GREENHOUSE GAS PROTOCOL

WORLD RESOURCES INSTITUTE

Policy and Action Standard

Road Transport Sector Guidance

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Contributors (alphabetically)

Erin Cooper, World Resources Institute
Joanne Green, Clean Air Institute
James Harries, Ricardo-AEA
Benoit Lefevre, World Resources Institute
Anjali Mahendra, World Resources Institute
Hilda Martinez (lead), Embarq Mexico
Jacob Mason, Institute for Transportation and Development Policy
Jen McGraw, Center for Neighborhood Technology
Apurba Mitra, World Resources Institute
Juan Pablo Orjuela, Clean Air Institute
Kerstin Robertson, VTI
Ko Sakamoto, ADB
Marion Vieweg, Current Future

Introduction

This document provides sector-specific guidance to help users implement the GHG Protocol *Policy and Action Standard* in the road transport sector. The road transportation sector includes the movement of people and goods by cars, trucks, motorcycles and other road vehicles. The majority of greenhouse gas emissions from transportation are CO_2 emissions resulting from the combustion of petroleum-based products, such as gasoline, in internal combustion engines. The largest sources of transportation-related greenhouse gas emissions include passenger cars and light-duty trucks, including sport utility vehicles, pickup trucks, and minivans. Relatively small amounts of methane (CH_4) and nitrous oxide (N_2O) are emitted during fuel combustion. In addition, a small amount of hydrofluorocarbon (HFC) is released from the use of mobile air conditioners and refrigerated transport.

Users should follow the requirements and guidance provided in the *Policy and Action Standard* when using this document. The chapters in this document correspond to the chapters in the *Policy and Action Standard*. This document refers to Chapters 5–11 of the *Policy and Action Standard* to provide specific guidance for the road transport sector. The other chapters have not been included as they are not sector-specific, and can be applied to the road transport sector without additional guidance. Chapters 1–4 of the *Policy and Action Standard* introduce the standard, discuss objectives and principles, and provide an overview of steps, concepts, and requirements. Chapters 12–14 of the *Policy and Action Standard* address uncertainty, verification, and reporting. The table, figure, and box numbers in this document correspond to the table, figure, and box numbers in the standard.

To illustrate the various steps in the standard, this guidance document uses a running example of a hypothetical policy for the expansion, improvement and promotion of public transport through the implementation of a Bus Rapid Transit (BRT) system. The appendix provides two additional policy examples: a hypothetical transit oriented development policy and a hypothetical light duty fuel efficiency standard.

We welcome any feedback on this document. Please email your suggestions and comments to David Rich at drich@wri.org.

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Chapter 5: Defining the policy or action

In this chapter, users are required to clearly define the policy or action that will be assessed, decide whether to assess an individual policy or action or a package of related policies or actions, and choose whether to carry out an ex-ante or ex-post assessment.

5.1 Select the policy or action to be assessed

Table 5.1 provides a non-exhaustive list of examples of policies and actions in the sector for which this guidance document will be useful by policy/action type.

Table 5.1 Examples of policies/actions in the road transport sector by policy/action type

Type of policy or action	Examples
Regulations and standards	Light duty energy efficiency standards Heavy duty energy efficiency standards Zoning for transit oriented development (TOD), mixed-use, and higher density Reduced parking requirements for developments Bike parking requirements Vehicle use restrictions based on license plate number
Taxes and charges	Carbon tax Fuel taxation Parking tariff Congestion charging Truck weight-distance charging Distance-based pricing/mileage fees
Subsidies and incentives	Elimination of fuel subsidies Tax reduction due to cleaner technologies Development density bonuses Transportation demand management (TDM) programs Grants to local governments to provide alternative fuel infrastructure (e.g., electric car charging stations)
Voluntary agreements	Programs to improve fuel-efficiency, mainly for freight shippers, carriers and logistics companies (e.g., SmartWay[1]) Transportation demand management (TDM) programs initiated by employers
Information instruments	Public awareness campaigns Mobility management and marketing schemes Eco-driving promotion
Research and development (R&D)	Research grants for cleaner technologies, fuel improvements, tailpipe control devices
Public procurement policies	Government purchase requirements for high-efficiency cars
Infrastructure programs	Public transport (e.g., Bus Rapid Transit systems, metros, rail, integrated systems) Cycling facilities Park-and-ride facilities Transit oriented development (TOD)
Implementation of new technologies, processes, or practices	Cleaner vehicle/truck technologies Logistics management Telecommunication technologies (telework/teleconference, intelligent transportation systems/ ITS)

[1] Available at http://www.epa.gov/smartway.

	"Smart" parking systems, Bike-sharing / car-sharing
Financing and investment	Carbon finance, nationally appropriate mitigation actions (NAMAs), private finance, national financing programs targeted for the transport sector

5.2 Clearly define the policy or action to be assessed

A key step in Chapter 5 is to clearly define the policy or action, through a checklist of information provided in the chapter. Table 5.2 provides an example of reporting the information in the checklist for the example policy: Expansion, improvement and promotion of public transportation through the implementation of a BRT (Bus Rapid Transit) ("avoid" policy).

Appendix A & B provide examples of reporting the same information for two other policies: Transit Oriented Development (City Scale) ("shift" policy) and Light duty fuel efficiency standard ("improve" policy).

Table 5.2 Checklist of information to describe the policy: Expansion, improvement and promotion of public transportation through the implementation of a BRT (Bus Rapid Transit)

Information	Example
The title of the policy or action	Expansion, improvement and promotion of public transportation through the implementation of a Bus Rapid Transit (BRT) system
Type of policy or action	Strategy framed in terms of the desired outcome of promoting public transportation
Description of the specific interventions included in the policy or action	• Implementation of a BRT system with exclusive roads along three routes • Construction of the required infrastructure for the BRT (stations, lanes) • Improvement of sidewalks • Adjustments of regular bus routes and BRT to make the offer of public transport match the demand • Redefinition of the public transport system including concession contracts to improve accountability, control and modal integration with the BRT • Integration with regular buses and other transport modes • Public campaigns for communication, education, and promotion of the new transport system
The status of the policy or action	Planned
Date of implementation	Planned to start in the year 2015
Date of completion (if applicable)	First BRT route to be completed by end of 2016 Additional routes to be completed by end of 2017 and end of 2018
Implementing entity or entities	City administration
Objective(s) of the policy or action	• Reduce local pollutants and CO_2 emissions from mobile sources per passengers • Reduction in average traveling time • Increase public transport share of the modal distribution • Improve the city's public transport system • Improve local air quality
Geographical coverage	A city in Latin America
Primary sectors, subsectors, and emission sources or sinks	Emissions from public and private transport

targeted	
Greenhouse gases targeted	CO_2
Other related policies or actions	*Fuel pricing polices* Traditionally transport fuels are subsidized by the national government. New legislation introduced in 2012 will gradually phase out these subsidies, effectively increasing the level of fuel prices in the country. According to the legislation, subsidies should be completely removed by 2018. *Congestion charges* In 2010 the city introduced congestion charges for driving within the inner city limits between 7am and 8pm. The charge only applies to private vehicles. The charge is increasing by 2.5 percent per year and the level will be reviewed every 5 years.
Optional information	
Key performance indicators	• Increase in number of trips by public transport • Number of trips done using BRT system • Index of passengers per kilometer (IPK) • Vehicle-kilometer traveled (VKT) • Reduction in average traveling times • Number of scrapped buses • Changes in modal distribution • Km of road improved • Km of sidewalks improved • Emission factors for public transportation (BRT, buses) • Total emissions from public transportation • Emissions per passenger • Road accidents • Level of public transport service (passengers per square meter)
Intended or target level of mitigation to be achieved	Reduction in 30% of CO_2 emissions and 50% of PM 2.5 and PM 10 emissions from public transport relative to baseline emissions by 2020
Title of legislation or regulations or other founding documents	The strategy will be implemented through a package of policies: Integrated transportation system city level directive Emission standards Air quality management plans Regulation of transport service level
Monitoring Reporting and Verification (MRV) procedures	Monitoring arrangements will be included in the actual legislation once adopted.
Enforcement mechanisms	-
Reference to relevant guidance documents	GHG emissions inventories, IPCC guidelines and emission factors, emission models (IVE, MOVES, MOBILE 6, COPERT IV, TEEMP), Manual for Calculating Greenhouse Gas Benefits of Global Environment Facility Transportation Projects, O/D matrix, transport models (VISUM, EMME 3), official vehicle registration statistics, published studies related to BRT implementation in developing countries (e.g., TransMilenio CDM reports, TranSantiago reports).
The broader context/significance of the policy or action	The transport sector in the city is extremely disorganized and the local authorities have virtually no control over bus operation. About 80% of the vehicles used are old and do not comply with emission standards or road safety guidelines. There is a clear oversupply of public transport during off-peak hours and undersupply in peak hours. The system is not reliable, workers receive low salaries and

	are not well trained. There is a generalized low level of service with up to 10 passengers per square meter. The tariff system is based on the number of passengers, resulting in bad practices overloading buses. Public transport is responsible for more than 80% of the PM emissions of the city which affects human health. The informality related to the system results in poor maintenance practices that lead to high CO_2 emissions (about 30% of CO_2 emissions come from public transport). Private transport is responsible for about 60% of CO_2 emissions and is the main cause of congestion in the city. Motorcycle use has increased, resulting in high numbers of accidents and high emissions (two-stroke motorcycles are still in use). There are currently no incentives to use public transport due to its bad quality and private transport is the preferred mode. With the implementation of this policy, the public transportation system will be improved and integrated with the implementation of a BRT. This policy includes modal integration, improvement of sidewalks and scrappage of old traditional buses.
Outline of non-GHG effects or co-benefits of the policy or action	• Reduction of local pollutant emissions • Reduction in criteria pollutant concentrations • Positive effect in health issues related to air quality • Congestion will be improved • Quality of life and productivity of the citizens will be improved • Accident reduction • Increase in accessibility

5.3 Decide whether to assess an individual policy/action or a package of policies/actions

Chapter 5 also provides a description of the advantages and disadvantages of assessing an individual policy/action or a package of policies/actions. Steps to guide the user in making this decision based on specific objectives and circumstances include identifying other related policies/actions that interact with the initial policy/action.

The first step here is to conduct a policy mapping exercise to inform whether to assess an individual policy/action or a package of policies/actions for the example of the BRT policy. Let us assume that other relevant policies identified in table 5.2 target the same emission sources. The user will need to undertake a preliminary analysis to understand the nature of these interactions and determine whether to assess an individual policy/action or a package of policy actions. This analysis can be brief and qualitative, since detailed analysis of interactions would be taken up in subsequent chapters. Illustrative examples for the BRT policy are provided below (Table 5.5).

Table 5.5 Mapping policies/actions that target the same emission source(s)

Policy assessed	Targeted emission source(s)	Other policies/ actions targeting the same source(s)	Type of interaction	Degree of interaction	Rationale
Expansion, improvement and	Fuel combustion in public and	Fuel pricing polices	Overlapping	Minor	High fuel cost provides an additional

promotion of public transport through the implementation of a BRT	private transport				incentive to shift from private to public transport
		Congestion charging policies	Overlapping	Moderate	The charges provide an additional incentive to shift from private to public transport

Table 5.6 Criteria to consider for determining whether to assess an individual policy/action or a package of policies/actions

Criteria	Questions	Guidance	Evaluation
Use of results	Do the end-users of the assessment results want to know the impact of individual policies/actions, for example, to inform choices on which individual policies/actions to implement or continue supporting?	If "Yes" then undertake an individual assessment	No
Significant interactions	Are there significant (major or moderate) interactions between the identified policies/actions, either overlapping or reinforcing, which will be missed if policies/actions are assessed individually?	If "Yes" then consider assessing a package of policies/actions	Yes
Feasibility	Will the assessment be manageable if a package of policies/actions is assessed? Is data available for the package of policies/actions? Are policies implemented by a single entity?	If "No" then undertake an individual assessment	No
	For ex-post assessments, is it possible to disaggregate the observed impacts of interacting policies/actions?	If "No" then consider assessing a package of policies/actions	No

<u>Recommendation for the BRT policy</u>

This policy should be assessed as part of a package if the proposed mode directly affects the operation of the BRT and public transport buses. When possible, overlapping and reinforcing policies should also be evaluated as part of a package. Data availability and relative costs should also be considered.

