervised timetable of the project. They result when a financial mechanism, established as part of a project, remains in place and keeps providing support for GHG-reducing investments beyond the lifetime of the project.
4. **Calculate the indirect emission reductions.** These are reductions that occur from replication and market expansion outside of the logframe or in the post-project period which have a "causal" link to the GEF intervention. If it is appropriate for the situation, use both the Bottom-up and the Top-down methodologies to create a range of potential impacts. In some cases, only the Bottom-up method will make sense. For certain types of transportation interventions, accepted (default) replication rates based on observed impacts can be used.

Each of these steps will be discussed in more detail in the following sub-headings. Figure 1 (next page) contains a flowchart illustrating this process.

Broad Assumptions in Applying the GEF Methodology

The data and assumptions necessary for the GHG emissions reduction assessment will vary by the type of transportation sector intervention. However, some general rules are important in all steps of the GHG emission reductions assessment for the GEF:

a. All GHG impacts are converted to metric tons of CO_2 equivalence.

b. The CO_2 reductions reported are cumulative reductions, calculated for the lifetimes of the investments. No GEF projects may claim impacts for more than 20 years.

c. There is no discounting for future GHG emission reductions.

d. Whether or not the TEEMP models are used, all GEF impact estimations should incorporate as much local measured data as possible. When none is available, applicants can rely on the conservative default values provided in the TEEMP. The default values are based on research and past experience agreed upon by experts.

e. As a general rule when applying this methodology, the project proponent should err on the side of transparency, and generally be cautious and conservative when making assumptions on GHG emission reductions.

Required Data for GEF Methodologies

For each GEF project, the proponent is required to provide extensive data in the following broad categories:

(a) Lifetime of the Investment

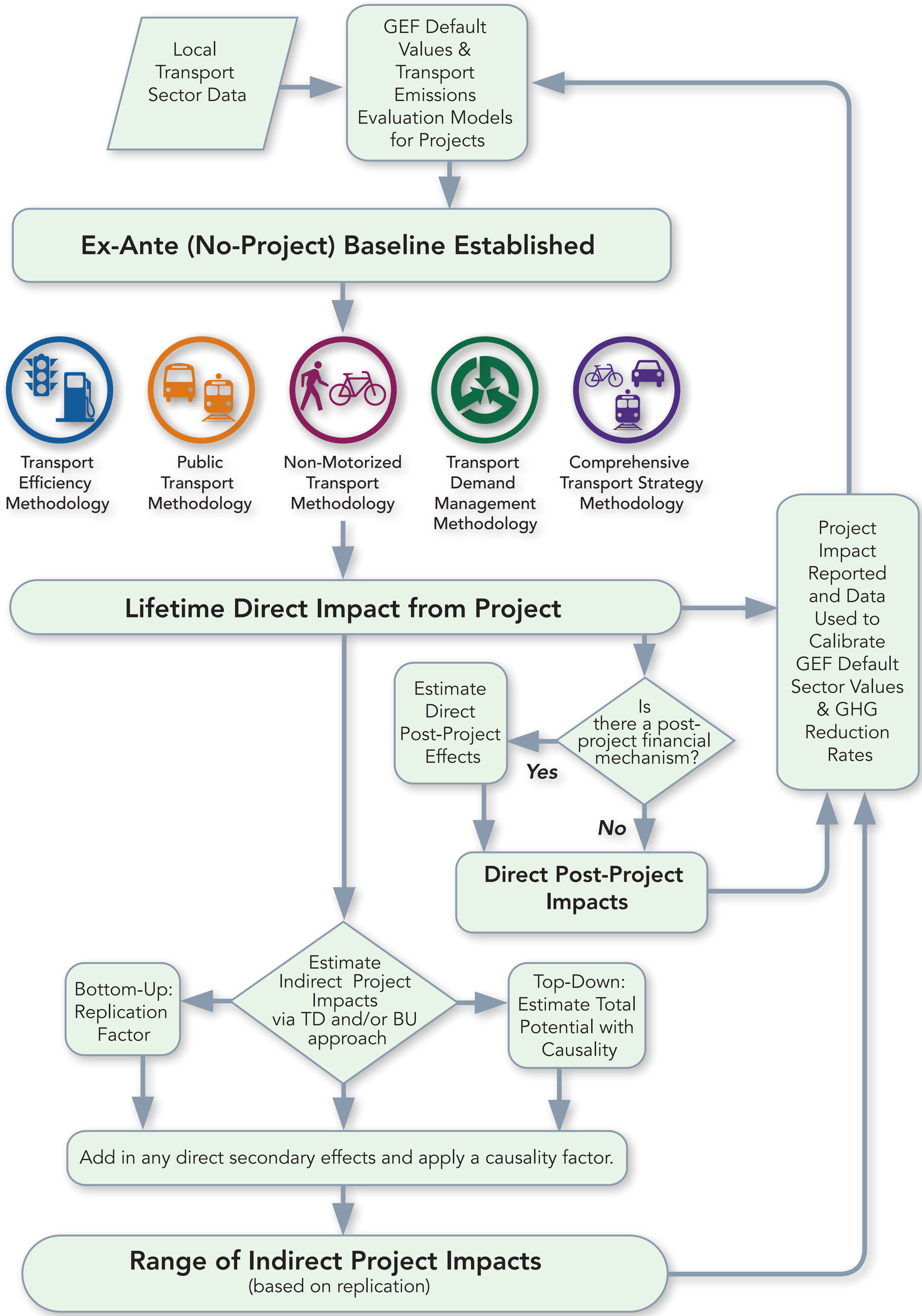
(b) Baseline Scenarios

(c) Emission Factors

These three categories are the "input channels" for the TEEMPs.

A detailed explanation of these three categories follows.

Figure 1: Steps for Data Collection and Development of Baselines, Impact Estimations, and Calibration over GEF Transport Project Lifetime



Lifetime of the Investment

A critical parameter that must be determined is the lifetime of the investment (project). This lifetime is impacted by the various technologies, investment conditions, and assumptions associated with each project. Since these vary widely from one project to the next, applicants should use sound judgment is assigning values for each of these interwoven factors. The GEF methodology specifies preapproved default values for the lifetimes of the relevant technologies, and proponents are encouraged to utilize these default values. The calculation of these values for each type of project is discussed in detail in the later Sections of this Manual. Each Section addresses a specific project type and discusses how the TEEMPs are used to support the project design.

Baseline Scenarios

Whatever methodology is applied, it is imperative that a dynamic, "no-project" baseline scenario be developed. The baseline scenario should incorporate analyses of the sector's current static conditions as well as growth trends of transport behavior, different technologies, mode shares, carbon-intensity of fuels, fuel economy of vehicles, etc. This measurement must forecast emission values for the specific market that would occur without the GEF or co-financing intervention over the period of the intended project. TEEMP models are constructed to generate the baseline so that it overlaps the GEF alternative scenario (the GEF investment).

When developing the Baselne Scenario, GEF applications should follow the guidance below:

a) A dynamic baseline forecasts the emissions inventory of the affected market in a **"business-as-usual" scenario**. The baseline ignores any contribution that would be made by a GEF or co-financing project. (If TEEMP models are used for the ex-ante direct impact estimation—discussed below—a separate baseline need not be created because the TEEMP automatically calculates a "no-project" dynamic baseline in its market-shed analysis of the GHG impact from a GEF project.)

b) Baselines should contain a **description of the market's likely development and transportation activities** as they would evolve without investments from the GEF or co-financing. The baseline should also include all non-GEF interventions that would be introduced to the sector by the implementing agency. Proponents should describe the characteristics of the transportation sector, the emission factors, the markets to be transformed, and the lifetime of the investments. In absence of good local data, the ex-ante baseline will be developed by combining local traffic and travel counts/surveys and the default values from the TEEMP models for fuel cycle and emissions factors.

   In cases where local travel activity data is weak, its acceptance is subject to GEF approval and could possibly be disallowed. So, a strong effort must be made to collect valid local data in the project preparation phase. A potential source of funding to support this task can come from applying for a GEF Project Preparation Grant (PPG) in the initial Project Concept (PIF) document.

   The GEF has separate guidelines for Incremental Cost Analysis. These guidelines relate to the incremental costs incurred through developmental activities of national governments and implementing agencies in caring for the environment.

c) **Include impacts for other major, planned transport sector interventions that are not GEF-funded** but are within the impact area of a proposed GEF-funded transport initiative. If, for example, a new ring road or major roadway expansion is being implemented in or around the impact zone of a proposed GEF project, the impacts of these should be included in the baseline analysis. The GEF TEEMP includes sketch models that can be used to evaluate these impacts.

d) GEF projects should **incentivize the development of plans for gathering observation-based data** at all points of the project. More accurate data can be used to strengthen the baseline developed in the project application phase. It better informs planning and regulation, helps secure wider funding, and is valuable in monitoring and evaluating the project. Better data can help refine the TEEMP models, and, later, makes a successful project easier to replicate. For these reasons, all projects should design tools for monitoring and evaluation, and for the systematic collection of data that relates to the GEF project. Collection tools could include traffic counts, household surveys, GPS vehicle and personal activity monitoring, local fuel and emissions testing, etc.

   The GEF also encourages the use of enhanced modeling methodologies, when possible, that can co-relate fluctuations in transport demand with changes in travel time and cost of different modes, and have some capacity to estimate longer-term impacts on land development patterns.

e) Baselines must **include all transportation modes affected by the project within the project area**. Thus projects that shift travel loads among multiple modes will need to establish baselines which include multiple modes over the entire area. Others may only need basic data about a small group of vehicles to establish a reliable baseline for estimating the eventual impact of the project. Projects that combine multiple interventions will need to establish baselines for each type of intervention for which they claim direct impacts. In general, significant benefit will be realized by combining multiple strategies into an integrated approach.

Emission Factors

For the baseline technologies, as well as for the technologies to be deployed under the GEF Alternative Scenario, the proposal needs to contain the expected emissions factors, i.e., how many kilograms of CO2e are going to be emitted for each vehicle-kilometer of travel (VKT) by mode and vehicle type. This value is derived using either the default emission factors provided by the GEF TEEMP or more accurate locally-measured data. Emission factors will vary considerably based on vehicle fleet composition, vehicle speed and operating conditions, and vehicle occupancy, with additional variation based on temperature, fuel characteristics, and other factors. Use of emission factor models, such as COPERT, in conjunction with regional travel models and local travel and vehicle activity survey data is encouraged, where these are available and deemed to be adequately calibrated to observed local conditions.

The default emissions factors used in all TEEMP models are illustrated in the table below.

For many GEF projects, the principal GHG emission focus will be on CO_2, which is closely tied to fuel use. However, there are several other contributing factors to GHG emissions and, where possible, applicants are encouraged to include them.

Table 2 reproduces the Intergovernmental Panel on Climate Change (IPCC) figures, which should be used for all purposes in GEF projects where non-CO_2 gases are considered. Typically, the 100-year figures are used.

Not included in this table is black carbon, formed through the incomplete combustion of fuels. Black carbon is a potent climate forcing agent emitted in the transport sector. Its effects on global warming are considered to be second only to CO_2. Mitigating black carbon may be one of the most effective means of controlling climate change.

This manual does not incorporate emissions of black carbon in its methodologies because, at the time of publication, the UNFCC has not yet assigned a

Table 1: Default Emission Factors for GEF TEEMP Models

Vehicle Type	Speed	Fuel Type			Fuel Efficiency @ 50 km		CO_2 emissions factor per liter of fuel		CO_2 emissions per vkt		Average CO_2 efac by veh type
	km/hour	% Split			km/liter		kg CO_2/liter		kg CO_2/km		kg CO_2/km
		Petrol	Diesel		Petrol	Diesel	Petrol	Diesel	Petrol	Diesel	All Fuels
Cars	22	95%	5%	100%	9	11	2.75424	2.94348	0.306026667	0.267589091	0.304105
2-Wheeler	22	100%		100%	60	0	2.75424	2.94348	0.045904		0.045904
3-Wheeler	22	100%		100%	22	24	2.75424	2.94348	0.125192727		0.125193
Taxi	22	30%	70%	100%	8	11	2.75424	2.94348	0.34428	0.267589091	0.290596
Bus	22		100%	100%	1.8	2.2	2.75424	2.94348	1.530133333	1.337945455	1.337945
Jeepney/RTV	22		100%	100%	6	7	2.75424	2.94348	0.45904	0.420497143	0.420497
Walking	4										
Cycling	12										
LRT											

GWP for black carbon. Even so, projects are urged to account for black carbon in their calculations when reliable data is developed. Shifting from fossil fuels to other fuel sources and adopting newer engine technology and emissions standards are all methods of reducing black carbon.

Calculating Direct Emission Impacts

Many advanced approaches can produce GHG reductions in the transportation sector. These include the development of voluntary carbon funds, voluntary markets for certified emission reductions, obligatory markets for carbon emissions, and the methodological progress in the Clean Development Mechanism. All of these mechanisms target emission reductions resulting from specific investment projects. In GEF projects this target measurement is referred to as "direct emission reductions," or "direct GHG impacts."

Several methodologies have been published to analyze the direct emission reduction effects of CDM projects. These methodologies tend to be more rigorous and data-intensive than the TEEMP models. However, they can be applied to calculate direct emission reductions for GEF projects in place of using the TEEMP.

Almost all GEF projects combine different categories of investments that yield reductions in different ways. Tangible investments in infrastructure or planning yield direct emissions impacts.

Other investments intervene through less tangible project components such as education, capacity-building, and/or public outreach. The impacts from these investments accrue beyond the lifetime of the project, following only indirectly from the project activities. When this is the case, these reductions should be calculated separately. The TEEMP models provide methods for calculating both direct and indirect impacts. These approaches are discussed thoroughly in this Section and throughout this Manual.

The most clear-cut criterion to decide whether investments should be counted toward direct or indirect emission reductions is whether the investment is included in the log frame of the GEF project, and whether it is monitored as part of the project's success indicators. Even so, in many cases, a project component's impact is included in the project's log frame but there is no reliable way to quantify its impact on emissions. In this case, no impact should be recorded. Normally, direct impacts should only be recorded for investments with known and quantifiable impacts, such as infrastructure, policy, and planning.

TEEMP models incorporate baseline calculation in their "market-shed" approach to calculating GHG

Table 2: Global Warming Potential of Other Greenhouse Gases[1]

Gases	Lifetime (years)	Global Warming Potential Time Horizon		
		20 years	100 years	500 years
Methane (CH4)	12	72	25	7.6
Nitrous Oxide (N20)	114	289	298	153
HFC-23 (hydro fluorocarbon)	270	12,00	14,800	12,200
HFC-134a (hydro fluorocarbon)	14	3830	1430	435
Sulfur Hexafluoride	3200	16,300	22,800	32,600

*IPCC AR3 figures in parenthesis where different from AR4 values.

1 2007 IPCC Fourth Assessment Report (AR4), Chapter 2: Changes in Atmospheric Constituents and in Radiative Forcing. http://ipcc-wg1.ucar.edu/wg1/Report/AR4WG1_Print_Ch02.pdf)

impact. If a project's impact cannot be calculated using a TEEMP model, the general equation below should be followed. It is derived from international best practices and based on the "ASIF" model. All investments responsible for direct effects are evaluated in terms of the energy or fuel saved over the lifetime of the respective investments. Different technologies have different assumed lifetimes.

The saved fuel or energy is then multiplied by the marginal CO_2 intensity of the energy supply. The formula is:

$$CO_2\ direct = E * c = e * l * c;\ with$$

CO_2 *direct = direct GHG emission savings of successful project implementation in* CO_2 *eq, in tonnes*

E = cumulative fuel or energy saved or substituted, e.g., volume/mass of fuel used (or MWh if electric); $E = \Sigma l\ e$

$c = CO_2$ *intensity of fuel/energy*

e = annual fuel/energy replaced, e.g., in *volume/mass of fuel used (or MWh if electric)*

l = average useful lifetime of equipment in years

The lifetime of the infrastructure determines the duration over which the GHG savings may occur. Regardless of when they occur, savings are represented as totals at the <u>completion</u> of the project. That means that the impact of all investments that are made during the project is the same, irrespective of whether they are realized in year one or five of project implementation. However, they must be introduced during the project's supervised operations to count as "direct" GHG emission reductions.

Because of the structure of GEF projects (and a conservative interpretation of the GEF co-financing rules), investments are counted toward this sum regardless of whether they are financed by GEF support or by co-financing. The decisive criterion for the question of whether to include or exclude an investment is whether it is included in the M&E framework proposed in the logframe.

Calculating Direct Secondary Impacts

Another type of direct impact—referred to collectively as "direct secondary impacts"—may also accrue from secondary effects of GEF and co-financer investments. These include GHG impacts from supportive policy reforms, fuel standards, motorization rates, and land use changes that are catalyzed by GEF and co-financer investments. An example of a direct secondary impact would be when there is an intensification of land uses as a result of a GEF-financed transit project (BRT), that in turn further reduces private auto trips within the BRT corridor.

Direct impacts from these secondary effects can be calculated using the same methodologies used to calculate direct impacts. However, a GEF causality factor should always be applied to reflect the degree of influence the project provided in creating the GHG impact. For instance, in the BRT project example above, the project may not have been the only factor contributing to the intensification of land use. A supportive zoning reform may have occurred within the timeframe that the project was implemented, and, thus, also become an additional inducement for the intensification of land use. Therefore, the GEF project by itself cannot claim full credit for the GHG impact of the land use intensification. Instead a GEF causality factor—expressed as a percentage—should be applied in proportion to the degree of influence generated by the GEF project.

