IV Assessment of I&FF for Mitigation in the Transport Sector

4.1 Introduction

Global warming is one of the most serious developmental challenge for mankind as opposed to being another environmental problem. The Greenhouse Gas (GHG) emissions of the transport sector are one of the major contributors to global warming. They account for about one-quarter of the total global GHG emissions and currently experience a rapid growth, particularly in developing countries. The developing world will account for the largest share of this growth, with forecasted growth rates (2000-2030) between 3.5% and 5.3% per year, as compared to 1.2% to 1.4% in the OECD[1].

In the last decades, the transport sector has become a crucial issue for the development and productivity of cities and countries, particularly public transport due to: a) steep economic growth, b) economical policies towards opening foreign markets with low price automobiles and low fuel prices (e.g., fuel subsidies) c) high growth rate of motorization d) a fragile public transport system encouraging private car usage e) spatial development which does not take into account transit oriented development and f) weak public institutions.

Emission reductions in the transport sector can be achieved basically by three different means (see Table 4-2):

- Emission reduction per kilometre driven: This leads to improved efficiency of transporting goods or people without changing trip structures, trip numbers or trip motives. Measures in this area include change of technologies (e.g., usage of hybrid vehicles), fuel-switch (e.g., usage of biofuels), behavioural/operational changes such as eco-drive or improved fleet management (e.g., improved maintenance, efficient tires and oils etc), and infrastructure projects, e.g., to reduce congestion and thus improve average driving speed.
- Emission reduction per unit transported: i.e., Fewer emissions per passenger-kilometre or per ton-kilometre. The efficiency of transporting goods or persons is improved without changing trip structures or trip numbers or trip motives. Emissions per trip may be reduced through modal switch (e.g., from passenger car to bus or from transporting freight by truck to transport by rail), the use of larger capacity units (e.g., usage of large articulated buses instead of a large number of small units), and the increment of occupation rates, e.g., by increasing the attractiveness of public transit or by increasing load factors of trucks through management and/or policy measures.
- Reduction of driven distances or number of trips taken reduce GHG emission by reducing the necessity or duration of trips. Options in this area include changing people's

[1] Price, L., S. et al, 2006. Sectoral trends in global energy use and greenhouse gas emissions. Lawrence Berkeley National Laboratory, Berkeley, CA. Accessible at: http://ies.lbl.gov/iespubs/56144.pdf

behaviour, better traffic management, improved urban planning e.g., through Transit Oriented Development (TOD) or Transit Efficient Development (TED) as well as infrastructure investments e.g., building shorter connections (e.g., tunnels).

Mitigation measures in the transport sector not only reduce GHG emissions but – in general – also contribute to sustainable development providing potentially significant co-benefits, such as:

- Improved air quality with lower particle matter, NO_x (nitrogen oxides), SO_x (sulfur oxides) and ground-level ozone emissions. Measures that improve significantly local air quality are basically in the area of public transit policies, TOD[2], and fuel-switch policies.
- Economic benefits at the macroeconomic levels (e.g., by increasing the attractiveness of cities through the establishment of modern mass transit systems), reduction of congestion costs and reduced fuel consumption.
- Social benefits resulting from improved air quality and therefore less air-pollution related diseases including lower morbidity and mortality basically from respiratory diseases. Many measures, e.g., in the field of public transit, TOD and infrastructure, also reduce noise pollution and risks of accidents.

This chapter seeks to provide a guide for the implementation within the transport sector of I&FF assessments for the identification and prioritization of policies, measures and technological options and investments directed to mitigate climate change.

4.2 Application of I&FF Methodology to Transport Sector Mitigation

This section describes how the I&FF methodology described in Chapter II should be applied to estimate the additional financial needs or reallocation of investments and financing in order to implement the key mitigation options in the transport sector. For this reason and to avoid repetition, some of the information provided in Chapter II that is relevant to all sectors is not included in this chapter. Careful reading of Chapter II previous to this chapter is highly recommended.

As described in Chapter II, the estimation of I&FF involves a series of eight steps which will be described in detail, in the following:

1) Establish key parameters of the assessment
2) Compile relevant (historical, current and projection) input data for scenario elaboration
3) Define baseline scenario
4) Estimate I&FF and O&M costs under baseline
5) Define mitigation scenario
6) Estimate I&FF and costs under mitigation scenario
7) Estimate changes in IF, FF and O&M costs to implement mitigation scenario
8) Evaluate policy implications

[2] Transit Oriented Development

Step #1: Establish key parameters of assessment

>>> Define detailed scope of the sector

The first step assumes that each country defines with precision the transport sub-sectors that will be taken into account in the I&FF assessment (road, rail, air, water-born, pipeline transportation, off-road if significant and data are available) as well as their definitions. The definition of the determined sub-sectors is based on the needs, priorities and availability of the information held in each country. This definition also relies on the programs and plans determined and evaluated by each country and the relative importance of each sub-sector within GHG emission terms and the contribution to the economic level, among others.

Table 4-1 is a proposal of sub-sectors within the transport sector, based on the IPCC-2006[3] (Intergovernmental Panel on Climate Change). However, the definition and level of disaggregation of each sub-sector is determined by each country in accordance to the items mentioned previously and must follow the preliminary evaluation established in the document *Preparing a Workplan for the Investment & Financial Flows*[4].