This example assumes that the interaction of the BRT policy with the fuel price policy is minor, because the increase of transport cost applies to both private and public transport and the overall effect of the cost increase from removing the fuel subsidies is expected to be minor. The fuel pricing policy will therefore not be assessed together with the BRT policy, but will be included in the baseline scenario.

The congestion charge on the other hand is expected to have a moderately overlapping effect. Given the difficulty in disaggregating the effects between the congestion charge and the BRT development, this policy should be assessed jointly with the BRT policy. For the sake of simplicity, however, the following sections only assess the BRT as an individual policy.

Chapter 6: Identifying effects and mapping the causal chain

In this chapter, users identify all potential GHG effects of the policy or action and include them in a map of the causal chain.

6.1 Identify potential GHG effects of the policy or action

Using reliable literature resources, combined with professional judgment, expert opinion, or consultations, users can develop a list of all potential GHG effects of the policy or action and categorize them into: In-jurisdiction effects (and sources/sinks) and out-of-jurisdiction effects (and sources/sinks). In order to do this, users may find it useful to first understand how the policy or action is implemented by identifying the relevant inputs and activities associated with the policy or action (Table 6.1).

Table 6.1 Examples of inputs, activities, and effects for the BRT policy

Indicator types	Examples for BRT policy
Inputs	Investment in BRT infrastructure Staff employed for maintenance of the BRT
Activities	Construction and operation of the BRT
Intermediate effects	Increased modal share of BRT Altered land use planning
GHG effects	Reduced local pollutants and CO_2 emissions from private transport due to shift to public transport Reduced emissions from densification of urban areas close to the BRT corridors Increased emissions from construction Increased emissions from manufacturing construction materials
Non-GHG effects	Reduced road congestion Improved air quality due to reduced local pollution

For the BRT policy example, an illustrative list of possible effects (by type) for the policy is provided below (Table 6.2).

Table 6.2 Illustrative examples of various effects for the BRT policy

Type of effect	Effect
Intended effect	• Reduced emissions from private transport due to shift to public transport
Unintended effect	• Increased emissions from congestion during construction • Increased emissions (rebound) caused by the reduction in congestion which incentivizes people to change back to private transport • Reduced emissions from public and private transport due to reduced congestion
In-jurisdiction effect	• Increased emissions from public transport due to higher use • Increased emissions from construction
Out-of-jurisdiction effect	• Increased emissions from manufacturing imported construction materials
Short-term effect	• None in addition to effects mentioned above
Long-term effect	• Reduced emissions from densification of urban areas close to the BRT corridors

6.2 Identify source/sink categories and greenhouse gases associated with the GHG effects

Users next identify and report the list of source/sink categories and greenhouse gases affected by the policy or action (Table 6.3).

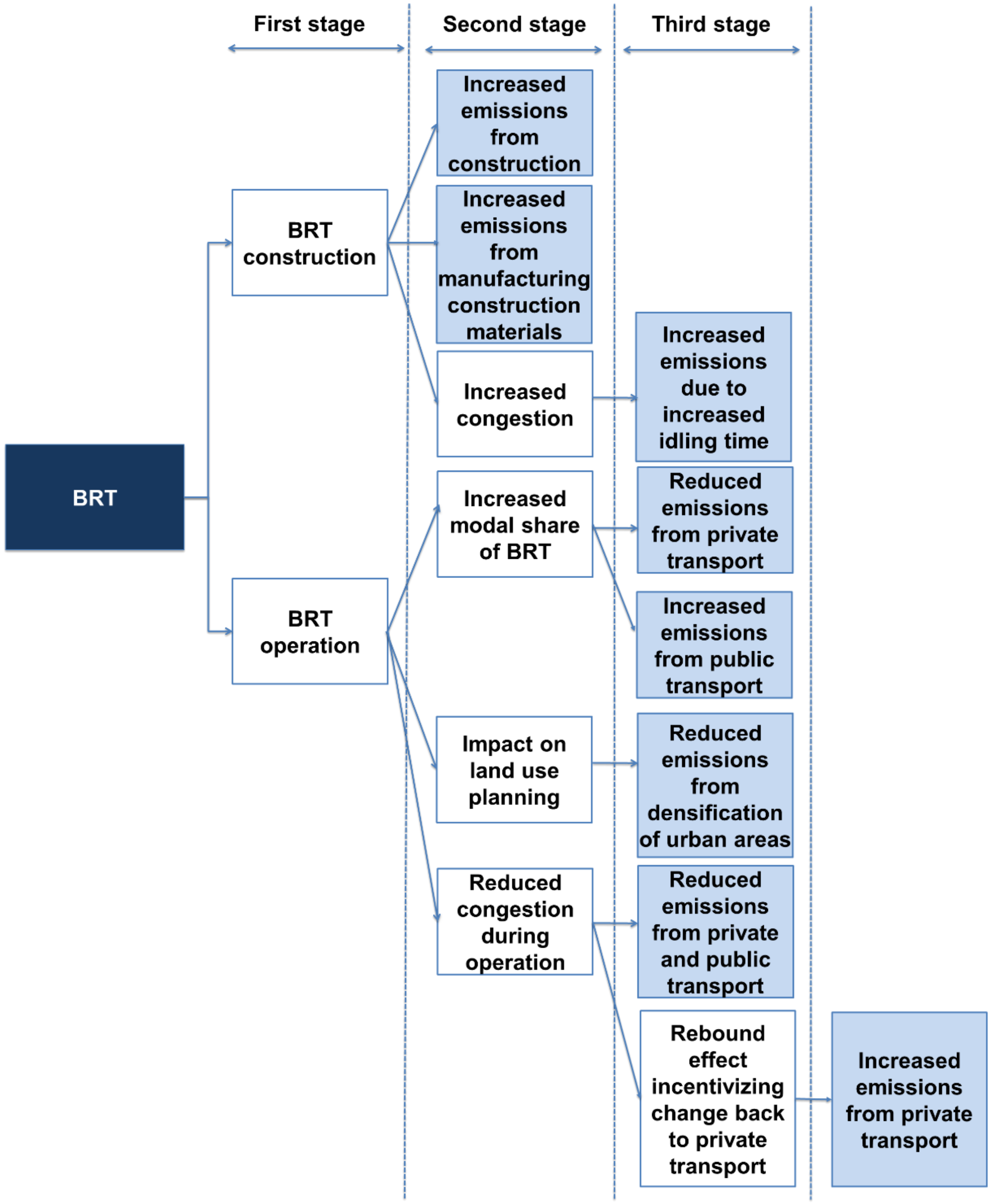
Table 6.3 Sources/sinks and greenhouse gases affected by the BRT policy

Source category	Description	Examples of emitting equipment or entity	Relevant greenhouse gases
Road transport (buses)	Fuel combustion and fugitive emissions from public transport	Buses	CO_2, CH_4, N_2O
Road transport (cars, motorcycles)	Fuel combustion and fugitive emissions from private transport	Cars, motorcycles, vans	CO_2, CH_4, N_2O
Construction material	Fuel combustion and fugitive emissions from construction material production (iron and steel, cement)	Industrial facilities	CO_2, CH_4, N_2O
Construction	Fuel combustion during construction	Construction equipment	CO_2, CH_4, N_2O

6.3 Map the causal chain

Once effects have been identified, developing a map of the causal chain allows the user and relevant stakeholders to understand in visual terms how the policy or action leads to changes in emissions. Figure 6.3 presents the causal chain for policy example based on the effects identified above.

Figure 6.3 Mapping GHG effects for example BRT policy



There are a number of sector-specific resources such as guidance documents, tools, and databases of projects that can be referred to while brainstorming possible effects of transportation policies. However the extent of available literature and resources varies by policy type and geography. Examples of some of these resources are provided in the methods and tools spreadsheet provided on the GHG Protocol website, which can be filtered by sector. Most of these resources will not be applicable in their entirety; however, select sections of these resources could provide a preliminary basis for further brainstorming and analysis.

Chapter 7: Defining the GHG assessment boundary

Following the standard, users are required to include all significant effects in the GHG assessment boundary. In this chapter, users determine which GHG effects are significant and therefore need to be included. The standard recommends that users estimate the likelihood and relative magnitude of effects to determine which are significant. Users may define significance based on the context and objectives of the assessment. The recommended way to define significance is "In general, users should consider all GHG effects to be significant (and therefore included in the GHG assessment boundary) unless they are estimated to be either minor in size or expected to be unlikely or very unlikely to occur".

7.1 Assess the significance of potential GHG effects

Examples of effects that may be significant for policies in this sector include:

- Rebound effect: Increased activity due to reduction in cost (e.g., energy consumption increases); a light duty energy efficiency policy can increase the number of diesel vehicles since they have a higher mileage, therefore increasing the vehicle miles traveled (VMT) for the overall fleet
- Leakage effect: With vehicle scrapping policies, vehicle owners sometimes prefer to sell their vehicles outside the city, and buy better vehicles. This can reduce local emissions but the polluting vehicles would still be used and might increase emissions elsewhere.

For the BRT policy example, an illustrative assessment boundary is shown below (Table 7.3).

Table 7.3 Assessing each GHG effect separately by gas to determine which GHG effects and greenhouse gases to include in the GHG assessment boundary for the example policy

GHG effect	Likelihood	Relative magnitude	Included?
Reduced GHG emissions from private transport			
CO_2	Very likely	Major	**Included**
CH_4	Very likely	Moderate	**Included**
N_2O	Very likely	Moderate	**Included**
Increased emissions from public transport			
CO_2	Very likely	Moderate	**Included**
CH_4	Very likely	Minor	**Included**
N_2O	Very likely	Minor	**Included**
Reduced emissions from densification of urban areas close to the BRT corridors			
CO_2	Possible	Minor	Excluded
CH_4	Possible	Minor	Excluded
N_2O	Possible	Minor	Excluded
Increased emissions from construction			
CO_2	Very likely	Minor	Excluded
CH_4	Very likely	Minor	Excluded
N_2O	Very likely	Minor	Excluded
Increased emissions from manufacturing construction materials			

CO_2	Very likely	Minor	Excluded
CH_4	Very likely	Minor	Excluded
N_2O	Very likely	Minor	Excluded
Increased emissions due to increased idling time (from congestion) during construction			
CO_2	Very likely	Minor	Excluded
CH_4	Very likely	Minor	Excluded
N_2O	Very likely	Minor	Excluded
Increased emissions (rebound) caused by the reduction in congestion which incentivizes people to change back to private transport			
CO_2	Unlikely	Moderate	Excluded
CH_4	Unlikely	Minor	Excluded
N_2O	Unlikely	Minor	Excluded
Reduced emissions from public and private transport due to reduced congestion			
CO_2	Likely	Minor	Excluded
CH_4	Likely	Minor	Excluded
N_2O	Likely	Minor	Excluded

Figure 7.3 Assessing each GHG effect to determine which GHG effects to include in the GHG assessment boundary for the example policy