The general guidelines for applying the GEF causality factor are:

i. Level 5 = "The GEF contribution is critical and nothing would have happened in the baseline," GEF causality = 100 percent

ii. Level 4 = "The GEF contribution is dominant, but some of this reduction can be attributed to the baseline," GEF causality = 80 percent

iii. Level 3 = "The GEF contribution is substantial, but modest indirect emission reductions can be attributed to the baseline," GEF causality = 60 percent

iv. Level 2 = "The GEF contribution is modest, and substantial indirect emission reductions can be attributed to the baseline," GEF causality = 40 percent

v. Level 1 = "The GEF contribution is weak, and most indirect emission reductions can be attributed to the baseline," GEF causality = 20 percent

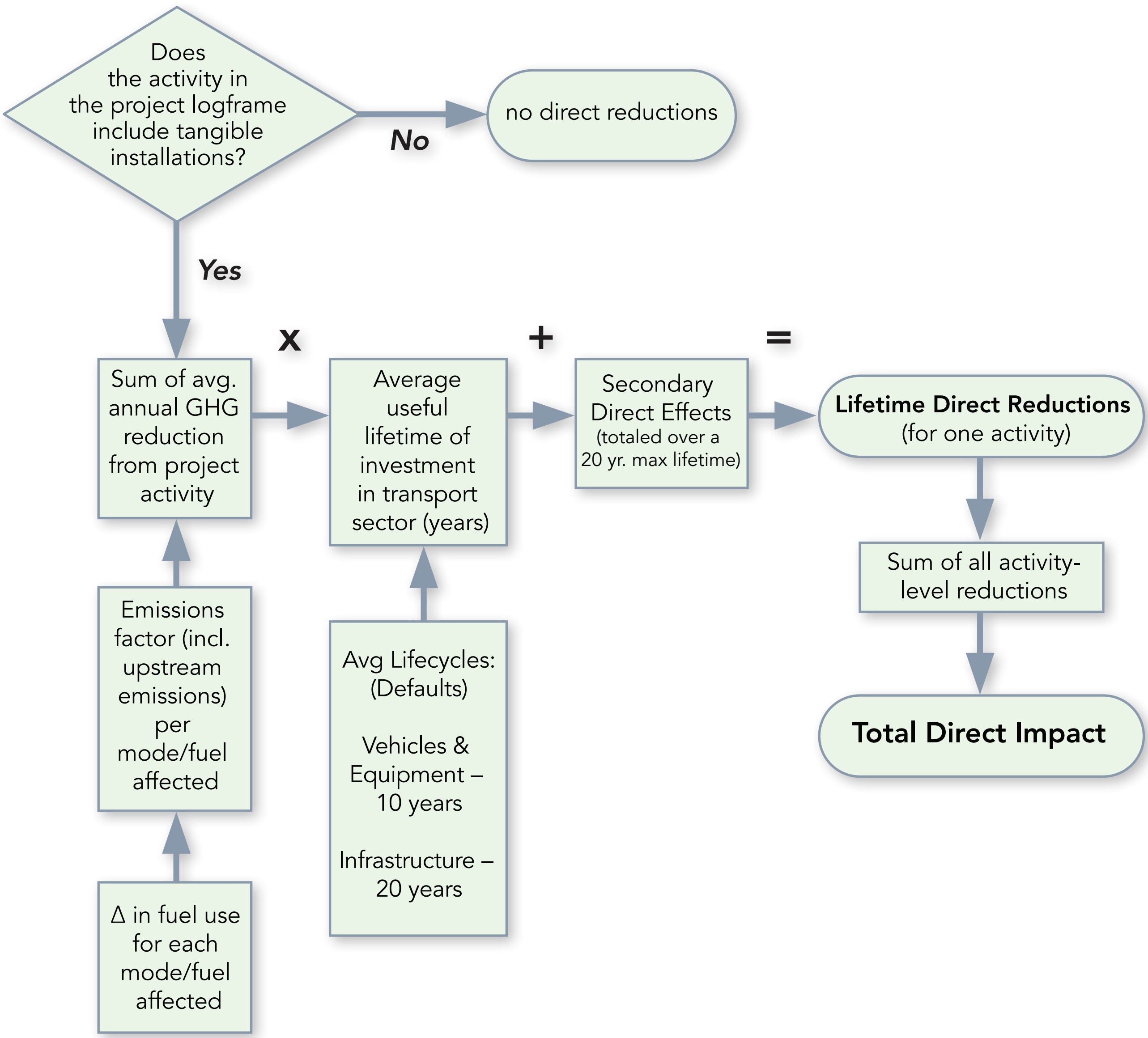
The chart in Figure 3 summarizes the process and variables in calculating direct GHG emission reductions for transport projects.

Calculating Direct Post-project Emission Reduction Effects

In some cases, GEF projects implement a GEF-supported financing mechanism that will continue to support direct investments after the supervision period of the project. An example is a revolving fund for up-front financing of bus rapid transit, parking management, and urban improvements, which is then refinanced from user fees, loan repayments. There might also be a partial credit guarantee facility that could be fully exposed at the end of the project, but then reduces its credit risk exposure and thus keeps looking for new investments. Depending on the leakage rate, facilities of this type can lead to a multiple of the original direct investment, which in turn can lead to a multiple of the associated emission savings long after the project itself has ended. (An example of a successful project in Pakistan, illustrating this dynamic, was given in Section I of this Manual.)

These "direct post-project" emissions are calculated by extrapolating from the direct effects achieved during project implementation. Clearly, some assumptions are needed. For a revolving fund, for example, the rates of reflow and leakage will determine how many investments can be financed after the supervised implementation period. A "turnover factor" (tf) is defined as the number of times the post-project investments will be larger than the direct investments.

Figure 3: Flowchart for Calculating Direct GHG Emission Reductions For Transport Projects



The general formula for calculating direct post-project GHG reductions is:

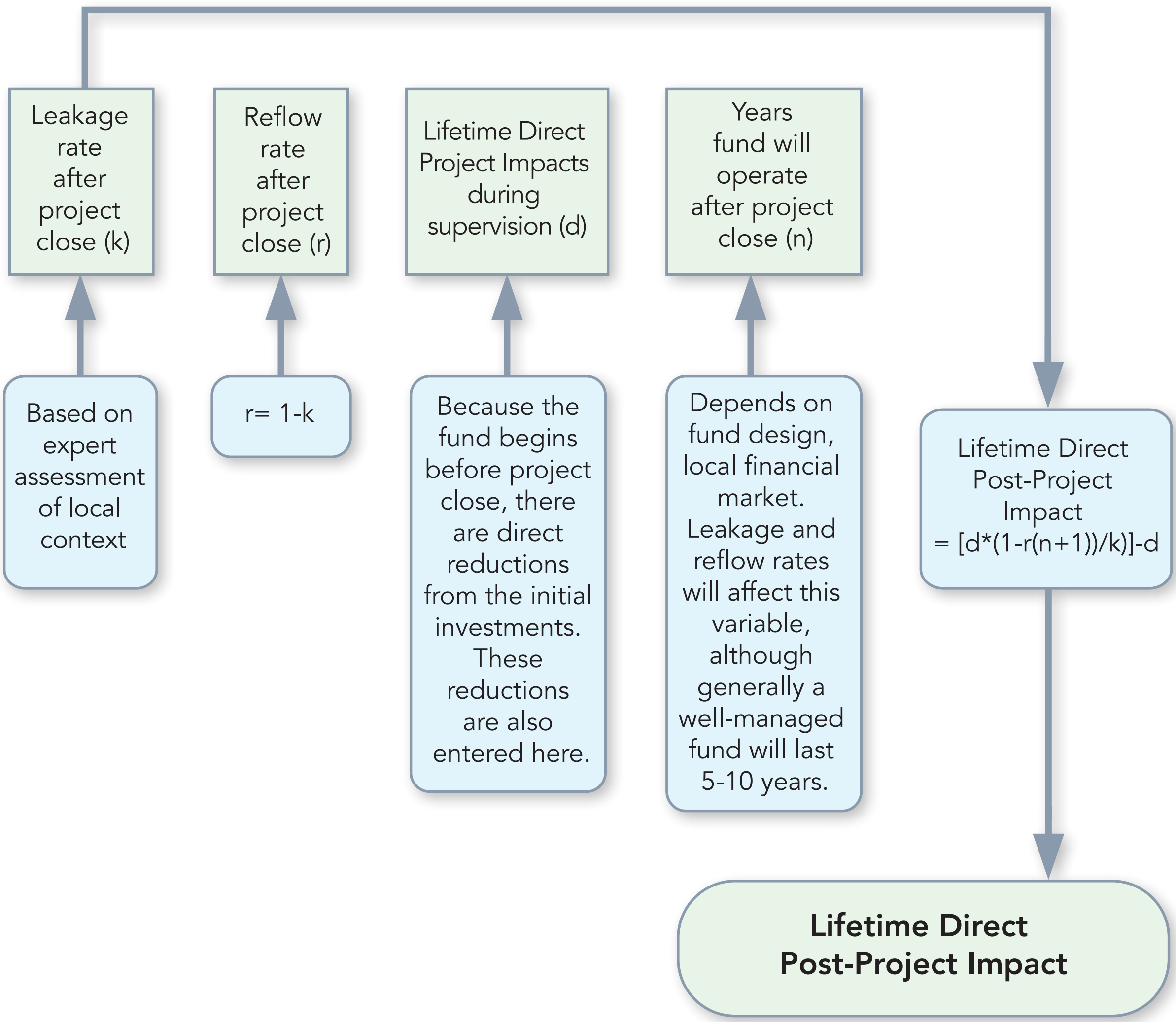
> *CO_2 DPP = CO_2 direct * tf; with*
>
> *CO_2 DPP = emissions saved with investments after the project, supported by post-project financial mechanisms*
>
> *CO_2 direct = direct emissions savings to the degree that they are supported through the mechanism that causes the post-project impacts*
>
> *tf = turnover factor, determined for each investment based on assumptions on the fund leakage and financial situation in the project country*

In this equation, the turnover factor "tf" is equal to the number of times that the whole fund volume is expected to be invested and reinvested after the project. The first turnover will usually happen within the project's supervised implementation period, and thus count toward the direct emission reduction. Subsequent turnovers would be counted as direct-post-project emissions impact.

By their very nature, the estimates for direct post-project effects carry a slightly higher degree of uncertainty than the direct GHG project outputs. But since they clearly can impact GHG emission reductions, they need to be accounted for in a GEF project. To provide this measurement, direct post-project effects should be reported separately from the direct emission impacts (described above). Direct post-project effects are actually a form of indirect emission reductions (covered below) But they can be assessed with a higher degree of certainty and so are calculated as a distinct category.

Figure 4 illustrates how to calculate direct post-project GHG impacts.

Figure 4: Direct Post-Project GHG Emission Reductions Calculation



Calculating Indirect Impacts

For many projects, direct GHG emission reduction impacts tell only half the story. GEF projects that catalyze replication of sustainable transport projects in multiple cities or regions, or remove barriers and bring sustainable transport technologies to a wider market, can—indirectly—accrue large GHG reduction impacts. These impacts—referred to as Indirect Emission Impacts—could potentially be larger than the direct impacts, and must be assessed within a GEF project.

During project design, proponents must estimate long-term (indirect) impacts of the interventions, and must include the data and assumptions used to estimate this impact. This is sometimes a difficult exercise. Essentially, the proponent is projecting the likelihood of a project's repetition after the original project is complete. The variables are considerable, and the initiative for project replication may not be in the hands of the proponent of the original project.

Thus, it is not practical to use a straight line formula to estimate indirect emission impacts. Instead, complimentary techniques are used to create portions of a broad vision for future possibilities. The results of these approaches are then merged to compose as responsible a picture as possible of a project's potential replication.

The two techniques used for these calculations are called "**Top-down**," and "**Bottom-up**." Top-down presents the most optimistic estimate of potential replication. Bottom-up presents the most conservative estimate.

The Top-down methodology uses the size of the entire national/regional market as a starting point, applying given assumptions for costs and benefits of the technology. For instance, a GEF bus-related investment may be designed to impact a city-wide bus fleet. But the potential market for replication could be the bus fleet of the entire nation or region. Clearly, this results in the most optimistic assessment – full market penetration—and thus it is the upper-most limit for the range of potential GEF project impacts.

Alternatively, using the Bottom-up methodology, one makes a conservative estimation of the number of times the project is likely to multiply in the long run, resulting in a lower limit of the range of the potential indirect impact.

Whenever appropriate, both methodologies should be used in a complementary manner. This is described in more detail below. Expert opinion is required to determine the Top-down market potential and the Bottom-up replication factor. To minimize the risk of exaggerated project expectations, one should use conservative estimates when using either methodology.

Market and replication potential for a project is not the only factor to drive indirect impacts. Three other factors must be considered in the expert analysis of a project's indirect impact:

1. Project activities which facilitate replication;
2. The creation of attractive local co-benefits from project activities; and
3. The quality of a project and its potential to be successful.

These activities, detailed in later Sections of this Manual, increase a project's replication factor in the Bottom-up method and may increase a project's causality factor in the Top-down method.

Some assumptions must be made to calculate indirect impacts:

a. A standard project influence period for GEF effects has been assumed to be 10 years. This means that a typical project will exert some influence on local market development for about 10 years. Thus, investments that happen within 10 years after the project—that were not projected in the baseline—can be counted toward indirect impacts. The GHG reductions of each subsequent investment are summed over their respective lifetimes for a cumulative measurement. Depending on the lifetimes of these investments, the influence period might be shorter than 10 years.

b. When applying either the Bottom-up method or the Top-down method, inserted data and values should be conservative and limited to a realistic scope.

c. If a project envisions a second phase or tranche at a later stage, and the GEF contribution to this second phase is not yet approved by Council, the GHG reductions achieved during the second phase are counted as indirect effects.

d. Most transport sector GEF projects should limit the tabulation of indirect impacts to impacts within the same region or country as the project. In some cases, innovative transportation projects have influence beyond their own country's borders. For example, small nations with only a single large city and no potential to replicate a large-scale transport project within their national borders may still play a catalytic role in the immediate region. This is especially true in regions of smaller, closely connected countries with strong cultural and commercial links. Countries within such regions as Central America or Southeast Asia could argue to accrue indirect impacts beyond a country's borders but within its sphere of influence. Examples of internationally catalytic projects are well-known: congestion pricing in Singapore, BRT in Curitiba, and bicycle-sharing in Paris.

e. To maintain integrity across the different segments of a project, double counting issues for indirect impacts need to be addressed and managed.

Some reality checks can be used to test the final results. For example, the Bottom-up indirect calculation should exceed the sum of the direct and direct post-project results. On the other hand, it should be smaller than the Top-down total market potential of the technology.

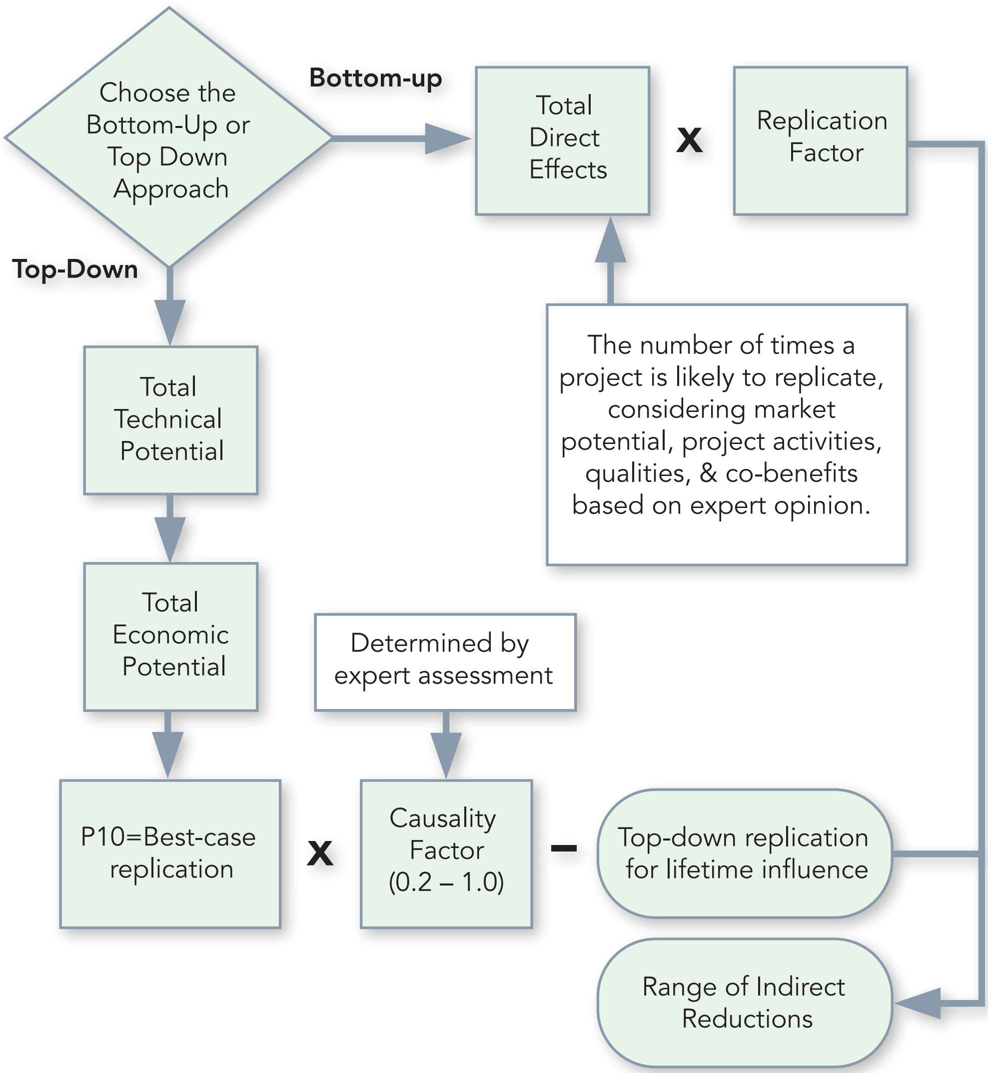
The potential for replication and indirect impact should also be linked to the funding and quality of project components which encourage replication. This includes publication of results, public outreach, educational outreach, capacity building, support for study tours and exchanges, etc.

Figure 5 illustrates how to calculate the indirect GHG impacts of GEF projects using both approaches. Details on each approach are covered discussed in the next pages.

Calculating Indirect Impacts—Bottom-up Approach

The Bottom-up approach for calculating indirect GHG reductions generally provides the lower extent in the range of possible indirect impacts from a project. It starts with the direct impacts of the investments under a project, and multiplies that number by a factor representing the number of times the project is likely to be replicated in other places/markets. For example, a bus rapid transit project developed through a GEF

Figure 5: Flowchart for Indirect GHG Emission Reductions



project might save 200,000 tons of CO_2 over the lifetime of the infrastructure. Judging from the local conditions, one could assume that within 10 years after the project ends, five more cities in the country will adopt BRT systems with similar levels of GHG reduction. Mathematically, the direct GHG emission reductions are then multiplied by the assumed factor of replication (five) to find the Bottom-up indirect reduction.

The Bottom-up replication factor should be determined by an expert and based on four factors:

a. **Market Potential**: a conservative estimate of its real potential for places and markets where it is likely to replicate

b. **Project Quality**: high-quality, full-featured projects are more likely to succeed, and successful projects are more likely to replicate.

c. **Project Activities Designed to Encourage Replication**: study tours, capacity building, technical assistance, public promotion, publication and dissemination of project information and results all help to promote and facilitate project replication.

d. **Local Co-Benefits**: When a project has strong local co-benefits in addition to global benefit, it becomes more attractive to other places and markets and thus more likely to replicate.

The formula for estimating indirect impacts with the bottom up approach is:

$$CO_2\ indirect\ BU = CO_2\ direct * RF;\ with$$

CO_2 indirect BU = emissions saved with investments after the project, as estimated using the Bottom-up approach, in tons of CO_2 eq

RF = replication factor, i.e., how often will the project's investments be repeated during the 10 years after project implementation, determined by expert and reflects the degree to which the project emphasizes activities which encourage replication

CO_2 direct = estimate for direct and direct post-project emission reductions, in tons of CO_2 eq

In the BRT example above, the replication factor would be 5, and the resulting indirect savings calculated by the Bottom-up methodology would be 1 million tons.

To date, there is no empirical assessment of the replication factors for the GEF portfolio, partly because the portfolio is not mature enough for systematic observation, and partly because no post-project evaluations are taking place. Therefore, for the time being, the replication factors should be explicitly determined in the project proposal for each project. When assessing these replication factors, two major aspects should be taken into account:

(a) The first is the expected probability of replication, which is mostly related to the question of whether a particular transportation intervention is profitable or politically desirable and for that reason offers some incentives to the local public or private stakeholders for replication.

(b) The second is the question of how this likelihood compares to the amount of investment already taking place directly under the project.

In the absence of empirical assessments, generalized replication factors can be employed in the assessment, relating to the design and activities of the project.

Developing these replication factors on the basis of experiences collected within GEF projects and from similar projects outside the GEF is underway but far from concluded. What is clear is that for a project to be widely replicated, it needs to be a 'high-quality, full-featured' project that is politically popular in the host city with sufficient status and visibility to impress other cities. The parameters of a 'high-quality, full-featured' project are defined in the project-specific sections of this document as necessary. Secondly, promotional and capacity building project components such as public outreach, study tours, policy guidance, and technical training all also drive replication.

The potential for replication and indirect impact should also be linked to the funding and quality of project components (noted earlier) that encourage replication. These activities increase a project's replication factor in the Bottom-up method and increase a project's causality factor in the Top-down method.

In the next Sections of this Manual, guidance is provided in calculating indirect emission impacts for all major categories of GEF transportation projects. However, in cases where the guidance may not be precise, each project should decide on a replication factor based on the knowledge of the local market. Keep in mind that the assessment should be conservative.