Table 4-1: Scope of Transport Sector

Sub-sectors	Passenger Transport Urban/interurban/domestic/international	Freight Transport
Road transportation	Passenger cars	Trucks
	Motorcycles	
	Buses	
	Motorized tri-cycles	
	Taxis	
	NMT (non-Motorized Transit	
Railways	Interurban Rail/Metro/LTRs[5]/Tram	Inter-urban rail
Civil Aviation	Domestic Aviation /International Aviation	Domestic Aviation /International Aviation
Water –borne navigation	Domestic water-borne navigation / International water-borne navigation	Domestic water-borne navigation / International water-borne navigation
Pipeline Transport		Oil, gas, chemicals, others
Off Road	Vehicles and mobile machinery used within the agriculture, forestry, industry (including construction and maintenance), residential, and sectors, such as airport ground support equipment, agricultural tractors, chain saws, forklifts, and snowmobiles.	

Source: Adaptation IPCC, 2006. Guidelines for National Greenhouse Gas Inventories. Chapter 3, Volume 2. Mobile Combustion[6].

Note: This list of sub-sectors is presented for illustration purposes only. Not all of them are always feasible in different developing countries, and for the purpose of the I&FF assessment only some of them (or even other sub-sectors defined at different levels of aggregation) are likely to be selected.

[3] IPCC, 2006. Guidelines for National Greenhouse Gas Inventories. Chapter 3, Volume 2. Mobile Combustion. Accessible at: http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_3_Ch3_Mobile_Combustion.pdf

[4] www.undpcc.org

[5] Light Transit Rails

[6] Includes the direct and indirect emissions generated for each of the sub-sectors

On the other hand, the definition of the sector and its sub-sectors must avoid double counting, e.g., a country decides to evaluate the use of bio-fuels or the improvement of vehicle maintenance as mitigation measurements for the I&FF assessment, these measures may include either the transport or energy sector, but not both, since a double counting would be generated. Also measures in the electricity generation field can affect transport emissions, especially in the rail sub-sector if traction energy is basically electricity.

>>> *Specify assessment period and base year*

Within the transport sector the recommended evaluation period is 25 years, due to the infrastructure lifespan (e.g., Massive Transport System Projects like Bus Rapid Transit (BRT) or Metros). However, some mitigation measures and their impact are short-termed and therefore the evaluation period is much shorter than 25 years. Measures with a limited time-impact include e.g., improved maintenance, eco-drive or behavioural changes which require constant expenditure to avoid slipping back to former levels. Also fuel-switch measures can be of short term nature as many vehicles allow users to choose from different fuels e.g., pure bio-fuel, bio-fuel blend or fossil fuel or usage of gas versus gasoline in dual-fuel vehicles. In such cases the impact of policies and measures depends also on relative price developments, taxes and other incentives which can vary in the short term.

As base year 2005 can be taken realizing the evaluation in constant 2005 US$. In spite of the previously mentioned, the definition of the evaluation period depends on the national planning, data availability, and analytical approach. Likewise, the assessment team may determine the definition of the base year.

>>> *Identify preliminary mitigation measures*

In order to be evaluated, a set of preliminary mitigation options need to be identified. Table 4-2 shows a list of actions associated to the different mitigation options. The foreseen criteria to assess the preliminary mitigation options include GHG mitigation potential, environmental and social benefits, investment and operational costs, economic impacts, as well as the sub-sector relevance within the transport sector in the assessment country.

Table 4-2: Transport Sector Mitigation Measure

MITIGATION MEASURES		
Emission reduction per kilometer driven	**Emission reduction per unit transported (pkm[7] or tkm[8])**	**Emission reduction through reducing distance driven or the number of trips**
• Fuel switch from high to low carbon fuels (bio-fuels, natural gas, electricity). • New vehicle technologies (such as hybrids, hydrogen in fuel cell vehicles, electric vehicles). • Introducing best practices (improved maintenance, ecological driving). • Changing behavior (such as buying energy efficient vehicles). • Infrastructure improvements to reduce congestion e.g., fly-over, intelligent traffic signals etc • Better vehicle dispatch.	• Modal switch from high to low emission vehicle; for passengers e.g., from car to public transit or motorized vehicle to NMT; for freight e.g., road to rail or road to ship Usage of large(r) units with comparable occupation rates. • Improvement of occupation rates e.g., through improved vehicle dispatch or increased attractiveness of transport mean. • Increase public transport ridership	• Behavioral change of people • Better traffic management e.g., through information on congestion, free parking lots etc. • TOD or TED measures.The basic idea is to integrate urban land development with public transport development by building dense, mixed-use, and pedestrian-friendly urban “nodes” concentrated around public transportation stations. • Road pricing (toll roads). • Restriction on car use. • Infrastructure measures to reduce trip distances e.g., shorter road connections, tunnels, bridges, etc.

Note: These are suggestions for possible mitigation measures within the transport sectors. Not all of them are always feasible in different developing countries, and for the purpose of the I&FF assessment only some of them are likely to be selected.

As a first step for the preliminary selection of mitigation options it is recommended to identify the relative contribution of each sub-sector within the transport sector and in this way, to identify sub-sectors with a large contribution assisting also in adjusting the country’s priorities. In order to perform this step it is recommended that the assessment team carry out a gross GHG estimate, following what is suggested in Annex 1[9].

Once the selection of sub-sectors or sub-sector has been realized, mitigation measures for each one must be identified based on a short, medium or long implementation period, as well as identifying the main implementation barriers, e.g., social, financial, environmental and institutional.

Notwithstanding the above, the choice of the different options must be based on the countries priorities and policies, development planning, and completed ex-ante studies for the prioritization of mitigation actions. The preliminary list often can be obtained from existing sectoral or national plans, National Communications, Nationally Appropriate Mitigation Actions (NAMAs).

[7] pkm:passenger - kilometre
[8] tkm: ton- kilometre
[9] In the case of an existing inventory study of GHG emissions, take this information or use the results of mitigation studies where there is already a prioritization of the measures to be implemented by the country

As a result of this preliminary identification it is suggested to obtain a list containing a number of feasible measures to be implemented in the assessment country that covers objectives and national goals identified in *"Preparing a Workplan for Investment & Final Flows Assessment"*.