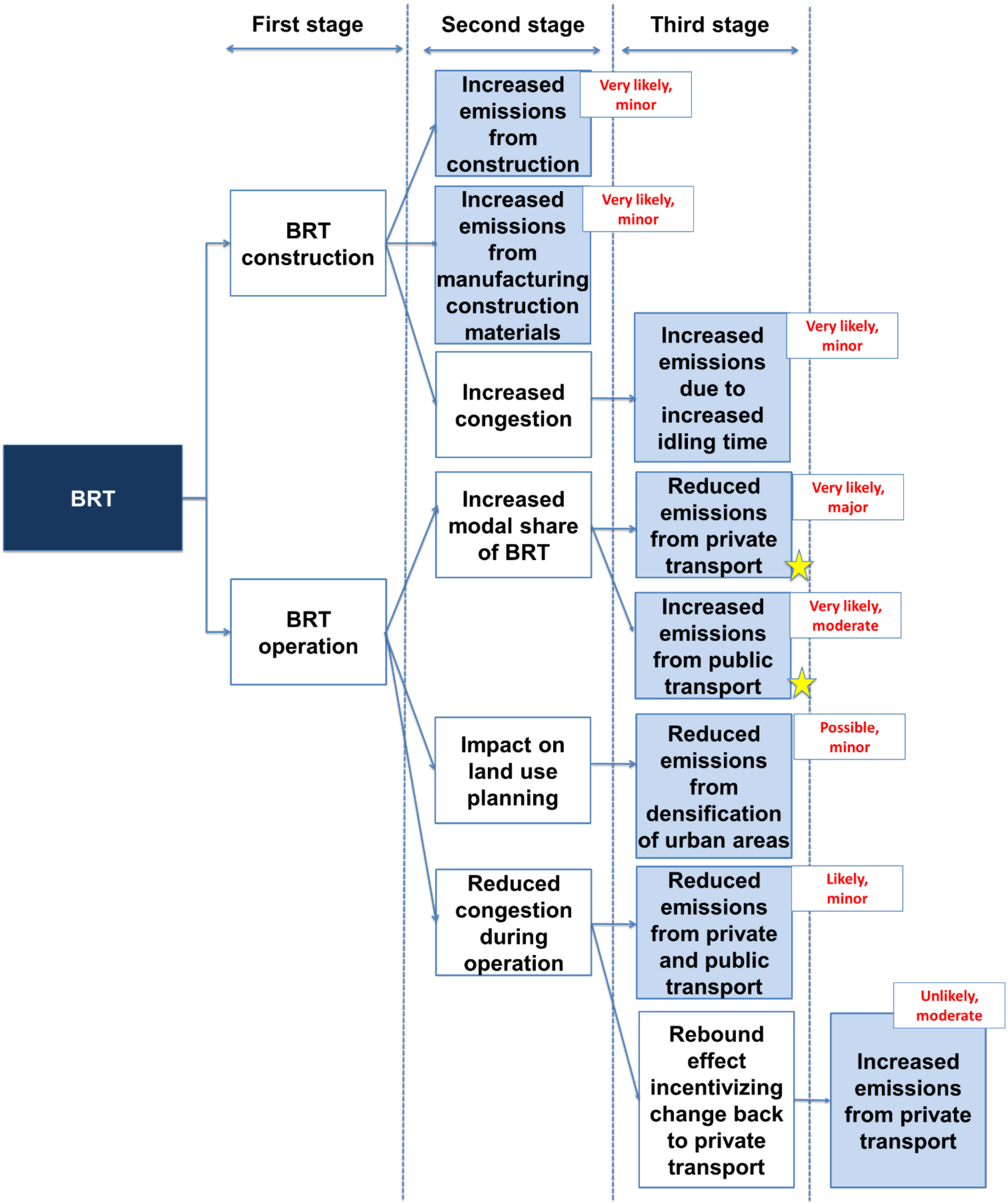


Table 7.4 List of GHG effects, GHG sources and sinks, and greenhouse gases included in the GHG assessment boundary for the BRT policy

	GHG effect	GHG sources	GHG sinks	Greenhouse gases
1	Reduced GHG emissions from private transport	Road transport (cars, motorcycles)	N/A	CO_2, CH_4, N_2O
2	Increased GHG emissions from public transport	Road transport (buses)	N/A	CO_2, CH_4, N_2O

Travel demand elasticity analysis with respect to price and travel time is used to determine effects in many cases. Standard values are available in literature and several meta-analyses have been done which can be used as sources for default values. For example, Ewing and Cervero (2010)[2] provides default values for impacts of land use policies on transportation based on a meta-analysis of 200 studies. (However the majority of these studies are US-focused.) Various models can also be used to determine elasticity values. For example, Mayworm, Lago, and McEnroe (1980)[3] contains information on demand elasticity models. More information on the elasticity of transit use can be found in Parody and Brand (1979), and Hamberger and Chatterjee (1987), among others. Published impacts (in terms of percent reduction in GHG emissions) from similar programs (e.g., ITS technologies, TDM programs) implemented elsewhere can also be used as guidance.

[2] Ewing, Reid and Robert Cervero (2010). "Travel and the Built Environment." Journal of the American Planning Association. Available at http://dx.doi.org/10.1080/01944361003766766.
[3] Mayworm, Patrick, Armando M. Lago, and J. Matthew McEnroe (1980). "Patronage Impacts of Changes in Transit Fares and Services." Washington, D.C.: The Office of Service and Demonstration Methods, U.S. Department of Transportation, 1980.

Chapter 8: Estimating baseline emissions

In this chapter, users estimate baseline emissions over the GHG assessment period from all sources and sinks included in the GHG assessment boundary. Users need to define emissions estimation method(s), parameter(s), driver(s), and assumption(s) needed to estimate baseline emissions for each set of sources and sinks.

8.4 Estimating baseline emissions using the scenario method

8.4.1 Define the most likely baseline scenario

Users may use a baseline developed by an external party, use baseline values from published data sources, or develop new baseline values. In all cases, users should identify other policies and non-policy drivers that affect emissions in the absence of the policy or action. Examples of other policies and non-policy drivers are provided in Tables 8.3 and 8.4.

Table 8.2 Examples of other policies or actions that may be included in a baseline scenario

Other policies	Sources of data for developing assumptions
Urban planning and land use	National and local policies, private developer master plans
Transportation demand management	National policies, voluntary initiatives implemented by employers, impact studies
Technology and fuel standards	National standards
Fuel, vehicle, and parking pricing strategies	National and local policies, policy impact studies, expert interviews

Table 8.4 Examples of non-policy drivers that may be included in a baseline scenario

Non-policy drivers	Sources of data for developing assumptions
GDP and economic growth rates	National statistics
Population and growth rates	National statistics
Changes in consumer preferences	Surveys
Land use changes and growth in development	Local origin-destination surveys and statistics
Fuel prices	Market analysis, government statistics
Cost of transit alternatives	National statistics
Changes in vehicle fuel economy	National and vehicle manufacturers' statistics, research institutes
Socio-economic status of commuters	National and local statistics, research institutes
Availability of cleaner technologies	Universities, research institutes, manufacturer or transport associations

Data needs for baseline assessment vary with the type of policy or action being implemented. However, some of the common data needs are:

- Fuel sales: This data can mostly be collected easily and accurately by national, regional or city level agencies. However, the location of activity and emissions may be different from the location where the fuel was purchased.
- Characteristics of the vehicle fleet: This includes, for example, data on the number of vehicles per vehicle type, the average age of vehicles and type of emission control technologies used.
- Activity (use intensity): Information on the distance traveled per vehicle by type, including information on the number of passengers carried.

- Gross efficiency of the fleet: average fuel use per type of vehicle.
- Fuel stock information.

This data may be difficult to collect for countries, regions, or cities. It often requires detailed surveys and/or transparent and reliable official registrations of vehicle fleet and activity, which are not available in all countries/jurisdictions.

Clean Air Institute (2012)[4] provides guidance for obtaining emission factors and activity data for assessments.

8.4.2 Select a desired level of accuracy

There are different methodological choices related to the level of accuracy of an assessment. Simplified methods can be used, such as IPCC Tier 1 methods, or more complex methods, such as IPCC Tier 3. The methods by which the parameter values of the selected method are derived also impacts the accuracy of the analysis. A further important factor is the source of data, where internationally applicable default values constitute lower levels of accuracy than jurisdiction or source specific data.

Further, emission factors can be static (calculated upfront and applied for the duration of the assessment) or dynamic (updated over time to reflect changes in vehicle technologies, fuels, etc.) and that can be another means of making the distinction. A low accuracy method could have the option of applying a static emission factor, and higher accuracy methods could update emission factors on a regular basis.

For the BRT policy, some examples for different levels of accuracy for selecting the method and data sources are provided below.

Low accuracy: According to published studies, economic development increases transport demand.[5] The actual emissions could be calculated using emissions from recent inventories and applying an annual increase proportional to the expected economic growth.

Intermediate accuracy: The correlation between transport emissions and economic growth could be based on national/local studies, instead of international literature. Baseline emissions could also be calculated by using the individual trend per fuel type, derived from country / jurisdiction level historic data.

High accuracy: Emissions could be determined based on a model using data on the historic development of the vehicle fleet, efficiency of vehicles and behavior patterns, including local emission factors.

Many sector-specific emissions estimation algorithms, equations, models, tools, and methodologies are available for estimating baseline emissions for the sector. Source documentation should be reviewed for transparency, completeness, and applicability to the standard and specific requirements of the analysis. Users should refer to the corresponding websites of the resources to review source documentation and additional information.

8.4.3 Define the emissions estimation method(s) and parameters needed to calculate baseline emissions

For the BRT example, the steps to be followed to determine baseline emissions are described below. It is assumed that relatively detailed data is available, allowing for a more complex calculation method.

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[4] Clean Air Institute (2012). "Development of a common assessments framework and proposed methodologies for integrated assessments of GHG and local pollutants of urban transport interventions in Latin America and the Caribbean region." Available at http://cleanairinstitute.org/helpdesk/download/Critical_Review_Final2012.pdf.
[5] For example, see IPCC Fourth Assessment Report, Chapter 5.

Equation 1 Estimating baseline emissions for road transport[6]

$$\text{Baseline emissions}_y = \sum[\text{Distance}_{a,b,c} \times \text{Emission factor}_{a,b,c}]$$

Where:
a = fuel type
b = vehicle type
c = emission control technology
y = year

Table A[7] **Examples of determining baseline values from published data sources**

Parameter	Sources of published data for baseline values
Emission factors	Sources include IPCC and the International Vehicle Emissions Model (IVE).[8] IVE includes standard emission factors, local emission factors for a number of cities and can be used to generate emission factors from measured data. Other sources include COPERT[9] and MOVES.[10] Emission factors can also be obtained from direct measurements. Emission factors can be either taken directly from real vehicle operation or from simulated vehicle operation in controlled laboratory conditions.
Distance[11]	Local or regional studies based on sampling and surveys. If there is little or incomplete local data on Vehicle Kilometers Travelled (VKT), IVE defaults or data from a comparable city may be used. The Transport Emissions Evaluation Models for Projects (TEEMP) is of potential use, as it provides comparable default values. However, most of these were not generated in Latin America and IVE would be preferred for this example as it includes comparable data from Latin America. Transport Activity Measurement Toolkit (TAMT) may be used (or other 'unobtrusive direct data collection methods') to estimate VKT if money and time can be invested in gathering data. This toolkit is designed to facilitate vehicle activity data gathering and management and will typically generate more exact values than those provided by TEEMP and IVE.
GWP values	For estimating CH_4 and N_2O emissions, GWP values published by the IPCC should be used.

[6] Based on IPCC Tier 3 with simplification by removing separate accounting for warm-up emissions and differentiation of operating conditions. For alternative methods see IPCC (2006) Guidelines.
[7] Table numbering differs, as there is no corresponding table included in the standard. The table is adapted from Table 8.7 in the standard.
[8] http://www.issrc.org/ive/
[9] http://www.emisia.com/copert/General.html
[10] http://www.epa.gov/otaq/models/moves/
[11] Distance (vehicle kilometres travelled or VKT) can be determined using data such as average trip length per person, population, and mode share.