Some reality checks:

a) The replication (Bottom-up) should always be smaller than the overall market potential (Top-down), and;

b) A comparison with the direct and direct post-project impacts should lend itself to a reasonable explanation.

Calculating Indirect Impacts—Top-down Approach

The underlying assumption of the top down approach is that each investment has the potential to economically impact 100% of the market being targeted by the initiative. This assumes the effective removal of barriers to sustainable transportation initiatives through capacity building and the promotion of the initiative. Therefore, the starting point for the Top-down Approach is forecasting the whole economic potential for GHG abatement of a given application in the project's host country or sphere of influence. This assumption has sweeping implications. It asserts that, if all barriers to market implementation are removed, market forces would move to exploit the full economic potential offered by the impacted market. Following this paradigm, in the case of a public transit intervention, full economic potential would be the maximum provision/demand for public transit within the region/country/sphere of influence of the project—all buses in the country, for instance.

As you can see, the Top-down indirect impact calculation generally presents the high extent of the range of potential indirect impacts. It starts by assessing the maximum possible market that could be leveraged using the specific transportation infrastructure initiated in the GEF project. This assessment assumes 100% impact within the project's entire host country or sphere of influence. This is determined, rather simply, by determining the number of cities or regions that could support such infrastructure, technical capacity, and typical investment rates in the country that can be expected under post-project circumstances. If it seems technically unfeasible to achieve 100% impact within 10 years of the project's completion, the total amount of potential additional project locations should then be corrected downward.

The Top-down calculation must also adjust the 10-year potential by accounting for "baseline shift." Baseline shift is that part of the potential that would have been progressively achieved by the market even without a GEF intervention. To make this adjustment, the GEF causality factor is used. The GEF causality factor describes how much of the buildup of capacity can really be attributed to the GEF intervention, and how much would have occurred in the business-as-usual scenario.

The calculation of indirect impacts should also account for the degree to which projects budget funding for specific program components that promote the project. The aggressiveness of a GEF project's promotion affects its causality of replication.

In most GEF climate change interventions, estimates for full economic potential are created in the project development phase. Many technologies that reduce greenhouse gases are already widely available and the trend in longer term production costs are widely known. So broader dissemination trends are easier to estimate with some degree of reasonableness. These estimates should be given greater credence than projects for newer technologies where performance and future production costs are difficult to determine. Such projects rely on expert estimates that are still unknown and/or difficult to verify independently. (The relatively disappointing results of previous GEF efforts involving hydrogen fuel cell vehicle development serve as a cautionary lesson in this regard.)

In addition, the identification of specific GEF causality in the dissemination of the technology needs to be carefully documented. Because market forces or government policies might generate some of these achievements at a later point in time even without a GEF intervention (baseline shifts), this figure is then multiplied by an assumed GEF causality factor, to be assigned by an expert in the field, which indicates to what degree the GEF intervention can claim causality for the reduction.

For the GEF causality factor, five levels of GEF impact and causality have been assumed:

a. Level 5 = "The GEF contribution is critical and nothing would have happened in the baseline," GEF causality = 100 percent

b. Level 4 = "The GEF contribution is dominant, but some of this reduction can be attributed to the baseline," GEF causality = 80 percent

c. Level 3 = "The GEF contribution is substantial, but modest indirect emission reductions can be attributed to the baseline," GEF causality = 60 percent

d. Level 2 = "The GEF contribution is modest, and substantial indirect emission reductions can be attributed to the baseline," GEF causality = 40 percent

e. Level 1 = "The GEF contribution is weak, and most indirect emission reductions can be attributed to the baseline," GEF causality = 20 percent

While the GEF causality factor is useful and can deliver consistent results, GEF causality factors should rely on situation-specific justifications and be estimated conservatively. If, in the future, the methodology shifts to a different method of setting the baseline, the GEF causality factor could be simplified.

The formula for calculating indirect impacts with the Top-down approach is:

CO_2 *indirect TD = P10 * CF; with*

> CO_2 *indirect TD = GHG emission savings in tonnes of* CO_2 *eq as assessed by the Top-down methodology*
>
> *P10 = technical and economic potential GHG savings with the respective application within 10 years after the project (not including direct and direct post-project impacts)*
>
> *CF = GEF causality factor*

Calculating the Local Co-Benefit of Transportation Projects

Wherever possible, local benefits that would be a direct result of project impacts should be quantified and included in the Project Document. In this manual, these are referred to as Local Co-Benefits. As noted in the above methodologies, the presence of significant local co-benefits in a project increases its likelihood of achieving success and the replication factor that determines its indirect impact. Co-benefits include, but are not limited to:

a. Travel time savings

b. Expanded travel options and opportunities

c. Job growth

d. Technical capacity building

e. Economic development

f. Income growth

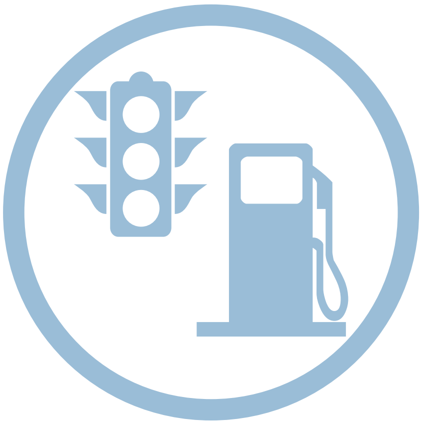
g. Additional employment

h. Air pollution reductions

i. Increases in physical activity that improve public health

j. User cost savings

Wherever possible, the TEEMP models calculate savings in particulate matter linked to respiratory illness and safety issues like traffic fatalities. These are detailed in the specific methodologies in the following sections of this Manual. Any and all verifiable co-benefits which result from transport projects should be detailed in GEF project documents, whether calculated by TEEMP models or via another methodology.



III. Step-by-Step Guide to Estimating The Direct Impacts of Transportation Efficiency *(Vehicle, Fuel, Network Efficiency)* Projects

BEFORE PROCEEDING

It is essential that the proponent read Section I *(Introduction, Concepts and Introductions)* and Section II *(Overview for Applying GEF Tools and Methodologies)* before moving forward. The core critical concepts, terminologies and foundations are detailed in those sections and are not repeated here. Unless the proponent is already quite familiar with GEF methodologies through prior experience, it is doubtful this current Section can be successfully navigated without first reading Sections I and II.

In this Section you will be working with the following TEEMP model:

EcoDriving_TEEMP.xlsx

Introduction

Transportation efficiency projects reduce the GHG emitted per vehicle kilometer traveled by reducing the GHG intensity of:

1. The vehicle operation,
2. The fuel, or
3. The transportation network.

Transportation efficiency projects generally focus on supply-side approaches to making existing transport services, infrastructure, and behavior less GHG-intensive, rather than changing transport modes, demand, or behavior. Examples of past GEF projects which would fall under this category include clean vehicle projects that replaced diesel buses with fuel cell buses, clean fuels projects, market development for electric plug-in two-wheelers, training programs that taught mechanics how to improve fuel efficiency via engine tune-ups, and transportation network efficiency projects which may include coordinated signal timing and enhanced real-time transit dispatching and operations management.

This methodology does not require the use of a TEEMP model. It should be used to find the reduction in GHG emissions in cases where an existing vehicle, mode, or network will be replaced or reconfigured to be more GHG-efficient. This methodology can be used in conjunction with the BRT model, for instance, if more efficient buses are introduced. It accounts for simple changes in demand due to the rebound effect—the change in the amount of fuel consumed due to the increase in travel resulting from the reduced time-cost of travel. The methodology does not account for changes in transportation activity levels—such as motor vehicle travel demand, trip length, or modal share.

Special care must be taken to evaluate whether there will be any associated changes in service, speed, or pricing related to an efficiency project, as these are likely to impact transportation activity. If such changes are anticipated, then the proponent must also use the Step-by-Step Guide to Public Transit Projects (Section IV) to calculate the GHG impact across the modes that will be affected. This choice has to be made early in the development of the project. The only projects of this type that would not result in changes in travel behavior would be technology projects that have no impact to users in the cost or performance of the transportation mode.

Measuring net gains in GHG reductions from transportation efficiency projects is a complex process. As efficiency factors are improved, GHG emissions are reduced. Yet, the benefit to the public, predictably, entices more travelers into the transportation system. This "give and take" dynamic must be quantified in a GEF project. The TEEMP model is designed to bring order to this process.

For example, an area-wide traffic signal system coordination that boosts average network travel speeds by 10 percent is likely to induce a several percent increase in traffic as travelers find that the generalized cost (in time and money) of travel is lower, spurring travelers to drive more vehicle-kilometers. Estimating complex interactions may be a challenging analytic exercise, even with good travel data and models. Where data and models are lacking, the evaluation will have to rely on ad-hoc sketch analysis while encouraging collection of better data and development of better models.

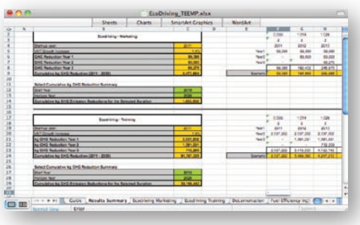
The GEF Alternative Scenario in some cases will simply identify the acceleration of emission reductions that would have happened anyway in the baseline scenario. For example, reduced emission intensities that would be reached in 10 years under a baseline scenario could be reached in four years under a GEF Alternative Scenario. This has to be included in the GHG analysis, as the difference in the emission paths of the two scenarios gives the cumulative emission reduction of the GEF intervention. Keep in mind that to be consistent with past estimates and reduce the number of assumptions necessary, cumulative emission reductions for GEF projects are calculated over the lifetime of the investment.

Data Requirements

The formulas used to calculate the impact of transportation efficiency projects are designed to measure the amount of fuel saved by the project. The basic data requirements include an estimation of the amount of each type of fuel to be used (or saved) in each scenario (baseline and GEF alternative). This estimation will be based on changes in the fuel/ consumption of the vehicles and/or networks. In order to calculate this, fuel economy and VKT must be known. It may also be necessary to know passenger kilometers traveled, vehicle speeds, price/speed sensitivity of travel demand, and other data, depending on the project type. If the project focuses on vehicle or fuel technology, the specific emissions factors for the vehicle models affected by the project must be known and should be calibrated for local conditions. This is true for both the Baseline estimation and the GEF investment. General defaults used in other scenarios are not sufficient for this type of project.

Eco-Driving TEEMP Model

For projects which include eco-driving and/or implementation of on-board display components, which instruct drivers how to operate vehicles more fuel efficiently, a TEEMP spreadsheet model is available to streamline the calculation of direct GHG impacts by the program. The eco-driving model examines the effectiveness of implementing eco-driving training programs for passenger and truck drivers. It also examines the effectiveness of adding on-board display tools to provide real-time feedback on fuel efficiency to drivers.

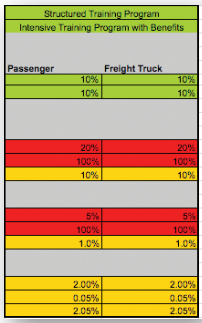


The model uses effectiveness rates based on a study that included U.S., European, and developing world results. It has been documented that when reinforcing lessons or tools are not applied, the effectiveness of the training declines after the first year. For that reason, the model includes a 66% reduction in effectiveness in Year 2 for drivers who do not have on-board display tools. The user must specify the percentage of the population reached by training programs, as well as the degree of penetration of on-board display tools.

The TEEMP model requires the user to select the type of program offered, and the number of people expected to be involved. It also allows the user to input VKT, vehicle mode share data, and emissions factor data, if local data is available. Table A-1 in the appendix illustrates all data required and default values provided for Eco-Driving TEEMP Model.

Types of Programs

The user has the option of selecting from two categories of training programs, with three levels of intensity for each:



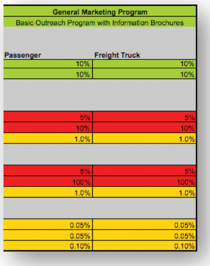
1. The "Structured Training Program" refers to training courses, generally targeted at relatively small groups of drivers. The levels of intensity in the model, from least to most effective, include:

    a. Basic Structured Training Program – Classroom program, in which participants are instructed on ecodriving techniques via presentations, lectures, or videos.

    b. Hands-on Training Program – A classroom program augmented with hands-on driving training, in actual vehicles or a simulator.

    c. Intensive Training Program with Benefits – A program with the characteristics of a hands-on training program that also includes an incentive structure to reward drivers who implement the course in practice. For instance, a commercial fleet might provide bonuses to drivers who use less fuel on the job.

2. "General Marketing Program" refers to a mass-market campaign, designed to reach a wide audience, but not including a formal training program. This could include, from least to most effective:



General Marketing Program	
Basic Outreach Program with Information Brochures	
Passenger	Freight Truck
10%	10%
10%	10%
5%	5%
10%	10%
1.0%	1.0%
5%	5%
100%	100%
1.0%	1.0%
0.05%	0.05%
0.05%	0.05%
0.10%	0.10%

a. Basic Outreach Program with Information Brochures—A marketing campaign in which brochures or other materials with information on eco-driving techniques are distributed to the public.

b. Interactive Marketing Program with Multimedia—A marketing campaign which also includes interactive multimedia to engage the audience to a greater level than brochures and static materials.

(c) Interactive Marketing Program with Feedback—A marketing campaign that involves some degree of personal interaction with marketers or trainers to reinforce the messages and provide individualized information.

Baselines

Projects that intend to introduce standards or new technology for specific vehicles or sectors—such as taxis, private cars, or buses—can focus on the local market baseline for technology, and the developmental trajectory the baseline would likely take in the market without GEF intervention. Typically, this baseline trajectory already contains some planned initiatives that would yield GHG reductions without a GEF intervention. This is what is referred to as "baseline shift." In forecasting GHG emission reductions, the effect of baseline shift must be accounted for as much as is reasonably possible. It cannot be assumed that the energy use and GHG emissions in a market would remain the same in the baseline throughout the implementation of the project.

Whether baseline shift is an issue depends on the situation in the country in question. In some cases, the GEF project supports a technology that is not currently available or used in the country. In that case, baseline shift does not need to be accounted for, except through the GEF causality factor in the indirect Top-down methodology. However, if a clean vehicle program replaces a bus fleet with an average age of 10 years, the baseline must assume that the buses would have been replaced over time regardless, (most likely at a rate to maintain this 10yr average age) and that the replacement buses would be more efficient than those running in the base year because buses and engines are becoming more efficient over time. In cases where a technology already shows an upward trend in usage, and the GEF projects will accelerate this trend, the baseline shift needs to be accounted for and described in the baseline scenario.

Clearly, this is a complex area of estimation. However, the process of completing the TEEMP models is designed to bring clarity to these items.

Calculating Direct Emissions Impact of Transportation Efficiency Projects

In transportation efficiency projects, the direct emission reductions can be calculated in two steps:

1. **Improving Vehicle Efficiency –** For transportation network efficiency projects and projects which improve average vehicle fuel economy, step one in calculating the direct emission reduction is to multiply the projected fuel savings by the corresponding emissions factor and summing this for each fuel affected. From this sum is subtracted the rebound effect, which is the estimated additional fuel consumed by traffic generated by the lower fuel cost of travel by this mode:

$$CO_2\ direct = \Sigma_{Fx,y,z}\ (F_x * c_{Fx}) - (Fr^* c_{Fx}),$$

where

CO_2 direct = sum of direct GHG emission savings from reducing use of fuels x,y, z due to successful project implementation of project, in tonnes of CO_2 eq.

F_x = amount of fuel x saved by the intervention, and cumulated over the lifetime of the respective investments, fuel savings are to be corrected by the "baseline shift," i.e., the amount of fuel savings that would have happened due to improved technology anyway, even without a GEF intervention.

c = CO_2 emission factor for fuel x

Fr = the rebound effect, or the amount of fuel consumed by the increase in travel resulting from the reduced fuel cost of travel

Evidence suggests that in the developed world, the rebound effect related to improvements in fuel economy standards is relatively modest. However, no similar assessment has been made for emerging economies where the price sensitivity of demand is generally much higher. So, further research is needed to develop some reasonable expectations with regard to projected rebound effects.

2. **Improving Fuel Efficiency –** For projects which involve the substitution for one vehicle fuel type with a different fuel that is less carbon-intensive (e.g. substituting hybrid or fuel cell buses for diesel buses), or changes in the carbon-intensity of the same type of fuel, the cumulative carbon emissions must be calculated for both the baseline and the intervention scenarios:

$$CO_2\ direct = (F_{intervention} * c_{Fintervention}) - (F_{baseline} * c_{Fbaseline}) - Fr,\ with$$

CO_2 direct = direct GHG emission savings of successful project implementation in tonnes of CO_2 eq.,

F = cumulative fuel used, in appropriate metric, cumulated over the lifetime of the respective investment

c = CO_2 emission factor for Fuel F. This emission factor should not only include direct carbon content of fuel, but also account for upstream greenhouse gas emissions connected with the extraction, production, and distribution process for the fuels. These factors will vary from locale to locale, depending on fuel type, refining source, distance from refining source, fuel raw material source[1] and raw material type. The GEF methodology provides a 14% default factor which should be adjusted based on local data, where available.

Fr = rebound effect, or the amount of fuel consumed or saved by the additional or reduced travel induced by the higher or lower cost of using the new fuel

In cases where energy from the electric grid is involved (e.g. the case of electric vehicles), the energy per vkt (in watts) should be multiplied by an emissions factor calibrated for the local power mix or the next power plant to come on line.

As a default, the CO_2 emission factor for additional power from a power grid should be for the marginal factor. "Marginal" refers to the emission factor for the additional energy demanded (not the average of all the energy produced). In exceptional cases where grid electricity is being saved or supplied at peak times, the emission factor can be an average emission factor. For example, if grid electricity is being saved, the formula uses the overall average emission factor of the local power sector, as opposed to the emissions attributable to the next power plant to come on line.

All emissions reductions are aggregated across all affected markets, modes, etc. for the expected useful economic lifetime in years. If annual savings vary, sum them for all years of useful lifetime. These economic lifetimes might be different for various vehicle types and intervention types.

Calculating Indirect GHG Impact in Transportation Efficiency Projects

The general guidance for calculating indirect impacts provided in section II should be used for transportation efficiency projects. Refer to page 22—Bottom-up approach.

Sometimes a project may include bringing to the market a vehicle technology utilizing fuel with lower CO_2 emissions that also lowers the price of fuel but increases vehicle procurement costs. In such cases, it is known that—at least in the freight sector—the savings in fuel needs to recoup the increased vehicle cost within 18 months or else the product will not sell.[2] This also assumes that fuel prices are sufficiently stable to project the economic value of these fuel savings. This dynamic is important to note when calculating the indirect impact of a project.

1 Synfuels, like gasoline produced from oil shales or coal, have much higher GHG emissions than conventional crude oil derived fuels. As the crude oil is extracted from ever more challenging and higher cost sources, its associated GHG intensity is likely to rise as well. Thus sourcing of fuels should be accounted for in any analysis.

2 comments by Cummings Engine Representative at MIT, 2008

IV. Step-by-Step Guide to Estimating Direct Impacts of Rapid Transit and Railway Projects

BEFORE PROCEEDING

It is essential that the proponent read Section I *(Introduction, Concepts and Introductions)* and Section II *(Overview for Applying GEF Tools and Methodologies)* before moving forward. The core critical concepts, terminologies and foundations are detailed in those sections and are not repeated here. Unless the proponent is already quite familiar with GEF methodologies through prior experience, it is doubtful this current Section can be successfully navigated without first reading Sections I and II.