>>> *Select analytical approach*

There are limitations in the capability of existing models to develop the baseline and mitigation scenarios as well as to estimate the GHG emissions and associated streams of annual IF&FF, and O&M costs. This needs to be taken into consideration when interpreting the results of such models.[10] The analytical approach recommended for the evaluation of the different transport mitigation options (Identify preliminary mitigation measures) is to build models that allow these possible options to be included. The construction of the model is based on data provided by completed studies, plans, projections and current situation data, among others.

In cases where the assessment country has any analytical approach developed within previous projects, i.e., for the elaboration of the National Communications, or has developed models for the transport sector, this should be taken into account as base of construction for the analytical approach.

Having not used any pre-determined model analytical approach for the estimate of IF, FF and O&M costs within the baseline scenario or mitigation scenario, the flows should be estimated with the available information found in the assessment country or foreign country sources adjusted to the assessment country. In cases where the information was obtained based on foreign country sources it is recommended to establish an upper and lower boundary in order to obtain a range of results.

In order to estimate GHG emissions within both the baseline and the mitigation scenarios it is suggested to apply either bottom-up or top-down approaches based data availability. In cases where the information was obtained based on a bottom-up and a top-down approach it is recommended to establish an upper and lower boundary in order to obtain a range of results.

Step #2: Compile Historical IF, FF, and O&M Cost Data, Subsidy Cost Data (if included explicitly), and Other Input Data for Scenarios

>>> *Compile historical annual IF and FF data, disaggregated by investment entity and source*

The methodology recommends the gathering of historical information within the last 10 years or as minimum the most recent last 3-years of I&FF data. The data must be collected for each investment type and the investment and financial flow should be disaggregated by entity, source and year. This disaggregation is illustrated in table 2-3, chapter II[11].

[10] ICF, 2008. Integrating Climate Change into the Transportation Planning Process. Accessible at: http://www.fhwa.dot.gov/hep/climatechange/climatechange.pdf

[11] Data availability might be limited. It is not recommended to invest too much effort in collecting these data as projections for different measures as well as future baseline costs are highly uncertain

The I&FF data that need to be collected may reside in one or more of several locations e.g., transport authorities, private and public research institutions, universities, energy authorities, planning authorities, secretary of treasury, among others[12].

As an example the investment flow in a Mass Transit System is associated to infrastructure costs (roads and bus stations), vehicle fleet costs, fare collection system as well as IT/traffic management systems. Or in the case of car use restrictions, like "pico y placa[13]", financial flows are associated to the implementation costs such as public information campaigns, logistical costs associated with compliance measures, etc.

If there is enough, detailed and good quality data including fleet distribution and total distance driven per vehicle category it is recommended to use the bottom-up rather than the top-down approach.

>>> Compile historical annual O&M cost data, disaggregated by investment entity and source

Similar to the previous item, the annual O&M costs must be collected since they are the base for the estimation of future costs from new assets (e.g., road and station infrastructure maintenance costs, O&M costs of buses). The data must be collected for each investment type and the investment and financial flow should be disaggregated by entity, source and year. This disaggregation is illustrated in table 2-4, chapter II.

The O&M data that needs to be collected may reside in one or more of several locations e.g., transport authorities, private and public research institutions, universities, energy authorities, planning authorities, secretary of treasury, among others[14].

As an example the O&M costs of a Mass Transit System are associated with infrastructure, fleet and fare collection O&M costs.

Likewise, the O&M cost data provide information for its first year and is used thereafter in the steps #4 and #6 of the evaluation. If O&M costs are not available, the methodology in Chapter II establishes two ways for its estimation: the first is based on data from other countries adjusted to the country evaluated while the second approach is based on estimating a percentage of investment costs as O&M costs. For example, the annual O&M infrastructure costs (roads and stations) within a BRT[15] can be between 1% and 3% of the total investment in infrastructure.

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[12] Data availability might be limited. It is not recommended to invest to much efforts in collecting this data as projections for different measures as well as future baseline costs are based on high uncertainties

[13] Restriction based on license plate number, vehicles have a traffic restriction during some days of the week and in peak hours or the whole day

[14] Data availability might be limited. It is not recommended to invest too much effort in collecting these data as projections for different measures as well as future baseline costs are highly uncertain

[15] Bus Rapid Transit

>>> Compile historical annual subsidy cost data, if subsidies are included explicitly in the assessment

The discrimination of subsidy costs is optional. In case that the evaluated country chooses to separate subsidies, an IF, FF and O&M cost disaggregation for each type of investment is required.

Subsidy cost estimates may be found within the government entities at the local and national level, within public and private entities and within academic institutions, among others. Disaggregation data coming from the information of subsidy costs is illustrated in table 2-5, chapter II.

>>> Compile other input data for scenarios

In addition to historical I&FF and O&M cost data, the characterization of the scenarios and estimation of annual costs for the scenarios will require the collection of other historical, current and projected/estimated data relevant to the sector.

The following list provides helpful information to build the baseline and mitigation scenarios. Not all information will be available and default values or estimates might be used at least in a first round:

- Planning studies of transport and mobility
- Economic growth data, population growth
- Sales by fuel type and sub-sector
- Characterization of the passenger and freight demand, by transport modes
- Characterization of the modal split by transport modes
- Characterization of the automotive fleet by category and fuel type
- Fuel consumption by category and fuel type
- Travelled kilometre by category and transport mode
- Occupation rate per vehicle mode
- Characterization of the available technologies within the market for the transport sector
- Environmental and social impact studies
- Economic valuation studies

Step #3: Define Baseline Scenario

The baseline scenario describes the "Business as Usual" (BAU) conditions, meaning the description of what commonly happens in absence of additional mitigation measures or policies. The definition of this scenario must be defined on the projection for the transport sector, national planning, expected programs and investments, technological changes, economical and population projections, National Communications, among other variables. The information to be included in the baseline scenario is the expected one for the period of time for which the evaluation takes place (see Step #1) and is provided by government institutions.