8.4.4 *Estimate baseline values for each parameter*

The following table provides an overview of the parameter values used for the baseline calculation. For simplification, this example assumes that only one type of vehicle/emission control technology is used per category.

Table 8.7 Example of parameter values and assumptions used to estimate baseline emissions for road transport emissions

Parameter	Baseline value(s) applied over the GHG assessment period	Methodology and assumptions to estimate value(s)	Data sources
Emission factors: gasoline for light duty vehicles (LDV) with oxidation catalyst[12]	CO_2: 323 g/km CH_4: 82 mg/km N_2O: 20 mg/km	Emission factors for the specific vehicle type / fuel type are expected to remain constant over the assessment period.	IVE Vehicle Emissions Report Mexico City (CO_2) IPCC 2006 (CH_4, N_2O)
Emission factors: diesel for buses[13]	CO_2: 723 g/km CH_4: 4 mg/km N_2O: 3 mg/km	Emission factors for the specific vehicle type / fuel type are expected to remain constant over the assessment period.	TEEMP, BRTS Project (CO_2) IPCC 2006 (CH_4, N_2O)
Distance travelled (VKT) with private light duty vehicle	12,300 million km (2010) 30,400 million km (2020)[14]	Population growth expected to be 40% between 2010 and 2020 Population 2010: 15 million 8614 km total average annual trips 19% of total trips conducted by car 40% by bus Average occupancy cars: 2 persons Average occupancy buses: 27 persons Non-policy drivers included in the baseline	TEEMP, BRTS Project National statistics office, National transport institute

[12] For simplification, the document only calculates emissions for one fuel type and one vehicle category. For a full assessment, this process will need to be conducted for each fuel type and vehicle category in use or expected to be in use during the assessment period within the boundary.

[13] For simplification, the document only calculates emissions for heavy duty diesel vehicles. See footnote above.

[14] Ideally a full time series should be provided. These numbers are only illustrative.

Distance travelled (VKT) with public heavy duty vehicle (buses)	1,900 million km (2010) 2,490 million km (2020)	scenario: • Autonomous efficiency improvement over time by moving towards newer, more efficient vehicles. This will reduce the distance travelled per type of less efficient vehicle, reducing VKT by 2% per year. • Population growth will increase overall travel and increase length of use of less efficient vehicles. Total VKT is expected to grow proportionately to population size. It is assumed that without the BRT policy, 70% of this growth would be covered by private vehicles.	TEEMP, BRTS Project National statistics office, National transport institute

8.4.5 Estimate baseline emissions for each source/sink category

The final step is to estimate baseline emissions by using the emissions estimation method identified in Section 8.4.3 and the baseline values for each parameter identified in Section 8.4.4.

Based on equation 1, baseline values for the BRT for the end year of the assessment period for the selected source categories can be calculated. For this example, the calculation for CO_2 is shown to illustrate the principle. In a full assessment, CH_4 and N_2O emissions should also be calculated using the same values for distance with the respective emission factors and GWP values:

Private transport: Baseline emissions$_{gasoline,LDV,oxi}$ (2020) = 30,400 million VKT x 323 g/VKT = 9.82 Mt CO_2

Public transport: Baseline emissions$_{diesel,HDV,all}$ (2020) = 2,490 million VKT x 723 g/VKT = 1.80 Mt CO_2

In a full analysis this calculation will need to be repeated within each source category for the different fuel types, vehicle types and emission control technologies used. The calculation will also need to be repeated for each year within the assessment period as far as data is available.

8.6 Aggregate baseline emissions across all source/sink categories

Table 8.9 Example of aggregating baseline emissions for the BRT policy

GHG effect included in the GHG assessment boundary	Affected sources	Baseline emissions
1 Reduced GHG emissions from private transport	Road transport (light vehicle gasoline vehicles)	9.82 Mt CO_2
2 Increased GHG emissions from public transport	Road transport (heavy duty diesel buses)	1.80 Mt CO_2
Total baseline emissions		**11.62 Mt CO_2**

Note: The table provides data for the end year in the GHG assessment period (2020).

Chapter 9: Estimating GHG effects ex-ante

In this chapter, users estimate policy scenario emissions for the set of GHG sources and sinks included in the GHG assessment boundary based on the set of GHG effects included in the GHG assessment boundary. Policy scenario emissions are to be estimated for all sources and sinks using the same emissions estimation method(s), parameters, parameter values, GWP values, drivers, and assumptions used to estimate baseline emissions, except where conditions differ between the baseline scenario and the policy scenario, for example, changes in activity data and emission factors.

9.2 Identify parameters to be estimated

Table A in chapter 8 forms the basis for determining which parameters are affected by the policy. In case the determination of affected parameters is not straight forward, the methodology to determine significance outlined in Chapter 7 can be used. For the BRT policy example, the steps for calculating ex-ante emissions are described below:

Table 9.1 Example of identifying affected parameters to estimate policy scenario values for the BRT policy

Parameter	Likelihood	Relative magnitude
Emission factor for gasoline consumed in light duty vehicles (LDV) with oxidation catalyst[15]	Very unlikely	Minor
Emission factor for diesel consumed in buses[16]	Very unlikely	Minor
Distance travelled (VKT) with private light duty vehicle	Very likely	Major
Distance travelled (VKT) with public heavy duty vehicle (buses)	Very likely	Major

In the BRT example, the emission factors for individual fuel/vehicle/technology combinations are assumed to be identical to baseline values. GWP values are also not affected by the policy. The distance traveled by public or private transport mode is the only affected parameter.

Additional information on the underlying parameters determining the distance travelled can be useful in the policy scenario:

- Population affected by each route
- Average trip distance per person
- Average amount of trips per person
- Average vehicle occupation rate

9.4 Estimate policy scenario values for parameters

Short term effects due to construction are excluded from the boundary. All remaining effects are expected to happen gradually with a linear trend beginning when the first BRT routes are finalized in 2016.

For the illustrative example, the note assumed that existing surveys were available that indicated that 10% of private vehicle users would shift to a BRT system if a user-friendly system were in place. Accounting for the fact that only a part of those responding positively in the surveys would in fact put this

[15] For simplification, the document only calculates emissions for one fuel type and one vehicle category. For a full assessment this calculation should be done for each fuel type and vehicle category in use or expected to be in use within the boundary during the assessment period.
[16] For simplification, the document only calculates emissions for heavy duty diesel vehicles. See footnote above.

in practice, a bias correction factor of 80% was included. This value is also assumed to be valid for increasing population.

Given the gradual nature of adoption, this example assumes that the full potential will be achieved two years after finalization of all routes.

Table 9.2 Example of reporting parameter values and assumptions used to estimate ex-ante policy scenario emissions for the BRT policy

Parameter	Baseline value(s) applied over the GHG assessment period	Policy scenario value(s) applied over the GHG assessment period	Methodology and assumptions to estimate value(s)	Data source(s)
Distance travelled (VKT) with private light duty vehicle	12,300 million km (2010) 30,400 million km (2020)[17]	12,300 million km (2010) 15,800 million km (2020)[18]	Population growth 40% between 2010 and 2020 Population in 2010: 15 million 8614 km total average annual trips 17.5% of total trips conducted by car Average occupancy: 2 persons	National statistics office, National transport institute
Distance travelled (VKT) with public heavy duty vehicle	1,900 million km (2010) 2,490 million km (2020)	1,900 million km (2010) 2,780 million km (2020)	41.5% of total trips conducted by bus Average occupancy: 27 persons	National statistics office, National transport institute

9.5 Estimate policy scenario emissions

Once parameter values have been determined, the same equations as used for the calculation of baseline values can be used to derive the policy scenario values:

Private transport: Policy $\text{emissions}_{gasoline,LDV,oxi}$ (2020) = 15,800 million VKT x 323 g/VKT = 5.10 Mt CO_2

Public transport: Policy $\text{emissions}_{diesel,HDV,all}$ (2020) = 2,780 million VKT x 723 g/VKT = 2.00 Mt CO_2

9.6 Estimate the GHG effect of the policy or action (ex-ante)

After calculating the GHG emissions for the policy scenario for each source category, the change resulting from the policy can be determined. Table 9.3 provides an overview of the results.

[17] Ideally a full time series should be provided. These numbers are only illustrative.
[18] Ideally a full time series should be provided. These numbers are only illustrative.

Table 9.3 Example of estimating the GHG effect of the BRT policy for year 2020

GHG effect included	Affected sources	Policy scenario emissions	Baseline emissions	Change
1 Reduced GHG emissions from private transport	Road transport (light vehicle gasoline vehicles)	5.10 Mt CO_2e	9.82 Mt CO_2e	**-4.72 Mt CO_2e**
2 Increased GHG emissions from public transport	Road transport (heavy duty diesel buses)	2.00 Mt CO_2e	1.80 Mt CO_2e	**0,20 t CO_2e**
Total emissions / Total change in emissions		**7.10 Mt CO_2e**	**11.62 Mt CO_2e**	**-4.52 t CO_2e**

Illustrative examples of addressing policy interactions

Non-motorized transport policies usually target bicycle and pedestrians, while the analyzed policy targets public transportation. Increasing a bicycle path network as a result of non-motorized transport policies can have an impact on GHG emissions because people may use this mode more often. The expansion, improvement and promotion of public transportation through the implementation of a BRT policy will have an impact mainly on transport so the effects in GHG do not interact and are considered independent.

Technology improvement of transport vehicles (traditional buses) will have an important impact on GHG increasing combustion efficiency and therefore improving emission factors if there is no other action to reduce emissions. The overall effect of this policy with the expansion, improvement and promotion of public transportation through the implementation of a BRT policy will be overlapping. The BRT policy is expected to improve emission factors and activity factors if implemented alone. If both policies are implemented together the impact of BRT on emission factors will be less, but it will still have an impact on activity factor of buses. The impact of both policies together will be less than the sum of them individually.

Policies promoting cleaner fuels are expected to cause significant emission reduction individually. If they are combined with other polices that improve the number of trips with the cleaner fuel, the expected reduction will be higher than if only one policy was implemented. Cleaner fuels have a big impact by improving emission factors from motorcycles, trucks, and private vehicles. The BRT implementation policy will have an impact on activity data, thus increasing the benefits of modal change when the policies are combined.

Figure B.1 Illustrative example of a policy interaction matrix

		Parameter: modal share										
		1	2	3	4	5	6	7	8	9	10	11
1	Expansion, improvement, and promotion of public transport through the implementation of a BRT system											
2	Vehicle maintenance policies	++										
3	Fuel pricing polices	+	0									
4	Congestion charging policies	++	0	-								
5	Fleet renewal policies	-	-	-	-							
6	Technology improvement policies	--	-	+	--	--						

7	Route optimization policies	--	0	0	+	-	-					
8	Policies for use of cleaner fuels	++	+	--	0	-	-	-				
9	Improvement of emission standard policies	0	-	-	0	-	-	-	-			
10	Policies aimed at the reduction of motorcycle use	0	0	-	-	+	+	0	-	-		
11	Non motorized transport policies	0	0	0	+	0	0	0	0	0	+	

Key:

Independent 0
Overlapping - - - major/-- moderate/- minor interaction
Reinforcing +++ major/++ moderate/+ minor interaction
Uncertain U

Chapter 10: Monitoring performance over time

In this chapter, users are required to define the key performance indicators that will be used to track performance of the policy or action over time. Where relevant, users need to define indicators in terms of the relevant inputs, activities, intermediate effects and GHG effects associated with the policy or action.