In this Section you will be working with the following TEEMP models:
BRT.xls • BRT_MAC.xls • TEEMP-Railway.xlsx • TEEMP-MRT.xlsx • TEEMP-Roads.xlsx • Metro.xls

Introduction

There are a very wide array of Bus Rapid Transit (BRT) and Mass Rapid Transit (MRT) systems worldwide, with widely varying performance metrics. GEF has funded many BRT projects but generally avoided funding metro and rail projects. Although these can also reduce transport CO_2 emissions, they tend to have higher costs and longer delivery times. Freight mode-shifting from truck to rail and logistics efficiency initiatives also offer potential to curb transport CO_2 emissions, but have not yet been funded by GEF.

In the interest of facilitating consideration of a variety of GHG reducing strategies, this chapter provides references to CO_2 analysis tools for BRT, MRT, and Railways, while focusing its discussion primarily on the application of the BRT TEEMP tool. These tools and methods could be extended to handle other forms of mode shifting and logistics improvement in the freight sector and other aspects of system modernization and operational enhancement in public transport.

Due to the size, scale, and variability in BRT and MRT projects, creating an ex-ante estimation of their direct impacts can be a very complicated, data-intensive exercise. TEEMP models have been developed to streamline this process for projects in the early planning stages. The models increase consistency of methods and assumptions, without requiring high levels of data.

The BRT TEEMP model offers both simplistic and more complex methods for estimating the emissions impact from BRT projects and the modal shift and other changes they can spur in urban transportation systems. The MRT TEEMP model enables users to consider the energy characteristics of electric generation used to power electrified trains.

The Railways TEEMP model also enables users to evaluate the impact of shifting a portion of freight from trucks to rail due to new or modernized railway lines and services, also considering energy sources and construction emissions.

Transit Projects generally create direct GHG impacts in five main ways:

a. Induced modal shift resulting from new or improved transit service.

b. Total transit vehicle kilometers are reduced by reorganized routes.

c. Fuel efficiency is increased due to improved transit vehicle speed and operations.

d. New or improved transit vehicles yield lower emissions per passenger-km due to more efficient vehicles and/or higher passenger capacities than the vehicles from which the passengers were drawn.

e. The new system could impact land use changes by stimulating higher density development around the system which in turn shortens future trip distances, reduces auto-mobility, induces modal shifts, and slows the conversion of land to urban usage on the periphery (Lane use changes are calculated as secondary direct impacts).

These potential benefits have to be weighed against construction emissions and any special emissions caused by traffic impacts of the construction of the public transit system, which can be significant and are accounted for in the TEEMP models.

BRT TEEMP Model

Since GEF projects require a GHG estimation before a project is implemented, and in some cases before detailed planning has begun, the BRT TEEMP model has two modes of impact estimation that can be selected by the user:

- Short Cut BRT Method
- Full Scenario Method

The user's choice will depend on the amount of local data available. Users can click on which method they would like to use when opening the BRT TEEMP model excel spreadsheet ("Model Choice" worksheet). Depending on which method the user selects, they will be guided through the model.

Shortcut Method

The Shortcut Method is a sketch analysis mode which works as a very simple calculator. It multiplies the proposed BRT corridor length times the average certified emissions reductions from several previously implemented projects. This provides an order of magnitude estimate for potential GHG reduction. The Shortcut Method is a very low-confidence estimate that may be appropriate at an early stage of planning, such as a PIF for a GEF project to scope or plan a BRT system. Ultimately, a more detailed estimate must be provided using the Full Scenario Method outlined below.

Full Scenario Method

The Full Scenario Method allows the user to input local and project-specific data for all data fields and produce a higher-confidence GHG impact estimate of the project. While some data-points are required (green cells) for the Full Scenario Method, many other data-points have default values (red cells) which can be used if dependable local data is not available. These defaults are conservative, encouraging the collection of local data.

Data Requirements

The calculations used to find the GHG impact of mass transportation projects are based on existing bus ridership in the corridor, the quality of the transit system design, and operation variables (which determine speed and shift from other modes). The basic data requirements include mode share, ridership, length of routes, frequency, passenger trip length, as well as bus capacity, engine type, fuel and average speeds currently found in the corridor. Planning information regarding the length, route, capacity, and features of the proposed transit project is also required. The default values used by the model can be found in Annex Table 5 (A-5).

The model requires the following basic data about existing bus services on the planned mass transit corridor, including:

a. **the total round trip length of each route**, (input onto the 'BRT Operations' worksheet)

b. **the km or percentage of the route that overlaps the project corridor**, (BRT Operations)

c. **the peak hour frequency** (BRT Operations) and average observed occupancy on the section of the corridor most heavily utilized by buses OR total boarding and alighting counts for each bus route serving the corridor (BRT Operations)

d. **the bus engine types** (% of pre-Euro, Euro II, Euro III), entered onto 'Tech%' Worksheet'.

e. **the bus fuel type** (petrol, diesel, CNG, LPG, hybrid, etc) entered into the 'Fuel Type' worksheet.

f. **the buses capacity**, (BRT Operations).

g. **average speeds**, entered on the 'Speed' worksheet.

h. **average passenger trip length** entered on the worksheet Trip.

Projecting Ridership on the New System

The model measures the changes in emissions brought about by the introduction of a new mass transit system by first identifying the likely number of future riders on the new system and making certain reasonable assumptions about how they would have made the trip if the new system never been built. It allows the user to assume that, without the intervention, historical trends towards ongoing modal shift will continue to occur. The benefits accrue because the potential passengers are presumed to generate far fewer CO2e emissions using the new system than they would have by using their previous mode.

Thus, the model first requires the user to generate an estimate of the projected number of passengers the new system will serve. The project proponent has two options for generating this ridership estimate:

- Input specific measures obtained from local surveys, or
- Use the default values provided in the TEEMP model.

Ideally the ridership estimate should be based on a detailed operational plan which is then run as a scenario in an acceptable traffic model designed to handle this type of demand analysis. **The development of a clear operational plan, and the creation of a transit model for the system, are the best indicators of good project planning and greatly increase the likelihood of project success.** Where a full operational plan has been developed and a demand estimate made using an accepted traffic model (we recommend Emme III, Visum, or TransCad, with other applications requiring review) no discount on projected demand should be applied.

The following data contributes to the calculation of ridership on the new system:

Price Change

If the new Mass Transportation System will introduce a change in the price of the mode, sketch modeling that shows the elasticity of transit demand—induced by the price change—should be employed. These estimates are calculated as part of the development of the new system's operational plan. However, the GEF recognizes that the preparation of the new system's operational plan is frequently included as one of the more important functions of the eventual project. So the preparation of a detailed plan should not be made a precondition for receiving GEF funding.

It is also recognized that, while inadvisable, the final operational plan is frequently not decided until weeks before project launch. So, the model provides a simple methodology for estimating future ridership that the applicant is required to follow in the planning phase. The methodology recommended here is only reliable plus or minus about 20%. For this reason, it is recommended that demand estimates be discounted 20% if this method is used rather than a traffic model.

Existing Routes in the Project Corridor

When recording the existing bus and minibus routes on the planned new transit corridor, using data collected from departments of transportation is notoriously unreliable. So, it is recommended that the project proponent collect this information directly by observing which bus routes are actually using the corridor and then using a GPS to record the coordinates of each bus route and bus stop that overlaps the planned corridor.

Some projects define a 'direct service' BRT system, meaning that some bus routes will operate in mixed traffic, enter the trunk BRT infrastructure, and then leave the BRT infrastructure. As such, the passengers using the system are likely to be a much greater share of total bus passengers currently using the BRT corridor than would normally be the case for a closed 'BRT' or MRT system.

Average Speeds

Average speeds can generally be collected by simply measuring them during the peak hour using GPS.

Average Passenger Length

The average passenger length is more difficult to collect, and using standard values from a household survey or spot survey is acceptable. Alternatively, a default value of 6 can be used.

Frequency and Occupancy Counts

The peak hour frequency and average peak hour occupancy for each route can easily be collected by taking surveys at the 'critical link—the most crowded part of the road. One approach is to simply count each bus and minibus servicing each route at the peak hour, and then estimating their average occupancy as a percentage (25%, 50%, 75%, etc). This percentage is then multiplied by the bus type's estimated capacity.

Another method utilizes video recordings (20 minutes in length) captured periodically during the day. The video can be reviewed later in slow motion to arrive at an estimated capacity.

Boarding and Alighting Counts

Boarding and alighting surveys, while more labor intensive than frequency and occupancy counts, are tremendously valuable to the project design. At stations along the existing routes—or on board the vehicles—riders are given the opportunity to complete a short survey that indicates basic details such as the origin and end of their trip, the frequency of their travel on this route and other simple details. Paper or electronic systems can be used directly on board, and in some cases kiosks may be effective.

Station by station boarding and alighting counts can be aggregated and used to estimate the potential boarding and alighting numbers on the new system. This is critical in designing the stations to avoid saturation.

Using the collected data, the project proponent should then clarify which of the existing routes identified are planned to be cut and replaced by new routes in the BRT or MRT system, and which will continue operation outside the BRT or MRT system. If the specific methodology to be used by the operational planning team has been selected, then that methodology should be used. If the methodology is not determined, then a simple assumption should be made that routes with greater than 50% of their length overlapping the proposed corridor will be replaced by the new BRT or MRT system. This assumption is used only to determine a baseline demand for bus transport estimate. It will yield a low level of demand because it is not known whether the system will be 'open' or 'closed', or have feeder routes. The new system's passengers will not be all of the current bus passengers using the corridor but a subset of them, because in any MRT or BRT project, some bus routes are likely to be cut or scaled back, while other bus routes remain to compete with the new system for certain trips not well served by the new system.

The frequency and occupancy counts will yield an estimated maximum passenger volume on the critical link estimate, whereas the boarding and alighting data will give an estimated total of passengers using the link. The relationship between these two is called the 'renovation rate.' The renovation rate is the number of times the bus turns over all of its seats in a single route. If both types of data are available, then the renovation rate can be calculated. If not, a renovation rate of 2 can be used as a default value.

Calculating Peak Hour Ridership using Boarding and Alighting or Frequency and Occupancy

On the 'BRT operations' worksheet, peak hour boardings in the corridor are calculated initially by adding up all the boarding and alighting passengers (one boarding and one alighting equals one passenger) on all the lines which the operational plan determined are likely to use the BRT corridor. This initial number is then multiplied by a specific default value to allow for the appropriate degree of uncertainty.

Not all of the passengers on the new BRT or MRT system will come from the existing bus and minibus system, but most of them will. The question is how many additional passengers are likely to be attracted from other modes, such as cars, motorcycles, etc.

The TEEMP model calculates the likely additional demand resulting from modal shift by multiplying the directly impacted bus and minibus passengers times a multiplier that is tied to 'System Type SF' (for 'Scaling Factors') worksheet. Based on empirical evidence collected from various BRT systems around the world, an assumption is used to determine the maximum number of passengers that might be attracted from alternative modes. The 'System Type SF' worksheet identifies all the different elements of a high quality mass transit system that are likely to affect ridership and attributes to them a value totaling up to a maximum score of 100%. Each point counts for a percentage of ridership bonus.

This ridership bonus percentage is then multiplied by the baseline ridership (BRT Operations) times the discount factor for unreliability fixed at 0.8, times the system type scaling factor ridership bonus to give the estimated peak hour ridership.

If the other methodology was used—Frequency and Occupancy counts—and maximum load on the critical link was applied (total buses times average occupancy), then deriving the total peak hour passenger demand requires also multiplying this number times the renovation rate (2.5 in this case).

To increase the ridership figure to a daily figure, the peak hour estimate should be multiplied by a default value of 10 unless full day bus occupancy and frequency counts have been done to give a more accurate multiplier. If a more accurate multiplier is known, then this multiplier can be used if the data backing up this multiplier is submitted.

To convert the daily estimated baseline demand for bus transport to an annual baseline demand for bus transport, one of two techniques can be used.

- If occupancy and frequency counts have been conducted on a weekday, a weekend, and a holiday, then the average daily demand for a weekday can be multiplied times the total weekdays in the year, the weekend demand by the total weekends in the year, and the holiday demand by the total holidays in the year.
- Alternatively, the daily demand can simply be multiplied by 310.

At this point, a reasonable total annual trips on the new BRT system has been estimated. This is the total number of trips impacted, and thus forms the basis of the CO2e calculation.

Calculating CO2e Emissions Using the TEEMP Detailed Model

Now that the baseline demand for bus transport has been estimated, the TEEMP model can calculate the estimated bus kilometers of the new system, if the majority of system details are known. If not, the sketch function is used and default numbers are used.

The user needs to first input the total length of the BRT trunk corridor in both directions. Then, the user must input the capacity of the planned buses or MRT vehicles that the new system plans to use. Average bus capacity is usually easily known. If not, a simple formula can be used. Bus capacity is simply the length of the bus in meters less 3 meters for the driver and engine, times ten, which is 10 passengers per meter of bus length (less 3 meters for the engine and driver). A standard 12 meter bus thus yields a capacity of 90 ([12 - 3] x 10 = 90)

The TEEMP model then imports the projected average speed. If the system is an MRT fully segregated from surface traffic, then the design speed can be input. If the system is a BRT or LRT operating on an existing road, the 'System Type SF' worksheet speed calculator should be used.

On the 'Operations' worksheet, all of the BRT system design components that impact system speed have been included. Each of these components carries a score that is weighted by its ability to induce speed increases and modal change. If the characteristic is absent, a zero value is given. (These parameters can be refined using local data).

The characteristics are these:

a. Dedicated right of way in central verge, w/barrier
b. Station separated from junction by min of 70 meters
c. Passing lanes at station stops, if pphpd >6000
d. Unique/attractively designed shelter
e. Weather protection at stations
f. Illumination
g. Security personnel at stations
h. Stations =>3.5 m wide
i. Multiple docking bays w/ space to pass, pphpd <6000
j. 3 or more doors
k. Boarding platform level with bus floor
l. Safe & attractive pedestrian access system and corridor environment
m. Bicycle parking at stations
n. Bike stations/bike rentals/public bikes at stations
o. Compliant w/ Access International BRT Accessibility guidelines
p. Bike paths leading to stations
q. Service offered throughout day
r. High frequency service < 5 min. avg.
s. Off-vehicle fare collection
t. On bus camera enforcement of ROW
u. Turning restrictions across > 60% of intersections (high volume) or bus priority at junctions (low volume)
v. Operational control system to reduce bus bunching
w. Extensive feeder bus services integrated into BRT
x. Integrated fare collection with other public transport
y. Peak-period pricing
z. Performance based contracting for operators
aa. Passenger information at stops, headway > 5 min., info on vehicles
bb. Quality branding of Vehicles & stations
cc. Brochures/schedules

These components affect system speed and service quality. If a BRT has all of the above components (100% of component points) it should achieve an average operating speed of 30 mph.. A score of 90% of points would yield a speed of 27 kph, etc.

This projected average speed for the new BRT system is then multiplied by the percentage of the total system that is operating inside the trunk corridor. The existing average bus speed is used for that portion of the BRT system that is operating outside of the trunk BRT infrastructure. From this the average speed for the entire system is calculated. This average system speed is then imported back into the other relevant sections of the BRT Operations worksheet.

At this point, the model can calculate the average fleet size needed, and the average peak hour bus kilometers operated. The only additional piece of information needed is the multiplier for converting the peak hour bus kilometers to daily bus kilometers. Because buses tend to operate with a lower occupancy off peak, the multiplier used for the bus kilometers should be higher than for the daily demand multiplier. If no local information is known, a multiplier of 14 can be used. For an annual figure, the same multiplier used for the bus ridership can be used. Now, the model can give estimated totals for daily and annual bus kilometers for the new system.

The 'BRT Operation' worksheet then takes this total projected bus kilometer data and derives the CO2e estimate of the new system from that. The model provides some default values for the fuel efficiency of different vehicle types using different fuels at 50 kph. These are listed on the worksheet 'Fuel Eff @ 50' and should be used by the applicant unless a clear justification can be given for using different default values. The model also provides default values for how fuel efficiency will vary for the same vehicle type and the same fuel type at different speeds. It multiplies this fuel efficiency by a scaling factor linked to a projected speed (+ or – the fuel efficiency at 50kmph depending on the actual speed).

The model multiplies the planned total bus kilometers per day and per year for the bus type used by the new system times the fuel consumption per kilometer at the estimated speed of the new system (drawn from the speed calculator mentioned above). This then is simply multiplied by CO2e per liter of fuel, which is taken from standard CO2e emissions factors supplied by the model.

The model now knows how many passengers are likely to ride the new system, how many new transit vehicle kilometers the new system will create, and how much CO2e this will generate. The total CO2e that will be generated by the new transit system then appears in the 'BRT Operations' worksheet. This figure is then carried forward to the 'GEF CO_2' summary worksheet.

Estimating the CO2e Impact of the Project over the No-Project Baseline Scenario

The model now estimates the amount of CO2e that is likely to be removed from the existing baseline traffic system and projected future baseline traffic system. The passengers on the new system will be diverted from their existing trips where they currently use some alternative mode and alternative vehicle. If the modes and vehicles these passengers were using before the new system was introduced generated more CO_2 than these same passengers generate using the new system, then CO_2 is reduced.

Before the CO2e impact of this change can be calculated, however, we need some additional information, which includes the following:

a. Existing modal split (share of trips made by each mode) data for the base year and projected modal split for 10 and 20 years after the base year needs to be input into the 'Mode Share' worksheet.
b. Average occupancy for all the non-bus modes needs to be input into the 'Occupancy' worksheet.
c. Average speed of all the non bus modes needs to be input into the 'Speed' worksheet.
d. The Average trip length for all modes including buses needs to be input into the 'Trip Length' worksheet.
e. Engine type of the non-bus modes needs to be input into the 'Tech%' worksheet.
f. Fuel type of the remaining modes needs to be input into the 'Fuel Type' worksheet.

Some guidelines on each item follow.

a. Modal split data can be taken from the last household survey conducted in the city, if available. A preferable methodology is to create a cordon around the planned BRT corridor. At each road with any significant traffic volume entering and leaving the planned mass transit corridor, traffic counts and occupancy surveys should be conducted in both directions during the morning and evening peak if possible. The total number of vehicle trips passing through the cordon are then simply added up. The passenger trips are then multiplied by the average occupancy per vehicle type to derive the total trips per mode. This method will give a reasonably site specific modal split without requiring too much work.
b. Average occupancy data can usually be taken from the same traffic counts used to conduct the modal split counts, but secondary source materials on average vehicle occupancy can be used.
c. Average speed data can be collected by riding up and down the planned corridor in a car or taxi and measuring the speeds during the peak and off peak hour using a GPS. Alternatively, average speed data can be used from secondary sources.
d. Average trip length can be taken from the latest household survey, user surveys in the corridor, or secondary sources can be used.
e&f. In terms of the engine type and fuel type of bus and the non-bus modes, it is ideal to have detailed records of vehicle type and fuel type from the vehicle registry. If this is not available, whatever secondary sources are available can be used. Fuels and vehicle experts should be consulted to derive better methodologies for estimating these when no secondary source materials are available.

The estimated CO2e benefit from drawing passengers to the new transit system from other modes is calculated on the 'modal shift' spreadsheet. The 'modal shift' worksheet imports the total ridership for the base year from the 'BRT Operation' worksheet. In some projects, there is only one type of bus involved. If, however, these original passengers are drawn from multiple bus types, then the passengers drawn from these modes should be the same ones that were used to calculate the demand on the new system, and should be drawn in the same proportion. For example, if minibuses constitute 60% of baseline public transit trips, and 12 meter buses constitute 40%, then the total new system passengers should be drawn from where they came from, 60% to minibuses and 40% from buses.

Any additional passengers now need to be drawn from different modes. Since we do not know exactly which modes they would be drawn from, we just assume that they are drawn from private vehicles in rough proportion to the preponderance of those modes in the general traffic. On the 'Mode Share' worksheet, the modal split of private modes is entered. The 'mode shift' worksheet derives the trips drawn from private cars by simply subtracting the total bus trips from total trips, and then multiplying the remainder by the proportion of private vehicle trips accounted for by private cars.