The mitigation measures to include in this scenario are those that have already been implemented as well as those expected to be implemented by the evaluated country, e.g., if within the national planning there is an addition of a new scheduled metro line, a new bus line (BRT[16]) within the evaluated period, this type of investment would be contemplated in the baseline scenario but not in the mitigation scenario.

As indicated in Step #1, it is suggested that the construction of the baseline scenario be based on bottom-up or top-down approaches, the selection criteria depends on the information availability of the assessment country. With the bottom-up approach, the demand is projected for passengers and freight as well as the required fleet by category for covering that demand and the traveled kilometers by vehicle category and fuel type for the different analyzed sub-sectors; these projections are to be done based on population growth trends, economical growth, expected technological changes, sectorial policies, as well as implemented mitigation strategies, urban planning, historical trends, among others. The top-down approach is based on sales projections by fuel type for each sub-sector, while this approach has a bigger degree of uncertainty than the previous, it all depends on fuel price projections and income projections.

Annex 1 contains information regarding assistance on GHG emission estimates.

Step #4: Estimate Annual IF, FF, and O&M Costs, and Subsidy Costs if included explicitly, for Baseline Scenario

>>> *Estimate annual IF and FF for each investment type, disaggregated by investment entity and funding source*

Within this step the IF & FF must be disaggregated for each investment type by source, entity and expected development year as shown in table 2-3, chapter II. The costs should be in real terms, meaning in 2005 US$ constants (see Step #1) or the determined base year defined by the assessment team and should be discounted using appropriate public and private discount rates.

The I&FF data that needs to be collected may reside in one or more of several locations e.g., transport authorities, private and public research institutions, universities, energy authorities, planning authorities, secretary of treasury, among others.

>>> *Estimate annual O&M costs for each IF, disaggregated by investment entity and funding source*

The estimation of annual O&M costs for each investment type must be disaggregated by entity and funding source, as shown in the table 2-4, chapter II. Likewise, annual O&M costs must be included for each operating asset purchased before the assessment period. Those costs should be collected for each one of the analyzed sub-sectors, as previously stated through the whole assessment those costs need to be base year constants, following Step #1 recommendation of 2005 US$ as base or the predetermined base year defined by the assessment team and should be discounted using appropriate public and private discount rates.

For those assets purchased during the assessment period that are expected to remain in operation after the last year of the assessment period, annual O&M costs should be estimated

[16] Bus Rapid Transit

for each additional year that the assets will be in operation, up to an additional five-year period after the end of the assessment period.

The O&M data that need to be collected may reside in one or more of several locations, e.g., transport authorities, private and public research institutions, universities, energy authorities, planning authorities, secretary of treasury, among others. In the case where O&M costs are not available, the methodology within Chapter II establishes two ways for determining them.

>>> Estimate annual subsidy costs for each investment type and for IF, FF, and O&M costs, if subsidies are included explicitly in the assessment

In the case where the country chooses to include split subsidy costs, a disaggregation is needed of the IF, FF and O&M costs for each investment type. The annual costs of the subsidies should be in real terms, meaning constants of 2005 US$ (see Step #1) or the predetermined base year defined by the assessment team and should be discounted using appropriate public and private discount rates.

The collection and/or estimation of the subsidy costs may be found within the government entities at a local and national level, public and private entities and academic institutions, among others. Disaggregated data coming from the information of subsidy costs is illustrated in table 2-5, chapter II.

Step #5: Define Mitigation Scenario

This step entails developing a description of what is likely to occur[17] in each sub-sector over the assessment period in the presence of additional policies to address climate change compared to the baseline scenario. The scenario definition should incorporate GHG mitigation measures for each sub-sector specifying the necessary investments, time, specific characteristics, among others, in order to implement measures, e.g., metro line construction, car use restriction, campaigns for carpooling programs, bus fleet technological changes, fleet maintenance improvements, among others. This allows identifying clearly IF, FF and O&M costs for each measure in order to carry out the corresponding estimation.

It is suggested for the definition of the mitigation scenario, to establish emission reduction targets over the projection's time-span. As indicated in Step #1, considering that the construction of the mitigation scenario is supported by the bottom-up approach based on the demand projections for passengers and freight as well as the required fleet estimated for covering that demand calculating the traveled kilometers by vehicle category and fuel type. These projections are to be done based on population growth trends, economical growth, sectoral policies, as well as new mitigation measures to be implemented in short, medium and long terms (including necessary technological changes).

[17]Bottom-up models tend to overestimate what is likely to happen because they do not consider human behavior. Top-down models tend to underestimate what is likely to happen because they have no good sense of technological change, including costs changes associated with new technologies that are developed in specific response to the issue of climate change. The description of "what is likely to occur" will thus always have uncertainty which can be shown in a more transparent manner by expressing outcomes in ranges (lower/upper level) instead of point estimates.

Annex 1 contains information regarding assistance on GHG emission estimates.

The methodology suggests that for the definition of the mitigation measures within each one of the identified sub-sectors in Step #1, the preliminary set of mitigation measures that were identified previously should be re-evaluated, given the analytical approach chosen in Step #1, the data compiled in Step #2, and the baseline analysis completed in Step #3.