10.1 Define key performance indicators

Performance can be monitored through indicators such as:

- Measuring (estimating) activity with and without the policy: vehicle-km by vehicle type
- Measuring (estimating) impact with and without the policy: grams GHG emissions/Km by vehicle type
- Number of passengers on BRT lines
- Number of private vehicles on selected roads
- Survey data for changes in transport preferences and use

Users are also required to create a plan for monitoring key performance indicators (and parameters for ex-post assessment if relevant). A monitoring plan is important to ensure that the necessary data is collected and analyzed. A city administration department needs to be defined to collect, aggregate and process the data in a useful way.

Table 10.5 Example of information to be contained in the monitoring plan for the BRT policy

Indicator or parameter (and unit)	Source of data	Monitoring frequency	Measured/modeled/ calculated/estimated (and uncertainty)	Responsible entity
Average traveling time	Origin-destination (OD) surveys, household surveys, surveys in public transport systems such as the BRT, traditional buses or bike lanes. Vehicle counts may also help as a proxy of modal distribution.	Annual	Measured (High uncertainty)	City administration transport division
Vehicle-kilometer traveled (VKT)		Annual	Measured (High uncertainty)	
Modal distribution		Annual	Calculated (High uncertainty)	
Number of trips done in BRT	Tickets sold, passenger surveys, household surveys	Annual	Measured (Moderate uncertainty)	BRT operator
Index of passengers per kilometer (IPK)		Annual	Calculated (High uncertainty)	BRT operator
Km of road improved	Official municipal records	Annual	Measured (Low uncertainty)	City administration roads department
Km of sidewalks improved	Official municipal records	Annual	Measured (Low uncertainty)	

Emission factors from public transportation (BRT, buses)	Remote sensing field campaigns	Annual	Estimated (Low uncertainty)	
Road accidents	Official municipal records	Annual	Measured (Low uncertainty)	

Chapter 11: Estimating GHG effects ex-post

A number of ex-post assessment methods have been described in this chapter, which can be classified into two broad categories i.e. Bottom-up methods and top-down methods. For the transport sector, the applicability of top-down or bottom-up methods is significantly influenced by the type of policy and objectives of the assessment.

11.2 Select an ex-post assessment method

A top-down accounting approach for transport sector may provide only the total GHG emissions from the sector, while bottom-up approach may provide detailed data on GHG emissions by mode, vehicle type, trip purpose, fuel type, and jurisdiction which are useful for designing intervention measures.

The applicability of individual ex-post quantification methods for the sector and illustrative sources of data are discussed in Table 11.1.

Table 11.1 Applicability of ex-post assessment methods

Bottom up methods	Applicability
Collection of data from affected participants/ sources/ other affected actors	• In the transport sector, the effect of the policy is regularly measured through metering vehicle activity and estimating GHG emissions. • Direct measurement of emission factors has been done but is usually very expensive for developing countries. • In transportation, the effect of the policy could be estimated using fuel consumption billing of the vehicles affected by such policy.
Engineering estimates	• The effect of the policy can be estimated using a model of an individual unit. For example, for an “improve” policy, a model of an individual vehicle with a new technology could be used to estimate GHG emissions.
Deemed estimate	• The effect of some policies, such as some “shift” policies (e.g. park-meters), can be estimated by applying a modal shift survey.
Methods that can be bottom-up or top-down depending on the context	**Applicability**
Stock modeling	• This method can be used to estimate the effect of “improve” policies, for example, in the case of a policy involving the introduction of hybrid vehicles. By stock and market statistics, emissions reduced because of the introduction of vehicles with new technologies could be estimated. However, this might be considered as a top-down approach since other factors can also influence stock and market statistics. It would also be important to differentiate the replacement of existing vehicles with different technologies, and the introduction of additional vehicles with new technologies.
Top down methods	**Applicability**
Monitoring of indicators	• This method is commonly used to estimate GHG in transportation based on fuel consumption statistics. However, it might not be accurate to measure the effect of specific policies since it is hard to associate any change in fuel consumption of the sector to specific vehicles affected by the policy. Location of

	fuel sales is also sometimes different from location of activity/ emissions, which makes this method less accurate.
Economic modeling	• If local surveys have been done to estimate the impact of policies such as increased parking charges or reduced transit travel time on the use of different modes, econometric modeling can be done to determine the magnitude of these relationships and generate local elasticities.

With reference to the example BRT policy, both bottom up methods and top down methods based on bottom up data are applicable. The applicability of individual ex-post quantification methods and illustrative sources of data for the policy examples are shown below.

Appendix A: Transit Oriented Development

This appendix provides examples of reporting select information for the policy example: Transit Oriented Development (City Scale) ("shift" policy).

Chapter 5: Defining the policy or action

5.2 Clearly define the policy or action to be assessed

Table 5.2 Checklist of information to describe the policy: Transit Oriented Development in India

Information	Example
The title of the policy or action	Transit Oriented Development in India (City Scale)
Type of policy or action	Infrastructure programs
Description of the specific interventions included in the policy or action	Land use strategies that preserve existing densities (people/square km) and mixed use (residential, commercial, and institutional) or encourage high density and mixed use where they are missing (e.g. areas of expansion). Public transport and non-motorized modes.
The status of the policy or action	Pilot
Date of implementation	2014
Date of completion (if applicable)	2041
Implementing entity or entities	City administration
Objective(s) of the policy or action	Increase the number of trips using non-motorized transport and public transport as opposed to the business-as-usual trend Reduce the trip distance as activities are closer Reduce the vehicle kilometer traveled in individual motor vehicles Reduce travel time, traffic fatalities, air pollution, total transport cost Reduce GHG emissions
Geographical coverage	City-wide
Primary sectors, subsectors, and emission sources or sinks targeted	Emissions from public and private transport
Greenhouse gases targeted	CO_2, CH_4, N_2O
Optional information	
Key performance indicators	Total trips, Percentage of trips by mode (walk/ bike/ motorcycles/ car/ public transportation), Trip distance by mode, CO_2e emissions by mode
Intended level of mitigation to be achieved and/or target level of other indicators	10.42 million ton of CO_2eper year
Title of establishing legislation, regulations, or other founding documents	Local regulations on land use, emissions, and air quality
Monitoring, reporting, and verification (MRV) procedures	-
Enforcement mechanisms	-
Reference to relevant guidance documents	Resources produced by EMBARQ Sustainable Transport and Urban development- Improving Access for the Majority, Saving Lives and Mitigating Negative Environmental Impacts, Dario Hidalgo, March 2012. Rayle, L. and Pai, M. (2010) Scenarios for Future Urbanization:

	Carbon Dioxide Emissions from Passenger Travel in Three Indian Cities, Transportation Research Record: Journal of the Transportation Research Board , Issue Number: 2193, Developing Countries, pp 124-131
The broader context/significance of the policy or action	In existing urban areas, land use and development strategies would preserve densities and a mixture of uses or encourage them where they are missing. In greenfield developments, master plans would zone for good densities and mixed uses, especially around public transport stations. This will help in preserving open spaces and producing affordable housing, with good connectivity to area jobs and areas of major activity. In existing and new urban development, public transport and non-motorized modes would be prioritized. Flexible bus based services for transit would be considered; bus of high level of service (BHLS) and bus rapid transit (BRT) are excellent options for medium to high capacity corridors – 5,000 to 15,000 passengers per hour per direction (pphpd) for a single lane BRT, and 15,000 to 45,000 pphpd for BRT with passing lanes at stations.[19] Metro lines are considered appropriate for corridors above 45,000 pphpd. High quality and safe pedestrian and bicycle infrastructure should complement these forms of transit. Finally, the efficiency of public transport and intermediate public transport (e.g. rickshaws) operations should be optimized. New technologies such as transit signal priority, centralized dispatch and control, automatic fare collection and real time information systems are helpful to enhance transport operations. Policies should also encourage the adoption of low emissions vehicle and fuel technologies.
Outline of non-GHG effects or co-benefits of the policy or action	The policy aims to reduce road fatalities, time spent in travel, air pollution and energy consumption

5.3 Decide whether to assess an individual policy/action or a package of policies/actions

Table 5.5 Mapping policies/actions that target the same emission source(s)

Policy assessed	Targeted emission source(s)	Other policies/actions targeting the same source(s)	Type of interaction	Degree of interaction
Transit oriented development in India	Fuel combustion in transportation vehicles	Mass transit systems (BRT, Metro, etc.)	Overlapping	Moderate
		Non-motorized transport	Overlapping	Major
		Transportation demand management (parking fees	Overlapping	Minor
		Congestion/pollution charges	Overlapping	Moderate
		Limiting parking available)	Overlapping	Minor

[19] Thredbo 12, Workshop 2. Bus Rapid Transit as part of Enhanced Service Provision, http://www.thredbo-conference-series.org/downloads/Thredbo12_Workshop_Reports/W2.pdf.

Table 5.6 Criteria to consider for determining whether to assess an individual policy/action or a package of policies/actions

Criteria	Questions	Transit oriented development
Use of results	Do the end-users of the assessment results want to know the impact of individual policies/actions, e.g. in order to inform choices on which individual policies/actions to implement or continue supporting?	No
Significant interactions	Are there significant interactions between the identified policies/actions, either overlapping or reinforcing, which will be missed if policies/actions are assessed individually?	Yes
Feasibility	Will the assessment be unmanageable if a package of policies/actions is assessed, e.g. is the causal chain and range of effects likely to become too complex?	No
	For ex-post assessments, is it possible to disaggregate the observed impacts of interacting policies/actions?	No

Recommendations

Transit oriented development ("Shift" policy): There is not a one size fits all solution for the transport sector therefore it is useful to assess the policies/actions as a package. In some cases, this will be simpler than undertaking individual assessments as it avoids the need to disaggregate the effects of individual measures.

Chapter 6: Identifying effects and mapping the causal chain

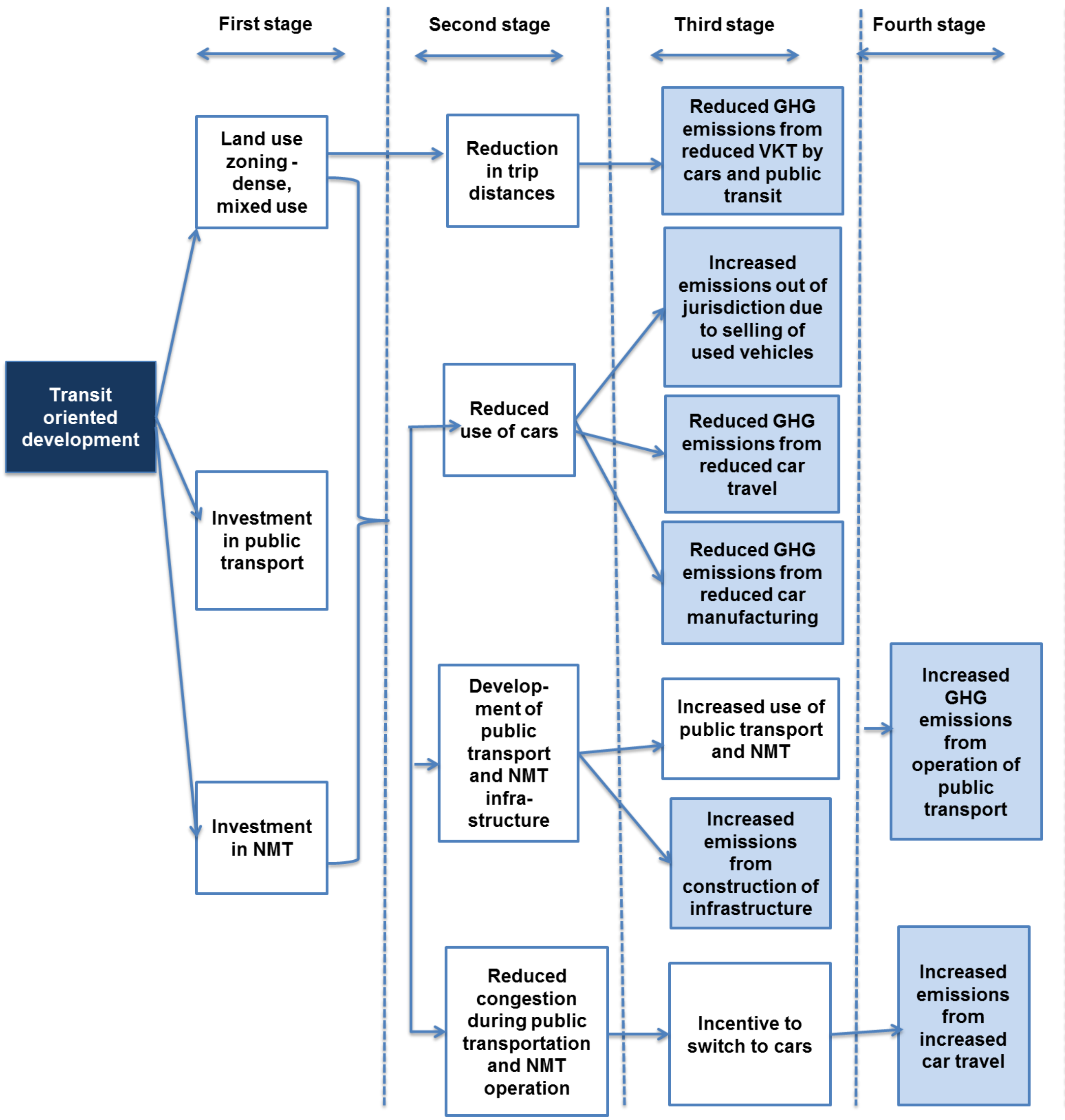
6.1 Identify potential GHG effects of the policy or action