These trips are then assigned to vehicles using the average vehicle occupancy figures collected above and recorded on the 'Occupancy' worksheet. These vehicles are then multiplied by average trip distances from the 'trip length' worksheet to yield the total vehicle kilometers removed by vehicle type. Each vehicle type was assigned an average speed from the 'Speed' worksheet. These vehicle kilometers per vehicle type at a specific average speed are then assigned an estimated fuel consumption based on the fuel efficiency factors included in the model. An estimated CO2e emission per litre of fuel consumed is also based on factors included in the model. Each of the withdrawn trips by mode—and their associated CO2e reduction—are then added up. Results appear in the 'modal shift' worksheet.

GHG Impact of Shifting Passengers to Newer, More Fuel Efficient Buses

The TEEMP model has the capacity to capture a shift from dirtier and less fuel efficient buses to cleaner and more fuel efficient buses. The engine type recorded by the user in 'Tech%', and the fuel type recorded in 'Fuel Type' affect the fuel efficiency of the vehicles used. In some cases, the vehicles are assumed to be the same vehicles as would otherwise operate in mixed traffic.

Impact on Mixed Traffic

A BRT project will also have significant impacts on mixed traffic. Currently the model does not account for these impacts, though they could be highly significant and complex.

A BRT system could increase or decrease mixed traffic congestion depending on design and circumstances. Some of the scaling factors included in the 'System Type SF' worksheet are good indicators of mixed traffic impacts, but there is not enough information in the sketch planning tools to make this predictable in any reasonable way. For this reason, we agree that the sketch model should not include any effort to measure these impacts without more complete demand modeling to back it up.

However, it should be recognized that where these impacts can be captured, they can be sizeable, more than tripling the CO2e savings benefit. In the Mexico City analysis done by Rogers (using Tranus), about 1/3 of the benefits were derived from energy efficiency improvements from reduced congestion in the mixed traffic lanes.

CO2e Generated in the Production of Vehicles

Some CO2e will also be generated in the production of the new transit vehicles. However, CO2e will be abated if modal shift results in fewer private vehicles consumed. No impact of this type was measured as it did not seem to add any additional useful information for the selection of better projects. Besides, the CO_2 from the production may have already been considered if the vehicles were manufactured in another jurisdiction that is already under a carbon restraining regime.

Construction Emissions

BRT construction emissions account for the emissions generated during material production and construction of infrastructure such as additional lanes, stations etc. In general for BRT projects they are not that significant in terms of total CO2e impact, but ideally they should be included. MRT construction includes highly energy intensive processes consuming vastly more construction materials, and neglecting construction-related CO2e production will fundamentally change the CO2e profile of the project.

The model includes some averages of typical tons of cement, steel and bitumen that are used per kilometer in constructing some MRT and BRT projects. It relates emissions to their production based on default values taken from available literature. Ideally, the project proponent should collect data specific to the project, but the model allows for the use of default values which are simply multiplied by the length of the planned system.

The worksheet 'construct' contains some baseline values of how much CO2e is likely to be generated per ton kilometer of bitumen, cement and steel. If the total tons used is known for the project, these can be included here. If they are not known, then the user can use the default values included in the model. This figure is then multiplied by the total proposed kilometers of trunk mass transit infrastructure on the 'construction' worksheet. This yields the estimated project CO2e generated by the construction. This is then reflected in the first year of the 'GEF CO_2' worksheet. It is assumed that there will be no additional construction related emissions after year one.

Indirect Effects: Impact of Land Use Changes

BRT projects have been shown to spur land-use intensification along their corridors[1] which has a

1 Cervero, Robert, Kang, Chang Deok: Bus Rapid Transit Impacts

resultant effect on decreasing VKT[2]. The TEEMP model accounts for land use changes by merely multiplying the total emissions savings from operations times a land use factor multiplier supplied by UNEP GEF based on very limited empirical evidence. To avoid distortions all applicants are required to use the same multiplier.

The multiplier currently uses a 1.45 multiplier after 10 years and a 1.9 multiplier after 20 years. This figure will be gradually improved as the database from which it is derived is improved. However, given the unpredictability of land use impacts, for GEF purposes this should be retained as a fixed multiplier to avoid distorting outcomes. The land use factor might also be scaled by the same scoring process used in the 'system type SF' worksheet to greater incentivize good design practice.

Alternatively, the land use impact could be dropped all together. There is certain to be some land use impact of a good transit system, and a reasonable assessment of that impact is useful. However, at this time too little is known about land use impacts to make this a significant element for the GEF in determining the quality of project submissions.

Special Notes for Calculating Indirect Impacts: Dissemination of Mass Transit Best Practice

Good practice engenders replication and good practice elsewhere. The world class TransMilenio BRT system, for example, has inspired other cities to follow suit in spectacular fashion. Ignoring this increase in replication potential for high-quality, full-featured BRT systems would be to miss one of the most important roles played by the GEF. Therefore, as part of this model, a 'Dissemination Rate' worksheet has been created tallying total global kilometers of BRT systems and linking them to the specific systems that inspired them. This spreadsheet should be used to calculate the Bottom-up, or lower extent, of the range of the project's indirect impacts. The general approach outlined in Section II should still be used to calculate the higher extent of the range of indirect impacts.

To illustrate the impacts of good practices on successive projects:

- Curitiba Phase I was roughly 46.2 kilometers. This high-quality, full-featured system inspired the construction of 206.28 km of new BRT systems both in additional corridors in Curitiba and in other Brazilian cities. Its replication effect, however, stalled after that. This is a multiplier of 4.4.
- Quito was then built, also a high-quality, full-featured system for its day, and its Phase I inspired additional BRT km about 3.3 times the original Phase I kilometers, mainly in Quito and Guayaquil.
- TransMilenio was then built, and it had by far the biggest replication impact, with 17 times the original Phase Ia length being more or less directly attributable to its inspiration, not only in Bogota and other cities in Colombia, but all around the world. This was in part due to much more aggressive international promotional efforts which clearly had an impact on hastening the replication, and in part due to a superior, second generation technology.

The way the dissemination factor works in the model is as follows. The average replication multiplier is 8.4 for a BRT with all the recommended features. If on the 'System type SF' worksheet, the system receives a score of 80 out of 100 points or more, then it receives a dissemination multiplier of 8.4 * .01 times the total number of points. If the system receives a score lower than 80 points then it receives zero dissemination multiplier points. This roughly simulates the degree to which only systems of a very high standard have proven to have any significant dissemination impact.

Summarizing Total CO2e Results

On the 'GEF CO2e' spreadsheet, the results are summarized in the CO_2 Emissions Savings table. Direct impacts are listed separately from indirect impacts. The direct impacts are calculated by taking the total emissions generated by the new system, and the emissions related to construction, and subtracting them from the emissions reduced from pulling trips off other modes.

The dissemination and land use multiplier is applied to the direct operational benefit as described in the previous section.

The CO_2 Emissions Savings table also includes a shortcut method of calculating CO2e benefits. This method requires only the baseline estimate of passenger ridership in the new system. This figure is then multiplied by the average CO2e benefit per passenger of all existing empirical data on BRT systems. Currently this data set is very limited. But as the methodology for collecting these estimates is standardized—and more data points are collected—the reliability of this approach should improve.

on Land Uses and Land Values in Seoul, Korea, 2009
2 Reid Ewing, Keith Bartholomew, Steve Winkelman, Don Chen: "Growing Cooler: The Evidence on Urban Development and Climate Change," 2008.

V. Step-by-Step Guide to Non-Motorized Transportation Projects *(Bicycle & Pedestrian)*

BEFORE PROCEEDING

It is essential that the proponent read Section I *(Introduction, Concepts and Introductions)* and Section II *(Overview for Applying GEF Tools and Methodologies)* before moving forward. The core critical concepts, terminologies and foundations are detailed in those sections and are not repeated here. Unless the proponent is already quite familiar with GEF methodologies through prior experience, it is doubtful this current Section can be successfully navigated without first reading Sections I and II.

In this Section you will be working with the following TEEMP models:
Bikeways_TEEMP.xls • Bikeway_TEEMP-MAC.xls • Bike-sharing_TEEMP.xls • Pedestrian_Improvement_TEEMP.xls

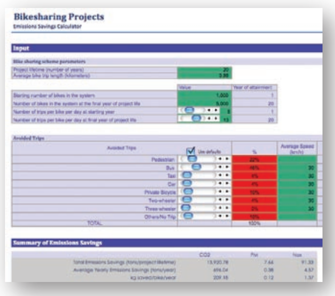
Introduction

Similar to transit projects, non-motorized transportation (NMT) projects seek to induce modal shift away from more GHG-intensive modes and toward bicycling and walking, which are GHG-neutral. TEEMP models are provided for use with Bikeways, Bike-sharing, and Pedestrian Improvement. These models will guide the user through the steps necessary to estimate the direct GHG impact of such projects. To estimate the direct GHG impact without the TEEMP model, use the no-project baseline scenario to compare against project scenarios to find impacts.

Estimating Direct GHG Impact for Bike-Sharing Systems with TEEMP Model

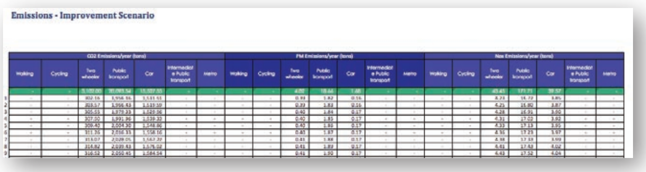
Bicycle-sharing systems make a large number of bicycles available for public use. For projects that incorporate the development of a bicycle sharing system, the Bike-Sharing TEEMP model can be used to estimate the direct emissions impact. This simple spreadsheet model requires the user to input details about the scale of the system and the types of trips avoided through modal shift, and then calculates the GHG impact of the system.

Estimating Direct GHG Impact for Pedestrian Improvement Projects with TEEMP Model

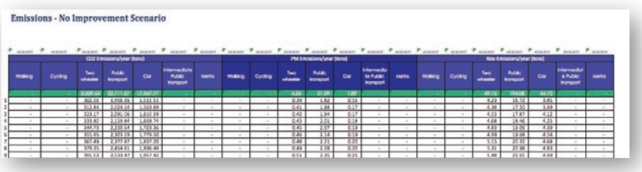


For projects that make an urban environment more walkable—be it by expanded sidewalks, block density, improved crossings, or otherwise improving pedestrian facilities—the Pedestrian Improvement TEEMP model can be employed to estimate GHG impact. The calculation is done in two stages:

- Calculating the No Improvement Scenario (Baseline)



- Calculating the Improvement Scenario (GEF Alternative Scenario)



In the No Improvement Scenario, the user estimates the number of walking trips as a % of total trips. The model assumes a decrease over time due to deteriorating pedestrian facilities coupled with increased motorized traffic. The user has 2 options to define this decrease:

a. The TEEMP model generates annual mode share changes using the values inputted by the user.

b. The mode share changes of the other travel modes (bus, auto, etc.) are automatically generated by allocating the trips shifted away from walking to the motorized modes. The allocation of the shifted trips is calculated on the basis of the size portion of each motorized mode in relation to the total motorized trips at the starting year of the project. A minimum capping limit of 10% walking trip mode share is also applied as a check.

The shifted walking trips are segregated in the calculations. The number of shifted walking trips are multiplied by the lengths of the walking trips. The non-shifted trips are multiplied by the respective trip lengths as defined in the input (basic) sheet. These two sets are added to get the adjusted trips (total km traveled). The adjusted trips are multiplied with the respective emission factors (defaults) to arrive at the final emissions for the No Improvement Scenario.

For the Improvement Scenario, the same quantification concept is applied, but after the project. This Scenario assumes that the number of walking trips as a % of the total trips will increase over time. The increase can be defined in three ways:

a. Direct input of the mode shares at the final year of the project life

b. Assume an annual increase in the percentage of walking trips out of the total trips

c. Determine the change in walking trip mode share by estimating the increase in the walkability score in the project areas

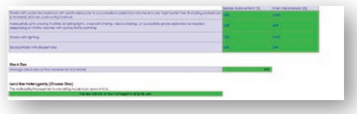
The model will generate the mode shares through time depending on the method chosen by the user.

In the first option (a), the model generates annual % changes in the mode shares using the values inputted by the user. (This is similar to the No Improvement Scenario's option a).

For the second option (b), the changes in the mode shares of the other travel modes (except for biking, which is assumed to be constant throughout time) are generated by distributing the trips shifted away from motorized modes to walking. The allocation of the mode origin of the shifted trips is dependent on the % of the different motorized modes in terms of the total motorized trips at the starting year. A maximum cap of 50% walking mode share is applied.

The third option (c) works similarly as the second option but the change in the walking mode share is calculated using the change in the walkability score. Pre-defined indicators are used in determining the walkability score.

Data Requirements for Walkability Model Project Scenario:



a. Streets with protected walkway with width adequate to accomodate pedestrian volume and which are kept barrier free (including parked cars & hawkers) with non obstructing furniture.

b. Adequately safe crossing facilities (crossing lights, crosswalk striping, raised crossings, or accessible grade separated as needed depending on traffic volume) with active traffic calming.

c. Streets with lighting.

d. Blocks/streets with shade/trees.

e. Block Size discount factor.

f. Land Use Heterogeneity discount factor.

The emissions in the No Improvement Scenario minus the emissions in the Improvement Scenario would give the emissions savings generated by the project.

Estimating Direct GHG Impact for Bikeways Improvement with TEEMP Model

For projects that incorporate the development of bicycle lanes or paths, the Bikeways TEEMP model can be used to estimate GHG impact. The Bikeways model has two modes of estimation:

1. A shortcut "shortcut" Sketch Analysis Method to be used to generate an 'order of magnitude' estimation of the impact if there is little local data, and

2. A "detailed" Full Model to be used to calculate the impact if there is a high level of local data and project design details available.

The user can determine which method to pursue on the first worksheet of the model. The model will guide the user from there.

Data Requirements of Bikeways TEEMP model

The Data Requirements for calculating GHG impacts for Bikeways projects vary depending on which Model the user selects:

Sketch Analysis Inputs – Width and length of Bikelanes, Average Bike trip length (6 km assumed as default)

Detailed Model for different scenarios – BAU – base year, BAU – Horizon year, With Project – Horizon Year

a. Average mode speeds - Cars, Two Wheelers, Three Wheelers, Taxi, Bus, Jeepney/RTV's, Walking and Cycling

b. Vehicle Emission Standards for modes

c. Fuel Type (Gasoline and Diesel)

d. Mode share of modes - Cars, Two Wheelers, Three Wheelers, Taxi, Bus, Jeepney/RTV's, Walking , Cycling and LRT

e. Average Trip Length - Cars, Two Wheelers, Three Wheelers, Taxi, Bus, Jeepney/RTV's, Walking and Cycling

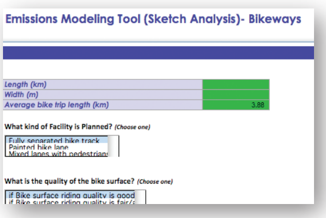
f. Average Occupancy

g. Fuel Consumption at 50 km speed (kmpl)

h. Quantity of Cement, Steel and Bitumen/km

i. Emission factors for Cement, Steel and Bitumen/ Ton (production)

For quantifying the emissions generated at the construction stage, the projected quantities of cement, bitumen and steel are requested. The emissions generated during the energy consumption for the production of these materials are calculated as construction emissions and are included in project analysis. This procedure may result in conservative estimates because emissions generated due to material movement, construction machinery usage, traffic diversion etc. are not included.



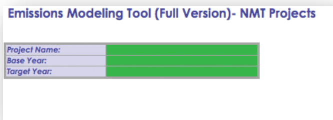
Sketch Analysis (Short cut)

In cases where no local data is available, the Sketch Analysis is useful tool. Default values are drawn from case studies of successful projects in Rio de Janeiro and Bogota. Thus, the proponent is still able to estimate the impacts of such variables as mode share, modal shift, trip lengths, etc.

It is assumed that roughly, 1 km of bikeways would attract 2173 trips. If narrow bike lanes are constructed with width less than 2m, the trips are scaled down by 50%. Average trip length suggested as default by the model is 6 km, and a 90% shift from public and intermediate public transport modes is assumed. The user can vary the shifts to quantify the impacts using local data.

Future refinements of the bikeway model may incorporate other factors that are likely to be significant. These may include the population and employment density of areas served by the bikeway; whether the bikeway connects to larger networks; the degree to which the area served by the bikeway is pedestrian and bicycle friendly or being made so as part of the initiative; the topography of the area; and other project elements that may provide added legitimacy and support for cycling in the area, such as car-free days, bike parking, and promotion programs.

Full Model (Detailed)



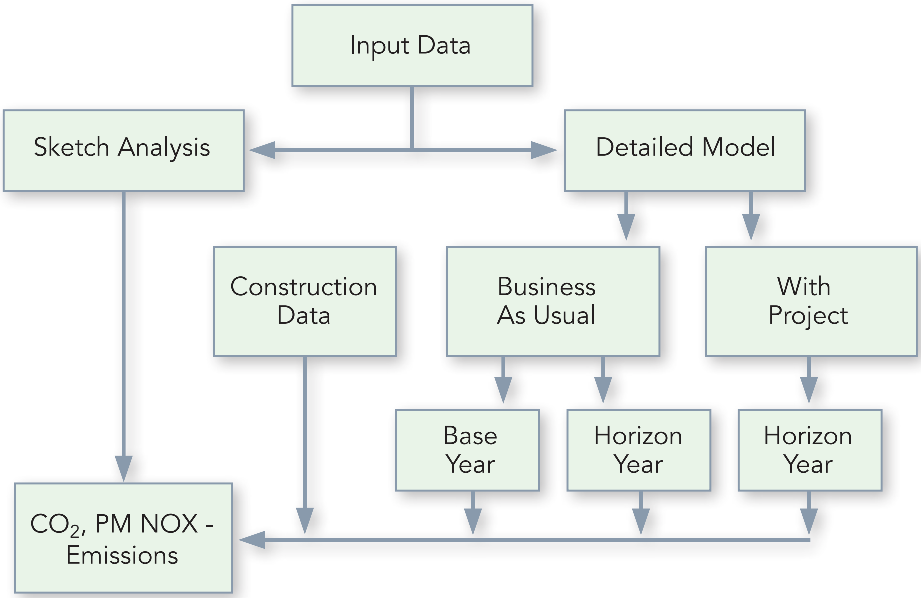
Using the data supplied by the user and ASIF logic, the Full Model tries to capture emissions for both the Baseline and the GEF Alternative Scenario. The emissions savings are highly dependent on the modal shift achieved, Trip Lengths and "stream speeds". Using the base 50 kph speed emission factors and estimated traffic speeds, the model first calibrates the emission factors and then processes the CO_2 emissions. Air pollutants – PM and NOx—are quantified in similar manners.

The emissions savings are assumed to be linear and thus using the base value and horizon year savings, total emissions during the project lifetime are quantified by the model. The emissions are increased by default 14% to include the "well-to-tank" upstream GHG emissions typical for motor fuels. The outputs include:

- Total emissions from scenarios,
- Total savings over lifetime, and
- Tons/km/year savings due to bike lane construction.

Figure 6 shows the structure of the TEEMP bikeway model.