For the country, it is suggested to perform a revision of the initial prioritization of mitigation measures (Step #1) based on the national development and transport sector priorities and using the following criteria as mitigation options to be prioritized:

- GHG reduction potential
- Economic evaluation contemplating economic costs and benefits of the mitigation measures including environmental benefits (excluding GHG benefits) in health, timesaving benefits and congestion reduction
- Financial evaluation of the measure
- Social evaluation taking into account impact criteria, such as job creation

Once the suggested prioritization criteria are obtained, it is recommended that each country establishes pondering criteria and a prioritization of the mitigation options.

Step #6: Estimate Annual IF, FF, and O&M Costs, and Subsidy Costs if included explicitly, for Mitigation Scenario

>>> Estimate annual IF and FF for each investment type, disaggregated by investment entity and funding source

In this step the IF & FF is estimated and disaggregated for each investment type by source, entity and projected developed year as it is illustrated in Table 2-3, chapter II. The costs must be in real terms, meaning constants of 2005 US$ (see Step #1) or the predetermined base year defined by the assessment team and should be discounted using appropriate public and private discount rates.

The I&FF data that need to be collected may reside in one or more of several locations e.g., transport authorities, private and public research institutions, universities, energy authorities, planning authorities, secretary of treasury, among others.

>>> Estimate annual O&M costs for each IF, disaggregated by investment entity and funding source

The estimation of the annual O&M costs for each new investment must be disaggregated by entity and funding source, as illustrated in table 2-4, chapter II. The costs should be collected for each analyzed sub-sector as previously stated through the whole assessment and those costs need to be base year constants, following Step #1 recommendation of using 2005 US$ as base or a predetermined base year defined by the assessment team and should be discounted using appropriate public and private discount rates.

For those assets purchased during the assessment period that are expected remain in operation after the last year of the assessment period, annual O&M costs should be estimated for each additional year that the assets will be in operation, up to an additional five-year period after the end of the assessment period.

O&M data that needs to be collected may reside in one or more of several locations, e.g., transport authorities, private and public research institutions, universities, energy authorities, planning authorities, secretary of treasury, among others. In case that the O&M costs are not available, the methodology within Chapter II establishes two ways for carrying out the estimations, the first one is the use of data from foreign countries which are adjusted to the ones of the country analyzed or the estimation of the O&M costs within foreign countries as a percentage of the capital cost of the investment type being analyzed.

>>> Estimate annual subsidy costs for each relevant investment type and for IF, FF, and O&M costs, if subsidies are included explicitly in the assessment

In case that the country chooses the inclusion of split subsidy costs, a disaggregation is needed for the IF, FF and O&M costs for each investment type, e.g., government subsidies to the country's Massive Transport System operation and maintenance, government subsidies to bio-fuels. The annual costs of the subsidies should be in real terms, meaning constants of 2005US$ (see Step #1) or the predetermined base year defined by the assessment team and should be discounted using appropriate public and private discount rates.

The collection and/or estimation of the subsidy costs may be found within the government entities at a local and national level, public and private entities and academic institutions, among others. Disaggregation data coming from the information of subsidy costs is illustrated in table 2-5, chapter II.

Step #7: Calculate the Changes in IF, FF, and O&M Costs, and in Subsidy Costs if included explicitly, needed to Implement Mitigation

To calculate the changes in IF, FF and O&M costs which are needed for the implementation of mitigation measures within each sub-sector, it is necessary to subtract the baseline scenario from the mitigation scenario costs, finding two primary objectives for this step: determining the changes of cumulative IF, FF and O&M costs and determining changes of annual IF & FF and O&M costs. As described in chapter II, the calculations should be done for each sub-sector.

Step #8: Evaluate Policy Implications

Taking into account the results of the previous step, the current step objective is the evaluation of policy implications regarding those results, based on the analyses that estimate magnitudes and timing of IF, FF and O&M changes for each investment entity and funding source needed for the implementation of mitigation measures within each sub-sector.

For the country, it is suggested to perform a revision of the initial prioritization of mitigation measures (Step #5) based on incremental cost estimates as well as determining the investments entities that are responsible for the most significant I&FF changes and predominant funding sources. Likewise, the evaluation of the policy measures which might be used for inducing those entities to implement the proposed measures, plus the additional funding sources used for new investments required. It is also necessary to differentiate public from private finance sources, as well as domestic from foreign sources.

For each one of the selected mitigation measures it must be determined which instruments and institutions are required and which barriers towards their implementation exist, as shown in Table 4-3.

Table 4-3: Mitigation measures, instrument, entities and barriers

MEASURE / TECHNOLOGY	INSTRUMENT	INSTITUTIONS	BARRIERS
Fuel switch from high to low carbon fuels (bio-fuels, natural gas, electricity).	Bio-fuel blending mandates. Incentives on fuel prices.	• National Government • Fuel distributing companies	• Fuel availability • Infrastructure adaptations • Technological adjustments
Introducing best practices: improved maintenance, ecological driving	Voluntary Agreements: between the governments and private fleets companies. Driver education and awareness	• Government • Transport companies • Private driver	• Resistance to change
New vehicle technologies (such as hybrids, hydrogen in fuel cell vehicles, electric vehicles).	Tax policies and incentives	• National Government • Fuel distributing companies • Technology suppliers	• Technological development • Implementation costs • Relative fuel prices
Improving urban public transit	Implementation of Mass Transport Systems (BRT[18], LTRs[19], Metros, Tram) Reorganization of public transportation	• National government • Local government • Transport companies	• Investment costs for construction of infrastructure and rolling material • Resistance of the existing transport sector • Technological implementation • Political resistance • Risk of Incomplete Implementation
Improved urban planning	Implementation of Transit Oriented Development (TOD)	• National government • Local government	• Resistance to the implementation by public and community institutions • Lack of know-how and experience • Political resistance • Risk of Incomplete Implementation

[18] Bus Rapid Transit
[19] Light Transit Rails

Likewise, in order to determine the effectiveness of the selected instrument or instruments for the implementation of mitigation measures, the instrument effectiveness must be determined based on the evaluation criteria.