Table 6.2 Illustrative example of various effects for the example policies

Type of effect	Effect
Intended effect	• Reduced GHG emissions from reduced VKT by cars and public transit • Reduced GHG emissions from reduced car travel
Unintended effect	• Increased emissions from increased private transport
In-jurisdiction effect	• Reduced GHG emissions from reduced car manufacturing • Increased GHG emissions from operation of public transport
Out-of-jurisdiction effect	• Increased emissions out of jurisdiction due to selling of used vehicles
Short-term effect	• Increased emissions from construction of infrastructure
Long-term effect	

6.3 Map the causal chain

Figure 6.3 Mapping GHG effects for each of the example policies



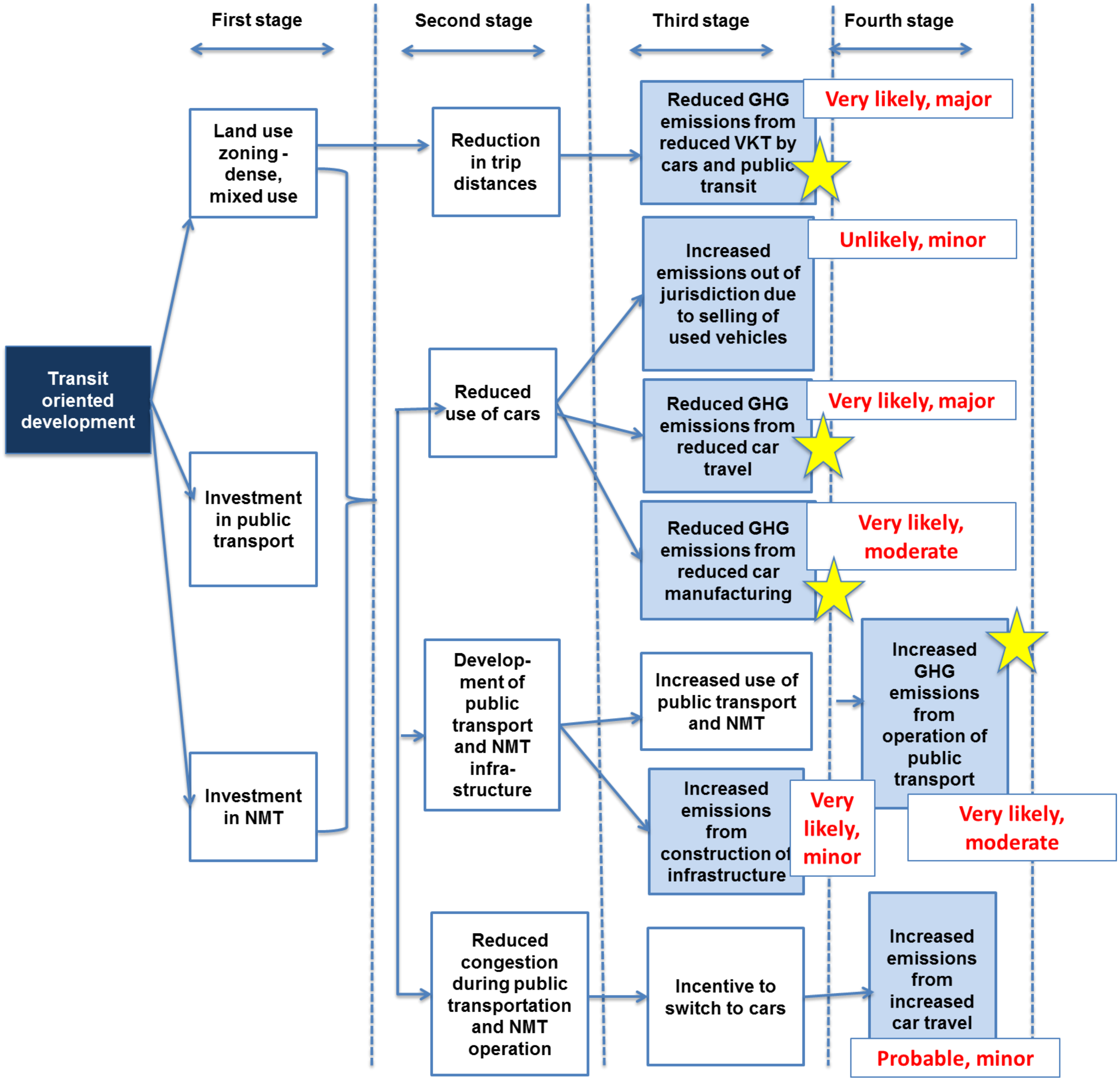
Chapter 7: Defining the GHG assessment boundary

7.1 Assess the significance of potential GHG effects

Table 7.3 Example of assessing each GHG effect separately by gas to determine which GHG effects and greenhouse gases to include in the GHG assessment boundary for the example policy

GHG effect	Likelihood	Relative magnitude	Included?
Reduced GHG emissions from reduced VKT by cars and public transit			
CO_2	Very Likely	Major	**Included**
CH_4	Very likely	Minor	Excluded
N_2O	Very likely	Minor	Excluded
Increased emissions out of jurisdiction due to selling of used vehicles			
CO_2	Unlikely	Minor	Excluded
CH_4	Unlikely	Minor	Excluded
N_2O	Unlikely	Minor	Excluded
Reduced GHG emissions from reduced car travel			
CO_2	Very likely	Major	**Included**
CH_4	Very likely	Minor	Excluded
N_2O	Very likely	Minor	Excluded
Reduced GHG emissions from reduced car manufacturing			
CO_2	Very likely	Moderate	**Included**
CH_4	Very likely	Minor	Excluded
N_2O	Very likely	Minor	Excluded
Increased GHG emissions from operation of public transport			
CO_2	Very likely	Moderate	**Included**
CH_4	Very likely	Minor	Excluded
N_2O	Very likely	Minor	Excluded
Increased emissions from construction of infrastructure			
CO_2	Very likely	Minor	Excluded
CH_4	Very likely	Minor	Excluded
N_2O	Very likely	Minor	Excluded
Increased emissions from increased private transport			
CO_2	Possible	Minor	Excluded
CH_4	Possible	Minor	Excluded
N_2O	Possible	Minor	Excluded

Figure 7.3 Assessing each GHG effect to determine which GHG effects to include in the GHG assessment boundary for the example policy



Chapter 8: Estimating baseline emissions

8.4 Estimating baseline emissions using the scenario method

Illustrative example of emissions estimation method

1. Obtain the baseline trip distance TD0; trip rate TR0; population P0; modal distribution: auto A0, motorcycle M0, bus B0, walking W0, biking K0; TD0; density D0; Area AR0=P0/D0
2. Obtain emissions rate in grams/km for the base year EA0, EM0, EB0, EW0=0, EK0=0
3. Obtain the future conditions for business-as-usual scenario (automobility and sprawl)

3.1. Population in year n PBAUn [from demographic estimations]
3.2. Density in year n DBAUn [from historic tendencies]
3.3. Area in year n ABAUn=PBAUn/DBAUn
3.4. Trip distance in year n TDBAUn =TD0*(ABAUn/AR0)^(1/2) [Trip distance is proportional to the area radii, which is equal to the square root of the area over Pi]
3.5. Estimate modal distribution in year n: ABAUn, MBAUn, BBAUn, WBAUn, KBAUn [from historic tendency]
3.6. Estimate emissions rates in year n: EAn, EMn, EBn
3.7. Estimate emissions: EMBAUn=TDBAU*(ABAUn*EAn+MBAUn*EMn+BBAUn*EBn) [Alternative is to have a trip distance by mode using the same proportional approach]

4. Obtain future conditions for policy scenario (transit oriented development=
4.1. Population in year n PPSn=PBAUn
4.2. Density in year n DPSn [target from the policy, e.g. keep current density levels]
4.3. Area in year n APSn=PPSn/DPSn
4.4. Trip distance in year n TPSn=TD0*(APSn/AR0) ^(1/2)^
4.5. Estimate modal distribution in year n: APSn, MPSn, BPSn, WPSn, KPSn
4.6 Estimate emissions rates in year n: equivalent to BAU scenario EAn, EMn, EBn
4.7. Estimate emissions: EMPSn=TPSn*(APSn*EAn+MPSn*EMn+BPSn*EBn)

5. Calculate emissions savings: Savings = EMBAUn-EMPSn

Illustrative example of parameters in the emissions estimation algorithm

Bus passengers, average bus trip length, passenger kilometers, average occupancy rate each mode, emissions factor per mode.

Examples of determining baseline values from published data sources

Parameter	Sources of published data for baseline values
Average bus trip length, occupancy, passengers kilometers.	Schipper, L., I. Bannerjee, and W.S. Ng. Carbon Dioxide Emissions from Land Transport in India: Scenarios of the Uncertain. In Transportation Research Record: Journal of the Transportation Research Board, No. 2114, Transportation Research Board of the National Academies, Washington, D.C., 2009, pp. 28-37.
Emissions factor	Government of India. 2011 Census – Provisional Population Totals Paper 1. Office of the Registrar General & Census Commissioner, Ministry of Home Affairs, Government of India, New Delhi. http://www.censusindia.gov.in/2011-prov-results/census2011_PPT_paper1.html. Accessed Jul. 30, 2011. Center for Environmental Planning and Technology (CEPT). Bus Rapid Transit System, Ahmedabad – Final Report. CEPT, Ahmedabad, 2008.

Table 8.3 and 8.4 Typical other policies and actions, and non-policy drivers and related data sources for developing assumptions

Typical other policies	Sources of data for developing assumptions
Urban development	Regulation on land use and city border (development authorities)
Investment in transit and non-motorized transport	City plans and budgets

Typical non-policy drivers	Sources of data for developing assumptions
Population	Demographic calculations, census

Chapter 9: Estimating GHG effects ex-ante

9.2 Identify parameters to be estimated

Illustrative example of identifying affected parameters for the example policy

Average bus trip length, passenger kilometers, average occupancy rates for each mode are typically expected to be affected by this type of policy.