Figure 6: Structure of Bikeways Emissions Impact Model



Developing a Baseline for NMT Projects Without TEEMP Model

A "quick but reasonable" baseline must be established in the application phase of a GEF Project. If the TEEMP model is not used, the baseline can be developed using a combination of any existing local data. The general sequence in establishing a baseline is as follows:

a. **Define a project impact area**. The project impact area includes any area where there will be a traffic impact from the project. It will most likely loosely follow the corridor of the project, including the corridor itself and any and all competing corridors.

b. **Estimate the number of trips, average trip distance, and vehicle occupancy** occurring within the project impact area for all modes during peak and non-peak hours. Data for this estimation can be derived from local traffic counts and travel surveys.

c. **Apply emissions factors and vehicle fleet data.** If local vehicle fleet and emissions factors (including upstream emissions) are not available, use the GEF Transportation Default Values.

d. Enter values into the following formula:

$$YGHG_1 = \Sigma_{Tx,yz...}[T_x * c_x], \text{ with}$$

$YGHG_1$ = *Yearly GHG Inventory for year 1;*

T_x = *yearly VKT for mode/vehicle X;*

c_x = *Emission factor of mode/vehicle X*

a. **Estimate the growth trend of travel** in this impact area using corresponding historical transportation data if available or by applying a growth factor based on related trends such as regional trends, land use forecasts, etc. for a no-project scenario. Take into account capacity limits.

b. **The baseline inventory should be calculated over the lifetime of the project.** Annual emissions inventories are then summed to find the cumulative emissions for the no-project scenario over the lifetime of the proposed project for comparison:

$$CGHG_{NP} = \Sigma_n YGHG_n, \text{ with}$$

$CGHG_{NP}$ = *Cumulative GHG Emissions for no-project scenario over lifetime of proposed project (years 1-n)*

$AGHG_n$ = *Annual GHG Inventory for all years of project lifetime*

Pick Y or A in the formula.

VI. Step-by-step Guide for Travel Demand Management Projects

BEFORE PROCEEDING

It is essential that the proponent read Section I *(Introduction, Concepts and Introductions)* and Section II *(Overview for Applying GEF Tools and Methodologies)* before moving forward. The core critical concepts, terminologies and foundations are detailed in those sections and are not repeated here. Unless the proponent is already quite familiar with GEF methodologies through prior experience, it is doubtful this current Section can be successfully navigated without first reading Sections I and II.

In this Section you will be working with the following TEEMP models:
Pricing_TEEMP.xlsx • Commuter_Strategies_TEEMP.xlsx • PAYD_TEEMP.xlsx

Introduction

Travel Demand Management (TDM) Projects include an array of strategies that use modal shift to either reduce the demand for transportation or encourage more efficient consumption of transportation resources through modal shift. Strategies include:

- Various transport pricing schemes,
- Integrated transport and land use planning,
- Parking management,
- Car-sharing programs, or
- Encouraging telecommuting, among others.

Data Requirements: Baseline Calculations

For all GEF projects, a quick but accurate baseline must be established in the application phase. If a TEEMP model is employed, the user can disregard the steps described below because the TEEMP will automatically calculate the baseline.

To estimate the emissions impact without a TEEMP, a no-project (no GEF or co-financing investment) a baseline must be created which quantifies the emissions for the area and modes that are affected by the proposed project. This can be developed through a combination of any existing local data.

Once the baseline is known, the degree to which the project will reduce that baseline transport activity and GHGs must be estimated to find the direct emission reduction.

The general sequence in establishing a baseline is as follows:

a. **Define a project impact area:** The project impact area includes any area where there will be a traffic impact from the project.

b. **Estimate the number of trips, average trip distance, and vehicle occupancy** occurring within the project impact area for all modes during peak and non-peak hours. Data for this estimation can be derived from local traffic counts and travel surveys.

c. **Apply emissions factors and vehicle fleet data:** If local vehicle fleet and emissions factors (including upstream emissions) are not available, use the GEF Transportation Default Values and apply them to this formula:

$$YGHG_1 = \Sigma_{Tx,yz...}[T_x * c_x], \text{ with}$$

$YGHG_1$ = *Yearly GHG Inventory for year 1;*

T_x = *yearly VKT for mode/vehicle X;*

c_x = *Emission factor of mode/vehicle X*

This note applies in two places in this Section and in other Sections. The "Y" and the "A" in these formulas represent distinct and different values. Making these accurate requires someone with an intimate understanding of the purpose of the formulas.

a. **Estimate the growth trend of travel** in this impact area using corresponding historical transportation data if available or by applying a growth factor based on related trends such as regional trends, land use forecasts, etc. for a no-project scenario. Take into account capacity limits.

b. **The baseline inventory should be calculated over the lifetime of the project**. Annual emissions inventories are then summed to find the cumulative emissions for the no-project scenario over the lifetime of the proposed project for comparison, using this formula:

$$CGHG_{NP} = \Sigma_n \, YGHG_n, \text{ with}$$

$CGHG_{NP}$ = *Cumulative GHG Emissions for no-project scenario over lifetime of proposed project (years 1-n)*

$AGHG_n$ = *Annual GHG Inventory for all years of project lifetime*

Calculating Direct GHG Impact for Commuter Strategies, Parking Pricing, Pay-As-You-Drive Insurance using TEEMP Modules

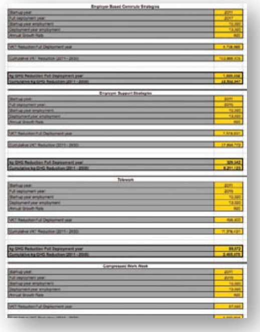
The TEEMP models developed for various commuter strategies, parking pricing, pay-as-you-drive insurance. These tools are all based on simple elasticity analyses applied to a market share framework, using default values derived from empirical experience. These tools can be customized with locally-available data where it provides a better basis for analysis, and they will be enhanced over time by better documentation of global empirical experience.

These models are provided within three Excel files, corresponding to the main model type:

1. Commuter Strategies
2. Pricing
3. Pay As You Drive (PAYD)

The following sections describe each model and worksheet.

Commuter Strategies (Employer-based Strategies)



There are four TDM strategies covered in the 'Commuter Strategies' TEEMP. Each is a separate worksheet (tab) within the same Excel file:

1. Employer support programs,
2. Telework,
3. Compressed work week,
4. Commute Strategies (Rideshare/transit subsidies)

Table A-2 in the appendix illustrates all the data required for and defaults provided for the Employer-Based Commute Strategies TEEMP module. The worksheets for these four areas are described more fully in the following sub-headings

1) Employer Support Programs (Transport Support)

The Employer Support Model (tab) examines the effect of employer support programs which encourage employees to utilize alternative modes. These may include provision of an on-site transportation coordinator, ride-matching, transit information, and other actions aside from time and cost incentives.

For a regional analysis, necessary inputs include both the existing and the alternative scenario participation rates (percent of employers participating) by program level for each mode. Program levels of "1" through "4" indicate varying levels of effort for the programs. Alternatively, levels of support and participation rates can be defined for office employment compared to non-office employment. This approach is borrowed from the US EPA Commuter Model, developed in part by Cambridge Systematics.

Examples of the four levels, which can be customized to match local support program conditions are:

a. Level 1 = Employer provision of baseline information activities (transit fare and route information, rideshare matching, etc.)

b. Level 2 = Level 1 plus employer assisted carpool/ vanpool matching, work hours flexibility, bike parking and shower facilities.

c. Level 3 = Level 2 plus preferential carpool parking, vanpool development and operating assistance, transit pass sales, secure bike parking.

d. Level 4 = Level 3 plus additional financial and technical support, guaranteed ride home, promotional activities.

VKT reduction impacts of support activities act as a multiplier to the effectiveness of employer incentive programs. Thus the results of employer financial incentives are multiplied by the VKT reduction effectiveness of support programs. Effectiveness estimates are based on a matrix evaluation of a full range of before and after participation rates in the Commuter model.

The critical inputs impacting employer support program strategy results are:

a. Total employment,

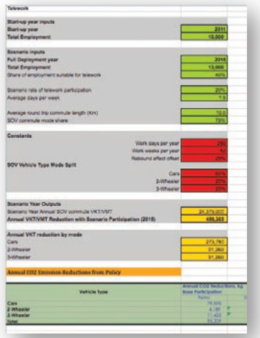
b. Baseline and Alternative Scenario participation rates and

c. Baseline and Alternative Scenario support levels.

In many US cities there are trip reduction ordinances, or Transportation Management Associations which support implementation of support programs. The successes of the incentive programs are tied directly to employee exposure, knowledge and ease of use of the programs that are available.

In developing world urban locations, the potential level of deployment for employer support programs is predominantly tied to the size of the employer, industry type and scale (i.e. local, national, continental or international). The inputs of Baseline and Alternative Scenario participation rates should take into account these types of characteristics of all the employers in the region, city, or district within which the strategy is tested.

2) Telework



The Telework Model (tab) examines the effect of employers implementing teleworking policies. The user can apply multiple assumptions, including the share of employers where teleworking would be a feasible practice and the share of employees at these employers that would telework.

The TEEMP model calculates VKT reduction from teleworking based on share of jobs amenable to teleworking and rates of participation, with a 25% rebound effect offset to account for additional non-commute trips taken by teleworkers on their non-commute days. Specific values used in the analysis include:

- Existing rates of telework participation,
- Average days per week teleworking,
- Total working days per year,
- Average round trip commute length,
- Rebound effect offset percentage (workers make trips from home on telework days that were previously chained with the work trip) and
- SOV commute mode share.

All of these values can be user specified based off local characteristics.

The critical inputs for scenario testing are:

a. Existing and scenario rate of telework participation, and

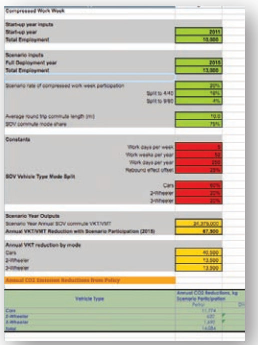
b. Existing and scenario average days of telework per week.

Surrounding conditions play a key role in determining both the potential for teleworking and its actual utilization. Despite a high level of interest for teleworking—expressed by most employees, as well as by a growing number of employers—the share of regular teleworkers is still relatively low (5 percent or less) in most countries. This is due to a combination of factors, including technological and economic barriers, legal and administrative barriers (such as lack of permission to telework from the company or lack of approval from the superior), and the perceived need for physical presence and face-to-face interaction in a number of jobs.

There are a number of research reports on potential ranges of teleworking participation worldwide that can serve as good references on potential scenarios for testing. Alternatively, given a specific employment profile for a region and a knowledge of the existing policy and technology environment, regional specific inputs can be entered.

3) Compressed Work Week

The Compressed Work Week Model (tab) examines the effect of shifting workers to shorter workweeks while maintaining the same total work hours per week or two week period (such as 4-day workweeks or 9 days of work per two weeks).



Average VKT reduced per week per worker who formerly drove is based on average daily round trip commute length. The reduction is offset by a rebound effect (estimated at 25% per US research) similar to the approach for telework.

The critical inputs are:

a. Existing rates of participation

b. Scenario rates of participation

Other local commuting characteristics such as total employment, SOV commute mode share and average round trip commute length are required for the calculation. The VMT reduction per week varies depending on a 4/40 (e.g., a 5-day 40-hour workweek compressed into 4 days) as opposed to a 9/80 compressed schedule (i.e. the average weekly impact of a 9/80 is 50% of a 4/40).

The same caveats at play for the teleworking strategy are relevant for compressed work weeks, except that barriers with regard to technology or costs are not an issue. Therefore this strategy is highly reliant on employer policy and willingness to offer flexible work schedules to employees. In addition, users should be sure to modify the constants for number of work days per week and year depending on local practice (such as whether work weeks are customarily 6 days instead of 5).

4) Commute Strategies (Rideshare/Transit Subsidies)

The Commute Strategies model (tab) examines the effect of providing new incentives (subsidies), or increasing existing incentives to commuters for ridesharing and transit. These programs work best to encourage commuters to switch from driving alone to carpooling or transit in dense employment districts where alternative modes to driving alone are available, traffic congestion is a significant challenge and parking is at a premium.

The model differentiates among the response expected for offices located in low density suburbs, activity centers, and CBDs. The model calculates the percentage reduction in VKT, based on the rate of employer participation, for each $1(USD) increase in daily subsidy provided. This estimate is based on a Victoria Transportation Policy Institute (VTPI) study of expected vehicle trip reduction in response to different subsidies in the U.S.

The critical inputs impacting employer financial incentives strategy results are

a. Total employment, base and scenario participation rates and

b. Base and scenario subsidy levels.

In many US cities there are trip reduction ordinances, or Transportation Management Associations, which support education and implementation of incentive or subsidy programs. The successes of these programs are tied to these management or regulatory practices.

The trip reductions used in this approach are estimated by VTPI, and include the impact of these external factors. In developing world urban locations, this regulatory and supportive institutional framework may not exist, suggesting that the effectiveness of subsidy programs may be less than the US example. In addition, competitive supporting infrastructure such as public transit, or programs such as regional ridesharing databases, may not exist, meaning that the effectiveness rates could, on average, be less in these regions. The consideration of user inputs and understanding of results from the model should take these factors into account.

Parking, Pricing, and Company Car Programs

The Pricing TEEMP contains worksheets (tabs) for calculating the direct GHG impact of TDM programs that focus on:

a. Parking,

b. Pricing, and

c. Use of company cars.

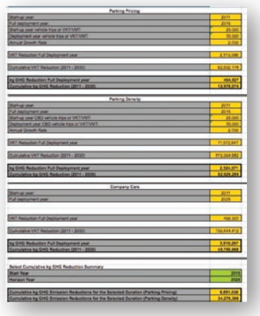
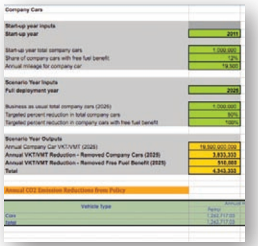


Table A-4 in the appendix illustrates all the data required—and defaults provided—for the Pricing TEEMP module.

The worksheets for these three areas are described more fully in the following sub-headings

Company Cars: Employer-Provided Vehicles



The Company Cars Model (tab) examines the effects of reducing or eliminating subsidies associated with the provision of company cars. Outside the U.S., company cars are a benefit often provided to employees. Since employees do not pay the costs of owning or operating the cars, they have little or no incentive to reduce costs by limiting driving. This model examines two policy options:

a. Eliminating the company car. The impacts will include some measure of increase in private auto travel.

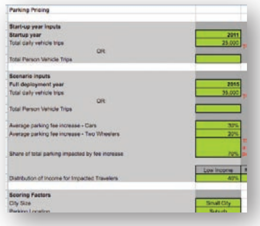
b. Keeping the company car but eliminating free fuel for non-business travel.

The model uses elasticities for response to elimination of company cars and elimination of the free fuel benefit to calculate VKT reduced. This analysis is based on a United Kingdom Revenue and Customs evaluation report on company car tax reform. Since households in the U.K. are more likely to have a private car available to replace the company car than households in the developing world, this analysis would likely be a conservative estimate of GHG reductions possible from this strategy.

Since the basis for application of the company car model is a study of company car tax reform in the UK, factors like vehicle ownership and level of employees who are accorded provision of company cars is likely to be different from cities in developing countries. Due to scant data on company car mileage in the developing world, data from UK and Canada has been used to determine the relationship between regular passenger car mileage and company car mileage. This is heavily dependent on policies guiding usage of company cars for private use, and hence is very policy specific. Other policies regarding provision of free fuel for non-business travel might vary from case to case.

Parking Pricing

The Parking Pricing Model (tab) examines the effects of increasing parking fees in urban areas. This analysis



uses a base parking pricing elasticity of -0.15 (from Shenzhen, China), which indicates a decrease of 1.5% of VMT as a response to 10% increase in parking price in the CBD. For parking converted from free to paid parking, the model uses a base -0.2 elasticity (e.g. 20% reduction in trips that made use of the free parking spots that are now priced) based on VTPI data. The model allows the user to implement separate policies for 4-wheel versus 2-wheel vehicles.

To account for local characteristics, scoring factors within the model are factored into the calculation of strategy effectiveness through a lookup process that modifies the base parking price elasticity upwards or downwards based on the combination of three unique region factors:

a. City Size – Characterized either as "Large" (generally the top tier metropolitan regions with an international presence) or "Small" (the second tier, rapidly developing cities serving as subnational or regional economic generators). May also follow official national classification schemes such as India's Compensatory City Allowance.

b. Parking Location – Characterized by "Urban Core" (Central Business District), "Near Core" (other regional employment centers), and "Suburb" (regional activity or town centers).

c. Transit Level of Service – Characterized as "High" (presence of a large Metro system), "Medium" (small or no Metro system, may have BRT or other high capacity bus transit), and "Low" (local and regional bus services only).

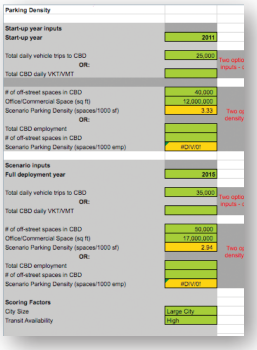
In general, larger city size, more densely developed location and more robust transit system results in a more sensitive price elasticity.

The worksheet is set-up to accommodate the impacts of parking pricing for three income groups – low, medium, and high (representing the lowest third of households in income, the middle third, and the highest third). This stratification is designed to capture the differing levels of price sensitivity of these groups—lower income travelers are more sensitive to price increases, and thus will respond with greater VKT reduction. Where different stratifications will be more useful, the user may aggregate finer income groups or divide into groups relative to median income or actual income data through acceptable means of data collection.

This worksheet does not account for the possible effect of drivers switching from four-wheelers to two-wheelers to mitigate the effect of parking price increases. In the U.S., it is generally assumed that the trips are shifted to non-auto modes (transit, bike/ped), or are not taken. In the developing world, however, since parking for two-wheelers is on the order of 25-50% of the cost of parking a car, it is possible that some car trips would be converted to 2-wheeler trips (as an inexpensive way to deal with the increased cost of parking).

Finally, the effectiveness of parking pricing policies depends heavily on the degree to which parking laws are enforced in an urban area. If drivers can park on the sidewalk with impunity, they are not likely to pay for parking. The input "share of total parking affected by fee increase" can be used as a proxy for the tolerance to illegal parking, with the relative share of parking affected decreasing in urban areas where illegal parking is not effectively controlled.

Parking Density (Availability)



The Parking Density Model (tab) examines effect of reducing the number of parking spots available in the Central Business District (CBD) per square foot of office space, or per employee. Thus it can be implemented as a parking spot reduction, or a parking spot freeze if the amount of office space and employment in the CBD is growing.

Our model uses a North American elasticity for the effect of parking availability on number of trips taken, obtained from a Canadian study which is cited in Transit Cooperative Research Program (TCRP) 95—Parking Management and Supply Traveler Response to Transportation System Changes.

To account for local characteristics, scoring factors within the model are factored into the calculation of strategy effectiveness through a lookup process that modifies the parking availability elasticity upwards or downwards based on the combination of two unique regional factors:

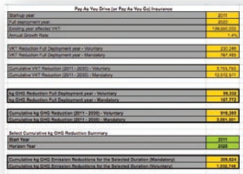
a. City Size – Characterized either as "Large" (generally the top tier metropolitan regions with an international presence) or "Small" (the second tier, rapidly developing cities serving as sub-national or regional economic generators). May also follow official national classification schemes such as India's Compensatory City Allowance.

b. Transit Availability – Characterized as "High" (presence of a large Metro system), "Medium" (small or no Metro system, may have BRT or other high capacity bus transit), and "Low" (local and regional bus services only).

In general, larger city size and more robust transit system results in greater sensitivity to parking availability.

One of the primary design factors that determines the number of parking spaces per unit floor space available is the peak demand for parking utilization. The Parking Density model bases its parking space availability on this peak demand. Since such parking design factors vary across different countries, the user should be sensitive to the basis of determination of parking availability and demand. Availability of parking by employees can be used as a proxy to availability by floor space or area, given the ability to adequately estimate the number of employees working in the targeted area.

Pay-As-You-Drive (PAYD)



The PAYD TEEMP examines the effects of turning the fixed costs of auto insurance into a per-mile (variable) cost.