Regarding the evaluation criteria, a great variety are considered in order to determine the convenience towards the implementation of an instrument, however, four main criterion which are used by the policymakers have been identified IPCC(2007)[20]: environmental effectiveness, cost-effectiveness, distributional considerations (equity) and institutional feasibility. The first one is related to the fulfilment of the proposed environmental objective (e.g., reduce GHG), the second is referred to the implementation of a low cost-impact instrument for society, the third is referred to the effects of the instruments implementation within different social groups and the last one is related to the feasibility and acceptance of the instrument implementation at a political, administrative and community level.

Concerning different instruments, table 4-4 shows criteria to be considered for the selection of effective instruments to be implemented within the transport sector.

Table 4-4: Instruments for implementation and evaluation criteria

INSTRUMENT	ENVIRONMENTAL EFFECTIVENESS	COST-EFFECTIVENESS	EQUITY	INSTITUTIONAL FEASIBILITY
Bio-fuel blending mandates	Emissions level set directly, though subject to exceptions Depends on deferrals and compliance They may be preferable when information or other barriers prevent firms and consumers from responding to price signals	Depends on design; uniform application often leads to higher overall compliance costs.	Depends on level playing field Small/new actors may be disadvantaged	Depends on technical capacity; popular with regulators in countries with weakly functioning markets
Incentives on fuel prices	Depends on program design; less certain than regulations/standards.	Depends on level and program design; can be market distorting.	Benefits selected participants, possibly some that do not need it.	Popular with recipients; potential resistance from vested interests. Can be difficult to phase out.
Voluntary Agreements: between governments and private fleets companies	Depends on program design, including clear targets, a baseline scenario, third party involvement in design and review and monitoring provisions	Depends on flexibility and extent of government incentives, rewards and penalties	Benefits accrue only to participants	Often politically popular; raise awareness among stakeholders and have played a role in the evolution of many national policies; requires significant number of administrative staff

[20] IPCC, 2007. Policies, Instruments and Co-operative Arrangements. In Climate Change 2007: mitigation. Contribution of Working Group III to the Fourth Assessment report of the Intergovernmental Panel on Climate Change. Accessible at: http://www.ipcc.ch/pdf/assessment-report/ar4/wg3/ar4-wg3-chapter13.pdf

INSTRUMENT	ENVIRONMENTAL EFFECTIVENESS	COST-EFFECTIVENESS	EQUITY	INSTITUTIONAL FEASIBILITY
Driver education and awareness	Depends on how consumers use the information; most effective in combination with other policies	Potentially low cost, but depends on program design	May be less effective for groups (e.g., low-income) that lack access to information	Depends on cooperation from special interest groups
Tax policies and incentives	Depends on ability to set tax at a level that induces behavioral change. They cannot guarantee a particular level of emissions	Better with broad application; higher administrative costs where institutions are weak	Regressive; can be improved with revenue recycling	Politically difficult to implement; Difficult to enforce with underdeveloped institutions
Implementation of Mass Transport Systems	Large benefits in the short, medium and long term	High implementation costs	Larger benefit coverage among User groups	Difficult to implement under certain bureaucratic structures Face strong political opposition
Implementation of Transit Oriented Development (TOD)	Large benefits in the short, medium and long term	High implementation costs	Larger benefit coverage among User groups	Opposition from the stakeholders Face strong political opposition

Source: IPCC, 2007. Policies, Instruments and Co-operative Arrangements. In Climate Change 2007: mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Accessible at: http://www.ipcc.ch/pdf/assessment-report/ar4/wg3/ar4-wg3-chapter13.pdf
IPCC, 2007: Transport and its infrastructure. In Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth. Assessment Report of the Intergovernmental Panel on Climate Change. Accessible at: http://www.ipcc.ch/pdf/assessment-report/ar4/wg3/ar4-wg3-chapter5.pdf

Once identified the evaluation criteria for each of the selected instruments, it is suggested to the assessment team to determine a pondering weight for each evaluation criterion in order to prioritize the instrument selection. Once the distribution is completed, adjustments to the I&FF assessment may be required.

In Table 4-5 a summary of examples of measures applied in different developing countries that support the policy assessment of the country being evaluated is presented.

Table 4-5: Policies applied in developing countries for the transport sector

OBJECTIVE	INSTRUMENT	REGULATIONS AND RULES	ENTITIES	COUNTRY
Substitution of liquid fuels by natural gas in mobile applications	Differential prices and taxes for NGV and gasoline	National law	Government, private companies, car owner, taxi fleet	Bolivia
Improving urban public transit	Implementation of a mass transit system (BRT[21]) in cities with more that 600.000 citizens and implementing Collective Public Transport Reorganization Systems in smaller cities Government and local funding sources established by laws	National law and Agreements of infrastructure funding	National government, local government, private companies, bus fleet	Colombia
Improving the energy efficiency of the vehicle fleet.	Fuel Economy Standards, advanced fuel efficient vehicle technologies (Hybrid Electric Vehicles (HEVs)	National law	National government, local government, private companies	China
Promotion of ethanol as primary energy source	a) Tax exemptions to biofuels b) Technology promotion through subsidies c) Development of vehicles for biofuel use, or of “flex-fuel” engines d) Subsidies for ethanol production	National law	National government, local government, private companies	Brazil

Source: Tirpak et al, 2008. National Policies and Their Linkages to Negotiations. Accessible at: http://www.undp.org/climatechange/docs/English/UNDP_National_Policies_final.pdf
Wagner et al, 2006. Climate Change Mitigation Strategies for the Transportation Sector in China. Accesible at:
http://www.hm-treasury.gov.uk/d/Final_Draft_China_Mitigation_Transport_Sector_Research.pdf
DNP, 2003. Política nacional de Transporte Masivo Colombia.
Accesible at: www.dnp.gov.co/archivos/documentos/Subdireccion.../3260.pdf

[21] Bus Rapid Transit

ANNEX 1

For carrying out the emissions estimation in the transport sector it is necessary to identify which are the emission sources considered for the GHG emissions calculation. In this sense, the emissions are classified as direct emissions, indirect emissions and leaks.