Illustrative example of determining expected effects on parameters

The construction of scenarios for city development necessitates understanding of the current transport and urban conditions, and involves projecting alternative futures based on reasonable assumptions. This example projects two alternative futures: automobility and sustainable transport and urban development. Automobility implies continuing the trend towards motorization (i.e., increasing the share of individual motor vehicle trips) and urban growth (reducing city density). Sustainable transport and urban development entails reducing slightly the shares of non-motorised trips, increasing the share of public transport trips (through provision of safe facilities and services) and maintaining the city density (through land use policies).

The process involved to estimate the impacts of each scenario in the following steps which take into account the change in parameters:

1. Get current population, area, modal shares and trip distances
2. Get population growth for target year (e.g., 2021, 2041) from official sources
3. Get emissions factors for different modes in gms/km (usually decrease in time)
4. Get accident factor (fatalities/km) for base years. Assumption is to keep them constant over time. This depends in many other factors, like vehicle traffic speeds, quality of the infrastructure, rules, enforcement and post-incident attention, among other. A constant factor might be conservatory, as speeds increase in the automobilty scenario and decrease in the sustainable transport scenario.
5. Make assumptions on trip rates (i.e. trips per person per day)
6. For each scenario make assumptions on city density and modal shares. Estimate trip length per mode. Transform trips into vehicle km using observed trip occupancy for each mode. Estimate vehicle km for each mode.
7. Calculate fatalities and emissions.

The example case of Ahmedabad uses base population and transport data for 2000 and project to 2021 and 2041 as shown in Table 1 (Based on Rayle and Pai, 2010).

Illustrative examples of addressing policy interactions and overlaps

Favorable interaction: Policy for TO + Energy Efficiency Regulations (the emissions rates in the target year will be lower than in business as usual scenario)

Overlapping policy: construction of roads will reduce the participation of non-motorized and public transport in the target year, hence reducing the impact of the policy for transit oriented development

Overlapping policy: low density land development in the fringes as a source of local funding will reduce the impact of the TOD Policy

Reinforcing policy: transportation demand management (e.g. parking or congestion charges) will increase the participation of non-motorized and public transport trips

Figure B.1 Illustrative example of a policy interaction matrix

		Parameter- modal share				
		1	2	3	4	5
1	TOD Policy					
2	Energy efficiency	++				
3	Road construction	Uncertain	Uncertain			
4	Low density land development in expansion zones	Uncertain	Uncertain	-		
5	Transportation demand management	++	+	Uncertain	Uncertain	

Key:

Independent	0
Overlapping	- - - major/-- moderate/- minor interaction
Reinforcing	+++ major/++ moderate/+ minor interaction
Uncertain	U

Chapter 11: Estimating GHG effects ex-post

11.2 Select an ex-post assessment method

Table 11.1 Applicability of ex-post assessment methods

Bottom up methods	Applicability
Collection of data from affected participants/ sources/other affected actors	• Fuel sales (for verification)
Engineering estimates	• -
Deemed estimate	• Travel characteristics including mode share, trip length and vehicle occupancy from a city-wide travel survey and travel behavior study • Example, Emission Data from a comprehensive study conducted by the Automotive Research Association of India (ARAI) in 2008
Methods that can be bottom-up or top-down depending on the context	**Applicability**
Stock modeling	• -
Diffusion indicators	• -
Top down methods	**Applicability**
Monitoring or indicators	• -
Economic modeling	• -

Appendix B: Light Duty Fuel Efficiency Standard

This appendix provides examples of reporting select information across chapters (tables, boxes and descriptions) for the policy example: Light duty fuel efficiency standard ("improve" policy).

Chapter 5: Defining the policy or action

5.2 Clearly define the policy or action to be assessed

Table 5.2 Checklist of information to describe the policy: Light duty fuel efficiency standard

Information	Example
The title of the policy or action	Light duty fuel efficiency standard
Type of policy or action	Regulations and standards
Description of the specific interventions included in the policy or action	Fleet average tailpipe CO_2 emissions target
The status of the policy or action	Ongoing
Date of implementation	2010
Date of completion (if applicable)	-
Implementing entity or entities	Transport ministry
Objective(s) of the policy or action	Increase in the average fuel efficiency of new vehicles
Geographical coverage	Usually national or regional
Primary sectors, subsectors, and emission sources or sinks targeted	Emissions from private transport
Greenhouse gases targeted	CO_2
Optional information	
Key indicators	Fleet sales-weighted average tailpipe CO_2 emissions (gCO_2/km) Numbers of low carbon cars as a proportion of total sales Numbers of low carbon models brought to market
Intended level of mitigation to be achieved and/or target level of other indicators	Will depend on the stringency of the tailpipe CO_2 target
Title of establishing legislation, regulations, or other founding documents	Light duty fuel efficiency standard
MRV procedures	-
Enforcement mechanisms	-
Reference to relevant guidance documents	-
The broader context/significance of the policy or action	Can be seen as part of a package of measures to develop green economic growth and to stimulate supply chains in low carbon technologies
Other related policies or actions	
Outline of non-GHG effects or co-benefits of the policy or action	Air quality (potentially negative and positive), job creation in low carbon technologies sector. Reduced energy consumption.
Other relevant information	-

5.3 Decide whether to assess an individual policy/action or a package of policies/actions

Table 5.5 Mapping policies/actions that target the same emission source(s)

Policy assessed	Targeted emission source(s)	Other policies/actions targeting the same source(s)	Type of interaction	Degree of interaction
Light duty fuel efficiency standard	Fuel combustion in private transport vehicles	CO_2-graduated vehicle taxation	Reinforcing	Minor
		CO_2 labeling	Reinforcing	Moderate
		Incentives for low carbon cars	Reinforcing	Moderate
		Provision of necessary infrastructure (e.g. electric charging points, hydrogen refueling stations, etc.)	Reinforcing	Moderate
		Local policies such as exemption from congestion charges, use of bus lanes, free/ reduced parking etc.	Reinforcing	Moderate
		Biofuels obligations	Independent	-
		Eco-driving lessons	Independent	-
		Encouragement of walking and cycling	Independent	-
		Demand reduction measures (e.g. video-conferencing, spatial planning)	Independent	-
		Congestion charging (if revenue raising)	Overlapping	Minor
		Increased public transport (e.g. train, bus, light rail)	Overlapping	Major

Table 5.6 Criteria to consider for determining whether to assess an individual policy/action or a package of policies/actions

Criteria	Questions	Light duty fuel efficiency standard
Use of results	Do the end-users of the assessment results want to know the impact of individual policies/actions, e.g. in order to inform choices on which individual policies/actions to implement or continue supporting?	Yes
Significant interactions	Are there significant interactions between the identified policies/actions, either overlapping or reinforcing, which	Yes

	will be missed if policies/actions are assessed individually?	
Feasibility	Will the assessment be unmanageable if a package of policies/actions is assessed, e.g. is the causal chain and range of effects likely to become too complex?	No
	For ex-post assessments, is it possible to disaggregate the observed impacts of interacting policies/actions?	No

It is often appropriate to assess the fuel efficiency standard as part of a package with vehicle labeling, CO_2-graduated vehicle taxation and any incentives, as all operate at the national level and in practice it will be difficult to isolate the impacts of the individual measures.

Chapter 6: Identifying effects and mapping the causal chain

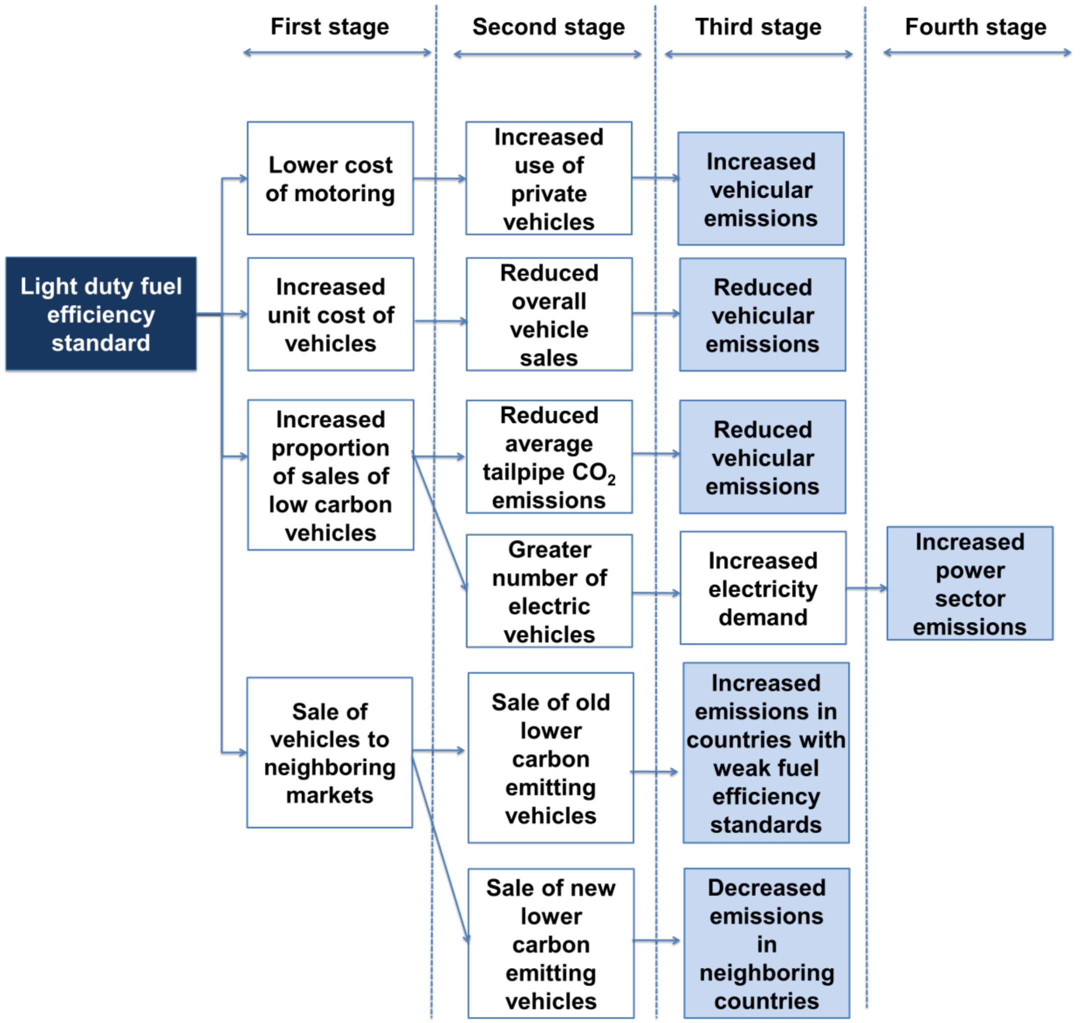
6.1 Identify potential GHG effects of the policy or action

Table 6.2 Illustrative example of various effects for the example policies

Type of effect	Effect
Intended effect	• Reduction in fleet average tailpipe CO_2 emissions.
Unintended effect	• Increase in driving distances due to the lower cost of motoring (i.e. rebound effect)
In-jurisdiction effect	• Increase in proportion of sales of lower carbon vehicles
Out-of-jurisdiction effect	• Sale of lower carbon emitting vehicles to neighboring markets • Sale of higher carbon emitting vehicles to countries with no or weak fuel efficiency standards
Short-term effect	• Increase in overall car prices
Long-term effect	• (No additional effects identified)