The PAYD Model's result is calculated by adding the cost of PAYD insurance to the per-mile cost of driving, and using the price elasticity of VKT to calculate a reduction in VMT. This price elasticity of VKT is stratified by income level, to account for drivers' increasing price sensitivity as incomes decline. The user should input driver participation by income category, with the income categories determined by regional or national income distribution:

a. Low income represents the lowest third of households

b. Medium income represents the middle third of households

c. High income represents the highest third of households

The analysis uses a U.S.-based price-elasticity of VKT, but with default values of insurance and the price of driving based on developing world data. The user can specify different values for insurance costs and elasticities if known.

The user can also specify different shares of the population that participates in PAYD, depending on whether the policy is voluntary or mandatory. For a voluntary system (e.g., a system in which drivers have a choice of purchasing other types of auto insurance instead of PAYD insurance), we again use a U.S.-based default value of 30% participation. For a mandatory system, it is assumed that drivers seeking insurance can only purchase PAYD. Table A-3 in the appendix illustrates all the data required for and defaults provided for the PAYD TEEMP module.

The cost of driving (expressed as the total cost per mile, including fuel, maintenance, and vehicle depreciation or capital costs) and the cost of insurance vary considerably around the world, and users should input local data wherever possible. Also, it is important to note that given the relatively low rates of insurance among the driving population in the developing world, insurance reform (mandating more consistent levels of insurance) might need to be part of a PAYD policy.

PAYD policies are most effective when purchasing insurance is mandatory in order to own a vehicle. If insurance is optional or not widespread, PAYD effectiveness will be reduced since higher mileage drivers may choose not to purchase insurance at all to avoid the added cost per mile.

Calculating Direct Emission Reductions for Other TDM Projects

TDM projects generally increase transportation GHG efficiency by reducing the demand for—or distribution of—transportation activity. The impact of the TDM project on the transportation sector must employ appropriate project-specific methods – surveys or the use of local models, etc. – to reliably estimate the effect of the TDM strategy on the transportation sector in question. An emissions factor is then applied to the changes in transportation activity and the direct GHG impact of the project is known.

The formula for calculating the direct emissions for other TDM projects is:

$$CO_2 \text{ direct year } 1 = \Sigma_{Tx,y,z} [(1- R_x)* T_x *c_x], \text{ with}$$

T_x = VKT for mode/vehicle X

R_x = Reduction factor for travel activity of mode/vehicle X due to TDM program in year 1

c_x = Emission factor of mode/vehicle X

The reductions for each year of the projects' life should then be summed together to find the cumulative emissions reduction of the TDM project:

$$CGHG_P = \Sigma_{1\text{-}n}\, CO_2 \text{ direct year } n, \text{ with}$$

$CGHG_P$ = Cumulative GHG Emissions for the project scenario over lifetime of proposed project (years 1-n)

CO_2 direct year n = CO_2 direct impact for each year of project lifetime

VII. Step-By-Step Guide For Comprehensive Regional Transport Initiatives

BEFORE PROCEEDING

It is essential that the proponent read Section I *(Introduction, Concepts and Introductions)* and Section II *(Overview for Applying GEF Tools and Methodologies)* before moving forward. The core critical concepts, terminologies and foundations are detailed in those sections and are not repeated here. Unless the proponent is already quite familiar with GEF methodologies through prior experience, it is doubtful this current Section can be successfully navigated without first reading Sections I and II.

In this Section you will be working with the following TEEMP model:
Expressway_TEEMP.xls

Describing the Baseline and the GEF Impact Case

Comprehensive Regional Transport Initiatives involve the coordination of multiple strategies – at least three from different transportation sub-sectors –that have mutually reinforcing impacts and are implemented in concert to reduce the GHG intensity of a regional transport sector. This approach focuses on strategies that are complimentary and synergistic, allowing the impact of each project component to leverage greater impacts of accompanying components.

A simple example of this approach could be a strategy combining increased residential density along new BRT corridors with new parking pricing program in the central business district. Each of these components can reduce transport sector emissions, but when implemented in concert they leverage the efficacy of each other. For this very reason, the comprehensive approach is considered to be highly effective, although quantifying the impacts becomes more complicated.

Comprehensive Regional Transport Initiatives are best evaluated by the assemblage of a comprehensive ex-ante baseline including historical trends for the region. This baseline should be submitted in two forms: one baseline, which includes all walking and bicycling modes, and other non-motorized transportation (NMT) modes, and another that excludes all NMTs.

The data requirements for this baseline include:

a. Two to three modal splits are desired: a recent modal split and 1-2 modal splits that pre-date the most recent modal split data by approximately five years and/or ten years respectively. The historical data is used to track trends in the transportation sector and project the future growth of emissions in the no-project (no GEF or co-financing investment) baseline.

b. Average trip distances by mode (if possible also by trip purpose) are also desired to accompany all modal splits unless specific distances can be taken from modeled project specific traffic system impacts (if available).

c. The mix of the vehicle fleet by vehicle type is also desired.

d. If freight transport is targeted in the comprehensive strategy, then data should be provided for all relevant freight modes in the baseline.

This data is best derived from recent household origin-destination surveys if possible. If these are not available, use vehicle and vehicle occupancy counts around, within, and across cordons. Once assembled, the data can be combined with appropriate emissions factors to create a transport sector emissions inventory for the region, based on a simplified ASIF philosophy of quantifying for transport sector emissions, which relies on per kilometer emissions factors for various vehicles:

$$AGHG_1 = \Sigma_{Tx,yz...}[T_x * c_x], \text{ with}$$

$AGHG_1$ = Annual GHG Inventory for year 1

T_x = yearly VKT for mode/vehicle X

c_x = Emission factor of mode/vehicle X

The baseline inventory should be calculated over the lifetime of the project, requiring at least two data points (project start and finish) to interpolate the annual emissions over the lifetime of the project. These annual emissions inventories are then summed to find the cumulative emissions for the no-project scenario over the lifetime of the proposed project for *comparison:*

$$CGHG = \Sigma_{1\text{-}n} AGHG_{1\text{-}n}, \text{ with}$$

CGHG = Cumulative GHG Emissions for no-project scenario over lifetime of proposed project (years 1-n)

$AGHG_1$ = Annual GHG Inventory for year 1

Calculating Direct Emission Reductions

The previous sections of this Manual discuss how to find the direct emissions reduction for the vast majority of transportation efficiency interventions that would be funded by the GEF. Comprehensive regional transportation initiatives are likely to have components—such as a public transportation or NMT strategies—for which direct emission reduction estimation methodologies are found in this document.

The **first step** of calculating the direct emissions reduction for a comprehensive regional transportation initiative is to **calculate the direct emissions impact of each component** of the initiative separately according to the methodology outlined in this guide.

The **second step** is to **sum the direct lifetime emissions impacts** for each project components with direct impacts.

The **third step**, unique to comprehensive regional transportation initiatives, is to **apply a leveraging factor** to the total lifetime emissions reductions for all the components, which recognizes the enhanced efficacy of a comprehensive and synergistic approach. The leveraging factor should be determined by an expert and justified within the text of the Project Document. The following guide breaks down the extents of leveraging factor awards for comprehensiveness of strategies.

Leveraging Factor	
Minimum - 10%	Low Leveraging Factor – project components will have mutually reinforcing synergistic effects on one another, but countervailing actions will undermine this effect.
Maximum - 30%	High Leveraging Factor – Project Components will have highly significant mutually reinforcing synergistic effects on another without interference from other countervailing policies or actions.

A high leveraging factor shall be used only if, in the applicable metropolitan area, there are no planned or currently underway major transport sector investments or policies that might undermine the synergistic impact of the comprehensive approach that is being proposed. Transport investments and policies that should be considered as undermining a comprehensive approach include:

a. Motorway expansion or flyover development for private vehicles expected to increase lane-km of motorways or flyovers in the impact area or region by more than 5% in the next decade.

b. Any planned increase in direct or indirect motor fuel subsidies or tax reductions.

c. Any planned increase in parking requirements or subsidies for new parking developments.

d. Any new restrictions to limit non-motorized vehicle travel in the region or impact area.

A low leveraging factor shall be used if these conditions are not met but an otherwise comprehensive strategy is being advanced.

VIII. Appendices: TEEMP Model Data Defaults & Sources

Appendix 1: Data Required and Defaults Provided for Eco-Driving Module

Telework Model				
Data Point	**Default Value**	**Source**	**Acceptable Means of Collection**	**Remarks**
VKT by mode				
Cars	85,000,000	Dummy Value Input	Highway Statistics Data, Regional Studies, Surveys with inventory information from Vehicle Registrations	
2W	22,000,000	Dummy Value Input		
3W	13,000,000	Dummy Value Input		
Taxi	19,000,000	Dummy Value Input		
Bus	3,600,000	Dummy Value Input		
Jeepney/RTV	7,700,000	Dummy Value Input		
Walk	—	Dummy Value Input		
Cycle	—	Dummy Value Input		
LRT	—	Dummy Value Input		
Medium Freight Truck	10,000,000	Dummy Value Input		
Heavy Freight Truck	40,000,000	Dummy Value Input		
Passenger				
Percent of population reached by Ecodriving training programs	10%	Dummy Value Input	Penetration Rates from Studies	
Percent of population with on-board display tools	0%	Dummy Value Input	Penetration Rates from Studies	
Freight				
Percent of population reached by Ecodriving training programs	10%	Dummy Value Input	Penetration Rates from Studies	
Percent of population with on-board display tools	0%	Dummy Value Input	Penetration Rates from Studies	
Ecodriving Training:				
Nature of Ecodriving Training (Choose one)	Structured Training Program OR General Marketing Program	Types of Ecodriving Training Programs	In-vogue training programs	SUTP Review of Ecodriving Training Programs
Program Type in Detail under corresponding Training	Basic Structured Training Program Hands-on Training Program Intensive Training Program with Benefits OR Basic Outreach Program with Information Brochures Interactive Marketing Program with Multimedia Interactive Marketing Program with Feedback	Depending upon the nature of ecodriving training program, the program details provide different levels of participation and involvement resulting in varying levels of results when it comes to implementation rates and fuel reduction rates.	Literature review of ecodriving training programs.	

Telework Model				
Data Point	**Default Value**	**Source**	**Acceptable Means of Collection**	**Remarks**
Individual Fuel Use Reduction from training	Based on Scoring Factors	International Transport Forum Leipzig 2008 Transport and Energy: The Challenge of Climate Change Research Findings and Indonesian Study Eco Driving: Saving Fuel Around the World Clean Fleet Management Toolkit Training 3 March 2009	Case Studies or Surveys	50 country members include some Asian Countries
Percent of population reached that implements lessons learned	Based on Scoring Factors	Michigan Department of Environmental Quality (DEQ) - based on European examples (Netherlands and Sweden)		
Percent of that population that continues to implement ecodriving in Year 2	33%	Michigan DEQ - based on European examples (Netherlands and Sweden)		
On-board display tools:				
Individual Fuel Use Reduction from on-board display tools	5%	International Transport Forum Leipzig 2008 Transport and Energy: The Challenge of Climate Change Research Findings	Case Studies or Surveys	50 country members include some Asian Countries
Percent of population reached that implements lessons learned	50%	Michigan DEQ - based on European examples (Netherlands and Sweden)		

Appendix 2: Data Required and Defaults Provided for Employer-Based Commuter TDM Strategies

Telework Model				
Data Point	**Default Value**	**Source**	**Acceptable Means of Collection**	**Remarks**
Base rate of telework participation	0.062	"From workplace to anyplace assessing the opportunities to reduce greenhouse gas emissions with virtual meetings and telecommuting", WWF Report		
Average days per week (telework) - Base Year	1.14	"From workplace to anyplace assessing the opportunities to reduce greenhouse gas emissions with virtual meetings and telecommuting", WWF Report		

Telework Model				
Data Point	**Default Value**	**Source**	**Acceptable Means of Collection**	**Remarks**
Average round trip commute length (Km)	10	Millennium Cities Database (IATP)		User can pick details at City/Region from the database
Scenario rate of telework participation	0.084	"From workplace to anyplace assessing the opportunities to reduce greenhouse gas emissions with virtual meetings and telecommuting", WWF Report		
Average days per week (telework) - Scenario Year	1.29	"From workplace to anyplace assessing the opportunities to reduce greenhouse gas emissions with virtual meetings and telecommuting", WWF Report		
Rebound effect offset	0.25	"From workplace to anyplace assessing the opportunities to reduce greenhouse gas emissions with virtual meetings and telecommuting", WWF Report		Assumptions on this rebound effect are based on the review of over 30 studies undertaken by Steven Sorrell UKERC (2007). (http://www.ukerc.ac.uk/support/tiki-index.php?page=ReboundEffect)
Total employment	10000		Employment Department Data/ Government Agency/ Census Data	
SOV Vehicle Type Mode Split				
Cars	0.6	Millennium Cities Database Supply Indicators		
2-Wheeler	0.2	Millennium Cities Database Supply Indicators		
3-Wheeler	0.2	Dummy Input	Only used if the three wheelers are a significant share of traffic - Example India (Collection and use based on Individual City Studies/vehicle registration data)	
Share of employment suitable for telework	0.4	Dummy Input	Knowledge Intensive Sectors' share of Total Employment (highest participation rate of all sectors)	

Compressed Work Week Model

Data Point	Default Value	Source	Acceptable Means of Collection	Remarks
Existing rate of compressed work week participation	0.1	US Data - US EPA Commuter Model		No Developing Country Data
Split to 4/40	0.08	US Data - US EPA Commuter Model		No Developing Country Data
Split to 9/80	0.02	US Data - US EPA Commuter Model		No Developing Country Data
Average round trip commute length (km)	10	Millennium Cities Database (IATP)		User can pick details at City/Region from the database
Scenario rate of compressed work week participation	0.2	US Data - US EPA Commuter Model		No Developing Country Data
Split to 4/40	0.16	US Data - US EPA Commuter Model		No Developing Country Data
Split to 9/80	0.04	US Data - US EPA Commuter Model		No Developing Country Data

Commute Strategies Model

Data Point	Default Value	Source	Acceptable Means of Collection	Remarks
Total Employment	10000	Dummy Input	Employment/Census Data, Other Govt Sources	
Share office	0.7	Dummy Input	Employment/Census Data, Other Govt Sources	
Share non-office	0.3	Dummy Input	Employment/Census Data, Other Govt Sources	
Split of total employment by area type				
Low Density Suburb	0.2	Dummy Input	Regional Studies	
Activity Center	0.3	Dummy Input	Regional Studies	
Regional CBD	0.5	Dummy Input	Regional Studies	
Base Employer Participation Rate - Office	0.1	Dummy Input	Regional Studies	
Base Employer Participation Rate - Non Office	0	Dummy Input	Regional Studies	
Base Financial Incentives				
Daily Transit/Rideshare Subsidy (in USD)	0	Dummy Input	Regional Studies	
SOV Vehicle Type Mode Split				
Cars	0.6	Millennium Cities Database Supply Indicators (Dummy Input)		
2-Wheeler	0.2	Millennium Cities Database Supply Indicators (Dummy Input)		

Commute Strategies Model

Data Point	Default Value	Source	Acceptable Means of Collection	Remarks
3-Wheeler	0.2	Dummy Input	Only used if the three wheelers are a significant share of traffic - Example India (Collection and use based on Individual City Studies/vehicle registration data)	
Average roundtrip commute length (Km)	10	Millennium Cities Database Mobility Indicators	Travel Demand Model, Highway Mobility Statistics, Sutveys	
Average HOV occupancy	2.25	2000 US Census default being used (average occupancy for 2-4 person carpools) - varies by vehicle occupancy data for individual countries		

Employer Support Model

Data Point	Default Value	Source	Acceptable Means of Collection	Remarks
Total Employment	10000	Dummy Input	Employment/Census Data, Other Govt Sources	Based on USEPA Commuter Model Methodology
Share office	0.5	Dummy Input	Employment/Census Data, Other Govt Sources	
Share non-office	0.5	Dummy Input	Employment/Census Data, Other Govt Sources	
SOV commute mode share	0.75	Millennium Cities Database -Supply Indicators (Dummy Value - US example)	Travel Demand Model, Surveys/Inventory Statistics	
Total employee use of employer operated commute shuttles	0	Dummy Input		
Average roundtrip commute length (Km)	10	Millennium Cities Database Mobility Indicators	Travel Demand Model, Highway Mobility Statistics, Sutveys	
Average HOV occupancy	2.25	2000 US Census default being used (average occupancy for 2-4 person carpools) - varies by vehicle occupancy data for individual countries		

Appendix 3: Data Required and Defaults Provided for PAYD

Data Point	Default Value	Source	Acceptable Means of Collection	Remarks
		VKT by mode		
Cars	85,000,000	Dummy Value Input	Highway Statistics Data, Regional Studies, Surveys with inventory information from Vehicle Registrations	
2W	22,000,000	Dummy Value Input		
3W	13,000,000	Dummy Value Input		
Taxi	19,000,000	Dummy Value Input		
Bus	3,600,000	Dummy Value Input		
Jeepney/RTV	7,700,000	Dummy Value Input		
Walk	—	Dummy Value Input		
Cycle	—	Dummy Value Input		
LRT	—	Dummy Value Input		
Percent of Drivers who are insured	30-50%	Designing a New Automobile Insurance Pricing System in China-Actuarial and Social Considerations Daqing Huang and J. Tim Query AND India Road Transportation Efficiency Study, World Bank, 2005	Data from Insurance Corporations, Regulation Agencies	Chinese and Indian Studies
Percent of policies that are PAYD (rate of participation by insured drivers)	30%	Bordoff and Noel		
Price elasticity of VKT/VMT	Pegged to Income	Impacts of Policy Instruments to Reduce Congestion and Emissions from Urban Transportation The Case of São Paulo, Brazil	Census Data, Government Income Data Sources etc.	Discuss short/long term elasticities
Cost per km of driving, without insurance	\$0.145	Informal survey of India experience	Regional Studies	Transport Cost data also available in Millennium Cities Database (Data from India = 0.13)
Insurance cost per km	\$0.005	Informal survey of India experience	Data from Insurance Corporations, Regulation Agencies	
PAYD Driver Participation by Income Category	Low Income Medium Income High Income	Income stratification	Aggregation of Income quintiles, other fine classifications.	