Direct emissions are caused by transportation activities (road transportation, railways, civil aviation, water-borne navigation, pipeline transport). Its main sources, coming from fuel combustion, are CO_2 and small amounts of CH_4 and N_2O. These emissions are also referred as "tank to wheel" emissions, e.g., the direct emissions of a MRTS are based on the electricity consumption used for its operation multiplied by the respective carbon emission factor of electricity.

Indirect emissions are "upstream" emissions, also referred as "well to tank" emissions and are those related to the extraction, production and transport of fuels and other energy carriers for vehicle fuel supply that results in GHG emissions, e.g., the indirect emissions by the operation of a BRT system are associated with the fuel consumption multiplied by the emission production factor of the fuel.

Downstream or leakage emissions are caused through non-intended indirect impacts of transit measures taken. Well discussed in this context is the rebound effect which basically includes additional traffic caused by transit measures e.g., part of the congestion improvement caused by building additional roads is again eliminated through the additional traffic this measure provokes.

The analytical approach for quantification of emissions may be based on methods established by the IPCCC (2006) "Guidelines for National Greenhouse Gas Inventories"[22] for each of the analyzed sub-sectors. Emissions can be estimated under two approaches, the first one is Top-down and the second Bottom-up. The application of each one of the approaches depends on the information availability in each country.

1) Top-down: This method is based on the consumption by fuel type in the evaluation country. The information needed for calculating emissions is based on the available sales statistics for each type of fuel (gasoline, diesel, CNG (Compressed Natural Gas), LPG (Liquified Petrol Gas) electricity) in each sub-sector of the transport sector.
2) Bottom-up: This emissions calculation method estimates the total fuel consumption by fleet, through the fleet breakdown for each sub-sector, the fuel type, the VKT (vehicle kilometers traveled) and the average fuel consumption per kilometer.

For the two approaches, it is necessary to have the carbon emission factor that must be determined for the different fuel types and technologies used as well as modes used for the quantification of emissions.

[22] http://www.ipccnggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_3_Ch3_Mobile_Combustion.pdf

The following section presents some data to ease the determination of GHG emissions.

a. Data (information) for emission calculation

a.1.1 Modal Split in developing cities

Modal split data refers to current mode usage in the city (baseline mode usage). Through policy measures this mode-split might be changed. Over time a trend exists to use less public and more private modes of transit under a BAU case thus increasing GHG emissions.

Mode Share of various Transit Means in Latin-American Cities

Country	City	Year	Metro	Bus	Trolley bus/train	Taxi	Passenger cars	BRT	Motor cycle	NMT[23]/ walk
Mexico	Mexico City-D.F.	70s[24]	8,5%	51,2%	4,6%	12,6%	23,2%			
		80s[25]	19,1%	42,3%	3,2%	10,5%	25,0%			
		90s[26]	13,5%	65,8%	0,6%	2,5%	17,6%			
		00s[27]	5,5%	49,1%	2,0%	11,6%	31,4%	0,3%		
	Monterrey	70s[28]	1,0%	53,0%		2,0%	38,0%			6,0%
		80s[29]	1,0%	60,0%		2,0%	34,0%			3,0%
		90s[30]	1,0%	65,0%		3,0%	28,0%			3,0%
		00s[31]	2,0%	48,0%		9,0%	38,0%			3,0%
Colombia	Bogotá	90s[32]		15,0%		3,9%	47,3%			33,8%
		00s[33]		15,8%		4,0%	51,1%	10,4%		18,7%
	Medellin	90s[34]	6,2%	29,6%		19,2%	24,7%		3,6%	16,8%
		00s[35]	7,8%	33,1%		11,4%	12,4%		4,7%	30,5%
	Barranquilla	90s[36]		53,6%		4,8%	12,0%		3,4%	26,1%
		00s[37]		54,0%		6,6%	3,8%		16,6%	19,0%
Chile	Santiago de Chile	90s[38]	8,5%	59,6%		3,5%	18,5%			9,8%
		00s[39]	6,7%	42,2%		6,0%	38,6%			6,4%