6.3 Map the causal chain

Figure 6.3 Mapping GHG effects for the example policy



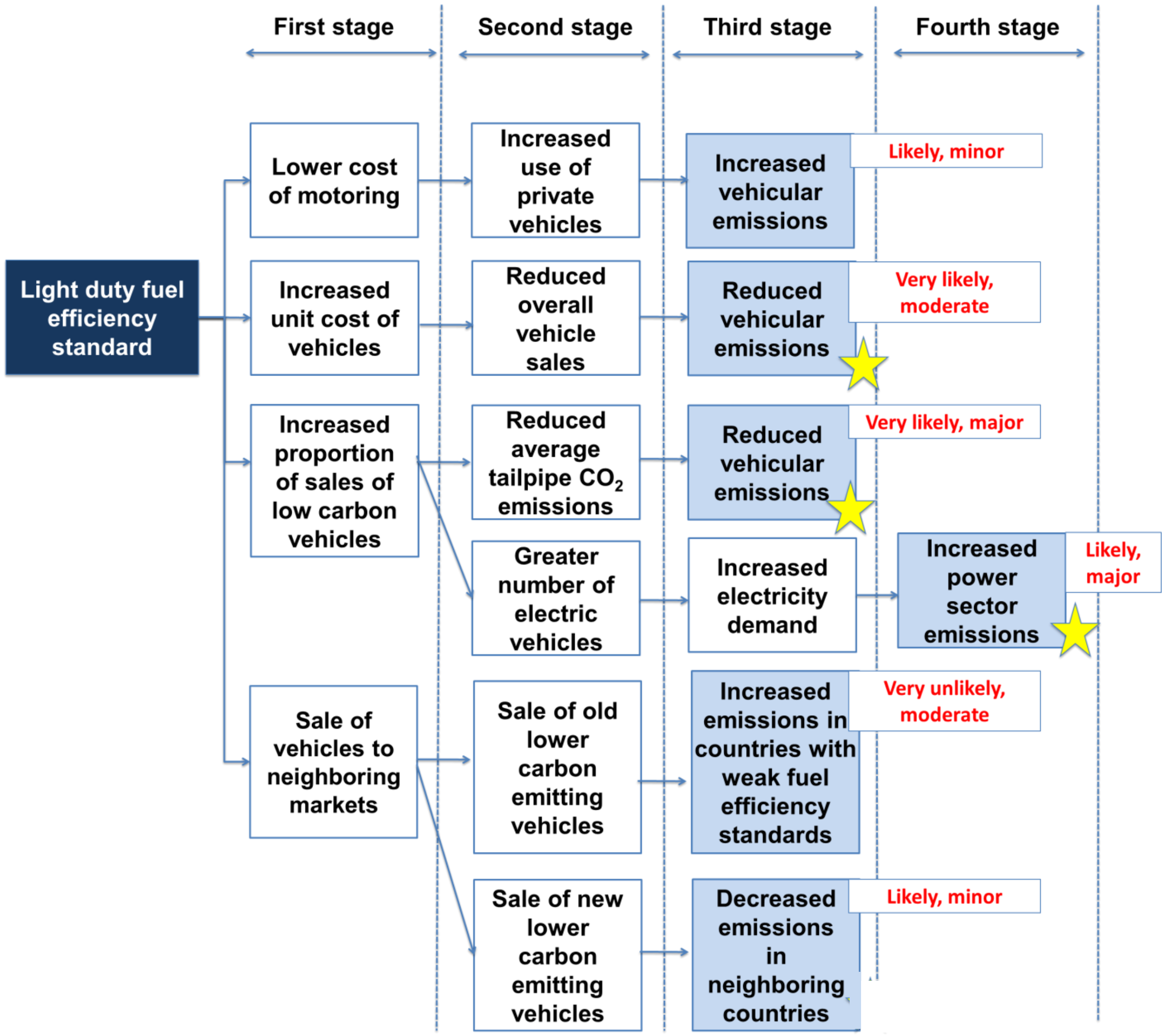
Chapter 7: Defining the GHG assessment boundary

7.1 Assess the significance of potential GHG effects

Table 7.3 Example of assessing each GHG effect separately by gas to determine which GHG effects and greenhouse gases to include in the GHG assessment boundary for the example policy

GHG effect	Likelihood	Relative magnitude	Included?
Increased vehicular emissions due to lower cost of motoring			
CO_2	Likely	Minor	Excluded
CH_4	Likely	Minor	Excluded
N_2O	Likely	Minor	Excluded
Reduced vehicular emissions due to increased cost of vehicles			
CO_2	Very likely	Moderate	Included
CH_4	Very likely	Minor	Excluded
N_2O	Very likely	Minor	Excluded
Reduced vehicular emissions due to reduced tailpipe emissions			
CO_2	Very likely	Major	**Included**
CH_4	Very likely	Minor	Excluded
N_2O	Very likely	Minor	Excluded
Increased power sector emissions due to electric vehicles			
CO_2	Likely	Major	Included
CH_4	Likely	Minor	Excluded
N_2O	Likely	Minor	Excluded
Increased emissions in countries with weak fuel efficiency standards			
CO_2	Very unlikely	Moderate	Excluded
CH_4	Very unlikely	Minor	Excluded
N_2O	Very unlikely	Minor	Excluded
Decreased emissions in neighboring countries			
CO_2	Likely	Minor	Excluded
CH_4	Likely	Minor	Excluded
N_2O	Likely	Minor	Excluded

Figure 7.3 Assessing each GHG effect to determine which GHG effects to include in the GHG assessment boundary for the example policy



Chapter 8: Estimating baseline emissions

8.4 Estimating baseline emissions using the scenario method

Illustrative example of emissions estimation method

The projected impact on vehicular GHG emissions can be calculated as follows:

*GHG emissions from light duty (private) vehicles = sales-weighted average vehicle fuel efficiency (gCO_2/km) * vehicle journey demand (VKM)*

Vehicle fuel efficiency will need to take account of assumptions regarding autonomous fuel efficiency increases. New vehicle sales can be taken from industry forecasts or can be calculated by applying a vehicle survival rate to vehicle stock forecasts. Vehicle stock forecast data can be obtained from government forecasts, or can be calculated from GDP and population.

If vehicle fuel efficiency is only available in MJ/km then there is an extra step in the algorithm:

*GHG emissions from light-duty (private) vehicles = emission factor (kg/MJ) * energy consumption*

*Energy consumption (J) = vehicle journey demand (VKM) * sales-weighted average vehicle fuel efficiency (MJ/km)*

This calculation can be performed most simply by assuming a vehicle journey demand (e.g. based on literature review, expert judgment etc.). For example, it could be assumed that vehicles are on average driven 10,000km a year. A more robust approach to vehicle journey demand can be to calculate it as follows:

Vehicle journey demand (VKM) = Service demand (PKM)/load factor

Service demand can be derived from relevant literature of government forecasts. Alternatively it can be estimated from population and GDP projections, for example using a 'Gompertz Curve'. Similarly, load factor, can be taken from relevant literature (e.g. academic studies) or calculated from household data.

Illustrative example of parameters in the emissions estimation method

Emissions factor: kgCO_2/MJ
Vehicle fuel efficiency: MJ/km or gCO_2/km
Vehicle journey demand: vehicle kilometers
Service demand: passenger kilometers
Load factor: payload per vehicle (so for passenger modes, people per vehicle)

Examples of determining baseline values from published data sources

Parameter	Sources of published data for baseline values
Emissions factor	UNFCCC guidance
Vehicle fuel efficiency	Manufacturers data (often from trade associations)
Vehicle journey demand	Literature review
Service demand	Government statistics, government forecasts (e.g., for transport projects)
Load factor	Census data

Table 8.3 and 8.4 List of typical other policies and non-policy drivers and related data sources for developing assumptions (for developing new baseline values)

Typical other policies	Sources of data for developing assumptions
Fuel duty	Government statistics
Procurement policies	Impact assessments for these policies
Demand management policies (e.g., road pricing)	Impact assessments for these policies
Car sharing policies (e.g., high-occupancy vehicle lanes)	Impact assessments for these policies

Typical non-policy drivers	Sources of data for developing assumptions
Household incomes	Government statistics
Fuel prices	Government statistics
Population	Census data, Government forecasts, academic forecasts

Illustrative examples of estimating baseline emissions using different levels of accuracy

Low accuracy: Collect gCO_2/km forecasts from manufacturers and multiply by an assumed vehicle journey demand figure (e.g. 10,000km per car per year, with an 11 year life for each car). Intermediate accuracy: calculate vehicle journey demand from collected or assumed values for service demand and load factor.

High accuracy: Calculate load factor and service demand from robust macro-economic projections (e.g. latest Government macro-economic forecasts) and from modeling using the Gompertz Curve, and use these calculated values to calculate vehicle journey demand.

Chapter 9: Estimating GHG effects ex-ante

9.2 Identify parameters to be estimated

Illustrative example of identifying affected parameters for the example policy

Most of the parameters within the emissions estimation method will be effected in the policy scenario.

Illustrative example of determining expected effects on parameters and defining parameter values

Higher transport emissions due to rebound effect: make assumption on level of rebound effect through literature review, stakeholder consultation and expert judgment. If helpful, the rebound effect can be broken down into different effects (e.g. increased mileage, driving more aggressively, taking extra comfort when driving, such as increased use of air conditioning etc.).

Lower transport emissions due to greater proportion of sales of low carbon vehicles: calculated as in the baseline but with vehicle fuel efficiency set by the relevant standards and assumptions made about the profile of fuel efficiency improvements in years where no standard applies (e.g. if compliance with the standard only needs to be demonstrated every 5 years.

In relation to cost, an assumption needs to be made regarding the extent to which the reduction in average tailpipe CO_2 emissions is delivered through lower carbon technologies or through downsizing (encouraging consumers to switch to smaller vehicles). This assumption can be agreed through expert judgment and by an assessment of the likely structure of the standards. For example, as in the case in Europe, a mass-based utility parameter approach (where the CO_2 target for a manufacturer is based on the average weight of the vehicles it produces) might discourage manufacturers to meet the targets through downsizing, so it would be reasonable to assume that the target is purely met through technology. However if using this simplifying assumption, it needs to be noted that the resulting cost figures will be upper bound estimates.

Figure B.1 Illustrative example of a policy interaction matrix

		Parameter: Vehicle fuel efficiency										
		1	2	3	4	5	6	7	8	9	10	11
1	Light duty fuel efficiency standard											
2	CO_2-graduated vehicle taxation	+ to +++										
3	CO_2 labelling	+										
4	Incentives for low carbon cars	+ to +++	++									
5	Provision of necessary infrastructure (e.g. electric charging points, hydrogen refueling stations etc)	+	+	+								

6	Local policies such as exemption from congestion charges, use of bus lanes, free/reduced parking etc	+ nationally, ++ locally	0	0	0							
7	Biofuels obligations	0	+	+	+	0						
8	Eco-driving lessons	0	++	+	+	0	0					
9	Encouragement of walking and cycling	--	+	+	+	0	-	0				
10	Demand reduction measures (e.g. video-conferencing, spatial planning)	-	+	+	+	0	--	0	+			
11	Congestion charging (if revenue raising)	-	--	--	--	+	+	0	++	-		
12	Increased public transport (e.g. train, bus, light rail)	--	+	+	+	+	++	0	0	0	++	

Key:
Independent 0
Overlapping - - - major/-- moderate/- minor interaction
Reinforcing +++ major/++ moderate/+ minor interaction
Uncertain U

Chapter 11: Estimating GHG effects ex-post

11.2 Select an ex-post assessment method

Table 11.1 Applicability of ex-post assessment methods

Bottom up methods	Applicability
Collection of data from affected participants/ sources/other affected actors	• Measurement of individual fuel efficiency of new cars by manufacturers, using the agreed test cycle for that country/region
Engineering estimates	• May be needed by manufacturers to calculate the fuel efficiency on the test cycle.
Deemed estimate	• -
Methods that can be bottom-up or top-down depending on the context	**Applicability**
Stock modeling	• Can use stock modeling to calculate new vehicle sales if this data is not available from manufacturers (or to act as a cross-check on the data collected by manufacturers).
Top down methods	**Applicability**
Monitoring or indicators	• Can be used to derive CO_2 emissions from fuel sales (but not very robust)
Economic modeling	• Can be used to derive GDP and population data if needed.