Appendix 4: Data Required and Defaults Provided for Employer-Based Commuter TDM Strategies

Parking Pricing Model				
Data Point	**Default Value**	**Source**	**Acceptable Means of Collection**	**Remarks**
Average trip length (Km)	10.0	Millennium Cities Database (IATP) Mobility Indicators, average trip distance		
Average occupancy - 2 wheelers	1.5/1.3	The demand for road-based passenger mobility in India: 1950-2030 and relevance for developing and developed countries and Vehicle Occupancy in Malaysia According To Land Use and Trip Purpose - Easts Conference		Indian/Malaysian Sources
Average occupancy - private cars	3.2/1.6	The demand for road-based passenger mobility in India: 1950-2030 and relevance for developing and developed countries and Vehicle Occupancy in Malaysia According To Land Use and Trip Purpose - Easts Conference		Indian/Malaysian Sources
Total daily vehicle trips	25,000	Dummy Input Values	Country Highway Statistics Data or Travel Demand Model or Estimation of VMT based on average trip length and population	
OR:				
Total regional daily VKT/VMT		Dummy Input Values		
OR:				
Total Person Vehicle Trips				
Distribution of Income for Impacted Travelers	Low Medium High	Dummy Input Values. Percentage travelers in Each Income group		
Scoring Factors				
City Size	Small City Large City	TCRP 95 Chapter 13		
Parking Location	Urban Core Near Core Suburb	TCRP 95 Chapter 13		
Level of Transit Service	Low Medium High	TCRP 95 Chapter 13		
Elasticity to Travel Cost by Income	Pegged to Income	Impacts of Policy Instruments to Reduce Congestion and Emissions from Urban Transportation The Case of São Paulo, Brazil AND TCRP 95 Chapter 13		
% of total public parking on-street (with charge)	60%	Dummy Input Values	Parking Studies, Surveys.	Got Parking Spaces by Parking Purpose from Paul Barter (Singapore), followed up for aggregate data. ADB Study for 12 Asian Cities about to come out soon.
% of total public parking off-street (with charge)	15%	Dummy Input Values		
% of total public parking free of cost	25%	Dummy Input Values		

Parking Pricing Model

Data Point	Default Value	Source	Acceptable Means of Collection	Remarks
Vehicular Mode split				
Cars	60%	Millennium Cities Database Supply Indicators (Dummy Input Values)		Vary largely by city, can provide some mode split by City data points to the user for familiarization
2-Wheeler	20%	Millennium Cities Database Supply Indicators (Dummy Input Values)		
3-Wheeler	20%	Millennium Cities Database Supply Indicators (Dummy Input Values)		
Private vehicle mode share (all trips)	40%	Millennium Cities Database Supply Indicators (Dummy Input Values)		
Split to 2 wheelers	40%	Millennium Cities Database Supply Indicators (Dummy Input Values)		
Split to private cars	60%	Millennium Cities Database Supply Indicators (Dummy Input Values)		

Parking Density Model

Data Point	Default Value	Source	Acceptable Means of Collection	Remarks
# of off-street spaces in CBD		Dummy Value Input	City Department of Transportation/ Parking Enforcement/ Revenue Collection Office statistics, Other Govt/Commerce Associations Data, Parking Studies/ Surveys	
Office/Commercial Space (sq ft)		Dummy Value Input	Department of Commerce, Town Planning, Commerce Studies/Surveys	
Vehicular Mode split				
Cars	60%	Millennium Cities Database Supply Indicators (Dummy Input Values)		
2-Wheeler	20%	Millennium Cities Database Supply Indicators (Dummy Input Values)		
3-Wheeler	20%	Millennium Cities Database Supply Indicators (Dummy Input Values)		
Average trip length (Km)	10.0	Millennium Cities Database Mobility Indicators - Trip Length by Regions of the World	Travel demand models, surveys, Insurance/ Govt agency statistics	
Scoring Factors				
City Size	Small City Large City	TCRP 95 Chapter 13		
Level of Transit Service	Low Medium High	TCRP 95 Chapter 13		
Elasticity to Travel Cost by Combination of Scoring Factors	Pegged to Income	Impacts of Policy Instruments to Reduce Congestion and Emissions from Urban Transportation The Case of São Paulo, Brazil AND TCRP 95 Chapter 13 and Parking Density Elasticity TCRP 95 travelers response to parking strategies Chapter 18		

Company Cars Model				
Data Point	**Default Value**	**Source**	**Acceptable Means of Collection**	**Remarks**
				Canadian and UK study
Average daily commute trip length (round trip)	10.0	Millennium Cities Database (IATP) Mobility Indicators, average commute trip distance		
Average daily business trip length	15	Drive Green: Company Car Tax Shift - Analysis of Proposed Changes in Tax Treatment for Company Cars in Canada (Company Car Tax Shift)		
Travel Elasticity to Reduction in Company Cars	0.004	HM Revenue and Customs "Report on the Evaluation of Company Car Tax Reform - Stage 2" - March 2006		
Travel Elasticity to Reduction in Company Cars with Free Fuel Benefit	0.0003	HM Revenue and Customs "Report on the Evaluation of Company Car Tax Reform - Stage 2" - March 2006		
Base total company cars	1,000,000	Dummy Value Input (Data from HM Revenue and Customs "Report on the Evaluation of Company Car Tax Reform - Stage 2" - March 2006)	Company Car Studies - Vehicle Registrations as Company Cars	
Share of company cars with free fuel benefit	12%	Dummy Value Input	Surveys/Studies	
Annual mileage for company car	19,500	Drive Green: Company Car Tax Shift - Analysis of Proposed Changes in Tax Treatment for Company Cars in Canada (Company Car Tax Shift)	General rule of thumb is 50% more than regular trip - translates to about the same annually	

Appendix 5: Default Values for Various TEEMP Models

Total Trips

The total trips by motorized and non-motorized transport modes refer to cumulative daily one-way trips between an origin and destination. Based on the economic growth, city planning and transport network, the total number of trip varies among zones, cities and regions. In case the user does not have any indication of total number trips in the study area,[1] per capita trip rates can be multiplied by the population data from the zone/city/region to estimate the total number of trips. Per capita trip rate values are available from the International Association of Public Transport's Mobility in Cities Database (UITP-MCD)[2]. This would allow the user to compute emissions at sketch level.

1 Can refer to zone, city, region.
2 See http://www.uitp.org/publications/Mobility-in-Cities-Database.cfm

Per Capita Trip Rate Default Values (in Number of Trips)

Region	Per Capita Trip Rate	Source
Latin America	1.71	UITP-MCD
Africa	1.60	UITP-MCD
India	1.13	MOUD
China	2.58	GEF
Other Asia	2.21	UITP-MCD

Trip Mode Share

The trip mode share indicates the distribution of the trips in the study area with different modes of transport. The trip mode share is one of the indicators for measuring sustainable transport. Trip mode share is an integral parameter for calculating emissions from any urban transport project as it helps in converting person trips to vehicular trips when combined with average occupancy. If trip mode share data is not available, the following default values (expressed in %) are proposed based on literature survey from different countries:

Default Trip Mode Share (%)

	Description	Walk	Cycle	Two wheeler	Car	IPT	Bus	Metro
India	Average of 30 cities, Ministry of Urban Development	31	11	21	16	5	16	-
China	GEF and other sources (Average of 16 cities)	32	26	6	11	5	19	1
Latin America	UITP-MCD	25		36			40	
Africa	World Bank (average of 14 cities)	37	4	12	12	8	27	-

Average Trip Length

It is the average distance travelled during a trip i.e. one way between an origin and destination. This is generally estimated as the ratio of total passenger- kilometers to the total number of trips and by using origin and destination (O-D) surveys and often represented in km. The size, structure, economic growth, density and transport system has implications on the average trip length of the study area. The data on average trip length allows the analyst to link the trip characteristics with vehicle emission factors to determine emissions. The following default values can be used for sketch analysis in case the average trip length data is not available.

Default Values for Average Trip Length (kilometers)

	Walk	Cycle	Two wheeler	Car	IPT	Bus	Metro	Source
Asia	1.1	3.5	6.7	9.9	7.3	10.5	10.0	various - GEF, UITP-MCD, others
Africa	-	-	-	12.39		13.1	13.1	UITP-MCD
Latin America	-	-	-	13.79		11.8	11.8	UITP-MCD

Average Occupancy

The average occupancy is calculated person-kilometers per vehicle –kilometers or simply as the number of people traveling divided by the number of vehicles. Higher the occupancy rates, the lesser the emissions per person trips. Average occupancy can be easy calculated using field occupancy surveys. In case no data is available, following default values can be used:

Average Occupancy

Region		Walk	Cycle	Two wheeler	Car	Public transport	IPT
Asia	UITP-MCD and others	1.00	1.01	1.26	2.38	41.34	1.92
Latin America	UITP-MCD and others			2	2	26.47	
Africa	UITP-MCD					36.3	

Emission Factors

Emission factors are generally derived from dynamometer-based drive cycle tests to simulate typical driving conditions and traffic speeds. They are generally represented in grams per kilometer traveled or one of its derivatives. Fleet-based emission factors often used in sector calculations depend on "driving behavior" (how do we drive), "fleet characteristics" (what vehicles we drive), "infrastructure" and geographical conditions (where we drive). It is to be noted that "no two vehicles will have the same emission factor profile, even if they are nominally identical models, produced on the same day on the same production line."[3]However, in order to simplify the calculations, the analyst needs to tailor the emission factors to fit "best possible local conditions and the fleet". These "tailoring" are often done using local studies on various models.

In other words, by using an on-road mobile source emissions model like the International Vehicle Emissions (IVE) Model with local data on vehicle technology distributions, power-based driving factors, vehicle soak distributions, and meteorological factors, one can tailor the model to suit the local conditions. This would give the best accuracy for computing emission factors. For example, IVE Model has over base emission rates for over 1300 vehicles[4] to capture the different fleet characteristics and thus allow better representation.

In case, the data is not available for the analyst to use models such as IVE, one can use national averages, local averages or use fuel consumption data reported via surveys etc. It is to be noted that the approved CDM baseline methodology AM0031 "Baseline Methodology for Bus Rapid Transit Projects"[5] suggests the following alternatives:

"Two methodological alternatives are proposed for the fuel consumption data (in order of preference):Alternative 1: Measurement of fuel consumption data using a representative sample for the respective category and fuel type. Factors such as the specific urban driving conditions (drive-cycle, average speed etc), vehicle maintenance and geographical conditions (altitude, road gradients etc) are thus included. The sample must be large enough to be representative … and Alternative 2: Use of fixed values based on the national or international literature. The literature data can either be based on measurements of similar vehicles in comparable surroundings (e.g. from comparable cities of other countries) or may include identifying the vehicle age and technology of average vehicles circulating in the project region and then matching this with the most appropriate IPCC values. The most important proxy to identify vehicle technologies is the average age of vehicles used in the area of influence of the project…."

In the present TEEMP models, a detailed set of emission factors based on IVE has not been suggested due to the time and data availability.[6] Instead as an alternative option, it is recommended that analyst use city-specific studies and national/city surveys to generate the emission factors for the TEEMP models. In order to capture the impact of speed, following default index values have been proposed taking insights from COPERT and other studies.[7] Many studies have suggested that vehicle travelling near 50 kmph have best efficiency. Thus 50kmph was kept as the basis to compute the effect on efficiency and calibrate the emission factor.

3 DIESEL study- PCD Bangkok, http://www.cleanairnet.org/caiasia/1412/article-48845.html
4 Different combinations of vehicle types, fuel, weight, air/fuel control, exhaust emission controls and age.
5 See http://cdm.unfccc.int/UserManagement/FileStorage/CDMWF_AM_IK6BL2878HZ4NHV86V65CBJ2Y1ZBDI

6 Corrective factors need to applied to the base emission rates in order to adjust them to local conditions.
7 Copert-3, CORINAIR, green transport, diesel, updated road user cost study of India and trl emission factors for 2009 for department of transportation, UK.

Speed and Emission factors Index (assuming 0 at 50 kmph)[8]

	CO_2						PM				NOx			
SPEED	2W	3W	Cars	LCV	Bus	HCV	Car	LGV	Bus	HGV	Car	LGV	Bus	HGV
15	-70	-70	-61	-69	-61	-61	-43	-30	-21	-60	-43	-35	-56	-44
20	-43	-43	-34	-38	-51	-51	-26	-18	-16	-55	-32	-23	-46	-36
25	-26	-26	-20	-22	-39	-39	-18	-10	-12	-45	-23	-14	-37	-28
30	-21	-21	-12	-18	-23	-23	-11	-4	-9	-35	-16	-8	-29	-22
35	-7	-7	-5	-6	-15	-15	-6	-1	-7	-25	-10	-3	-21	-15
40	-4	-4	-3	-3	-9	-9	-3	1	-4	-16	-5	-1	-14	-10
45	-1	-1	0	0	-3	-3	-1	1	-2	-7	-2	0	-7	-4
50	0	0	0	0	0	0	0	0	0	0	0	0	0	0
55	0	0	-1	-1	2	2	0	-2	2	6	1	-2	6	6
60	-2	-2	-3	-4	5	5	-1	-4	3	10	1	-4	13	9
65	-4	-4	-6	-7	5	5	-3	-8	3	12	1	-7	13	9
70	-8	-8	-9	-12	6	6	-6	-11	3	12	-1	-11	13	9
75	-12	-12	-13	-16	0	0	-9	-15	1	12	-3	-15	10	7
80	-18	-18	-18	-23	-4	-4	-13	-19	-1	10	-5	-19	7	4
85	-23	-23	-24	-29	-7	-7	-17	-23	-5	7	-9	-24	4	1
90	-30	-30	-30	-37	-12	-12	-22	-28	-8	4	-12	-28	1	-2
95	-37	-37	-36	-45	-16	-16	-27	-32	-8	-14	-16	-33		
100	-37	-37	-36	-45	-16	-16	-32	-36	-8	-16	-20	-38		

8 % decrease in fuel efficiency assuming fuel efficiency at 50kmph as 0, - value is indicative

The TEEMP model allows users to quantify the air pollutants PM and NOx using the emission factors. The analyst is encouraged to look for national level emission factors for local projects. As a first approximation, several studies in Asia were collated to capture a set of default vales for Asian fleet.

Fuel Consumption and Emission Factors for Different Vehicles in Asia

Vehicle distribution			Fuel Consumption L/100KM	CO_2 (kg/L)	PM (g/Km)	NOx g/Km	KMPL	CO_2 g/VKM
MC-two	P	Two Stroke	1.8	2.416	0.057	0.050		24.170
		Four Stroke	1.8	2.416	0.015	0.540		24.820
		NO data		2.416	0.03	0.34		24.56
MC-three	P	Two Stroke	3.5	2.416	0.045	0.200		62.410
		Four Stroke	3.5	2.416	0.015	0.530		73.800
		NO data		2.416	0.03	0.4		69.24
PC	P	Pre Euro	8	2.416	0.008	0.950	12.5	193.28
		Euro I	8	2.416	0.000	0.200	12.5	193.28
		Euro 2	8	2.416	0.000	0.090	12.5	193.28
		Euro 3 and Above	8	2.416	0.000	0.080	12.5	193.28
		NO data	8	2.416	0.004	0.518	12.5	193.28
	D	Pre Euro	7	2.582	0.145	0.450	14.3	180.74
		Euro I	7	2.582	0.060	0.490	14.3	180.74
		Euro 2	7	2.582	0.015	0.280	14.3	180.74
		Euro 3 and Above	7	2.582	0.050	0.250	14.3	180.74
		NO data	7	2.582	0.087	0.359	14.3	180.74

Vehicle distribution			Fuel Consumption L/100KM	CO_2 (kg/L)	PM (g/Km)	NOx g/Km	KMPL	CO_2 g/VKM
LCV	P	Pre Euro	10	2.416	0.008	0.950	10.0	241.6
		Euro I	10	2.416	0.000	0.200	10.0	241.6
		Euro 2	10	2.416	0.000	0.090	10.0	241.6
		Euro 3 and Above	10	2.416	0.000	0.080	10.0	241.6
		NO data	10	2.416	0.004	0.518	10.0	241.6
	D	Pre Euro	8	2.582	0.655	1.710	12.5	206.56
		Euro I	8	2.582	0.475	1.600	12.5	206.56
		Euro II	8	2.582	0.100	0.820	12.5	206.56
		Euro III and Above	8	2.582	0.050	0.250	12.5	206.56
		NO data	8	2.582	0.3675	1.151	12.5	206.56
BUS	D	Pre Euro	28	2.582	1.213	6.240	3.6	722.96
		Euro I	28	2.582	0.610	6.660	3.6	722.96
		Euro II	28	2.582	0.150	6.240	3.6	722.96
		Euro III and Above	28	2.582	0.100	5.930	3.6	722.96
		NO data	28	2.582	0.6715	6.178	3.6	722.96
HCV	D	Pre Euro	30	2.582	1.294	6.450	3.3	774.6
		Euro I	30	2.582	0.601	7.620	3.3	774.6
		Euro II	30	2.582	0.366	6.450	3.3	774.6
		Euro III and Above	30	2.582	0.100	5.860	3.3	774.6
		NO data	30	2.582	0.7768	6.332	3.3	774.6

For the references of the above emission factors please see the endnote.

Construction Emissions

Emissions quantification from transport projects should ideally consider construction emissions. The quantum of construction emissions varies depending upon the quantity and type of construction materials used and the methodology adopted. In absence of any data, in order to have ballpark estimates, default values have been proposed for per km construction based on materials used (cement, steel and bitumen).

Construction Emission Factors

1 km of infrastructure	Description	tons of CO_2	Source
BRTS	Considering only the quantity of steel, cement and asphalt.	1900	Assuming material quantity - Cement -737.8 tons/km, Asphalt - 403.5 tons/km and Steel - 143.2 tons/km. A multiplier of 1.75 has been proposed for actual construction works based on Kwangho Park, et. al. (2003),. Estimates from Mexico BRTS (Lee at al.) and Transmilenio (monitoring report) have indicated 3475 and 1390 tons .
Bikeways	Considering only the quantity of steel, cement and asphalt.	20	Assuming material quantity - Cement -15.5 tons/ km, Asphalt - 40 tons/km and Steel - 1 tons/km for constructing 1km of 2.5 m wide bikeway
MRTS	2 lines for 80% elevated and 20% underground	15600	Bangalore metro calculations using quantity of materials used - steel and cement. Research from japan as summarized in TEEMP model indicates a range between 7119 to 19487 tons of CO_2
Railways	Considering only the quantity of steel and concrete for single track	875	Assuming a track requires 570 tons of concrete and 117 tons of steel, 350 tons of CO_2 is generated during material production. Scotland Transport depatment recommends 500 tons of CO2 per track based on material production.A multiplier of 1.75 has been proposed for actual construction works based on Kwangho Park, et. al. (2003) for Road works
Roads	Considering only the quantity of steel, cement and asphalt for a four lane road	2100	An analysis based on the quantity of construction materials used – cement, steel and bitumen indicates that the approximate emissions of a two lane to four lane improved highway is approximate 1100 tons/km. When all the quantities are considered including the emissions generated by machinery, the emissions range from 2100 to 2400 tons/km for high-speed roads (four-lanes) based on traffic, topography and type of improvements suggested.

Mode shift from different modes to a bike share program

The development of bike sharing scheme would attract new riders from different modes. Actual surveys can determine the extent of transition from different modes. In case the analyst does not have any insights on the magnitude of transition, the following default values derived from the evaluation of different bike sharing schemes are proposed. The majority of the riders using bike sharing schemes come from public transport modes. The analysis of 51 schemes in Europe by the "Optimising Bike Sharing in European Cities" study[9] indicates that nearly 25% and 9.3% of trips have been shifted from walking and cycling.

Mode Shifts towards Bike Sharing Schemes Around the World

<table>
<tr><th>Mode shift from (%)</th><th>Hangzhou</th><th>Shanghai</th><th>Beijing</th><th>Paris</th><th>Barcelona</th><th>Lyon</th><th>London</th><th>Default Values</th></tr>
<tr><td>Pedestrian</td><td>16</td><td>26</td><td>23</td><td>20</td><td>26</td><td>37</td><td>21</td><td>22</td></tr>
<tr><td>Bus</td><td>51</td><td>40</td><td>48</td><td>65</td><td>51</td><td>50</td><td>34</td><td>46</td></tr>
<tr><td>Taxi</td><td>4</td><td>4</td><td>3</td><td>5</td><td></td><td></td><td></td><td>4</td></tr>
<tr><td>Car</td><td>4</td><td>4</td><td>5</td><td rowspan="2">8</td><td rowspan="2">10</td><td rowspan="2">7</td><td rowspan="2">6</td><td>4</td></tr>
<tr><td>E-Bike/ Motorcycle</td><td>4</td><td>5</td><td>3</td><td>4</td></tr>
<tr><td>Private Bicycle</td><td>8</td><td>14</td><td>8</td><td></td><td></td><td>4</td><td>6</td><td>10</td></tr>
<tr><td>Others/No Trip</td><td>13</td><td>7</td><td>10</td><td></td><td></td><td>2</td><td>23</td><td>10</td></tr>
</table>

Source: Various studies

9 http://www.obisproject.com

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