Source: Adapted by Grütter Consulting

[23] Non-Motorized Transport, e.g. bicycle
[24] year :1972, Study "Definición de Políticas para el Transporte Público Concesionado conforme a las implicaciones financieras y ambientales" and information adapted to period 1972- 1986: Coordinación General de Transporte, Departamento del Distrito Federal. Programa Integral
[25] year: 1986, Idem
[26] year: 1994. INEGI, 1994. "Encuesta de origen –destino de los viajes de los residentes del AMCM".
[27] year: 2007. Secretaría de Transporte y Vialidad, 2007. "Estudio Origen – Destino".
[28] year: 1974. Rizoma No7, 2008. "Movilidad Sustentable Competitividad y Calidad de Vida."
[29] year: 1984, Idem.
[30] year: 1995, Idem.
[31] year: 2005, Idem.
[32] year: 1995. Steer Davis and Gleave, 1999. 2Diseño Tecnico Operacional del Sistema TransMilenio".
[33] year: 2005. DANE, 2005. "Encuesta de Movilidad".
[34] year: 1997. Metro de Medellin, 2000. "Proyecto Metroplus - Más Calidad de Vida. Segunda Fase del Metro de Medellín - Sistema de Transporte Masivo de Mediana Capacidad para el Valle de Aburrá".
[35] year: 2005. Universidad Nacional de Colombia., 2005. "Encuesta Origen- Destino para la ciudad de Bogotá".
[36] year: 1998. Cantillo Víctor, 2000. "Generación de viajes en el distrito de Barranquilla".
[37] year: 2009. Universidad del Norte – TransMetro, 2009. "Investigación aplicada en gestión y modelación del sistema del de transporte y medio ambiente urbano para el diseño de rutas que permitan integrar el transporte colectivo con el transporte masivo para mejorar las condiciones de operación del sistema colectivo del Distrito de Barranquilla y del área Metropolitana".
[38] year: 1991. Transantiago, 2008. "Con base en resultados de encuesta Origen- Destino".
[39] year: 2001. Transantiago, 2008. "Con base en resultados de encuesta Origen- Destino".

Mode Share of various Transit Means in Chinese Cities[40]

City	Year	Walk/ bicycle	Public Transit	Private automobile	Taxi	Motorcycle	Other
Beijing	2000	38%	27%	23%	9%		3%
	1986	58%	32%	5%	1%		4%
Nanjing	1999	64,5%	21,0%	5,7%	1,7%	5,2%	1,9%
	1997	83,4%	8,2%	4,5%	0,9%	2,2%	0,7%
	1986	77,2%	19,2%	2,5%	0,1%	0,3%	0,7%

Source: Adapted by Grütter Consulting

a.1.2 Mode shift potential for MRTS[41]

The mode-shift potential is based on monitored results in various cities which have implemented modern MRTS (BRTs, metros). Results are based on surveys of passengers and show the potential for a shift from private to MRTS means of transit. They can thus be used to estimate the GHG potential of mode-shift of MRTS.

Shift towards MRTS

BAU mode used	Shift towards MRTS Low Value[42]	Shift towards MRTS High Value[43]
Passenger cars	2%	33%
Taxis	6%	11%
Motorcycles	1%	8%
Buses	27%	92%
NMT[44]/Induced traffic	0,5%	3%

Data Source: Grütter Consulting based on monitored values of various cities in Colombia, India and China
Explanation: 2% passenger cars means that 2% of users of the MRTS would have used passenger cars under BAU i.e., in absence of the MRTS

a.2. Emissions per PKM[45]

Emissions per PKM indicate the efficiency of passenger transport per distance of various modes. Data is based on actual monitored values of various cities. Data depends not only on vehicle technologies but on traffic situations, occupation rates of vehicles as well as other factors such as fuel used and are thus presented in a range instead of a point estimate.

[40] Peng, Zhong. "Urban Transportation Strategies In Chinese Cities And Their Impacts On The Urban Poor"
[41] Mass Rapid Transit System
[42] Lowest measured value
[43] Highest measured value
[44] Non-Motorized Transport
[45] Passenger - Kilometre

Emissions per PKM of Various Transit Modes (grCO_2/PKM)

Mode	Emissions
Passenger car	100-250
Taxis	250-450
Motorcycles	30-60
Motorized tri-cycles	70-90
Bus	25-70
Metro	15-30
NMT	0

Data Source: Grütter Consulting based on monitored values of various cities in China, Colombia, India, and Mexico.

c. EA/SMP Transport Model

Over the past two years, the IEA has worked with the WBCSD's Sustainable Mobility Project (SMP) to develop a global transport spreadsheet model that can serve both organizations in conducting projections and policy analysis. The IEA/SMP Transport Spreadsheet Model is designed to handle all transport modes and most vehicle types. It produces projections of vehicle stocks, travel, energy use and other indicators through 2050 for a reference case and for various policy cases and scenarios. It is designed to have some technology-oriented detail and to allow fairly detailed bottom-up modelling. The model does not include any representation of economic relationships (e.g., elasticity) nor does it track costs. Rather, it is an "accounting" model, anchored by the "ASIF" identity:

a) Activity (passenger and freight travel)
b) Structure (travel shares by mode and vehicle type)
c) Intensity (fuel efficiency)
d) Fuel type = fuel use by fuel type (and CO_2 emissions per unit fuel use).
e) Various indicators are tracked and characterized by coefficients per unit travel, per vehicle or per unit fuel use as appropriate

The modes, technologies, fuels, regions and basic variables are included in the spreadsheet mode. Not all technologies or variables are covered for all modes. Apart from energy use, the model tracks emissions of CO_2, and CO_2-equivalent GHG emissions (from vehicles as well as upstream), PM, NOx, HC, CO and Pb.

Webpage:http://www.wbcsd.org/plugins/DocSearch/details.asp?type=DocDet&ObjectId=MTE0Njc

d. CO2DB

CO2DB is a database containing detailed data on carbon mitigation technologies. The database currently contains approximately 3000 technologies, including detailed technical, economic, and environmental characteristics as well as data on innovation, commercialization, and diffusion. Users can add to, select, filter, arrange, and compare CO2DB's data according to any of the technology characteristics included in each database entry. Users can also make energy chain calculations as well as comparison tables and graphics on the technology and the chain level.

IIASA disseminates CO2DB free of charge so that it can be useful to researchers in their individual studies. In return, they request that users share the data they enter into the database.

Webpage: http://www.iiasa.ac.at/collections/IIASA_Research/ECS/docs/test.htm